



THE REPUBLIC OF UGANDA

MINISTRY OF WORKS AND TRANSPORT

General Specifications for Road and Bridge Works



Ministry of Works and Transport

Plot 57 -59, Old Port Bell Road
PO BOX 7174, Kampala, Uganda

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FOREWORD

By the powers entrusted to me under the Roads Act 2019, I am pleased to present the General Specifications for Road and Bridge Works, 2026. As Government, we are committed to enhancing the quality and safety of Uganda's road infrastructure. The General Specifications will be part of the legal and technical framework for use in planning, design, construction, maintenance and operation of efficient and effective public road and bridge infrastructure in our country.

The Ministry of Works and Transport, in consultation with stakeholders has undertaken a comprehensive review of the previous specifications that were launched in 2005 and updated them accordingly. The revisions have incorporated the latest advancements in technology, the best practices observed locally, regionally and internationally, as well as the valuable experiences gathered from practitioners in the road construction industry.

The importance of well-designed, constructed and maintained public roads cannot be overstated. They are vital to our national development and facilitate trade, tourism, security, agriculture, mining, mobility, and connectivity across our communities. It is our responsibility to ensure that these roads are built and maintained to the highest standards and with the lowest possible costs while ensuring durability, safety, and sustainability.

As we roll out the new specifications, I encourage all stakeholders who include among others Government Ministries, Departments, Agencies, Local Governments, engineers, contractors, consultants, manufacturers, and suppliers to familiarize themselves with the provisions and apply them rigorously in their work. Your continuous feedback to the Ministry, will be invaluable as we welcome insights and suggestions that can further refine our approach towards public roads design, construction and maintenance.

Additionally, while these specifications serve as the national standard for all public roadworks, I want to emphasize that special specifications may be developed for projects. Any deviations from these specifications must also receive prior approval as we strive to maintain the integrity and consistency of our road infrastructure across the nation. All proposals for deviations with accompanying rationale and justification, shall before incorporation into projects, be submitted to the Engineer-In-Chief, Ministry of Works and Transport for technical advice before approval by the Minister.

I extend my sincere appreciation to all the Stakeholders from Government Ministries, Departments, Agencies, private sector consultants and contractors, academia among others who have dedicated their time in providing input in updating these General Specifications.

Together, let us work towards building a robust and efficient road network that meets the needs of our people and supports Uganda's aspirations for growth and development.



Hon. Edward Katumba-Wamala
Gen.

MINISTER OF WORKS AND TRANSPORT

PREAMBLE

The Ministry of Works and Transport in collaboration with key stakeholders within Uganda's construction industry who included representatives from Government Ministries, Departments, Agencies, Local Governments, Consultants, contractors, manufacturers and suppliers prepared the General Specifications for Road and Bridge Works 2026. These specifications serve as the updated technical and minimum quality standards that will guide the planning, design, construction and maintenance of road and bridge infrastructure across the country.

Replacing the earlier Ministry of Works and Transport General Specifications of 2005, the 2026 edition incorporates extensive inputs drawn from local industry experiences, regional best practices, international standards, and the latest advancements in road construction technologies. This comprehensive update aims to enhance the quality, efficiency, and sustainability of road and bridge projects, as aligned with National Development goals and global industry trends.

The specifications are organized into eight series, each addressing specific aspects of road and bridge works with the following improvements:

Series 1000 – General

This has been updated to improve project quality, strengthen site supervision, and incorporate environmental and social safeguards. It emphasizes occupational health and safety, stakeholder involvement, sustainable practices, and addresses challenges related to the availability of suitable construction materials within economic haulage distances.

Series 2000 – Drainage

This focuses more on the use of high-quality prefabricated concrete and metallic steel culverts, and promote the adoption of geosynthetics to enhance drainage systems.

Series 3000 – Site Clearance, Earthworks and Pavement Layers of Gravel or Crushed Stone

This introduces the reuse and recycling of pavement materials, prohibits the use of inferior G3 materials for earthworks, and encourages the application of earth lateral systems, geosynthetics, and ground improvement techniques. It also specifies higher classes of stabilized materials for improved performance.

Series 4000 – Bituminous Layers, Seals, and Concrete Pavement

This has been comprehensively revised to incorporate contemporary practices and technological advancements in pavement engineering. Notably, this series introduces concrete pavements as a standard option for durable and high-performance road surfaces, expanding beyond traditional bituminous layers.

The specification provides for the use of various bituminous binders, including the adoption of performance grade (PG) bitumen, which ensures materials are suitable for the climatic and loading conditions of Uganda. The series also promotes the use of stone matrix asphalt (SMA), known for its superior rut resistance and durability, as well as polymer and rubber-modified binders to enhance flexibility, resilience, and lifespan of asphalt surfaces.

Further innovations include the introduction of cold asphalt mixes, which facilitate faster and more environmentally friendly repairs, and the recycling of asphalt mixes to promote sustainable practices and resource conservation. Additionally, the series details other sealing techniques

such as cape seals, which combine chip seals with slurry or asphalt overlays to improve surface sealing and extend pavement life.

These updates aim to deliver pavements that are not only robust and long-lasting but also environmentally sustainable and cost-effective, aligning with modern standards and the national objectives of infrastructure resilience and sustainability.

Series 5000 – Ancillary Road Works

The Series 5000 has been further enriched to encompass a broader range of ancillary road infrastructure essential for the safety, efficiency, and convenience of road users. This series now includes specifications for the design, installation, and maintenance of:

- **Road Lighting:** In order to ensure adequate illumination for safety and security during night-time and low-visibility conditions;
- **Traffic Signals:** These are standardized requirements for the installation and operation of traffic control devices to optimize traffic flow and enhance safety;
- **Bus Stop Shelters:** These are specifications for durable and accessible shelters that provide comfort and protection for public transport users.
- **Axle Weigh Bridges:** Standards for the construction and operation of weigh bridges to enforce load regulations, prevent road damage, and ensure equitable freight practices; and
- **Toll Plazas:** Standards for toll collection facilities, including traffic management, payment systems, and safety considerations.

Series 6000 – Structures

The Series 6000 has been updated to include provisions for specialized types of concrete and structural repair practices, reflecting advancements in construction technology and maintenance strategies. The key updates are as follows:

- **Self-Compacting Concrete (SCC):** Specifications now accommodate the use of SCC, a highly flowable, non-segregating concrete that consolidates under its own weight, enabling easier placement in complex formworks and congested reinforcement areas, thereby improving construction efficiency and quality;
- **Cable Concrete:** The series introduces requirements for cable-reinforced concrete, suitable for structures that require enhanced tensile strength, durability, and flexibility, supporting the construction of bridges, tunnels, and other critical infrastructure; and
- **Repairs and Maintenance of Structures:** The updated series emphasizes standardized methods and materials for the repair and maintenance of existing structures, ensuring their longevity, safety, and performance.

These enhancements aim to improve the durability, safety, and sustainability of Uganda's structural infrastructure through the adoption of modern concrete technologies and best practices in structural maintenance.

Series 7000 – Tolerances, Testing, and Quality Control

The Series 7000 has been updated to incorporate the latest advancements and state-of-the-art test methods, ensuring robust quality control and quality assurance processes across all stages of construction.

Series 8000 – Dayworks

The Series 8000 has been introduced as a new component, encompassing labor, materials, and equipment used for dayworks. The inclusion of dayworks is essential to provide a flexible and efficient mechanism for addressing unforeseen or additional works that arise during construction, while ensuring timely completion and maintaining quality standards. Dayworks will facilitate effective management of minor, urgent, or supplementary tasks, enabling contractors to adapt to site conditions promptly while maintaining transparency and accountability in project execution.

The General Specifications for Roads and Bridge Works 2026 serve as the baseline requirements for all public road and bridge projects in Uganda. It is essential that every practitioner fully understands and applies them correctly in their respective projects. Many construction disputes originate from misinterpretation or overlooked details within the specifications. Where project-specific conditions necessitate deviations from the General Specifications, Special Specifications may be prepared with proper justification and approved by the Minister. Special specifications may be necessary to address conditions such as: unique terrain and geological conditions, unusual loading or climatic scenarios, specific aesthetic requirements, technological advancements or innovations, among others.

For purposes of reading and interpreting the General Specifications, you need to begin with the scope which defines the boundaries of application of a given section. You also need to pay close attention to words like “shall”(mandatory), “should”(recommended), “may”(optional) and “will”(future action). These dictate the level of compliance required.

The Specifications also contain cross references to other standards, codes or sections and you are required to follow these references to ensure you have the complete requirements. You also need to understand the required tests, frequencies and acceptance criteria in order to determine how best quality control will be undertaken on the project

I warmly invite all stakeholders in the construction industry to adopt and actively implement the General Specifications for Road and Bridge Works, 2026. Your collaboration is vital to ensure the successful delivery of high-quality, sustainable, and resilient infrastructure across Uganda.

I also encourage you to provide regular feedback on the specifications and their application. Your insights, experiences, and suggestions are invaluable for continuous improvement, helping us refine standards and address emerging challenges effectively. Together, through open communication and shared commitment, we can advance Uganda's infrastructure development to meet both national and international standards.



Eng. Stephen Kiwanuka Kitonsa
Engineer-In-Chief
MINISTRY OF WORKS AND TRANSPORT

ACKNOWLEDGEMENT

The development of the General Specifications for Road and Bridge Works 2026 has been a collaborative effort achieved through the valuable contributions of a diverse range of stakeholders in Uganda's construction industry. We extend our sincere gratitude to contractors, consultants, manufacturers, suppliers, engineers, and professionals from both the public and private sectors whose insights, expertise, and feedback have been instrumental in shaping these specifications.

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The following individuals from the public and private sectors are specifically recognized for their contribution:

1.	Eng. Stephen Kitonsa	MoWT
2.	Eng. Samson Bagonza	MoWT
3.	Eng. Dr. Moses Odongo	MoWT
4.	Eng. Wilfred Okello	MoWT
5.	Eng. Tonny Mugenyi	MoWT
6.	Eng. Ben Kyemba	MoWT
7.	Eng. Fred Kayima	MoWT
8.	Eng. Jeroboam Okullu	MoWT
9.	Eng. Paul Ssesanga	MoWT
10.	Mr. Daniel Kasule	MoWT
11.	Eng. Moses Kibirige	MoWT
12.	Eng. Musa Mwine	MoWT
13.	Eng. Patrick Osele (RIP)	MoWT
14.	Mr. Mutemo Charles	MoWT
15.	Ms. Juliet Atino	MoWT
16.	Mr. Francis Abedkane	MoWT
17.	Eng. Raymond Mugabi	MoWT
18.	Mr. Lambert Busulwa	MoWT
19.	Eng. Patrick Muleme	MoWT
20.	Ms. Monicah Seruma	MoWT
21.	Eng. Norman Byamukama	MoWT
22.	Eng. Michael Ochola	MoWT
23.	Eng. Ronald Olaki	MoWT
24.	Eng. Fredi Kaheru	MoWT
25.	Eng. Emmanuel Wobuya	PEC
26.	Eng. Charles Bakaki	PEC
27.	Eng. Sam Bbira	GAUFF
28.	Eng. Willy Tibwita	GAUFF
29.	Eng. David Kaddu	Makerere University
30.	Eng. Jonathan Tugume	UNABSEC
31.	Eng. Jingo Kizito	CIC
32.	Mr. Feng Junpeng	CCCC
33.	Mr. Li Jianghua	CCCC

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SERIES 1000

GENERAL

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1101 DEFINITIONS AND TERMS

Unless inconsistent with the context, in these Specifications the following terms, words or expressions shall have the meanings hereby assigned to them.

ACCEPTED

Accepted in writing by the Engineer (or by the Employer where appropriate) as meeting the requirements of the Contract Documents and of any authorised variations thereto. "Acceptance" means accepted in writing as aforesaid. "Acceptable" means acceptable to the Engineer as aforesaid.

ACCESS CULVERT

An access culvert provides an opening under an intersecting side road or entrance to plots along the project road.

ACCESS ROAD

A portion of the haul route built or used during the contract period to gain access from the public road to sources of materials or spoil areas.

ADDENDUM

Amendment or revision to any of the Contract Documents.

AGGREGATE

Crushed stone of specified size and quality to be used in the Works.

ANCHORAGE

Anchorage is the device comprising all the components and materials required for retaining the force in a tensioned tendon and to transmit this force to the concrete of the structure.

ANCHORAGE REINFORCEMENT

Anchorage Reinforcement is the spiral and other reinforcement which forms part of the Anchorage and is required for strengthening the Anchorage and/or assisting in transmitting the tendon force to the concrete.

ANCHORED EARTH

It is a form of reinforced soil which uses anchors embedded within the soil mass to provide stability/resistance to pull-out by passive action of the anchor and friction along the anchor shaft or loop.

APPROVED

Approved in writing by the Engineer, including subsequent written approval or confirmation of previous verbal approval by the Engineer. "Approval" means approval in writing as aforesaid.

ASPHALT CONCRETE SURFACING

The layer or layers of a bituminous mix constructed on top of

the base course made of a mixture to predetermined proportions of aggregate, filler and bituminous binder material prepared in a mixing plant to meet the requirements for surfacing material and placed by means of a paving machine.

ASPHALT CONCRETE WEARING COURSE

The uppermost layer of asphalt concrete surfacing.

ASPHALT CONCRETE BINDER COURSE

The Middle layer of Asphalt that lies between the base course (or subbase) and the surface (or wearing) course.

AUXILIARY LANE

An additional lane on the road, which is not part of the main line traffic flow, designed to support specific traffic movements. Examples include; acceleration lanes, deceleration lanes, climbing lanes and turning lanes.

BACK FILL

Excavated material from the borrow Area/ Existing roadway excavation, which is placed and compacted in trenches and around foundations.

BASE COURSE

A layer of material directly beneath the asphalt wearing course or asphalt binder course.

BEMIX (BITUMEN EMULSION MIX)

Bituminous base course material made in accordance with this SPECIFICATION with approved bitumen emulsion by mixing in appropriate equipment or as specified in a cold process.

BERM

A berm is a ridge or raised barrier that runs alongside a road, constructed of compacted soil, gravel, rocks, and stones to prevent flooding of road.

BID

Shall mean the same as tender.

BILLS OF QUANTITIES (BOQ)

The contractual Bills of Quantities of the Works, including any additional and modified BOQ approved by the Employer.

BINDER

A material such as bitumen, cement, lime or other approved material, which is added to and mixed into aggregate, granular materials or soils to bind the mixture together to form a solid cohesive mass.

BITUMINOUS BASE COURSE

The lowest layer of hot or cold mixed bituminous material (asphalt) constructed on top of the road base or in the absence thereof, the subbase layer.

BITUMEN CONTENT

Percentage of residual bitumen by weight of total mix excluding water.

BITUMINOUS MIX

A mixture of a bituminous binder and aggregate.

BITUMINOUS SEAL

A bituminous surfacing made by the application of one or more layers of bituminous binder with or without layers of aggregate.

BOND BREAKER

Bond breaker is the coating or sheath placed on a tendon to prevent it from bonding to the surrounding concrete.

BORROW AREA

An area within designated boundaries, approved for the purpose of obtaining borrow materials.

BORROW PIT

The excavated pit in a borrow area.

BORROW MATERIAL

Any gravel, sand, soil, stones or ash obtained from borrow areas, dumps or sources other than cut within the road prism and which is used in the Works. It shall not include crushed stone, rock or sand obtained from commercial sources or quarries.

BRIDGE

A structure for carrying motor, railways, pedestrian or other traffic or services over a river, watercourse, or any other gap, with a single span length, or sum of span lengths, of 4.0 metres or more. The length is measured between the abutment faces, or pier head faces respectively, along the centre line of the bridge deck.

CABLE

Cable is the Tendon together with the Anchorage, Sheathing and all fittings.

CAMBER

The transverse surface profile of a carriageway. Generally, a 'balanced camber' describes the situation where a single carriageway has a raised 'crown' in the centre and the road surface slopes down at a regular % to each side. The purpose is to ensure that surface water drains rapidly from the road.

CARRIAGEWAY

The surface normally traversed by vehicles and which consists of one or a number of contiguous traffic lanes, including auxiliary lanes, but excluding shoulders.

CATCHWATER DRAIN OR BANK

A longitudinal drain or bank outside the road prism for diverting water that should otherwise flow into the road prism.

CERTIFICATE OF GUARANTEE

A signed statement by a person having legal authority to bind a company or supplier to its product, and which confirms that the materials and test results conform to the standards of the Specifications.

CHANNELISING ISLAND

A traffic island located in the carriageway area to control and direct specific traffic movements to definite channels.

CLIMATE CHANGE MITIGATION

Climate change mitigation refers to actions or activities that limit the emission of Greenhouse Gases (GHGs) from entering the atmosphere.

CLIMATE CHANGE ADAPTATION

Refers to actions that help reduce vulnerability to the current or expected impacts of climate changes such as weather extremes and hazards.

COEFFICIENT OF CURVATURE (CC)

$$CC = \frac{(D_{30}^2)}{D_{60} \times D_{10}}$$

Where D_{60} , D_{30} and D_{10} are the sieve sizes that 60%, 30% and 10% pass.

COMBINED SHEET PILE WALL

It is an embedded wall using a combination of sheet piles and king piles (box, H, tubular steel tubes, etc.) to create large bending resistance. King piles can also be used as end-bearing piles with the intermediary sheet piles acting mainly as soil retaining and load-transferring elements.

COMMON EXCAVATION

Classification of excavation for payment purposes. Denotes all excavation, except rock excavation, required from the road prism, drains, etc. according to the Drawings and the Specifications.

COMPLETION

Works are completed in accordance with the contract so that they can be used for the purpose for which they were designed and accepted by the employer.

CONCESSIONAIRE

A private entity that invests in road infrastructure construction, operation, maintenance and rehabilitation and in return typically earns revenue through toll collections or other agreed means over the concession period.

CONDITIONS OF CONTRACT

The appropriate edition of the General Conditions of Contract together with any Special or Particular Conditions of Contract forming part of the Contract.

CONTRACTOR'S EQUIPMENT

All the apparatus, machinery, vehicles and other things required for the execution and completion of the Works and the remedying of defects. However, Contractor's Equipment excludes Temporary Works, Employer's Equipment (if any), Plant, Materials and any other things intended to form or forming part of the Permanent Works.

CONTRACT MANAGER

The person appointed by the Employer to act as the Contract Manager for the purposes of the Contract and named as such in the Contract. The Engineer and Contract Manager can be used interchangeably.

CONTRACTOR'S PERSONNEL

The Contractor's Representative and all personnel whom the Contractor utilises on Site, who may include the staff, labour and other employees of the Contractor and Sub-Contractor(s); and any other personnel assisting the Contractor in the execution of the Works.

CONTRACT

An agreement between a procuring and disposing entity and a provider, resulting from the application of the appropriate and approved procurement or disposal procedures and proceedings as the case may be, concluded in pursuance of a bid award decision of a Contracts Committee or any other appropriate authority.

COURSE

Separately defined and specified layer in a road pavement.

COUPLER

Coupler is the device comprising all components required to

join up two tendons.

CRIMPING

It is spot pressure indentation which permanently locks one sheet pile to another in order to increase resistance against bending, and thereby allowing faster pile installation.

CROSSFALL

The situation where the transverse gradient is uniform from one side of the carriageway to the other. This is typical of each part of a dual carriageway. The purpose is to ensure that surface water drains rapidly from the road.

CROSSFILL

Crossfill is earthworks materials taken from cuts within the road reserve and placed in embankments at a distance of 50m or less from its original position, measured along the centreline of the road.

CRR

Crushed Aggregate made from fresh, quarried rock compacted to a percentage of the maximum dry density of the rock, with enhanced requirements for workmanship during construction.

CRS

Crushed Aggregate made from stones, boulders, oversize from borrow pits or quarried rock, compacted to a percentage of the maximum dry density of the material at BS-Heavy compaction

CULVERT

A structure other than a bridge, which provides an opening under the carriageway or median or access road for drainage or other purposes.

CURING COMPOUND

A liquid which is applied as a surface coating to (newly placed) concrete and hardens to form a membrane that inhibits the evaporation of moisture from the concrete.

CULTURAL HERITAGE RESOURCES

The term 'cultural heritage' shall be interpreted to encompass tangible and intangible heritage. Tangible cultural heritage shall be taken to include movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance. Intangible heritage shall be taken to include non-physical aspects of culture, such as practises, knowledge and expressions that communities recognise as part of their cultural identity.

CUT

A section of the road where the formation level is below the original ground level requiring excavations before the construction of the pavement layers.

DBM40

Hot mixed material of bitumen and aggregate having a maximum particle size of 40 mm.

DBM30

Hot mixed material of bitumen and aggregate having a maximum particle size of 30 mm.

DEFLECTOR

A deflector is the device used to deflect a tendon alignment within a structural element.

DENTAL SHOTCRETE

This is shotcrete applied to fill/cover or repair a specific area/feature.

DETOUR

A detour is a diversion of traffic on existing roadways because of obstruction to the existing roadway and is required to facilitate safe construction of works.

DIAPHRAGM PANEL

It comprises of one individual unit of the wall constructed against another (one side or two) in pre-planned rotation to final completion of the diaphragm wall.

DIAPHRAGM WALL

It is an embedded wall constructed using a narrow trench excavated into in-situ ground and supported by an Engineered fluid (typically bentonite slurry) until the slurry is replaced by permanent material. Permanent material generally comprises reinforced concrete, though unreinforced walls can also be used.

DIRECTED

Instructed in writing by the Engineer including verbal instruction when subsequently confirmed in writing.

DISPUTE REVIEW BOARD (DRB)

A board established under the contract to resolve disputes that may arise during execution of the project.

DITCH OR DRAIN

Lined or unlined open drain constructed for the collection of surface water from the pavement, shoulders and adjacent land.

DRAWINGS

The contractual Drawings of the Works, including any additional and modified drawings issued by (or on behalf of) the Employer in accordance with the Contract.

DRIVING CAP

This is a sheet pile capping to provide consistent energy transfer between hammer and sheet pile section thus preventing damage to the top end of the pile.

DRY-MIX SHOTCRETE

These are constituent materials, comprising of a mixture of cementitious binder and aggregates, that are mixed and delivered to the application nozzle in dry form. Water and admixtures are added at the application nozzle under high pressure while being sprayed onto the receiving surface.

DUCT

Duct is the void formed to house the tendon(s) and may be formed by coring, or by using sheaths or by way of extractable cores.

EARTHWORKS

Term describing works in connection with construction of cuts and fills, roadbed and subgrade and removal to spoil of unsuitable or surplus materials, including excavation, compaction and finishing.

EMBANKMENT

Portion of the road prism that lies above the original ground and is bounded by the side slopes and the formation level.

EMBEDDED WALL

This is a structural wall, partially or fully embedded in subsoils. Embedment may be achieved by driving the

structure or elements of the structure into the subsoils or by placement into preformed holes or trenches. The structural wall is designed either as a cantilever to provide the primary support, or to act as a support system against which braced or tie-back forces are mobilised. Embedded walls may comprise:

- Steel sheet piles
- Precast concrete sheet piles
- Steel soldiers
- Concrete soldier piles
- Contiguous and secant pile walls
- Diaphragm walls

EMPLOYER

The person named as Employer in the Contract and the legal successors in title to this person.

ENGINEER

The person appointed by the Employer to act as the Engineer for the purposes of the Contract and named as such in the Contract. The Engineer and Contract Manager can be used interchangeably.

FILL

That portion of the road prism consisting of approved material, which lies above the roadbed and is bounded by the embankment side slopes and on which the subgrade is placed. Material imported to replace unsuitable material in the roadbed shall also be classified as fill when placed below the subgrade.

FBMIX (FOAM BASED MIX)

Bituminous base course material made in accordance with this SPECIFICATION with approved foamed bitumen by mixing in an appropriate equipment or as specified in a cold process.

FOAMED BITUMEN

Bituminous binder temporarily expanded as specified in this Specification by the aid of appropriate techniques for introducing water into hot bitumen.

FORCE ACCOUNT

This is where the Employer undertakes the road and bridge works of construction, maintenance, operation using own labour, equipment, materials and supervision rather than using a Contractor under Contract. The provisions of these specifications shall apply and Contract may be used interchangeably with Force Account.

FORMATION LEVEL

The level of the top of the subgrade upon which the pavement is placed.

FOUNDING LEVEL

The term "founding level" shall have the following meanings in respect of:

- i) Foundation fill
The surface of the in-situ material that has been prepared to receive foundation fill.
- ii) Bases
The underside of the base.
- iii) Piles
The underside of the underream, bulbous base or rock socket; the tip of the pile shoe or lower pile end, as may be relevant.

iv) Caissons

The underside of the cutting edge.

FRENCH DRAIN

A subsoil drainage system of permeable material constructed to intercept and remove subsoil water.

FUNDING AGENCY

A Funding Agency that provides funds for a Particular purpose or Project.

FUGITIVE SOURCES OF POLLUTION

Fugitive sources refer to emissions that are distributed spatially over a wide area and not confined to a specific discharge point. They originate in operations where exhausts are not captured and passed through a stack.

GEOSYNTHETIC MATERIAL

Geo-synthetic materials are synthetic products made from polymers and used in construction projects to serve functions such as reinforcement, separation, filtration, drainage and erosion control. The types of geo-synthetic materials include:

- i) Geotextiles
Permeable polymeric fabrics which can be woven, non-woven or knitted, used for filtration, separation and reinforcement, and may be in the form of a sheet, a strip or a 3-dimensional structure;
- ii) Geomembranes
Impermeable sheets used for containment;
- iii) Geogrids
Grid-like synthetic materials used to strengthen soil and distribute loads or polymeric, planar structures consisting of an open network of connected polymeric yarns used in geotechnical and civil Engineering applications;
- iv) Geonets
Net-like structures that assist with drainage and water flow;
- v) Geo-composites
Combinations of different geo-synthetic types for multifunctional purposes; and,
- vi) Geocells
Three-dimensional honeycomb synthetic structures used for soil stabilisation.

GRADE LINE

A reference line in longitudinal sections of the road indicating at regular intervals the elevations according to which the road is to be constructed. The grade line may refer to the level of the finished road, base or any other layer and may indicate the elevations either along the carriageway centre line or along any designated position on the road cross-section.

GRADING COEFFICIENT (GC)

$$GC = \frac{((\% \text{pass} 26.5 \text{mm} - \% \text{pass} 2 \text{mm}) \times \% \text{pass} 4.75 \text{mm})}{100}$$

GRIEVANCE REDRESS MECHANISM

A set of specified procedures through which dispute resolution is sought and provided.

GRADING MODULUS (GM)

The cumulative percentages by mass of material in a representative sample of aggregate, gravel or soil retained on the 2 mm, 0.425 mm and 0.075 mm sieves, divided by

100.

GM

= 3

$$- \left[\frac{(\% \text{ Pass } 2\text{mm} + \% \text{ Pass } 0.425 \text{ mm} + \% \text{ Pass } 0.75 \text{ mm})}{100} \right]$$

GUIDE FRAME

It is a frame used to enable the exact placement and vertical orientation of king pile elements in combined sheet pile walls.

GUIDE WALL

It comprises of two shallow reinforced concrete, brick or concrete block walls constructed to ensure panel excavations are aligned within acceptable tolerances. The internal wall is usually removed after completion of the diaphragm wall.

HAZARDOUS WASTE

Refers to waste classified, characterized and categorized as hazardous waste in accordance with Schedule 2, Schedule 3 and Schedule 4 of the NATIONAL ENVIRONMENT (WASTE MANAGEMENT) REGULATIONS 2020.

IMPROVED SUBGRADE

The upper layer or layers of the earthworks, which is constructed directly onto the fill or in some cases onto the roadbed.

INLET AND OUTLET DRAINS

Channels leading into or discharging from culverts storm water conduits and minor bridges.

INTERLOCK

The sheet pile interlock is preformed through coupling edges allowing individual steel piles to lock onto one another thereby providing a tight high-strength bond.

LANE

Part of a carriageway intended to accommodate a single line of moving vehicles.

LOT

A portion of the Work or quantity of material, which is assessed as a unit for the purpose of quality control and selected to represent material or work produced by essentially the same process and materials.

LOS ANGELES COEFFICIENT (LA)

The percentage of the test portion passing a 1.6 mm sieve after completion of the test.

LOCAL COMMUNITY

The residents, businesses, institutions/organisations along or within the immediate vicinity of the project.

LUX

Lighting is measured by how much the incident light illuminates a specific surface; a term referred to as illuminance. Illuminance refers to the total luminous flux or light intensity incident on a plane surface per unit area. The unit of measurement is Lux.

MARSHALL DENSITY

Density of Marshall Specimens excluding water. Standard Marshall Compaction with 75/75 blows is assumed unless alternative compaction methods giving similar densities are used on approval of the Engineer.

MEDIAN

The area between the two carriageways of a dual carriageway, excluding the inner shoulders.

MEDIAN DRAIN

A longitudinal drain situated between the inner shoulders of a dual carriageway.

MITRE DRAIN AND BANK

A drain constructed at an angle to the centreline of the road to divert water from a side drain. Mitre drains include mitre banks placed across the side drains.

MILLING

Excavating and removing a layer of material exceeding 25 mm in thickness from an existing pavement by means of an approved milling machine. Milling is normally used only in asphalt and cemented layers.

MODIFIED BINDER – HOMOGENEOUS

A blend of polymer and bitumen where two distinct phases cannot be detected on a microscopic level; or where two phases are interwoven to such an extent that the material behaves as a single-phase material. Examples of homogeneous binders are Ethylene Vinyl Acetate (EVA), Styrene Butadiene Rubber (SBR) and Styrene Butadiene Styrene (SBS) polymer modified binders.

MODIFICATION

The term Modification refers to the improvement of the engineering properties of construction materials such as load bearing capacity (CBR strength), plasticity index, grading or other properties of natural materials by adding or mixing with other materials.

MODIFIED BINDER – NON-HOMOGENEOUS

Binders that show two distinct, detectable phases; and where there will be localised differences in properties depending at what stage a test is performed. Bitumen-rubber falls into this category as it consists of rubber crumbs partially dissolved in a bitumen matrix.

MOISTURE CONTENT

Amount of water in a material expressed as a percentage of the dry weight.

MORTAR

A mixture of fine aggregate, cement and/or hydrated lime usually in predetermined proportions, with water, to create a fine-grained cementitious material suitable for the bedding of bricks, blocks and masonry.

MUTATIS MUTANDIS

With necessary alterations.

NOMINATED SERVICE PROVIDER

The Employer's selected Sub-Contractor (person or entity) providing a specific service or executing a specified component of works.

OVERBURDEN

Material within or covering a borrow area or quarry, which is not required or is unsuitable for use in construction.

OVERHAUL

Overhaul is the distance in excess of any free-haul distance. In these specifications, work performed in haulage of material shall not be paid separately and the cost thereof is deemed to be included in other rates.

PANEL RECESS

A panel recessing via stop ends is required to link individual reinforced concrete panels into a continuous watertight wall.

PAVEMENT

The upper layers of the road normally comprising the subbase and gravel wearing course for gravel roads; the subbase, base and bituminous surfacing for flexible pavements; or subbase and concrete surfacing for rigid pavements; and the shoulder layers.

PERFORMANCE CERTIFICATE

A certificate issued by the Engineer at the end of the Defects Notification Period to confirm the acceptance of the works or specific parts of the works.

PERMANENT WORKS

This refers to the structures, installations and elements of the project as specified under the contract that are intended to remain in place after construction is completed and form part of the final lasting components of the project.

PILE EXTRACTOR

It is used in temporary works to extract piles for re-use.

PILE THREADED

This is a mechanical device used to interlock sheet piles into panels for grouped installation.

PIONEER LAYER

An initial layer constructed over a weak roadbed where selected material is used to provide a stable platform for the construction of subsequent layers.

PITCHING

This means raising or lifting construction elements into a vertical position.

PLANT

The apparatus, machinery and the like intended to form or forming part of the Permanent Works.

PLASTICITY MODULUS (PM)

PM = Plasticity Index x percentage passing the 0.425 mm sieve.

PLASTICITY PRODUCT (PP)

PP = Plasticity Index x percentage passing the 0.075 mm sieve.

PREFABRICATED VERTICAL DRAINS

These are vertical drains comprising pre-manufactured long cylindrical having cusped cores wrapped in a geotextile filter jacket.

PRE-STRESS

Pre-stress is the stress induced in concrete by tensioned tendons.

PRE-STRESSED CONCRETE

Pre-stressed concrete is structural concrete in which effective internal stresses are induced by means of tensioned tendons.

PRE-STRESSING

Pre-stressing is the inducement of compressive stress into a structural concrete element either by pre-tensioning or post-tensioning tendons comprising cables, wires or bars incorporated into the element.

PRE-TENSIONED CONCRETE

Pre-tensioned concrete is pre-stressed concrete where the tendon is tensioned before the concrete has been cast.

PROJECT LIAISON COMMITTEE (PLC)

A group of persons formed to facilitate communication and coordination between the project implementers (Contractor and/or Employer) with the local authorities and the local community with the key role of monitoring the overall impact of the project on the affected community.

PROOF ROLLING

A proof roll is an assessment of a layer prior to installing overlying pavement layers. The proof roll is a visual assessment to determine whether the compacted layer would be good enough to withstand construction of the subsequent pavement layers.

POLYMERIC REINFORCEMENT

This is a generic term that encompasses geo-synthetic materials used as soil reinforcement in geotechnical engineering such as geotextiles, geo-grids and geo-strips.

POST-TENSIONED CONCRETE

Post-tensioned concrete is pre-stressed concrete where the tendon is tensioned after the concrete has hardened.

POINT SOURCE OF POLLUTION

These are discrete, stationary, identifiable sources of emissions that release pollutants to the atmosphere (asphalt plant, diesel powered energy generators, concrete batching equipment, Diesel powered water pumping stations etc.).

QUARRY

Area outside the road prism where rock is extracted for production of crushed aggregate and which is used in the construction of the Works.

REINFORCED SOIL

This is a general term which refers to the use of imported or in-situ soil or other material in which tensile reinforcements act through interface friction, bearing or other means to improve stability.

REINFORCED SOIL SEGMENTAL BLOCK STRUCTURE

This is a reinforced soil structure with facing comprising dry stacked blocks with a fixed connection, without compressible joints between blocks and without joint fillers/covers.

REINFORCING ELEMENT

This shall be metallic in form of Strips (aluminium alloy, Copper, Carbon Steel, Galvanised Steel, Stainless Steel, Ladder) or mats (Steel Grids, Woven and Welded Steel Wire Meshes) or Synthetic (PET, HDPE, PVA, PP) reinforcement in the form of grid or Strip or Strap or combination of metallic or synthetic or any other proprietary material, which may be approved by the Engineer and as shown on the drawings or as specified in the special specifications.

RETAINED BACKFILL

This is the fill material located between the reinforced mass and natural soil.

ROAD AUTHORITY

A road authority shall be that entity designated by the Minister of Works and Transport as responsible for the construction, alterations, rehabilitation, maintenance, protection and supervision of any type of road in accordance with SECTION 4 OF THE ROADS ACT CAP. 346.

ROAD BASE

A pavement layer constructed on top of the subbase or in the absence thereof, the subgrade. The road base may extend outside the carriageway.

ROADBED

A layer of material directly beneath the asphalt wearing course or asphalt binder course.

ROAD FURNITURE

Any fixtures on the road and within the road reserve that are intended to provide information or safety to a road user and which includes, but not limited to traffic lights, signposts, traffic signs, guardrails, marker posts, fences, reflectors and centre-line pads (cat's eyes).

ROAD PRISM

The cross-sectional area bounded by the original ground level and the outer boundaries of the slopes of cuts, fills and side drains, excluding the pavement.

ROAD RESERVE OR RIGHT-OF-WAY

The strip of land legally awarded to the Road Authority, in which the road is or will be situated. The width of the road reserve is measured at right angles to the road centreline.

ROADSIDE STATION

A facility along expressways, class A national roads and ferry landing sites and includes toilets, bathrooms, parking yards, restaurants, mini groceries, supermarkets, garages and resting centres.

ROADWAY

The area consisting of the carriageway and shoulders.

ROCK EXCAVATION

Classification of excavation for payment purposes. Denotes excavation required from the road prism, drains, etc. according to the Drawings and the Specifications that require drilling and blasting or the use of pneumatic or hydraulic jackhammers in order to be loosened sufficiently for loading and transportation.

ROLLER PASSES

An area will be taken to have received one roller pass when a roller has passed over such area once. Additional passes made only as a result of nominal overlapping so as to ensure full coverage shall not be taken into account.

SITE

The area of land within which the Contractor will construct the permanent works and areas set aside for temporary works such as camps, borrow areas, quarry sites and deviations.

SERVICE ROAD

A road that runs parallel to a highway and that provides access to the property bordering it.

SERVICES

This refers to utility infrastructure such as cables, pipes, ducts and other overhead or buried structures, such as conduits for electricity, communication, water, sewage, oil pipelines etc.

SHEET PILE WALL

This is an embedded wall comprising individual steel or precast concrete sheet piles linked together and driven into the ground to provide lateral support and/or an impermeable barrier. Steel sheet piles are more common than precast concrete.

SHOTCRETE

This means mortar which can be pneumatically projected at high velocity onto a surface. It is also the process whereby mortar is pneumatically projected at high velocity onto a surface. It can comprise of dry-mix or wet-mix shotcrete.

SHOULDER

- i) When referred to as a surface
The area between the outside edge of the carriageway and the shoulder break point.
- ii) When referred to as pavement layer(s)
The upper pavement layer(s) lying between the outside edge of the base and surfacing courses and the shoulder breakpoint.

SHOULDER BREAKPOINT

The point on the cross section at which the extended flat planes of the surface of the shoulder and the outside slope of the fill and pavement intersect.

SHRINKAGE PRODUCT (SP)

The product of Linear Shrinkage (LS) and the percentage passing the 0.425 mm sieve:

$$SP = (LS)X (\%pass\ 0.425)$$

SIDE DRAIN

An open longitudinal drain situated adjacent to and at the bottom of cut or fill slopes.

SIDEWALK

That portion of the road prism constructed for the use of pedestrians.

SLINGING HOLE

This is a lifting hole located near individual pile sheets approximately 32 mm in diameter usually located 150 mm from the sheet ends.

SLOPE

Unless otherwise apparent from the context, slope is the ratio of the vertical difference in elevation and the horizontal distance between two points. This ratio may also be expressed as a percentage.

SPECIFICATIONS

The Specifications relating to a specific project, which form part of the Contract documents for such project, and which contain the General Specifications together with the Special Specifications.

SPOIL (MATERIAL)

Material originating from construction operations and which is not utilised for construction purposes.

STABILISATION

The treatment of the materials used in the construction of the roadbed, subgrade or pavement layers by the addition of a cementitious binders such as lime/ cement/ bituminous stabilizing agent, or other commercially available stabilizers for modifying the properties of a soil to improve its engineering performance. Stabilised materials for base course or subbase are classified according to Unconfined Compression Strength (UCS) as follows:

- i) C4.5
Stabilized material with a nominal unconfined compression strength of minimum 4.5 MPa with an approved stabiliser.

- ii) C3
Stabilized material with a nominal unconfined compression strength of minimum 3 MPa with an approved stabiliser.
- iii) C1.5
Stabilized material with a nominal unconfined compression strength of minimum 1.5 MPa with an approved stabiliser.
- iv) C1
Stabilized material with a nominal unconfined compression strength of minimum 1 MPa with an approved stabiliser.
- v) CM
Material with a nominal unconfined compression strength of minimum 0.5 MPa modified with an approved stabiliser.

STEEL SHEET PILES

These are Z- and U-shaped hot rolled steel sheet pile elements (manufactured and imported from Europe or the UK).

STOP END

It is a vertical steel tube, polystyrene or precast concrete column placed at panel edges to provide, on withdrawal, a recess joint between adjacent panels. The recess joint promotes water tightness.

STRUCTURE

Structures shall comprise all objects constructed of materials other than earth, required by the Contract to be built or to be removed, but not including pavement layers.

SUBBASE

The pavement layer on top of the subgrade and below the base course and shoulders.

SUBGRADE

The upper layer or layers of the earthworks upon which the pavement is constructed.

SUBSTRUCTURE

All of that part of the structure below the bearings of simple and continuous span bridges, below skewbacks of arches, below deck slab of box and slab culverts, together with return walls and wing walls.

SUBSOIL DRAINAGE

Subsoil drainage pipes (including any permeable material) constructed to intercept and remove subsoil water.

SUITABLE MATERIAL

Materials that comply with the requirements of the Specifications in respect of the relevant layer or position where the material is intended to be used.

SUPERSTRUCTURE

All of that part of the structure above and including the bearings of simple and continuous span bridges, skew backs of arches, deck slab of box and slab culverts, including headwalls and parapets but excluding return walls and wing walls.

SURFACE TREATMENT

A bituminous seal made with a bituminous binder and chippings, graded aggregate or sand or a mix of bitumen emulsion and crusher dust.

TAKING OVER CERTIFICATE

A certificate issued by the Engineer after the tests on

completion signifying formal completion of the works in accordance with the contract.

TEMPORARY WORKS

All works of every kind (other than the Contractor's Equipment) required for the execution and completion of the Works and the remedying of any defects but not incorporated into the permanent Works.

TESTS ON COMPLETION

These are typically a set of inspections and tests specified in the contract that are carried out to verify that the works conform to the contractual requirements and are ready for completion and taking over.

TIE RODS

These are anchors used in sheet piling to retain sheet pile walls to remote deadman anchorages. They may comprise stand-alone steel elements suitable for protection against corrosion or reinforced concrete beams.

TOLL

A charge levied on a vehicle using a toll road.

TOLL OPERATOR

An authority or private entity responsible for collection of road tolls, and may be involved in the construction, operation, maintenance and rehabilitation of the toll road.

TOLL ROAD

The whole length or portion of a national, district, urban or community access road, declared by the Minister under the ROADS ACT CAP. 346 SECTION 7(1) or established and maintained by a road authority under SECTION 6(4), where tolls are levied and collected from vehicles using the road;

TOLL STATION

A structure on a toll road where a toll is payable under the ROADS ACT CAP. 346 or any electrical or mechanical device on a toll road for recording the liability to pay a toll or any combination of such structure or device.

TOPSOIL

Soil containing organic or vegetable materials in the upper strata of the natural ground and is capable of supporting the growth of vegetation.

TURNBUCKLE

A turnbuckle joins plain tie-rod ends to upset end of a tie rod.

UTILITY LINES

All infrastructure such as telephone, power, water and sewer lines laid for public services.

UNSUITABLE MATERIAL

Materials that do not comply with the requirements of these Specifications in respect of the relevant layer or position where the material is intended to be used.

VERGE

The area between the outer edge of the road prism and the boundary of the road reserve.

WALER

This is a horizontal beam capable of transferring load between individual anchor elements (tie-rods, props, ground anchors, etc.).

WEIGHBRIDGE

A machine for weighing vehicles under the ROADS ACT CAP.

346, and includes all its associated peripherals and software.

WEIGHBRIDGE OPERATOR

Any person, including an authorised officer, and a person acting under his or her authority who manages and operates weighbridge equipment or performs vehicle load control under the ROADS ACT CAP. 346.

WEIGHING STATION

A check point or installation along a public road for weighing vehicles and includes all facilities found in it.

WET-MIX SHOTCRETE

These are constituent materials, comprising of a mixture of cementitious binder, aggregates, water and admixtures, that are premixed and delivered to the application nozzle as a wet-mix before being sprayed onto the receiving surface.

WORKING DRAWINGS

Shop drawings, steel bending schedules, stress sheets, fabrication and erection drawings, falsework drawings, and any other supplementary drawings or data which the Contractor is required to submit to the Engineer for approval before such Works commence.

WORKS

The Permanent Works and the Temporary Works, or either of them as appropriate.

1102 COST CAP

The costs associated with Series 1000, encompassing Sections 1100 to 1800, shall not exceed 10% of the overall contract sum. Any costs beyond this cap shall require approval by the Employer with justification submitted in writing by the Engineer.

SERIES 1000: GENERAL

SECTION 1200: GENERAL REQUIREMENTS AND PROVISIONS

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1201 SCOPE

(a) General

This Section covers matters which relate to the Contract as

a whole. Definitions, phrases or wording which would otherwise require repetition in other Sections of the Specifications are also covered by Clauses in this Section. Matters covered by the Conditions of Contract are not repeated in this Section, except where necessary for providing more detailed information.

(b) Modifications and Amendments to the General Specifications

The General Specifications are to be read together with modifications, additions or amendments which are written in the Special Specifications.

(c) Precedence of Specifications

In any case where there appears to be any conflict between the General Specifications and the Special Specifications, the Special Specifications shall govern.

(d) Intent of the Contract

The intent of the contract is to prescribe a complete outline of work that the Contractor undertakes to do in full compliance with the drawings and specifications. The Contractor shall perform all works i.e., earthwork, subbase, base and surface courses, drainage works, structures, and such additional, extra, and incidental construction as may be necessary to complete the work to the finished lines, grades, and using materials, equipment, tools, labour, and incidentals, unless otherwise provided in the Contract, and shall include the cost of these items in the unit prices tendered for the several bill items.

(e) Differing Site Conditions

During the progress of the work, if subsurface or latent physical conditions are encountered at the Site differing materially from those indicated in the Contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognised as inherent in the work provided for in the Contract, are encountered at the Site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before they are disturbed and before the affected work is performed.

Upon written notification, the Engineer will investigate the conditions, and if they determine that conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an adjustment, excluding loss of anticipated profits, will be made and the Contract varied in writing accordingly. The Engineer will after consultations with the Employer, notify the Contractor of their determination whether or not a variation to the Contract is warranted.

No contract adjustment which results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice. No contract adjustment will be allowed for any effects caused on unchanged work.

Any adjustment in compensation because of a change or changes, resulting from one or more of the conditions described in the foregoing paragraph will be made according to the provisions of the contract.

1202 SERVICES

(a) Location of Services

The Contractor shall acquaint themselves with the position of all existing services, such as drains, underground and overhead telephone and electricity lines, ducts, poles, water mains, fittings, railway lines, etc. before any excavation or other work likely to affect the existing services is commenced.

The Employer will, in the Contract documents, provide information regarding the location of existing utility services, but the Employer does not accept responsibility for the

accuracy of this information.

The Contractor shall check and determine on the Site the position of any services. This shall be done by consultation with owners of services, visual inspections, using detecting apparatus and by making excavations as required to expose the position of the service. This shall also be done where no services are nevertheless believed to be present. The positions of all services so detected shall be marked carefully and then drawn in on the Drawings. These services will then be defined as known services.

These investigations shall be completed over the entire project within 4 months "for Projects with a Project duration of up-to 18 months" and within 6 months "for Projects with a Project Duration more than 18 months", or unless otherwise specified in the Particular Specifications.

(b) Damage to Services

The Contractor shall take all reasonable precautions not to damage the services during the search, when the onus shall rest with them to prove that, in the event of damage being done to such services during the search, it was not their fault that they had been damaged. The Contractor will be held responsible for any damage caused by them to known services, unless they can prove that they have taken all the above precautions to the satisfaction of the Engineer.

The Contractor shall take all reasonable precautions to protect existing services during construction and during the relocation of such services. Where protective measures involve the construction of permanent work, the Contractor shall execute the work in accordance with the Engineer's instructions, and payment shall be made as provided for in the Special Specifications.

All pipes, cables, conduits or other known services of any nature whatsoever damaged as a result of the Contractor's operations shall be repaired and reinstated forthwith by the Contractor or by the Authority concerned, to the satisfaction of the Engineer, all at the expense of the Contractor.

(c) Safety by Overhead Power Lines

Where work is to be carried out in the vicinity of overhead power lines, the Contractor shall ensure that all persons working in such areas are aware of the relatively large distance that high voltage electricity can "short" to earth when cranes, or other large masses of steel, are in the vicinity of power lines. The Contractor shall be required to work outside the clearances stated in BS EN 50522:2022 which gives safe clearance for the various voltages.

(d) Relocation of Services

It shall be clearly understood that, in certain instances, existing services can be relocated only after the Contractor has advanced sufficiently on or has completed certain sections of earthworks or certain structures. Whenever services are encountered which interfere with the execution of the Works and which require to be moved and relocated, the Contractor shall advise the Engineer, who will determine the extent of work, if any, to be undertaken by the Employer in moving, relocating and reinstating or protecting such services.

The Employer shall be responsible for arranging the removal or alteration of such services in conjunction with and to the specifications of the relevant statutory authority subject to the prior agreement of the Engineer and where necessitated by the Works.

(e) Negotiations with owners of services

The Employer shall work in close co-operation with private Owners or public authorities controlling services, which have to be protected, moved or relocated.

Details regarding the state of negotiations concluded

between the Employer and the Owner at the time of bidding in respect of the time when the Owner is prepared to start moving such services, and the duration of such operations, will be made available within 30 days of the Commencement Date for the Works.

Further such consultations and negotiations with private owners or public authorities shall be carried out as required by the Employer. Should the Owners of services refuse to co-operate with the Engineer in a reasonable manner in connection with the protection or moving of services belonging to them, the Engineer shall refer the matter to the Employer.

(f) Programming Relocation of Services

When the Contractor details their program of work as referred to in the relevant clause of the Conditions of Contract, they shall, in consultation with the Engineer, clearly indicate the start and conclusion of the moving of each service.

In detailing their program of works, the contractor shall suitably include the requirements of service ducts to be constructed transversely across the major road at major junctions, within the footpaths of proposed new bridges and longitudinally at junctions where the minor road is to be paved and at other places, wherever required or directed by the Engineer. The Contractor shall construct service ducts for the easy installation and maintenance of existing, new and future cables and other services. The pipe shall be laid at 500m intervals in urban and semi-urban areas across the carriageway and at all side roads, unless otherwise specified in the contract. Service ducts shall be constructed from one or more of the materials as specified in CLAUSE 2215.

The actual type of pipe required shall be in accordance with the Specifications. The pipes shall be installed in the required positions and accurate records shall be kept regarding the depth, position and number of pipes installed in each duct. Pipes shall be laid at the grades shown on the Drawings to facilitate flushing with water and shall, where required, be encased in concrete or soil cement.

Unless otherwise specified in the contract, the following shall apply:

- The width of excavation for service-duct trenches shall be equal to the nominal inside diameter of the pipe, plus 150 mm on each side of the duct. Where ducts consist of two or more units, the minimum spacing between the units shall be 75 mm, and the 150 mm side clearance shall apply to the outside units of the group.
- Below the carriageway the depth of excavation shall accommodate a minimum cover of 1 m above the upper side of the installed service duct.
- All pipes shall be joined with watertight proprietary couplings made from the same material as the pipe. Fibre-cement couplings shall be of the rubber-ring type.
- Split pipes shall normally be used only for providing ducting for existing services which cannot be severed and threaded through the ducts. The pipes shall be accurately cut longitudinally in two halves and opposite halves shall be matched as sawn. Split pipes shall be placed around the service as required, firmly bound by steel straps and if required, encased in concrete.
- Excavating, laying and bedding the pipes shall be in accordance with the Specifications for prefabricated culverts with any modifications as may be necessary or specified in this Clause.
- Duct ends shall be provided with suitable conical wooden stoppers to prevent dirt from entering the ducts. Two strands of galvanized steel wire,

2.5mm in diameter, shall be threaded through each unit, extended 2 m beyond each end, and firmly wedged into position with the wooden stoppers.

- The end of each duct shall be marked with a duct marker block constructed to the details shown on the Drawings. Each duct marker block shall be at least 50 mm proud of the finished surface level.

Should it thereafter, through delays on the part the Employer or the Owner of the service to be moved, be impossible to adhere to the programme of work, such programme shall be suitably amended by the Contractor in consultation with the Engineer so as to limit, in so far as is possible, the extent of any damages or delays. Should it be impossible to limit entirely the damages or delays resulting from the amendments necessary to the programme of work, the Contractor shall be reimbursed for any additional costs incurred or damages suffered by them.

(g) Payment

Any work required to be undertaken by the Contractor in relation to protecting or moving of public services for which no provision is made in the Contract Documents, will be classified and paid for at Daywork Rates, or if no applicable Daywork Rates exist, the Contractor shall submit a quotation for the Engineer's approval.

1203 ROAD INTERSECTIONS AND JUNCTIONS

Except where otherwise specified, no additional payment over and above payment for the various items of work included in this Contract will be made for the construction, in a confined space, of curves, tapers, bell mouths, traffic islands, farm accesses and other appurtenant Works in connection with the construction and maintenance of road intersections and junctions.

The Contractor shall be required to provide the safe and unrestricted flow of public traffic at all times during the construction and maintenance of such intersections and junctions.

1204 PROGRAMME OF WORKS AND TEMPORARY WORKS

(a) Programme of Works

In accordance with relevant clauses of the Conditions of Contract and prior to commencement of permanent works, the Contractor shall plan and submit a fully detailed, time related and resourced programme showing the order of procedure and method in which the Contractor proposes to carry out the Works for timely project completion. If specified in the Contract, the Contractor should also allow for such construction in the work program for which provisional sums are considered in the BOQ.

The Programme will be based on the Contractor's method statement and shall include the production rates developed and proposed in his method statement.

The Works shall be carried out to achieve a continuous and consecutive output of a fully completed road. The Contractor is to fully complete sections of the works within the timelines as stated in the Particular Conditions. The order of execution of the Works shall be subject to reasonable adjustment as requested by the Engineer.

The Programme shall be revised, if necessary, every ninety (90) calendar days, unless otherwise specified in the Contract. The revised schedule and narrative shall, as determined by the Engineer, be sufficient to meet the requirements for completion of any separable part and all of the Works as set forth in the Contract. To qualify for an Interim Payment Certificate the Contractor, when requested by the Engineer, MUST submit, within a period of 30 calendar days, an updated programme.

The Contractor shall always keep a copy of his current/latest Programme prominently displayed in his offices on site for ease of reference by all parties concerned.

The Engineer will not consider any claim for an increase in the Contract Sum or Extension of Time unless the above Programme and reports are properly maintained, current and followed in works execution at the time when the event giving rise to the claim took place.

The acceptance by the Engineer of any Programme shall have no contractual significance other than that the Engineer would be satisfied if the work is carried out in accordance with such Programme and that the Contractor undertakes to carry out the work in accordance with the Programme.

i) Master Programme

The master programme shall be so detailed as to show, but not necessarily be limited to, the following:

- The order of work;
- Quantities and planned rate of progress based on the method statement;
- Amount and type of labour and equipment proposed based on the work gangs developed in the method statement;
- Details of methods to be employed;
- Details of temporary works;
- Critical path;
- Approvals required from statutory authorities and agencies;
- Clearly identified contract milestone dates with an activity code; and
- Off-site activities including, for example, setting up a crushing plant in quarries and production rates of the plant and details of ongoing production (for revised programmes).

The Contractor shall submit a complementary and detailed narrative description of their plan for performing the Work which may be separate or part of the method statement. The narrative description shall summarize equipment and personnel requirements by craft to complete a resource loaded schedule, productivity rates used to build the schedule, activity and resource code structure, pictorial presentation of the schedule, critical path description and other relevant information as agreed with the Engineer.

The project shall be divided into an agreed Work Breakdown Structure (WBS) and developed in enough detail and submitted to the Engineer for comment. It shall show total float and free-float times. The master programme shall not be in form of a bar chart only but shall show clearly the anticipated quantities of work to be performed each month, as well as the anticipated earnings for the various sections of work. The contractor is to take into account, the style of programmes, schedules and reports used by the Employer or as directed by the Engineer including a time-chainage chart showing the direction of progress of work. No payments, other than the advance payment, will be made to the Contractor until the Engineer is satisfied that the Programme of Works has been submitted in enough detail and as outlined in this CLAUSE.

ii) Sub-programme

In addition, the Contractor shall submit sub-programmes as required by the Engineer to show further details at important stages of the project. The first such sub-programme is his mobilisation, which shall indicate, but not necessarily be limited to, the following:

- Approval and Mobilisation of Contractor's key staff.
- Pre-construction activities, in general, to include Contractor's Establishment on Site, Engineer's Establishment (housing, offices), crushing installation, asphalt installation, vehicles, survey equipment, laboratories including lab. Equipment).
- Sub-contract procurement.
- Materials procurement and pre-orders, setting up of quarries and borrow areas.
- Schedule for the main submittals such as, drawings, technical and material submittals, Quality Assurance (QA)/ Quality Control (QC) plan to include submission of all materials, laboratory trials and site trials and time to gain approval, EMP, H&S etc.
- A detailed schedule for mobilisation on site, plant and labour.

The Contractor will also submit weekly programmes to include a list of the work to be undertaken in a week showing the locations, work items, quantities, number of gangs based on production rates as developed in the Contractor's method statement and other information as agreed with the Engineer.

iii) Revision of Programmes

Should the Contractor fall behind the Programme submitted by him in terms of the relevant clause of the Conditions of Contract, which Programme has been approved by the Engineer, or if the sequence of operations is altered, or if the Programme is deviated from in any other way, the Engineer may, without prejudice to the Employer's rights in terms of the relevant clause of the Conditions of Contract, require the Contractor to submit, within **Seven (7) days** of the date on which he has received a notice to this effect, a revised Programme in terms of this Clause, which indicates the manner in which the Contractor undertakes to complete the Works within the required time. Any proposal in the revised Programme to improve the rate of progress shall include detailed information on the positive steps to increase production by more and/or better labour and equipment being provided on the Site or by the available labour and equipment being utilised more effectively or by carrying out activities in parallel. In addition, the Contractor will update his method statement.

Failure on the part of Contractor to work according to the Programme or revised Programme shall be sufficient reason for the Employer to take steps as provided for in the Conditions of Contract and shall be construed, as not executing the Works in accordance with the Contract. The Contractor under these circumstances shall have no right to claim for extension of time and any costs associated with the time required to complete the works.

iv) Contractor's Staffing

The Contractor shall have on the Site adequately qualified full-time staff that have the ability to develop and maintain a master programme and sub-programmes as required to plan and manage the works. The contractor shall also be required to properly manage the staff deployed on site including ensuring that they are always engaged for the minimum prescribed working hours per day.

v) Software

The Contractor's Works programmes shall be written on the latest versions of software, unless otherwise specified in the Contract. The Contractor is to provide the Engineer with a copy of the software he chooses to use.

(b) Reporting Requirements

i) Weekly and Bi-Weekly Reports

The Contractor shall submit to the Engineer at the end of every week (or second week if so directed by the Engineer) a report on the general progress of the Works including details as specified in the template approved by the Engineer. The report should cover the progress made during the period under consideration and any repetition or copy and paste of previous reports shall lead to the report being rejected by the engineer and returned to the contractor. The weekly progress report shall as a minimum include the following:

- Summary of activities undertaken in the reporting period.
- Planned activities for the next reporting period including a brief on resource mobilization (staff deployment schedules, equipment deployment schedules and Materials).
- Productivity and production rates achieved versus target production rates and reasons for the variance.
- Target productivity and production rates for the next reporting period to compensate for any slippages in the previous reporting period.
- Construction works quality compliance issues identified and how they are to be rectified in the next period.
- Signed forms (by both contractor and the Engineer) for equipment and staff showing the times each day when they commenced and stopped works. For cases where they stopped work before the expected working hours in the day, reasons shall be provided on the form.

Approval and Payment of interim payment certificates shall be conditioned on compliance with the weekly reporting requirements above.

ii) Monthly Progress Reports

Each month, within 3 working days of the last day of the period to which the report relates, the Contractor shall submit a Monthly Progress Report in a format and media agreed with the Engineer, unless otherwise specified in the Contract or as agreed with the Engineer. The Report shall indicate the progress and financial status of the Works of the previous month. The report shall accurately estimate the work completed on each activity shown on the accepted Programme. The Contractor's Monthly Progress Report shall include relevant progress photographs in a format to be agreed with the Engineer. The Contractor shall agree with the Engineer and shall implement progress control procedures. The Contractor's progress report shall as a minimum provide the following:

- Executive summary of the month's events.
- Physical Progress:
 - Total work progress at the end of the month with a progress chart showing progress achieved as a percentage against planned progress, also demonstrated as S-curves, presenting early and late curves.
 - Production rates achieved versus target production rates and reasons for the variance.
 - Strategies for recovery of lost time and compliance with the construction schedule during the next reporting period.
 - Target production rates for the next reporting period to compensate for any slippages in the previous reporting period.

- Activities completed with photographs attached including dates of completion, activities re-scheduled or re-estimated, added or deleted since the previous report.
 - Major activities to be carried out in the next reporting period, and the effect on the programme of the latest information available.
 - Environmental and Social impact mitigation.
 - Problem areas and proposed corrective measures.
 - Request for Information (RFI) summary/status.
 - Key decisions required from the Engineer.
 - Submittals summary/status.
 - Instructions summary/status.
 - Defects summary/status.
 - Details of stakeholder communications and management including details of the stakeholder issues addressed, ongoing communications, new stakeholders identified, ongoing stakeholder engagement activities and details of lessons learned.
- c. Resources:
- Contractor's Organisation Chart.
 - Staff performance plans with clear indication of roles and responsibilities, expected key performance indicators and expected outputs. This shall also include staff deployment schedules for Design, Procurement and Construction, as applicable.
 - Labour returns including deployment schedules for both the main contractor and all the Sub-contractors.
 - Plant returns with detailed deployment schedules and particulars of the plant.
 - Materials delivered to the Site including material sources and particulars of suppliers and respective materials supplied or to be supplied.
 - Schedule of source(s) of accepted materials including those materials accepted during the Reporting Period and any materials whose source acceptance has been cancelled during the Reporting Period.
- d. Quality Management
- Details of the plan detailing the quality standards that have been applied to the project works and how they were satisfied.
 - Details of the quality control measures in place covering details of how specific project activities are monitored to ensure they comply with relevant standards as well as identified ways of improving overall quality.
 - Details of the quality assurance process covering details of how the overall project is evaluated to ensure it satisfies the relevant quality standards.
 - Effectiveness of processes and systems to avoid quality issues before they occur.
 - Construction works quality compliance issues identified and how they are to be rectified in the next period.
- e. Commercial
- Variation Summary/Status inclusive of costs.
 - Materials on Site.
- f. Financial
- Value of Work completed during the reporting period and in aggregate to date, also demonstrated as 'S-Curves' presenting earned value against earnings as anticipated at Contract commencement (earnings/cash flow submitted with Programme of Works).
- Anticipated cash flow and estimated final cost at completion to be presented monthly, although updated quarterly. The estimated cost at completion shall include all variations (ordered and anticipated) and all significant changes in quantities from the original Bills of Quantities (BoQ) contained in the signed Contract. Agreed or anticipated claims for any additional costs shall be included in the cost at completion report.
 - Schedule of Warranties/Guarantees and validity dates.
 - Schedule of Insurances and validity dates.
 - Particulars of Suppliers/Sub-contractors and their scope on the project.
 - Sub-Contracts awarded in the previous month.
- g. Risk Management.
- Details of the identified risks and proposed mitigation measures covering the following aspects amongst others:
- Financial (project cash flow and budgets).
 - Legislative compliance (Quality standards, OH&S etc).
 - Personnel (Employee competences/Staff availability).
 - Political and community (environmental considerations, community expectations etc)
 - Project management (time, cost, quality, realistic scope, etc).
 - Operational management (Availability of technology, equipment, materials etc).
 - System (Record keeping, information management system, Quality assurance measures).
 - Third party (contracts with suppliers, subcontractors etc).
- h. Environmental Social, Occupational Health & Safety Reports.
- The Contractor shall indicate details of sensitisation/awareness activities carried out for staff/workers for gender-based violence (GBV)/sexual exploitation and abuse (SEA), sexual harassment (SH) and violence against children (VAC)
 - Details of all GVB/SEA/SH/VAC incidents recorded during the reporting period.
 - Record of all accidents (fatal and nonfatal) reported on site related construction operations or interface with the public traffic including actions taken following the accident occurrence.
 - Measures in place to control noise, dust, and accidents on construction and quarry sites.
 - Details of the measures taken to address the issues raised by the environmental and social audit.
 - Environmental and social permits acquired during the period.
- Approval and Payment of interim payment certificates shall be conditioned on compliance with the monthly reporting requirements above.
- iii) **Progress Meetings**
- Within 4 weeks of the Commencement Date of the Works, the Contractor and the Engineer will agree on

a schedule for weekly progress meetings. The Contractor shall make himself available for any other meetings called for by the Engineer outside the schedule.

The focus of the meetings shall be resolution of issues identified on site, agreement on strategies to remedy the noncompliance related to works progress, works quality, resource mobilisation, etc.

iv) Daily Site Diaries

The Contractor shall maintain detailed daily site diaries (to be recorded by the end of each day, not afterwards, and checked by the Engineer), detailed written records and/or digital photographic records of all contractual correspondence and data; all work stoppages or delays; accidents on site; official visitors to site; weather records; all activities in progress at any time on site showing the start and end time and full details of the resources employed per activity.

v) Electronic Storage of Information

The Contractor shall establish a GIS based system of electronic storage of all communication, drawings and other documentation for the project including laboratory results, survey field checks documenting the quality of the works. Only documents not prepared by the Contractor, or handwritten notes and drawings, shall be scanned using suitable software for digital storage in the system. Electronic copy of laboratory results and other documentation shall be issued by the Contractor to the Engineer alongside the hard copy version, the latter being considered as the official issue. The electronic laboratory results and survey field checks shall be presented in a system approved by the Engineer. The Supervisors shall not be expected to consider evaluating the laboratory results and survey checks before the electronic copy has been submitted.

All electronic documentation shall be copied on a monthly basis to the Supervisors for central storage in applicable formats such as PDF-files as well as Word-files and Excel-files (with formulas readable) for documents and AutoCAD (.dwg) files for drawings and GIS files. At the end of the project, a complete electronic project file shall be compiled by the Contractor and issued to the Engineer.

(c) Temporary Works

The Contractor shall supply the Engineer with drawings for approval showing the layout and general arrangement of all Temporary Works they propose to construct for the purpose of the Contract including, but not limited to:

- Camps, including accommodation for staff and labour;
- Offices;
- Laboratory;
- Workshops;
- Stores;
- Aggregate crushing plants;
- Bitumen storage facilities, etc.;
- Concrete manufacturing plants;
- Precast concrete yards;
- Temporary river crossings;
- Temporary bypass and access roads; and
- Fuel dispenser.

No separate payment will be made for Temporary Works; the relevant cost being included in the rates of the Bill of Quantities for other work.

1205 WORKMANSHIP AND QUALITY CONTROL

(a) General

The Contractor shall, not later than 4 weeks after the notice to commence the Works, submit a Quality Management System, including the Work Method Statements and Quality Audit for major items of work, showing how the Contractor's system will ensure that all the works will conform to the Contract documents. The onus rests with the Contractor to produce work which conforms in quality and accuracy of detail to all the requirements of the Specifications and Drawings, and the Contractor shall, at their own expense, institute a quality control system and provide experienced engineers, foremen, surveyors, materials technicians, other technicians and other technical staff, together with all transport, instruments and equipment, to ensure adequate supervision and positive control of the Works at all times. The Contractor shall provide chainmen and labourers as necessary for the Engineer to carry out checks on the Works.

No construction works shall be allowed to start before a complete Quality Assurance System (Plan) complying with the norms specified in:

- ISO 9000 Quality Management System;
- ISO 14001 -Environmental Management Systems (EMS);
- ISO 45001- Occupational health and safety management systems – (OH&S);
- 19100- Geographic Information Standards – (GI)
- Laboratory Recognition Scheme (LRS) based on ISO/IEC 17025 Competence for testing and calibration laboratories and accepted by the Engineer; and
- Or any other Quality Management System at the discretion of the Engineer.

This document shall include:

- The name of the Quality Officer (different from the Materials Engineer);
- The complete set of method statements;
- The complete procedures for quality assurance (checks, resources, hold points, etc...); and
- The forms to be used.

The Contractor shall erect and maintain on site a suitably equipped and staffed laboratory for undertaking all regular material and workmanship tests throughout the contract period.

The Contractor's laboratory personnel must be suitably qualified to perform their duties professionally. The laboratory manager must be a qualified materials technician/technologist with experience as specified in the Contract.

Unless otherwise specified in the Contract, the rest of the laboratory personnel shall consist of at least the following:

- Laboratory technicians;
- Laboratory assistants; and
- Laboratory labourers.

All costs of materials testing and process control testing, other than that specified in the Special Specifications or BoQ, shall be included in the rates.

The quality of materials used by the Contractor for the execution of the Contract shall comply with the requirements of the Specifications. If the Contractor is of the opinion that materials of higher quality than those stated in the Specifications need to be used in order to ensure compliance with the Contract, he shall use such better materials, without being entitled to higher prices or remunerations.

Under no circumstances may the Contractor make any claim based on the insufficient quality of materials used by him, even if the material used was authorized by the Engineer.

The Contractor shall carry out at his own cost the laboratory and other tests that he needs to verify if the materials to be used comply with the Specifications, and shall keep records of such tests. If requested by the Engineer, the Contractor shall hand over the results of the tests.

Unless otherwise specified in the Contract, the in-situ densities shall be performed as agreed with the Engineer.

The Contractor shall conduct tests or have them conducted continually on a regular basis, to check the properties of natural materials and processed natural materials and of products manufactured on the site, such as concrete and asphalt. Although not a requirement for the Contractor to conduct regular tests on any commercially produced products such as cement, bitumen, steel and pipes, the Contractor shall remain fully responsible for any defective material or equipment provided by them. Similarly, the quality of all elements of the Works shall be checked on a regular basis so as to ensure compliance with the specified requirements.

The intensity of control and of tests to be conducted by the Contractor in terms of these obligations is not specified but shall be adequate to ensure that proper control is being exercised.

Where any natural materials or products made from natural materials are supplied, and upon completion of each element of the construction work, the Contractor shall test and check such materials, products and/or elements for compliance with the specified requirements and shall submit their results to the Engineer for approval. Such submission shall include all their measurements and test results and shall furnish adequate proof of compliance with the specified requirements.

No specific pay items are provided as compensation for the above obligations, including the provision of all samples delivered to the Engineer, the repair of places from which samples were taken, and the provision of the necessary personnel and testing apparatus and facilities, for which compensation shall be included in the bid rates of the Contractor for the various items of work to which these obligations apply.

- The Contractor's attention is also drawn to the provisions of Clause 7208 in regard to instituting specific process-control systems. The Contractor's attention is also drawn to the provisions of the various Sections of the Specifications regarding the minimum frequency of testing that will be required to undertake process control. The Contractor shall at their own discretion increase this frequency where necessary to ensure adequate control.

The Contractor shall maintain on site fully fledged office of a Chief surveyor registered by the Surveyors' Registration Board for undertaking all regular survey works, checks, control extension, setting out among others throughout the entire contract period.

Unless otherwise specified in the Contract, the rest of the survey team shall consist of at least the following:

- Survey Assistants;
- Survey Technicians; and
- GIS Officer
- Chainmen

Under no circumstances may the Contractor make any claim based on negligence of his survey team causing reworks even if the Engineer had approved.

The Contractor shall submit to the Engineer for examination, the results of all relevant tests, measurements and levels indicating compliance with the Specifications on completion of every part of the Work.

(b) Source of Supply and Quality Requirements

The materials used on the work shall meet all quality requirements of the Contract. In order to expedite the inspection and testing of materials, the Contractor shall notify the Engineer of the proposed sources of materials prior to delivery. At the option of the Engineer, materials may be approved at the source of supply before delivery is started. If it is found after trial that sources of supply for previously approved material do not produce uniform and satisfactory products, or if the product from any source proves unacceptable at any time, the Contractor shall furnish acceptable materials from other sources.

All materials to be permanently incorporated in the work shall be new unless otherwise specifically prescribed in the Contract Documents.

All iron and steel products, which are to be incorporated in the work shall be manufactured, produced or fabricated at recognised factories meeting specified standards. Where domestically manufactured materials meet the Specifications, the Contractor should take them as the first choice of material supply before consideration of another source. The Contractor shall obtain from the iron or steel producer and or fabricator a certification that all materials meet the specified standards.

(c) Unacceptable Materials

All materials not conforming to the requirements of the Contract at the time they are used shall be considered as unacceptable and all such materials will be rejected and shall be removed immediately from the site of the work unless otherwise instructed by the Engineer. If in place, they shall be removed by the Contractor at their expense and replaced with acceptable materials. No rejected material, the defects of which have been corrected, shall be used until approval has been given by the Engineer. Upon failure of the Contractor to comply forthwith with any other of the Engineer's requirements pursuant to the provisions in the Conditions of Contract, the Engineer shall have authority to remove and replace defective materials and to deduct the cost of removal and replacement from any monies due or becoming due to the Contractor.

(d) Samples and Tests

All materials should be inspected, tested, and approved by the Engineer before incorporation in the work. The Contractor shall give sufficient advance notice of placing orders to permit tests to be completed before the materials are incorporated in the work, and the Contractor shall afford such facilities as the Engineer may require for collecting and forwarding samples and making inspections. All samples shall be furnished without charge to the Employer.

(e) Guidance on Handling of Nuclear Gauges

The in-situ densities may be performed with nuclear gauges (Troxler). No person, company or organisation will be permitted to determine in-situ density by means of a nuclear-type density measuring device without complying with the following requirements:

- Before importation of the nuclear density gauges, clearance must be obtained from the Atomic Energy Council.
- Permission to possess, operate and store the gauges shall be granted if the Atomic Energy Council is satisfied that the identified storage location of the device is suitable and safe, and that an approved radiation officer has been appointed by the Contractor.

- The nuclear devices shall be calibrated by the Uganda National Bureau of Standards (UNBS). The Validity of any calibration certificate shall not exceed six months.
- A General and Detailed storage location plan is to be provided by the pertinent bodies in Uganda for each device. A letter of undertaking from the organisation stating that for each device, should there be a need for it to be stored elsewhere at any time overnight, the Ministry of Works and Transport will be notified in advance to ensure compliance with storage requirements.
- Only persons holding a valid user certificate issued by the relevant body shall be permitted to operate these devices. Such certificates shall only be issued after the applicant has demonstrated competence in operating the device both technically and safely. The validity of any certificate shall not exceed six months.

(f) Stored materials

If it is necessary to store materials, they shall be protected in such a manner as to ensure the preservation of their quality and fitness for the work. All stored materials shall be inspected at the time of use in the work, even though they may have been inspected and approved before being placed in the storage. The Contractor may use the road reserve for storage of materials, but the stockpiles shall be confined to such cleared areas as may be approved by the Engineer. If the stockpiling is done outside the road reserve, the additional space required shall be provided by the Contractor at their own expense.

(g) Handling Materials

All materials shall be handled in such a manner as to preserve their quality and fitness for the work. Aggregates shall be transported from the storage sites to the work in tight vehicles as to prevent loss or segregation of materials after loading.

1206 THE SETTING OUT OF WORK AND PROTECTION OF BEACONS

The Contractor's attention is drawn to the requirements of the relevant clause of the Conditions of Contract, and they shall also comply with all legal provisions in regard to surveying and setting out work.

The Contractor shall be responsible for the proper and accurate setting out of the works as required in the Contract Documents. The Contractor shall provide all survey and measuring equipment and instruments necessary for their use in the execution of the scheduled Works.

The Contractor shall allow in their bid rates for being unable to use up to 30% of the Engineer's control points where such are provided in the Contract, through loss or damage occasioned prior to the commencement date. When the Contractor requires the establishment of a new control point or points due to the above-mentioned loss or damage, they shall advise the Engineer who will, if they deem it necessary, arrange for the establishment of a new control point or points.

The Contractor shall check for the existence of original marks, lines and levels of reference not less than one month prior to commencing works in any section, to allow sufficient time for reinstatement of markings, and checking of lines and levels. Any discrepancies encountered shall be immediately reported to the Engineer, for instruction and co-ordination. The Contractor shall be deemed to have allowed in their bid price for checking and reinstatement of original markings.

The Contractor and Engineer shall jointly check and verify the coordinates and levels of all reference and level beacons and shall be confident that they have not been displaced and

are true in regard to position and level. These data shall be compared with the data provided on the drawings. If beacons have been destroyed, displaced or damaged before the site is handed over to the Contractor, the Engineer will arrange to have new beacons installed. A beacon, which has been displaced, shall not be used unless its true position and level have been re-established and the new values verified by the Engineer.

Original Ground level survey shall be jointly carried out with the Engineer at an interval not greater than 20 m or as advised by the Engineer along the stations of the longitudinal alignment. All sudden changes in level of the ground shall be picked, recorded and coded for the entire construction corridor. The raw data, code list and analysed data will be shared with the Engineer for approval. The Original Ground level shall be referenced to the approved control coordinate system.

Where a beacon is likely to be displaced during construction operations, the Contractor shall establish suitable reference beacons at locations where they will not be displaced during construction. No beacon shall be covered over, displaced or destroyed before accurate reference beacons have been established and details of the positions and levels of such beacons have been submitted to and approved by the Engineer. The Contractor's reference beacons shall be of at least the same quality and durability as the existing beacons.

Control points not affected by the Works shall be protected and preserved by the Contractor. In the case of negligence on the part of the Contractor, or their employees, resulting in the destruction of control points, an amount equal to the cost of replacing the same may be deducted from subsequent payments due the Contractor.

Control points affected by the Works shall be offset by the Contractor to the satisfaction of the Engineer.

The Contractor shall, prior to any setting out, submit to the Engineer for their approval, the method of setting out they propose to employ. The plan shall include the accuracy, positions of the various types of stakes, method of marking stakes, and methods to be used for protecting stakes, etc. No survey work shall proceed prior to the Engineer's approval of the Contractor's plan. At least 24 hours before they intend to survey any portion of the Works, the Contractor shall give written notice to the Engineer. Such notice shall include time, location and type of Works to be set out. The Contractor shall set out the Works and obtain approval of their setting out before proceeding with construction.

The Engineer may if they deem it necessary, revise the line and grade and will require the Contractor to adjust the stakeout accordingly.

The Contractor shall ensure beyond all doubt that the complex elements of the road, such as traffic interchanges, structures and other important features are located truly and correctly, the Contractor shall check all setting-out by a second method. The Engineer may at any time request the Contractor to submit proof that their setting-out has been satisfactorily checked.

No additional payment will be made to the Contractor for costs associated with the provision of additional staff and equipment (which may require renting the equipment at the contractor's expense in the first instance) for himself and for the Engineer to ensure completion of the Setting out of Works, including all survey work for the full length of the project establishing, additional reference beacons, staking of the road and verification of levels, the taking of cross-sections or for other survey work necessary to complete the Works as specified. The Contractor's rates shall also include full compensation for the provision of all survey equipment and assistants for himself to undertake and the Engineer to take control measurements during the construction of the Works.

Unless otherwise specified in the Contract, setting out of works shall be completed over the full length of the project road within "4 months for a project duration up-to 18 months" and "6 months for a project of duration more than 18 months". Failure to complete this work within the specified time may lead to a penalty, as specified in the Contract, being imposed which shall be deducted from the next Interim Payment Certificate.

Special care shall be exercised during construction not to damage, displace or disturb property and cadastral survey beacons. If such beacons are disturbed or destroyed by the Contractor they shall be replaced without delay by a registered land surveyor at the Contractor's expense.

In cases where the displacement of or damage to property beacons or cadastral survey beacons is unavoidable, the Contractor shall notify the Engineer in good time so that they may arrange to have such beacons suitably referenced and later on reinstated. The cost of such work, if paid for by the Contractor, shall be reimbursable as extra work, as provided for in the Conditions of Contract.

For the purposes of this Clause and of the relevant clause of the Conditions of Contract, any beacon made from a metal peg cast in concrete and any boundary beacon, whether or not cast in concrete, shall be regarded as a beacon. Centre-line pegs shall not be classified as beacons.

To protect beacons, the boundary fences of the road reserve shall be splayed at corners so as to avoid the use of corner posts in the same position as property or cadastral survey beacons, all as shown on the Drawings.

Accurate horizontal and vertical control shall be provided by the Contractor at all stages of construction as detailed in Section 7300 of these Specifications.

Where directed by the Engineer, the Contractor shall provide to the Engineer camber boards to the profile of the normal camber, 3.0 m long straight edges and measuring wedges.

The camber boards shall be constructed of stout timber, angle iron or metal tubes so as to span 6.5m without deflection, and preferably supported on trollies and fitted with a device for raising and lowering the board. The bottom of a timber board shall be shod with steel plate, the width of the timber, and at least 5mm thick. The construction of the boards shall be to the satisfaction of the Engineer.

The 3.0 m long straight edges and measuring wedges shall be made of durable strong materials such that they are inflexible and will not warp and do not suffer from abrasion.

The setting-out of work will not be measured and paid for separately, and compensation for the work involved will be deemed to be covered by the rates bid and paid for in the various items of work included in this Contract. No separate payment will be made to the Contractor for the provision of camber boards, straight edges and measuring wedges, their cost being included by the Contractor in their rates in the Bill of Quantities.

No separate payment will be made for stakeout, adjustments to the stakeout, or to establish and compute new points/benchmarks the relevant costs being deemed to be included in the bid rates for other items in the Bill of Quantities.

1207 NOTICES, SIGNS AND ADVERTISEMENTS

The Contractor and subcontractors shall not erect any signs, notices or advertisements on or along the Works or the site of the works without the approval of the Engineer or according to a format given by the Engineer.

No signboards other than those specified above will be permitted on or adjacent to the Works, except that the Contractor may permit each of their sub-contractors to

display one, and only one, signboard of less than 2 m² at the works office.

At each end of the Works the Contractor shall provide and erect, as part of their obligations under SECTION 1300, and on approved locations, at the starting and ending points of the Works, sign boards of sound, weatherproof construction, painted by an approved firm of sign writers in accordance with the details shown on the Drawings or the description in SUB-CLAUSE 1302 (c) of these Specifications.

These signs are to be erected not later than one month after the Contractor has been given access to the Site.

The Engineer shall have the right to have any sign, notice or advertisement moved to a better position or to have it removed from the site of the Works if it should in any way prove unsatisfactory, inconvenient or dangerous to the general public.

All advertisements, notices and signs shall be removed by the Contractor upon issuance of the final certificate of completion.

The Contractor shall ensure that before embarking on any construction works that inconvenience traffic or require diversion of traffic, he publishes in print, electronic, mass, and social media as well as erects public notices in designated areas with necessary guidance information for public consumption following approval by the Engineer. The Engineer shall not approve the commencement of works unless the required notices are published in advance of commencement of works.

1208 METHODS OF MEASUREMENTS

(a) Units of Measurements

All work shall be measured in accordance with the SI system of metric units.

(b) Bill of Quantities

The quantities set out in the Bill of Quantities are estimated quantities and are used for the comparison of bids and for awarding the Contract. It must be clearly understood that only the actual quantities of work done or materials supplied will be measured for payment, and that the scheduled quantities may be increased or decreased as provided for in the Conditions of Contract.

(c) Measurement of Completed Work

All distances along the centre line of the road as shown on the Drawings are horizontal distances, which will be used in calculating the quantities of fill and pavement layers for purposes of payment. All cross-sections shall be taken in a vertical plane.

No material shall be measured in the vehicle for payment purposes.

The quantity of bituminous and similar materials to be paid by volume shall be measured at the temperature of application and paid for in accordance with approved application rates.

The quantity of bitumen in mixes and stabilisers in cemented materials shall be paid by mass in accordance with approved mix design proportions.

Structures shall be measured to the neat lines shown on the Drawing and shall include any changes ordered in writing by the engineer and, for purposes of payment, the calculated volume of concrete structures shall include the volume of reinforcing steel, and minor ducts up to 150 mm in diameter.

1209 METHODS OF PAYMENT

(a) Contract Rates

In computing the final Contract amount, payment shall be based on the actual quantity of authorised work done in accordance with the specifications and drawings. The bid rates shall apply, subject to the provisions of the Conditions of Contract, irrespective of whether the actual quantities are more or less than the scheduled quantities.

Where no rate or price has been entered against a pay item in the Bill of Quantities by a bidder it shall be understood that they do not require any compensation for such work. Where, however, a pay item described in these Specifications or in the Special Specifications does not appear in the Bill of Quantities, the Contractor will receive reasonable compensation for such work if required, unless anything to the contrary has been determined elsewhere.

(b) Rates to be Inclusive

The Contractor shall accept the payment provided for in the Contract and represented by the rates bid by them in the Bill of Quantities, as payment in full for executing and completing the work as specified; for procuring, furnishing, placing and installing all materials, for procuring and providing labour, supervision, constructional plant, tools and equipment, for wastage, transport, loading and off-loading, handling, maintenance, temporary work, testing, quality control including process control, overheads, profit, risk and other obligations and for all other incidentals necessary for the completion of the work and maintenance during the Defects Notification/Liability Period.

The Contractor shall note that the cost of all Works and materials for minor construction details at bridges, for example small quantities of caulking compound and joint filler (other than expansion joints), anchor-bar covers, etc, not shown in the Bill of Quantities, shall be included in the bid rates for concrete.

This Clause shall apply in full to all pay items except where these requirements may be specifically amended in each case.

(c) The Meaning of Certain Phrases in Payment Clauses

i) Procuring and Furnishing (Material).

Where any of the words "supply", "procure", "provide", "provision of", "furnish (material)", are used in the description of a pay item, it shall mean the supply and delivery to the point of use of all materials of any kind required for the work covered by the particular pay item, including all tax, and duties, purchase costs, claims, damages, royalties and transport costs involved, but excluding overhaul.

In the case of borrow materials, stone and sand, it shall also include all negotiations with the Owners concerned, excavating, producing, preparing, processing, testing, hauling and delivering the material to the point of use; the construction, repair, maintenance and making good after completion of all access roads, and all work required in opening, using and finishing off borrow pits unless covered by other pay items in the Bill of Quantities.

ii) Placing Material

The phrase "placing material" shall mean the off-loading, spreading, blending, processing, watering, mixing, shaping and compacting (where specified) of the material in the pavement layer, fills and bypasses, as well as the procuring, furnishing, applying and admixing of water, the breaking-down of oversize material, the removing of oversize material which cannot be broken down, correcting irregular or uneven surfaces or layers, the thickness of which is not to specification, finishing-off to within the specified

tolerances, the refilling of test holes and maintaining the completed work. In the case of asphalt course and bituminous seals, it shall also mean the heating and spraying of binder, the spreading of aggregate or asphalt mixtures, rolling, compacting, finishing-off to within the specified tolerances, and maintaining the completed work.

The phrase "procuring, furnishing and placing" shall mean procuring and furnishing in addition to placing, all as defined herein.

(d) Pay Items

The description under the pay items in the various Sections of the Specifications, indicating the work for which allowance shall be made in the bid rates for such pay items, is for the guidance of the Contractor and does not necessarily repeat all the details of work and materials required by and described in the Specifications.

These descriptions shall be read in conjunction with the relevant Specifications and Drawings, and the Contractor shall, when bidding, bear in mind that their rates shall be inclusive as specified in SUB-CLAUSE 1209 (b) above.

(e) Materials on the Site

Payment in respect of Materials on Site for subsequent incorporation into the Permanent Works will be in accordance with the relevant clause of the Conditions of Contract, subject to such payment being allowable in said clause.

(f) Rights in and Use of Materials Found on the Work

The Contractor with the approval of the Engineer, may use on the Work such stone, gravel, sand, or other material determined suitable by the Engineer as may be found in the excavation, and will be paid both for the excavation of such materials at the corresponding contract unit rate and for the pay item for which the excavated material is used.

The Contractor shall replace, at his own expense, with other acceptable material, all of that portion of the excavation material so removed and used which was needed for use in the embankments, backfills, approaches, or otherwise. No charge for the materials so used will be made against the Contractor.

Unless otherwise provided, the material from existing old structure may be used temporarily by the Contractor in the erection of the new structure. Such material shall not be cut or otherwise damaged except with approval of the Engineer.

(g) Rate-Only Items

Against an item in the Bill of Quantities where no quantity is given but a rate only is required, the Contractor shall fill in a rate or amount which will constitute payment for work which may be done in terms of this item. Such rate only item is used where it is estimated that little or no work will be required under the item, or where the item is to be considered as an alternative for another item where a quantity is given, or for variations in rates of application or mix proportions in terms of CLAUSE 1212.

Work under rate-only items will be paid for only if it has been executed in terms of a written instruction by the Engineer.

(h) Provisional Sums

The Bill of Quantities may contain Provisional Sums, so designated, which are entered as a preliminary allowance to cover the cost of work, materials, goods or services to be provided by the Contractor and which have not been fully specified or measured or to cover the cost of unforeseen items of work or contingent expenditure, for which no rates are applicable but for which the Contractor is to be paid according to the applicable provisions of the Contract.

Work done under such Provisional Sums shall only be executed upon a written order by the Engineer which order shall also specify the method of payment. The expenditure in respect of a Provisional Sum for work ordered by the Engineer shall be entirely at their discretion and any final expenditure in respect of a Provisional Sum may be more, less or equal to the amount provided in the Bill of Quantities.

Payment as specified in the order given by the Engineer shall be either at Contract rates, where such are applicable, or where none is applicable; the Contractor shall submit a separate quotation to the Engineer.

1210 COMPLETION OF THE WORKS

Completion of the Works (Taking Over) in terms of the relevant clause of the Conditions of Contract will be certified by the Engineer only if the following sections of the Works as may be applicable have, inter alia, been duly completed according to the Specifications:

- The gravel wearing course, seals, asphalt or concrete pavement;
- All above-ground and subsoil drainage structures;
- All fencing;
- The finishing-off of medians and slopes of cuts and fills;
- All the necessary road signs and road-surface markings;
- All guardrails;
- All structures;
- All traffic signals;
- All pedestrian facilities;
- All lighting;
- All landscape works; and
- Reinstatement of all areas employed by the contractor as required in CLAUSE 1703.

Unless otherwise stated in the special conditions of contract, Completion/ Taking-Over of the Works will only be considered by the Employer in respect of the entire Contract. That is to say, no portion of the Contract shall be separately

taken over by the Employer.

(a) Taking-over inspection/ Tests on Completion

Taking-over inspection shall be carried out before the Works are taken over by the Employer. The inspection shall consist of the following three groups:

- Group A: Checking of quality assurance documents
- Group B: Checking of contractual and financial documents and reports
- Group C: Site inspection and the Tests on Completion

For Groups A and B, the Contractor shall present all the necessary documents maintained by the Contractor that will be specified in the checklist provided by the Engineer.

The Group C inspection and tests shall be carried out in accordance with the Conditions of Contract before the Works or a Section (as the case may be) are taken over by the Employer.

The detailed programme and schedule for Group C, including inspection and test items shall be prepared by the Contractor considering the contents of TABLE 1210/1 and shall be submitted to the Engineer for a no-objection. Visual inspection shall be done throughout the Project based on the inspection items. If a sign of internal defect is observed, non-destructive/ minor destructive tests shall be carried out as requested by the Engineer.

The Engineer shall judge a pass or fail of each inspection/test based on the criteria. The Contractor shall carry out the cleaning, repair, remedial works, etc. in accordance with the judgement and recommendations made by the Engineer. The Contractor shall submit a proposal for the schedule and repair methods, if necessary, to satisfy the criteria after the inspection as soon as practicable.

The tests on completion shall be as shown in the Table 1210/1 but shall not be limited to them. The Engineer shall, based on his judgement, instruct any other test to be carried out as part of the tests of completion to facilitate making a decision on taking over the works.

TABLE 1210/1: TEST AND INSPECTION ITEMS AND CRITERIA FOR THE TESTS ON COMPLETION

CATEGORY/AREA	TYPE OF DEFECTS/THRESHOLD VALUE/ACTION
Concrete surface (visible inspection)	Defect: Crack on the surface Cracks wider than the following values shall be repaired with the method proposed by the Contractor and agreed by the Engineer. • Prestressed concrete: 0.2 mm • Reinforced concrete: 0.3 mm Any cracks that are wider than 0.1 mm and located at structurally important locations shall be visually recorded and reported to the Engineer and the Employer for further maintenance works. If the Engineer requests, the Contractor shall repair any structural and/or critical cracks irrespective of their width.
	Defect: Inadequate concrete cover Appropriate repairs shall be done where exposure of rebars and/or a sign of inadequate concrete cover is observed. Non-destructive tests are recommended for checking the extent of concrete cover.
	Defect: Deformation of the surface (Delamination, blistering, curling, warping, birdbaths, form offsets, etc.) which is outside the tolerance specified in Section 6800 of the Specifications. Appropriate repairs shall be proposed by the contractor for approval by the Engineer.
	Defect: Surface air voids (bugholes) The voids on the surface shall be filled with mortar or cement paste if the number of voids larger than 10 mm is more than 25 per square metre.
	Defect: Honeycomb Honeycomb larger than the threshold shown below shall be repaired with the method proposed by the Contractor and agreed by the Engineer. • 10 mm in depth • 25 mm x 25 mm in area If the honeycomb is found at a structurally important or aesthetically conspicuous location, it shall be repaired as instructed by the Engineer.

CATEGORY/AREA	TYPE OF DEFECTS/THRESHOLD VALUE/ACTION
	Defect: Form streaks, sand streaking, The defects which exceed the threshold shown below shall be repaired with the method proposed by the Contractor and agreed by the Engineer. • 10 mm in depth • 50 mm x 50 mm in area • Total area of defects covers more than 5% in an area of 1.0 m².
	Defect: Rebar/tie wire exposed on the concrete surface. Cut off the concrete around the exposed part of the reinforcement and repair with material such as polymer cement mortar proposed by the Contractor and agreed by the Engineer.
	Defect: Holes of separator Holes of the separator shall be filled with material such as polymer cement mortar or any other material proposed by the contractor.
	Defect: Cracks at Cold joints The crack at the cold joint shall be repaired with the method proposed by the Contractor and agreed by the Engineer. It is recommended that insignificant cold joints without cracks are protected with polymer cement paste depending on a location of the cold joints.
	Defect: Uncleaness Stain, dirt and/or graffiti on the concrete surface which spoils the appearance of the concrete structure shall be cleaned using a water jet, grinder or other suitable method. Any kind of debris on abutment and pier tops shall be removed.
Concrete strength	Concrete strength tests shall be conducted at a representative location of the major concrete structures as instructed by the Engineer with a test hammer. The concrete strength shall not be less than the concrete strength specified in the Drawings and the Specifications.
Steel bridge	Missing and/or loosen bolts shall be fixed
	Manhole and maintenance facilities. Manholes shall be manually inspected to check if they can be opened and be closed tightly. The elements of the ladders shall be individually inspected to check whether they are installed in accordance with the Drawings.
Protection of steel surface	Damage on protective layer. Any damage on painting and galvanising shall be fully repaired.
Bridge deck	Surface geometry: The survey of the geometry of the deck surface shall be carried out and compared with the Drawings. If the deviation is more than the tolerance in the Specification, the Contractor shall carry out remedial works as agreed with the Engineer.
	Local surface irregularities: The maximum difference in level with respect to a 3m straight edge is: • 3mm in the longitudinal direction, • 5mm in the transverse direction. • Any local water ponding after rainfall shall not be allowed.
Bridge Components	Expansion joints: • Water tightness shall be checked. • Anything blocking the movement of the joint shall be removed. • Openings of expansion joints shall be measured at mid-morning. Air temperature at the time of the measurement shall be recorded.
	Bearings: • The bearings shall be inspected for cracks, rusting, inclination and spacing. • The conditions of the fixings shall be inspected. • Displacement (accuracy of 1 mm) of the top plate in relation to the fixed base shall be recorded and shall be justified theoretically.
	Drainage: • Anything in gullies and drainage pipes shall be cleaned. • Functionality of the drainage shall be inspected by draining water (after a rainfall).
Reinforced Earth	Concrete panel: • Deformation of the concrete panel wall surface shall be inspected. Remedial works shall be necessary if the deformation is more than 3% of the height of each panel.
Asphalt pavement	Cracking: • Any cracks and crack affected areas shall be repaired. The repair method shall be determined depending on the categorisation and cause of the cracking.
	Roughness: • IRI (International Roughness Index) shall not be more than 2.4 mm/m.
	Rutting: • Any rutting shall be repaired. Rut depth shall not exceed 5 mm.
	Deflection: • Deflection shall be measured not less than every 200 m and sag point of the vertical profile using the falling weight deflectometer (FWD). The deflection amount shall not exceed 500µm.
	Debonding: • Any debonding affected area shall be repaired.
	Flushing: • Any flushing affected area shall be repaired.
	Ravelling: • Any ravelling affected area shall be repaired.
	Uncleaness: • Any dirt on the asphalt pavement surface shall be cleaned.

CATEGORY/AREA	TYPE OF DEFECTS/THRESHOLD VALUE/ACTION
Concrete interlocking block/tile pavement	Cracking/damage: Any damaged concrete block/tile shall be replaced with a new one.
	Concrete Block/Tile missing: A new Concrete block/tile shall be placed.
	Loose concrete Block/tile: Check the base course and replace the loosen block.
	Flatness/Unevenness: Repair the base of the concrete blocks/tiles if the unevenness exceeds ± 10 mm.
	Uncleanliness: Clean or replace dirty concrete blocks/tiles.
Drainage	Damaged/Clogged Kerb, catch pit, catch pit cover: Any damaged segment shall be replaced with a new one and any clogging removed.
	Clogged/waterlogged Pipe culvert, box culvert, side drain: - Any sediments and rubbish at open drains and catch pits shall be removed. - All pipe and box culverts shall be desilted. - All drainage structures should be inspected after a downpour/rainfall for proper function and fixed if dysfunctional.
Guardrail/fencing	Quantities/damages: - Railing and fencing elements shall be individually inspected to check whether they are locally bent, flattened or missing or rusting. - Any defects identified shall be repaired by the contractor.
	Verticality/horizontality: - Vertical tolerances of the guardrail post and railing position from the ground are as follows. - Guardrail post : -30 mm - Railing : -20 mm, +30 mm - Any defects identified shall be repaired by the contractor.
	Fixing and anchoring: - The railings shall be manually inspected to check if the railings are fixed tightly. - Bolts used for the railings shall be visually inspected. - Any defects identified shall be repaired by the contractor.
	Defects on surface protection: Any damages on the surface protection shall be repaired.
Traffic signs	- All the traffic signs shall be placed at the right position in accordance with the Drawings and with any other instruction made by the Engineer. Signs in the wrong positions shall be relocated to the correct positions. - Elevation of the sign board from road/bridge surface shall not be lower than the Drawings. Elevation of the sign board or Height of Mounting that is not in line with the drawings or the prescribed Traffic Signs Manuals shall be dismounted and remounted in the correct positions. - Signs whose visibility is obscured in terms of height, direction and obstacles shall be checked and all obstacles removed, or the sign relocated. - Any damages on posts and signs, inclination, uncleanliness, and instability of the signs shall be rectified. - Any sign with Retro reflectivity of the sheeting not compliant with the specification of ASTM 4956 – minimum of sheeting IV for highways and Sheeting IX for Expressways shall be replaced. - All standard warning signs whose size is less than 720 mm for 50 kph, 900 mm for 50 – 80 kph and for 1100 mm for speeds > 80 kph shall be replaced. - All standard regulatory signs whose size is less than diameter 600mm for 50 kph, 750 mm for 50 – 80 kph and 900 mm for speeds > 80 kph should be replaced. - All Guidance signs that do not comply with x-height requirement of 100 mm for speed 50 kph, 150 mm for 50 – 80 kph, and 200 mm for speeds > 80 kph shall be replaced. - All signs with incorrect spellings or with words unacceptable to the respective communities shall be replaced.
	Gantry: Vertical/horizontal accuracy, bolt connections and surface protection shall be inspected. The headroom for the road shall be checked.
Road Markings	- All the road markings shall be appropriately executed in accordance with the Traffic Signs Manual and with any other instruction made by the Engineer. Any inappropriate road markings shall be redone. - All road markings considered not applicable in the locations where they are provided, shall be redone. - Visibility requirement for all road markings shall be adhered to. The retro-reflectivity of the road markings not complying with the following minimum requirements shall be redone. - The Day Time retro-reflectivity of 130 mcd/m²/lux (Qd). - The Night-time Retro-reflectivity, RL (both Initial, within 7 days of application & sustained) of 350 mcd/m²/lux - All road markings whose thickness is less than 3 mm for all lines except acoustic edge line which should be 5 mm (+/-0.5 mm) shall be redone.

CATEGORY/AREA	TYPE OF DEFECTS/THRESHOLD VALUE/ACTION
Road Studs	The colours of reflective road studs should be as follows. • White Studs marking the lanes or the centre line of the road. • Red studs marking the left edge of the road. • Amber studs marking the central reservation of a dual carriageway or expressway. • Green studs marking the edge of the main carriageway at lay-bys or slip roads. Spacing of studs should be as per the drawings or the prescribed traffic signs manual or MoWT Traffic Signs Manual. All studs not complying with the above requirements shall be replaced
Rumble Strips/ Ribbed Edge	Defect: Incorrect application of Rumble strip and ribbed edge: Any damaged piece shall be reconstructed. Tolerance is as follows: • Rumble Strip ○ Interval is 500 mm $\pm$30 mm ○ Width is 300 mm $\pm$10 mm ○ Height is 10 mm $\pm$4 mm • Ribbed Edge ○ Interval is 200mm $\pm$30 mm ○ Width is 130 mm $\pm$10 mm ○ Height is 8 mm $\pm$4 mm All rumble strips and ribbed edges not complying with the above requirement shall be redone.
Road/ Street lighting / Illumination	Street lighting: • The distribution board, switches and power supply unit shall fully function in accordance with the requirements. • The illuminance shall be inspected at each road section and at the centre of the intersections at night. • The inclination of the posts shall be inspected visually. • In case of abnormal inclination, the base plate, bolts and the post itself shall be inspected. • Anti-corrosion protection of bolts shall be inspected. • The access doors at post bases shall be inspected. • Lantern arms inclination and lantern fixing on arms shall be inspected. • In the case of lanterns directly fixed to steel or concrete structures, their positions and angles shall be inspected. • The fixings of the lanterns shall be inspected. They shall be re-tightened at the right position or substituted as necessary. • The headroom for the road shall be checked. Decorative Illumination for bridges and parks: • The distribution board, switches and power supply unit shall fully function in accordance with the requirements. • The illuminance and angle of each light and illumination shall be inspected at night. • Water tightness of the ascent lighting shall be checked.
Traffic signal	Signal, vehicle detector, push button, etc: • All traffic signals shall be placed at their right positions in accordance with the Drawings and with any other instruction made by the Engineer. • The inclination of the posts shall be inspected visually. • In case of abnormal inclination, the base plate, bolts and the post itself shall be inspected. • The function of all the equipment shall be tested as the traffic signal system (Traffic signal, Vehicle Detector, Push Button Box). • Headroom for the roads shall be checked. • The checklist for traffic signal phasing & timing and traffic signal commissioning shall be signed off and each item verified to comply with the specifications.
Landscaping	Vegetation: • Any withered trees, shrubs and grass shall be replaced with fresh ones. Natural cobbles and stone tiles: • Cobbles shall be fixed to the base tightly. • Any damaged cobbles and tiles shall be replaced with new ones. • Check the base course and replace any loose tiles. • Repair the base of the tiles if the unevenness exceeds $\pm$10 mm. Fountain and irrigation system: • All the functions required for the fountain and the irrigation system shall be checked. Toilet Facilities: • All the functions of the toilet, lavatory, lighting, water supply and sewer system, including all fittings and fixtures are in place and functional.

(b) As-Built Drawings / Database

The Contractor upon completion of all the construction works shall submit to the Engineer detailed As-built drawings (.dwg) for the works done and populated GIS data base capturing all features and their attribute information of the

completed works.

1211 TRAFFIC OVER COMPLETED PAVEMENT LAYERS

The Contractor's traffic including that for hauling materials over structures or pavement layers of an uncompleted road

shall, insofar as is possible, and in addition to other restrictions specified elsewhere, be limited to a minimum by planning of the sequence of operation and the use of construction roads and diversions.

The Contractor's traffic over structures or the completed road will be restricted to the maximum axle load permitted in terms of statutory provisions. Any damage to structures or completed layers caused by the Contractor's traffic shall be repaired at their own cost.

1212 VARIATION FROM SPECIFIED NOMINAL RATES OF APPLICATION OR NOMINAL MIX PROPORTIONS

The various Sections of these specifications specify nominal rates of application or nominal mix proportions for materials such as bituminous materials, aggregates, fillers, stabilising agents, paint and the like. Bidders shall base their bids on these nominal rates of application and mix proportions.

Allowance is made in the various Sections of these Specifications where such rates of application mix and mix proportions are given, for variations arising out of different rates of application or mix proportions ordered by the Engineer to suit the materials and conditions on the Site in every particular case.

Where the actual rates of application or mix proportions used in the works vary from the nominal specified rates or mix proportions, adjustment or compensation will be made:

- a. As a payment to the Contractor in respect of any authorised increase in quantities from those specified, where such increase has been ordered in writing by the Engineer;

or

- b. As a refund to the Employer in respect of any authorised decrease in quantities from those specified which has been ordered in writing by the Engineer.

Payment for a varied rate of application or mix proportion shall be based on the actual rate of application or mix proportion used or ordered by the Engineer, provided that the actual rate of application or mix proportion is within the specified tolerance.

If the actual rate of application or mix proportion is below the prescribed rate of application or mix proportion ordered, payment shall be based on the actual rate of application or mix proportion regardless of any tolerance allowed. Notwithstanding the above, the Engineer shall be fully entitled to reject work which has not been constructed in accordance with the specifications or the rate of application or mix proportions prescribed by them.

The Employer shall be refunded for any decrease in the specified rates of application or mix proportions at the same rate per unit of measurement as that tendered by the Contractor for additional materials required by an increase in the rates of application or mix proportions.

1213 CONTRACTOR'S ACTIVITIES IN RESPECT OF PROPERTY OUTSIDE THE ROAD RESERVE AND OF SERVICES MOVED, DAMAGED OR ALTERED

(a) Statutory Provisions

The Contractor shall exercise any rights that may be ceded to them by an Authority in terms of any statutory provisions for purposes of executing the Contract, on condition that:

- i) The Contractor complies strictly with the requirements of such statutory provisions, particularly in regard to the

matters relating to serving notice on the Owner or consultation with them.

- ii) In each case a written agreement is made with the Engineer regarding the details of the Contractor's proposed actions before the rights of the Contractor in terms of the statutory provisions are exercised.

The provisions shall apply mutatis mutandis to:

- Those areas approved for the purpose of disposing of spoil material; and
- Those areas occupied by the contractor for their establishment on the site or for any other purpose and for the engineer's houses, office and laboratory.

(b) Agreements with Owners or Legal Users of Property

The Contractor shall put in writing all their agreements with Owners of property outside the road reserve or of services inside or outside the road reserve in respect of the following matters:

- i) The location, extent and use of borrow pits, haul roads, construction roads and bypasses outside the road reserve.
- ii) Compensation, if applicable, for land or materials taken or for land temporarily used or occupied or for any properties and crops that may be affected and for implementation of the corresponding livelihood restoration measures.
- iii) The reinstatement of property occupied, used, damaged or destroyed, or compensation therefore in lieu of reinstatement.
- iv) The procedure for the moving of services and details as to how and when this is to be done.
- v) Any similar matter directly related to the Contractor's activities on or in respect of private property or services.

These agreements shall be signed by all the parties concerned and delivered to the Engineer. Compensation Payment for all land, materials or any affected properties and crops that may be affected shall etc as agreed,

Where the Contractor cannot obtain the Owner's agreement in writing, they shall refer the matter to the Engineer and shall furnish them with details, in writing, of any verbal agreement made. The Contractor shall not be liable to pay compensation for the occupation and/or use of the land within the Road Reserve.

The Road Reserve comprises those places where the Permanent Works are to be carried out, being areas within the designated project site.

(c) Notice on Owner

Where, in addition to any agreement with the Owner of any property to be entered upon or temporarily occupied or any service to be moved, it is understood or required that the Contractor shall serve notice on the Owner immediately before actually entering upon or occupying the private property or moving a service, and shall give proper notice thereof in writing, and the Engineer shall be supplied with a copy of such notice, together with acknowledgement of receipt.

(d) Completion Statement from Owner

On completion of their operations, the Contractor shall obtain from the owner concerned, a written statement to the effect that the Contractor has fulfilled their obligations under a written agreement including confirmation that the Owner has received all the compensation they are entitled to and is also satisfied that all property occupied, including borrow pits, haul roads and construction roads, have been properly restored and is in a satisfactory condition.

All such statements shall be signed, dated and delivered to

the Engineer.

(e) Use of Land Outside Provided Area

Should the Contractor wish to use land outside the area provided by the Employer for storing or keeping material or equipment required for the construction of the permanent works, it will be subject to the following:

- i) That the Engineer approves any area selected for this purpose.
- ii) That such land be physically separated from any production plant or activities and suitably fenced in.
- iii) That the area used for the aforesaid purpose be surveyed to ascertain ownership, tenure, area and cadastral boundaries, and, where the land does not belong to the Contractor, they shall enter into a contract of lease with the Owner of such land in respect of the full period for which such land shall be used for such purpose.
- iv) Which contract shall stipulate that the Owner shall not have any right whatsoever to any material stockpiled on such land during the currency of the contract of lease. That suitable, permanent reference beacons, approved by the Engineer, be placed next to the area, at the cost of the Contractor, for use by the Engineer with a view to, if applicable, taking cross-section for determining quantities.
- v) That only material used for this contract shall be stored on such land.

(f) Fences, Gates and Signs (Private)

The Contractor shall be responsible for ensuring that livestock cannot stray as a result of their operations or enter a construction area including borrow areas. When existing fences and gates have to be removed or altered for the proper execution of the Works or are required to exclude livestock, the Contractor shall, at their own expense, erect temporary fencing and gates, and if necessary, provide watchmen to ensure that livestock cannot stray. New tension wires shall be used when re-erecting existing mesh fences. For permanently relocated existing fences and new fences, each horizontal wire shall be tensioned between braced posts using a wire strainer. Each wire shall also be securely fixed to each post using wire ties through drilled holes.

The permanent relocation of existing fences and private signs and the construction of new permanent fences as shown or as directed by the Engineer shall be paid for at the contract price per unit of measurement shown in the Bill of Quantities which price shall include for furnishing and placing all materials, including all labour, equipment, tools and incidentals necessary to complete the work.

1214 LAND ACQUISITION

The Employer shall be solely responsible for the acquisition of land required for the permanent works and for obtaining all necessary consents, compensation, rents, and rights in respect of that land. No entry upon such land for the execution of the Works shall take place without the Engineer's prior written approval, which shall be given or refused in accordance with the terms of the Contract and shall not be unreasonably withheld or delayed.

It is entirely the Contractor's own responsibility to obtain all land required for the erection of their offices, stores, workshop, quarters, camps and the like, including land required for the Engineer's accommodation, offices and laboratory as specified in SECTION 1400. Such provision of land shall be considered part of the Contractor's general obligations as defined in SECTION 1300.

Unless specified in the Special Specifications, all land that may be required by the Contractor outside the road reserve for opening of borrow pits and quarries, including access roads, will be the responsibility of the Contractor, but the approval of the Engineer must be sought before entry upon such land.

The attention of the Contractor is drawn to the provisions of CLAUSE 1213 as regards their activities on private land and to SECTION 3400 for the acquisition of land for borrow pits, quarries and temporary works.

The Contractor shall observe all the legal provisions and the provisions of the Special Specifications in respect of their activities at borrow pits, quarries, camp sites etc. and when finishing off such areas.

The Contractor shall satisfy themselves that all necessary negotiations have been made with the Owner or Legal Occupants of the ground prior to entry.

1215 INFORMATION FURNISHED BY THE EMPLOYER

The Employer shall provide in good faith, soil and site condition information as part of the contract documents or separately. Such information shall include soil tests, soil mappings, drilling results, geophysical surveys, borrow-pit data, materials surveys and reports, geological reports among others. The information supplied may be incomplete or inaccurate due to testing limitations, natural variability or evolving site conditions and may not reflect in-situ conditions at all locations. The information may be subject to change as site conditions are encountered. The Employer shall not be liable for any direct or indirect damages arising from inaccuracies or changes in the information supplied or for any consequences of relying on such information for construction activities. The Contractor shall verify the information as directed by the Engineer and shall undertake any additional investigations necessary to execute the works. The Contractor shall bear the risk of consequences arising from reliance on information that is incomplete, inaccurate or not representative.

Certain information contained in these contract documents or provided separately is being offered in good faith, but, in the circumstances pertaining to the type of information furnished, no guarantee can be given that all the information is necessarily correct or representative of the in-situ condition.

This applies more specifically to all soil tests, soil mapping, drilling results, geophysical survey, geological reports, borrow-pit information, material surveys and reports, and similar information, the accuracy of which is necessarily subject to the limitations of testing, sampling, the natural variation of material or formations being investigated and the measure of certainty with which conclusions can be drawn from any investigations made. It also applies to any materials utilisation plan provided, as the diagram may be subject to major alterations during the progress of the work, depending on site conditions.

The Employer will not accept any liability for the correctness or otherwise of the information furnished or for any resulting damage, whether direct or consequential, should it appear, during the course of the Contract, that the information supplied is either incorrect or not representative.

1216 PROTECTION OF THE WORKS AND REQUIREMENTS TO BE MET BEFORE CONSTRUCTION OF WORK

(a) Nature of Ground and Condition of Work

The Contractor must satisfy themselves as to the general circumstances at the site of the Works and the construction thereon, the form of river beds, and banks, the flows in the rivers, the surface of the ground and nature of the materials to be excavated, the possibility of subsidence from soft ground and bad and broken materials, and falls of rock in or arising out of the Works, and the possibility of floods and landslides, and the rates and prices in the Bill of Quantities will be held to cover all such contingencies.

In order to minimise the possible adverse effects of flooding, the drainage of the natural ground in the vicinity of the earthworks and the drainage works generally shall be carried out in advance of the rest of the Works.

(b) Landslides

The removal of materials in slips, slides or subsidence and overbreak of rock extending beyond the lines and slopes or below the levels shown on the Drawings or required by the Engineer will not be paid for unless such occurrences were, in the opinion of the Engineer, beyond the control of the Contractor and could not have been prevented by the exercise of due care and diligence.

Where payment is made for the removal of such materials, it will be paid as a variation at the appropriate rate inserted in the Bill of Quantities having regard to the condition and situation of the material at the time of removal and regardless of its condition and situation prior to the slip.

(c) Drainage and Dealing with Water

The Contractor shall be responsible for dealing with water, whether from existing drainage systems, watercourses, underground springs, precipitation, the new drainage system, or any other source or causes. In discharging and diverting water he shall avoid flooding or damaging other works, services, or existing properties causing erosion and/or polluting watercourses.

The Contractor at his own expense shall keep the whole of the Works free from water and shall provide all dams, cofferdams, pumps, piles, shoring, temporary drains, sumps etc. necessary for this purpose. The Contractor shall not block existing drainage and where his works affects existing drainage, he shall provide temporary drainage.

Well in advance of commencing the permanent Works, the Contractor shall at his own expense, cut drains and ditches and carry out any other measures necessary to effectively drain the original ground and/or shall programme his Works such that the necessity of temporarily draining the original ground is partially or totally obviated by working in the dry season.

The Contractor shall, at his own expense, take all necessary precautions to prevent damage due to erosion and siltation during construction. Precautions will include temporary drainage berms, scour checks, riprap and the like. Spoil material or stockpile material shall be dumped, so as not to interfere with streams, watercourses or any of the drainage works and this shall be approved by the Engineer before commencing his activities.

On cessation of the works each day, the surface of each completed layer shall be trimmed, so that ponding and concentration of surface run-off does not occur. Should any water accumulate on any part of the Works either during construction or after construction until the end of the Defects Notification Period, giving rise to soaking or eroding conditions, the Engineer may order the Contractor to remove and replace, at the Contractor's expense, any material or Works that have been so affected.

Any damage to the Works or to adjacent land and properties resulting from the Contractor's failure to take the necessary precaution shall be made good at the Contractor's expense.

(d) Damage by Wet Material

Material in borrow pits shall not be allowed to become excessively wet. All completed layers shall be properly drained, dumps of material on completed layer work shall not inhibit surface drainage or form wet spots under and around dumps, and all parts of the Works shall be protected against erosion by floods and rain.

Material shall not be spread on a layer that is so wet as to result in the danger of any damage being caused to the layer

during compaction of a subsequent layer, or when opened to traffic.

When material is spread out on the road, the Contractor shall ensure that, during wet periods, it will have a good cross-fall and a light compaction on the surface in order to facilitate run-off during rainy weather.

Materials or works that are damaged by wet weather due to the Contractor's work method shall be repaired or replaced as necessary at the Contractor's expense.

(e) Fill and Cut Slopes

Fill and cut slopes shall be repaired immediately whenever damaged by surface water. Where erosion occurs on high fills, the slopes shall be repaired by cutting back to form benches and by compacting the backfill mechanically to the specified densities, using suitable light equipment.

(f) Excavations

Excavations for pipe drains, culverts, service ducts and similar structures shall be adequately protected against the possible ingress of water during rainstorms.

(g) Completed Layer Work

All completed layer work shall be protected and maintained until the following layer is constructed. Maintenance shall include immediate repairs to any damage or defects which may occur and shall be repeated as often as may be necessary to keep the layer continuously intact and in good condition.

(h) Preparation of Layer Work

Before any completed layer is primed or a succeeding layer is constructed thereon, any damage to the existing layer shall be repaired, so that, after repair or reconstruction if necessary, it will conform in all respects to the requirements specified for that layer. All repair work other than minor surface damage repairs shall be submitted to the Engineer for inspection before it is covered up.

The previously constructed layer shall be thoroughly cleaned by the removal of all foreign material before construction of a succeeding layer or application of a prime coat, surfacing or surface treatment. In the case of all bituminous work in particular, the existing layer shall be thoroughly broomed and all dung, clay, mud and other deleterious material completely removed. Where necessary, the surface shall be sprayed with water before, during and after brooming to remove all foreign material.

Work performed as part of the above obligations shall not be measured and paid for separately, and the cost thereof shall be included in the rates bid for the various items of work requiring protection and the items for the Contractor's establishment on the site, as specified in SECTION 1300.

1217 FAULTY WORK, REMEDIAL WORK

(a) General

Any work which fails to comply with the Specifications shall be rejected and the Contractor shall, at their own expense, make good any defects, as directed by and to the satisfaction of the Engineer.

When any part of the Works or any equipment or material is found, upon examination by the Engineer, not to conform to the requirements or at any stage before final acceptance is damaged so that it no longer conforms to the requirements of the Specifications, the Engineer may order its complete removal and replacement, at the Contractor's expenses, with satisfactory work, equipment or material, or they may permit the Contractor to apply remedial measures in order to make good any such defects or damage. The actual remedial measures taken shall at all times be entirely at the Contractor's own initiative, risk and costs, but subject to the

Engineer's approval regarding the details thereof.

In particular, remedial measures shall ensure full compliance with the requirements of the Specifications of the final product, shall not endanger or damage any other part of the Works, and shall be carefully controlled and submitted to the Engineer for examination when completed or at any intermediate stage as may be required.

For the guidance of the Contractor, an indication is given below of what would normally be required in the more common cases of defects or damage, but the Engineer will in no way be bound to accept or approve the measures given below, as the actual remedial measures will be dictated by the circumstances of each particular case.

(b) Earthworks

- i) Where a cut slope has been over excavated or undercut or where the floor of a cutting has been taken too deep, backfilling and re-compaction shall be carried out as set out in Section 7400. All necessary measures shall be taken to drain away groundwater that may accumulate in back filled sections.
- ii) Excess width of fills shall be trimmed down if required by the Engineer.
- iii) Where erosion has damaged the surface of cuts or fills, the damage shall be made good by backfilling with suitable material and re-trimming. In more serious cases in the opinion of the Engineer, the slopes shall be cut back by benching, backfilled and compacted to the required standard of compaction with suitable light equipment and then re-trimmed, all in accordance with Section 7400.

(c) Stabilising

Any sections failing to meet the requirements specified or damaged to the extent that they require breaking-up and re-compaction will have to be re-stabilised with the type and quantity of stabilising agent ordered by the Engineer. The Engineer may also order that the layer be removed entirely and replaced with fresh material to be stabilised.

(d) Localized Defects in Pavement Layers

Where remedial measures are taken to make good Localised defects in Pavement Layers, the width of the area to be repaired by machines shall be such as will be necessary to accommodate the full width of the machines used, and it shall be of a reasonable length to ensure effective operation by the machinery. The depth to which material will have to be removed will depend on the type of material. Gravel will require breaking up to a depth of at least 75mm and crushed stone will usually require breaking up over its full depth. Asphalt material will normally require removal over its full depth.

(e) Concrete

Concrete work will normally require the cutting-back and complete removal of any weak or honey combed sections and making good by using special epoxy adhesives to bind fresh concrete to old concrete. Cracks, when permitted to remain, shall be injected with suitable epoxy compounds, and test cores shall then be drilled for testing the efficacy of the injection process.

1218 WATER

It is the Contractor's responsibility to provide clean and sufficient supply of fresh water for both construction purposes and also for all the houses, camps, offices, workshops, laboratories, workers etc.

In this respect the Contractor's attention is drawn to the Water Act Cap.152, including the Water Resources Regulations, the Water (Waste Discharge) Regulations, the Water Supply Regulations and the Sewerage Regulations, which the Contractor must comply with.

The construction water shall be clean, free from suspended solids and undesirable concentrations of deleterious salts and from any matter in quantities considered by the Engineer to be deleterious to the proposed work. The water shall be applied at the location, in the amounts, and during the hours, including nights, as directed by the Engineer.

The distributors used for watering shall be equipped with a spray bar and shall be of ample capacity and of such design as to ensure uniform application of water in the amounts directed by the Engineer.

Water supplied to the Resident Engineer's offices; laboratories and all houses and camps shall be drinkable to the satisfaction of the Medical Officer of the Area and the Engineer. The water for drinking and cooking purposes shall be filtered, boiled or treated as necessary for human consumption. All water sources used shall be approved by the Engineer.

The Contractor's attention is drawn to the fact that no separate payment will be made for the provision of water and the Contractor shall include in their rates and lump sum items for the provision of all water required in and for the Works.

Where in projects no perennial source of water is available and the quantity of water from source in the vicinity of the project road is insufficient, the Contractor may be required to drill water bore wells to fulfil the requirement. Prior to undertaking the activity, the Contractor is required to obtain all the necessary permissions from the concerned authorities and pay all necessary fees for acquiring such permits and shall make such acquired permits available to the Engineer promptly. At a later stage, as directed by the Engineer, the bore wells shall be handed over to the Employer, to serve as a source of water to the local community or for any other purpose as decided by the Employer along with the required infrastructure.

1219 AUTHORISED MEASUREMENTS AND TOLERANCES

The work specified in the various Sections of these Specifications shall comply with the various dimensional and other tolerances specified in each case. Where no tolerances are specified, the standard of workmanship shall be in accordance with normal good practice. No representation is made that the full specified tolerances will be available independently of each other, and the Contractor is cautioned that the liberal or full use of any one or more tolerances relating to other aspects of the Work may lead to its rejection. The latter would apply particularly in respect of level tolerances on layer work and the related requirements regarding layer thicknesses.

In the description of certain pay items, where it is stated that quantities will be determined from the authorised dimensions, this shall be taken to mean the dimensions as specified or shown on the Drawings, or, if changed, as finally instructed by the Engineer, without any allowance for tolerances being specified. If the work is therefore constructed in compliance with the authorised dimensions, plus or minus any tolerances allowed, quantities will be based on the authorised dimensions regardless of the actual dimensions to which the work is constructed.

Where the work is not constructed in accordance with the authorised dimensions, plus or minus any tolerances allowed, the Engineer may nevertheless, in their sole discretion, accept the work for payment. In such cases no payment will be made in respect of quantities of work or material in excess of those calculated from the authorised dimensions and where the actual dimensions are less than the authorised dimensions, minus any tolerance allowed. Quantities for payment shall be based on the actual dimensions as constructed.

1220 DRAWINGS PROVIDED BY THE CONTRACTOR

Where the Contractor is required to prepare any drawings for the purpose of this Contract, they shall be prepared as specified below and in accordance with any further requirements specified by the Engineer.

All drawings and charts to be supplied by the Contractor shall be in native format (.dwg, .plan, .mpp, .xlsx) along with a copy in Portable Document Format (PDF).

The Drawings shall be compiled in the English language and shall comply in all respects with the requirements of the Employer.

Accepted Drawings shall form an integral part of the Contract documents, and any drawing not accepted and signed will not be permitted on the site of the Works for construction purposes and/or used for the manufacture of any item. Notwithstanding the approval and/or acceptance and signing of the Drawings, the Contractor shall take full responsibility for all details, discrepancies, omissions, errors, etc, in respect of the said Drawings as well as for the consequences thereof.

The Contractor shall also supply to the Engineer as-built drawings of all the Works as executed, and submit them to the Engineer for review as to sizes, the referencing system, and other details.

The Contractor shall submit only fully complete Drawings in accordance with this specification and shall not be entitled to claim for delays resulting from the submission of incomplete drawings. The Engineer will require a period of four to eight weeks, depending on circumstances, for reviewing the complete drawings.

No direct payment for design, preparation and submission of Drawings will be made and all costs shall be included in the rates bid for the relevant pay items as provided in the Bill of Quantities. The cost of reviewing the design/drawings shall be for the Contractor's account.

1221 USE OF EXPLOSIVES

For handling of explosives and blasting, the Contractor shall employ only persons experienced in blasting and these persons must be in possession of an approved current blasting certificate and be able to demonstrate their experience to the satisfaction of the Engineer. The purchase, transport, storage and use of explosives shall be carried out in accordance with the most recent Explosive Ordinance and Rules issued by the Government of Uganda.

The Contractor shall appoint a responsible person or persons to order and receive explosives and to be responsible for all blasting activities.

The Contractor shall obtain all necessary permits and pay all necessary fees for the acquisition, storage and use of explosives and explosive devices. He shall submit full details in writing to the Engineer at least 24 hours in advance of blasting and obtain approval in writing for each occasion when he intends to use explosives. Such details, shall include, without limitation the date and time of the blast, the size of charge, method of firing, and protective measures to be adopted.

Notwithstanding the above such approval shall not relieve the Contractor from any of his liabilities or responsibilities to ensure that blasting operations are carried out in a safe manner and in full compliance with all relevant statutory obligations.

The Contractor shall use explosives for blasting in connection with the Works only at such times and places and in such a manner as the Engineer may approve but such approval shall not relieve the Contractor from their

responsibilities for injury, loss, inconvenience and annoyance to persons, damage to the work and adjoining structures, roads, places and things, and injury or damage to animals and property consequent to the use of such explosives. The Contractor shall be entirely liable for any accident which may occur and shall hold the Employer and the Engineer harmless and indemnified from all claims arising therefrom. Where loss, inconvenience, injury or accident is likely to be caused to persons, animals, works, property, places and things, the Engineer shall have the power to regulate or prohibit blasting and in the event of such regulations or prohibition the Contractor shall have no claims against the Employer.

Contractor will be permitted to use explosives for breaking up rock and hard materials during excavation, for demolishing existing structures, and for such other purposes for which it may normally be required, on the approval of the Engineer and subject to the following conditions:

- The Engineer will have the right to prohibit the use of explosives in cases where, in their opinion, the risk of injury to persons or damage to property or adjoining structures is too high. Such action by the Engineer shall not entitle the Contractor to any additional payment for having to resort to other less economical methods of demolition unless otherwise provided in the Special Specifications or the Bill of Quantities.
- The provisions of Section 3400 shall be complied with:-
- Legal provisions in regard to the use of explosives and the requirements of the Inspector of Explosives or equivalent shall be strictly complied with.
- The Contractor shall, at their own cost, make arrangements for supplying, transporting, storing and using explosives.
- Before any blasting is undertaken, the Contractor together with the Engineer, shall examine and measure up any buildings, houses or structures in the vicinity of the proposed blasting and establish and record, together with the Owner thereof, the extent of any cracks or damage that may exist before blasting operations are commenced. It shall be the responsibility of the Contractor to make good at his own expense, any further damage to such houses, buildings or structures which results from the blasting operations.
- Where there is danger of damage to power or telephone lines or underground or other services or any other property, the Contractor shall suitably adapt their method of blasting and the size of the charges, and shall take adequate protective measures, such as cover blasting, in order to limit the risk of damage as far as possible.
- The Engineer shall, twenty-four hours before each blasting operation is carried out, be advised thereof, in writing, unless otherwise agreed on by the Engineer.
- The public shall also be notified within twenty-four hours before each blasting operation is carried out and if required temporarily relocate affected persons;
- No explosives of any kind shall be used by the Contractor without the prior consent of the Engineer in writing. The Contractor shall purchase and import their own explosives for use in connection with the Works and shall comply with all relevant ordinances, instructions and regulations which the Employer, or other person or persons having due authority, may issue from time to time regarding the handling, transportation, storage and use of explosives.

- The Contractor shall comply with the Statutory Regulations in force in Uganda regarding the use and storage of explosives.
- Before commencing demolition work on any unit, the Contractor shall ensure that all affected public utilities have been disconnected as directed by the Engineer and any necessary temporary arrangements made. Any material or equipment required by the Employer shall be transferred to their own store and the remaining debris shall become the property of the Contractor who shall dispose of it from the Site.
- The Contractor shall at all times when engaged in blasting operations post sufficient warning flags and other measures to the full satisfaction of the Engineer.
- The people likely to be affected by the blasting shall be informed in advance and no such blasting should be carried out at night.
- Special care to be taken near pipelines especially those conveying oil and sewage because of risk of contamination in case of damage.

The Contractor shall store explosives and detonators in separate secured locations and in accordance with statutory requirements and as approved by the Engineer.

The Contractor shall provide a properly equipped secure vehicle, which shall be maintained in good condition, for the transportation of explosives. Explosives and detonators shall not be transported at the same time in the same vehicle.

The Contractor shall provide an approved system of warning the public (including road traffic) and all site personnel of an impending blast by both audible and visible means and shall ensure that the blasting area (area at risk to personnel) is cleared of all personnel prior to blasting.

Warning blank detonations shall be used to scare away any wildlife. These shall consist of two warning detonations. The first shall be given five minutes prior to the blast; the second shall be given 20 seconds prior to the blast.

The Contractor shall take all necessary measures to protect personnel and property and to prevent any fragments due to blasts from being projected in a dangerous manner. The Contractor shall not commence blasting before:

- Accurately determining the bounds of the blast area,
- Providing effective access controls to risk areas,
- Providing adequate blasting shelters and
- Putting in place an efficient communications mechanism.

If blasting is to be carried out in the vicinity of overhead electrical power cables the Contractor shall check for stray electric currents at the blasting site prior to commencing charging. If blasting is to be carried out at locations which are likely to cause damage to structures and properties in the vicinity, controlled blasting measures as approved by the Engineer shall be adopted.

The Contractor shall keep a current inventory of all explosives and explosive devices obtained and used and shall submit a monthly report to the Engineer, detailing the usage and current holding of all explosives and explosive devices by date and location.

Records must be kept by the Contractor of all drilling and blasting operations showing whole diameters, drilling pattern, explosive charge and type per hole, detonator delay times and total charge per blast. These records must be submitted to the Engineer on completion of charging. Care shall be taken that no unexploded cartridges remain in the

excavation. Careless or indiscriminate use of explosives will result in the Engineer withdrawing permission for their use and under such circumstances the Contractor shall resort to other methods of excavation.

When forming final cut faces, pre-splitting blasting techniques shall be carried out to ensure that blasting damage to the cut face is minimized. Details of the pre-splitting techniques to be used shall be notified to and approved by the Engineer in advance of the blasting operation.

Care shall be taken during all blasting operations to ensure that stability of adjacent cutting slopes and natural hillsides is not in any way impaired. Particular care in this respect shall be taken if blasting operations take place during the rainy season.

1222 WORK ON, OVER, UNDER OR ADJACENT TO RAILWAY LINES

All work carried out on, over, under or adjacent to railway lines shall be carried out strictly in accordance with the latest edition of the Specifications of the Uganda Railways Corporation, a copy of which will normally be included in the Special Specifications or where the copy included in the Special Specifications is amended or superseded by another, the Contractor shall obtain the latest edition, which shall be kept on the site before any work of this nature is commenced.

Attention is drawn particularly to the requirements contained in the Specifications regarding the approval that must be obtained from the Uganda Railways Corporation for a work permit or occupation of its property and the approval of falsework and formwork plans.

1223 THE HANDING OVER OF THE SITE

The Site will be handed over to the Contractor for construction, subject to such conditions as may be specified in the Special Specifications regarding matters such as the sequence in which sections will be handed over and must be completed, the maximum total length of bypasses that will be allowed to be in operation at any time and any other matters relating to the Contractor's use and occupation of the Site.

1224 HAUL ROADS

The Contractor shall submit to the Engineer for approval full details of any haul construction roads they propose to build. Such details shall be submitted well in advance in order to afford the Engineer sufficient time to investigate their implications. Haul roads may not be built without the Engineer's prior approval, and shall be kept to a minimum, particularly in areas where their impact on the environment may be serious.

- The Contractor shall have the right to use public roads, including bypasses open to public traffic, but where his own traffic causes damage or wear to such roads or constitutes a condition hazardous to public traffic, the Engineer shall have the right to regulate the Contractor's traffic over such public roads and bypasses.
- Cost of Construction of haul and/or construction roads for accommodating construction traffic, shall be accounted for in the Contractor's rates for other items.
- Maintenance, including gravel wearing-course and watering bypasses, haul and/or construction roads (including public roads and bypasses open to public traffic that are approved for use as haul roads), would be responsibility of the Contractor and shall be accounted for in Contractor's rates for other items.

- When community roads are used as haul roads, the Contractor, in addition to maintaining the roads, shall ensure control of dust including by watering/wetting and observing speed limits recommended by the Engineer.
- Where regulation of the Contractor's traffic does not alleviate the traffic hazard satisfactorily or the maintenance of the bypasses cannot be or is not properly executed, the Contractor shall, where conditions permit, divert his traffic over construction roads provided and maintained at his own cost.

1225 MEASUREMENT OF DEPTH OF TRENCHES AND FOUNDATION EXCAVATIONS

Where trenches or foundation excavations are required below the level of mass excavations for the road prism, the depth of excavation of the trenches or foundation shall be measured from ground level after completion of the mass excavation, unless the Engineer is satisfied that the excavation of the trenches or foundation from the original ground level or any lower level was unavoidable. The Contractor shall ensure that they obtain such instructions in good time and, where required, shall submit proposals to the Engineer for approval.

1226 ACCESS TO CONTRACTOR'S RECORDS, MONTHLY SITE MEETINGS AND PROGRESS PHOTOGRAPHS

The Engineer shall at all times have full access to all files, drawings, documents, records and whatsoever in connection with the execution of the Works.

The Contractor or their authorised representative shall attend monthly meetings on the site with representatives of the Employer and Engineer, at dates and times to be determined by the Employer. Such meetings will be held for evaluating the progress of the Contract and for discussing matters pertaining to the Contract which any of the parties represented may wish to raise.

Such meetings are not intended for discussing matters concerning the normal day-to-day running of the contract. In addition to the meetings mentioned above, the Contractor or his Authorised Representative shall attend monthly meetings, on the site, with the representative of the Engineer, at the dates and times to be determined by the Engineer. Such meetings will be held to discuss matters of a more technical nature, or any such matter which any of the parties may wish to raise.

The Contractor and Engineer shall jointly make photographic and other records of the surfaces and condition of the Site as agreed by the Engineer immediately prior to entering the Site for the purpose of constructing the Works. The records must include all work sites including borrow pits, quarries, campsites, water sources etc. The Contractor shall send a signed colour hard copy of these records to the Engineer under their letterhead along with a digital copy of the records on an external hard drive or similar. The records shall also be uploaded to the online project management system if created for the project.

After Commencement of the Works the Contractor shall take monthly progress photographs for the duration of the Contract, as agreed with the Engineer. These shall be in an approved digital format and shall be forwarded to the Engineer on an external hard drive or similar.

All photographs provided by the Contractor shall be labelled in a manner approved by the Engineer with the following data:

- Project name and reference number;
- Date of exposure (automatically recorded on the photograph); and

- Photograph identification number, brief description, chainage, location and direction of view.

The Contractor shall also provide and maintain digital cameras, complete with charging facilities, approved software for labelling/cataloguing recorded photographs and an external hard drive or similar for preparing back-up records, for the use of the Engineer for the duration of the contract.

The progress photographs referred to shall be taken by a digital camera and as agreed with the Engineer or as specified in the Contract. The Employer shall hold the copyright of all these photographs which shall not be used for any other purpose without the approval of the Employer.

No separate measurement or payment shall be made in respect of compliance with the provisions of this Section of the Specification.

The Contractor shall be deemed to have made allowance for such compliance with these provisions in the preparation of his prices for items of work included in the Bills of Quantities and full compensation for such compliance will be deemed to be covered by them.

1227 LEGAL PROVISIONS

The Contractor shall keep themselves fully conversant with the latest enactments, provisions and regulations of all legislative and statutory bodies and in all respects and at all times shall comply with such enactments, provisions and regulations in regard to executing the Contract.

1228 FINAL CLEARANCE

Upon completion of each section of the Works, Contractor shall clean-up the Site, remove all temporary buildings, plant and debris. They shall level off and fine grade all excavated material, which is surplus to requirements. The whole of the site shall be left in a clean and workmanlike condition to the satisfaction of the Engineer. No separate payment shall be made for any work included in the paragraph and the costs shall be deemed to be included in the rates of the relevant items entered in the Bill of Quantities.

1229 RECORDING OF INFORMATION RELATING TO CLAIMS FOR ADDITIONAL COMPENSATION OR EXTENSION OF TIME

Should any circumstances arise or order be given by the Engineer which the Contractor considers may fairly entitle him to additional compensation, or extension of time for completion of the Contract, then the Contractor shall at the earliest practicable opportunity inform the Engineer of these circumstances so that he may have the opportunity to investigate the circumstances and take such action as he considers desirable in order to reduce possible costs to the Employer. The Contractor shall at the same time inform the Engineer of his intention either to claim additional compensation or extension of time, or to reserve his right to claim at a later stage. The Contractor shall also state on which clause or clauses of the Conditions of Contract; the Special Specifications or other parts of the Contract Documents his claim is based.

In order that the extent and validity of such claims may be properly assessed when they are submitted at a later date, all circumstances relating to claims must be investigated, recorded and agreed upon as far as possible between the Contractor and the Engineer as and when they occur. For this purpose, the Contractor shall furnish the Engineer from day to day with records, in a form approved by the Engineer, of all the facts and circumstances that the Contractor considers relevant and may wish to rely upon in support of his claims. The Engineer may in turn record such other facts and circumstances as he considers relevant and the Contractor shall for this purpose, supply him with all the

information that he may require in this respect.

The Engineer and the Contractor shall at the time of recording, indicate in writing and by signature, their agreement or disagreement as to the correctness of the information recorded. Additional compensation shall for the purposes of this Clause be taken to mean compensation over and above the payments at unit rates and prices bid or agreed upon for work ordered by the Engineer.

1230 EXTENSION OF TIME ARISING FROM ABNORMAL RAINFALL

Extension of time as provided in the General Conditions of Contract arising from abnormal rainfall shall be calculated separately for each calendar month or part thereof in accordance with the formula given below. It shall be calculated for the whole period for completion of the Contract including any extensions thereof:

$$V = (N_w - N_n) + \frac{(R_w - R_n)}{x}$$

If V is negative and its absolute value exceeds N_n the V shall be taken as equal to minus N_n .

The symbols shall have the following meanings:

V = Extension of time in calendar days in respect of the calendar month under consideration.

N_w = Actual number of days during the calendar months upon each of which a rainfall of y mm or above has been recorded by the Meteorological Department of the Ministry of Water, Lands and Environment, at the station closest to the Site, or from a source agreed to in writing by the Engineer

R_w = Actual rainfall in mm for the calendar month under consideration obtained from the Meteorological Department of the Ministry of Water, Lands and Environment, or from a source agreed to in writing by the Engineer.

N_n = Average number of days, as derived from the existing rainfall records of the Department of Meteorology provided in the Special Specifications, or as agreed to, in writing by the Engineer, on which a rainfall of Y mm or more has been recorded for the calendar month.

R_n = Average rainfall in mm for the calendar month, as derived from the rainfall records of the Department of Meteorology provided in the Special Specifications, or as agreed to, in writing, by the Engineer.

x = 20 unless otherwise provided in the Special Specifications.

Y = 10 unless otherwise provided in the Special Specifications.

The total delay that will be taken into account for the determination of the extension of time for the contract shall be the algebraic sum of the monthly totals for the period under consideration. But if the grand total is negative, the time for completion shall not be reduced.

Extensions of time for part of a month shall be calculated using pro rata values of N_n and R_n . The total extension of time for any calendar month shall not exceed $(N_c - N_n)$ calendar days, where N_c = number of days in the month under consideration on which work may be executed in accordance with the provisions of the Conditions of Contract and/or Specifications.

The factor $(N_w - N_n)$ shall be considered to represent a fair allowance for variations from the average number of days during which rainfall exceeds Y mm.

The factor $(R_w - R_n)/x$ shall be considered to represent a fair

allowance for variations from the average in the number of days during which rainfall does not exceed Y mm but wet conditions prevented or disrupted work.

The Contractor shall allow in their Programme for the number of Rain days above 10 mm (N_n) for each calendar month

The Contractor shall erect rain gauges, one at each principal area of the road where work is in progress and as approved by the Engineer. Rain gauges shall be jointly read, and rainfall data recorded, by representatives of the Contractor and the Engineer, at 08:00hrs each morning. Extension of time shall be based on rainfall recorded by the gauge nearest to the area where work is in progress. Where work is being undertaken adjacent to more than one weather station/rain gauge, the extension of time due to rainfall shall be the average of the extensions calculated from records for each rain gauge station.

In determining extension of time, the Engineer may, at his discretion, take into consideration rainfall data supplied by the Department of Meteorological Services from the weather station nearest to the site.

It must be noted that the extension of time resulting from abnormal rainfall shall not be regarded as an event for which additional compensation can be claimed. This means that no additional payments, whatsoever, will be made, including no additional payments under time-related obligations, regardless of the length for which the contract period may be extended due to abnormal rainfall

If no suitable rainfall records are available, the above formula will not apply, and rain gauges shall be installed by the Meteorological Department at locations approved by the Engineer. These shall include all sections where the Contractor is working including Borrow Pits. All readings shall be taken by the Meteorological Department and agreed jointly with the Engineer on a daily basis.

As soon as is practicable after the end of each month, the Contractor shall collect daily records for that month and shall calculate V for that month, as specified. The records and calculations shall be submitted to the Engineer without undue delay.

1231 ELECTRICITY SUPPLY

The Contractor shall provide and maintain at their own expense their own electricity supply. This supply must be adequate to supply the area set aside for the housing of their staff and for their own and the Engineer's office, site laboratory as well as for the housing of the Engineer's staff.

The Contractor shall provide and maintain all necessary temporary power and lighting and all associated apparatus for the duration of the Contract at their own expense. They must make allowances for the use of the said supplies and equipment by all sub-contractors.

Once equipment becomes redundant and having received the approval from the Engineer, the Contractor shall disconnect and remove said equipment and make good any works disturbed at their own expense.

1232 POSITION OF WORKS

The Works are shown on the Drawings, but the precise positions, lines and directions of all the Works are not necessarily indicated and will be determined by the Engineer as the Contract proceeds.

1233 ACCESS TO SITE

The Contractor shall make their own arrangements for access to the various parts of the Site where works are to be constructed but all such accesses shall be subject to the approval of the Engineer.

Where the access to the Site proposed to be used by the Contractor lies across the land of any third party, the Contractor shall produce to the Engineer the written consent of the owner and the occupier of the land over which the access lies before making use of the same.

The Contractor shall also make a record to be agreed by the Engineer of the conditions of the surfaces of any land (and of any crops on such land) over which access lies before they use it for access purposes and they shall keep all such surfaces in a reasonable state of repair during the execution of the Works. On the termination of the Contractor's use of such access they shall restore the lands to a condition at least equal to that existing before their first entry on them.

1234 COOPERATION AT SITE

All work shall be carried out in such a way as to allow access and afford all reasonable facilities for any other Contractor and their workforce and for all the workforce of the Employer and any other person who may be employed in the execution and/or operation at or near the Site of any work in connection with the Contract or otherwise.

The Contractor shall use their best endeavours to cooperate with such persons without interfering with them and shall observe all the instructions and orders of the Engineer in that connection.

In the preparation of their programme of work the Contractor shall at all times take full account of and coordinate with the programming of work of other contractors.

1235 ROADS AND SITE TO BE KEPT TIDY

The Contractor shall take all necessary care and precautions to ensure that the existing roads and thoroughfares including the project road and the site access roads used by them either for the construction of the works or transportation of equipment, labour and materials are kept in good repair and conditions and not damaged or made untidy as a result of such construction or transport to and from the site. In addition, other existing roads, which may be affected indirectly by the diverted traffic due to the Contractor's works, shall be maintained by the Contractor according to the instructions of the Engineer. In the event of their becoming thus damaged and dirtied in the opinion of the Engineer, the Contractor shall immediately take all necessary steps to rectify as required by the Engineer.

Maintenance of the existing road shall be the Contractor's obligation, unless otherwise stated in the Conditions of the Contract. Such maintenance obligation applies to those areas of the existing road where the Contractor has not completed permanent works and are to be maintained by the Contractor and/or as instructed by the Engineer and kept to the standard specified, throughout the duration of the contract. The Engineer shall, at the commencement of the contract, take pertinent photos and a video of the whole road which will be used as a reference for the condition of the road and drainage on contract award. The Contractor will be given the opportunity to accompany the Engineer when he takes the photos/video and he will receive a copy of the photographic record from the Engineer.

Regarding payments to the Contractor, the following shall apply:

- In the case of a gravel road, as specified in the bill of quantities, for which the Contractor carries out a grading operation on the existing carriageway, restore the shape of the road or to effect necessary repairs to allow safe passage of all vehicles at a minimum speed as given in the Special Specifications: The Contractor shall be paid for such grading operations on a Km basis after the works are completed in all respect to the satisfaction of the Engineer.

- In the case of a paved road, as specified in the bill of quantities, the Contractor carries out necessary maintenance on the existing carriageway to restore the road to its original condition or to effect necessary repairs to allow safe passage of all vehicles at a minimum speed as given in the Special Specifications. The Contractor shall be paid for such maintenance operations on a Km basis after the works are completed in all respects to the satisfaction of the Engineer.

The continued failure or refusal by the Contractor to maintain the existing road at the proper time, or to take the necessary precautions for the safety and convenience of public traffic as required by statutory authorities or as instructed by the Engineer, shall be sufficient cause for the suspension of a portion of the Works as determined by the Engineer until all provisions prescribed have been complied with to the satisfaction of the Engineer.

The Contractor shall comply strictly with all specifications for maintenance of the existing road in this clause. The Employer shall deduct as a penalty an amount as given in the Special Specifications per day for each kilometre of non-compliance from monies due in the next interim payment certificate until the non-compliance(s) is corrected.

The imposition of the above penalty will not preclude the Engineer from stopping the works until the matter is rectified should the Contractor continuously disregard his instructions, or should he feel the situation warrants this measure for safety reasons. Should the Engineer stop the works for any reason related to non-compliance with the Specifications on accommodation of traffic or maintenance of the existing project road, there shall be no compensation for any costs incurred by the Contractor as a result of such stoppage, nor shall there be any extension of time granted as a result.

1236 SECURITY OF THE WORKS

Security of the Works shall be provided by the Contractor at their own expense. If the Engineer considers it necessary, they will order in writing that additional watchman be provided, all at the Contractor's expense.

1237 SAFETY

The Contractor shall immediately notify the Engineer of any accident, on or off the site, in which the Contractor is directly involved and which results in injury to any person, whether associated with the site or a third party. Initial notification may be given verbally, but a detailed written report must follow within 24 hours of the accident.

Photographs of each accident shall also be included in the aforesaid report. The Engineer has the right to conduct any or all enquiries, either on Site or elsewhere, as to the causes and consequences of any such accident.

The Contractor shall maintain a register of all accidents and injuries on the worksite (road, offices, yard, workshop, borrow pits, quarries, etc.). A general summary of all records shall be attached to his monthly report.

Unless otherwise specified in the Contract, a Safety Officer shall be provided by the Contractor as per the requirements of CLAUSE 1502 (j) of the General specifications. Besides the requirements of fulfilling Contractor's obligations under 'Accommodation of Traffic' given under CLAUSE 1502 (j), responsibilities of the safety officer shall include complying with all requirements as stated under this CLAUSE.

Transportation of any material by the Contractor shall be in suitable vehicles which when loaded does not cause spillage and all loads shall be suitably secured. Any vehicle that does not comply with this requirement or any of the local traffic regulations and laws shall be removed from the Site.

Arrangement shall be made with the appropriate Authority before entering in or working on existing and associated works.

1238 METHOD OF WORKING

The method of working to be adopted shall be such as to permit the satisfactory completion of the Works and to limit disturbance and damage to a minimum. Constructional equipment used in the execution of the Works shall be of a design and be used in a manner approved by the Engineer.

The Engineer may at any time withdraw their approval and Contractor shall immediately adopt another method of working. The Contractor shall have no claim against the Employer for costs incurred by them in changing the method of working or in the provision and use of other equipment.

1239 DISPUTE REVIEW BOARD

In accordance with the provision of the General Conditions of Contract, the Conditions of Particular Application and any such related sub-Clauses, and/or any Annexure concerning the Disputes Review Board's rules and procedures contained in the Contract, the Contractor shall make all payments to Dispute Board Members within the specified number of days from receipt of the Members' invoices.

The Contractor shall thereafter submit such invoices to the Engineer and include one-half of the amounts of such invoices in his monthly statement submitted in accordance with the relevant provision ITEM 12.04 of the General Conditions of Contract.

The Employer shall pay such Contractor's invoices within the time stipulated in the Contract for other payments to the Contractor by the Employer.

1240 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
12.03 MAINTENANCE OF EXISTING ROAD	
(a) CONTRACTOR TO MAINTAIN EXISTING ROAD	MONTH
(b) ADDITIONAL GRADING OF EXISTING ROAD AS INSTRUCTED BY THE ENGINEER	KILOMETRE (Km)

The monthly payment shall be for the Contractor to maintain the existing road and all drainage in accordance with the Engineer's instructions in order to restore and retain the road to a condition that existed prior to contract commencement or as improved by the additional grading at the commencement of Contract as described below.

Should the Engineer instruct that additional grading is necessary to achieve an acceptable road condition at the commencement of the Contract, the Contractor will be paid per kilometre as ITEM 12.03 (b) above.

Additional grading includes shaping the existing gravel road, bringing loose material back to the road from the slopes and ditches if instructed by the Engineer; shaping by motor grader or equivalent equipment approved by the Engineer, watering and compacting the material. There shall be no potholes and the surface shall be such as to allow light vehicles to travel at a nominal speed as specified in the Contract or as directed by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
12.04 DISPUTES REVIEW BOARD	
(a) PAYMENT FOR THE EMPLOYER'S SHARE OF THE COST OF THE DISPUTES REVIEW BOARD	PROVISIONAL SUM
(b) CONTRACTOR'S OVERHEADS AND PROFIT AS A PERCENTAGE OF SUB-ITEM 12.04 (a)	PERCENT (%)

The Provisional Sum shall be made only on the instruction of the Engineer for the reimbursement of the net cost of compensating the Dispute Board (DB) Members for the Employer's portion of the payment in accordance with the General Conditions of Dispute Adjudication Agreement. The percentage inserted by the Contractor shall be for overheads and profit. The percentage of such overheads and profit should be kept to a maximum (not more than 10%).

SERIES: 1000 GENERAL

SECTION 1300: CONTRACTOR'S ESTABLISHMENT ON SITE AND GENERAL OBLIGATIONS

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1301 SCOPE

This Section covers the establishment of the Contractor's organisation, camp and constructional equipment on the Site and their removal on completion of the Contract. It also covers payment for certain general obligations, risk and liabilities and general items of cost not covered elsewhere.

1302 GENERAL REQUIREMENTS

The Contractor shall in his establishment on site comply with all relevant requirements of SECTIONS 1700 AND 1800.

(a) Camps, Constructional Equipment and Testing Facilities

The Contractor shall establish their construction camps, offices, stores, workshops and testing facilities on the Site. The exact location of these facilities shall be approved beforehand by the Engineer. Accommodation, ablution and other facilities for site staff shall also be provided as required and the standard of accommodation and the location of all facilities shall comply with the requirements of the authorities concerned and those of the Engineer.

The requirements specified in CLAUSES 1703 AND 1705 concerning preservation of landscape and trees shall be complied with when selecting sites for construction camps, offices, stores, workshops etc. This implies that it is undesirable to locate such facilities in woodland and forest areas requiring the felling of trees with a diameter of more than 0.25 metre in a height of 1.0 m above ground level.

Before choosing the sites for work camps it shall be ensured that waste and sewage cannot pollute the local water resources for instance by placing the work camps away from human habitation. Preferably work camps should be located more than 500 metres from larger water courses. According to Ugandan law it is not permitted to build anything closer than 200 meters from rivers.

Adequate potable water supplies must be guaranteed by the Contractor to all personnel working on the Works and to the local people if their access to water is hindered by the Works.

Prior to starting with construction, the Contractor shall move all constructional equipment and personnel to the Site. On completion of the work and after receiving approval in writing from the Engineer, all constructional plant, buildings, fencing and other temporary structures shall be removed and the camp site shall be restored to its original condition and left neat and tidy.

In addition to the construction equipment required by the Contractor to carry out the Works, he shall provide a weighbridge at each quarry site prior to stone being transported from that quarry for inclusion in the Works. Each weighbridge shall be capable of weighing trucks to an accuracy of +2% and it shall provide a printed output with

lorry number and weight; the printouts being handed to the Engineer at the end of each day. Printouts for rock being dumped in pioneer layers and swamps shall be handed to the Engineer's staff on site at the time of dumping.

In addition to any other requirements, and to the satisfaction of the Engineer, the Contractor shall:

- Provide an adequate potable water supply both for drinking and sanitary use in the camps and work sites to World Health Organisation (WHO) standards;
- Provide adequate fire-fighting facilities/fire extinguishers at each block in the camps and periodically maintain as per the requirements of the supplier's standard procedures;
- Confine all liquid waste and solid waste to a suitably designed and constructed storage facility (such as septic tanks, pit-latrines, containers for garbage wastes) until removed from the site. The liquid waste generated in the camps will be conveyed to a designated treatment site or treated on site prior to discharge into the environment;
- Ensure the safe and effective disposal of sewage from the camp sites and treatment of latrines;
- Ensure the safe and effective disposal of waste and garbage. Oils and greases shall be recycled or disposed of by burning and solid waste shall be disposed of by burning or by burial. Under no circumstances will disposal on the surface or to water courses be tolerated;
- Provide all project personnel with suitable prophylactics for the prevention of STD and HIV/AIDS, and diseases associated with insects and pests;
- Establish reasonably equipped and staffed health clinics at each camp depending on the number of workers accommodated at each site and as required by the Particular Specifications;
- Employ only qualified drivers and operators; provide refresher training; ensure careful and responsible driving and operation; apply speed limits in settlements, on open roads and through construction areas. Violation of speed limits and driver safety shall render the operator or driver subject to dismissal;
- Liaison and regular consultation with the affected local communities in order to promote good community relations, including the establishment of a Project Liaison Committee (PLC);
- Ensure that the servicing and repair of all plant and vehicles, whether hired by the Contractor, or owned by him, is carried out in his site compound and not on the Works Site;
- Submit proposals to the Engineer for approval and subsequent recommendation to the Employer for the location of temporary diversions, access roads, haulage roads, camps and borrow pits;
- Ensure that all quarries and borrow pits shall be trimmed and drained to the approval of the Engineer to ensure that no ponding of water remains.

On completion of construction, the Contractor shall be responsible for the complete reinstatement, at his own cost, of all property that he has occupied, used, damaged or destroyed during the course of the contract. The Contractor shall also dismantle and remove the camp, laboratory and workshop and reinstate these areas to the approval of the Engineer.

Any tree removal activities for camp sites shall be undertaken on the approval of the Engineer in collaboration with the local Forestry Department. Before removing any

tree, the Contractor shall survey the number, size and types of trees/bushes to be removed. In consultation with the Engineer and local Forestry Department, the Contractor shall plant replacement trees and additional trees during site establishment and at appropriate locations during reinstatement.

All camp sites shall be established with appropriate and standard sanitation facilities including lined septic tanks to reduce possible pollution impact on ground and surface water resources. The Contractor shall dispose of all waste from the camp in designated or authorised places and shall take all necessary measures and precautions to avoid any nuisance or disturbance to inhabitants arising from establishment, operations and reinstatement of the camp work sites.

(b) Building Regulations

All buildings erected by the Contractor upon the site and camp site or sites and the layout of the buildings and the sites shall comply with the Laws of Uganda and all Bye-Laws insofar as they are applicable.

(c) Sign Boards

The Contractor shall provide and erect a sign board at each of the main entrances to the Site and at the site camp, as part of his obligations under SECTION 1300, and on approved locations, where directed by the Engineer. Sign boards shall be of sound, weatherproof construction, painted by an approved firm of sign writers in accordance with the description as per specification or as directed by the engineer. The boards, with suitable inscription, shall include the name of the Project, the name of the Employer, the name of the Financing Institution, the name of the Consultant and the name of the Contractor etc. The boards of approx. 3.30 m x 3.20 m size, shall be approved by the Engineer, before erection.

Suitable inscription shall include the logos of the respective entities, and both text and logo shall be in colours to be approved by the Engineer.

(d) Maintenance During Construction

During construction the Contractor's camps, staff living quarters and other facilities shall be maintained in a neat and tidy condition.

(e) Legal and Contractual Requirements and Responsibility to the Public

The Contractor shall take all the necessary steps to comply with the Conditions of Contract, particularly in respect of the insurances and sureties required and their general obligations to the public and the Employer. They shall comply with all the regulations of statutory bodies.

(f) Liaison with Government and Police Officials

The Contractor shall keep in close contact with the Police and other Government officials of the area regarding their requirements in the control of traffic and other matters and shall provide all assistance or facilities which may be required by such officials in the execution of their duties.

Prior to the establishment of the camp and other facilities, the Contractor shall in consultation with the Engineer and Road Authority, consult with local authorities, administrative offices and representatives of local communities on the possible future utilisation of such camp facilities for the local community(ies). If agreed, the Contractor shall prepare a confirmation letter regarding the future hand-over conditions of such facilities to the local community(ies). A copy of the letter shall be attached to the monthly progress report for record purposes.

(g) Electricity Supply

The Contractor shall provide and maintain his own electrical

supply. This supply must be adequate to supply the areas set aside for the housing and offices of his own staff and those of the Engineer and his staff.

The Contractor shall provide and maintain all necessary temporary power and lighting and all associated equipment for the duration of the Contract.

Once equipment becomes redundant, and with the approval of the Engineer, the Contractor shall disconnect and remove said equipment and make good any affected areas.

(h) Laboratory

If required under the Special Specifications, the Contractor may be required to establish a site laboratory:

i) General

The Contractor shall provide, erect and maintain for the duration of the contract, a laboratory on site for his exclusive use, in order for him to undertake all necessary tests as described in the specifications.

ii) Access to the Contractor's Laboratory by the Engineer

The Engineer shall have full and continuous access to the Contractor's laboratory as necessary for reviewing and monitoring the tests undertaken for the works.

1303 CONTRACTOR'S OFFICES, STORES, WORKSHOPS, CAMPS, ETC

(a) General

It is entirely the Contractor's own responsibility to obtain land or make whatever arrangements with landowners or legal occupiers regarding use of land for the purpose of erecting their offices, stores, workshops, garages, stockpiling of materials, camps and quarters for housing of labour and staff, welfare facilities, etc. and all costs incurred in connection with obtaining, lease or rental of such land shall be at the Contractor's expense.

Offices for the Contractor's supervisory staff and administration, stores, workshop, camps etc. shall be erected by the Contractor at their own expense at a location to be agreed upon with the Engineer.

Before giving such approval, the Engineer will give particular attention to the temporary and permanent effects of the proposed activities on the drainage of the area and the Contractor's proposals for reinstatement.

(b) Contractor's Offices, Stores and Workshops

The Contractor shall provide and maintain at an approved location a suitable main office together with such site offices as may be necessary for the efficient control of the Works. They shall also provide and maintain on approved sites sufficient suitable stores, tanks and workshops for the proper storage of materials, fuel, plant and equipment and the efficient maintenance of all such equipment.

The stores shall be of such size and construction as to provide adequate storage and protection for stocks of materials, fuel, spares and the like in quantities ensuring uninterrupted progress of the work and the workshops shall be suitably equipped for carrying out major repairs, overhaul or modification by the Contractor of all plant and equipment in or on the Works and other work connected with the permanent work.

(c) Contractor's Quarters and Camps

The Contractor shall provide, erect, maintain and clear away on completion all quarters and camps for staff and labour necessary for the efficient control and execution of the Works. Suitable, sufficient and properly equipped messing, cooking and sanitary accommodation, an adequate supply of clean water, proper disposal of refuse and sewerage and

sufficient labour in attendance shall be provided. The Contractor shall be responsible for meeting the requirements of the local authorities, labour officers and other officers regarding the camp accommodation, sanitation and messing of all workforces and provide the staff necessary for proper control and supervision.

All sites selected by the Contractor for the erection of offices, stores, workshops, quarters, camps and the like are subject to the prior approval of the Engineer. The Contractor shall, by notice in writing, indicate their requirements for sites well in advance in order that the Engineer and the local administration may consult local interests.

(d) First Aid

The Contractor shall provide, equip and maintain adequate first-aid stations throughout the Works, and erect conspicuous notice boards directing where these are situated and provide all requisite transport. The Contractor shall comply with the government medical or labour requirements at all times and provide, equip and maintain base dressing stations where directed and at all times have experienced first-aid personnel and dressers available throughout the Works for attending to minor injuries.

(e) Measurement and payment

Compliance with the requirements, performance of all work, furnishing of all equipment, materials, including water, labour, tools and incidentals necessary to complete the work prescribed in this Clause shall not be measured for direct payment but shall be considered as a subsidiary obligation of the Contractor, covered under the prices quoted for other contract items.

1304 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
13.01 CONTRACTOR'S PRELIMINARY AND GENERAL OBLIGATIONS:	
(a) FIXED OBLIGATIONS	LUMP SUM
(b) TIME RELATED OBLIGATIONS	MONTH

Payment of the lump sums tendered under SUB-ITEMS 13.01 (a) and (b) shall, for the two sub items together include full compensation for all the Contractor's charges in respect of the following Items, collectively termed the 'Contractor's General Obligations':

- i) Complying with the requirements of the Conditions of Contract and SECTION 1200 of the Specifications, including the effecting of insurances and providing the sureties required;
- ii) Setting up and maintaining their organisation, camps, accommodation and construction plant on the site and their removal on completion of the Contract.

The lump sum tendered under SUB-ITEM 13.01 (a) above shall represent full compensation for the fixed part of the Contractor's general obligations (i.e. that part which is substantially fixed and is not a function of the time required for the completion of the Contract). This lump sum shall not be subject to variation.

Payment of the lump sum tendered under SUB-ITEM 13.01 (a) will be made in three instalments, as follows:

- i) The first instalment, 50% of the lump sum, will be paid in the first payment certificate after the Contractor has completed his mobilisation and establishment on the Site.
- ii) The second instalment, 35% of the lump sum, will be paid when the value of the permanent work done reaches one half of the tendered amount, excluding contingencies and price adjustments in terms of the Conditions of Contract.
- iii) The third and final instalment, 15% of the lump sum, will be paid when the Works have been completed and the Contractor has fulfilled all the requirements of this Section.

Before any payment is made under this Sub-Item, the Contractor shall satisfy the Engineer that they have provided camps and constructional equipment of good quality on the site, the value of which exceeds that of the first instalment.

The Contractor may also be required to furnish documentary proof that they own the camps and constructional equipment on the site, the value of which shall exceed that of the first instalment. In the event of the Contractor not being able to satisfy the Engineer as to the ownership of the camps and constructional plant, the Engineer shall have the right to withhold parts of any payments to be made under this Subitem, until the Works have been completed.

The tendered rate per month for SUB-ITEM 13.01 (b) represents full compensation for that part of the Contractor's general obligations which are mainly a function of construction time such as general site and office overheads, profit, financing costs, risks, legal and contractual responsibilities, insurances and sureties, plus other costs and obligations of a general nature which are not specifically measured for payment under any other item(s) of payment.

The tendered sum will be paid monthly, pro rata for parts of a month, from the date on which the Contractor has received a written instruction, in terms of the General Conditions of Contract, to start the work until the end of the period for completion of the Works, plus any extension thereof as provided for in the General Conditions of Contract, provided that:

- i) should the Works be certified as having been completed before the contractual date for completion of the Works, the Contractor will then be entitled to payments in regard to the unexpired period for completion;
- ii) should the progress of the Contractor in terms of the value of work done be in arrears in regard to his approved original Programme, payments in respect of this item shall be limited to payments for the period which, in his original Programme (after suitable adjustments in respect of the extension of time granted), correspond to the actual value of work done.

The adjustments specified in SUB-ITEM 13.01 (b) above will be made only if the value of the work or the period for completion were to change and it is agreed that such adjustments will be in full settlement of the changed compensation for amended general obligations.

<u>ITEM</u>	<u>UNIT</u>
13.02 ROAD PROJECT SIGN BOARD	NUMBER (NO.)

Payment shall be for the number of project sign boards as per the Engineer's Instruction. The final layout shall be subject to the approval of the Engineer.

The cost shall be inclusive of all materials necessary for the erection of the board as instructed by the Engineer, and the replacement of the board if damaged.

SERIES 1000: GENERAL

SECTION 1400: ENGINEER'S ACCOMMODATION AND ATTENDANCE UPON ENGINEER AND THEIR SITE PERSONNEL

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1401 SCOPE

This Section covers the provision of site facilities for the Engineer's supervisory staff in terms of accommodation and transport. The accommodation shall include the necessary office and laboratory accommodation, houses and quarters for employees and the provision of the required furniture, equipment and services.

In providing accommodation, transportation and facilities for the Engineer's supervisory staff, it will be essential to thoroughly evaluate and explore all potential hire, lease, and rental solutions before considering outright purchase and/or construction. The Employer will assess and approve any construction or purchase decisions based on the viability and cost-effectiveness of the proposed solution.

The Section sets out three options for the Engineer's accommodation covering the likely needs of large, medium and small projects. The Particular Specifications shall state the option that applies and any specific amendments to that option as required and approved by the Engineer.

1402 FACILITIES FOR THE ENGINEER

(a) General

The Contractor shall provide and maintain an office, houses, site cabins, vehicles, survey equipment etc. for the Engineer, their staff and for the Employer. Materials and workmanship shall be to generally recognised standards for permanent buildings of this type. Detailed drawings showing the design, the construction details, the type of materials proposed and their characteristics, shall be submitted by the Contractor for the Engineer's approval, which shall be obtained before starting the construction of the office or houses or ordering the relevant materials.

All buildings for accommodation, offices and laboratories shall be constructed from approved materials. Materials containing asbestos shall not be used.

The Contractor shall provide the buildings with potable water, electricity, telephone lines, sanitary installations, sewage disposal arrangements, air-conditioning, furniture and equipment, and shall maintain them, all to the satisfaction of the Engineer 24 hours a day during the Contract Period.

All facilities shall conform to the best standards for the required types. The facilities described herein shall be

understood to represent the minimum requirements. The Contractor shall provide all additional incidentals necessary, so that the facilities will be completely adequate and satisfactory in every respect for the intended use. All equipment and furniture shall be new and unused when initially put in place.

The Contractor shall maintain, replace and/or restore as directed, any facilities or parts thereof that become damaged, worn out, lost or stolen, except through causes due to negligence of the occupying Engineer's staff. The Contractor shall also provide an adequate stock of all expendable items, such as light bulbs, light tubes, kitchenware, soap, towels, toilet paper, paper towels, drinking cups, materials and accessories and at all times ensure proper and continuing functioning of all components and parts of the Engineer's houses and office.

The houses, offices and installations, etc. including all required equipment to be provided under this Contract shall be handed over to the Engineer in finished and fully habitable condition not later than 3 months after the Engineer's order to commence Work (according to the relevant clause of the Conditions of Contract) and such buildings shall be to the entire satisfaction of the Engineer. Suitable temporary office and residential accommodation for the Engineer and their staff shall be provided from the date of the order to commence the Works until such time as the permanent office and residential accommodation are available for use.

(b) Siteworks for "Engineer's Compound"

The houses and buildings shall be sited within the "Engineer's Compound" to the satisfaction of the Engineer. The Type I, II and III houses and multiple accommodation units shall be placed on separate plots of approximately 0.2 hectares each. The location of the houses shall be separate from that of the Contractor's staff housing.

Separate access roads 3 m wide shall be provided for each house and shall be surfaced with at least 150mm consolidated thickness of gravel properly graded, cambered, drained and culverted.

The Contractor shall be responsible for raising the ground (if necessary), grading and drainage in the vicinity of each facility, with suitable access walkways, gravelling, seeding and sodding of the ground, all as directed and approved by the Engineer. Also, the Contractor shall construct a roofed parking area for the Engineer near the buildings, large enough for 8 vehicles, and a satisfactory access road to the parking area. The ground around the buildings, the parking area and the access road shall be raised high enough for them not to be inundated during the rainy season.

Outside lighting, around the buildings and on the parking area, shall be installed to the satisfaction of the Engineer, and appropriate signs shall be erected to inform the public of the purpose of the facilities.

The whole of the "Engineer's Compound" shall be fenced with chain link fencing (or equivalent) 2.0 m high, with necessary gates complete with padlock and chain as directed by the Engineer. The Contractor shall be responsible for the security of the compound and shall provide such gatemen and watchmen, etc., as required to ensure this security.

(c) Construction

The housing shall consist of concrete block masonry or aluminium or prefabricated timber units on concrete floors raised not less than 150 mm above natural ground level.

The roofs shall be constructed from aluminium or corrugated iron roof sheeting and the roof space between the sheeting and the ceilings shall be adequately ventilated and the openings shall be screened with mesh screening to prevent the entry of vermin, etc. into the roof space.

The ceilings shall not be less than 2.8 m inside height and shall be of 10 mm hard boarding or similar approved materials.

Air conditioners shall be wall mounted - not window mounted.

Internal wall partitions shall be of timber framed construction lined on both sides. All doors shall be of flush timber type, plywood faced and a minimum size of 2.0 m x 0.80 m. All timber construction shall be termite proofed.

The windows shall be dust proof, of aluminium framing with glass tightly fitted or similar approved and shall be located in the design to provide the maximum amount of cross ventilation.

The kitchens shall be equipped with adequate benches, wall cupboards and shelves and with a stainless-steel double sink with hot and cold running water built into a special sink cabinet.

The bedrooms shall be provided with built in wardrobes and wall mirrors.

Bathrooms shall be provided with a western flush type WC with hinged cover, a shower with hot and cold running water and soap dish on wall, wash basin with hot and cold running water, and wall mirror with light above.

Toilets shall be provided with a western flush type WC with hinged cover, wash basin with hot and cold running water and wall mirror with light above.

(d) Finishing

All external walls and doors shall be provided with one prime coat, one undercoat and two finishing coats of gloss paint. Internal walls, doors and ceilings shall be painted with one prime coat, one undercoat and two finishing coats of P.V.C. emulsion paint. All paint shall be from an approved manufacturer. The concrete floor shall be covered with an approved type of P.V.C. floor tiles or sheeting.

All windows and doors shall be burglar-proofed and insect-screened to the satisfaction of the Engineer.

(e) Services

The Contractor shall provide, maintain and install the following services to the Engineer's approval:

- i) Adequate piped supply of clean potable water connected to toilets, bathrooms and kitchens in each house.
- ii) An automatic 270 litre electric immersion water heater in each house Types I-III (see below) connected to the piped water supply.
- iii) 220 Volt, 50 cycle A.C. electricity supply with sufficient wiring, light fittings and socket outlets in each house. The power shall be adequate to operate the electrical equipment specified. Socket outlets shall be provided in each room to the Engineer's approval. The Contractor is also required to provide an uninterrupted power supply to the Engineer's offices, laboratories and housing. For this purpose, at least one 25 KVA (minimum), 3-phase diesel-driven generator with a 12-hour fuel capacity will be required fitted with an automatic start up, changeover switches and wiring connection to the offices and laboratory. The motor-alternator shall be suitable to maintain the voltage so that it will not deviate by more than plus or minus 5% from the normal voltage, and will maintain the frequency so that it will not deviate from the nominal frequency by more than plus or minus 2 Hz over the entire load range from 0% to 100% of full load.
- iv) The Contractor shall bear the costs of supply of all fuel, lubricants, spare parts and maintenance for this generator during the full contract period. The generator will revert to the Contractor upon completion of the contract.

v) Suitable soil and wastewater drainage.

vi) Water borne sewage disposal

vii) Rubbish disposal by providing outside bins and a daily collection service to a central disposal area.

viii) The Contractor shall supply to the Engineer and his staff, emergency equipment, safety clothing (including overalls and reflective jackets), helmets, safety boots and tools as required. No separate payment shall be made in respect of emergency equipment and safety facilities, except where a specific item is provided for in the Bill of Quantities. Otherwise, full compensation for the supply of emergency equipment and safety facilities shall be deemed to be included in the tendered rates for the various items in the Bills of Quantities for offices and laboratory.

ix) The Contractor shall pay all charges associated with installation, subscription and consumption of public utilities (water, electricity and telephone).

1403 HOUSES FOR THE ENGINEER

(a) General

Upon completion of the Contract, the houses, furniture, equipment and services specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in CLAUSE 1412 are invoked in the Special Specifications.

The Contractor shall be responsible for providing temporary fully furnished accommodation in the form of suitable rental or hotel accommodation for the Engineer and their staff and the HIV/AIDS Nominated Service Provider(s) from the date of Notice to Commence the Works until the houses specified in the contract are completed and available for habitation. This temporary accommodation shall be of a standard at least equal to that to be provided in the permanent housing.

If the temporary accommodation is provided in a hotel, then the Contractor will be responsible for payment of subsistence costs such as food and laundry. If the temporary accommodation provided is rental accommodation, then the Contractor will not pay subsistence costs for food and laundry but will pay housekeeper/service costs for each rental property.

The rate for providing, maintaining and paying all rents and services for temporary accommodation paid to the Contractor in Pay ITEM 14.01 (e) (i) shall be deemed to cover all the Contractor's costs of such alternative accommodation prior to completion of the specified housing. Temporary accommodation shall be provided for the Engineer and support staff until the housing specified in the contract is completed but reimbursement to the Contractor will only be made for the first 3 months after the Notice to Commence the Works.

Should the Engineer have to appoint additional staff to monitor the work of the Contractor as per Special Specifications, the Contractor shall not be reimbursed under Pay ITEM 14.01 (e) (i) for accommodation or other costs (or additional vehicle costs) for such staff.

(b) Furniture and Equipment

The general description of the type of houses to be supplied is as follows:

i) Type I House

As illustrated in the Drawings or described in the Special Specifications having an internal floor area of approximately 150 m² complete with furnishings and equipment as listed in TABLE 1403/1. The cost of providing the houses, furnishings, equipment, water, electrical supply, drainage and maintenance during the whole period of the Contract shall be deemed to be included in the Bill of Quantities.

TABLE 1403/1 TYPE I HOUSE FURNITURE AND EQUIPMENT.

NEW FURNITURE AND EQUIPMENT, TO THE APPROVAL OF THE ENGINEER.

FURNITURE	NO.
Kitchen Table (Formica Top)	1
Kitchen Chair	4
Dining Table	1
Dining Chairs	6
Dining Chairs with arms	2
Writing Desk (3 drawer)	1
Bookshelf	1
Settee (3 cushions)	1
Easy Chairs	4
Coffee Tables	2
Sideboard	2
Beds, double with inner-spring mattress	2
Beds, single with inner-spring mattress	3
Pillows	10
Side Tables	5
Dressing Tables with Mirrors	2
Dressing Table Stools	2
Chest of Drawers	3
Bedside Chairs	5
Bathroom Cabinet with Mirror	1
Bathroom Stool	1
Floor Rugs	5
EQUIPMENT	NO.
Air Conditioner 12,000 BTU/hr	4
Refrigerator min. 0.40 m ² (Electric frost-free)	1
Electric or gas cooker with 4 burners, separate grill and oven	1
Television Set (LCD Minimum 32 Inches)	1
Microwave Oven (Minimum 20 Litres)	1
Fume Hood	1
Water Filter	2
Dust Bin metal with lid (outdoor type)	1
Door Mats	2
Vacuum Cleaner (electric)	1
Ceiling Fans	3
Set of 8 pieces crockery, cutlery, Glassware	1
Set of Kitchen utensils	1
Set of Pots, pans, etc.	1
Deep-Freeze cabinet 0.40 m ²	1
Water cooler/dispenser	1
Fire Extinguisher	2
Standard lamps	2

EQUIPMENT	NO.
Table Lamps	2
Toilet Tissue Holders	2
Waste Baskets	5
Vacuum Cleaner (electric)	1
Mixer (Electric Portable)	1
Bedside lights	5
Wall lights	6
Pelmets and runners	all windows
Curtains	all windows
Bed sheets	20
Pillowcases	10
Blankets	10
Towel rails	2

ii) Type II House

As illustrated in the Drawings or described in the Special Specifications having an internal floor area of approximately 130 m² complete with furnishings and equipment as listed in TABLE 1403/2. The cost of providing the house, furnishings, equipment, water, electrical supply drainage and maintenance during the whole period of the Contract shall be deemed to be included in the Bill of Quantities.

TABLE 1403/2 TYPE II HOUSE FURNITURE AND EQUIPMENT.

NEW FURNITURE AND EQUIPMENT, TO THE APPROVAL OF THE ENGINEER.

FURNITURE	NO.
Kitchen Table (Formica top)	1
Kitchen Chair	4
Dining Table	1
Dining Chairs	4
Dining Chairs with arms	2
Writing Desk (3 drawers)	1
Bookshelf	1
Settee (3 cushions)	1
Easy Chairs	3
Coffee Tables	2
Sideboard	1
Beds, single with inner-spring mattress	3
Beds, double with inner-spring mattress	1
Pillows	8
Side Tables	4
Dressing Tables with Mirrors	1
Dressing table stools	1
Chest of Drawers	2
Bedside Chairs	4
Bathroom Cabinet with Mirror	1

FURNITURE

Bathroom Stool

NO.

1

Floor Rugs

4

EQUIPMENT

Air Conditioner 12,000 BTU/hr

NO.

2

Refrigerator min. 0.40 m² (Electric frost-free)

1

Electric or gas cooker with 4 burners, separate grill and oven

1

Television Set (LCD Minimum 32 Inches)

1

Microwave Oven (Minimum 20 Litres)

1

Fume Hood

1

Vacuum Cleaner (electric)

1

Fire Extinguisher

2

Mixer (Electric Portable)

1

Water Filter

1

Dust Bin Metal with lid (outdoor type)

1

Door Mats

2

Ceiling Fans

2

Set of 6 pieces crockery, cutlery, glassware

1

Set of Kitchen utensils

1

Set of Pots, pans, etc.

1

Deep-Freeze cabinet 0.40 m²

1

Water cooler/dispenser

1

Standard lamps

2

Bedside lights

4

Wall lights

5

Pelmet and runners

all
windows
all
windows

Curtains

Bed sheets

16

Pillowcases

8

Blankets

8

Towel rails

2

Table Lamps

1

Toilet Tissue Holders

1

Waste Baskets

4

iii) Type III House

As illustrated in the Drawings or described in the Special Specifications having an internal floor area of approximately 70 m². complete with furnishings and equipment as listed in TABLE 1403/3. The cost of providing the house, furnishings, equipment, water, electrical supply, drainage and maintenance during the whole period of the Contract shall be deemed to be included in the Bill of Quantities.

TABLE 1403/3 TYPE III HOUSE FURNITURE AND EQUIPMENT.

NEW FURNITURE AND EQUIPMENT, TO THE APPROVAL OF THE ENGINEER.

FURNITURE**NO.**

Kitchen Table (Formica top)

1

Kitchen Chair

4

Dining Table

1

Dining Chairs

4

Writing Desk (2 drawers)

1

Bookshelf

1

Settee (3 Cushion)

1

Easy Chairs

2

Coffee Table

1

Sideboard

1

Beds, single with inner-spring mattresses

2

Pillows

2

Side Table

1

Dressing Table

1

Dressing Table Stool

1

Chest of Drawers

1

Bathroom Cabinet with Mirror

1

Bathroom stool

1

Floor Rugs

4

EQUIPMENT**NO.**

Air Conditioner 12,000 BTU/hr

2

Refrigerator min. 0.40 cu.m (Electric frost-free)

1

Beds, single with inner-spring mattress

2

Electric or gas cooker with 2 burners,

1

Television Set (LCD Minimum 32 Inches)

1

Microwave Oven (Minimum 20 Litres)

1

Fume Hood

1

Water Filter

1

Dust Bin Metal with Lid (outdoor type)

1

Door Mats

2

Vacuum Cleaner (electric)

1

Ceiling Fans

2

Set of 4 pieces crockery, cutlery, glassware

1

Set of Kitchen utensils

1

Set of Pots, pans, etc.

1

Mixer (Electric Portable)

1

Water cooler/dispenser

1

Fire Extinguisher

1

Standard lamps

1

Bedside lights

2

EQUIPMENT	NO.
Wall lights	3
Pelmets and runners	all windows
Curtains	all windows
Bed sheets	8
Pillowcases	4
Blankets	4
Towel rails	1
Toilet Tissue Holder	1
Waste Baskets	2

iv) Multiple Living Accommodation

1 block of 4 units of multiple living accommodation each unit consisting of 17 m², containing two rooms with common ablution block, kitchen, dining room and external veranda all to the approval of the Engineer, as shown in the Drawings, complete with furnishings and equipment as listed in TABLE 1403/4.

TABLE 1403/4 MULTIPLE LIVING ACCOMMODATION, HOUSE FURNITURE AND EQUIPMENT.

NEW FURNITURE AND EQUIPMENT, TO THE APPROVAL OF THE ENGINEER.

FURNITURE	NO.
Kitchen Table (Formica Top)	1
Kitchen Chair	4
Dining Table	1
Dining Chairs	8
Sideboard	2
Beds, single with mattresses	8
Pillows	8
Side Table	8
Bedside Chair	16
Bathroom Cabinet with Mirror	2
Bathroom stool	2

EQUIPMENT	NO.
Electric Fan	8
Refrigerator min. 0.40 m ² (Electric or equivalent)	1
Fire Extinguisher	4
Vacuum Cleaner	1
Electric Cooker with 4 burners, separate large grill and oven	1
Television Set (LCD Minimum 32 Inches)	1
Microwave Oven (Minimum 20 Litres)	1
Water Filter	1
Water cooler / dispenser	1
Dust Bin Metal with Lid (outdoor type)	1
Door Mats	2

EQUIPMENT	NO.
Ceiling Fans	2
Set of 10 pieces crockery, cutlery, glassware	1
Set of Kitchen utensils	1
Set of Pots, pans, etc.	1
Mixer (Electric Portable)	1
Wall lights	3
Pelmets and runners	all windows
Curtains	all windows
Bed sheets	32
Pillowcases	16
Blankets	16
Towel rails	3
Toilet Tissue Holder	1
Waste Baskets	2

Each unit shall be furnished with one bed, complete with a mattress, one table and 2 chairs and one electric fan. The cost of providing the block of 4 units, furniture, equipment, water, electrical supply, drainage and maintenance during the whole period of the Contract shall be deemed to be included in the Bill of Quantities.

1404 OFFICE FOR THE ENGINEER

(a) General

Upon completion of the Contract, the Engineer's office buildings, furniture, equipment and services specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in CLAUSE 1412 are invoked in the Special Specifications.

The Contractor shall provide, furnish and maintain office accommodation for the Engineer as detailed hereunder.

The Site office shall be erected at a location to be agreed with the Engineer. The plot shall be not less than 0.3 hectares in area and if so required shall be fenced with a 2.0 m high chain link fence and gate, with padlock and chain.

Adequate electric lighting shall be provided in each room of the office building together with sufficient power points to supply all of the office equipment.

The office building shall be provided with dedicated internet access fitted into the office building for the sole use of the Engineer along with multiple internet connections in all offices. The reliability and bandwidth provided must be such as to allow efficient uninterrupted use of the various management systems the Engineer uses over the web to manage the contract on site. Dedicated telephone lines shall be provided, and the Contractor shall supply mobile telephones as requested by the Engineer for his staff and pay all costs associated with the use of these mobile telephones.

The Contractor shall pay all charges associated with connecting and establishing telephone and internet access, the supply of electricity and, if necessary, an incoming power line, and shall further pay all electricity and telephone consumption by the Engineer for the duration of the Contract.

The Contractor shall provide an access road at least 6.0 m wide to the Engineer's office and parking area for 10 cars. The road and car park shall be surfaced with a minimum of 150 mm compacted thickness of gravel.

The office shall be erected and handed over to the Engineer fully furnished and equipped, within three months from the date of the Engineer's order to commence work.

The Contractor shall be responsible for providing temporary serviced office facilities for the Engineer and their staff and the HIV/AIDS Nominated Service Provider(s) from the date of Notice to Commence the Works until the office specified in the contract is completed and available for use.

Acceptable temporary office facilities might be the lounge area of a large house or the conference room of a hotel. There should be room to accommodate 10 chairs and desks to be supplied by the Contractor if not already available in the temporary facility and there shall be mains electricity and flush toilets. All shall be to the approval of the Engineer.

The rate for providing, maintaining and paying all rents and services for the temporary office entered in Pay ITEM 14.01 (e) (ii) shall be deemed to cover all the Contractor's costs of such temporary office prior to completion of the specified office. The temporary office shall be provided for the Engineer and support staff until the office specified in the contract is completed but reimbursement to the Contractor will only be made for the first 3 months after the Notice to Commence the Works.

(b) Construction

The Contractor shall provide and erect for the duration of the Contract a site office for the exclusive use of the Engineer's staff.

The office building shall comprise an area of approximately 180 m² with internal access to the following rooms:

- 1 single person office of minimum 15 m²
- 1 reception office of 12 m²
- 5 single person offices of minimum 10 m² each
- 4 double/triple person offices of minimum 15 m² each
- 1 meeting room of minimum 20 m²
- 2 storerooms of minimum 5 m² each

The office building shall in addition be equipped with flush toilets and kitchen facilities. The kitchen area shall be provided with a fixed table for hot plates, sockets for hot plates and a refrigerator and a steel sink with running water.

The building shall be constructed with a minimum of 2.8 m internal headroom, and be complete with ceiling, linoleum tiled or wooden floor, and a covered veranda around the entrance to the office. The rooms shall be adequately ventilated and lighted.

The layout of the office building shall be as shown on the drawings unless otherwise approved by the Engineer.

The roofs shall be constructed from aluminium or corrugated iron roof sheeting and the roof space between the sheeting and the ceilings shall be adequately ventilated and insulated and the openings shall be screened with mesh screening to prevent the entry of vermin, etc. into the roof space.

Internal wall partitions shall be timber framed and lined on both sides. All doors shall be of flush timber type, plywood faced and a minimum size of 2.0 m x 0.80 m. All doors shall be provided with locks with three keys outside doors with cylinder locks. All external walls and doors shall be provided with one prime coat, one undercoat and two finishing coats of gloss paint. Internal walls, doors and ceilings shall be painted with one prime coat, one undercoat and two finishing coats of P.V.C. emulsion paint. All paint shall be from an approved manufacturer.

(c) Furniture and Equipment

The options set out in TABLE 1404/1 are itemised under three categories of Large Scale, Medium Scale and Small-Scale Works contracts. The three options shown are:

- i) Option 1: Large Scale Projects (50 MUSD and above)
- ii) Option 2: Medium Scale Projects (10 MUSD to 50 MUSD)
- iii) Option 3: Small Scale Projects (Up to 10 MUSD)

The Contractor shall supply new furniture and equipment for the offices of the Engineer and his staff as detailed in TABLE 1404/1. All furniture and equipment shall be of a make and quality approved by the Engineer.

TABLE 1404/1: OFFICE FURNITURE AND EQUIPMENT

ITEM	DESCRIPTION	QUANTITY		
		OPTION 1	OPTION 2	OPTION 3
1	Meeting table, minimum 3.6 m x 1.5 m, with 8 chairs	1	1	As specified in Special Specifications
2	Desk, minimum 1.8 m x 0.9 m, with lockable double chest of drawers	8	4	2
3	Desk, minimum 1.5 m x 0.75 m, with lockable single chest of drawers	10	5	2
4	Tables with smooth flat top, minimum 1.8 m x 0.9 m	4	2	1
5	Table for printers and scanner, minimum 1.2 m x 0.6 m	3	1	As specified in Special Specifications
6	Swivel type sturdy and comfortable desk chairs	18	10	5
7	Visitors' chairs	10	6	3
8	Table lamps	20	10	5
9	Wastepaper baskets	18	9	5

ITEM	DESCRIPTION	QUANTITY		
		OPTION 1	OPTION 2	OPTION 3
10	Whiteboard with accessories	6	4	As specified in Special Specifications
11	Wall boards 2.4 m x 1.2 m	12	6	2
12	Steel filing cabinets, 1300 mm high, 460 mm wide and 600 mm deep, each fitted with four lockable drawers on runners	10	5	3
13	Steel general purpose lockable cabinets with shelves with at least 15 sqm shelf area	10	5	3
14	Steel drawing cabinets suitable for storing all contract drawings	2	1	1
15	Drawing board for A1 drawings including draftsman's stool	1	1	1
16	Filing trays	18	8	4
17	Laptop computers and software having the capacity indicated in the Special Specification	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
18	Desktop computers and software having the capacity indicated in the Special Specification	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
19	Laser printer with speed of 15 pages per minute and a resolution of 1200x1200 DPI having a carriage for up to A3 paper, plus stationery for the duration of the Contract	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
20	Desktop hard drive for data storage with capacity up to 500 GB, including USB connections	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
21	Photocopier and scanner with copy size up to A3, capable of reducing or enlarging between A3 and A4, plus paper and other supplies for the duration of the Contract	1	1	1
22	A4 size laser colour printer	1	1	1
23	Electronic calculators	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
24	Handheld GPS (Garmin GPSMAP 76C) or equivalent	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
25	Binding machine	1	1	1
26	Paper punches	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
27	Heavy duty paper punch	2	1	1
28	Paper staplers	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
29	Rain gauges	2	2	Numbers as specified in Special Specifications
30	Thermometer (max/min)	2	2	2
31	First aid and snake bite kit	2	2	2
32	Fire extinguishers (dry type)	Numbers as specified	Numbers as specified	Numbers as specified

ITEM	DESCRIPTION	QUANTITY		
		OPTION 1	OPTION 2	OPTION 3
		in Special Specifications	in Special Specifications	in Special Specifications
33	Ceiling fans or portable fans as agreed with the Engineer	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
34	Air conditioning for all rooms (12,000 BTU in typical)	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
35	Refrigerator (minimum 120 litres)	1	1	1
36	Twin hot plates	1	1	1
37	Electric kettle	2	2	2
38	Water filters	2	1	1
39	Thermos jugs, 45 litres capacity	18	10	5
40	Set of plates, cups and glasses for 36 persons plus cutlery	1	1	1
41	Kitchen Set as specified in Special Specification	1	1	1
42	Safe, min size approx. 0.8 m x 0.5 m x 0.4 m, to be concreted in place (either wall or floor mounted) complete with lock and keys	1	1	1
43	Digital Camera as specified in the Special Provisions	2	1	1
44	Slide projector with a screen	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
45	Two-way radio communication system (or satellite phones)	1	1	1
46	Cellular phone	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
47	Internet connection (High speed and required devices (Landline or wireless) for all computers	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications	Numbers as specified in Special Specifications
48	LAN Networking for all computers and printers			

The site office shall have connections to potable water and electricity supplies, with both providing constant sources of water and power. The Contractor shall be responsible for cleaning and maintaining the offices and toilets and shall provide soap, towels and all necessary fittings and cleaning materials.

The site office will be connected on a 24-hour basis to the internet facility to be provided by the Contractor.

1405 WASH HOUSE

The Contractor shall provide a Washhouse comprising two rooms of 20 m² each with electricity, water, wastewater outlet and water borne sewage disposal and equipped with two automatic washing machines, two stainless steel tubs with hot and cold running water and an automatic electric water heater, all to the approval of the Engineer.

The cost of providing the house, furnishing, equipment, water, electrical supply and maintenance during the whole period of the Contract shall be deemed to be included in the rates provided in the Bill of Quantities.

Upon completion of the Contract, the Engineer's wash house, furniture, equipment and services specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in CLAUSE 1412 are invoked in the Special Specifications.

1406 SITE CABIN/ OFFICE

The Contractor shall, if so instructed by the Engineer, provide and maintain during the duration of the Contract portable site cabins. Each site cabin shall have a floor area of at least 10 m² and shall be equipped with one bedstead including mattress, blankets, pillows, bed sheets, one wardrobe, one desk with drawers, one metal cabinet, shelves, two chairs and a small gas refrigerator. These units shall always be positioned close to the Work and moved from one location to another by the Contractor as may be directed by the Engineer. The Contractor shall supply the units with light, potable water if possible and sanitary facilities.

The cost of providing the Site Cabins furnishing, equipment, water, electrical supply (where available), moving the site cabins to different locations and maintenance during the

whole period of the Contract shall be deemed to be included in the price inserted in ITEM 14.04 of the Bill of Quantities.

Upon completion of the Contract, the Engineer's site cabin/office, furniture, equipment and services specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in CLAUSE 1412 are invoked in the Special Specifications.

1407 VEHICLES FOR THE ENGINEER AND EMPLOYER

The Contractor shall provide new vehicles as listed below licensed and comprehensively insured for replacement value and shall maintain and provide fuel, oil and replacement parts during the whole of the Contract period. The vehicles shall be for the exclusive use of the Engineer, their staff and the Employer during the Contract period. The Contractor shall also insure the vehicles and passengers fully comprehensively for any driver at all times throughout the Contract Period. The Contractor shall supply a qualified driver to the Engineer's approval for each of the vehicles supplied to the Engineer and Employer.

- i) 4 Wheel Drive Station Wagon with a minimum engine cubic capacity of 2.8 litres
- ii) 4 Wheel Drive Pickup, with double cabin with a minimum engine cubic capacity of 2.7 litres

The vehicles shall have factory installed air-conditioning units and power steering. The vehicles shall have diesel engines and be provided with the following optional equipment, factory installed seat belts, rear pintle hook, front hook, door mirrors, spare wheel, toolbox with necessary tools, jack etc. Makes of vehicles shall be approved by the Engineer prior to ordering.

The Contractor shall service and maintain in good working order the vehicles at all times. In the event of any vehicle being unavailable for use due to accident, damage or its being maintained or repaired, the Contractor shall immediately provide a substitute acceptable to the Engineer.

In the event of the Contractor defaulting on this obligation, the Engineer shall be authorised to hire a substitute similar vehicle for the period of non-availability of the Contractor's vehicles, and the cost incurred will be recovered from the Contractor.

Upon completion of the Contract, the Engineer's vehicles specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in CLAUSE 1412 are invoked in the Special Specifications.

1408 ATTENDANCE UPON ENGINEER

(a) Staff

The Contractor shall provide night and day watchmen, gardeners, labourers, cleaners and sanitary staff as well as

all necessary cleaning materials as may be required by the Engineer to keep the offices, the laboratory and houses in first class condition. Inhouse Supervisors shall be provided to organize all the inhouse staff for the Engineer's facility.

(b) Stationery

The Contractor shall provide any stationery required for the office and laboratory of the Engineer.

All equipment provided shall be kept fully serviceable by the Contractor at all times. The Contractor shall repair/replace any defective equipment within 3 (three) days of notification by the Engineer or his staff. The Contractor shall also provide all paper (including special quality photo paper), photocopier toner, laser printer toner cartridges, colour and black ink cartridges, external hard drives and storage containers required by the Engineer. Supplies for toner, ink, etc. are to be from the original manufacturer.

(c) Assistance to the Engineer

The Contractor shall provide all assistance such as labourers, all tools and protective clothing, wooden pegs, iron pins and pickets, water, cement and aggregate for concreting, transport for labour and materials, as may be required by the Engineer and their staff for checking, setting out, surveying and measuring or testing the work.

(d) Payment

No separate payment will be made for attendance upon the Engineer the relevant cost being included by the Contractor in rates in the Bill of Quantities or elsewhere. If the Contractor fails in their obligations under these Specifications, the Engineer is authorised to employ any staff and/or labourer and to buy any material, as mentioned above, and the costs incurred will be recovered from the Contractor.

1409 PROVISION OF SURVEY EQUIPMENT

The Contractor shall provide at all times during the period of the Contract all such workforce and instruments for the exclusive use of the Engineer as they may deem to be necessary for carrying out their duties in connection with the Contract. The workforce shall be approved by the Engineer for their relevant qualifications and experience and knowledge of the English language and as far as possible the same personnel shall be provided throughout the period of the Contract.

Upon completion of the Contract, the Engineer's survey equipment specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in CLAUSE 1412 are invoked in the Special Specifications.

The instruments to be provided include those given in TABLE 1409/1 or equivalent as specified in Special Specifications:

TABLE 1409/1: SURVEY EQUIPMENT TO BE PROVIDED TO THE ENGINEER

ITEM	EQUIPMENT	QUANTITY	REMARKS																										
1	GNSS Receivers (1 Base and 2 Rovers	1 Set	A set of GNSS receivers (1 Base and 2 Rovers) including all accessories perpetual licences for both on-board and post processing software including 3 antennas, 1 tribrach, 1 optical plummet, 1 pole extension, 3 hardcover carrier case, 1 wooden tripod, 6 internal batteries, five 3m tape measure, 2 data loggers, 1 charging kit, and 3 telescopic GNSS poles. The on-board software for the data loggers should be Android based. The model year of the receiver should be almost 3 years before the date of signing of contract. <table><tr><th>Parameter</th><th>Minimum Requirement</th></tr><tr><td>Total Channels</td><td>≥555 channels</td></tr><tr><td>Constellation Support</td><td>GPS + GLONASS + Galileo + BeiDou</td></tr><tr><td>RTK Initialization Time</td><td>≤10 seconds (baseline ≤10 km)</td></tr><tr><td>Positioning update rate</td><td>1 Hz minimum</td></tr><tr><td>RTK Single Baseline</td><td>Horizontal ≤10 mm + 1 ppm RMS Vertical ≤20 mm + 1 ppm RMS</td></tr><tr><td>Network RTK Mode</td><td>Horizontal ≤10 mm + 0.5 ppm RMS Vertical ≤20 mm + 0.5 ppm RMS</td></tr><tr><td>PPK Accuracy</td><td>Horizontal ≤5 mm + 1 ppm RMS Vertical ≤10 mm + 1 ppm RMS</td></tr><tr><td>Static Post Processing</td><td>Horizontal ≤3 mm + 0.1 ppm RMS Vertical ≤5 mm + 0.4 ppm RMS</td></tr><tr><td>Bluetooth</td><td>Version 4.0 or higher, ≥100 meters Range</td></tr><tr><td>Internal UHF Radio Modem</td><td>410-470 MHz Frequency Range ≥8 km Maximum Range</td></tr><tr><td>Internal Cellular Modem</td><td>4G LTE / 3G WCDMA / 2G GSM</td></tr><tr><td>Wifi Connectivity</td><td>IEEE 802.11 a/b/g/n minimum</td></tr></table>	Parameter	Minimum Requirement	Total Channels	≥555 channels	Constellation Support	GPS + GLONASS + Galileo + BeiDou	RTK Initialization Time	≤10 seconds (baseline ≤10 km)	Positioning update rate	1 Hz minimum	RTK Single Baseline	Horizontal ≤10 mm + 1 ppm RMS Vertical ≤20 mm + 1 ppm RMS	Network RTK Mode	Horizontal ≤10 mm + 0.5 ppm RMS Vertical ≤20 mm + 0.5 ppm RMS	PPK Accuracy	Horizontal ≤5 mm + 1 ppm RMS Vertical ≤10 mm + 1 ppm RMS	Static Post Processing	Horizontal ≤3 mm + 0.1 ppm RMS Vertical ≤5 mm + 0.4 ppm RMS	Bluetooth	Version 4.0 or higher, ≥100 meters Range	Internal UHF Radio Modem	410-470 MHz Frequency Range ≥8 km Maximum Range	Internal Cellular Modem	4G LTE / 3G WCDMA / 2G GSM	Wifi Connectivity	IEEE 802.11 a/b/g/n minimum
Parameter	Minimum Requirement																												
Total Channels	≥555 channels																												
Constellation Support	GPS + GLONASS + Galileo + BeiDou																												
RTK Initialization Time	≤10 seconds (baseline ≤10 km)																												
Positioning update rate	1 Hz minimum																												
RTK Single Baseline	Horizontal ≤10 mm + 1 ppm RMS Vertical ≤20 mm + 1 ppm RMS																												
Network RTK Mode	Horizontal ≤10 mm + 0.5 ppm RMS Vertical ≤20 mm + 0.5 ppm RMS																												
PPK Accuracy	Horizontal ≤5 mm + 1 ppm RMS Vertical ≤10 mm + 1 ppm RMS																												
Static Post Processing	Horizontal ≤3 mm + 0.1 ppm RMS Vertical ≤5 mm + 0.4 ppm RMS																												
Bluetooth	Version 4.0 or higher, ≥100 meters Range																												
Internal UHF Radio Modem	410-470 MHz Frequency Range ≥8 km Maximum Range																												
Internal Cellular Modem	4G LTE / 3G WCDMA / 2G GSM																												
Wifi Connectivity	IEEE 802.11 a/b/g/n minimum																												
2	Total Station	1 set	A set of total station including all accessories perpetual licences for both on-board and post processing software including 1 tribrach, 1 optical plummet, 1 hardcover carrier case, 1 wooden tripod, 2 internal batteries, 3m tape measure, 1 charging kit, 3 reflector prisms and 3 prism poles. The on-board software for the data loggers should be Android based. The model year of the total station should be almost 3 years before the date of signing the contract supplied with a calibration certificate.																										
3	Automatic Digital Level	2	A Set of digital level with all the Accessories with perpetual licences. Accessories include 2 wooden tripods, 4 four meter foldable levelling staves, 4 ground plates and 2 charging kits. The model year of the Automatic digital level should be almost 3 years before the date of signing the contract supplied with a calibration certificate.																										
4	Rugged Tablets	2	Minimum storage capacity of 500GB, minimum battery capacity 10,000mAh, charging kit and the model year of the rugged tablet should be almost 3 years before the date of signing the contract.																										
5	Bipods	6	Dual strut support to hold the Prism in place when capturing details																										
6	UHF FM 2-way Portable Radios (short range)	3 pairs	Plus, accessories including batteries and a charger																										
7	Precision Measuring Wheel	2	Precision measuring wheel with folding grip for distance measuring in the field Shockproof counting mechanism fitted over the measuring wheel																										
8	Steel measuring tape	2	Two 50 m and Four 30 m Nylon Clad steel open-reel tape																										
9	SD memory card 32 GB	5	Fast Industrial grade SD memory card 32 GB with holder																										
10	Collapsible Safety Traffic Cones	10	For road safety																										
11	Hammers	5	2 Sledgehammers 4kg weight and 3 2kg steel hammer																										
12	Reflective Road Safety Vests	20	For the Survey Staff, various sizes - to be advised																										

ITEM	EQUIPMENT	QUANTITY	REMARKS
13	Vehicle mountable Flashing road light	Numbers as specified in Special Specifications	With adapters and a power cable for the safety of the survey team during field work
14	Scientific Calculator	5	For the Survey Staff
15	First Aid Kit	5	With first aid stuffs to be supplied as required during the project
16	Marking Paint	2 Doz	White spray paint in cans (inverted marking paint) To be supplied as required during the project
17	Survey Field Books	As required	With Hard Cover
18	Surveying Umbrella	As required	Umbrella for protecting the Total Station from obstructing light Large diameter with carrying bag, dismountable poles and guy ropes
19	Pangas	6	Normal garden pangas or Machete To be supplied as required during the project
20	Gum Boots	As required	For the Survey Staff, various sizes - to be advised
21	Permanent Markers Pens and Colour Roll Flagging tape	As required	Red and Blue Markers To be supplied when required
22	Safety Hard Hat	As required	For the Survey Staff
23	3 metre straight edge and metric wedge	1	used to determine the lateral surface regularity of a road
24	Safety boots	As required	
25	Raincoats	As required	
26	Hand axes	5	

All the above survey equipment shall be of a make and quality approved by the Engineer and shall be supplied to the Engineer within one month of the Notice to Commence the Works. If not supplied on time, the Contractor shall hire equipment at his own expense for use by the Engineer as a temporary measure so that the joint survey specified in CLAUSE 1206 is not delayed.

The Contractor shall be solely responsible for the maintenance of all such instruments and shall ensure that they are at all times in good condition and adjustment. Repairs shall only be carried out by persons or organisations approved by the Engineer.

Supply of miscellaneous survey items (e.g. spray paint, beacon materials, spades, axes, rubber boots, assistants, drawing equipment, approved surveying forms A4 size and field-surveying books).

1410 LABORATORY FOR THE ENGINEER

(a) General

The Contractor shall provide, erect and maintain for the duration of the Contract a laboratory adjacent to the Engineer's Representative's office or where directed by the Engineer.

The laboratory shall be inspected, registered and licensed to operate by the Ministry of Works and Transport in accordance with provisions of the Road Act.

As specified in the Special Specifications the laboratory shall either:

i) be for the sole use of the Engineer; or

ii) be a combined laboratory used both for the Contractor's own testing and the independent testing of the Engineer.

In case of the latter the laboratory building shall be provided with a two-person office of minimum 10 m² for the exclusive use of the Engineer's site personnel and be provided with new furniture as listed in TABLE 1410/1. A telephone line extension to the Engineer's office building shall be provided.

TABLE 1410/1 NEW FURNITURE, TO THE APPROVAL OF THE ENGINEER.

ITEM	NUMBER
Desk 1.6 x 0.9 m with lockable single chest of drawers	2
Table lamps	2
Table with smooth flat top, min. area 2 m ²	1
Swivel type desk chairs	2
Visitors' chairs	2
Wastepaper baskets	2
Wall boards 2.4 x 1.2 m	2
Steel cupboard with shelves	1
Steel filing cabinet	1
Filings trays	2
Air conditioner 12,000 BTU/hr	1

Upon completion of the Contract, the Engineer's laboratory building, laboratory equipment, air conditioners and furniture

specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in CLAUSE 1412 are invoked in the Special Specifications. If a combined laboratory building is provided it shall revert to the Contractor upon completion of the Contract.

In case a laboratory for the sole use of the Engineer shall be provided, the laboratory shall be dimensioned as shown in the Drawings or described in the Special Specifications with a minimum of 2.8 m headroom internally complete with ceiling, smooth concrete floor and a 5m wide covered veranda extending along the length of the front with a concrete floor for drying of material and sufficient covered outdoor space for location of soaking basins for CBR testing where required.

The rooms shall be adequately ventilated and lighted. Walls shall be constructed of prefabricated timber sections or sand cement blocks. All external doors shall be provided with cylinder locks with three keys.

The working area floor shall have a strengthened section incorporated consisting of 3.0 m x 3.0 m x 450 mm mass concrete plinth. A separate sample store of at least 12 m² floor area shall be provided.

The laboratory shall be provided with electric lighting and power points to the satisfaction of the Engineer (to be 220 Volts, 50 cycles).

The permanent fixtures in the laboratory shall include:

- 2 no. double draining board stainless sinks, piped drinkable water supply to each and wastewater outlets.
- Workbenches, comprising a working surface and one full length and width shelf under, of seasoned timber 1.0 m wide and 0.9 m high.
- Soaking tanks for CBR and concrete specimens shall be provided at floor level, in the stores section of the laboratory and on the veranda. The CBR tank shall have drainage pipes built in.

The laboratory for the Engineer shall be complete with furnishings and equipment as listed in TABLE 1410/2.

Table 1410/2 Laboratory for the Engineer: Furniture and Equipment to the approval of the Engineer

ITEM	NUMBER
Desks 1.5 m x 0.75 m with 2 chests of drawers	2
Armchairs	2
Chairs	6
Air conditioners 12,000 BTU/hr. 5 No.	2
Work benches in numbers as given in the Special Specifications	
Curing tanks.	3
Stationery cupboard 2 cu. m.	2
Book-cases, purpose made to accept box files	2
Shelves 2.0 m long	2
Stools, 1 m high	4
Stools, 0.4 m high	4
Metal filing cabinet with 2 drawers	2

(b) Testing Equipment, Materials and Testing Standards

The Contractor shall provide and install in the laboratory 2 stainless steel fan-circulated drying ovens, minimum 70 litre capacity, and all the necessary apparatus and materials for the performance of all tests required for the testing and control of the works and materials.

The Contractor shall supply one new copy of the latest edition of the Specifications for all referred material standards and testing standards used for the Contract.

All the laboratory equipment, including air conditioners, shall be new and of a make approved by the Engineer.

The equipment and apparatus shall permit the execution of the AASHTO, ASTM, SANS and BS standard tests mentioned in these Specifications. Such tests include, but are not necessarily limited to, those summarised in TABLE C1410/3, TABLE C1410/4 and TABLE C1410/5 below. However, testing equipment shall not be provided for specialised tests indicated with an asterisk in the tables. Such specialised tests may be performed at authorised testing institutes approved by the Engineer.

TABLE C1410/3: APPLICABLE STANDARD TESTS FOR SOILS, GRAVEL AND CEMENT TREATED MATERIALS

CML NO.	NAME OF TEST	TEST METHOD
1.1	Moisture Content	BS 1377-2:2022
1.2	Liquid Limit (Cone Penetrometer)	BS 1377-2:2022
1.3	Plastic Limit & Plasticity Index	BS 1377-2:2022
1.4	Linear Shrinkage	BS 1377-2:2022
1.5	Particle Density Determination - Pycnometer	BS 1377-2:2022
1.6	Bulk Density for undisturbed samples	BS 1377-2:2022
1.7	Particle Size Distribution - Wet sieving	BS 1377-2:2022
1.8	Particle Size Distribution - Hydrometer Method	BS 1377-2:2022
1.9	Compaction Test - BS Light and BS Heavy	BS 1377-2:2022
1.10	CBR Test - One-point method	BS 1377-2:2022
1.11	CBR Test - Three-point method	BS 1377-2:2022 & TMH1 method A8
1.12	Compaction Test - Stabilised Materials	BS 1924-2:2018
1.13	UCS of Stabilised Materials	BS 1924-2:2018
1.14	Initial Consumption of Lime - ICL	BS 1924-2:2018

CML NO.	NAME OF TEST	TEST METHOD
1.15	Density of Soil In-place by Sand Cone Method	AASHTO T 191-14 (2022)

TABLE C1410/4: APPLICABLE STANDARD TESTS FOR AGGREGATES AND CONCRETE

CML NO.	NAME OF TEST	TEST METHOD
2.1	Moisture Content of Aggregates	BS 5835-1:1980
2.2	Relative Density and Water Absorption	BS EN 1097-3:1998
2.3	Sieve Tests on Aggregates	BS 812-103.2:1989
2.4	Flakiness Index (FI), Average Least Dimension (ALD)	BS EN 933-3:2012
2.5	Elongation Index	BS 812-105.2:1990
2.7	Ten Percent Fines Value (TFV)	BS 812-111:1990
2.9	Los Angeles Abrasion Test (LAA)	ASTM C535-16
2.10	Sodium Soundness Test (SSS) *	ASTM C88/C88M-24
2.11	Slump Test	BS EN 12350-2:2019
2.12	Making of Concrete Test Cubes	BS EN 12390-1:2021
2.13	Concrete Cube Strength	BS EN 12390-3:2019
2.14	Quality of Water to be used in Concrete *	BS EN 1008:2002
2.15	Polished Stone Value *	BS 812-114:1989 or BS EN 1097-8:2020
2.16	Soluble Chloride Content *	BS EN 1744-1:2009+A1:2012
2.17	Organic Impurities in Sands for Aggregate	AASHTO T 21M/T21-20
2.18	Clay Lumps and Friable Particles in Aggregates	AASHTO T 112-23
2.19	Sand Equivalent	AASHTO T 176-22
2.20	Cement Content	AASHTO T 211-90 (2021)
2.21	Washable Particles	BS 5835-1:1980

TABLE C1410/5: APPLICABLE STANDARD TESTS FOR BITUMINOUS MATERIALS

CML NO.	NAME OF TEST	TEST METHOD
3.1	Preconditioning of Bitumen Samples Prior to Mixing or Testing	NPRA 014 test 14.511
3.2	Density of Bituminous Binders	ASTM D70/D70M-21
3.3	Flash and Fire Point by Cleveland Open Cup	ASTM D92-18
3.4	Rolling Thin-Film Oven Test (RTFOT)	AASHTO T 240-23
3.5	Guide for the Laboratory Evaluation of Modified Asphalt Systems	AASHTO PP 5
3.6	Guide for Grading or Verifying the Performance Grade of an Asphalt Binder	NPRA 014 test 14.511
3.7	Selection of Asphalt Binders	ASTM D70/D70M-21
3.8	Specification for Penetration Graded Asphalt Cement	ASTM D946/946M-20
3.9	Specification for Viscosity Graded Asphalt Cement	ASTM D3381/3381M-18
3.10	Practice for Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)	AASHTO PP 5
3.11	Practice for Sampling Bituminous Material	AASHTO M 320-23
3.12	Solubility of Bituminous Materials in Organic Solvents	AASHTO PPX
3.13	Method for Flash and Fire Points by Cleveland Open Cup	AASHTO T 48-22
3.14	Method for Water in Petroleum Products and Bituminous Materials	AASHTO M 226-80 (2021)
3.15	Test Method for Effect of Heat and Air on Asphalt Materials (Thin-Film Oven Test)	ASTM D2872-22
3.16	Kinematic Viscosity of Asphalts	AASHTO T40 or BS 598-1:2011 and ASTM D2170/D2170M-18
3.17	Viscosity of Asphalts by Vacuum Capillary Viscometer	AASHTO T 44-23
3.18	Test Method for Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR) *	ASTM D6648-08(2016)
3.19	Test Method for Determining the Fracture Properties of Asphalt Binder in Direct Tension (DT) *	ASTM D95-13
3.20	Test Method for Determining Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR) *	ASTM D1754/D1754M-20
3.21	Penetration of Bituminous Materials	ASTM D5/D5M-20
3.22	Softening Point Test	ASTM D36/D36M-14(2020)

CML NO.	NAME OF TEST	TEST METHOD
3.23	Ductility	ASTM D113/D113M-17(2023)e1
3.24	Viscosity Determination using Brookfield Thermosel Apparatus	AASHTO TP3
3.25	Density and Water Absorption of Aggregates Retrieved on a 4.75 mm Sieve	AASHTO T 315-22
3.26	Density and Water Absorption of Aggregates Passing the 4.75 mm Sieve	ASTM D5/D5M-20
3.27	Calibration of Glass Pycnometers (0.5-1 litre)	ASTM D36/D36M-14(2020)
3.37	Sand Equivalent	ASTM D113/D113M-17(2023)e1
3.38	Short Term Ageing	ASTM D4402/D4402M-23
3.40	Distillation of Cut-back Asphaltic Products	ASTM C127-24
3.41	Moisture and Volatile Distillates	ASTM D1461-17(2022)
3.44	Kinematic Viscosity of Asphalts	NPRA 014 test 14.5922
3.45	Viscosity of Asphalts by Vacuum Capillary Viscometer	AASHTO T 202-22

Note: Tests marked by an asterisk may be carried out at an authorised testing laboratory/institute approved by the Engineer, who may also accept manufacturer's specifications and/or certificates of test results

Construction of the Permanent Works shall not be commenced before the Contractor has established the independent laboratory for the Engineer as well as his own laboratory to the satisfaction of the Engineer, including the relevant test equipment.

(c) Engineer's Laboratory Equipment

As stated above the equipment and apparatus shall permit the execution of the AASHTO, ASTM, SANS and BS standard tests mentioned in these Special Specifications. Such tests include, but are not necessarily limited to, those summarised in TABLE C1410/2, TABLE C1410/3 and TABLE C1410/4.

As a minimum the Contractor shall provide and maintain in an excellent state of repair the laboratory equipment listed below in TABLE C1410/5. All equipment shall be a well-known brand as used and available.

However, this list may not be exhaustive and does not preclude the need for the Contractor to provide such further equipment as is necessary for the Engineer to undertake any and all testing procedures he so requires. Such equipment shall be of approved manufacture and shall be for the Engineer's exclusive use. All equipment shall be ready to

use and complete to perform the tests. The laboratory equipment shall be purpose-made for use in soils testing laboratories and shall comply with the relevant British (BS) or American (AASHTO/ASTM) Standards. The equipment supplied, less consumable items used during the Works, shall be retained by the Employer upon completion of the Contract.

Any delays to the Contractor or the Contractor's activities caused by the Engineer being unable to perform survey work or field and laboratory tests due to the Contractor's failure to supply the scheduled equipment in timely fashion and/or to keep it adequately maintained shall be deemed to have been caused entirely by the Contractor's own actions, and any consequence of such delays shall be interpreted accordingly. The Contractor shall also make provision for the occasional use by the Engineer, as and when required, of any of the scheduled equipment during the Defects Liability Period.

TABLE C1410/6: EQUIPMENT AND APPARATUS TO BE PROVIDED FOR THE ENGINEER'S LABORATORY

ITEM	DESCRIPTION	QUANTITY		
		OPTION 1	OPTION 2	OPTION 3
General (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads and Concrete Structures)				
1	Set of ISO 3310-1 stainless steel Sieves diameter 300 mm including, but not limited to, the following aperture sizes: 75.0 mm; 63.0 mm; 50.0 mm; 37.5 mm; 28.0 mm; 25.0 mm; 26.5 mm; 20 mm; 19.0 mm; 16.0 mm; 14.0 mm; 12.5 mm; 10.0 mm; 9.5 mm; 6.3 mm; 5.00 mm; 4.75 mm; 4.0 mm, including lid and receiver.	3 sets	2 set	1 set
2	Set of ISO 3310-1 stainless steel Sieves diameter 200 mm including, but not limited to, the following aperture sizes: 2.36 mm; 2.0 mm; 1.70 mm; 1.18 mm; 1.00 mm; 600 micron; 500 micron; 425 micron; 300 micron; 150 micron; 125 micron; 75 micron, including lid and receiver.	3 sets	2 set	1 set
3	Sieve brush, double-ended nylon	4	2	2
4	200 mm diameter x 200 mm deep washing sieve with 75-micron mesh	2	1	1
5	Sieve shaker, gyratory for 200- and 300-mm dia. sieves	1	1	1
6	Electronic weighing scale/balance, 3.5 kg capacity, 0.1 g accuracy, calibrated with underwater weighing capability	4	2	1
7	Electronic weighing scale/balance, 0.25 kg capacity, 0.01 g accuracy and calibrated	2	1	1
8	Weighing scale/balance, 25 kg capacity, 1 g accuracy and calibrated	2	1	1
9	Drying oven, 225 litre capacity, fan circulated, thermostatically controlled, 220-240 v, 50/60 Hz, single phase with 3 shelves and dial thermometer	3	2	1
10	Warm air-drying unit, 100°C max, 220-240 v, 50/60 Hz, single phase	1	-	-
11	Hotplate, 200 mm diameter, 220-240 v, 50/60 Hz, single phase with Simerstat	4	2	1
12	Hotplate, 300 x 500 mm, digital temperature indicator 0-300 °C, 220-240 v, 50/60 Hz, single phase	1	-	-
13	Glass plates 0.5 x 0.5 x 0.05 m	2	1	1
14	Set of Spatulas, 100 mm blade, 150 mm blade and 200 mm blade	6 sets	3 sets	2 sets
15	Chattaway spatula, 125 mm blade	3	2	1
16	Moisture content tins	100	60	40
17	Sample trays 306 x 306 x 38 mm	10	5	3
18	Sample trays 406 x 406 x 50 mm	10	5	3
19	Sample trays 610 x 610 x 63 mm	6	3	2

ITEM	DESCRIPTION	QUANTITY		
		OPTION 1	OPTION 2	OPTION 3
20	Sample splitter, large capacity, 100 mm down, 28.3 litre hopper capacity	1	-	-
21	Riffle box, steel, 10 mm, 12 slots	2	1	1
22	Riffle box, steel, 25 mm, 10 slots	2	1	1
23	Riffle box, steel, 50 mm, 8 slots	2	1	1
24	Thermometer, min/max, double scale, -20 to +50 °C	4	2	1
25	Thermometer, laboratory mercury, 0 to 110 °C	4	2	2
26	Thermometer, surface, 64 mm diameter, dial 0 to 160 °C	1	1	1
27	Thermometer, electronic portable digital, 0 to 300 °C	2	1	1
28	Thermometer, digital probe, 50 – 300 °C	2	1	1
29	Timing Device	3	2	1
30	Gloves – heat resistant	As required		
31	Gloves – water and chemical resistant	As required		
32	Glass beakers, 100 mm, squat form with spout	6	4	2
33	Glass beakers, 600 mm, squat form with spout	6	4	2
34	Glass beakers, 1000 mm, squat form with spout	6	4	2
35	Measuring cylinder, 100 x 1 ml, soda glass	2	1	1
36	Measuring cylinder, 250 x 2 ml, soda glass	2	1	1
37	Measuring cylinder, 500 x 5 ml, soda glass	2	1	1
38	Measuring cylinder, 1000 x 10 ml, soda glass	2	1	1
39	Measuring cylinder, 100 x 1 ml, plastic	2	1	1
40	Measuring cylinder, 250 x 2 ml, plastic	2	1	1
41	Measuring cylinder, 500 x 5 ml, plastic	2	1	1
42	Measuring cylinder, 1000 x 10 ml, plastic	2	1	1
43	Evaporating dish, 100 mm dia. x 40 mm depth	3	2	1
44	Evaporating dish, 150 mm dia. x 45 mm depth	3	2	1
45	Evaporating dish, 200 mm dia. x 55 mm depth	3	2	1
46	Water test kit for chlorides, alkalinity and hardness	1	1	1
47	Pocket Calculator, Scientific	12	7	3
48	Triangle type 30' and 45' - 300 mm	3	2	1
49	Triangle type 30' and 45' - 150 mm	3	2	1
50	Metric Ruler	12	7	3
51	Large Logbook	12	7	3
52	Pencil Sharpener	12	7	3
53	Protractor, 150 mm	3	2	1
54	Assorted French Curve Set	1	1	1
55	Claw hammer	3	2	1
56	Hammer 1 kg	1	1	1
57	Hammer 2.5 kg	1	1	1
58	Tool kit, multipurpose with box	3	2	1
59	A4 Clip Board	As required		
60	Cross Section paper (Graphiquest Canson) - Pad	1	1	1
61	Slide callipers	1	1	1
62	Micrometre (mm reading)	1	1	1
63	Vacuum Pump	1	1	1
64	Wash bottles	10	6	4
65	Pipettes, 5 ml, 10 ml, 20ml, 50 ml and 100 ml	3 sets	2 sets	1 set
66	Brushes, paint brush type at 100 mm, 50 mm and 25 mm	3 sets	2 sets	1 set
67	Polyethylene bags 40 lt.	As required		
68	Polyethylene bags 10 lt.	As required		
69	Polyethylene bags 2 lt.	As required		
70	Rubber mallet	2 no.	1	1
71	Trowel	5 no.	3	1
72	Pycnometer set suitable for SG and relative density measurement of soils and aggregates to ASTM D854-23	1 set	1 set	1 set
73	Water baths, thermostatically controlled capable of maintaining constant temperatures up to 60°C	2	1	1
74	Scoops, large for aggregate	6	4	2
75	Scoops, medium for sand	6	4	2
76	Bulk Density measures, steel with capacity, 3 litre, 7 litre, 10 litre, 15 litre and 30 litre, all with handles except for 3 litre containers.	1 set	1 set	1 set
77	Field scale 2.6 kg	3	2	1
78	Field scale 20 kg	3	2	1
79	Lubricating oil	As required		
Soil Sampling (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads)				
80	Soil colour chart	1	1	1
81	Soil auger head, 100mm dia., heavy duty steel	1	1	-
82	Soil auger head, 150mm dia., heavy duty steel	1	-	-
83	Soil auger head, Dutch type, 50 mm, heavy duty steel	1	-	-
84	Gravel auger head, 150mm dia., heavy duty steel	1	1	-
	Extension rods, 27mm dia., 1m length for use with auger heads, heavy duty steel			

ITEM	DESCRIPTION	QUANTITY		
		OPTION 1	OPTION 2	OPTION 3
85		10	10	-
86	Stillson wrench, size 14	2	1	-
87	Handle and T-piece for hand boring, heavy-duty steel	2	1	-
88	Jarring link for driving sample tubes	2	1	-
89	Spiral auger, 40 mm dia., one-piece, heavy duty	1	1	-
90	Sample tube, 38 mm dia. x 230 mm long with end caps	10	10	-
91	Adaptor for extension rods	2	1	-
92	Rubber headed pestle and Porcelain mortar suitable for sample reduction	1	1	-
93	Sample extruder, 38 mm dia., hand-operated, hydraulic complete with trimming knife, 38mm split former and cutting tool	1	1	-
94	Sample extruder for 100 mm (including Marshall Asphalt specimens) and 150mm samples including frame and hydraulic jack	1	1	1
95	Moulds, core cutter and collar for 100 mm dia. and 150 mm dia. samples for in-situ dry density and CBR determinations including driving dolly to fit the core cutter and driving rammer	10	6	-
96	Melting pot, 4 litre capacity, 50 - 300°C range suitable for melting paraffin wax or capping compound	1	1	-
Atterberg Limits (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads)				
97	Liquid limit apparatus to ASTM D423-66 with a hard rubber base of shore D value 85-95 @ 23°C, grooving tool and calibrating plate	2	1	1
98	Ground glass plate, 250 mm x 250 mm	2	1	1
99	Shrinkage troughs for bar linear shrinkage tests to SANS 3001-GR10, 25 mm x 25 mm x 150 mm long with paint brush, spatula and dividers with a millimetre scale	10	6	4
Standard Laboratory Compaction (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads)				
100	Compaction hammer, 4.536 kg, drop 457.2 mm, 50.8 mm dia.	3	2	1
101	Compaction hammer, 2.495 kg, drop 304.8 mm, 50.8 mm dia.	3	2	1
102	Moulds, 152.4 mm dia. x 152.4 mm high, with detachable collar and base with a 25.4 mm spacer plate to give an effective mould depth of 127mm	10	6	4
103	Steel straight edge, 300 mm long with a bevelled edge	4	2	1
104	Moulds, 101.6 mm dia. x 116.43 mm high with detachable collar and base plate	6	4	2
Laboratory CBR test (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads)				
105	A hydraulic compression testing machine with a capacity of at least 55 kN load recordable to the nearest 50 N and capable of applying load at a rate of strain of 1.27 mm/min, including a metal circular piston of 50 mm dia. and weighing 4.536 kg	1	1	1
106	Moulds, 152.4 mm dia. x 152.4 mm high, with detachable collar and base with a 25.4 mm spacer plate to give an effective mould depth of 127 mm and perforated soaking base plates (also see item 87)	10	6	4
107	Annular 4.536 kg surcharge weights used during soaking	10	6	4
108	Annular 5.56 kg surcharge weights for use during penetration	10	6	4
109	1.024 kg perforated plates with adjustable stems	10	6	4
110	A tripod for measuring swell	10	6	4
111	Dial gauges or equivalent reading 0.01 mm with a range of 25 mm	12	8	6
112	Dial gauge or equivalent with 0.127 mm divisions, range 25 mm and 1.27 mm per revolution	2	2	2
113	Filter paper (CBR) in packs of 100	10	6	4
114	Copper or brass gauze discs of 30 mesh and 170 mm dia.	10	6	4
115	Galvanised iron mixing bath, 450 mm x 650 mm x 200 mm deep	1	1	1
116	Soaking bath, 300 mm deep	1	1	1
Dynamic Cone Penetrometer (DCP) (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads)				
117	Dynamic Cone Penetrometer, complete with 10 No threaded extension rods, 5 No. spare cones and carrying case	2 sets	1 set	1 set
118	DCP software package	1	1	1
Dry Density – Sand Replacement (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads)				
119	Sand density device/funnel/bottle with accessories including a density ring with a 152 mm dia. hole for ASTM D1556 or AASHTO T 296-22 and T 297-94 (2016)	2	1	1
120	Sand suitable for calibration	As required		
121	Calibration sieves, 0.425 mm and 0.25 mm	1 set	1 set	1 set
122	Basin 400 mm dia.	1	1	1
123	Cylindrical calibration container, internal diameter and height 152 mm	1	1	1
124	Glass plate, 180 mm x 180 mm x 7 mm thick	1	1	1
125	Hammer, 2 kg	2	1	1
126	Chisel, cold steel 25 mm	2	1	1
127	Tablespoons	4	2	2
128	Containers, tins of 5 litre capacity	10	6	4
Density and Moisture Content - Nuclear Method (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads)				
129	Particular Specification. Only to be provided on approval by the Employer	-	-	-

ITEM	DESCRIPTION	QUANTITY		
		OPTION 1	OPTION 2	OPTION 3
Aggregate Testing (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads and Concrete Structures)				
130	Aggregate Impact Value Device to BS 812-112:1990, including cylinder and tamping rod	1	1	1
131	Compression machine, hydraulic, capable of applying a load of 400 kN at a uniform rate so that the load can be reached in 10 min suitable for Aggregate Crushing Value (ACV) and 10% Fine Aggregate Crushing Test (10% FACT) testing, including an open-ended steel cylinder of 150 mm dia. with plunger and base plate, a cylindrical measure of 155 mm x 180 mm deep and a metal tamping rod 16 mm dia. 500 mm long with a hemispherical end.	1	1	-
132	Flakiness index gauge of metal 1.6 mm thick having rectangular slots for each size fraction of aggregate to be tested	1	1	1
133	Average Least Dimension (ALD) Device	1#	-	-
134	Los Angeles Abrasion Machine including charges	1*	-	-
135	Durability Mill, including charges	1*#	-	-
* Except for gravel surface roads # Except for Concrete Structures				
Concrete Testing (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads and Concrete Structures)				
136	Compression machine, hydraulic, capable of applying a load of 2000 kN at a uniform rate. (NB One (1) universal compression machine could be considered for aggregate testing, concrete cube testing and CBR testing on approval by the Engineer)	1	1	1
137	Concrete test cube moulds 150 mm x 150 mm x 150 mm, including tamping bars/rods	24.(50)	12 (30)	6 (20)
138	Curing tanks, thermostatically controlled, minimum 600 mm square and 500 mm deep	4 (6)	2 (4)	1 (2)
139	Coring device with the capability of taking 100 mm and 150 mm diameter cores from cementitious and bituminous materials	1@	-	-
140	Cylinder moulds 100 mm diameter x 200 mm long for ITS and UCS testing	6@	3@	-
141	Cylinder moulds 150 mm diameter x 300 mm long for ITS and UCS testing	6@	3@	-
142	Slump test device, cone and tamping rod	2 (4)	1 (2)	1 (2)
143	Concrete Test Hammer (Schmidt Hammer or similar)	1	-(1)	-(1)
144	Straight edge	3	2	1
145	Steel ruler	3	2	1
@ Only in case of Asphalt Concrete Roads () Values in brackets are exclusively for concrete structures				
Sand Equivalent Test (Asphalt Concrete Roads; Surface Sealed roads; Gravel Surfaced Roads and Concrete Structures)				
146	Sand Equivalent Test Set	1	1	1
147	Sand Equivalent Stock Solution (1 kg)	10.	10	10
Asphalt Concrete Testing (Asphalt Concrete Roads)				
148	Bitumen extraction machine, centrifuge type, 3000 gm capacity, electrically operated having Dimmerstat for controlling speed from 2400 to 3600 rpm with a pack of Filter Paper (50 Circles)	1	1	1
149	Beakers for above	6 no.	6	6
150	Solvent	as required		
151	BI-metal thermometer (0 - 300 °C) 100 and 300 mm	6 no.	4	2
152	Electrical thermometer (0 -300 °C)	2 no.	1	1
153	0.10 m core drilling machine with 12 core drills	1 no.	-	-
Sampling and Testing Bituminous Materials (Asphalt Concrete Roads)				
154	0.5 lt. Sample Can	24	12	6
155	0.5 lt. Small Mouth Can	24	12	6
156	Bitumen Penetrometer with 5 needles and sample holders	1	1	1
157	Softening point devices including a heating system	1	1	1
158	Brookfield viscometer and associated apparatus	1	-	-
159	Rolling Thin Film Oven and associated apparatus	1	-	-
Marshall Test (Asphalt Concrete Roads)				
160	Bench Mixer, 5 lt capacity with bowl heater and whisk	1	1	1
161	Stirring Rod	2	1	1
162	Automatic Marshall compaction machine with hammer and pedestal	2	1	1
163	Marshall compaction moulds complete	12	6	4
164	Filter paper for moulds	As required		
165	Compression Machine, hydraulic, 50 kN capacity with calibrated load rings, flow and stability gauges and stability breaking head	1	1	1
166	Sample ejecting device	1	1	1
167	Thermostatically controlled Standard Water Bath to 60°C	1	1	1
168	Balance, water container and basket for bulk relative density and void contents of compacted bitumen mixtures	1	1	1
SuperPave equipment or similar for design and performance testing of Asphalt mixes (Asphalt Concrete Roads)				
169	Particular Specifications. Only to be provided on approval by the Engineer.	-	-	-

(d) Time for Erection of the Engineer's Laboratory

The Engineer's laboratory, laboratory office and kitchen complete with furniture and equipment shall be provided within 3 months of the Notice to Commence the Works. Suitable temporary facilities shall be provided by the Contractor for the Engineer's laboratory staff until the permanent facilities become available for use.

However, the construction of any permanent works will not be permitted until the Engineer's mobile laboratory has been accepted by the Engineer as complete and laboratory staff are able to function effectively regarding the proposed works to be undertaken.

Should the Contractor fail to hand over the offices and laboratories within the period specified, the Engineer may make such alternative arrangements as he considers necessary. These arrangements may include the use of rented accommodation and/or the hire or purchase of caravans, portacabins, etc. and laboratory equipment to allow testing of the works. The Contractor will be responsible for all costs of such temporary arrangements made by the Engineer, including those of additional transport if required. While the Engineer's Laboratory remains incomplete:

- i) No payment will be made under ITEM 14.09 (b); and
- ii) 3% of ITEM 14.09(A) will be permanently deducted for each month or part thereof after the first three months following the Notice to Commence the Works.

1411 ENGINEER'S NORMAL WORKING HOURS

The Engineer's normal working hours are from 08:00 hours to 17:00 hours on Monday to Friday and from 08:00 to 13:00 on Saturdays. Should the Contractor wish to execute work which is part of the Permanent Works outside of the Engineer's normal working hours he shall gain approval from the Engineer before doing so. The work forming the Permanent Works shall be supervised by the Engineer and hence should the Engineer approve that the Contractor should continue his operations outside the Engineer's normal working hours, the Contractor shall make available and pay overtime for all staff provided by the Contractor to the Engineer as well as reimburse the Engineer for overtime payments to his staff within 30 days of receiving a request for payment from the Engineer. This request from the Engineer for reimbursement shall include an additional 15% for administrative overheads.

Should the Contractor wish to execute work on a regular basis outside the Engineer's normal working hours or over an extended period, or on additional unprogrammed work fronts, the Engineer, if he deems it to be necessary shall employ additional supervisory staff. The Contractor shall reimburse the Engineer for the salaries, accommodation and any extra vehicle or other costs incurred by the Engineer for such additional supervisory personnel within 30 days of receiving a request for payment from the Engineer. Administrative overheads shall be included in this request for reimbursement.

1412 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
14.01 HOUSES FOR THE ENGINEER:	
(a) PROVIDE TYPE I HOUSE FULLY FURNISHED AND EQUIPPED FOR THE ENGINEER	No.
(b) PROVIDE TYPE II HOUSE FULLY FURNISHED AND EQUIPPED FOR THE ENGINEER	No.
(c) PROVIDE TYPE III HOUSE FULLY FURNISHED AND EQUIPPED FOR THE ENGINEER	No.
(d) PROVIDE MULTIPLE ACCOMMODATION UNITS FULLY FURNISHED AND EQUIPPED FOR THE ENGINEER	No.
(e) PROVIDE FULLY FURNISHED AND EQUIPPED TEMPORARY ACCOMMODATION FOR THE ENGINEER	No.
(f) PROVIDE FULLY FURNISHED AND EQUIPPED TEMPORARY OFFICE ACCOMMODATION FOR THE ENGINEER	MAN MONTH
(g) MAINTAIN AND PAY ALL RENTS AND MUNICIPAL SERVICES FOR TYPE I HOUSE FULLY FURNISHED AND EQUIPPED FOR THE ENGINEER	(HOUSE UNIT) X (MONTH)
(h) MAINTAIN AND PAY ALL RENTS AND MUNICIPAL SERVICES FOR TYPE II HOUSE FULLY FURNISHED AND EQUIPPED FOR THE ENGINEER	(HOUSE UNIT) X (MONTH)
(i) MAINTAIN AND PAY ALL RENTS AND MUNICIPAL SERVICES FOR TYPE III HOUSE FULLY FURNISHED AND EQUIPPED FOR THE ENGINEER	(HOUSE UNIT) X (MONTH)
(j) MAINTAIN AND PAY ALL RENTS AND MUNICIPAL SERVICES FOR MULTIPLE ACCOMMODATION UNITS FULLY FURNISHED AND EQUIPPED FOR THE ENGINEER	(HOUSE UNIT) X (MONTH)
(k) MAINTAIN AND PAY ALL RENTS AND MUNICIPAL SERVICES FOR FULLY FURNISHED AND EQUIPPED TEMPORARY ACCOMMODATION AND OFFICES FOR THE ENGINEER	(HOUSE UNIT) X (MONTH)

All SUB-ITEMS 14.01 (a) to (k) shall be applied in the case where the houses, furniture and equipment revert to the Employer upon completion of the Contract.

Only SUB-ITEMS 14.01 (f) to (k) shall be applied in the case where the houses, furniture and equipment revert to the Contractor upon completion of the Contract.

<u>ITEM</u>	<u>UNIT</u>
14.02 OFFICES FOR THE ENGINEER	
(a) PROVIDE FULLY FURNISHED AND EQUIPPED OFFICES FOR THE ENGINEER	No.
(b) MAINTAIN AND PAY ALL RENTS AND MUNICIPAL SERVICES FOR FULLY FURNISHED AND EQUIPPED OFFICES FOR THE ENGINEER	(OFFICE UNIT) X (MONTH)

Both SUB-ITEMS 14.02 (a) and (b) shall be applied in the case where the houses, furniture and equipment revert to the Employer upon completion of the Contract.

Only SUB-ITEM 14.02 (b) shall be applied in the case where the houses, furniture and equipment revert to the Contractor

upon completion of the Contract.

<u>ITEM</u>	<u>UNIT</u>
14.03 WASH HOUSE FOR THE ENGINEER:	
(a) PROVIDE AND MAINTAIN FULLY FURNISHED AND EQUIPPED WASH HOUSE FOR THE ENGINEER	No.
(b) MAINTAIN AND PAY ALL RENTS AND MUNICIPAL SERVICES FOR FULLY FURNISHED AND EQUIPPED WASH HOUSE FOR THE ENGINEER	(WASH HOUSE UNIT) X (MONTH)

Both SUB-ITEMS 14.03 (a) and (b) shall be applied in the case where the houses, furniture and equipment revert to the Employer upon completion of the Contract.

Only SUB-ITEM 14.03 (b) shall be applied in the case where the houses, furniture and equipment revert to the Contractor upon completion of the Contract.

<u>ITEM</u>	<u>UNIT</u>
14.04 SITE CABIN/OFFICE FOR THE ENGINEER:	
(a) PROVIDE FULLY FURNISHED AND EQUIPPED SITE CABIN / OFFICE FOR THE ENGINEER	No.
(b) CABIN / OFFICE FOR THE ENGINEER MAINTAIN AND PAY ALL RENTS AND MUNICIPAL SERVICES FOR FULLY FURNISHED AND EQUIPPED SITE	(SITE CABIN /OFFICE UNIT) X (MONTH)

Both SUB-ITEMS 14.04 (a) and (b) shall be applied in the case where the houses, furniture and equipment revert to the Employer upon completion of the Contract.

Only SUB-ITEM 14.04 (b) shall be applied in the case where the houses, furniture and equipment revert to the Contractor upon completion of the Contract.

<u>ITEM</u>	<u>UNIT</u>
14.05 FOUR WHEEL DRIVE STATION WAGON FOR THE ENGINEER/ THE EMPLOYER:	
(a) PROVIDE VEHICLES FOR THE ENGINEER (SPECIFY TYPE AND NUMBER)	No.
(b) PROVIDE VEHICLES FOR THE EMPLOYER (SPECIFY TYPE AND NUMBER)	No.
(c) OPERATE AND MAINTAIN VEHICLES (SPECIFY TYPE AND NUMBER) FOR AN AVERAGE OF 3,000 KM PER MONTH	VEHICLE X MONTH
(d) OPERATE VEHICLES SPECIFIED FOR TRAVEL DISTANCE IN EXCESS OF AVERAGE 3,000 KM PER MONTH	KILOMETRE S (km)

All SUB-ITEMS 14.05 (a) to (d) shall be applied in the case where the vehicles revert to the Employer upon completion of the Contract.

Only SUB-ITEMS 14.05 (c) and (d) shall be applied in the case where the vehicles revert to the Contractor upon completion of the Contract.

The station wagon(s) for the Employer may be based in the head office/ regional office of the implementation agency and should be serviced at the nearest available authorized service centre to the place where the vehicle is based rather than on site. The Contractor shall arrange an account with the dealer for the make of vehicle supplied for servicing, repairs and maintenance of the vehicle. The Contractor shall

also arrange an account with a filling station at the place where the vehicle is based for the supply of fuel for the vehicle. Reimbursement will be made under SUB-ITEM 14.05 (c).

<u>ITEM</u>	<u>UNIT</u>
14.06 FOUR WHEEL DRIVE DOUBLE CAB PICK-UP FOR THE ENGINEER/ THE EMPLOYER	
(a) PROVIDE VEHICLES FOR THE ENGINEER (SPECIFY TYPE AND NUMBER)	No.
(b) PROVIDE VEHICLES FOR THE EMPLOYER (SPECIFY TYPE AND NUMBER)	No.
(c) OPERATE AND MAINTAIN VEHICLES (SPECIFY TYPE AND NUMBER) FOR AN AVERAGE OF 3,000 KM PER MONTH	VEHICLE X MONTH
(d) OPERATE VEHICLES SPECIFIED FOR TRAVEL DISTANCE IN EXCESS OF AVERAGE 3,000 KM PER MONTH	KILOMETRES (km)

All SUB-ITEMS 14.06 (a) to (d) shall be applied in the case where the vehicles revert to the Employer upon completion of the Contract.

Only SUB-ITEMS 14.06 (c) and (d) shall be applied in the case where the vehicles revert to the Contractor upon completion of the Contract.

The double cab pick-up(s) for the Employer may be based in the head office/regional office of the implementation agency and should be serviced at the nearest available authorized service centre to the place where the vehicle is based rather than on site. The Contractor shall arrange an account with the dealer for the make of vehicle supplied for servicing, repairs and maintenance of the vehicle. The Contractor shall also arrange an account with a filling station at the place where vehicle is based for the supply of fuel for the vehicle. Reimbursement will be made under SUB-ITEM 14.06 (c).

<u>ITEM</u>	<u>UNIT</u>
14.07 SURVEY EQUIPMENT FOR THE ENGINEER	
(a) PROVIDE SPECIFIED SURVEY EQUIPMENT FOR THE ENGINEER	LUMP SUM
(b) MAINTAIN SPECIFIED SURVEY EQUIPMENT FOR THE ENGINEER	MONTH
(c) PROVIDE LABOURERS FOR SURVEY	No. X MONTH

All SUB-ITEMS 14.07 (a), (b) and (c) shall be applied in the case where the survey equipment reverts to the Employer upon completion of the Contract.

SUB-ITEM 14.07 (b) and (c) shall be applied in the case where the survey equipment reverts to the Contractor upon completion of the Contract.

The rates entered for labourers under SUB-ITEMS 14.07 (c) shall include for all overtime as required by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
14.08 LABORATORY FOR THE ENGINEER	
(a) PROVIDE LABORATORY FULLY FURNISHED FOR THE ENGINEER	LUMP SUM
(b) MAINTAIN LABORATORY FULLY FURNISHED FOR THE ENGINEER	MONTH

Both SUB-ITEMS 14.08 (a) and (b) shall be applied in the case where the laboratory and furniture revert to the Employer upon completion of the Contract.

Only SUB-ITEM 14.08 (b) shall be applied in the case where

the laboratory and furniture revert to the Contractor upon completion of the Contract.

<u>ITEM</u>	<u>UNIT</u>
14.09 LABORATORY EQUIPMENT FOR THE ENGINEER	
(a) PROVIDE SPECIFIED LABORATORY EQUIPMENT FOR THE ENGINEER	LUMP SUM
(b) MAINTAIN SPECIFIED LABORATORY EQUIPMENT FOR THE ENGINEER	MONTH
(c) PROVIDE MISCELLANEOUS UNSPECIFIED LABORATORY EQUIPMENT	PROVISIONAL SUM
(d) CONTRACTOR'S PROFIT AND OVERHEADS AS A PERCENTAGE OF SUB-ITEM 14.09 (c)	PERCENT (%)
(e) PROVIDE LABOURERS FOR LABORATORY	NO. X MONTH

Both SUB-ITEMS 14.09 (a) and (b) shall be applied in the case where the laboratory equipment reverts to the Employer upon completion of the Contract.

Only SUB-ITEM 14.09 (b) shall be applied in the case where the laboratory equipment reverts to the Contractor upon completion of the Contract.

SUB-ITEM 14.09 (c) shall be applied in the case where any surplus equipment is required which is not specified in the list of laboratory equipment in the contract and should revert to the Employer upon completion of the Contract.

The rates entered for labourers under SUB-ITEM 14.09 (e) shall include for all overtime as required by the Engineer.

Payment for providing, laboratory, and survey equipment, for the Engineer's Representative will be made at the Lump Sum entered in the Bill of Quantities, for each single item of each type, on the following basis:

- i) 80% of the Lump Sum when the respective facilities are completed, and accepted by the Engineer, fully furnished and equipped.
- ii) 20% of the Lump Sum will be paid at the end of the Contract period.

Payment for operating and maintaining vehicles under ITEMS 14.05 and 14.06, SUB-ITEMS (b) and (c) above, for the Engineer, their staff and the Employer, will be made as follows:

- i) By rates per vehicle month, SUB-ITEM (b). Such rates shall include for the first 3,000 km per vehicle travelled in any calendar month. Should a vehicle be used for less than 3,000 km in a particular month, then the unused distance shall be offset against months when the distance travelled exceeds 3,000 km.
- ii) By a rate per km, SUB-ITEM (c), over and above the first 3,000 km per vehicle travelled in any one calendar month, subject to the condition mentioned in above.

The rates bid by the Contractor shall include for provision of the vehicle all licensing, insurance, fuel, lubricants, maintenance and repairs, drivers' salaries overtime and allowances and replacement of the vehicles should this be considered necessary by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
14.10 HOTEL ACCOMMODATION FOR THE ENGINEER AND THEIR STAFF	
(a) COST OF HOTEL ACCOMMODATION FOR THE ENGINEER AND APPROPRIATE STAFF WHILST ON OFFICIAL BUSINESS OUT OF STATION	PROVISIONAL SUM
(b) CONTRACTOR'S PROFIT AND OVERHEADS AS A PERCENTAGE OF SUB-ITEM 14.10 (A)	PERCENT (%)

<u>ITEM</u>	<u>UNIT</u>
14.11 COMMUNICATION FACILITIES FOR THE ENGINEER	
(a) PROVIDE INTERNET ACCESS	LUMP SUM
(b) MONTHLY SUBSCRIPTIONS FOR INTERNET ACCESS	MONTH
(c) AIRTIME FOR MOBILE TELEPHONES	PROVISIONAL SUM
(d) PROVIDE MOBILE TELEPHONES	PROVISIONAL SUM
(e) CONTRACTOR'S PROFIT AND OVERHEADS AS A PERCENTAGE OF SUB-ITEMS 14.11 (C) AND (D)	PERCENT (%)

<u>ITEM</u>	<u>UNIT</u>
14.12 SKILLS DEVELOPMENT AND KNOWLEDGE TRANSFER	
(a) PAYMENT FOR SKILLS DEVELOPMENT AND KNOWLEDGE TRANSFER	
(i) GRADUATE TRAINEES	PROVISIONAL SUM
(ii) CONTRACT MANAGEMENT TEAM	PROVISIONAL SUM
(b) CONTRACTOR'S PROFIT AND OVERHEADS AS A PERCENTAGE OF SUB-ITEM 14.12 (A)	PERCENT (%)

The Contractor shall pay the costs for the graduate trainees on a monthly basis and within 14 days of receipt of invoice. The Contractor shall be reimbursed under ITEM 14.12.

Payment for vehicles, including motorcycles, will be made on the following basis:

- i) Payment for the provision of vehicles will be made when the vehicle is received by the Engineer fully equipped as specified in CLAUSE 1407.
- ii) Operation and maintenance will be reimbursed both on a time related cost (e.g. tax, insurance) and a travel related cost (e.g. fuel, lubricants, spares, servicing).

The bid rates for vehicles shall include for provision of the vehicle, all licensing, insurance, fuel, lubricants, maintenance and repairs, drivers' salaries overtime and allowances, and replacement of the vehicles should this be considered necessary by the Engineer.

The Contractor shall reimburse the Employer for the cost of graduate trainee engineers within 14 days of receipt of invoice. The Contractor shall be reimbursed under ITEM 14.12.

SERIES 1000: GENERAL

SECTION 1500: ACCOMMODATION OF TRAFFIC**CONTENTS:**

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1501 SCOPE

This Section covers the construction and maintenance of the necessary diversions and detours, barricades and signs, and everything necessary for the safe and easy passage of all public traffic during the construction and maintenance periods, as well as the obliteration of diversions as they become redundant.

This Section also covers the maintenance of the existing project roads for public traffic where possession of the Site is given to the Contractor in accordance with the Conditions of Contract; and the construction and/or maintenance of hauling and access roads in the project.

1502 GENERAL REQUIREMENTS

It is the intention of the Contract that traffic should be able to conveniently pass along the road to be upgraded at all times during construction under all weather conditions. The Contractor shall be responsible for providing a good quality access to the public through or around the Works, which is in good motorable condition. The Contractor shall be at liberty to pass traffic through the Works.

The Contractor shall be aware that maintenance of existing, as well as diversion roads, and protection of traffic through the Works during construction, is considered of equal importance to the actual construction. The Contractor shall at all times conduct his operations in a manner to ensure the convenience and safety of motorists, pedestrians and adjoining property owners as well as the safety of his own employees and those of the Engineer.

No vehicle shall be held up by the Contractor's work for more than ten (10) minutes at any one working area, except at river crossings where the construction of a service road is practically impossible.

The existing road reserve shall be handed over to the Contractor in sections (separate lengths of road) for maintenance purposes in accordance with the requirements of the work's programme and as agreed, unless otherwise specified by the Engineer. Road sections for which the Contractor has occupation shall be maintained to the satisfaction of the Engineer.

Unless otherwise specified in the contract, at least thirty (30) days prior to commencement of the Works, the Contractor shall prepare and submit to the Engineer for approval, a Traffic Management Plan (TMP) which will ensure the safe and easy passage of public and construction traffic through or around the Works at all times.

The Contractor shall:

- Provide safety education and workshops to the staff, operators, drivers and employees of the Contractor, Sub-Contractors, Engineer and suppliers. The local police and local Labour Officers should also be invited to participate;
- Make every effort to minimise road safety hazards and inconveniences to other road users, resulting from the passage of his or his sub-contractor's haulage vehicles and construction equipment;
- Impose and enforce compliance with speed limits, especially at active construction sites and in rural towns;
- Ensure that all diversions and detours used for the works shall be watered at least three (3) times a day during the dry season to suppress dust for health and safety reasons.

The Contractor shall prepare and submit a TMP for the entire, or agreed sections, of the road. The TMP shall be prepared based on latest version of the Road Safety Audit Manual issued by the Ministry of Works and Transport (THE REPUBLIC OF UGANDA) and include all the requirements stated in SECTION 1500. The Plan shall be submitted to the Engineer for approval and final acceptance by the Employer.

The Plan should consider, but shall not be limited to, provision of the following:

- Diversions with suitable and reflective road signs;
- Barricades, delineators and flagmen to guide the traffic: For regulation of traffic, the flagmen shall be equipped with red and green flags;
- At night, the passage shall be delineated by reflectors or other similar suitable materials;
- Deep cuts of the ground or road surface more than 500 mm at any location accessible by road users shall be protected to avoid any potential accidents;
- Alternative pedestrian routes where these are interrupted;
- Clear, suitably labelled and meaningful traffic signs and speed limits, especially at designated road crossings for people and animals;
- One-way traffic operation where the traffic is to be passed over part of the carriageway inadequate for two lane traffic. This should only be considered where the topographical and environmental restrictions do not allow widening of the works road sections or provision of any diversions. This should be done with the help of temporary traffic signals or flagmen;
- Traffic awareness workshops, especially at schools, churches and other community meeting places at agreed times during the construction works, but at least at the start and end of each school semester;
- Accident protection structures (e.g. concrete slabs) painted with reflective paint and placed at

schools, churches and other community gathering areas which are close to the road reserve.

The key summary of the TMP shall be distributed to the entire staff, operators, drivers and employees of the Contractor, Sub-Contractor, Engineer and suppliers. The Contractor shall also conduct a "Safety Awareness and Enhancement meeting" every week at a pre-fixed date and time for attendance by the entire staff, operators, drivers and employees of the Contractor, Sub-Contractor, Engineer and suppliers.

The Contractor shall not commence any work prior to the approval of the detailed TMP by the Engineer and before completing a series of initial external and internal "Safety Workshops" as approved by the Engineer.

The Contractor shall plan for maintaining the flow of through traffic at all times. In exceptional circumstances road closures of up to one (1) hour duration may be permitted by the Engineer or as specified in the contract. The Contractor shall give reasonable notice of any proposed road closures and shall comply with all regulations relating to the temporary closure of the road.

On completion of a day's work the Contractor shall leave the Works in a condition that allows the safe passage of through traffic.

Should the road width be restricted or should there be any form of obstruction or danger to traffic, the Contractor shall supply adequate flagmen, signs, barriers, lights, communications and staff to ensure that the traffic is safely conducted through the Works.

Non-compliance by the Contractor to ensure that traffic is accommodated safely may result in suspension of the Works by the Engineer in accordance with the Conditions of Contract, until the Engineer is satisfied that all necessary safety measures are in place.

(a) Handing Over the Site

The Site will be handed over to the Contractor in the lengths and sequence specified in the Special Specifications. Where no other provision is made in the Special Specification, the Contractor will be given possession of the Site in sections in accordance with the approved Performance Programme, sufficiently ahead of road construction works to enable diversions to be constructed in good time and to the Engineer's satisfaction.

(b) Providing Diversions

Except where the existing road is to remain in use for through traffic, the Contractor shall provide, construct or put in order such diversions as may be provided for deviating traffic from such sections of the road as are handed over to them.

(c) Passage of Public Traffic

The Contractor shall be responsible for the safe and easy passage of public traffic past or over sections of roads of which they have occupation. The Contractor shall at all times in all their operations and in using their constructional equipment take the necessary care to protect the public and to facilitate the flow of traffic.

Further, the passage of public traffic on sections of a road may be allowed prior to the "Taking-Over Certificate" where this is clearly in the interest of the public and the traffic can be accommodated on the road surface in a safe manner without damage to structures or pavement layers and without undue disruption of the Contractor's work. The Contractor shall be responsible for the control of public traffic over such sections, including temporary traffic control facilities, as provided in CLAUSE 1503.

(d) Minimum Vertical Clearance

The minimum vertical clearance over any section of a diversion shall be 5 m.

(e) Property and Survey Beacons

Where possible, diversions shall be constructed so as not to damage or displace property or trigonometrically surveyed beacons. In exceptional cases where this is not possible, the Contractor shall notify the Engineer in good time so that they may arrange to have them suitably referenced before they are displaced.

(f) Access to Properties

The Contractor shall also provide and grant access to persons whose properties fall within or adjoin the area over which they are working, and in this respect the Contractor's attention is drawn to the Conditions of Contract.

(g) Approval of Diversions

The need for details concerning all diversions shall be approved by the Engineer before the construction of such diversions commences, and the Contractor shall satisfy themselves before bidding that they can make arrangements in respect of any diversions as may be necessary for the safe and convenient passage of traffic.

(h) Temporary Works

The diversions provided by the Contractor shall include the construction of temporary gates, grid gate, fences, drainage works and other incidentals considered by the Engineer to be necessary.

Prior to commencement of the temporary Works, the Contractor shall submit drawings for the approval of the Engineer. In the case of temporary traffic diversions, these shall include but not be limited to:

- Pavement type and width;
- Pedestrian facilities, if any and access to adjacent properties;
- Length of diversion and the expected duration of its use
- Access and egress arrangements;
- Temporary drainage arrangements;
- Temporary traffic control, signage and markings.

(i) Public Services

The Contractor, in co-operation with the Engineer, shall make arrangements for all public services such as power lines, telephone lines, water mains, etc, to be moved where required for the construction of diversions and they shall be solely responsible for the safety of such services. No payment will be made for any additional expenses caused by delays in moving such services. Where the moving of services is not required, the Contractor shall clearly indicate where such services cross the diversion so that these points will be clearly visible to the operating staff.

The Contractor's attention is drawn to SUB-CLAUSE 1202 (d) of the Specifications as regards to relocation of existing services that, in certain instances, may only be relocated after the Contractor has advanced sufficiently. The Contractor's Programme of Works must allow enough time for relocation of such existing services.

(j) Safety Officer

The requirement for a safety officer is specified in SUB-CLAUSE 1803 (d). The Contractor shall provide the safety officer with the necessary resources to enable him to carry out his duties efficiently. The safety officer shall liaise directly with the Engineer regarding matters related to the control of traffic.

The safety officer shall, inter alia, control and co-ordinate the movement of construction vehicles, be responsible for training the Contractor's staff in terms of road safety, ensure that reflective clothing is worn by all employees working on or near public roads, be responsible for implementing actions requested by the traffic authorities with regard to the work to be carried out, be responsible for the erection and maintenance of all traffic signs necessary for the accommodation of traffic, ensure that all obstructions related to the Contractor's activities are removed before nightfall every day, and ensure that the roads are safe for night traffic. He shall also be available after hours if required to rectify problems or deal with emergencies.

The safety officer shall have specific responsibility in ensuring that temporary traffic accommodation requirements comply with the Specifications;

The safety officer shall ensure that the Contractor's staff are fully trained regarding traffic mobility and safety issues and informed of the requirements of this clause before any road closure is made.

No payment will be made for the site safety officer. The rates tendered for SECTION 1500 shall be deemed to include full compensation for all costs pertaining to the site safety officer and his duties.

1503 TEMPORARY TRAFFIC CONTROL FACILITIES

(a) Programme for Control of Traffic

Following the award of the Contract, the Contractor shall submit to the Engineer a detailed Traffic Control Plan. Such a Plan shall be approved by the Engineer before the Contractor commences work, and shall show amongst other things the method of protection of the public and give details of the hours of operation, location, types and numbers of traffic safety devices, barricades, warning signs, flagmen and the like. The Traffic Control Plan shall be in accordance with and complementary to the Programme of Works submitted under SECTION 1200 above. In developing this Traffic Control Plan, the Contractor shall liaise with the police and the competent national and local authorities to obtain information and data. The Engineer will seek the consent of the Employer and other Authorities prior to giving his approval and the Contractor shall not commence any operations that might interfere with the free movement of traffic until such approval is granted.

In the preparation of this Traffic Control Plan, the Contractor should take into consideration the following:

- The Contractor shall conduct their operation in such a manner that no greater length or amount of work is undertaken than they can carry out efficiently having due regard to the rights and convenience of the public.
- If the Contractor proposes a road closure they shall provide an alternative routing of the traffic, which must be approved by the Engineer.
- No revisions shall be made to the approved Traffic Control Plan without the prior written permission of the Engineer, and the Contractor shall allow 14 days for the Engineer to review any request for a revision of the Traffic Control Plan.
- The Traffic Control Plan shall conform in all respects with the requirements of this Specification.
- Traffic control signs shall be erected in accordance with the requirements of the Traffic Police and to the satisfaction of the Engineer and in accordance with the latest edition of the "Ministry of Works and Transport Traffic Signs Manual" supplemented by the latest edition of the "Traffic Signs Manual Chapter 8, Road works and

temporary situations", Department for Transport (UK).

- Provide improved refuges and arrangements for pedestrians, including appropriate designed crossings.
- Provide safe visible area for road-side stalls, parking and pick-up areas for semi-collective transport services.
- Limit speed to a maximum of 40 km/h within all working areas or as contained in the Traffic Control Plan.

(b) Traffic Control Devices

Traffic control devices involve, but are not restricted to, the use of flagmen, traffic lights, portable STOP and GO signs or STOP and SLOW signs, and all temporary traffic management signs, whichever may be the most suitable methods under prevailing circumstances. The traffic control devices and all temporary traffic control signs should conform to standard international signage complying with BS EN 13422:2019, BS EN 12368:2024, ASTM D3350:2014 or equivalent.

The type of construction, spacing and placement of traffic control facilities shall be in accordance with the prescriptions and recommendations of the latest editions of the Safety at Roadworks Code of Practice and the Traffic Signs Manual. The Contractor shall present suitable proposals for the approval of the Engineer. The various traffic control facilities which may be required are the following, or as directed by the Engineer:

i) Road Signs and Barricades

Road signs shall comply with the requirements of SECTION 5400.

ii) Channelisation Devices and Barricades

Channelisation devices shall include cones, delineators and drums. Barricades include barrier lattices, movable barricades or other types approved by the Engineer.

Steel drums shall be cut, painted in black and white stripes and provided with reflective tape strips. Drums shall be kept in position with ballast of sand or soil. Stones shall not be used for this purpose. Drums shall be maintained in a clean and serviceable condition.

iii) Barriers

Barriers for preventing vehicles from leaving the permitted lanes may consist of guardrails on both sides, steel drums for separating two opposite traffic streams, movable concrete barriers (New Jersey type), plastic HDPE barriers (sand-filled or water-filled), or ordinary guardrails which comply with the provisions of SECTION 5200.

iv) Warning Devices and Illuminated Traffic Signs

Warning devices and illuminated traffic signs are essential for ensuring visibility and safety, especially during night-time or low-light conditions. They shall be operated automatically, by radio or manually in a proper manner by adequately trained staff. They include, but are not limited to, the following:

- Flashing Illuminated Arrow Board: made up of LED light sources powered by battery or other suitable means, mounted on a backing board.
- Illuminated Road Signs: Made up of LED light sources powered by battery or other suitable means. The illuminated colours must match the regulation sign colours specified in the traffic signs manual.
- Mobile Variable Message Sign: Mounted on a trailer and located in a safe position where it can easily be seen by the travelling public. It is used to provide information regarding the road and/or traffic conditions ahead.
- Sign Mounted flashing lights: consisting of two rectangular amber flashing lights, each at least 120

mm wide x 45 mm high using 10 W LEDs. The lights shall be visible from a distance of at least 800 m.

- **Warning Flags:** Made from durable, bright red material, and shall be square with a minimum side length of 600 mm. The flag shall be attached to a flagpole staff at least 1m in length.
- **LED Strobe Light Wands:** These shall be handheld, battery powered LED wands with an amber lamp tube at least 200 mm in length which can be operated in continuous or flashing mode.

v) Road Markings

Road markings, as specified in SECTION 5500, may be required on sealed surfaces and will include road – marking studs wherever necessary. The road markings shall be made in accordance with the provisions of SECTION 5500. Any painted road markings which no longer apply shall be removed or overpainted with black road paint. Road marking studs shall be removed completely.

(c) Passage and Control of Traffic

It is an intention of the Contract that public traffic should be able to pass along the road to be reconstructed/ rehabilitated including bridges at all times during construction and in all weather conditions. For this purpose, the Contractor will be required to order their work etc. in such a way as to assure that a single lane of at least 3.25 m wide is available for public traffic at all times and they shall furnish sufficient pilot-cars and drivers, competent flagmen and the like to control and regulate the flow of traffic under one-way traffic operations.

The frequency and duration of delays to traffic while passing through, over or across the Works, shall be kept to a minimum. They shall, in no case exceed half an hour and should normally be less than 20 minutes. Any method of working which requires road closures in excess of 30 minutes shall be the subject of 48 hours prior notice and agreement of the Engineer, who may refuse to allow such closure in default of due notice.

The Contractor shall take particular care, when passing traffic through their Works, that all excavations and other hazards are properly protected with barriers and are illuminated at night.

1504 CONSTRUCTION OF DIVERSIONS

(a) General

Where in the opinion of the Contractor it is preferable not to pass traffic through the Works, the Contractor will, upon previous approval of the Engineer, be allowed to construct and maintain diversions provided that such diversions are passable to traffic at all times, subject to the provisions of SECTION 1507 below. The Contractor shall ensure that his construction plant does, not exceed the legal axle load limit for Ugandan roads, or any other limit established for the project road.

The Contractor shall give at least one month's notice in writing of his intention to commence construction of any detour/deviation along any section of the Works and such notice shall include details of locations of any deviation, cross-overs, one-way traffic operations, restricted widths, culverts, drainage, drifts, bridges, gradients in excess of 6%, earthworks, signs, barriers, lights, traffic lights and methods of operation of the entire system. Upon approval of such notice in writing from the Engineer, the Contractor shall become responsible for the passage of traffic, including maintenance of the detour/deviation and the project road in that section. The Contractor should note that failure to submit full details to the satisfaction of the Engineer and obtain approval from the Engineer in reasonable time will not provide cause for an Extension of Time.

The length of the diversions shall be of the shortest practical length having regard to gradient and obstruction and shall be sited as agreed between the Engineer and the Contractor.

Where required in the Special Specifications or by the Engineer, temporary diversions shall be provided with bituminous surfacing in accordance with the requirements of the Special Specifications or of SERIES 4000, or as may be prescribed by the Engineer.

(b) Widths, Gradient, Camber

For the diversion of an existing trunk road, the carriageway width of the temporary road shall be the width of the existing carriageway or 9.0 m whichever is the lesser. If wider diversions are required, such widths shall be specified in the Special Specifications or on the Drawings.

For the diversion of a minor public road or a private road, the width of the temporary carriageway shall be the same as the existing carriageway, or such lesser width as agreed by the Engineer.

Where diversions consist of two separate one-way lanes, the minimum cleared width and formation width of each lane shall be 6 m and 3.7 m respectively.

Where in the opinion of the engineer, it is impracticable to provide a two-lane diversion, a single lane carriageway not less than 3.0 m wide with traffic control and passing places shall be provided.

The verges of the diversion shall be cleared and maintained clear for a width of at least 1.5 m beyond the edge of the carriageway or such lesser width as the Engineer may agree.

The temporary traffic diversions shall have a minimum horizontal radius of 30 metres and a maximum gradient of 8 percent unless otherwise agreed to by the Engineer in exceptional cases. Any acute intersection of gradient shall be properly graded to a smooth vertical curve, to the satisfaction of the Engineer.

Diversions shall be constructed to ensure the uninterrupted flow of public traffic and where the installation of temporary drainage structures are required the flow area shall be at least equal to the existing structure being replaced at the location.

Diversions shall be restricted to 2 km in length, and subject to the Engineer's approval, with intervals of no less than 2 km between diversions.

1505 TEMPORARY DRAINAGE WORKS

(a) General

Temporary ditches and culverts of adequate size and strength shall be provided alongside and under the temporary road to the satisfaction of the Engineer.

The Contractor shall construct the necessary temporary drainage works such as side drains, catch water drains, mitre drains, culverts, etc to deal adequately with surface run-off. The temporary culverts of adequate type and size shall be installed on existing drainage channels wherever required by the Engineer. Any suitable prefabricated culverts salvaged from an existing road or an abandoned diversion may be re-used if in good condition and approved by the Engineer.

(b) Temporary Bridges

Where it is necessary to construct a diversion to permit construction of a new bridge, the Contractor shall provide and maintain a temporary bridge over the waterway. The minimum clear width of a temporary bridge shall be 3.5 m and the strength shall be adequate for normal road vehicles. The bridge design and specification shall be approved by the Engineer before construction is commenced. Approach roads shall comply with CLAUSE 1504 above.

(c) Drifts

Where a road is deviated to cross a large watercourse which

is impracticable to bridge or culvert, a drift shall be constructed of stones or small boulders with the intersections filled with spalls to make a firm bottom. This pitching shall be carried up the banks of the watercourse above the flood level of the stream. The dimension of the drift shall be such that there is less than 0.15 m of water over the road at all times, except in flood. The edge of the drift shall be defined with posts or other markers and a gauge installed to indicate the maximum depth of water over the road. The minimum width of the drift shall be 3.5 m.

The Contractor shall render to the public all possible assistance, particularly in times of flood, and if necessary shall provide a vehicle, labour and tow rope to extract vehicles immobilised in the drift.

1506 EARTHWORKS FOR DIVERSIONS OR EXISTING ROADS USED AS DIVERSIONS

The Contractor shall shape and grade the diversions and shall make full use of all material that can be obtained from alongside the diversion, from side cuts or from the immediate vicinity. If an adequate quantity of material cannot be obtained in this manner, they shall import material from other sources. Where necessary, cuttings shall be made to obtain a satisfactory vertical alignment. The Contractor shall also perform the necessary clearing and grubbing, including the removal of all trees and stumps. Where the subgrade is not sufficiently dense in its natural state, it shall be given three roller passes of compaction as specified in SERIES 3000 prior to the construction of the earthworks.

All material shall be watered, mixed and compacted with suitable compaction equipment to give sufficient density to the material so that it will be capable of carrying traffic without undue wear or distress. In case of disagreement between the Engineer and the Contractor as to the adequacy of this compaction, dry density of 90% of BS-heavy density shall be taken as the required minimum density.

Wherever possible, fords shall be constructed from rock fill or coarse material. Pollution and siltation of water courses shall be controlled. The Contractor shall construct cuttings where required.

1507 GRAVELLING OF DIVERSIONS OR EXISTING ROADS USED AS DIVERSIONS

The diversions shall be provided with a wearing course of suitable gravel approved by the Engineer.

The Contractor shall provide, spread, water, mix and compact such material to a density where it can carry traffic without undue wear and tear. In case of disagreement between the Engineer and the Contractor as to the adequacy of compaction, a dry density equal to 90% of BS-Heavy density shall be taken as the required minimum density.

1508 ASSISTANCE TO THE PUBLIC

The Contractor shall be responsible for safely maintaining and directing traffic through or around any part of the Works included in the Contract, with the maximum practical convenience, for the full twenty-four hours of each day.

The Contractor shall render to the public all possible assistance when they are passing over roads maintained by them and over minor, private or temporary roads or bridges when used as diversion or when passing through the Works.

Whenever the Contractor's operations create a condition hazardous to traffic or to the public, they shall furnish, erect and maintain such fences, barricades, lights, signs and other services, as are necessary to prevent accidents or damage or injury to the public.

The Contractor shall also train and furnish such guards and flagmen as are necessary to give adequate warning to traffic or to the public of any dangerous conditions that might be

encountered and shall provide prompt assistance to any vehicle experiencing difficulty in passing over the Works under construction, or through any diversions or roads maintained by the Contractor, if necessary by providing a towing vehicle, labour and tow rope to assist such vehicles.

Should the Contractor appear to be neglectful or negligent in furnishing warning and protective measures, as above provided, the Engineer may direct attention to the existence of a hazard, and the necessary warning and protective measures shall be furnished and installed at the Contractor's expense. Should the Engineer point out the inadequacy of warning and protective measures, such action on the part of the Engineer shall not relieve the Contractor from responsibility for public safety or relieve them of their obligation to furnish and pay for these devices.

1509 USE OF MINOR PRIVATE ROADS AS DIVERSION

Where agreed by the Engineer that the Contractor may use a minor or private road as a diversion, the Contractor shall be entirely responsible for negotiation with and obtaining the prior consent of the authorities and owners, and shall pay for any additional maintenance costs or shall if necessary, themselves maintain the minor road for the period it is used as a diversion, shall reinstate the road afterwards to the satisfaction of the authority or owner, and shall compensate the authority or owner for any damage arising out of the use of the road as a diversion.

The standard of such minor or private road when used as a diversion shall at least comply with Clause 1504 above for temporary roads and if necessary the Contractor shall, at their own expense improve the road to bring it to this standard before it is used as a diversion, and shall maintain it to that standard while it is used as diversion.

The length of the diversion shall not be excessive and shall be kept as short as practicable. As a guide, any part of the diversion shall generally not exceed twice the undeviated length of the corresponding part of the original road, while the total route distance via all diversions shall generally not exceed that via the original road by more than 25%.

1510 RIDING QUALITY AND MAINTENANCE OF DIVERSIONS AND EXISTING ROADS USED AS DIVERSIONS

The surface of all diversions shall be maintained smooth, free from ruts and potholes and loose material, and shall be graded and watered as required.

Where existing roads are to be used as diversions, the Contractor shall after consultation with the Owner or Authority having control of such road, carry out any improvements, repairs, alterations or additions to such roads as may be required to bring them to a condition suitable for traffic and to the satisfaction of the Engineer.

All diversions and existing roads used as diversion shall be maintained by the Contractor in a safe trafficable condition. The roads and diversions shall be graded and watered to provide a smooth riding surface free from corrugations and to keep dust down. All potholes shall be repaired immediately.

The Contractor shall also water the diversions to keep down dust or to facilitate the proper suppressant as may be required instead of water if considered by the Engineer to be more effective. Regular watering, at least twice a day or more often if necessary, shall be carried out to minimise the nuisance of dust. All drainage works shall be maintained in a good working order.

Diversions shall be maintained to a standard that generally allows a travelling speed of at least 40 km/h for all vehicular groups.

1511 SIGNS, BARRIERS AND TEMPORARY FENCING, GATES AND GRID GATES

The Contractor shall be responsible for the provision, erection, maintenance and removal of all temporary signs and barriers necessary for safety and convenience, to pass traffic not only upon the existing road to be constructed or realigned and such temporary roads or bridges as they may construct, but also on all minor and private roads off the site of the Works which are used as diversions.

Temporary "Diversion Ahead" signs shall be erected before any road junction and a "Diverted Traffic" sign shall be erected at the junction of the diversion route and other minor roads where there is any possibility of the diverted traffic mistaking the route of the diversion, and there shall be mounted on the same posts, a sign bearing the inscription "Diversion Ahead" or "Diversion".

In addition, any hazard such as a narrow bridge, drift, level crossing, steep hill, sharp bend, etc. occurring on the diversion shall be marked by the Contractor with the appropriate sign, if the existing sign is inadequate or non-existent. All sharp bends and all places where the shoulder is higher than 2.0 m above the natural ground shall be marked with painted posts.

Where ordered by the Engineer or specified on the Drawings or in the Special Specifications, the Contractor shall make their own arrangements for providing either new fencing and gates or moving and subsequently reinstating existing fencing and gates in accordance with the provisions of SECTION 5300.

1512 ACCOMMODATION OF TRAFFIC WHERE THE ROAD IS CONSTRUCTED IN HALF WIDTHS

Whereby for reasons of difficult terrain or for any other reason, the construction of diversions is not feasible, the Contractor shall upon the written instruction of the Engineer, construct the road in half widths to allow traffic to use that half of the road not under construction. The length of the half width construction shall be kept to a minimum, with provision for traffic travelling in opposite directions to pass at frequent intervals.

The length of half-width construction, where the other roadway lane is open to one-way traffic only, shall be restricted to 1 km in length and the distance between such sections shall not be less than 2 km. Traffic control for short sections of maximum 250 m in length of one-way traffic may be controlled by qualified flagmen and portable STOP and GO signs. Traffic lights shall be used for longer sections unless otherwise agreed to by the Engineer. Unless clear vision can always be maintained between the staff operating the traffic control, communication shall be established through radio systems (walkie-talkies). Where flagmen are controlling traffic, the Contractor shall supply a movable, identifiable, raised plinth painted with stripes and having a sunshade for the operator, from which the Stop-Go sign will be operated.

The Contractor shall arrange their work so as to allow traffic to have free one-way access to at least half the width of the roadway at all times during the Construction period. They shall maintain that half of the road, which is being used for traffic for the time being, free from corrugations to the satisfaction of the Engineer

Should the road be not in a safe trafficable condition for two-way traffic over the entire width at the end of each day's work the Contractor shall provide adequate flagmen, signs, traffic lights, barricades, light and the necessary staff at their own cost to ensure a free flow of traffic alternately in each direction through the entire period when the roadway is open to one-way traffic only.

1513 THE USE OF DIVERSIONS BY THE CONTRACTOR

Where the Contractor constructs haul or construction roads for accommodating construction traffic, they shall construct and maintain them at their own cost and in accordance with details previously agreed with the Engineer, in writing. Such roads shall be obliterated and their surfaces properly reinstated when no longer required, all at the Contractor's own cost.

The Contractor shall have the right to use public roads, including diversions open to public traffic, but where their own traffic causes excessive damage or wear to such roads or constitutes a condition hazardous to public traffic, the Engineer shall have the right to regulate their traffic over such diversions and require the Contractor to provide at their own cost, such maintenance as in the Engineer's opinion will be necessary.

1514 OBLITERATION OF DIVERSIONS

When traffic is routed permanently onto the new road following the completion of construction, the diversions which are no longer required and, unless otherwise instructed by the Engineer, such sections of obsolete roads and road marking as instructed by the Engineer, shall be obliterated in accordance with SECTION 5700.

1515 PENALTY FOR FAILURE TO COMPLY WITH THESE SPECIFICATIONS

The Contractor shall comply strictly with all accommodation of traffic specifications and instructions from the Engineer. The failure or refusal of the Contractor to construct and/or to maintain bypasses at the proper time, or to take the necessary precautions for the safety and convenience of public traffic as required by statutory authorities or as instructed by the Engineer, shall be sufficient cause for the closing down of all work under this contract until all provisions prescribed have been complied with to the satisfaction of the Engineer.

The Employer shall deduct from any payments due to the Contractor all reasonable expenses necessitated by the failure of the Contractor to comply with the provisions of these Specifications.

1516 THE CONTRACTOR'S USE OF TRAFFIC DIVERSIONS

When the Contractor constructs Traffic Diversions, haul or construction roads through the Contractor's own initiative for accommodating construction traffic, the Contractor shall construct and maintain them at the Contractor's own cost and only in accordance with details previously agreed upon in writing with the Engineer. Such roads shall be removed and the surface properly reinstated when no longer required, also at the Contractor's own cost.

The Contractor shall have the right to use public roads including Traffic Diversions open to public traffic. Where the Contractor's own traffic causes excessive damage or wear to such roads; or constitutes a hazardous condition to public traffic; the Engineer shall have the right to regulate the Contractor's traffic over such Traffic Diversions. In such circumstances the Contractor shall provide, at the Contractor's own cost such maintenance, including wearing course gravel and watering, as in the Engineer's opinion is necessary in addition to what would be required to properly maintain the Traffic Diversions when not used by the Contractor's construction traffic. Where regulation of the Contractor's traffic does not alleviate the traffic hazard satisfactorily; or the maintenance of the Traffic Diversions cannot be or is not properly executed; the Contractor shall, where conditions permit, divert his traffic over construction roads provided and maintained at the Contractor's own cost.

1517 REMOVAL OF TRAFFIC DIVERSIONS

On completion of the permanent Works, unless agreed otherwise in advance with the Local Administrations and Communities and covered by a confirmation letter, diversions shall be reinstated to their original state by the Contractor.

1518 MEASUREMENT AND PAYMENT

Provisional quantities for signs and some equipment for diversion and/or lane closures have been included in the Bill of Quantities. The Contractor is to provide, at his own expense, additional traffic control equipment he may need to allow him to operate at any one time the number of diversions or lane closures as required by his Programme.

In addition, all other equipment such as traffic cones, stop/go signs, traffic lights, plastic marker tape, reflectors, traffic barricades, pedestrian barricades etc, are to be provided by the Contractor in order to ensure all traffic control is safe and to the satisfaction of the Engineer. These are to be used and moved as and when appropriate throughout the period of road and drainage construction to maintain safe driving and working conditions for the public, and the Contractor, on all parts of the Site.

<u>ITEM</u>	<u>UNIT</u>
15.01 ACCOMMODATING TRAFFIC AND MAINTAINING DIVERSIONS AND DETOURS	MONTH
<u>ITEM</u>	<u>UNIT</u>
15.02 TEMPORARY TRAFFIC CONTROL FACILITIES: PROVISION OF FULL SET OF SIGNS AND TRAFFIC CONTROL FOR:	
(a) TYPE 1 CONTROL – HALF WIDTH WORKING	NUMBER (NO.)
(b) TYPE 2 CONTROL – TEMPORARY ROAD SURFACE	NUMBER (NO.)
(c) TYPE 3 CONTROL – 2 LANE DIVERSION	NUMBER (NO.)
(d) TYPE 4 CONTROL – 2 SINGLE LANE DIVERSION	NUMBER (NO.)
(e) TYPE 5 CONTROL – DETOURS	NUMBER (NO.)
<u>ITEM</u>	<u>UNIT</u>
15.03 PROVISION OF BARRICADES AND DELINEATIONAL DEVICES:	
(a) NEW JERSEY BARRIERS	NUMBER (NO.)
(b) DRUMS	NUMBER (NO.)
(c) PLASTIC HDPE BARRIERS	NUMBER (NO.)
(d) DELINEATORS INCLUDING MOUNTING BASES SINGLE SIDED	NUMBER (NO.)
(e) DELINEATORS INCLUDING MOUNTING BASES DOUBLE SIDED	NUMBER (NO.)
(f) TRAFFIC CONES (HEIGHT MIN. 750 MM)	NUMBER (NO.)

(g) ILLUMINATED TRAFFIC SIGNS (LED ARROW BOARDS, SIGN MOUNTED FLASHING AMBER LIGHTS, ILLUMINATED ROAD SIGNS, MOBILE VARIABLE MESSAGE SIGN ETC)	NUMBER (NO.)
(h) TRAFFIC CALMING DEVICES (RUMBLE STRIPS, HUMPS ETC)	METRE (M)

The bid rate for ITEM 15.01 is to include full compensation for accommodating traffic and maintaining diversions, for moving the signs and barricades and delineation devices plus the replacement of additional signs, barricades and delineation devices that are lost plus provision of additional devices and /or equipment required by the contractor so he may undertake works as planned. The rate includes roads constructed in half widths and existing roads used as detours during construction and maintenance periods but excluding maintenance and repair work for which payment is specifically made under other pay items such as ITEM 12.03.

The bid rate shall include full compensation for the provision of communication equipment required for regulating the traffic, arranging for the removal or relocation of services, solving traffic problems, complying with the legal requirements of all Authorities concerned, for providing temporary access to private property and for the provision and maintenance of temporary drainage.

Payment will be made per month from month 7 of the construction period for accommodating traffic to the satisfaction of the Engineer during the construction period, for providing and maintaining diversions and detours and for working on half road widths.

Where the Contractor uses roads, diversions or detours which are used by public traffic as his haul roads, the Engineer shall have the right to regulate the Contractor's traffic over such diversions should his vehicles or equipment cause excessive damage or wear to such roads, or reduce the monthly payment for accommodating traffic until such time as the Contractor complies with the Engineer's instructions.

Payment for the first 6 months' instalments of ITEM 15.01 shall become due when traffic can be accommodated on the new road, all diversions have been obliterated and re-instated and the general obligations of the Contractor have been complied with to the satisfaction of the Engineer.

The bid rate for ITEM 15.02 is to include full compensation for the provision of the full set of traffic control facilities and temporary road signs complying with the latest version of the Ministry of Works and Transport Traffic Signs Manual for the respective types of traffic control as detailed in the drawings.

The bid rates for ITEM 15.03 is to include full compensation for the provision of the respective traffic control facilities specified under (a) to (f).

SERIES 1000: GENERAL

SECTION 1600: OVERHAUL

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1601 SCOPE

This Section covers the hauling of overhaul materials as defined herein from the place of excavation to the position of placement, where such haul distance is in excess of the free haul distance as defined herein. Overhaul will be paid for as specified in the Special Specification.

1602 DEFINITIONS

(a) Layers to which Overhaul Applies

The Contractor's attention is drawn to the provision that overhaul will only be paid for in cases where it is so specified in the Special Specifications. Overhaul material shall be transported material to which overhaul applies when hauled in excess of the free haul distance and shall include only the gravel materials, soil or rock materials used in the construction of fills, pavement layers, banks and dykes as follows:

- i) Earthworks where the following material types are prescribed as the minimum quality:
 - Fill materials: G7 and Rock Fill/ Dump Rock DR
 - Improved subgrade: G7 and G15
- ii) Pavement layers where the following material types are prescribed as the minimum quality:
 - Subbase or base course: G30, G45, G60, G80, C4.5, C3, C1.5, C1.0, C0.7 and CM
 - Gravel wearing course: GW

Overhaul shall not be paid for materials made from crushed stone or crushed rock such as material types CRR and CRS, nor for materials used inside fill, bituminous layers and bituminous seals, concrete and rip-rap.

(b) Haul Distance

The haul distance shall be the distance between the centre of volume of the overhaul material in the cut or borrow pit before excavation and the centre of volume of the portion of the fill constructed with the overhaul material.

The distance between the centres of volume shall be measured along the centreline of the road, and any additional distance of haul ascribed to the following of a different haul route will not be considered. Cut and fill volumes for ramps, road approaches and connections on either side of the road shall be considered as concentrated at the centre line of the main roadway under construction for computing overhaul quantities for payment, unless otherwise specified in the Special Specifications.

The haul distance for material from the borrow pit shall be measured along the shortest route determined by the Engineer as being feasible and satisfactory. Should the Contractor choose to haul material over some other longer route, computations for payment shall nevertheless be based on the haul distance measured along the shortest route approved by the Engineer. The haul distance for borrow materials shall be measured to the nearest 0.1 km.

Any handling of materials such as stabilisation, crushing and/or screening oversize materials, etc. shall not have any effect on the haul distance.

If the Contractor chooses not to utilise all the identified suitable borrow areas and quarry sites, but haul material over some longer distance, the overhaul computations will be based on the identified suitable sources and not the actually utilised sources.

(c) Free-haul Distance

The free haul distance shall be the distance which material as described in SUB-CLAUSE 1602 (a) must be transported on any trip before overhaul becomes payable. This distance shall be as given in TABLE 1602/1 for material in the respective layers.

Overhaul shall apply to all overhaul in excess of the distance given for materials where the following material types are prescribed as a minimum quality in the Specifications or on the Drawings:

TABLE 1602/1: FREE HAUL DISTANCES

MATERIAL FOR LAYER	FREE HAUL DISTANCE (KM)
Fill and improved subgrade layers (G7, G15)	30.0
Rock Fill/ Dump Rock DR	30.0
Base course (C4.5, C3, G60, G80)	30.0
Subbase (G30, G45, C1.5, C1.0, C0.7, CM)	30.0
Gravel wearing course (GW)	30.0

(d) Overhaul Distance

The overhaul distance shall be the total haul distance, minus the free haul distance measured to the nearest 0.1 km.

(e) Quantity of Material

The quantity of material overhauled shall in all cases be measured after placing and compaction in its final position calculated in the same manner as the item for the layer to which the overhaul applies.

1603 MEASUREMENT AND PAYMENT

Overhaul will only be paid for in the cases where it is so specified in the Special Specification. In the cases where overhaul is paid for, the measurement and payment shall be as follows:

ITEM	UNIT
16.01 OVERHAUL OF MATERIAL HAULED IN EXCESS OF ITS RESPECTIVE FREE HAUL DISTANCE	
(a) MATERIAL FOR FILL OR IMPROVED SUBGRADE LAYERS	CUBIC METRE X KILOMETRE (m ³ km)
(b) MATERIAL FOR PAVEMENT LAYERS AS SPECIFIED	CUBIC METRE X KILOMETRE (m ³ km)
(c) MATERIAL FOR GRAVEL WEARING COURSE	CUBIC METRE X KILOMETRE (m ³ km)

The unit of measurement shall be the cubic metre of overhaul material for layers described in SUB-CLAUSE 1602 (a), measured in accordance with SUB-CLAUSE 1602 (e), hauled in excess of free haul distance prescribed in SUB-CLAUSE 1602 (c), multiplied by the overhaul distance measured for payment purposes in as described SUB-CLAUSE 1602 (d).

The bid rates for overhaul shall include full compensation for hauling material in excess of the free haul distances.

SERIES 1000: GENERAL

SECTION 1700 ENVIRONMENT MANAGEMENT

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1701 SCOPE

This section covers the general and specific provisions for management of the environmental and climate change aspects of road development in accordance with the applicable National laws and international best practices. The section presents guidelines for effective mainstreaming of Environment and Social Management Practices during the execution of all works under the contract.

The obligations herein do not prejudice any other Clauses in this Specification.

1702 GENERAL

This section handles the general and specific provisions for management of the Environmental, climate change and social aspects associated with road development. The specifications require that the Contractor complies with environmental, social and climate change obligations as prescribed by the National Laws and/or international standards as per specific project requirements.

Before commencement of works, the Contractor shall develop and submit to the Engineer for approval an Environmental and Social management system in line with the National laws and applicable international standards. The Contractor may align their management system to that of the Employer, if available, and absence of such a system on the side of the Employer shall not be an excuse for the Contractor not to prepare their own. For efficiency and effectiveness, the system should cover all aspects in SECTIONS 1700 AND 1800.

The Contractor will review and update the Management System on an annual basis and submit to the Engineer for review and confirmation of the measures taken to achieve continual improvement. The Contractor shall engage and maintain a competent team of personnel to implement the Environmental Management System.

Based on the impacts and mitigations prescribed in the Environmental and Social Impact Assessment for the project, the Contractor shall prepare a Construction Environmental, Social Management and Implementation Plan (C-ESMIP). The C-ESMIP should be submitted to the Engineer for confirmation that it addresses all aspects in the ESIA and any other aspects, which may have not been captured in the ESIA, but are evident by the time of preparation of C-ESMIP.

Upon satisfactory review, the Engineer shall submit the C-ESMIP to the Employer for final concurrence, and obtain a No-objection in case of Development Partner financed projects. The C-ESMIP shall be prepared by NEMA certified experts approved by the Engineer and confirmed by the Employer's Environmental Experts.

(a) Management Plans

As part of the C-ESMIP, the Contractor shall prepare and submit to the Engineer Management plans which may include, but not be limited to, the following:

- Traffic Management;
- Occupational Health and Safety;
- Community Health and Safety;
- Waste Management including hazardous wastes;
- Noise control;
- Dust control;
- Air quality management;
- Emergency preparedness;
- Management of Explosives;
- Spills contingency management plan;
- Blasting Management Plan;
- Heritage Resource Management Plan with Chance finds procedure;
- Biodiversity Management Plan (where required by the ESIA plans for management of identified flora and fauna of conservation);
- Deep Excavation Management Plan;
- Water Resources Management Plan (including drinking water);
- Transport Management Plan for materials;
- Control of access for unauthorised individual's management plan;
- Worker's Accommodation Management Plan;
- Erosion and Sediment Control Plan;
- Invasive Plants Management Plan;
- Road Construction Decommissioning Plan;
- Labour Mobilization Plan;
- Stakeholder Engagement Plan;
- Grievance Redress Plan/Mechanism;
- Gender Action covering aspects of Gender Equity and Equality, Gender Based Violence, Violence against Children and Sexual Exploitation and Assault;
- Resettlement Policy Framework;
- Community Health and, Safety Management Plan;
- Security Management Plan.

The C-ESMIP shall include aspects covered in SERIES 1800 and be updated annually as a minimum or at shorter intervals as need may arise and or as instructed by the Engineer.

(b) Statutory Approvals and Permits

The contractor shall to the extent possible obtain all the necessary statutory Permits, Agreements and Approvals during the mobilization period, which may include but not be limited to, the following:

- ESIA certificate for the Project where applicable;
- ESIA Certificate for the ancillary sites (such as Camps, Equipment yard, Quarry, Asphalt Plant, Concrete Batching Plant, Borrow Pits, where applicable);
- Registration Certificate for the camp, quarry, crusher and equipment yard as a workplace from the relevant Government Agency;
- ESIA certificate for the rock quarry and crusher where applicable;
- ESIA certificate for the Asphalt Plant where applicable;
- ESIA Certificate for the concrete batching plant where applicable;
- License for constructing and operating a fuel dispensing facility from the Ministry of Energy and Mineral Development where applicable;
- Water Abstraction Permits (both ground and surface) from the relevant Government Agency, where applicable
- Construction permits (permits for construction across water courses) from the relevant Government Agency, where applicable;
- Permits for lifting equipment, where applicable;
- Explosive Storage Permit;
- Hazardous waste storage, transportation and disposal license, where applicable;
- For any other permits not listed, the Contractor shall obtain them in line with national laws and regulations.

(c) Climate Change Mitigation and Adaptation

Where the contractor is required to prepare designs, they shall be required to develop a separate operation phase climate change mitigation and adaptation action plan. The plan shall detail mitigation measures on scope 1, scope 2 and scope 3 emissions where applicable. The action plan shall also detail adaptation measures for all identified risks (refer to SECTION 1718) for details on risk assessment.

1703 ESTABLISHMENT OF TEMPORARY ANCILLARY FACILITIES

(a) Workers Camps and Equipment Yards.

The establishment of any workers' camp and equipment yard shall be subjected to an appropriate level of Environment and Social Assessment as prescribed in the NATIONAL ENVIRONMENT ACT CAP. 181 and THE NATIONAL ENVIRONMENT (ENVIRONMENT AND SOCIAL ASSESSMENT) REGULATION. The contractor shall procure the services of a registered Environment Practitioner to carry out the assessment in accordance with the Act.

The contractor shall be required to develop a site layout plan as guided by the contractor's Environment, Social, Health and Safety Experts and approved by the Engineer. The site layout shall form an annex to the Environment and social impact report to be submitted to NEMA. Authentic land acquisition documents shall form part of the Annexes to the ESIA.

Environment Management at the camp shall include the following among others:

i) Domestic Waste Management

As part of the Waste Management Plan, the Contractor shall establish a Solid waste management system comprising movable receptors located appropriately at all potential waste generating sites (offices, residences, kitchens, laundry areas, mechanical workshops, laboratories etc). Covered colour coded receptors are to be used.

A Central Waste storage bank shall be included and will be clearly demarcated on the site layout plan. The waste bank shall be a sheltered concrete platform compartmentalised to enforce segregation of wastes (Metallic, Paper, leather/textiles, glass, plastics, and general garbage).

Waste disposal shall be at a gazetted facility approved by the local authorities and the Engineer.

ii) Sewage Management

A waterborne sewerage system shall be constructed to service the camp. The facility and network must be clearly shown on the site layout plan. For public outdoor systems a stance loading density of 1:8 while indoor loading density shall be maintained at 1:4. The facility shall be kept functional and tidy at all times, equipped with hand washing detergents and sanitary paper. A cleaning schedule shall be posted at an appropriate position for inspection purposes.

All toilet facilities shall observe gender segregation. Entrance to public facilities will be on opposite sides for the different sexes and shall be appropriately marked using conventional signage and language(s) common in the project location.

Where sewage treatment ponds are used and wastewater is to be released into the surrounding Environment, water must be treated to meet national effluent discharge standards as contained in THE NATIONAL ENVIRONMENT (STANDARDS FOR DISCHARGE OF EFFLUENCE INTO WATER OR LAND) REGULATIONS, 2020. Proper impact analysis shall be covered in the Environment and Social Impact Assessment where such systems are to be set up.

iii) Hazardous Waste Management

Where a Contractor decides to handle their own hazardous waste, they will furnish the Engineer with approvals and certifications from the relevant Government Agency allowing them to handle such waste.

iv) Fire Management

Fire is a common hazard in camps and equipment yards. The contractor shall take all necessary measures to control fire outbreaks and further prepare for its control in the event of an outbreak. The contractor shall implement provisions as contained in a fire management plan included in C-ESMP.

v) Leisure and Recreation Facilities

The Contractor shall establish recreation facilities in the camp to motivate and enable its staff to keep physically and emotionally strong. To improve Staff welfare, the Contractor shall at a minimum establish the following facilities:

- high speed internet;
- outdoor games facility;
- a facility for indoor games;
- Basic collective social/rest spaces. Standards range from providing workers multi-purpose halls to providing designated areas for radio, TV etc.

vi) Air and Noise Pollution

The contractor shall be required to undertake baseline air quality and noise levels prior to the establishment of

temporary camps. Monitoring shall be required as specified in CLAUSES 1709, 1710 AND 1711 of these specifications.

vii) Camp Decommissioning and Restoration

On completion of the work and after receiving approval in writing from the Engineer, all constructional plant, buildings, fencing and other temporary structures shall be removed and the camp site shall be restored to its original condition and left neat and tidy. Decommissioning shall be guided by a decommissioning plan approved by the relevant Environment authority and the Engineer.

(b) Rock Quarry and Crusher

Acquisition of the Rock Mass will be based on willing buyer willing seller considerations. For affected persons who may not be part of the willing seller willing buyer transactions, but may be displaced or impacted by operations of the Quarry, the Contractor shall trigger involuntary resettlement standards applicable to the entire project.

As part of the ESIA Process for the Quarry, the Contractor shall scope the activities of each phase (acquisition, establishment, operations and decommissioning), and based on the scale of operations, determine the period for which land occupancy will be required. In the event that the quarry will remain active beyond the Defects Notification Period, the contractor will document in the Resettlement Action Plan (RAP) the time of occupancy of the affected land, compensate landowners and restore livelihoods in line with applicable Environment and Social Standards for the project.

The establishment of rock quarries and Crusher plants shall be subjected to an Environment and Social Assessment as prescribed in the NATIONAL ENVIRONMENT ACT CAP. 181, THE NATIONAL ENVIRONMENT (ENVIRONMENT AND SOCIAL ASSESSMENT) REGULATIONS 2020, THE LAND ACT, CAP. 227, THE MINING AND MINERAL ACT, CAP. 159 and THE EXPLOSIVES ACT CAP. 298 among other instruments. The contractor shall procure services of a team of registered Environment Practitioners to carry out the assessment in accordance with the Act. The team shall observe all regulations regarding the impact assessment of rock quarries guided by the Regulations and professional judgement.

The Contractor shall register the quarry site as a workplace and obtain a Workplace Registration Certificate (OSH Permit) from the authorized Government Agency.

In addition to the construction equipment required by the Contractor to carry out the Works, they shall provide a weighbridge at each quarry site prior to stone being transported from that quarry for inclusion in the Works. Each weighbridge shall be capable of weighing trucks to an accuracy of $\pm 2\%$ and it shall provide a printed output with lorry number and weight; the printouts being handed to the Engineer at the end of each day. Printouts for rock being dumped in pioneer layers and swamps shall be handed to the Engineer's staff on site at the time of dumping.

Other facilities including asphalt plant, bitumen boilers etc. shall be subjected to an independent Environment and Social Assessment.

The contractor shall only utilise quarries that are already in existence if they conform to minimum requirements that will be provided by the Engineer and Employer. The sites must hold valid NEMA permits and do comply with the permit requirements before the contractor can consider them for use.

i) Location

The selected rock for blasting shall be located at a safe distance from sensitive receptors (natural ecosystems and social setups) such as (schools, health facilities, administrative centres, religious institutions, markets and heavily settled area) as will be determined by

relevant laws and the ESIA approval conditions. While locating rock quarries and crusher plants, places with high population concentrations (trading centres) should be avoided and where avoidance is not possible, the ESIA shall give specific attention to the impact associated with such sites and present plausible and implementable mitigation actions.

In addition to the above, the principle of involuntary resettlement should apply.

ii) Cultural Heritage Resources

Prior to acquisition of potential rock sites for quarry establishment, the contractor shall undertake to screen the sites to determine their status in terms of physical cultural resources. Consultations with the Department of Museums and Antiquities in the Ministry of Trade and Tourism, Cultural Institutions among others shall be required. Where deemed necessary the contractor shall procure the services of a competent archaeologist to assist in rock site screening.

iii) Consultation with the Directorate of Geological Surveys and Mines

Prior to acquisition, consultations with the Directorate of Geological Surveys and Mines shall be made to determine the status of the proposed rock formations in relation to awarded mineral exploration licenses and any other requisite licensing requirements.

iv) Acquisition of Rights to Mine Rocks

The contractor shall follow the relevant national laws to acquire rights to extract rock materials. Local district level rights shall also be negotiated by the contractor and the concerned districts. The rights of current land users/owners as per the different tenure systems shall be recognised as specified in the various land laws.

v) Temporary/ Permanent Resettlement of Communities in the Buffer Zone

The contractor shall resettle households located in the buffer zone (refer to relevant laws for distance) on a temporary or permanent basis. The Contractor shall follow procedures as contained in the relevant land laws and project specific funders' requirements to plan and implement resettlement activities. Resettlement Action Plan shall be approved by the authorised agencies such as the Chief Government Valuer and the Contractor shall follow the principles of involuntary settlement applicable to the Project.

vi) Documentation of the Status of Properties

The contractor shall undertake to document the status of properties within the exclusion zone in a manner that is easily retrievable (video, photographic etc.). Where the ESIA so determines, properties outside the exclusion zone shall also be documented to safeguard the contractor against fictitious claims. The distance to be considered for documentation outside the exclusion zone shall be determined by the ESIA and should appear on the ESIA Certificate of approval. The contractor shall determine the exclusion zone considering the technology used during blasting."

vii) Screening Off of Quarry and Crusher

The contractor shall be required to fence off the entire facility using the most appropriate material as approved by the Engineer. The Quarry shall be fenced off before any operations are carried out.

While fencing off the site, the contractor shall consider roads, trucks, foot paths to ensure they are not blocked or where it becomes inevitable that foot paths will be affected, acceptable diversions are made at the expense of the contractor. Diversions shall meet specification that allow smooth flow of all forms of traffic all year round.

The contractor's satellite camp at the quarry shall be established outside the perimeter to safeguard quarry personnel from health and safety impacts. All environment and social safeguard provisions considered for the major camp described in SUB-CLAUSE 1703 (a) shall apply to the satellite camp at the quarry.

viii) **Blasting and Management of Explosives**

The contractor shall produce a Blasting and Explosives Management Plan for the approval of the Engineer prior to transporting explosives to site and subsequent blasting.

The contractor shall acquire and comply with all the necessary permits and authorisations as contained in EXPLOSIVES ACT, CAP. 298, THE NATIONAL ENVIRONMENT ACT CAP.181 and other relevant laws and regulations of the Department of Geological Survey and Mines (DGSM), Directorate of Occupational Safety and Health, National Environment Management Authority (NEMA) and other national and local regulations for the use, storage, transportation, and handling of explosive materials.

The contractor shall provide DGSM with copies of all required permits prior to commencing blasting operations. Only workers trained and experienced in handling explosives will be permitted to supervise, handle, haul and detonate explosives. Blasting shall be superintended by a Certified Blaster (Ministry of Internal Affairs). A valid copy of the certificate shall be displayed on site.

The contractor will provide the Client with proof of a license to obtain and use explosives for every person directing or conducting blasting operations. The Contractor shall recruit a qualified competent person to assist in the preparation of site-specific blasting procedures and to provide an engineering report showing recommended charges and blasting methods to be used at specific locations.

ix) **Explosive Storage and Transportation**

The contractor shall obtain necessary permits and comply with all conditions governing the storage and transportation of explosives. THE EXPLOSIVES ACT, CAP. 29 stipulates that a license is obtained from the Ministry of Internal Affairs. Contractors shall apply to the Ministry for relevant permits for transportation of explosives and their storage as stipulated in the EXPLOSIVES ACT CAP. 29. While in transit, vehicles carrying explosives may be required to carry a copy of the permit.

Loading and vehicles transporting explosives shall follow the guidelines specified in REGULATION 29-38 of the Act. While loading, blasting cartridges shall not be loaded on the same truck or vehicle as detonators, inflammable or combustible materials, acids or uncovered iron or steel, except with the special sanction and such special permission shall be endorsed on the transport permit.

Every vehicle used for the transport of explosives shall be easily identifiable from front and rear by having affixed to it at either side a red flag at least 18 inches square. All iron and steel portions of the transport vehicle that may likely come into contact with cases or barrels shall be covered with wood, cloth or any other suitable material. The consignment shall always be covered by tarpaulins or any other suitable material. While in transit, explosives shall be under the guard of police personnel assigned for that purpose.

The contractor shall obtain the requisite permit for the construction of a Magazine and its location. While selecting the location, the contractor shall follow regulations set out in the Act in relation to buffer

distances from properties, social infrastructure and other facilities.

Stored explosives in a licensed facility shall not exceed the quantity for which the magazine was licensed to hold and storage shall only be in the designated chambers. The contractor shall keep a storage logbook that shall indicate receipts and disbursements. The in-charge of the magazine shall be responsible for all entries in the logbook.

x) **Blasting Procedure**

The contractor shall be required to develop a blasting procedure to be submitted to the Engineer for approval. The procedure that shall be part of the Blasting Plan and shall include among others the following:

- Blast Timing and Frequency;
- Notification Protocol;
- Warning Signs and Signals;
- Functions of the Blaster;
- Protocols to be observed;
- Designating the blasting area; and
- Designating the danger area.

xi) **Disposal of Explosives**

All unused explosives shall be properly batched, stored and transported back to the supplier. Explosive contaminated materials shall be treated as hazardous waste and will be handed over to a NEMA licensed waste handler. Personnel and other property damage will be avoided by sheltering the detonation area. Small quantities of explosives may be added to production charges in blast-holes for destruction. The contractor shall manage disposal through a well-developed manifest used to manage hazardous waste.

xii) **Post Blast Inspections**

The blaster, Safety Manager, Sociologist, Environment Manager and the quarry Manager or their representatives and a member of the local quarry committee shall carry out a post blast inspection targeting the blast area, the danger zone and the established buffer zone. The post blast inspection shall target a number of things such as damage to properties within the buffer, blast area and danger zone, distance travelled by flying projectiles etc. The team under the leadership of the blaster shall produce a post blast report to be submitted to the Engineer.

Any grievance arising out of blasting shall be reported to the Grievance Committee for the quarry that shall have been established. The grievance committee shall be comprised of representatives from the contractor, the Engineer, the client, Local Authorities and any other co-opted member(s).

xiii) **Site Decommissioning and Restoration**

A Decommissioning and Restoration plan shall be provided by the contractor or as part of the general road construction decommissioning. Decommissioning and restoration of the quarry and crusher shall involve the following:

- Equipment demobilisation;
- Management of waste and derelict equipment at the crusher;
- Management of quarry pit slopes;
- Management of emplacement area;
- Site drainage;
- Landscaping and revegetation;
- Maintenance;
- Closing the grievance mechanism and addressing all community complaints; and

- Any other issues as raised by the Engineer, the Client, NEMA and Local Authorities.

Where not required by the community or landowner, haul roads must be obliterated, scarified and earth banks constructed to prevent erosion and all damaged fences and structures reinstated.

The contractor shall not under these specifications be allowed to transfer a stone quarry to another contractor before restoration. Where there is absolute need to transfer a quarry, the Contractor shall conduct an audit to confirm compliance with the approval conditions, before applying to NEMA to authorise the transfer.

xiv) Outsourcing Material from Third-party Quarry Operators

Where a contractor is outsourcing material from a third party or a commercial quarry, environment, social and health standards applicable to the project shall apply to the third party supplier. The contractor shall ensure that the third-party supplier fully complies with the acquisition, resettlement of affected persons in the buffer zone, ESIA approvals and requirements under SUB-CLAUSE 1703 (a) before proceeding to obtain materials from those sources.

xv) Certificate of Environment, Social, Health and Safety Compliance

Upon successful restoration of the quarry, other material sources, borrow area, any other excavated or disturbed sites as well as after settlement of all works related grievances, the Contractor will receive a Certificate of Environmental, Social, Health and Safety Compliance issued by the Employer. Issuance of the Certificate shall be preceded by a final inspection by the Engineer and the Employer's Environmental, Social, Health and Safety Experts. The Certificate of Environmental, Social, Health and Safety Compliance shall form Part of the submissions by the Contractor to the Employer seeking payment of the final certificate or retention fees. A Contractor who has not fulfilled the requirements for issuance of the Certificate of Environmental, Social, Health and Safety Compliance in line with provisions under SERIES 1700 and SERIES 1800, shall not be issued a Final Completion Certificate by the Engineer and receive payment of retention fees.

(c) Borrow Areas and Spoil Stocking Areas

All proposed borrow sites and spoil stocking areas shall be subject to appropriate levels of Environment and Social Assessment in compliance with THE NATIONAL ENVIRONMENT ACT CAP. 181. When selecting borrow area and spoil stocking sites, the Contractor notwithstanding the ESIA shall always observe regulations relating to sensitive environment and social receptors (wetlands, protected forests, wildlife zone etc.). When in doubt of the status of a given area, the Contractor shall refer to relevant laws including:

- THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS AND LAKESHORES MANAGEMENT) REGULATIONS 2000
- THE NATIONAL ENVIRONMENT (MOUNTAINOUS AND HILLY AREAS MANAGEMENT) REGULATIONS, 2000
- THE NATIONAL FORESTRY AND TREE PLANTING ACT

The contractor shall only utilise borrow pits that are already in existence if they conform to the minimum requirements that will be provided by the Engineer and Employer. The sites must have NEMA permits that are valid and comply with the permit requirements before the contractor can consider them for use. Before inheriting an existing borrow site the Contractor should first conduct due diligence and submit a report to the Engineer confirming that all legacy obligations have been settled and all permits, agreements and approvals are up to date.

i) Topsoil Stockpiling

The contractor shall designate a section of the acquired area for stockpiling topsoil derived from clearance and grubbing. The stockpile shall be of a height that rhymes with the surrounding landscape. Topsoil shall be used during restoration and must be reserved for that purpose.

ii) Extraction of Gravel

The contractor shall provide a material excavation plan to the Engineer for approval before any exploitation takes place. The plan shall be in line with the requirements of THE DISTRICT ROAD MANUAL VOLUME 5 and ensure pit stability, ease of restoration and access to the site among others. The Contractor shall always follow an approved method statement that allows for preservation of topsoil and progressive restoration.

iii) Community Safety and Health

An established borrow area shall be screened off using the most appropriate material approved by the Engineer. Community access paths shall not be affected, and where it is inevitable, relocation with minimum inconvenience shall be considered. A minimum buffer from social service centres (Schools, health facilities etc.) and homesteads shall be observed so as not to disrupt normal functions.

iv) Drainage

The contractor shall establish a series of cutoff drains to divert surface flow away from borrow pits. Appropriate drains shall be constructed to drain borrow pits that will be subject to inundation during the rainy season.

v) Restoration

Restoration of borrow pit/area should be done in accordance with the restoration plan approved by the Engineer.

All borrow pits affected by the project shall be restored either progressively or after exploitation. The Contractor shall conduct an assessment of the borrow area and develop a restoration plan which will include but is not limited to; earthworks, erosion control, revegetation, water management, recontouring, regrading to match natural contours and submit the decommissioning plan to the Engineer for approval. The restoration plan shall comply with all environmental laws and standards. Borrow pits shall be back benched to a reasonable slope and backfilled using suitable material either derived from construction spoil, excess stockpiled material or any other material as may be approved by the Engineer. During the restoration process, the Contractor shall take special care not to affect the hydrology of the surrounding area.

Haul roads must be obliterated, scarified and earth banks constructed to prevent erosion and all damaged fences and structures reinstated.

Erosion mitigating measures shall be given priority to ensure proper drainage, being of the great importance around human habitation, where permanent water holes might be a health risk.

The site shall be inspected by the relevant Environment Authority (NEMA, Local Government), the Engineer and the owner before a handover certificate is given to the contractor.

1704 ENVIRONMENTAL PROCEDURES

Work especially in environmentally sensitive areas will require that the contractor produces an Environmental Procedure (Methods Statement) for approval by the Engineer. The Environment and Social Safeguards team of

the contractor and the relevant construction units shall be guided by the Supervising Consultant to come up with an appropriate Environmental Procedure. The Environmental procedure is a site-specific contextual document that shall include the following among others:

- Baseline Environment and Social Conditions of the site with locational coordinates;
- Description of nature of work proposed at the site including staging, equipment to be used, schedule of activities;
- Potential Environment and Social risks/impacts;
- Mitigation procedures and action (specific);
- Emergency response plan in case mitigation measures fail or unanticipated risks emerge in the course of works; and
- Environment and Social Monitoring indicators.

Environment and social Sensitive Areas shall be derived from the Project Environment and Social Impact Assessment Report and Construction Environment and Social Management Plan (C-ESMP). The Engineer shall have the powers to designate a given work site a sensitive area. Any of the following can be designated a sensitive area among others:

- Wetlands/areas of impeded drainage;
- Surface water streams and rivers;
- Lake shores;
- Demolition of existing structures;
- Works near health facilities;
- Works near schools and other educational institutions;
- Forest reserves;
- Works through National Parks and other Wildlife areas;
- Busy population concentration centres e.g., trading centres;
- Areas of cultural heritage significance;
- Informal settlements; and
- Refugee settlements.

1705 TEMPORARY SOIL EROSION AND SEDIMENT CONTROL

(a) Scope

All works shall be undertaken in a manner that avoids or absolutely minimizes erosion and the discharge of siltation and/or other deleterious substances into any watercourse. Any works on a watercourse or in a wetland shall be carried out in line with THE NATIONAL ENVIRONMENT ACT CAP. 181:2019 and THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS, AND LAKESHORES REGULATIONS) NO. 3 OF 2000.

Erosion control Works shall consist of temporary control measures as shown on the Drawings or required by the Engineer during the process of the Works, to control soil erosion and water pollution, by use of berms, dykes, silt fences, brush barriers, dams, sediment basins, filter mats, netting, gravel, mulches, grasses, slope drains, and other erosion control devices or methods. Appropriate control measures will be required to avoid emission of high concentration of sediments into wetlands, swampy areas and other particular sensitive areas.

The temporary erosion control provisions shall be coordinated with permanent erosion control features to assure economical, effective and continuous erosion control throughout the period of the Works.

(b) Construction

The contractor shall prepare an Erosion and Sediment Control Plan (ESCP). The plan shall among other actions include a schedule of proposed temporary (and permanent) soil erosion control Works developed by the Contractor at the commencement of the Contract, in consultation with the Engineer and to their satisfaction. The ESCP is a living document that shall be updated to reflect changing conditions on site.

The Contractor shall carry out (and maintain) temporary erosion control to prevent soil erosion that will adversely affect construction operations, damage adjacent properties, or cause contamination of adjacent streams or other watercourses, lakes, ponds, swamps or other areas of water impoundment. Such Works may involve construction of temporary berms, dykes, dams, sediment basins, slope drains or use of temporary mulches, mats, seeding or other control devices or methods as necessary to control erosion. Cut and fill slopes shall be seeded and mulched as the excavation proceeds, to the extent considered desirable and practicable by the Engineer.

Temporary erosion control may include construction outside the right-of-way where such work is necessary, as a result of roadway construction, such as borrow pit and quarry operations, haul roads and equipment storage sites.

The Contractor shall incorporate all permanent erosion control features as shown on the Drawings into the Works at the earliest practicable time as outlined in their schedule, to minimise the need for temporary erosion control measures.

Where erosion is a problem, clearing and grubbing operations shall be so scheduled and performed that grading operations and permanent erosion control features can follow immediately thereafter if conditions permit; otherwise, temporary erosion control measures may be required between successive construction stages.

The Engineer will limit the area of clearing and grubbing, excavation, borrow and embankment operations in progress commensurate with the Contractor's capability in keeping the finished grading, mulching, seeding and other permanent erosion control measures current in accordance with the schedule. Should seasonal limitations make such co-ordination unrealistic, temporary erosion control measures shall be taken immediately to the extent feasible and justified.

The Engineer may increase or decrease the amount of surface area of erodible earth material to be exposed at one time by clearing and grubbing, excavation, borrow and fill operations as determined by their analysis of project conditions.

In the event that temporary erosion control measures are required due to the Contractor's negligence, carelessness or failure to install permanent controls as part of the Works, scheduled or ordered by the Engineer, such Works shall be carried out by the Contractor at their own expense.

During works near surface water courses, the contractor shall have clean materials on site to prevent spills into water and where recovery is necessary, equipment must be availed immediately. Recovery shall be to the satisfaction of the Engineer.

The contractor shall always maintain erosion and sediment control measures such that they function as designed. Immediate action in any case not more than 48 hours shall be taken by the contractor to rectify any deficiency observed in the functioning of such measures. However, should the deficiency be of such a magnitude as to occasion an emergence, the contractor shall within 1 hour take immediate action to undertake corrections.

The contractor shall be responsible for preparation of the

Erosion and Sediment Control Plan (ESCP) which will form part of the C-ESMP to be approved by the Engineer and the Client. The ESCP shall include the following among other elements:

- i) Prior to commencement of construction activities, the contractor assisted by staff from the Supervising Consultants shall identify major construction activities that require an ESCP. The contractor may then be required to prepare separate plans for each activity were deemed necessary.
- ii) Erosion and Sediment Control Plans for each material source area (quarries borrow areas), Spoil stocking areas, haul roads or access roads, equipment parking areas and disposal sites, shall be prepared for the approval of the engineer.
- iii) The validity of a contractor's Erosion and Sediment Control Plan shall apply so long as the conditions and anticipated conditions pertaining to its approval have not changed. Validity will lapse in the event of changes.
- iv) At the request of the Engineer and/or the client, the Contractor may be required to update and resubmit the ESCP at any time during execution of works and may further require the contractor to cease work until updates are submitted and approved. It shall remain the responsibility of the contractor to always have an approved plan on site.
- v) The Supervising Environmentalist may order the Contractor to stop work or to take other precautionary or remedial measures should it be observed that the Contractor's actions, procedures, intended or unintended contravene the ESCP. All costs of any resultant delays shall be borne entirely by the Contractor.

The Contractor shall construct sediment control ponds should they be deemed necessary to control the release of runoff carrying substantial loads of sediment with potential to impact biophysical resources and landscape aesthetics. The choice of nature of the facility to be constructed shall depend on site conditions and land morphological characteristics.

The Works prescribed in this CLAUSE 1705 shall not be measured for direct payment, but shall be considered as subsidiary Works, the costs of which will be deemed to be included by the Contractor in their rates in the Bill of Quantities for other items of work.

1706 CONSERVATION OF VEGETATION AND HABITATS

(a) General

Clearing and grubbing shall be undertaken in such a manner so as to limit unnecessary loss of vegetation cover and habitats. The Contractor shall prepare a Clearing and Grubbing Plan (CGP) for sites identified with a diversity of flora and fauna and trees of conservation significance together with sites under legal protection (forest reserves, wildlife conservation areas, National Parks, Community Conservation Areas) among others for approval by the Engineer.

Clearing and Grubbing in legally protected sites shall be allowed to commence on acquisition of relevant permits from statutory Agencies. The Contractor shall refer to the following legal provisions while drafting the CGP:

- THE NATIONAL ENVIRONMENT ACT CAP. 181
- THE NATIONAL FORESTRY AND TREE PLANTING ACT
- THE UGANDA WILDLIFE ACT
- THE PROHIBITION OF BURNING OF GRASS ACT
- THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS AND LAKESHORES MANAGEMENT) REGULATIONS 2000.

Where in the opinion of the Engineer, a site-specific plan is required, the Contractor shall prepare such a plan for

approval and work may not commence without such an approved plan.

(b) Establishing Activity Zone

The Contractor shall establish limits for clearance and grubbing on sites to be indicated on drawings. The designated zone shall be marked using high reflective tapes or any other appropriate material. The designated zones shall be inspected and approved by the Supervising Environmentalist prior to commencement of works. Where Environment and Socially Sensitive sites exist including but not limited to wetlands, Cultural sites among others, the Contractor may be required to use close cut or no grub practices (cutting trees at ground level and not excavating roots).

While working near surface water courses or wetlands, the Contractor shall observe specifications of THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS AND LAKESHORES MANAGEMENT) REGULATIONS 2000 and shall be carried out after obtaining a relevant permit from the National Environment Management Authority. While carrying out Clearance and grubbing in Forest Reserves, the Contractor shall seek a permit allowing works in a Forest Reserve from the responsible authority or Ministry of Water and Environment. Management of scheduled trees in the clearance zone shall the harvested in line with THE NATIONAL FOREST AND TREE PLANTING ACT.

(c) Conservation of Vegetation

All trees and shrubbery which are not specifically required to be cleared or removed for construction purposes shall be preserved and shall be protected from any damage that may be caused by the Contractor's construction operations and equipment. Special care shall be exercised where trees or shrubs are exposed to injuries by construction equipment, blasting, excavating, dumping, chemical damage, or other operations; and the Contractor shall adequately protect such trees by use of protective barriers or other methods approved by the Engineer. The removal of trees or shrubs will be permitted only after prior approval by the Engineer.

The layout of the Contractor's construction facilities such as workshops, warehouses, storage areas, and parking areas; location of access and haul routes; and operation in borrow and spoil areas shall be planned and conducted in such a manner that all trees and shrubbery not approved for removal by the Engineer shall be preserved and adequately protected from either direct or indirect damage by the Contractor's operations. Except in emergency cases or when otherwise approved by the Engineer, trees shall not be used for anchorage. Where such use is approved, the trunk shall be wrapped with a sufficient thickness of approved protective material before any rope, cable, or wire is placed.

(d) Replacement

Trees or shrubs that, in the opinion of the Engineer, are beyond saving shall be removed and replaced early in the next planting season. The replacements shall be the same species, or other approved species, and of the maximum size that is practicable to plant and sustain growth in the particular environment. Replacement trees and shrubs shall be staked, watered, and maintained for a period of 1 year; all as described in SECTION 5600.

To obtain the maximum success with the planting, the trees shall be well suited for the environment. This will normally mean native species of trees or cultivated trees from local nurseries.

1707 PRESERVATION OF FAUNA AND FLORA

Protection of Fauna within the road development corridor shall be carried out through a combination of protection of habitats and direct intervention for individual threatened species. The Contractor shall be required to develop a Biodiversity Management Plan to be submitted to the

Engineer as part of the C-ESMIP for approval.

Provisions contained in the National legislations listed below among others shall anchor the Biodiversity Management Plan:

- NATIONAL ENVIRONMENT ACT CAP.181
- THE NATIONAL FORESTRY AND TREE PLANTING ACT, 2003
- UGANDA WILDLIFE ACT 2019
- THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS AND LAKESHORES MANAGEMENT) REGULATIONS 2000
- THE NATIONAL ENVIRONMENT (WASTE MANAGEMENT) REGULATIONS, 2020
- NATIONAL ENVIRONMENT (STANDARDS FOR DISCHARGE OF EFFLUENT INTO WATER OR ON LAND) REGULATIONS, 2020
- NATIONAL ENVIRONMENT (ENVIRONMENT AND SOCIAL ASSESSMENT) REGULATIONS 2020

The Contractor shall identify sites rich in fauna by reviewing the Environment and Social Impact Assessment (ESIA) report and carrying out field rapid assessment during drafting of the C-ESMIP. Identified areas shall be mapped and species identified recorded. The site shall be screened off using high visibility tape. Prior to commencement of works, the Environment Manager shall undertake to:

- Use a soft start method to scare away wildlife especially reptiles and amphibians that may have found a habitat in such areas. The use of a vibrator is one such approach.
- Ensure that the work crew are sensitized on wildlife conservation.
- Ensure proper management of food waste and avoid littering that may attract wildlife to sites.
- Avoid spill contamination of surface water.
- Protect trees used as nesting places for birds.
- Avoid bitumen spills and where spills are detected, they shall be recovered immediately.
- Where relocation of wildlife becomes necessary, the Contractor shall liaise with relevant mandated authorities to effect such relocation and acquire necessary authorisation.

1708 PREVENTION OF WATER POLLUTION AND MANAGEMENT OF WATER RESOURCES

(a) General

Construction activities carry an inherent potential to pollute surface water sources and underground water aquifers. Inappropriate stripping, earthworks, bridge and culvert construction, bitumen sprays, asphalt application, borrow area operations are associated with contaminated runoff loaded with silt, chemical spills and litter which become active pollutants in nearby surface water (lakes, rivers, streams, wetlands, ponds among others).

Wastewater from concrete casting yards, equipment repair workshops, washing bays and camp sewage is critical in compromising water quality in nearby water bodies. Construction activities shall be performed by methods that will prevent entrance, or accidental spillage, of solid matter, contaminants, debris, and other pollutants and wastes into streams, flowing or seasonal watercourses, lakes, and underground water sources. Such pollutants and wastes include, but are not restricted to, refuse, garbage, cement, concrete, sanitary waste, industrial waste, radioactive substances, oil and other petroleum products, aggregate processing tailings, mineral salts, and thermal pollution.

(b) Legal Provisions for Prevention of Water Pollution

Water pollution prevention on road projects shall be managed in accordance with National Laws and Guidelines listed in here and any others as may be appropriate:

- THE WATER ACT CAP. 152;
- THE NATIONAL ENVIRONMENT ACT CAP. 181;
- THE NATIONAL ENVIRONMENT (STANDARDS FOR DISCHARGE OF EFFLUENT INTO WATER OR LAND) REGULATIONS;
- THE WATER RESOURCE REGULATIONS;
- THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS AND LAKE SHORES) MANAGEMENT REGULATIONS;
- THE NATIONAL ENVIRONMENT (MOUNTAINOUS AND HILLY AREAS MANAGEMENT) REGULATIONS.

(c) Management Measures at Work Sites

The contractor shall at all times while carrying out construction activities implement measures that eliminate or reduce the possibility of pollutants reaching water bodies. The contractor shall before commencement of works submit a Water resources and pollution management plan to the Engineer for approval. The plan shall among others target areas listed here under:

- i) **Stripping Operations:** the contractor shall limit the duration of exposure while working on sites with easily erodible materials. Where such areas have been identified prior, the contractor shall seek written approval of the Engineer on submission of an acceptable methods statement.
- ii) **Stripped materials:** shall not be placed near surface water courses or wetlands. Sites for placement of stockpiles shall be subjected to appropriate levels of Environment and Social Impact Assessment (ESIA). The placement of stockpiles shall abide by provisions of THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS AND LAKE SHORES) MANAGEMENT REGULATIONS. Erosion control measures shall be implemented for all stockpiles with the Engineer's approval.
- iii) **Earthwork:** All excavated waste and surplus material shall be disposed of in line with existing legislation. All proposed dumpsites shall be subjected to appropriate levels of Environment and Social Assessment. The Contractor shall indicate the locational coordinates of the site, volume to be handled, area of the proposed site, methods to be used and erosion control measures among other key aspects. The Contractor in selecting the site for dumpsites shall ensure the location does not contravene THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS AND LAKESHORES MANAGEMENT) REGULATIONS.
- iv) All stockpiles shall be properly drained with a slope of 1:3 with erosion control measures.

During the establishment of Material Source Areas (Quarries and Borrow areas), the Contractor shall abide by the Erosion and Sediment Management Plan together with all measures as spelt out in CLAUSE 1703 (b) and (c).

(d) Working on and/ or Near Surface Water Courses

i) General

Control of water pollution while working on and or near surface water courses shall be implemented in accordance with current laws. Work on surface water courses may not commence unless the Contractor has obtained the Permit to Construct over Surface water from the Ministry of Water and Environment and further Permit to use Wetlands, Riverbanks and Shorelines from the National Environment Management Authority (NEMA). All other provisions of THE NATIONAL ENVIRONMENT (STANDARDS FOR DISCHARGE OF EFFLUENT INTO WATER OR LAND) REGULATIONS 2020 and THE WATER RESOURCE REGULATIONS AND THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS AND

LAKE SHORES) MANAGEMENT REGULATIONS shall be complied with.

The Contractor shall be required to produce a method statement detailing procedures at such sites as may be identified for approval of the Engineer. The activities listed here under among others at the discretion of the Engineer shall require detailed procedures:

- Construction of Bridges;
- Maintenance of Bridges;
- Installation of culverts;
- Installation of temporary crossing points on water courses;
- Water course diversions; and
- Construction and maintenance of ditches.

Under no circumstances shall discharges into surface water or on land take place without prior treatment at an appropriate wastewater treatment facility such that any discharges comply with THE NATIONAL ENVIRONMENT (STANDARDS FOR DISCHARGE OF EFFLUENT INTO WATER OR ON LAND) REGULATIONS, 2020.

Dewatering work for structure foundations or earthwork operations adjacent to, or encroaching on, streams or watercourses shall be conducted in a manner to prevent muddy water and eroded materials from entering the streams or watercourses by construction of intercepting ditches, bypass channels, barriers, settling ponds, or by other approved means. Excavated materials or other construction materials shall not be stockpiled or deposited near or on-stream banks, lake shorelines, or other watercourse perimeters where they can be washed away by high water or storm runoff or can in any way encroach upon the watercourse itself.

Turbidity increases in a stream or other bodies of water that are caused by construction activities shall be strictly controlled. When necessary to perform required construction work in a stream channel, the turbidity may be increased as approved by the Engineer for the shortest practicable period required to complete such work. This required construction work may include such work as diversion of a stream, construction or removal of cofferdams, specified earthwork in or adjacent to a stream channel, pile driving, and construction of turbidity control structures. Mechanised equipment shall not operate in flowing water except as necessary to construct crossings or to perform the required construction.

Wastewaters from aggregate processing, concrete batching, or other construction operations shall not enter streams, watercourses, or other surface waters without the use of such turbidity control methods as settling ponds, gravel-filter entrapment dikes, approved flocculating processes that are not harmful to fish, recirculation systems for washing of aggregates, or other approved methods. Any such wastewaters discharged into surface waters shall contain the least concentration of settleable material possible. For the purpose of these specifications, settleable material is defined as that material which will settle from the water by gravity during a 1-hour quiescent detention period.

ii) Baseline Water Quality Tests

Where construction activities are likely to affect a water course or are within the vicinity of a water course, the Contractor shall conduct baseline water quality tests (prior to commencement of construction activities) at his own costs. After the baseline water quality tests, the Contractor will be required to conduct periodic water quality tests (preferably on a quarterly) basis to determine that there are no significant changes in

water quality (based on the parameters). In case of any significant change in water quality, the Contractor will take immediate corrective measures and/or implement appropriate mitigation measures at his own cost.

The Contractor will be required to prepare a method statement for construction works within the vicinity of water courses and seek approval for the same from the Engineer.

iii) Location of Staging Area

Where a staging area is required for any work near/on surface water, the Contractor shall ensure that an appropriate level of Environment and Social Assessment is carried out. The Contractor shall install Erosion and Sediment Control measures at the staging area as contained in the ESCP plan section 1706. Discharge of wastewater from the different facilities including concrete batching plants, equipment washing areas, asphalt plant among others shall be done after treatment using an appropriate facility approved by the Engineer and contained in the ESIA for the site.

iv) Stocking Areas for Excavated Materials

Excavated material stockpiles shall not be established within the protection zone as defined in THE NATIONAL ENVIRONMENT (WETLANDS, RIVERBANKS AND LAKE SHORES) MANAGEMENT REGULATIONS 2000. The contractor shall identify a stocking area/s and carry out the necessary Environment and Social Assessment. The location should be selected so as to facilitate restoration of sites in future at decommissioning and site restoration.

v) Fills into Water Courses

The Contractor shall use appropriate methods including construction of appropriate cofferdams while carrying out fills in water courses to avoid pollution of such courses. After fill activities, the fill shall be protected using methods approved by the Engineer.

vi) Temporary Water Crossings

The Contractor shall in the course of constructing temporary water crossings apply control measures to avoid pollution of surface watercourses, appropriate measures including protecting temporary fill embankments using sandbags, rock etc. whichever is approved by the Engineer shall be applied.

vii) Diversion of Surface Watercourses

Diversion of streams shall only be undertaken on the approval of the Engineer on submission of a method statement. The method statement shall be prepared in accordance with terms and conditions as specified on the Permit to construct on surface water granted by the Ministry of Water and Environment. The contractor shall ensure the protection of banks through appropriate measures including but not limited to sandbags, rocks etc.

viii) Equipment Working On/ Near Surface Watercourses

Equipment to be used must be inspected and approved by competent personnel commissioned by the Engineer. Equipment must be devoid of oil and fuel leakages, duly serviced and in proper working order with a certificate of worthiness issued by a competent authority. Equipment shall under no circumstances be serviced or repaired on sites near water nor shall they be refuelled while on sites near water. All such operations shall be done away from the protected zone as established by law. Servicing and repairs shall be carried out at designated approved equipment yards and service bays. All waste generated as a result of servicing and repairs (oil filters, fuel filter, air cleaners, waste oil, lubricants, used tyres, worn out equipment parts etc.) shall be disposed of in the most appropriate manner as stipulated in the waste management section.

ix) Management of Spills Near Surface Watercourses

The Contractor shall be required to prepare a Spills Management Plan to be approved by the Engineer. Among other aspects, the Plan shall address management of spills on or near watercourses. The Spills Management plan shall address the under mentioned among others.

- Spills management equipment to be stationed at the construction site.
- Materials on site for abatement of spills (an inventory shall be held on site).
- Each site supervisor shall have an approved spill kit with capacity to serve the magnitude of the site. The spill kit shall contain at a minimum (PPE, Spill containment equipment, absorbent material and a disposal container).
- Trained personnel to manage spills.
- Toolbox content for management of spills on/near water.

In the event of a spill, the contractor shall apply the Emergence Response Procedure as contained in these specifications. To avoid water pollution and ensure safety, the Contractor personnel shall be required to undertake rapid appraisal of safety of all personnel and risk of explosion. Personnel are required to turn off and isolate the source of leakage, locate a spills kit and use appropriate equipment to stop the spill from spreading.

Where the spill magnitude is beyond the capacity and resources of site personnel, the Safety Manager shall notify the Police Fire Brigade for assistance. Notification shall be made to the Engineer immediately and the Client within 24 hours. Incident investigations shall be commissioned and reports required.

Materials used to manage hazardous spills shall be treated as hazardous wastes and will be handed over to the licensed waste manager for subsequent management.

x) Restoration and Compliance with Laws and Regulations

The Contractor shall comply with all applicable Ugandan laws, orders, regulations, and water quality standards concerning the control and prevention of water pollution. Failure to comply with the regulations, the contractor shall be held liable. Ensuing legal actions including legal notifications, restoration orders etc. from regulatory agencies (NEMA, Ministry of Water and Environment among others) shall be the responsibility of the contractor. Where community drinking water sources are involved, the Engineer shall direct the Contractor to avail safe alternative drinking water sources.

(e) Wastewater Contaminated by Cement

Wastewater contaminated with cement including wastewater from concrete batching plant, curing areas etc. shall be disposed of through an appropriate sedimentation facility approved by the Engineer. The facility shall have the capacity to hold wastewater for above 48hrs or until acceptable PH levels are achieved as per national specifications. Should PH level persist, the Contractor shall be required to treat wastewater until acceptable PH levels are achieved.

1709 WASTE MANAGEMENT (NON-HAZARDOUS)**(a) General**

The Contractor shall as much as possible avoid the generation of wastes through proactive planning. All subcontractors and suppliers shall be required to take back material packaging. Prior to commencement of work, the

Contractor shall be required to prepare a Waste Management Plan (WMP) as part of the C-ESMP to be approved by the Engineer and the Client. The WMP shall clearly present the waste management hierarchy (Storage, Collection, transportation and Disposal) of the Contractor. Before disposal, the Contractor shall be required to demonstrate the absence of possible re-use and recycling of wastes.

Waste Management shall be undertaken in line with THE NATIONAL ENVIRONMENT ACT CAP. 181, THE NATIONAL ENVIRONMENT (WASTE MANAGEMENT) REGULATIONS 2020, THE PETROLEUM (WASTE MANAGEMENT) REGULATIONS 2019, and THE PUBLIC HEALTH ACT CAP 281 among other relevant laws. The Waste Management Plan shall therefore be prepared in close reference to these and other laws.

The Contractor shall be required as part of the Waste Management Plan to document and characterise the main waste streams anticipated on the project. Where possible, anticipated volumes and risks associated with identified waste streams shall be documented as required by THE NATIONAL ENVIRONMENT (WASTE) REGULATIONS 2020.

Should the Contractor so desire to undertake waste disposal, guidelines as contained in the Regulations shall be followed including obtaining the requisite authorisations from Local Governments, undertaking Environment and Social Assessments, paying required fees among others.

(b) Collection and Storage

The Contractor shall be required to design category specific storage systems for waste as specified in THE NATIONAL ENVIRONMENT (WASTE MANAGEMENT) REGULATIONS 2020. Colour coded receptors shall form the basis of storage to facilitate easy removals and evacuation to disposal trucks. On-site waste storage facilities will be provided as a secure, short-term store for all waste streams generated on site prior to them being collected by licensed or gazetted agencies acting as waste handlers for final disposal. Wastes will be segregated in accordance with THE NATIONAL ENVIRONMENT (WASTE) MANAGEMENT REGULATIONS 2020 to ensure that each category of waste transported by or on behalf of the Contractor meets the waste acceptance criteria of the authorized waste receiving site/process. The Contractor shall ensure a daily domestic collection and transportation schedule is implemented. Appropriate collection trucks for domestic solid waste are self-loading vehicles with proper covers.

The Contractor shall construct a central storage bank (receptor) with chambers to hold different categories of wastes. The Bank shall be set of a raised concrete platform and sheltered with appropriate material.

In line with provisions of THE NATIONAL ENVIRONMENT (WASTE) REGULATIONS 2020, the Contractor shall ensure that no littering occurs at the generation, storage and during transportation.

(c) Domestic Waste Disposal

Domestic wastes shall be taken to include general household domestic kitchen waste including food waste, wrappings, vegetative matter, soft paper, household item packaging materials, leather and textiles. Such wastes shall be mainly generated from residences, offices and kitchen/dining places.

Domestic waste disposal shall be in a licensed facility; the Contractor shall procure the services of a licensed waste handler to undertake waste disposal. Waste transfer trucks shall be designated for such functions; material delivery trucks shall not be used to transport wastes unless prevailing circumstance dictate so. The use of such trucks shall be approved by the Engineer specifying the period and conditions of approval.

Where wastes are handed over to Local Governments including municipalities or any other local government facility, the Contractor shall be required to prove that the facility is gazetted and/or permitted by the National Environment Management Authority in line with THE NATIONAL ENVIRONMENT (WASTE) REGULATIONS 2020.

(d) Construction Debris

Construction debris shall be taken to comprise cut to spoil, excavated materials, demolition wastes among other inactive debris. Cut to spoil excavated materials or other construction rubble and surplus materials shall not be stockpiled or deposited near or on-stream banks or other watercourse perimeters where they can be washed away by high water or storm runoff or can in any way encroach upon the watercourse itself. Stockpiling of wastes shall not be done near schools, residences or health facilities. Stockpiling sites shall be subject to an appropriate level of Environment Assessment in accordance with THE NATIONAL ENVIRONMENT ACT CAP. 181 and THE NATIONAL ENVIRONMENT (WASTE) REGULATIONS. Before disposal the Contractor shall explore all means of reuse or recycling. Such materials shall, as far as possible, be used in embankment construction if the quality so warrants or in the backfilling of temporary quarries if such areas are available, otherwise the Contractor shall dispose of surplus material in the places so designated in the final designs, and/or so authorized by the Engineer.

1710 WASTE MANAGEMENT (HAZARDOUS WASTE)

(a) General

The management of wastes classified as hazardous or containing hazardous substances shall be managed according to the NATIONAL ENVIRONMENT (WASTE) REGULATIONS 2020. Schedules 2 and 3 of the regulation specify what is to be considered as hazardous waste or waste containing hazardous substances. The Waste Management Plan to be prepared by the Contractor shall clearly indicate hazardous wastes to be anticipated on the project e.g., wastes contaminated with explosives, chemicals, health care waste, used oils and lubricants among others shall fall in this category.

The Contractor shall ensure that hazardous waste is segregated from non-hazardous waste and further ensure that different types of hazardous waste do not cross-contaminate. Throughout the management cycle, waste shall be managed in such a way so as not to cause harm to human health and the environment. The Contractor shall ensure that hazardous waste is containerised at all stages. The Contractor shall procure services of a waste handler licensed to receive hazardous wastes. The Contractor shall be required to properly package and label hazardous wastes with information regarding type and source as required by Good International Industry Practices.

(b) Hazardous Health Care Waste

Hazardous healthcare waste according to THE NATIONAL ENVIRONMENT (WASTE) REGULATIONS 2020 INCLUDE:

- Sharps waste, including needles, hypodermic needles, scalpels, blades, knives and infusions;
- Infectious waste, including waste contaminated with blood and other body fluids, cultures and stocks of infectious agents from laboratory work and waste from infected patients in isolation wards;
- Pathological waste, including waste consisting of tissues, organs, body parts, blood, body fluids and other waste from surgery and autopsies on deceased persons with infectious diseases;

- Pharmaceutical waste, including cytotoxic and genotoxic waste and expired, unused, split and contaminated pharmaceutical products;
- Chemical healthcare: including discarded solid, liquid and gaseous chemicals; and
- Radioactive healthcare waste, including materials contaminated with radionuclides.

The Contractor shall be obliged to ensure segregation by type and containerized management of healthcare waste at all times. Healthcare wastes shall not be mixed with other waste streams. Hazardous Healthcare waste generated shall be stored in colour coded lined self-closing air and leak proof receptors. These shall be handed over to a licensed waste handler or facility licensed by NEMA to manage such waste. Should the Contractor desire to manage their own healthcare waste, they shall apply for licensing by NEMA.

Hazardous waste generated from the laboratory, mechanical workshop and any other facility shall be properly documented by the Environment Manager and classified according to the Regulations. The Environment Manager shall produce a manifest describing the exact nature of waste that will be handed over to the licensed waste handler. All persons handling hazardous waste shall be provided with appropriate Personal Protection Gear and be given relevant training.

At the cessation of construction operations, the contractor shall undertake to decommission all hazardous waste storage facilities on site following guidance given in THE NATIONAL ENVIRONMENT (WASTE MANAGEMENT) REGULATIONS 2020.

(c) Contaminated Runoff and Wastewater from Equipment Washing Platforms and Parking Yards

Contaminated runoff and wastewater at the camp shall be managed in accordance with THE NATIONAL ENVIRONMENT (STANDARDS FOR DISCHARGE OF EFFLUENCE INTO WATER OR LAND) REGULATIONS 2020. All platform shall under no circumstance discharge runoff into the general stream. Equipment washing bays shall be connected to interceptors and sumps to allow removal of floating oil and lubricants. A system of dykes/sumps shall be constructed around the platform to control water ingress.

(d) Spills and Lubricants from Service Bays and Fuel Dispensing Units

The service bay generates reasonable quantities of accidental spills and waste oils that may end up contaminating the surrounding environment. Fuel spills from the dispensing facility have the potential to contaminate the site. The following measures shall be applied to mitigate water and land pollution arising from runoff from facilities:

- The service bay shall be set on a concrete screed platform with an appropriate shelter to exclude ingress by rain. Cut off drains shall be established;
- All wastewater arising from cleaning the platforms shall be directed to an interceptor before discharge into the environment;
- The fuel dispensing facility shall be roofed with an appropriate apron; and
- The entire fuel dispensing facility shall be set on a concrete screed platform protected by cut off drain to eliminate ingress by runoff.

The contractor shall leave ample buffer between the camp and adjoining properties to serve as buffers. Buffer zones shall be vegetated.

(e) Asphalt Plant and Asphaltic Materials

The Contractor shall install their asphalt mix production plant on flat land, cleaned of vegetable topsoil, with suitable access for all types of vehicles, and far from urban

settlements. The plant installation shall provide adequate storage space, bonded and protected as necessary, for raw and surplus materials, and ample space for traffic circulation, thus, preventing hindrance to loading and unloading operations. Installation of asphalt mixing plants in private land shall not be permitted, unless with written authorisation from the owner(s) or their legal representative and with the approval of the lead agencies responsible for environmental management.

The asphalt mix production plant shall be adjusted to operate in such a manner that, to the extent possible, the dust discharge to the surrounding area is kept minimal. When transporting mixed asphalt, dump trucks shall be fitted with adequate devices to prevent material spillage. In addition, the existing local regulations for transportation of hazardous materials shall be observed.

1711 ABATEMENT OF AIR POLLUTION

(a) General

The Contractor shall be required to prevent or minimize the impact of emissions resulting from their activities by ensuring that emissions do not result in pollution concentrations that reach or exceed Uganda National ambient air quality guidelines and Standards. Construction activities and operation of equipment shall be conducted in such a manner so as to minimise atmospheric emissions. Construction activities and operation of equipment shall be conducted in such a manner that limits atmospheric emissions in accordance with THE NATIONAL ENVIRONMENT (AIR QUALITY STANDARDS) REGULATION 2024.

Prior to commencement of project activities (all auxiliary facilities and work sites), the contractor shall be required to undertake baseline air quality studies to provide benchmarks for future monitoring purposes and where required form the basis for modelling atmospheric processes for example dispersion.

The contractor, based on baseline air quality studies undertaken during Environment and Social Impact Assessments (ESIA) shall identify sections with poor air quality or sensitive ecological areas including at all auxiliary facilities and take all necessary measures to ensure that any increase in pollution levels remains within the national standards. The contractor shall ensure that facilities associated with significant sources of emissions, are not located in areas of poor air quality or are categorized as ecologically sensitive areas.

The Contractor shall be required to use approved fuels or technologies, application of comprehensive pollution control measures among other strategies recommended by regulatory authorities, development partners and local authorities.

(b) Point Sources

The Contractor shall be required to monitor emissions from Point Sources, which are discrete, stationary, identifiable sources of emissions that release pollutants to the atmosphere (asphalt plant, diesel powered energy generators, concrete batching equipment, Diesel powered water pumping stations etc.). Point sources are characterized by the release of air pollutants typically associated with the combustion of fossil fuels, such as nitrogen oxides (NO_x), sulphur dioxide (SO₂), carbon monoxide (CO), and particulate matter (PM), as well as other air pollutants including certain volatile organic compounds (VOCs).

The Contractor shall take all necessary provisions to avoid and control emissions from point sources according to good international industry practice (GIIP). Location of facilities relative to sensitive receptors shall be considered a major mitigation measure.

The stack height for all point sources of emissions, whether 'significant' or not, should be designed to conform to National Laws and according to GIIP to avoid excessive ground level concentrations due to downwash, wakes, and eddy effects, and to ensure reasonable diffusion to minimize impacts. For projects where there are multiple sources of emissions, stack heights should be established with due consideration to emissions from all other project sources, both point and fugitive. Non-significant sources of emissions shall also be fitted with stacks of appropriate design.

(c) Fugitive Sources

Fugitive sources refer to emissions that are distributed spatially over a wide area and not confined to a specific discharge point. They originate in operations where exhausts are not captured and passed through a stack. Fugitive emissions have the potential for much greater ground-level impacts per unit than stationary source emissions, since they are discharged and dispersed close to the ground. The two main types of fugitive emissions are Volatile Organic Compounds (VOCs) and particulate matter (PM). Other contaminants (NO_x, SO₂ and CO) are mainly associated with combustion processes. The Contractor shall undertake ambient air quality assessment and monitoring as per schedule to be determined based on baseline data and nature of receptors identified in the ESIA and further the C-ESMP. The Contractor shall avoid open burning of solid wastes, whether hazardous or non-hazardous since it is considered not a good practice as the generation of polluting emissions from this type of source cannot be controlled effectively.

1712 DUST CONTROL

The Contractor shall be required to implement dust suppression measures to minimise dust impact on sensitive receptors such as crops, orchards, cultivated fields, and dwellings, or settlements. The Contractor will be held liable for any damage resulting from dust originating from their operations under these specifications on the right-of-way or elsewhere. The Engineer may direct sprinkling or other measures for dust abatement if necessary to obtain adequate control.

When transporting any materials that may be susceptible to spillage or being dropped on the road, adjacent land or any public area, trucks, lorries and other equipment shall be covered with tarpaulins or similar sheeting to cover the material and prevent loss or spillage. The protective sheeting shall have fixing eyes or tie downs so that it can be securely fitted to the body of the truck or lorry, etc. The Engineer will ban from the project any transport equipment to be used on public roads that is not so equipped.

The Contractor's sealing works programmes shall be formulated to minimise delays (and minimise the environmental and human health impacts) between the laying of pavement sub-base and base reconstruction and final surfacing. The time exposure of crushed stone shall be minimised as agreed with the Engineer.

1713 NOISE ABATEMENT

(a) General

The Contractor shall comply with THE NATIONAL ENVIRONMENT (NOISE STANDARDS AND CONTROL) REGULATIONS, THE OCCUPATIONAL HEALTH AND SAFETY ACT and other relevant applicable Ugandan laws, orders, and regulations concerning the prevention, control, and abatement of excessive noise at work sites and auxiliary facilities.

The Contractor prior to commencement of work, shall present a Noise Management Plan to be approved by the Engineer as part of the C-ESMP. The Noise Management Plan shall among others identify key sensitive noise receptors and characterise them according to existing laws and Good International Industry Practices. Special

precautions shall be taken when the constructor is working in the proximity of hospitals, residential premises, geriatric homes, churches, schools, parks and recreational areas.

(b) Noise Control Standards

The Contractor shall ensure compliance with applicable noise standards as contained in THE NATIONAL ENVIRONMENT (NOISE STANDARDS AND CONTROL) REGULATIONS 2003. The Contractor shall observe the following among others:

- i) The maximum permissible noise levels from a facility in the general environment to which a person may be exposed: As prescribed under REGULATION 6 (1) of the NOISE STANDARDS AND CONTROL REGULATIONS, the limits apply to facilities and receptors which are not located within designated noise control zones but are nevertheless likely to receive noise emissions;
- ii) The maximum noise levels of continuous or intermittent noise from a factory or a workshop to which a person may be exposed;
- iii) The limits may apply to workshops that could be used during execution of the proposed activities, for instance, at the asphalt plant, quarry, mechanical workshop etc.; and
- iv) PART III SECTION 8 (1) of the regulations requires machinery operators, to use the best practicable means to ensure that the emission of noise does not exceed the permissible noise levels. The regulations require that persons to be exposed to occupational noise exceeding 85 dBA for 8 hours should be provided with the requisite ear protection. These regulations will guide operations at the stone quarry where noise from blasting and crushing will ensue and in regard to protection of construction crew and local communities from excessive noise from workshops, blasting and road construction equipment.

(c) Noise Control Measures

The Contractor shall undertake appropriate measures aimed at reducing noise levels where possible and mitigating through protection where noise source reduction measures are less effective.

i) Equipment and Tools

The Contractor shall always procure and deploy modern equipment with low noise emissions as specified by national regulations and/ or Good International Industry Practices. The Contractor shall be further obliged to undertake general housekeeping including servicing all equipment regularly.

Under no circumstance will equipment including heavy duty earth moving equipment and crushers be allowed to overshoot their service dates. The Contractor shall be required to install noise abatement accessories (noise mufflers, sound hoods etc.) and undertake routine maintenance of such devices.

The Contractor will strictly observe equipment specifications to do with loading and operational procedures. All personnel operating equipment with the Contractor and sub-contractors shall be required to turn off equipment when not in use. All high noise emission pumps, generators, compressors and saws shall be enclosed in appropriate noise barriers. High noise generating activities including using rock drills, jack hammers, blasting and any other activity at the quarry shall be scheduled during daytime hours unless otherwise permitted.

ii) Equipment Clusters

Workers operating on sites with equipment clusters including heavy earth moving equipment, drilling equipment, generators, vibrators etc. that create a constant roar for over 8 hours on worksites shall be protected against such noise. The Contractor shall be required to supply appropriate noise protection kits as instructed by the Engineer. These are to be replaced

following the manufacturer's specification, national laws and guidelines.

iii) Permitting Conditions and Monitoring

The Contractor shall be responsible for defraying the costs of noise level reduction of the construction equipment, as well as any cost associated with delays in execution of the works for non-temporary fulfilment of the above requirement. The Engineer will undertake to monitor the level of noise, as he deems appropriate. Noise generating activities shall only be permitted beyond the recommended time on obtaining a permit from NEMA. The Engineer basing on the NEMA permit may authorise the conducting of construction activities in prescribed areas for a period beyond legally allowed time. Blasting operations shall not take place beyond 6.00pm.

1714 LIGHT ABATEMENT

The Contractor shall exercise special care to direct all stationary floodlights to shine downward at an angle less than horizontal. These floodlights shall also be shielded so as not to be a nuisance to the surrounding areas. No lighting shall include a residence in its direct beam.

The Contractor shall be responsible for correcting lighting problems when they occur as directed by the Engineer.

1715 MANAGEMENT OF VIBRATIONS

(a) General

The management of activities that have the potential to generate vibrations (blasting over pressure, use of rock hammers, rock drills, heavy equipment including rollers, Dozers, haul trucks, excavators etc.) shall be undertaken within the relevant national legislation including THE EXPLOSIVES ACT CAP. 298, THE OCCUPATIONAL SAFETY AND HEALTH ACT, THE MINING ACT, SECTION 110 (2b), and THE NATIONAL ENVIRONMENT ACT CAP. 181 among others.

The Contractor shall develop a Blasting Management Plan as the basis for managing vibrations associated with rock blasting especially at the quarry, though blasting will also be anticipated in earthworks and demolition of concrete structures found in the carriageway. The Blasting Management Plan shall specify charging procedures blasting ratios; delayed, micro delayed, or electronic detonators; and specific in situ blasting tests. Other parameters including shot hole dimensions shall also be presented.

The Contractor shall observe restricted zones and buffer zones as prescribed by the relevant laws and regulations including NEMA Conditions of approval for the quarry. The same shall apply to all Rock blasting in any other areas including the carriageway. All conditions regarding activities in these zones shall comply with the relevant laws and the principle of involuntary resettlement.

(b) Monitoring Vibrations

The Contractor shall document baseline conditions of structures within work areas using appropriate methods including videography and photography. The obtained data shall be deposited with the Engineer and also archived by the Contractor. Monitoring impacts of vibrations shall be carried out following a schedule to be determined by the Engineer after consideration of baseline conditions of existing structures.

The Engineer may issue a work stop order should the Engineer observe impacts resulting from the Contractor's activities on structures. The Contractor shall bear all resultant costs.

The Contractor shall be required to procure and install standard and calibrated equipment to monitor vibrations especially vibrations arising from blasting activities. Records

of which shall be kept and submissions made to the Engineer on a regular basis as determined by the ESIA.

Pile driving shall be carried out following methods approved by the Engineer. Pile driving shall not cause any damage to nearby structures. Baseline documentation of surrounding structures shall be made through video recordings or photography. Any impacts occurring as a result of pile driving shall be compensated at the Contractor's cost.

1716 MANAGEMENT OF CULTURAL HERITAGE

(a) General

The term 'cultural heritage' shall be interpreted to encompass tangible and intangible heritage. Tangible cultural heritage shall be taken to include movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance. Tangible cultural heritage may be above or below land or under the water; Intangible cultural heritage, shall be taken to include practices, representations, expressions, knowledge and skills as well as the instruments, objects, artefacts and cultural spaces associated therewith that communities and groups recognise as part of their cultural heritage.

Any damage due to the negligent and/or rush actions of the contractor on heritage resources that have been documented in the ESIA or subsequent processes or that are gazetted by the relevant authorities shall be at the cost of the Contractor.

(b) Preservation of Identified Heritage Resources

The Contractor shall carry out their activities in accordance with provisions of the Historical Monuments Act, 1968, other relevant laws of Uganda and international best practices for the preservation of heritage resources. Prior to commencement of work, the Contractor shall produce a Heritage Resource Management Plan which shall form part of the C-ESMP to be approved by the Engineer. The Contractor shall be required to map out heritage resources and potential sites holding heritage resources as identified during the ESIA and use appropriate methods of screening them off during works. Work near identified heritage resources may not commence without the Contractor providing a method statement indicating actions that will be used to protect the particular Heritage Resources.

(c) Chance Finds Procedure

Compliance with legal provisions and other management principles for the management of archaeological, paleontological, historical or architectural artefacts shall be based on THE HISTORICAL MONUMENTS ACT, 1968 and any other relevant laws and regulations. The Contractor shall develop a Chance Finds Procedure to be approved by the Engineer and the purpose of which shall be to guide management of discoveries of materials with heritage value along road works and auxiliary sites.

Discoveries of archaeological, paleontological, historical or architectural artefacts of cultural or scientific interest shall remain the property of the Government of Uganda and shall be communicated to the Engineer and the relevant authorities notified within 48 hours. The Contractor shall cease work and be required to provide assistance in protecting, documenting, preserving for relocation and any other assistance deemed necessary by the Engineer.

The Contractor shall take all necessary measures including but not limited to drainage or erosion control, slope stabilization, erecting fences/barriers to protect archaeological, paleontological, historical or architectural sites that are situated within or adjacent to a project site. A buffer zone may be required to protect the heritage resource so identified; the dimensions of such a zone shall be determined by a professional Archaeologist identified by the

Engineer in consultation with the Client and the relevant authorities with mandate over heritage resources.

The Contractor shall be held responsible for all acts of vandalism carried out by employees or sub-contractors on chance finds and the unlicensed collection of artefacts from designated archaeological sites around the construction area.

Where appropriate by reason of a discovery, the Engineer may order delays in the time of performance, or changes in the work, or both. If such delays, or changes, or both, are ordered, the time of performance and contract price shall be adjusted in accordance with the applicable clauses in the Conditions of the Contract. The Contractor shall agree to insert this Clause in all subcontracts which involve the performance of work on the terrain of the site.

1717 DECOMMISSIONING, RESTORATION OF SITES AND FINAL ENVIRONMENT AND SOCIAL MITIGATION REPORT

Upon completion of construction, all temporary auxiliary facilities including camps, equipment yards, quarries, borrow areas, bridge construction sites and road work sites shall be decommissioned and restoration undertaken. Decommissioning shall not commence without a Decommissioning and Restoration Plan approved by the Engineer and relevant authorities. All restoration procedures shall be documented and documentation of guidelines for maintenance provided to the Engineer.

The Contractor shall ensure that all project related sites are left in an environmentally acceptable state subject to approval by the National Environment Management Authority (NEMA) or other delegated agencies. Restoration shall ensure that the sites revert back to near original state as far as possible. Unless so permitted and following the laid down procedures under the law change of land use shall not take place at decommissioned and restored sites.

Special Specifications shall be drafted by the different implementing agencies to detail level of approval where need be.

The Contractor shall be required to submit a Final Environment and Social Mitigation Report. The report is a de-facto environmental and social status report of the project as the contractor exits the site. The contractor shall be required to present a report on environment and social conditions after decommissioning and restoration of sites including material source areas such as borrow areas, rock quarry and spoil areas. The report will also handle the decommissioned workers camp and equipment yard. The contractor shall describe all management actions implemented during construction and advise on future environment and social management strategies including statutory audits and permits acquired.

1718 ENVIRONMENT, SOCIAL, HEALTH AND SAFETY (ESHS) AUDIT

The Contractor shall be required to undertake annual audits on facilities for which they hold NEMA Certificates as prescribed under THE NATIONAL ENVIRONMENT (AUDIT) REGULATIONS 2020. The Employer will engage a Service Provider to carry out annual environmental and social audits for the whole project. The costs associated with these services will be covered under ITEMS 17.02 (a) and (b).

1719 CLIMATE CHANGE MITIGATION AND ADAPTATION

The National Climate Change Act prescribes the provisions for mitigating climate change for development projects that include road construction.

(a) Mitigating Climate Change (Climate Neutrality)

Mitigating climate change involves decarbonisation, promoting energy efficiency, energy savings, and deploying renewable forms of energy. It involves taking action to reduce GHG emissions or increase GHG sequestration. Road construction projects emit greenhouse gases into the atmosphere either directly (e.g. fuel combustion or production process emissions) or indirectly through purchased electricity and/or heat.

The contractor shall be required to undertake measurement of GHG emissions on the project. This shall include Scope 1, Scope 2 and Scope 3 emissions.

The Developer shall be required to undertake GHG assessments during the ESIA and SEA processes. The assessment shall be used to rank and select options.

The carbon footprint methodology based on the concept of scope or any other internationally recognized methodology shall be used to compute GHG emissions.

(b) Climate Change Mitigation and Adaptation (Climate Resilience)

Where the contractor is responsible for the design, they shall be required to undertake measures that promote resilience to climate. They shall carry out the following during feasibility and detailed design stage:

- Climate Risk and Vulnerability Assessment;
- Identification of Adaptation Responses and Opportunities;
- Adaptation to Climate Change Responses and Strategies; and,
- Climate Change Adaptation Plan.

1720 MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
17.01	ENVIRONMENTAL AND SOCIAL MANAGEMENT AND IMPLEMENTATION PLAN, SAFETY AND HEALTH MANAGEMENT PLAN, DECOMMISSIONING PLANS, FINAL ENVIRONMENTAL MITIGATION REPORTS AND OTHER REPORTS	LUMP SUM

Payment for preparation of the Construction Environmental and Social Management and Implementation Plan (C-ESMIP), safety and health management plan, decommissioning plans, final environmental mitigation reports and other reports will be made at the lump sum entered in the Bill of Quantities for ITEM 17.01 on the following basis:

- i) 10% of the lump sum will be paid upon approval of the Contractor's Environmental Management and Implementation Plan;
- ii) 20% of the lump sum will be paid upon completion of the construction and equipping of all site facilities, including workers' site accommodation and toilet facilities in line with the provisions of this specification and to the satisfaction of the engineer;
- iii) 20% of the lump sum will be paid upon decommissioning of all site facilities in line with an approved decommissioning plan and a mitigation report to the satisfaction of the National Environment Management Authority (NEMA) the Engineer and the Employer;
- iv) The balance of the lump sum (50%) will be paid in monthly instalments over the duration of the contract as part of the

Interim Payment Certificate. The instalments will only be paid following the approval of monthly environmental and social compliance reports by the Engineer;

- v) Failure to comply with the environmental and social conditions of contract and the provisions contained in the Approved Construction Environmental and Social Management and Implementation Plan will result in the Employer deducting UGX 1,000,000 per day for each non-compliance event which shall be deducted from monies due in the next interim payment certificate until the non-compliance(s) is corrected;
- vi) In the case of non-compliance on matters other than environmental and social protection (e.g. dust control, blasting precautions, likely breach of the law etc.) the Contractor shall rectify any problems identified by the Engineer within a maximum of 24 hours of receiving the instruction, or other such time period as the Engineer shall reasonably require. Should the Contractor not comply with the instructions of the Engineer, a penalty as specified in paragraph (v) above for payment ITEM 17.01 will apply.
- vii) Notwithstanding the aforementioned penalties, failure or refusal by the Contractor to comply with any safety, environmental and social conditions of this contract, requirements of statutory authorities, or the instructions of the Engineer to rectify non-compliance, shall be sufficient cause for the suspension of a portion of the Works associated with the breach or as determined by the Engineer, until all provisions prescribed have been complied with, to the satisfaction of the Engineer. Should the Engineer stop the works for any reason related to non-compliance with the specifications on environmental and social protection, there will be no compensation for any costs incurred by the Contractor as a result of such stoppage, nor will there be any extension of time granted as a result.

	<u>ITEM</u>	<u>UNIT</u>
17.02	ENVIRONMENTAL AND SOCIAL AUDITS	
(a)	EMPLOYER'S SERVICE PROVIDER FOR ANNUAL ENVIRONMENTAL AND SOCIAL AUDITS	PROVISIONAL SUM
(b)	CONTRACTOR'S OVERHEADS AND PROFIT AS A PERCENTAGE OF SUB-ITEM 17.02 (A)	PERCENT (%)

The Service Provider (SP)'s invoices will be submitted to the Employer who will forward them to the Contractor via the Engineer. The Contractor shall make payment directly to the SP within 14 days of receiving the invoice. The NSP will issue a receipt directly to the Contractor who will give a copy to the Engineer as evidence of payment.

The Contractor will be reimbursed under SUB-ITEM 17.02 (a) while the rate entered under SUB-ITEM 17.02 (b) shall cover all costs in liaising with the SP and complying with the above.

SERIES 1000: GENERAL

SECTION 1800: OCCUPATIONAL HEALTH AND SAFETY, HIV/AIDS, GENDER AND SOCIAL SAFEGUARDS

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1801 SCOPE

The Section covers measures and methods which the Contractor shall put in place to ensure occupational health and safety (OHS), to prevent and manage the spread of HIV/AIDS and sexually transmitted diseases (STDs), to ensure equal employment opportunities for men and women as well as addressing their specific gender needs and social safeguards.

1802 GENERAL

The Contractor shall comply with among others the following Laws, Statutory Regulations, policies, rules and bylaws with respect to OHS, HIV/AIDS and STD prevention & management support, Gender equity and social safeguards.

- i) **OHS:** THE OHS ACT 2006, THE PUBLIC HEALTH ACT 1935, THE FACTORIES ACT 1948, THE WORKERS' COMPENSATION ACT 2000, THE TRADE UNION DECREE, THE EMPLOYMENT DECREE and other statutory regulations, rules and bylaws that may be enacted from time to time by the Government in respect of OHS.
- ii) **HIV/AIDS:** The National multi-sectoral HIV/AIDS policy and the National Strategic Framework for the HIV/AIDS prevention, care and treatment, THE NATIONAL HIV/AIDS MAINSTREAMING GUIDELINES, THE NATIONAL HIV/AIDS ANTI STIGMA POLICY, THE HIV/AIDS PREVENTION AND CONTROL ACT, which obligate line Ministries and the private sector to ensure that people living with HIV/AIDS are not discriminated against at the workplaces.
- iii) **Gender and Equity:** THE LOCAL GOVERNMENT ACT, THE NATIONAL GENDER POLICY 2007, THE NATIONAL EMPLOYMENT POLICY 2011, THE NATIONAL ORPHANS AND VULNERABLE CHILDREN POLICY 2004, THE NATIONAL COUNCIL FOR DISABILITY ACT 2003 and THE SOCIAL DEVELOPMENT SECTOR STRATEGIC INVESTMENT PLAN, which provide for a basis for equal opportunities for all categories of project beneficiaries irrespective of gender and nature of vulnerability.
- iv) **Social Safeguards:** THE SOCIAL, SAFETY AND HEALTH SAFEGUARDS IMPLEMENTATION GUIDELINES 2020 and THE STAKEHOLDER ENGAGEMENT PLAN 2021 which mitigate against social risks and or adverse effects on people during implementation of projects.

Together with the above, the Contractor's attention is also drawn to any current international protocols or conventions on OHS, to which Government of Uganda is a signatory. In compliance with above mentioned government and international regulations on OHS, HIV/AIDS and Gender equity and on the basis of available social impact assessments related to the project, the Contractor shall

prepare an Occupational Health and Safety (OHS) Management Plan, Traffic Management Plan, HIV/AIDS Management Plan, Gender Management Plan, Labour management plan, Grievance Management Plan and Stakeholder Engagement Plan. These plans shall include details of measures they propose to adopt in a bid to:

- Prevent and reduce accidents and injuries to the staff and workers and minimise health hazards to the adjacent community and general public;
- Prevent the spread of HIV/AIDS and STDs between his staff, labourers and the immediate local community;
- Care for workers and staff who are infected with HIV/AIDS and STDs including provision of counselling and clinic services;
- Encourage the recruitment of men and women as well as addressing their specific gender working and living needs in the road construction environment; and
- Provide guidance on stakeholder engagement by detailing the contractor's liaison with the community and local authorities.

The OHS Management Plan, Traffic Management Plan, HIV/AIDS Management Plan, Gender Management Plan, Labour Management Plan and Stakeholder Engagement Plan shall be submitted to the Engineer not later than 4 weeks after the notice to commence the Work. These plans will constitute part of the Construction Environment and Social Management Plans under SECTION 1700.

1803 OCCUPATIONAL HEALTH AND SAFETY

The Contractor shall ensure, so far as is reasonably practicable, the health, safety and welfare at work of their employees including those of their sub-contractors and of all other persons on the Site. In this respect the Contractor shall liaise with the various relevant local, regional and national authorities with respect to OHS issues.

The Contractor's responsibilities shall among others include the requirements specified in the following SUB-CLAUSES.

(a) Health and Safety Management Systems

The Contractor shall develop a Health and Safety Management Systems (MS) framework in line with the national laws and other internationally acceptable standards. All requirements within the manual shall be implemented to the detail. The Contractor shall undertake quarterly Health and Safety MS audits and document the findings and implement improvements. The health and safety audit report shall be shared with the Engineer and Employer.

(b) Safety Risk Assessment

The Contractor should undertake risk assessments and implement safe systems of work for all activities prior to commencement. Risk Assessments and proposed Safe Systems of Work shall be reviewed and approved by the Employer prior to implementation. General Risk Assessments must be reviewed every six months or when the need arises.

The proposed risk reduction measures shall be integrated within work method statements and made as an integral part of all activities. Contractors' HSE Manager shall review all method statements and ensure that the requirements of the Risk Assessments are embedded there in.

(c) First Aid Facilities

The Contractor shall employ on the Site, during the execution of the Works, competent and qualified first-aid practitioners with at least five (5) years' experience in first-aid and hygiene.

The Contractor shall provide the first-aid practitioner with a stock of medicines and medical equipment of a scope, quantity and standard deemed adequate by the appropriate medical authorities, and shall keep such stock and equipment replenished and in good order.

The contractor shall provide and maintain well stocked first aid kits at all active work fronts, in the Engineer's vehicle, and in the vehicle of his own staff. These kits shall be adequately and regularly replenished on depletion or if out of date.

The contractor shall make provision for the presence of an ambulance on the project as part of the emergency plan whenever deemed necessary. The ambulance will be manned by a trained driver and Nurse (advance first aid). An ambulance will not be used to transport workmen to and from work. The ambulance shall be maintained in good mechanical condition. Where the contractor is not able to provide an ambulance, the Engineer shall provide the service and reimburse from the Contractor's budget.

The Contractor would need to take all required measures to minimize risk of injuries/ accidents to workers and communities from project related activities to as low as reasonably practicable and in line with THE OSH ACT 2006. In addition, the Contractor shall make suitable arrangements for anti-malaria precautions and for the prevention of epidemics and for all necessary welfare and hygiene requirements.

First aid facilities at the main campsite may include the shared use of the HIV/AIDS clinical facility described in SUB-CLAUSE 1804 (b) of this Specification. However, as described in this paragraph, the Contractor will have full responsibility for financing and organising patient transfer and treatment at local clinics and hospitals. In the event that the Contractor utilises the services of the clinical nurse provided on site by the HIV/AIDS service provider for first aid and basic medical services, the Contractor must accept that the medical opinion of that nurse is final and the Contractor will follow all advice given by that nurse with respect to medical matters.

(d) Safe Constructional Plant, Equipment and Methods of Work

This covers the provision and maintenance of constructional plant, equipment and systems of work that are lighted, safe and without risks to health. This shall include maintaining equipment, engines, and related electrical installations in good working order; maintaining a clean and tidy workspace; providing guards and rails, signals and lighting; providing work site rules, safe working procedures and allocating appropriate places to carry out the work.

The Contractor shall develop and implement maintenance plans for vehicles plant and equipment in line with the manufacturer's specification. Records demonstrating the maintenance shall be maintained on file throughout the life of the project. Periodically the Employer and Engineer will undertake audits of the implementation of this plan.

The Contractor's equipment shall be maintained and serviced as per the manufacturers' specifications and national regulations. All modifications and downgraded equipment shall be logged by the Health and Safety Officer.

(e) Safe Handling, Storage, Transport and Disposal of Hazardous Substances

This covers the execution of suitable arrangements for ensuring safety and absence of risks to health and the environment in connection with the use, handling, storage, transport and disposal of particles and substances.

The contractor shall prepare and implement a hazardous substances management plan and procedures and shall maintain material safety data sheet (MSDS) for all

hazardous substances used in project.

The Contractor must ensure that all stores are located in such a manner that reduces risks to the workers on site. Stores must further be arranged so as to facilitate safe use handling, and storage of hazardous waste, as well as its transfer to a licensed hazardous waste handler for final transfer to a gazetted hazardous waste management facility.

(f) Personal Protective Equipment (PPE)

This covers the provision of protective clothing and equipment, first aid stations with such personnel and equipment as are necessary and such information, instruction, training and supervision as are necessary to ensure the health and safety at work of all persons employed on the Works all in accordance with the Laws of Uganda.

The Contractor shall ensure that all employees and all visitors to the site are equipped with approved safety vests/jackets utilizing retro-reflective and/or fluorescent panels in red, yellow, white and/or silver and that the safety vests/jackets are worn whenever his personnel and visitors are on the site of the works. Any person found not wearing a safety vest/jacket while on the site of the works, including any of the Engineer's or the Employer's staff, shall be instructed to leave the site until they are in possession of and wearing a safety vest/jacket. All safety vests/jackets shall be kept clean and in good condition and any safety vests/jackets that are, in the opinion of the Contractor's safety officer and/or the Engineer, ineffective shall be immediately replaced by the Contractor, Engineer or Employer, as applicable.

The Contractor shall provide, at their own expense, the protective clothing and safety equipment to all staff and labour engaged on the Works to the satisfaction of the Engineer. Prior to provision of PPE, hazard identification to determine the appropriate type of PPE shall be undertaken by the Contractors' Safety Officer. The quality of PPE to be provided will be approved by the Engineer.

Such clothing and equipment shall include, as a minimum:

- High visibility vests for workers directing traffic;
- Protective boots and gloves for the workforce undertaking concrete mixing work;
- Protective boots, gloves and masks for the workforce performing bituminous pavement works;
- Protective footwear, gloves and dust mask for the workforce undertaking screening, crushing or grinding;
- Protective footwear and hard hats for the workforce engaged in bridge construction and in all locations subject to rockfall;
- Ear protectors and dust masks for the workforce engaged in rock drilling or in using vibrating equipment such as rollers and compactors;
- Safety equipment for working over water;
- Rescue equipment; and
- Fire extinguishers.

If the Contractor fails to provide such clothing and equipment, the Employer shall be entitled to provide the same and recover the costs from the Contractor.

(g) Safety Officer

The Contractor shall designate a qualified Safety Officer from one of their senior staff who has specific knowledge of safety regulations, experience of safety precautions on similar works and who shall advise on all matters affecting the safety of the workforce and on measures to be taken to promote such safety.

The Safety Officer shall work full time directly on the project at the construction site. They might have other obligations in relation to similar topics, e.g. environment, social and/or medical aspects including HIV/AIDS prevention, as long as at least half of the time is devoted to Occupational Health and Safety.

The Safety Officer shall have specific training in the Contractor's safety and health management system and procedures, practices, etc.

The Safety Officer shall routinely provide workers with training in safe work practices and general awareness of potential danger situations to avoid injuries.

The Contractor shall establish procedures to enable a rapid response to accidents and ensure access to clinical services for workers and staff for the duration of the contract. The Safety Officer shall also ensure that safety services are provided and utilized, including PPEs to workers, and should work with the Nominated Service Provider (NSP) specified in SUBCLAUSE 1804 (d) in the sensitization of workers and communities about road safety issues.

The Safety Officer shall be qualified in accordance with set standards for this work and shall have the authority to issue instructions including taking protective measures to prevent accidents.

(h) Safety Training

All employees and visitors shall be given training on how to ensure their own personal safety and on ways to reduce the accident risk on those sites where heavy vehicles and equipment or equipment with moving parts are in use. All employees handling dangerous/toxic materials shall be trained on how to handle such materials in a safe manner.

An induction training on safety and health at the site shall be held for all the Contractor's personnel before starting to work and for all visitors before they are allowed to access the site. The information and training shall be on the site and have a duration of at least one hour. It shall be conducted in English and, if necessary, also in a relevant local language to ensure that all personnel can understand the information and instruction. The Site Manager shall take part in at least the first part of the training. They shall present the Contractor's safety policy and goal, the responsibilities and roles in relation to safety and health of all individuals, and the more specific responsibilities and roles of key staff.

The topics of the training can include but are not limited to the following and shall be customised for the target group:

- Contractor's safety policy and goal.
- Organisation of safety and health work and the responsibilities and roles of the Site Manager, the superintendents/supervisors/foremen, the Safety Officer and of each individual worker.
- Mandatory use of personal protective equipment on the Site.
- Specification of the type of equipment, where and when to use it and how it shall be used, stored, cleaned and maintained correctly.
- Placement and content of first aid equipment.
- How to use the equipment and information on who are specially trained in first aid and how to contact them.
- How to transport an injured person to a medical doctor or to the hospital.
- Safety rules for the site, e.g. in relation to the use of different equipment, tools, vehicles, fuel, oil, chemicals, explosives and abrasives.

- Cleaning, housekeeping and maintenance of the site, including vehicles, equipment, tools, workshops, houses etc.
- If work permits are required for specific tasks.
- Manual handling, transport, storage and disposal of equipment, goods, etc. in a safe way preventing accidents and too heavy burdens.
- How to ensure that equipment, goods, etc. will not be an obstacle imposing a risk to other persons due to inadequate placement and protection of it.
- Welfare facilities and access to drinking water and water in case of skin burns on the site when handling asphalt.
- Procedure for specific instruction when working with new work function, machinery, tool, chemicals, etc.
- The use of safety signs and protective barriers.
- Safe use of fuel, oil, chemicals, explosives.
- Prevention of dust generation and exposure.
- Road safety aspects, sign posting and principles and measures for minimising the risk of traffic accidents.
- HIV/AIDS prevention (only an introduction, more information shall be provided within one month of employment on the Site).
- Management of contagious diseases or epidemics in case of such outbreaks.
- Consequences of breach of discipline and not complying with rules.

Different introduction courses can be held for different types of workers ensuring the correct weight on relevant topics, e.g. vehicle operators, workers in the quarry, workers in the asphalt plant, workshop workers etc.

A Safety Booklet written in English shall spell out the most important aspects of occupational health and safety. The Safety Booklet may take its starting point in the Contractor's general description of safety and health, but it shall be very specific for contract works. The safety booklet shall be handed to all staff at the introduction course and used as training material. More training material might be relevant to use at the induction course.

(i) Safe Access

The Contractor shall provide and maintain access to all places on the Site in a condition that is safe and without risk of injury.

(j) Sanitation and Other Sanitary Arrangements

The Contractor shall provide adequate waterborne sanitation; and refuse collection and disposal, complying with the Laws of Uganda, all local Bye-laws, to the satisfaction of the Engineer, for all houses, offices, workshops and laboratories erected on the camp site or sites.

The use of pit latrines as site toilets is specifically prohibited. Site toilets shall be of the portable chemical type in a ventilated weatherproof housing, and shall be emptied at least once a week, well before they become full, by a Contractor who is duly authorised and licensed to carry out this activity. Separate well labelled facilities shall be provided for male and female site workers. The loading of toilets at each worksite shall be in a ratio of 1:8 for stances.

The Contractor shall provide appropriate sanitary/ablution facilities for the use of base-camp personnel, with separate facilities for males and females. The numbers of male and female toilets and male and female wash basins shall be appropriate to the peak numbers of staff of each sex working at the base camp.

The toilet facilities shall be provided at all times with adequate supplies of toilet paper. Wash basins shall be provided at all times with adequate supplies of water, soap and paper towels. The toilets/ablution facilities shall be maintained in a clean and hygienic condition at all times to the satisfaction of the Engineer. The arrangements for toilet/ablution facilities shall be approved by the Engineer, prior to commencement of base camp establishment. Toilets shall be of the flush WC type and shall be located in a ventilated weatherproof enclosure. An adequate water supply for flushing shall be available at all times.

In the event that connection to a municipal sewer is not feasible and, in the opinion of the Engineer, the soil conditions are suitable, all wastewater arising from toilets, ablution and other site office facilities shall be discharged to a septic tank connected to a soakaway. In the event that soil conditions are unsuitable for soakaways to be effective, wastewater discharges shall be to a cesspit, which shall be pumped out as and when necessary. Rainwater shall be prevented from entering septic tanks or cesspits.

The use of pit latrines as site toilets is specifically prohibited. Site toilets shall be of the portable chemical type in a ventilated weatherproof housing, and shall be emptied at least once a week, well before they become full, by a Contractor who is duly authorised and licensed to carry out this activity. Separate well labelled facilities shall be provided for male and female site workers. The numbers of toilets at each worksite shall be in a ratio of not less than one toilet for every 08 workers, with the provision that there shall be at least one toilet reserved for female use, if any female workers are present at the worksite.

The toilets shall have adequate supplies of toilet paper available at all times. Hand washing facilities including soap and paper towels shall be provided adjacent to each toilet and an adequate supply of water shall be available at all times. Toilet and hand washing facilities shall be maintained in clean, tidy and hygienic condition at all times, to the satisfaction of the Engineer.

The site toilet arrangements shall be subject to the approval of the Engineer.

(k) Control of Harmful Insects

The Contractor shall execute appropriate measures in consultation with the Public Health Authority to control within the Site, including the camp sites, mosquitoes, flies and pests including the application of suitable chemicals to breeding areas. Insect repellents and mosquito nets, preferably pre-treated, shall be supplied in areas of high malaria risk.

(l) Reporting of Accidents

The Contractor shall report details of any accident to the Engineer and the Uganda Police, if appropriate, as soon as possible (preferably within 24 hours) after its occurrence. The contractor shall also report such accidents to the competent authority whenever such report is required by law.

The Contractor shall keep clear records of any such incidents and also document them in the monthly progress reports.

(m) Contagious Diseases

The Contractor shall manage the risk of spreading contagious diseases (e.g. cholera, tuberculosis and other viral infections) through awareness raising programmes, especially when workers come from outside the locality. The Contractor shall manage the risk of harassment and sexual assaults, especially for the female workers. The Safety Officer or Health Services shall inform the workers and the community about the danger of communicable diseases including those transmitted by insects, water, faecal/oral and sexual contact. Prophylaxis shall be provided to all workers

free of charge if recommended by the Public Health Authority.

(n) Epidemics

The Contractor shall comply with Government regulations or the local medical authority in case of epidemic outbreaks. In case of an epidemic outbreak, the contractor shall prepare an Epidemic Management Plan.

(o) Occupational Health Hazards

The Contractor shall reduce occupational health hazards, such as:

- i) Physical hazards (continuous noise and vibrations, prolonged stay in high temperatures).
- ii) Chemical hazards (exposure to fumes, chemicals and dust including solvents, paints, exhaust gases and possible carcinogens such as bitumen).
- iii) Mechanical hazards (unguarded or exposed moving objects and other dangers from the use and operation of machines).
- iv) Risk of accidents with hand tools (slips, falls, eye injuries), heavy items (the accidental dropping of heavy items) and vehicles.
- v) Thermal hazards (heat stroke from long hours working in direct sunlight and burns due to contact with hot items (e.g. heated bitumen or the burner).
- vi) Electrical, fire or explosion hazards.
- vii) Ergonomic risk factors (personal injuries associated with poor working postures, heavy lifting, repetitive work, repetitive hand arm vibrations, manual transport).
- viii) Sanitation hazards (including contaminated drinking water, poor food practices, improper waste disposal, unhygienic toilet and washing facilities, contact with solid and/or biological waste).

The means of reducing the occupational health hazards shall include:

- i) Using vibration-reduced and sound-reduced equipment.
- ii) Providing shade at stationary workplaces and at welfare facilities.
- iii) Having only trained and experienced persons use dangerous chemicals and operate the machines.
- iv) Providing safety awareness training for all workers and visitors.
- v) Providing easily movable equipment to reduce the risk of injury associated with heavy lifting or strenuous work.
- vi) Varying job functions (to avoid excessive repetitive motions).
- vii) Providing on the Site, throughout working hours, adequate and easily accessible supplies of safe drinking water, access to washing facilities in case of chemical and biological hazards, proper eating places and waste disposal facilities. The water for drinking and cooking purposes shall be filtered, boiled or treated as necessary for human consumption. No separate payment will be made for the provision of water for the site.
- viii) Provide adequate signing, fencing and guards to ensure that unauthorised persons shall be kept off the Site. This is especially relevant for the dangerous parts of the Site, e.g. the quarry, the asphalt plant, the storage areas for oil, fuel, chemicals, machines, the car park, and the workshop, near deep holes, bridges, villages and power lines.
- ix) The Contractor shall keep the site free from all unnecessary obstructions, and shall store or dispose any equipment or surplus of materials. The Contractor shall clear away and remove from the site any wreckage, rubbish and temporary works that are no longer required.
- x) The Contractor is responsible for providing safe passage around and through the work site for all kinds of traffic, including non-motorised traffic and pedestrians. Traffic

signs, traffic control signals and barriers shall be used for direction and control of traffic and to inform drivers of the importance to slow down and drive carefully. The signs shall be reflectorised or adequately illuminated at night in a manner approved by the Engineer. The goal is to minimise road accidents, including accidents involving pedestrians and persons living, working and playing next to the construction site.

- xi) Vehicles shall at all times be maintained in accordance with the manufacturer's specifications and service manual to ensure low noise generation, low emission of diesel particle emission and that the vehicle will not cause accidents due to inadequate maintenance. Special inspection and maintenance are required for brakes, steering, lights and tyres. Seat belts shall be installed and used. All heavy vehicles shall have reverse warning signal. Experienced operators, who have received special instruction on safe methods of operating the vehicle, shall operate dozers, dumpers and other heavy vehicles. The operators shall be instructed to avoid spillage and overloading and driving at too fast speed. Operators shall be protected against the sun and a cabin shall protect against injuries if the vehicle is overturning.
- xii) All accidents shall be recorded and analysed by the Contractor in order to prevent similar accidents in the future. The Contractor shall notify the Engineer when any accident occurs, at the latest within 24 hours. Accident records shall be submitted to the authorities according to regulations, with a copy to the Engineer.
- xiii) Special precaution shall be taken when working close to overhead power lines. Special instruction shall be given to operators of vehicles or equipment working close to power lines. Signs and barriers shall be placed adequately.
- xiv) The Contractor shall comply with the regulations for safe storage and handling of explosives. The Contractor shall not use or bring onto the site explosives of any kind without the prior consent in writing of the Engineer. The explosives shall be stored in a manner and quantities acceptable to the relevant authorities and the Engineer in magazines provided by the Contractor and approved for such purpose. The Contractor shall be responsible for the prevention of unauthorised issue or improper use of explosives brought on the site, and shall employ only experienced and responsible people to handle explosives.
- xv) Blasting shall be restricted to such periods as the Engineer may agree to. If in the opinion of the Engineer, blasting would be dangerous to persons or property, or to any finished work, or is being carried out in a reckless manner, they may prohibit it and require excavation by other means. Where necessary, the Contractor shall use heavy blasting nets. Use of explosives by the Contractor in large blasts as in seams, drifts, pits or large holes is prohibited unless authorised in writing by the Engineer.
- xvi) Internal quarry roads shall be kept free of obstacles and spillage shall be removed. The crusher and other very noisy equipment shall be placed at a distance and with noise shield/embankment, so personnel working on adjacent sites will be exposed to as low noise level as possible. If persons are working at the crusher, they must either be in a noise insulated cabin or, if working at noise levels above 90 dB(A), wear hearing protection. If dust cannot be efficiently controlled, the persons shall wear filter masks.
- xvii) The Contractor shall take every precaution to avoid fire and health hazards at the asphalt plant. They shall always ensure that:
 - Bitumen is heated only to temperature required for the particular application;
 - Hot bitumen never comes in contact with water;
 - Suitable protective clothing and gloves are used when handling hot bitumen; and
 - Dust and fumes are reduced to a minimum.
- xviii) The Contractor shall by daily inspections ensure that:

- The specified personal protective equipment (PPE) is used;
- The working area is tidy and clean with no unnecessary obstacles;
- Dust generation and exposure are sufficiently low;
- Any visitors, new workers on the site, or planned to be hired in the near future, will receive induction courses; and
- Signing, barriers and fencing are adequately in place.

The Safety Officer shall at least on a monthly basis prepare a report on the result of the monitoring. The report shall be submitted to the Engineer and include:

- Number of workers and their work functions, the change in number since the last report;
- Number and type of accidents, and preventive measures implemented to minimise future similar accidents;
- Number of visitors who have attended an induction course during the period;
- Number of workers who have attended an introduction course and planned additional courses;
- Number of workers who have received special training, and the number of workers programmed for such training;
- Number of workers who have participated in the HIV/AIDS awareness training;
- Stock of personal protective equipment, records of PPE disbursed to workers;
- Maintenance and inspection of the vehicles and other equipment;
- First aid equipment in place with number of each item; and
- Accommodation of the workers.

(p) Access to Safe Drinking Water

The Contractor shall provide an adequate supply of drinking water with all necessary drainage on the site for the use of his staff and work people and shall make all the necessary arrangements thereof with the competent authorities.

1804 HIV/AIDS, STD PREVENTION & MANAGEMENT

The Contractor's, HIV/AIDS Management Plan shall include details of the measures they propose to adopt to combat the spread of HIV/AIDS and sexually transmitted diseases (STD) between their staff, labour and the local community. The plan shall also outline workplace policies and programmes for employees living with HIV/AIDS, information and awareness campaigns and effective screening and counselling policies for STD and HIV/AIDS cases of their project staff.

The HIV/AIDS and STD Prevention & Management shall among others include the requirements specified in the following SUBCLAUSES.

(a) The Role of the Contractor

In case HIV/AIDS interventions are implemented by the contractors, the contractor's responsibilities shall among others include the requirements specified below.

The contractor will in accordance with policies and guidelines of Uganda Aids Commission and MoH put in place non-discriminatory workplace measures to protect the employees living with HIV/AIDS and to ensure that they are cared for, treated and supported. Prevention measures will also be established to protect others against any risk of illness and injury, which can result in HIV/AIDS infection and

transmission.

The Contractor shall advise all site staff and labour of the dangers and impacts of STDs in general and HIV/AIDS in particular. To this end, the Contractor shall conduct information, education and consultation (IEC) campaigns at least every other month, targeting the aforementioned site staff, labour, and the immediate local communities. The Sociologist or another of the Contractor's staff may carry out the awareness training if qualified; otherwise, a person from outside (e.g. from Hospital) may be hired to carry out the awareness training.

The Contractor shall throughout the Contract provide, maintain, and operate at least one STD and HIV/AIDS clinic on the site or make alternative arrangements with an existing suitably qualified and equipped local clinic. The clinic shall be suitably staffed and equipped for the screening, diagnosis and counselling of STD and HIV/AIDS cases of the project staff and labour. The Contractor shall cover the costs of the clinic to provide free treatment for general STD cases for their workers, whereas the HIV/AIDS cases shall be referred to the national HIV/AIDS programme coordinated by the Ministry of Health (MoH).

The Contractor shall throughout the Contract liaise with MoH and designated local representatives to report progress and coordinate the STD and HIV/AIDS alleviation measures on Site with the MoH national programmes.

In accordance with the provisions of Clause 1804 of this Specification, the Contractor shall be responsible for providing condoms, HIV/AIDS information, education and communication materials or HIV and STI testing kits. The contractor in liaison with the Employer/ Client may nominate an Approved Service Provider to assist the contractor in performing these services.

The Contractor shall make available condoms throughout the year for each member of his labour force on site. All of the above provisions shall be provided free of charge to the workers.

The contractor shall at least on a monthly basis prepare a report on the results of monitoring the HIV/AIDS management Plan.

(b) The role of the Employer's Nominated Service Provider/ Nominated Sub-Contractor

In case HIV/AIDS interventions are implemented by the Employer, the Employer will provide the Contractor with the name and details of the Sub-Contractor (Nominated Service Provider (NSP)) that shall be implementing the HIV/AIDS, gender sensitisation awareness, and other social risks programmes. The methodologies shall be explained to the Contractor in advance of the main works; this shall demonstrate how the NSP will work for the prevention and mitigation of HIV/AIDS, raising of gender awareness, other social risks and how these programmes will facilitate the development of community level care and support and links to wider service provision. It shall also explain the interface between Contractor, Engineer and Employer.

i) The Approach

Upon signing of the works contract, the NSP will sign a contract with the Contractor on advice of the Employer such that the NSP's programme is synchronised with that of the Contractor. The NSP works with a Sociologist from the Engineer's staff to visit communities in the area of influence of the road to be rehabilitated/constructed and to inform community leaders of the forthcoming project and the potential social benefits and negative impacts associated with it. The NSP and the Sociologist may be joined and supported by the Contractor Health and Safety Officer or such other representative on these visits.

The Engineer's Sociologist will provide an ongoing supervision role, working one week per month (or as agreed with the Employer) through the construction period, to monitor the effectiveness of the programme, the Contractor and NSP and ensure effective communication and responses on emerging HIV/AIDS issues and other social risks. In conjunction with the NSP, they will prepare a report on a monthly basis about all social issues and present this at the monthly site progress meeting. They will collect information from each of the parties identifying any problems and making recommendations on remedial measures to be implemented.

On the basis of the information contained in the monthly report, the Engineer's Sociologist will certify monthly payments to the NSP after the EMPLOYER's approval of the NSP's corresponding reports.

During the course of the project, the Engineer's Sociologist and the NSP will work together to document their experiences and in their final report, will provide a set of recommendations for EMPLOYER to integrate into the development of EMPLOYER guidelines manual for the undertaking of HIV/AIDS and other social risks programmes on road projects in Uganda.

ii) Timing

It is anticipated that the initial sensitisation of local communities will take one month of the Sociologist and NSP's time and will be carried out prior to and during the Contractor's mobilisation period.

Workshops may be held with the Contractor's managerial personnel; these will be programmed when sufficient staff is in place.

Further workshops may be held with the Contractor's managerial personnel and workforce at regular intervals during the project works.

Interactive briefing sessions and training shall be held with the Contractor's workforce every month during the project works.

iii) Contractor's Obligations

The Contractor shall develop and implement a workplace HIV/AIDS policy approved by the Engineer.

The Contractor shall ensure that the Engineer, the NSP and the Employer have a copy of the Contractors workplace HIV/AIDS policy, Child Protection Policy, Gender Policy, Community/Occupational Health and Safety Policy and Contractor's Workers Code of conduct and give any representative of the NSP, the Employer and the Engineer all reasonable access to the Site in connection with the HIV Awareness and other social risks awareness programme.

In consultation with the NSP, schedule appropriate timings for the implementation of HIV/AIDS and other social risk activities as part of the work plan of the workforce and staff.

Allow the Contractor's Personnel to attend the HIV/AIDS and other social risk awareness activities in the course of their employment and during their normal working hours (three hours per month) or any period of overtime provided for in the relevant employment contracts, but excluding designated rest times such as lunch breaks or pay days (unless otherwise advised by the Engineer), and use all reasonable endeavours to ensure this requirement is implemented.

At each monthly site meeting, a draft work plan for HIV/AIDS and other social risk related activities with timings shall be agreed between the NSP, the Contractor, the Engineer and the Engineer's

Sociologist. This activity plan shall be confirmed in writing by the Contractor the Engineer and communicated to the NSP at least one week in advance of programmed site activities.

Provide suitable space for the delivery of the HIV/AIDS and other social risk Awareness programme and encourage Contractor's Personnel to attend the HIV/AIDS and other social risk Awareness activities. This will include at a minimum a secure clinical space in the main Contractor's Compound that is suitably equipped for testing and counselling for HIV/AIDS and other social risks among project staff and labour. This space will comprise four adjoining rooms. These include a reception area, a clinical space for medical treatment and testing, sick bay, a room for HIV/AIDS and other social risk counselling activities and a bathroom containing separate well labelled male and female toilets and wash basins. The Contractor shall also provide a separate office for the NSP Sociologist, detached from the clinical spaces. All the spaces shall be maintained and cleaned by the Contractor who shall ensure a clean and hygienic environment at all times; in addition, the main clinical area shall be kept by the Contractor in good clinical sterile condition at all times.

The clinical space shall be connected to a sufficient water and electricity supply. The Contractor shall be responsible for cleaning and maintaining the offices and toilets and shall provide soap, towels and all necessary fittings and cleaning materials.

The clinical space shall comprise:

- c. A Reception Area with a minimum of 2.5m² floor space and is temperature controlled with provision of air conditioning which shall always be maintained to a good working standard. The reception area shall contain at a minimum:

- 1 desk 1.6m x 0.9m with lockable single chest of drawers;
- 1 Table lamp;
- 1 Swivel type desk chair;
- 3 Visitor chairs;
- 4 wastepaper baskets;
- 1 two drawer lockable filing cabinet; and
- A television screen (24") and a DVD/Video player.

The reception area shall have two adjoining rooms, the first a clinic space for medical treatment and testing and the second a room for HIV/AIDS counselling activities.

- d. A Clinical Space for medical treatment and testing which shall also be used for simple first aid as defined in SUBCLAUSE 1803 (c) of these Specifications. It shall have a minimum floor space of 6m² and be temperature controlled with provision of air conditioning which shall always be maintained to a good working standard.

This clinical space shall contain as a minimum:

- 1 Examination table;
- BP Machine;
- Weighing Scale;
- Microscopes (1 electric and 1 non-electric);
- Table;
- Stethoscope;
- Thermometer;
- Parietal Machine;
- 1 medical screen;
- 1 refrigerator min 0.40 m² (electric frost free);

- 2 chairs with arms;
 - Printed Medical Forms;
 - Cabinet, reagents and test kits;
 - 2 lockable medical shelves suitable for the storage of drugs;
 - 1 notice board suitable for attaching posters, pictures and other notices; and
 - 1 water cooler and dispenser with supply of plastic cups maintained and kept filled for the duration of the contract.
- e. Two fully equipped separate sick bays, one for men and the other for women, each of which shall:
- Have a minimum floor space of 6 m². It shall be temperature controlled with provision of air conditioning which shall always be maintained to a good working standard;
 - Each sick bay shall contain as a minimum;
 - 1 bed/medical couch;
 - Blanket, bed sheets, pillow; and
 - Medical screen.
- f. A room for HIV/AIDS counselling activities which should provide a comforting and private environment for the discussion of sensitive and confidential personal issues. It shall have a minimum floor space of 6m² and be temperature controlled with provision of air conditioning which shall be maintained to a good working standard at all times.

It should contain a minimum of:

- 3 chairs with arms (1 for the counsellor and 2 clients);
 - 1 coffee table;
 - 1 two drawer lockable filing cabinet;
 - 1 notice board suitable for attaching posters, pictures and other notices; and
 - 1 water cooler and dispenser with supply of plastic cups maintained and kept filled for the duration of the contract.
- g. Office room for the NSP counsellor: which should provide a comforting work environment for the discussion of sensitive personal issues. It should contain a minimum of:
- 3 chairs with arms (1 for the Counsellor and 2 visitors);
 - Desk, minimum 1.5m x 0.75m, with lockable single chest of drawers;
 - 1 two drawer lockable filing cabinet; and
 - 1 notice board suitable for attaching posters, pictures and other notices.
- h. A bathroom containing separate male and female toilet facilities, each with a wash basin. The toilets will be of the WC flush type. The toilet facilities shall always be provided with adequate supplies of toilet paper. Wash basins shall always be provided with adequate supplies of water, soap and paper towels. The Contractor shall supply all necessary fittings and cleaning materials.
- i. The five rooms comprising the clinical space will each be supplied with adequate electric lighting, enough power points to supply all equipment and water supply.

The Contractor shall also:

- Minimize the number of migrant workers employed on the project and housed in the site camp;

- In conjunction with the NSP, identify from recruitment records suitable individuals for key education roles and allow those individuals special additional training of up to 4 hours each month during normal working hours;
- Encourage voluntary HIV/STI testing;
- Liaise with the NSP to provide information concerning counselling, support and care;
- Liaise with the NSP regarding the effectiveness of the campaign and notify any associated problems arising;
- Ensure that the NSP has access to all suitable site locations for the provision of condoms, both male and female, complying with the requirements of ISO 4074 available free of charge to all Contractor's employees at readily accessible points on the site, suitably protected from weather, for the duration of the contract;
- Permit the NSP to place and maintain HIV/AIDS and other social risks awareness posters of size not less than A1 in areas that are highly trafficked by construction workers and provide construction workers with a pamphlet, in language largely understood by construction workers, which reinforces the objectives and expected outcome of the HIV Awareness programme; and
- Allocate a vehicle and fuel, accommodation and security to facilitate the works of the NSP and Sociologist as may be necessary.

The Contractor's Safety Officer or another of the Contractor's staff will assist the NSP by identifying locations where stocks of condoms may be running low or where staff are requesting specific information regarding HIV/AIDS and STI's and other social risks. This individual should work with the NSP to ensure condom stock levels are maintained. If qualified, the Contractor's Safety Officer or other member of the Contractor's staff may also carry out awareness training.

In accordance with the policies and guidelines of Uganda AIDS Commission and Ministry of Health, put in place non-discriminatory workplace measures to protect the employees living with HIV/AIDS and ensure that they have access to treatment and counselling.

It is not a requirement of the Contract for the Contractor to undertake or pay for treatment or medication for personnel found to be infected with HIV/AIDS. However, such personnel shall not be discriminated against.

All provisions with respect to the HIV/AIDS Programme shall be provided free of charge to all workers.

Any request by the Contractor to the NSP for services not described in these specifications or in the NSP's Terms of Reference shall be the subject of an additional contract agreement between the NSP and the Contractor and shall not be paid under the provisions of this contract.

The Contractor shall support and facilitate all programme activities as described above, but the NSP shall report directly to the Engineer's Sociologist and the Engineer.

The Contractor shall ensure the prompt and timely payment of the NSP each month in any case not later than 14 days from receipt of the approved invoice. After payment of the NSP for the month in question, the Contractor shall claim reimbursement of payment and of management fee through the Interim Payment

Certificate. The Contractor shall submit a receipt from the NSP as evidence of this payment.

iv) HIV/AIDS and Other Social Risk Programme Activities

- Activities for HIV/AIDS and other social risk awareness and prevention undertaken by the NSP should be broad based, targeting individuals, couples and groups, and may consist of:
 - Information Education and Communication (IEC) materials displayed in accessible public places both on and off the site, such as trading centres, in eating places, bars, guest institutions like schools and in homes etc.
 - Availability of free condoms to both workers and communities in the project area.
 - Small focus group discussions and information covering key issues.
 - Theatre groups and video presentations.
 - Promotional events, such as football matches, to encourage openness and discussion of HIV/AIDS and other social risk issues.
 - Promotional billboards to raise awareness of the integration of road construction and HIV / AIDS and other social risk activities.
 - Inclusion of discussion and analysis of HIV / AIDS and other social risk activities at site progress meetings.
 - Availability of promotional IEC materials such as T-shirts, caps, bumper stickers, key rings etc.
 - HIV Counselling and Testing (HCT) – targeting individuals, couples and families.
 - STIs diagnosis and treatment.
 - On-going psychosocial support (including prevention and treatment of opportunistic infections) for workers infected and affected, as well as their families.
- Education will cover but not be limited to the following:
 - Stigma and discrimination issues;
 - Safer sex practices including partner reduction, condom use, undertaking couple HIV testing and Counselling, awareness and importance of treatment of STI's;
 - Undertaking HCT and early initiation of ART;
 - Skills including negotiating safer sex, correct condom use, acquiring condoms without embarrassment; and
 - Referral to local health centres and services available.

v) Outcome

The outcome of the HIV/ AIDS and other social risks Awareness Programme shall, as a minimum, result in the Contractor's Personnel exposed to the programme being able to:

- Communicate the existence of the problems associated with HIV and be able to outline the consequences of transmission of HIV to or from the local community.
- Recall and communicate the mode of HIV transmission and preventative measures including the proper use of the condom.
- Be aware of safer sex practices including the advantages of abstinence.

1805 GENDER

The Contractor's Gender Management Plan shall include a description of staff recruitment policy and procedures,

gender awareness raising meetings, gender sensitive working conditions and facilities to be provided at the workplace, and participatory gender sensitive monitoring.

The Contractor shall throughout the contract period liaise with both government and non-government organisations at all levels dealing with gender and social development issues. The local leaders and Community Development Officers shall be contacted to advise and mobilise communities during the recruitment and training process.

The contractor will increase awareness about gender-based discrimination and violence in the contractor workforce and local community in the project area; increase awareness of sexual exploitation or abuse, and promote and mainstream gender in project implementation.

The Contractor shall ensure that recruitment procedures and working conditions/facilities are gender sensitive and in particular that:

- i) Announcement notices of equal employment opportunities are posted in visible and popular places in the local communities and that such notices also reach women and youth leaders.
- ii) Both men and women are represented in any information and consultative meetings held at the site and that gender and social issues are raised and analysed.
- iii) Equal payment is made to men and women for similar work and that payment of wages is made to the workers and not to representatives.
- iv) Flexible working hours are introduced to the extent possible to take account of multiple roles of women and cultural norms.
- v) Separate toilet and accommodation facilities are provided for women, including sanitary facilities and shades for children of working mothers.

The Contractor shall submit monthly reports of labour attendance disaggregated by gender, and the Contractor shall use gender compliance monitoring and evaluation forms to assess and report how gender concerns are addressed in recruitment, promotion, payment, provision of gender sensitive facilities, on-the-job training, etc.

The Contractor shall ensure that their workers are sensitized on the 'No Sexual Harassment Policy' at the workplace and reports Sexual and Gender Based Violence cases. The 'No Sexual Harassment Policy' statement shall be displayed in an accessible place. The format shall be clear and eligible and the language shall be in English, local languages common to the areas and any other languages spoken by workers on site. The Contractor shall report and take action on Sexual and Gender Based Violence (SGBV) cases.

1806 SOCIAL SAFEGUARDS

As part of the social safeguards, the contractor shall prepare a Stakeholder Engagement Plan (SEP), Grievance Redress Mechanism (GRM) and Labour Management Plan and submit to the Engineer for approval within the first 4 weeks of commencement of works. The SEP, Grievance Redress Mechanism and Labour Management Plan will constitute the documents submitted under the Construction Environment and Social Management Plan. The purpose of the social safeguards documents will be to put in place measures by the contractor to mitigate social risks and/or adverse effects on people during the implementation of projects. As part of compliance, Social safeguards specialist shall prepare and submit monthly Social Safeguards Compliance reports to the Engineer.

The Contractor's responsibilities shall among others include the requirements specified in the following SUBCLAUSES.

(a) Stakeholder Engagement

The Contractor shall be responsible for stakeholder

identification and engagement throughout the project implementation period and for establishing a good working relationship between the project staff and local authorities, Government officials, traditional/cultural leaders and religious leaders. Stakeholder Engagement involves seeking active participation and contribution of communities and other stakeholders in decisions that affect their lives.

(b) Information Disclosure

In advance of all works, all road users and communities adjacent to the project roads and bridges especially identified as sensitive respecters, shall be informed of impending works and associated impacts and risks. The Contractor's Social Safeguards Specialist shall take particular responsibility for information disclosure and report to the Engineer and employer on a monthly basis on communications made and responses received.

At the commencement of the project, the Contractor shall hold community meetings in the main service centres in the vicinity of the Site to advise the local business community and the public of employment and business opportunities that will be available to them. These meetings shall be publicized at least two (2) weeks in advance of the meeting through the local authorities and local media including radio stations. The procedures for the recruitment of skilled and unskilled workers, and procedures for the selection of local suppliers and sub-contractors shall be explained at the meeting. This will be communicated in a language and form largely understood by people living and working in the project area and shall be approved by the Engineer no later than 4 weeks after the Notice to Commence the works.

(c) Grievance Redress Mechanism

The Contractor shall be responsible for implementing and documenting a functional Grievance Redress Mechanism arising from works activities for the duration of the contract. This will be communicated in a language and form largely understood by people living and working in the project area and shall be approved by the Engineer no later than 4 weeks after the Notice to commence the works.

The Contractor shall keep a log of all communications made and received and a register of all grievances, including actions taken to satisfy the complaint. Depending on the nature of the complaint, the Contractor shall address each grievance to the satisfaction of the Engineer and the Employer following guidelines as contained in the approved project grievance mechanism. The Contractor shall be responsible for reporting on grievances to the Engineer and employer on a monthly basis. The Contractor's Social safeguards specialist shall take responsibility for this issue.

(d) Labour and Working Conditions

The Contractor shall comply in all respects with the Labour Laws currently in force. The Contractor shall ascertain from the Ministry of Gender, Labour and Social Development, and shall strictly comply with, all the regulations, written or otherwise, of the Ministry or any of his duly appointed representatives affecting the employment of any class of local employee under the contract.

The Contractor shall limit the use of his permanently employed personnel on the Works to that of Key Personnel and shall execute and complete the works using a permanent/temporary local Workforce employed directly by the Contractor or Sub-Contractors to the extent that is practical and reasonable. The contractor shall employ local Ugandans irrespective of origin. The Contractor shall not recruit or attempt to recruit his staff and labour from amongst persons in the service of the Employer or the Engineer. Each worker shall sign and retain a copy of the signed contract of service and code of conduct with records kept at the site office. The Contract format and content shall be reviewed and approved by the Engineer and local labour office.

The Contractor may sub-contract work reserved for labour-

intensive methods to local contractors. The hire of plant and equipment from persons or small local companies shall be deemed to be sub-letting and hirers of plant and equipment shall be deemed to be "Sub-Contractors".

The Contractor shall select local Sub-Contractors to participate in the project from applications received following the public consultations. The Contractor shall implement a transparent selection process based on provable credentials.

The Contractor shall advise the Local Authorities in the vicinity of the project of the requirements of the Workforce. This shall include a list of specific skills and experience required and an indicative programme of recruitment. The Community shall be advised through the Local Authorities, Local Community Leaders and at community meetings of specific times when they should present themselves to the Contractor's premises for registration.

All recruitment conditions and procedures that apply to the contractor shall as well apply to the sub-contractors.

The Contractor shall provide a list of Key Personnel indicating the following criteria for presentation at the monthly Site meeting:

- Nationality of each person;
- Gender of each person;
- Proportion of Ugandan nationals; and
- Proportion of women.

The Contractor shall provide a list of the Workforce indicating the following criteria for presentation at the monthly Site meeting:

- Total size of the Workforce;
- Number of skilled and unskilled personnel;
- Total number of men;
- Total number of women;
- Proportion of women;
- Total number of local residents;
- Proportion of local residents;
- Total hours worked by men during the month;
- Total hours worked by women during the month;
- Proportion of total hours worked by women;
- Average number of hours worked per week by men; and
- Average number of hours worked per week by women.

The contractor shall ensure provision of accommodation and amenities, as it may be necessary for all staff and labour, including all fencing, water and electricity supply, sanitation, cookhouses, fire prevention and fire-fighting equipment and other requirements.

The Contractor shall arrange for the provision of sufficient supply of suitable food at reasonable prices for all the Contractor's staff, workforce, and sub-contractors for the purpose of, or in connection with the contract.

(e) Workplace Grievance Redress Mechanism

The Contractor shall establish a grievance committee to handle workers' grievances. The Contractor shall maintain a clear record of workers' grievances and maintain a copy of the records at the site office.

(f) Protection of Vulnerable Groups Against Any Form of Violence or Harassment

The Contractor shall ensure his workers are sensitised on

protection measures for vulnerable groups such as women, youths, children, People Living with Disabilities (PWDs), People Living with HIV/AIDS (PLWHIV) and elderly against exploitation, violence and harassment.

The Contractor shall:

- i) Sensitise them about their rights and obligations;
- ii) Undertake deliberate employment of vulnerable groups (where possible);
- iii) Provide facilities that allow access of PWDs; and
- iv) Increase awareness about promoting child protection (Violence against Children) in project implementation.

(g) Child Labour

Children, as defined by Government regulation shall not be employed under any circumstances. The Engineer and the Employer's representative have the right to decide whether any labourer employed by the Contractor or the Sub-Contractor is a child as defined by Government regulation and to refuse to allow any such labour to be employed on Site.

The Contractor shall to comply with requirements under THE EMPLOYMENT (EMPLOYMENT OF CHILDREN) REGULATIONS 2012.

(h) Notices

The Contractor shall display a notice in a conspicuous place in the Site camp on a minimum A1-size sheet, with 2cm high lettering in English and the relevant local language with the following information:

- Start and end date of the Works contract;
- Brief description of the Works;
- Minimum age required for employment;
- Proportion of female workers required in the Workforce;
- Conditions of employment;
- Normal working hours including breaks;
- Wage rates for each class of worker in the Workforce;
- Details of any deductions, including for sick days;
- Date of payment of wages;
- Details of any benefits, including Workers Compensation Insurance; and
- Provision of meals and drinking water.

In addition to the above requirements, the Contractor shall provide each employee with the above information printed on an A4 sheet in English and relevant local language.

1807 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
18.01 PROVIDE A QUALIFIED SAFETY OFFICER	MONTH

The tendered rate for ITEM 18.01 shall represent full compensation for the provision of a safety officer to carry out the requirements specified in SECTIONS 1500, 1700 and 1800 relating to traffic, environment, social, health and safety management.

The tendered sum will be paid monthly, pro rata for parts of a month, from the date of appointment of the Safety Officer until the completion of the Works or demobilisation of the local workforce, whichever comes first.

<u>ITEM</u>	<u>UNIT</u>
18.02 EMPLOYER'S NOMINATED SERVICE PROVIDER	

		PROVISIONAL SUM
(a)	EMPLOYER'S NOMINATED SERVICE PROVIDER FOR PROVISION OF HIV/AIDS PROGRAMME AND GENDER SENSITISATION, AWARENESS AND MONITORING	
(b)	CONTRACTOR'S OVERHEADS AND PROFIT AS A PERCENTAGE OF SUB-ITEM 18.02 (A)	PERCENT (%)

After contract signing and after the receipt of any advance payment, the Contractor shall, within 14 days and as directed by the Employer, make an advance payment of 20 percent of the total provisional sum in SUB-ITEM 18.02 (a) to the Employer's Nominated Service Provider. This advance will enable the service provider to mobilise and purchase essential HIV/ AIDS supplies. Thereafter the balance of the total will be paid on a monthly basis.

The NSP's invoices will be submitted to the Employer who will forward them to the Contractor via the Engineer. The Contractor shall make payment directly to the NSP within 14 days of receiving the invoice. The NSP will issue a receipt directly to the Contractor who will give a copy to the Engineer as evidence of payment.

	<u>ITEM</u>	<u>UNIT</u>
18.03	SEXUAL HEALTH AND FIRST AID CLINIC	
(a)	PROVIDE SEXUAL HEALTH AND FIRST AID CLINIC ON THE MAIN SITE COMPOUND FULLY FURNISHED AND EQUIPPED	MONTH
(b)	MAINTENANCE AND OPERATION OF SEXUAL HEALTH AND FIRST AID CLINIC	MONTH

The tendered rate for SUB-ITEM 18.03 (a) shall be full compensation for all the requirements of SUBCLAUSE 1804 (a).

The tendered rate for SUB-ITEM 18.03 (b) shall be full compensation for maintaining the clinic and re-supplying consumables not provided by the NSP.

	<u>ITEM</u>	<u>UNIT</u>
18.04	PROVISION OF SAFETY CLOTHING AND EQUIPMENT	
(a)	PROVISION OF SAFETY CLOTHING AND EQUIPMENT FOR THE WORKFORCE	MONTH
(b)	PROVISION OF SAFETY EQUIPMENT FOR VISITORS (VESTS, HARD HATS AND BOOTS)	NO. OF SETS

The tendered rate for SUB-ITEM 18.04 (a) represents full compensation for the part of the Contractor's obligations relating to the provision of all required safety clothing as prescribed in the specifications and replacing safety clothing as required. Payment will be paid as a percentage of the compliance with the provision of personal protection equipment (PPE) to the staff and workforce.

The tendered rate for SUB-ITEM 18.04 (b) represents full compensation for the part of the Contractor's obligations relating to the provision of the prescribed number of sets of safety equipment (vests, hard hats and safety boots) including maintenance of the equipment such as cleaning and replacement.

The imposition of the aforementioned penalty will not preclude the Engineer from stopping the Works should the Contractor continuously disregard his instructions, or should he feel the situation warrants this measure for health and safety reasons. Should the Engineer stop the Works for any reason related to non-compliance with the Specifications on HIV/ AIDS or Occupational Health and Safety, there will be no compensation for any costs incurred by the Contractor as

a result of such stoppage, nor will the Contractor be granted any extension of time as a result.

	<u>ITEM</u>	<u>UNIT</u>
18.05	CONTRACTOR'S ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (C-ESMP)	LUMP SUM

Payment for providing Contractor's Environmental and Social Management Plan (C-ESMP) will be made at the Lump Sum entered in the Bill of Quantities, for each single item of each type, on the following basis:

- i) 50% of the Lump Sum when the plans are, submitted and approved by the Engineer.
- ii) 50% of the Lump Sum will be paid on monthly submission of C-ESMP compliance reports.

Failure of the Contractor to comply with the requirements of this SECTION 1800 will result in the withholding of monies under ITEM 18.05 due for the month in question and forfeiture of that amount if after a further month the non-compliance(s) have not been rectified. In addition, the engineer will deduct UGX 1,000,000 per day for each non-compliance event from monies due in the next interim payment certificate until such a time as the Contractor is compliant.

SERIES 2000

DRAINAGE

CONTENTS OF THE GENERAL SPECIFICATIONS:

<i>SERIES 1000</i>	<i>GENERAL</i>
<i>SERIES 2000</i>	<i>DRAINAGE</i>
<i>SERIES 3000</i>	<i>SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE</i>
<i>SERIES 4000</i>	<i>BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT</i>
<i>SERIES 5000</i>	<i>ANCILLARY ROADWORKS</i>
<i>SERIES 6000</i>	<i>STRUCTURES</i>
<i>SERIES 7000</i>	<i>TOLERANCES, TESTING AND QUALITY CONTROL</i>
<i>SERIES 8000</i>	<i>DAYWORKS</i>

APPENDICES

SERIES 2000

DRAINAGE

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CONTENTS OF THE GENERAL SPECIFICATIONS:

SERIES 1000 GENERAL

SERIES 2000 DRAINAGE

SERIES 3000 SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SERIES 4000 BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

SERIES 5000 ANCILLARY ROADWORKS

SERIES 6000 STRUCTURES

SERIES 7000 TOLERANCES, TESTING AND QUALITY CONTROL

SERIES 8000 DAYWORKS

APPENDICES

SERIES 2000: DRAINAGE**SECTION 2100: DRAINS****CONTENTS:**

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2101 SCOPE

This Section covers all work, their measurement and payment. It covers work in connection with the excavation and construction of open drains, shallow drains, subsoil drainage, French drains and banks and dykes at the locations and to the sizes, shapes, grades and dimensions as shown on the Drawings or as directed by the Engineer, and the test flushing of subsoil drains.

It also covers the cleaning of open drains and the repairing of subsoil drainage. In special circumstances this work may be executed outside the road reserve.

It also covers the clearing of existing culverts, including amongst others the removal of all undesirable materials that have accumulated in and around inlet and outlet structures and in the barrels of the culverts.

2102 OPEN DRAINS

Open-drain excavation shall involve the excavating of open drains and channels, including channels to direct the course of streams, all as shown on the Drawings or as directed by the Engineer.

Any excavation required for constructing a channel or open drain within the road prism, such as median drains, side drains, Shallow drains and open drains on excavation-slope benches, shall be classed as Rock Excavation or Common Excavation as defined in CLAUSE 3603 and shall be measured and paid for under SECTION 3600.

Open drains shall be constructed true to line, grade and cross-section and shall be so maintained for the duration of the Contract.

Care shall be taken to avoid excavation below the required grades for the open drains and any excavation carried beyond the required grade shall be backfilled with suitable, approved, material as defined in CLAUSE 3602 and compacted to at least 90% of BS-Heavy density by the Contractor at their own expense.

Material resulting from the excavations for open drains shall be used in the construction of fills, banks and dykes, or for other purposes, or shall be disposed of to spoil, all as directed by the Engineer.

If ordered by the Engineer, all existing open drains, but excluding open drains constructed by the Contractor himself/herself, shall be cleared and, where necessary, shaped by removing the sediment and trimming the floors and sides.

Any pitching of open drains ordered by the Engineer shall

be done in accordance with the requirements of SECTION 2500. The concrete lining of open drains shall be done as specified in SECTION 2300.

The Contractor shall remove all undesirable materials, all silt, sediment, driftwood, debris and rubble that have accumulated in and around the culvert inlet and outlet structures and in the culvert barrels. All materials resulting from the clearing operations shall be disposed of at locations approved by the Engineer. The clearing shall preferably be done by means of hand tools in order to prevent damage to existing drainage and other structures. The Contractor shall repair all structures they damage at their own cost, and to the satisfaction of the Engineer.

2103 BANKS AND DYKES

Mitre banks, catchwater banks and dykes shall be constructed of approved soil or gravel obtained from open-drain excavation or, if no suitable material can be obtained from that source, from suitable alternative sources, and be placed in such a way that the water will flow on the natural ground and against the bank.

The banks and dykes shall be properly compacted to 90% of BS-Heavy density in layers not exceeding 150 mm in thickness or as approved by the Engineer.

If so preferred by the Contractor and approved by the Engineer, mitre banks may also be constructed of hand-packed stone, provided that the interstices are filled with an approved cohesive soil.

2104 SUBSOIL DRAINAGE**(a) Materials****i) Pipes**

Pipes for subsoil drainage shall have the specified internal diameter, which shall not be less than 100 mm, and shall be one of the following types:

- Perforated pitch-fibre pipes complying with BS 2760:1973 or equivalent.
- Perforated or slotted unplasticized PVC pipes complying with BS 4660:2022 and BS EN 1401-1:2019+A1:2023 or equivalent.
- Perforated high-density polyethylene pressure pipes complying with the requirements of BS EN 253:2019+A1:2023 or equivalent.

The size of perforations in perforated pipes shall in all cases be 8 mm in diameter ± 1.5 mm and the number of perforations per metre shall be not less than 26 for 100 mm pipes and 52 for 150 mm pipes. Perforations shall be spaced in two rows for 100 mm pipes and four rows for 150 mm pipes. All rows shall be in the lower half of the pipe but no row shall be closer than 36 degrees to the invert. Perforations in each row shall be a maximum of 100 mm centre to centre.

Slotted pipes shall have a slot width of 3 mm ± 1.0 mm and a slot length of 8 mm ± 1.5 mm and the inlet area per metre shall not be less than 22.5 cm²/m pipe. The arrangement of slots shall be to the Engineer's approval.

Pipes without slots or perforations required for conveying ground water from the subsoil drainage proper to the point of discharge, shall be unperforated pitch fibre, PVC or polyethylene pipes of the types specified above, or concrete pipes complying with the requirements of BS 5911-1:2021 and BS EN 1916:2002, or equivalent.

ii) Permeable Filter Material

Permeable filter materials for bedding and surrounding of drainpipes shall consist of crushed stone of suitable grading. Crushed stone shall be of hard, clean rock. If permeable filter material conforming to the criteria given below is not obtainable in the opinion of the Engineer, then geotextile shall be used as directed by the Engineer.

Permeable filter material shall be free of organic material, silt or clay lumps and shall conform to the following requirements:

- a. d_{85} for the permeable filter material shall be a minimum of 1.25 times the width of the slots in the drainage pipe;
- b. d_{15} for the permeable filter material shall be maximum 5 times d_{85} for the adjacent soils;
- c. d_{50} for the permeable filter material shall be maximum 25 times d_{50} for the adjacent soils;
- d. d_{15} for the permeable filter material shall be minimum 5 times d_{15} for the adjacent soils;
- e. the permeable filter material shall have maximum 50 % passing the 2 mm sieve; and
- f. the permeable filter material shall have maximum 3 % passing the 0.075 mm sieve.

Where:

d_{15} , d_{50} and d_{85} are the corresponding grain sizes which 15%, 50% and 85% respectively passes in the sieve analysis.

The filter criteria shall be complied with for both the surrounding soil (subgrade) and for possible pavement layers above the drainpipe.

Sieve analysis of the surrounding subgrade and or subbase shall be performed at each 100 m trench and the filter material shall be adjusted according to the above specified filter criteria. If necessary, the Engineer can at any position demand further sieve analysis.

The sieve analysis for the subgrade, subbase and filter materials must be approved by the Engineer before commencement of the drainpipe works. All costs to perform sieve analysis are to be included in the rates for subsoil drains.

iii) Geotextile Fabric

Should the use of geotextile fabric in subsoil drainage, or as filter blankets, or for any other purposes, be specified, it shall comply with the requirements as specified in SECTION 2700. The fabric shall not be exposed to direct sunlight for prolonged periods and shall be protected from mechanical damage during installation and construction.

iv) Composite In-Plane Draining Fabric

The make and class of fabric shown on the Drawings or approved by the Engineer shall be used.

(b) Construction of Subsoil Drainage Systems**i) With Natural Permeable Filter Material**

Trenches for subsoil drainage systems shall be excavated to the dimensions and gradients shown on the Drawings or as directed by the Engineer.

A layer of natural permeable filter material of the grade and thickness as shown on the Drawings

shall be placed on the bottom of the trench and be lightly tamped and finished to the required gradient.

Pipes of the type and size required shall then be firmly bedded on the natural permeable filter material, true to level and grade, and be coupled in accordance with the requirements. Thereafter the trench shall be backfilled with natural permeable filter material in layers not exceeding 250 mm thickness and lightly compacted to such height above the pipes as shown on the Drawings or as directed by the Engineer. The natural permeable filter material shall be lightly compacted and trimmed to the required level. Further layers of finer natural permeable filter material shall then be placed, lightly compacted and finished to an even surface, as directed by the Engineer. The remainder of the trench, if any, shall be backfilled with approved impermeable material and as required by the Engineer, in layers not exceeding 100 mm, and compacted to at least the same density as the surrounding material. The trench shall be specially protected against the ingress of water until the impermeable layer has been completed. The width of the backfill that will be measured for payment shall not exceed the specified width of the trench.

The total thickness of each type of natural permeable filter material shall be carefully controlled, and when the thinner layers are placed, suitable spacers shall be used. When successive layers are placed, the lower layer shall not be walked on and, as far as possible, shall not be disturbed. Care shall be taken to prevent the contamination of natural permeable filter material during construction of the subsoil drainage system and all-natural permeable filter material contaminated by soil or silt shall be removed and replaced by the Contractor at their own expense.

Perforated and slotted pipes shall be jointed by means of couplings. Perforated pipes shall be laid with perforations at the top or bottom as may be prescribed.

The higher end of each subsoil drainage pipe shall be sealed off with a loose concrete cap of class 20/19 concrete, as shown on the Drawings, and at the lower end the pipe shall be built into a concrete head wall providing a positive outlet or it shall be connected to storm water pipes or culverts. The complete system, together with head walls, shall be constructed in one process starting at the lower head wall.

Any section of a subsoil drainage system constructed of pipes without perforations or slots shall be backfilled with impermeable backfill material as described herein. Where suitable, the excavated material may be used for backfilling.

ii) With Polyethylene Lining to Trenches for Subsoil Drainage Systems

Where shown on the Drawings or directed by the Engineer, trenches for subsoil drainage systems shall be lined with approved polyethylene sheeting 0.15 mm thick. The polyethylene sheet shall cover the bottom of the trench and shall extend upwards on both sides for as far as may be directed by the Engineer in each particular case, in order to form a waterproof channel. At joints the polyethylene sheeting shall be heat-welded together or lapped by a minimum of 200 mm.

When backfilling the trench with natural permeable filter material, care shall be taken not to displace or damage the polyethylene lining in any way. The

use of plastic other than polyethylene will be considered, provided that the material is of equal quality and is approved by the Engineer.

iii) With Geotextile Fabric

Where specified that geotextile fabric shall be used for lining in subsoil drainage systems, it shall be procured, furnished and installed as specified and shown on the Drawings. The fabric shall not be displaced or damaged in any way when the trench is being filled with natural permeable filter material. The filter fabric shall be lapped both longitudinally and transversely by at least 300 mm or as prescribed by the manufacturer. The transverse lap shall be positioned on top of the box forming the drain and shall be stitched together with plastic/galvanised wire or strong synthetic thread at 1.0 m intervals. The longitudinal lap shall be in the direction of flow.

Geotextile fabric shall meet the requirements in SECTION 2700 and shall be stored under suitable cover. The fabric shall not be exposed to direct sunlight for prolonged periods and shall be protected from mechanical damage during installation and construction.

iv) With Composite In-Plane Drainage Fabric

Wherever specified, composite in-plane drainage systems shall be constructed in accordance with the details shown on the Drawings. The elements of the system shall be assembled above ground in manageable lengths, and all exposed surfaces shall be sealed with an approved geofibre seal. The trench sides shall be vertical and the composite in-plane system shall be installed against the side through which the subsoil flow is expected. The trench shall then be backfilled with sand, which shall be saturated with water after placement, up to the prescribed level. The upper part of the trench shall be backfilled with impermeable material which shall be compacted to the density of the surrounding material, in layers not exceeding 100 mm in thickness.

(c) Test Flushing

Final acceptance of longitudinal subsoil drains will be subject to satisfactory test flushing after completion and installation of the rodding eye inlets. Flushing tests shall be carried out in the presence of the Engineer's representative by flushing the drain and metering the outflow to ensure the drain is clear of blockage. Should blockages be apparent the Contractor shall locate and clear the obstruction and repeat the test.

(d) Transport and Storing of Drainpipes

The full length of the pipe shaft shall rest on the loading area of the lorry used for transporting the pipes. Overhanging of pipes, to prevent sagging and deformation shall be avoided. Rough handling and dragging of pipes and fittings shall be avoided. All pipes and fittings shall be protected from sunlight during transportation by use of tarpaulins. Grass cover will not be accepted.

The Contractor shall advise the manufacturer of the climatic and transporting conditions at the site of the Works and shall seek their advice on the storage of PVC materials on site. Subject to the Engineer's approval, this advice shall be followed at all times.

PVC pipes shall not be stored on top of each other to a height exceeding 1.5 m. Pipes shall be staggered to prevent the sockets from resting on the shaft of the pipes. The first tier shall be placed on a well-drained layer of sand.

(e) Drain Markers

Subsoil drains shall be marked on the ground as follows:

- i) Wherever practicable, concrete markers in accordance with SECTION 5100 shall be placed at the start of the subsoil drain. The concrete markers shall be painted and provided with an identification number as directed by the Engineer.
- ii) In rock cuttings or where concrete kerbs or linings are provided, paint marks, approximately 150 mm x 150 mm in size, shall be used in lieu of the above concrete markers. No separate payment for provision of such paint mark will be made.

2105 FRENCH DRAINS

French drains shall be constructed at the locations and to the dimensions shown on the Drawings or as directed by the Engineer.

The trench shall be excavated to the required width and depth, levelled, and smoothed to the satisfaction of the Engineer prior to filling with aggregates. The specified gradation of fine or coarse aggregate shall then be placed to the required depth and covered with the next specified layer of material. An outlet should be provided to drain away water.

When the use of geotextile is specified for lining the trench, the geotextile shall be delivered to the Site in such a manner to facilitate handling and incorporation into the work without damage. In no case shall the geotextile be stored and exposed to direct sunlight that might significantly diminish its strength or toughness. Torn or punched geotextile shall not be used.

After the trench has been approved by the Engineer, the geotextile shall be loosely rolled out so the centre of the geotextile is at the centreline of the excavated trench, and it will not tear when the aggregate is placed. When more than one section of the geotextile is used, the geotextile shall overlap a minimum of 600 mm or to the manufacturer's specification (whichever is more). Enough geotextile shall remain uncovered after the trench is filled to provide for geotextile overlap at the top.

Measurement and payment shall be made under ITEMS 21.01, 21.04, 21.06 AND 21.10.

2106 CLASSIFICATION OF MATERIALS

All excavations for open drains and subsoil drainage systems shall be classified as in TABLE 3603/1 for payment purposes.

(a) Rock Excavation

Material that conforms to the definitions in CLAUSE 3603 shall be classified as rock material.

(b) Common Excavation

All materials not classified as rock material in accordance with CLAUSE 3603 shall be classified as soft material.

2107 MANHOLES, OUTLET STRUCTURES AND CLEANING EYES

Manholes, outlet structures and cleaning eyes for subsoil drainage systems shall be constructed in accordance with the details shown on the Drawings or in positions as instructed by the Engineer.

2108 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
21.01 EXCAVATION FOR OPEN DRAINS:	
(a) EXCAVATING SOFT MATERIAL SITUATED WITHIN THE FOLLOWING DEPTH RANGES BELOW THE SURFACE LEVEL:	
(i) 0 m UP TO 1.5 m	CUBIC METRE (m ³)
(ii) EXCEEDING 1.5 m AND UP TO 3.0 m	CUBIC METRE (m ³)
(iii) EXCEEDING 3.0 m PER INCREMENT OF 1.5 m	CUBIC METRE (m ³)
(b) EXTRA OVER SUB-ITEM 21.01 (a) FOR EXCAVATION IN ROCK AS DEFINED IN CLAUSE 3603, IRRESPECTIVE OF DEPTH:	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorised dimensions, measured in place before excavation.

Irrespective of the total depth of the excavation, the quantity of material in each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for the excavation of the material to the required lines, levels and grades and the disposal of the material as directed, including all haulage.

<u>ITEM</u>	<u>UNIT</u>
21.02 CLEARING AND SHAPING EXISTING DRAINS:	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorised dimensions, measured in place before excavation.

The bid rates shall include full compensation for excavating the material to the required lines, levels and grades, protecting the existing drainage structure, trimming the sides and floors of the open drains and the disposal of the material as directed, including all haulage.

The clearing of existing concrete side drains will be measured and paid for under ITEM 21.17.

<u>ITEM</u>	<u>UNIT</u>
21.03 EXCAVATION FOR SUBSOIL DRAINAGE SYSTEMS:	
(a) EXCAVATING SOFT MATERIAL SITUATED WITHIN THE FOLLOWING DEPTH RANGES BELOW THE SURFACE LEVEL:	
(i) 0.5 m UP TO 1.5 m	CUBIC METRE (m ³)
(ii) EXCEEDING 1.5 m AND UP TO 3.0 m	CUBIC METRE (m ³)
(iii) EXCEEDING 3.0 m PER INCREMENT OF 1.5 m	CUBIC METRE (m ³)
(b) EXTRA OVER SUB-ITEM 21.03 (a) FOR EXCAVATION IN ROCK AS DEFINED IN CLAUSE 3603, IRRESPECTIVE OF DEPTH:	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorised dimensions, measured in place before excavation.

Irrespective of the total depth of the excavation, the quantity of material in each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for the excavation of the material to the required lines, levels and grades and the disposal of the material as directed, including a free haul determined according to SUB-CLAUSE 1602 (c).

Where subsoil drainage systems are adjacent to structures such as culverts, that part of the excavation for subsoil drainage systems which can be made by widening the excavation for the structure shall be measured and paid for under excavation for such structure, and not under excavation for the subsoil drainage systems.

<u>ITEM</u>	<u>UNIT</u>
21.04 IMPERMEABLE BACKFILLING TO SUBSOIL DRAINAGE SYSTEMS	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of completed backfill, measured in place in the subsoil drainage systems and calculated in accordance with the authorised dimensions.

The bid rate shall include full compensation for procuring, furnishing, placing and compacting the backfilling including all haulage.

<u>ITEM</u>	<u>UNIT</u>
21.05 BANKS AND DYKES	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material, measured in place in the banks or dykes, and calculated in accordance with the authorised dimensions.

The bid rate shall include full compensation for procuring, furnishing, placing, watering, compacting, shaping and trimming the material in the banks and dykes including all haulage.

<u>ITEM</u>	<u>UNIT</u>
21.06 NATURAL PERMEABLE MATERIAL IN SUBSOIL DRAINAGE SYSTEMS (CRUSHED STONE):	
(a) CRUSHED STONE OBTAINED FROM APPROVED SOURCES ON THE SITE (STATE GRADE)	CUBIC METRE (m ³)
(b) CRUSHED STONE OBTAINED FROM COMMERCIAL SOURCES (STATE GRADE)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of approved crushed stone in place in the drains, calculated in accordance with the authorised dimensions. The volume occupied by the pipe shall be deducted when calculating the volume of the permeable material.

The bid rate for ITEM 21.06 (a) shall include full compensation for procuring, furnishing and transporting from the source and placing the material as specified.

The bid rate for ITEM 21.06 (b) shall include full compensation for procuring and furnishing approved crushed stone from commercial suppliers, including the cost of transporting the material to the site, and placing the materials as specified.

For payment purposes a distinction shall be made between the different grades of crushed stone.

<u>ITEM</u>	<u>UNIT</u>
21.07 NATURAL PERMEABLE MATERIAL IN SUBSOIL DRAINAGE SYSTEMS (SAND):	
(a) SAND OBTAINED FROM APPROVED SOURCES ON THE SITE	CUBIC METRE (m ³)
(b) SAND OBTAINED FROM APPROVED SOURCES OUTSIDE THE SITE	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of approved sand in place in the drains, calculated in accordance with the authorised dimensions. The volume occupied by the pipes shall be deducted when calculating the volume of the permeable material.

The bid rate shall include full compensation for procuring, furnishing, transporting from the borrow areas on the site or outside the site as the case may be and placing the sand as specified.

<u>ITEM</u>	<u>UNIT</u>
21.08 PIPES IN SUBSOIL DRAINAGE SYSTEMS:	
(a) PITCH-FIBRE PIPES AND FITTINGS COMPLETE WITH COUPLING (STATE SIZE AND WHETHER OR NOT PERFORATED)	METRE (m)
(b) UN-PLASTICISED PVC PIPES AND FITTINGS, NORMAL DUTY, COMPLETE WITH COUPLINGS (STATE SIZE AND WHETHER OR NOT PERFORATED SLOTTED)	METRE (m)
(c) HIGH-DENSITY TYPE POLY-ETHYLENE PRESSURE PIPES AND FITTINGS, COMPLETE WITH COUPLINGS (STATE SIZE, TYPE AND CLASS AND WHETHER OR NOT PERFORATED)	METRE (m)
(d) CONCRETE PIPES (STATE TYPE AND DIAMETER)	METRE (m)

The unit of measurement for pipes shall be the metre of pipe, measured in place along its centre line, including the length of fittings.

The bid rate shall include full compensation for procuring, furnishing, laying and jointing the pipes and fittings as specified.

<u>ITEM</u>	<u>UNIT</u>
21.09 POLYETHYLENE SHEETING, 0.15 mm THICK, OR SIMILAR APPROVED MATERIAL, FOR LINING SUBSOIL DRAINAGE SYSTEM	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of polyethylene sheeting installed, measured net from the specified dimensions.

The bid rate shall include full compensation for procuring, supplying, cutting, overlapping, jointing, placing and protecting the sheeting as specified, as well as for wastage.

<u>ITEM</u>	<u>UNIT</u>
21.10 GEOTEXTILE FILTER FABRIC (DESCRIBE TYPE AND GRADE)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of Geotextile filter fabric supplied as specified in SECTION 2700.

The bid rate shall include full compensation for furnishing procuring, cutting, overlapping, jointing, placing and protecting the filter fabric as specified as well as for wastage.

<u>ITEM</u>	<u>UNIT</u>
21.11 COMPOSITE IN-PLANE DRAINAGE SYSTEMS (DESCRIBE TYPE AND GRADE)	SQUARE METRE (m ²)

The unit of measurement shall be the metre of composite in-plane drainage system measured in place along the centreline of the system.

The bid rate shall include full compensation for procuring, furnishing, assembling, installing and jointing the composite in-plane drainage system, including perforated or other types of pipes, complete as specified.

<u>ITEM</u>	<u>UNIT</u>
21.12 CONCRETE OUTLET STRUCTURES, MANHOLE BOXES, JUNCTION BOXES AND CLEANING EYES FOR SUBSOIL DRAINAGE:	
(a) OUTLET STRUCTURES	NUMBER (no.)
(b) MANHOLE BOXES	NUMBER (no.)
(c) JUNCTION BOXES	NUMBER (no.)
(d) CLEANING EYES	NUMBER (no.)

The unit of measurement shall be the number of outlet structures, manhole boxes, junction boxes and cleaning eyes for subsoil drainage systems constructed in accordance with the details on the Drawings and the Engineer's instructions.

The bid rates shall include full compensation for all excavation, backfilling, compacting to 90% of BS-Heavy density, disposing of surplus excavated material, keeping the excavations safe, dealing with any surface or subsurface water, procuring and furnishing all materials, providing, erecting and removing formwork, mixing, transporting, placing and curing the concrete, and all labour and constructional plant required for constructing the concrete outlet structures, manhole boxes, junction boxes and clearing eyes, complete as specified.

<u>ITEM</u>	<u>UNIT</u>
21.13 CONCRETE CAPS FOR SUBSOIL DRAINPIPES	NUMBER (no.)

The unit of measurement shall be the number of caps supplied and the bid rate shall include full compensation for supplying and installing the caps.

<u>ITEM</u>	<u>UNIT</u>
21.14 REPAIRING OR REPLACING EXISTING DRAINAGE SYSTEMS	PROVISIONAL SUM

The provisional sum given for repairing existing drainage systems shall be expended in terms of CLAUSE 1209.

<u>ITEM</u>	<u>UNIT</u>
21.15 BACKFILLING EXISTING ERODED SIDE DRAINS	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of approved granular material placed and compacted to 90% of BS-Heavy density, measured in place after compaction, where instructed by the Engineer.

The bid rate shall include full compensation for trimming the side drains disposing of the resulting material and procuring, furnishing, transporting, placing and compacting the granular material and all haulage.

<u>ITEM</u>	<u>UNIT</u>
21.16 TEST FLUSHING OF PIPE SUBSOIL DRAINS	NUMBER (no.)

The unit of measurement shall be the number of tests satisfactorily completed on unblocked sections of the drain. No payment will be made for tests which have to be repeated due to blocked pipes or faulty workmanship.

The bid rate shall include full compensation for the provision of a water tanker, water, equipment and labour necessary to carry out the tests, complete as specified.

<u>ITEM</u>	<u>UNIT</u>
21.17 EXCAVATION FOR THE CLEARING OF EXISTING DRAINAGE SYSTEMS:	
(a) MANHOLES AND INLET AND OUTLET STRUCTURES	CUBIC METRE (m ³)
(b) CULVERT BARRELS	CUBIC METRE (m ³)
(c) CONCRETE SIDE DRAINS	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material excavated and removed, measured in place before excavation.

The bid rate shall include full compensation for excavating the material, protecting the existing drainage structures, dealing with any surface or subsurface water and disposing of the excavated material, including shaping and levelling – off piles of soil material. The bid rate shall also include full compensation for all haulage of the material.

<u>ITEM</u>	<u>UNIT</u>
21.18 SELECTED BACKFILL MATERIAL UNDER CONCRETE- LINED SIDE DRAINS COMPACTED TO 90% BS-HEAVY DENSITY	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of compacted material and the quantity shall be calculated from the authorised dimensions given on the Drawings.

The bid rate shall include full compensation for procuring the material and transporting it from borrow pits, breaking down, placing and compacting the material in 100 mm layers, in accordance with the Drawings.

SERIES 2000: DRAINAGE

SECTION 2200: PREFABRICATED CULVERTS

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2201 SCOPE

This Section covers work in connection with the

construction using prefabricated units of culvert and other closed conduits such as storm water ducts, tremies and service ducts, as well as inlet and outlet structures, manholes and other appurtenant structures.

2202 TYPES OF PREFABRICATED CULVERTS

For the purpose of this specification, the term "prefabricated culvert" shall mean a culvert constructed from:

- Prefabricated concrete pipes with circular sections, hereafter referred to as "concrete pipe culverts";
- Prefabricated concrete culvert other than pipe culvert hereafter referred to as "portal culvert" or "rectangular culvert";
- Prefabricated corrugated metal pipes and pipe arches, hereafter referred to as "metal culvert".

Other types of prefabricated culverts not mentioned above shall be as shown on the Drawings or as specified by the Engineer.

2203 MATERIALS

The prefabricated culvert units shall be factory produced by a reputable manufacturer, or on site and shall comply with the following requirements as approved by the Engineer:

(a) Prefabricated Concrete Pipe Culvert Units

Prefabricated concrete pipe culvert units shall comply with the requirements of BS 5911-1:2021 and US EAS 426-1:2006 or equivalent. Unless otherwise specified in the drawings or approved by the Engineer, the requirements specified in TABLE 2203/1, TABLE 2203/2 and TABLE 2203/3 shall apply.

TABLE 2203/1: NOMINAL SIZES AND TOLERANCES

1 Nominal size of units	2 Limits of internal manufacturing diameter		3 Deviation of internal actual diameter from manufacturing diameter (mm) (±)	4 Variation of wall thickness (mm) (+)
	Minimum diameter (mm)	Maximum diameter (mm)		
150	150	155	5	6
225	225	230	5	6
300	300	305	5	6
375	365	385	6	6
450	440	460	6	6
525	515	535	6	6
600	580	610	6	4
675	655	695	6	6
750	730	770	6	6
825	805	845	6	6
900	875	950	8	4
975	955	995	6	6
1050	1030	1070	6	6
1125	1105	1145	6	6
1200	1180	1220	9	5
1500	1470	1530	11	5

TABLE 2203/2: SUMMARY OF TEST REQUIREMENTS AND INSPECTION PROCEDURES

Unit	Nominal size and category	Test	Required as, type test	Required as routine test	Tolerance
Pipe	All	Surface evenness	—	—	As per Appendix B.1 of Code BS 5911: Part 100
	All	Surface voids	—	—	Permissible up to 12 mm depth
	All	Straightness	—	—	As per Appendix C of Code BS 5911: Part 100
	All	Water absorption	✓	✓	Dry mass of a single test piece shall not exceed: a.) 3.6% after 30min b.) 6.5% after 24 h.
All reinforced	All reinforced	Hydrostatic	✓	✓	Pipes shall withstand an internal hydrostatic pressure of 0.14 N/mm ² (14m Head) for a period of 1 min without cracking, sweating.
	All reinforced	Works proof load	✓	✓	Appropriate works proof load shall not allow a crack width more than 0.25 mm.
	All	Maximum load	✓	✓	As per Appendix D of Code BS 5911: Part 100
	All ≤ DN 300	BMR	✓	✓	Nominal size of pipe DN Class L KNm Class M KNm 150 3.4 4.2 225 8.1 9.3 300 15.9 17.5
Bend (cast in one piece)	All reinforced	Cover reinforcement	✓	✓	15 mm
	All	Surface voids	—	—	Permissible up to 12 mm depth
	All	Water absorption	✓	✓	Dry mass of a single test piece shall not exceed: a.) 3.6% after 30min b.) 6.5% after 24 h.
	All reinforced ≤ DN 300	Hydrostatic	✓	✓	Pipes shall withstand an internal hydrostatic pressure of 0.07 N/mm ² (7m Head) for a period of 1 min without cracking, sweating.
Bend (built up)	All	Cube crushing	✓	✓	As per Clause 20.1 of Code BS 5911: Part 100
	All reinforced	Cover to reinforcement	✓	✓	15 mm
	All reinforced ≤ DN 300	Hydrostatic (See Note 2)	✓	✓	Pipes shall withstand an internal hydrostatic pressure of 0.07 N/mm ² (7m Head) for a period of 1 min without cracking, sweating.
	All	Surface voids	—	—	Permissible up to 12 mm depth
Junction (cast as one piece)	All	Water absorption	✓	✓	Dry mass of a single test piece shall not exceed: a.) 3.6% after 30min b.) 6.5% after 24 h.
	All reinforced ≤ DN 300 off ≥ DN 750	Hydrostatic	✓	✓	Pipes shall withstand an internal hydrostatic pressure of 0.07 N/mm ² (7m Head) for a period of 1 min without cracking, sweating.
	All	Cube crushing	✓	✓	As per Clause 20.1 of Code BS 5911: Part 100
	All reinforced	Cover to Reinforcement	✓	✓	15 mm
Junction (built up)	All reinforced ≤ DN 300 off ≥ DN 750	Hydrostatic (See Note 2)	✓	✓	Pipes shall withstand an internal hydrostatic pressure of 0.07 N/mm ² (7m Head) for a period of 1 min without cracking, sweating.

NOTE 1: These tests are to be carried out as and when required.

NOTE 2: Fabricated bends and built-up junctions are made from sections of pipe and do not require separate testing and inspection.

NOTE 3: Inspection procedures are not given in this Part for isolated batches of units subject to the hydrostatic or crushing strength test.

TABLE 2203/3: CRUSHING TEST LOADS FOR PIPES

Nominal size of pipe DN	Minimum Crushing Load (kN/m)
150	31
225	35
300	40
375	45
450	54
500	60
600	72
700	84
800	96
900	108
1000	120
1200	144
1500	180

Works Proof Load shall be calculated as 67% of the minimum crushing load obtained after testing

For 2m or 3m pipes, the minimum crushing load shall be multiplied by 2 or 3 respectively.

Pipes with ogee joints shall be provided, unless otherwise specified.

(b) Portal and Rectangular Prefabricated Concrete Culvert Units

Portal and rectangular prefabricated concrete culvert units shall comply with the requirements of BS 6073-2:2008 or equivalent.

(c) Corrugated Metal Culvert Units

Corrugated metal culvert units shall comply with the requirements of UNI-EN 10025 or equivalent for pipes and pipe arches, and for multi-plate pipes and pipe arches.

Metal culvert shall be supplied with inlet and outlet ends finished by one of the following two methods whichever is shown on the Drawings or has been prescribed by the Engineer:

- i) Where no concrete inlet and outlet structures but bevelled pipe ends are required, inlet and outlet units shall be bevelled to suit the skew angle of the culverts and the side slope of the fill and pavement.
- ii) Where concrete inlet and outlet structures are required, the ends of the culvert units shall be cut to the required plan skew (if any) and provided with anchor bolts projecting radially around the edge as shown on the Drawings for bonding the metal culvert into the concrete inlet and outlet structures.

The Contractor shall not store any nestable culvert units on the site in such a manner that moisture can accumulate between the contact faces of the nested units, as this may adversely affect the spelter coating and render the units liable to rejection. Any units damaged by corrosion shall, if not rejected, be repaired by cleaning all affected areas and applying at least two coats of an approved zinc- rich epoxy primer which complies with the requirements of SANS 926:1968 or equivalent, in accordance with the manufacturer's instructions, or as directed by the Engineer. Unless otherwise specified in the contract, the following specifications on metallic culverts as in TABLE 2203/4 shall apply.

TABLE 2203/4: SPECIFICATIONS FOR GALVANISED CORRUGATED METALLIC CULVERTS

Culvert Diameter (mm)	Description of Requirements	Thickness (mm)	Steel Grade Designation	Mechanical Properties			Chemical Composition (% Product Analysis)						Zinc Coating Mass on both sides (g/m ²)
				Yield Strength (MPa)	Tensile Strength (MPa)	% Elongation at Fracture	C	Mn	P	S	Cu	CEV	
600 900 1200 1500	Galvanized Corrugated Metal Steel Culverts with bolts and nuts complying with the requirements of EN 10025-2:2019, coated with an additional two-layer Epoxy Coating consisting of an epoxy primer of thickness 200µm and an acrylic polyurethane resin-based secondary coating of minimum thickness of 1mm. The Combination should provide corrosion protection up to C5 Corrosion Category in accordance with ISO 12944-5 and ISO 12944-9 Standard.	2.5 Minimum	S235JR	235 Minimum	360-510	20 Minimum	0.19 Maximum	1.5 Maximum	0.045 Maximum	0.045 Maximum	0.60 Maximum	0.35 Maximum	610 Minimum
1800 2100 2500		2.7 minimum	S275JR	275 Minimum	430-580	21 Minimum	0.24 Maximum	1.6 Maximum	0.045 Maximum	0.045 Maximum	0.6 Maximum	0.4 Maximum	

(d) Fine Granular Material

Wherever the use of fine granular material is specified in this Section for bedding of culverts, it shall mean sand or other cohesionless material, all of which shall pass through a 6.3 mm sieve and not more than 10% which shall pass through a 0.15 mm sieve.

(e) Protective Coating for Metal Culverts

Where soil or water conditions are likely to cause excessive corrosion of metal culverts, the Engineer may order that prefabricated units be protected by the application of a mastic asphalt protective coating. The coating shall be applied to the inside, the outside or both sides of the metal culvert units as may be directed by the Engineer.

The mastic asphalt shall bear a registered trademark, and approved filler and shall be supplied as a spray or brush-grade material as prescribed.

The surfaces to be protected shall be cleaned to remove all moisture, dirt, oil, paint, grease, alkalis, rust, mill scale or other deleterious matter.

The material shall be mixed until all filler is uniformly distributed.

Spray-grade mastic shall be applied by means of an airless gun and shall be of a suitable consistency without the addition of a harmful amount of thinners.

Brush-grade mastic shall be applied with an ordinary roofing brush, with the second coat being applied at right angles to the first coat.

The final film thickness measured on the crest of corrugations shall be a minimum of 1.3 mm or such other thickness as may be specified.

Care shall be taken not to damage the protective coating, and all damage to the coating shall be repaired before the culvert is put to use.

(f) Skewed Ends

Where culverts are to be constructed at a skew angle, the culvert shall be supplied with skew ends by the manufacturer, if required. The cutting of skewed ends on site shall not be allowed.

Portal and rectangular units shall be provided with square ends and any portions that would otherwise be cut off, shall project beyond the culvert head walls.

Where instructed by the Engineer, portal and rectangular culverts shall be provided with skewed ends constructed from cast in situ reinforced concrete in accordance with the details shown on the Drawings.

(g) Defects

All broken, bent, chipped, cracked, dented, corroded or otherwise damaged units shall be repaired to the Engineer's satisfaction or where this is not possible, they shall be removed and replaced with undamaged units.

Culvert units, which are thinner than the specified thickness, or the spelter coating of which has been bruised or broken, or which may exhibit signs of faulty work, will be rejected.

The following defects will be rejected as poor work, and the presence of any of or all such defects or any other defects in any individual unit or in general shall constitute adequate reason for rejection: Uneven joints, distorted shapes, deviations from a straight centre line, irregular or diagonally ruptured sides, loose rivets not in line or

irregularly spaced, poorly finished rivet heads, illegible trademarks, or a lack of rigidity.

(h) Material at Joints

Joint filter sealing material shall comply with the requirements of CLAUSE 6602.

(i) In-Situ Concrete

All concrete work shall be carried out in accordance with the requirements of SECTIONS 6200, 6300 and 6400.

2204 CONSTRUCTION METHODS

Prefabricated culverts shall be installed by either:

- The "trench method", where the units are laid in a trench excavated below the existing ground level or in a trench excavated in previously constructed subgrade and if necessary, subbase layers; or
- The "embankment method", where the units are laid approximately on the existing ground surface and the subgrade is then constructed on either side and over the culvert.

Culverts shall be constructed by the method shown on the Drawings or given in the Special Specifications.

The large sizes of metal culverts and the large portal or rectangular culverts shall normally be constructed by the embankment method.

Surface drainage shall be controlled by the construction of temporary earth berms and drainage channels.

The Contractor shall comply strictly with all the appropriate statutory provisions in regard to trench excavations.

2205 EXCAVATION FOR CONSTRUCTION BY THE TRENCH METHOD**(a) Depth of Excavation**

In the case of culverts to be constructed by the trench method, the Contractor shall first construct the fill, subgrade and if necessary, the subbase to such level of the top of the culvert, as described herein after for the various types of culvert. The Contractor may then commence excavating the trench for the culvert.

The amount by which the excavation is to exceed the proposed level of invert of the culvert shall be sufficient to allow the type and thickness of bedding material to be placed as specified or as shown on the Drawings.

Notwithstanding the provisions of SUB-CLAUSE 2205(a), the base shall be constructed before the culvert and the backfill have been completed.

i) Concrete Pipe Culverts

The minimum height of embankment construction over the top of the proposed pipe culvert before excavation may be commenced, shall be the minimum cover specified on the Drawings for the type of pipe and bedding onto which it shall be laid.

The minimum amount by which the excavation is to exceed the proposed level of the bottom side of the pipe shall be 75 mm or such other as may be required for accommodating the type of bedding required for the pipe in each case.

ii) Portal and Rectangular Culverts

The minimum height of embankment construction over the top of the proposed culvert before excavation may be commenced, shall be 100 mm

or such greater height as may be shown on the Drawings, whichever is the greater.

The minimum amount by which the excavation is to exceed the proposed level of the bottom of the culvert invert slab shall be 75 mm in the case of a culvert with precast invert slabs. In the case of culverts with cast in situ invert slabs, the excavation shall exactly accommodate the invert slab.

iii) Metal Culverts

The minimum height of embankment construction over the top of the proposed metal culvert before excavation may be commenced, shall be the minimum cover specified on the Drawings for the type of metal culvert, or 0.25 times the diameter of pipes, or 0.25 times the span of pipe arches, whichever is the greatest.

The minimum amount by which the excavation is to exceed the proposed level of the bottom of the pipe shall be 75 mm or such other amount required for accommodating the type of bedding required for the culvert in each case.

(b) Width of Excavation

The width of excavations shall be sufficient to allow the proper laying, bedding and backfilling of culverts. The widths of the excavation for each type and size of culvert shall be as shown on the Drawings or as may be prescribed by the Engineer.

If the width of an excavation is increased by the side of the trench slipping or collapsing, the Contractor shall immediately inform the Engineer who will review the circumstances and provide instructions to the Contractor accordingly.

2206 PREPARATION FOR CONSTRUCTION BY THE EMBANKMENT METHOD

Where culverts are to be constructed by the embankment method as defined in CLAUSE 2204, the Contractor shall level existing ground by excavating, filling and compacting as may be necessary so as to provide exactly the required slope and a uniform density over the entire length of the culvert.

The finished level of the ground for the bedding of the culvert shall be the same depth below the proposed bottom level of the culvert as specified in CLAUSE 2205 for the various types of culverts.

2207 UNSUITABLE FOUNDING CONDITIONS

Where the bottom of the trench does not provide a suitably firm foundation for the culvert on account of soft, mucky or otherwise unsuitable material being encountered, the unsuitable material shall be excavated to a depth below the bottom of the culvert as may be indicated by the Engineer.

The Contractor shall excavate the unsuitable material to the depth indicated and shall replace it with gravel or other approved material properly compacted to provide a firm earth cushion.

The width of the excavation shall be as prescribed by the Engineer, but in the case of culverts to be constructed by the embankment method, the width shall be at least one diameter or span, as the case may be wider than the culvert on each side.

Other special construction methods may be shown on the Drawings or specified in the Special Specifications in specific cases.

2208 CLASSIFICATION OF EXCAVATION

All excavations for prefabricated culverts shall be classified as provided in CLAUSE 3603 for payment purposes.

2209 DISPOSAL OF EXCAVATED MATERIAL

Where excavated material does not comply with the requirements for backfilling material as specified hereinafter or is surplus to backfilling requirements, such excavated material shall be removed from the site and used for rehabilitation of borrow pits or at other places as directed by the Engineer.

Material suitable for use in the Works, however, shall be used as prescribed by the Engineer.

Payment for such material will be made as for excavation under ITEM 22.01, and also under the appropriate item for such part of the Works as may be constructed from such material.

No haulage will be paid for excavated material.

2210 LAYING AND BEDDING OF PREFABRICATED CULVERTS

(a) Concrete Pipe Culverts

Concrete pipe culverts shall be laid on Class A, B, C or D bedding as shown on the Drawings or as directed by the Engineer. The pipe ends shall be laid hard up against each other so as to obtain tight joints. Ogee pipes shall be laid with their spigot ends downstream. The joints shall be sealed on the outside with two layers of bitumen impregnated burlap as specified in SUB-CLAUSE 2210(b).

The insides of the culvert shall be smooth and without any displaced joints. All pipes shall be laid true to line and level.

i) Class A Bedding

The pipe shall be laid with its bottom part on a 20 MPa concrete bedding of specified thickness below the lower part of the pipe, which concrete shall extend upwards on both sides of the pipe to a specified portion of its height.

Before concreting, the pipes shall be supported on suitably shaped cradles at the correct level. No longitudinal construction joints on the horizontal plane will be permitted.

ii) Class B and C Beddings

The pipe shall be laid on a bedding cradle of compacted selected granular material that meets the requirements of CLAUSE 3700 and compacted to 90% of BS-Heavy or as specified in the drawings. The bedding shall extend upwards on both sides of the pipe to a specified portion of its height, as shown on the Drawings. If no specific height of bedding cradle is mentioned the lower part of the pipe exterior should be supported for at least 1/2 the overall height of pipe for Class B and 1/5th of overall height of pipe for Class C. The compacted thickness of the bedding below the pipe shall be as shown on the drawings, and in no case shall it be less than 200 mm. Joint holes shall be formed in the bedding cradle for pipe sockets and couplings, to ensure that each pipe is fully supported throughout the length of its barrel on the bedding cradle. For pipes on Class B & C type bedding a minimum depth of 300 mm over the top of the pipe should be filled with densely compacted material or the cover depth mentioned in the drawings; whichever is more.

iii) Class D Bedding

The pipes shall be laid on the in-situ material in the excavation bottom after the bottom has been hand trimmed to support the pipe along the entire length of its barrel in accordance with the details shown on the Drawings. Wherever necessary, the in-situ material shall first be stabilised in accordance with the details shown on the Drawings or as prescribed by the Engineer.

iv) Rock Foundation

Where rock, shale or other hard material is encountered on the bottom of excavations, the installation of pipes on Class B bedding shall proceed as follows:

- a. The material below the pipe shall be excavated and replaced with a bed of sand or approved gravel or soil to a depth as shown on the Drawings or prescribed by the Engineer. Such material shall be classed as backfill for purposes of payment.
- b. The backfill material shall be watered and compacted to provide a firm earth cushion. Class B bedding shall then be prepared as described in SUB-CLAUSE 2210 (a).

v) Concrete Casing

Where shown on the Drawings or ordered by the Engineer, pipes shall be partly or fully encased in concrete according to class and dimensions as shown on the Drawings or as ordered by the Engineer. Supports shall be provided close to the pipe ends to support the pipes during the placement of concrete. The concrete shall be so placed as to fill all spaces below the pipe completely. Poker vibrators shall be used to ensure the proper filling of all spaces below and around the pipes with concrete. Concrete casing shall be cast in one continuous operation until completed.

(b) Portal and Rectangular Culverts**i) Cast In-Situ Floor Slabs**

Cast in situ floor slabs shall be constructed to the dimensions and at the locations as shown on the Drawings or as may be prescribed by the Engineer. They shall be reinforced with steel reinforcement as detailed on the Drawings. Joints of the types detailed on the Drawings shall be formed in the floor slabs, and the inlet and outlet structures.

ii) Prefabricated Floor Slabs

A layer of fine-grained material at least 75 mm thick shall be placed on the bottom of the excavation, levelled, compacted and trimmed to line and grade to form a bed to receive the precast slabs.

The slabs shall be carefully placed on the prepared bed, true to line and grade and so bedded that they will be uniformly supported over their whole area on the bedding.

iii) Placing the Portal Portions of Culverts

The portal portions of portal and rectangular culverts shall be placed accurately and symmetrically on the floor slabs with a thin layer of mortar of one part cement and six parts sand between the contact surface to ensure a firm and uniform support.

The units shall be butted end to end with butt joints, which joints shall be covered with two layers of burlap of 340 g/m², pre-impregnated with a bituminous emulsion, or a similar approved material. The strip of burlap shall be at least 150

mm wide and placed symmetrically over the joint. The units shall first be treated with a primer of 60% bitumen emulsion over the width of the strip of burlap.

Where two or more culverts are placed side by side to form a multi-barrel culvert, the space between the culverts shall be filled with concrete up to the level of the top of the culvert. Where prescribed, filter fabrics shall be applied to the vertical outer faces in accordance with the details shown on the Drawings.

(c) Metal Culverts

The excavation shall be trimmed to the shape of the invert of the culvert and a bed of fine granular material not less than 75 mm thick as defined in SUB-CLAUSE 2203 (d) shall be placed, watered, compacted and shaped to enable the culvert to be bedded as shown on the Drawings.

Where rock is encountered, the depth of excavation shall extend to a depth of at least 200 mm below the invert of the culvert and shall be filled with granular material as before.

The culverts shall be installed in accordance with the manufacturer's recommendations as approved by the Engineer. Where these Specifications are inconsistent with the manufacturer's recommendations, these Specifications shall have preference. Anchor bolts shall be installed at the ends of metal pipe culverts in accordance with the manufacturer's instructions to bond them into the inlet and outlet head walls, which head walls shall be constructed as soon as possible after installation of the culverts.

Where prescribed, the invert of metal culverts with diameters or spans exceeding 1500 mm which are laid on steep grades shall be protected with a layer of concrete with dimensions and class shown on the Drawings.

(d) Extension of Existing Culverts

Where an existing culvert requires extension or partial replacement, the new section shall be placed at the same grade and where it joins the existing structures at the same level as the existing structure.

Any sections of existing wing walls, approach slabs and head walls that may obstruct any work shall be demolished and removed. Existing culvert ends shall not be damaged, but should damage occur, the repair work shall be done before the placement of any fresh concrete or new culverts. Loose material shall be removed and joint faces thoroughly cleaned to the satisfaction of the Engineer.

Jointing shall be done in accordance with CLAUSE 2214.

After completion of the extension or partial replacement of a culvert, new approach slabs, head walls, wing walls, catch pits etc., shall be constructed in accordance with the Drawings and CLAUSE 2212.

(e) Construction of Culverts in Half Widths in Existing Roads

If necessary for accommodating traffic or for any other reasons or if so instructed by the Engineer, culverts shall be constructed in half widths.

Unless otherwise prescribed, the downstream section shall be constructed first. The end of the excavation adjoining the traffic lane shall be properly supported to prevent displacement from occurring. The necessary warning signs shall be erected in accordance with the

requirements of SECTION 1500.

Where the culvert is constructed in an existing road and it has been so prescribed by the Engineer, the pavement layers at least shall be benched and re-compacted during backfilling. The depth of benching shall equal the respective layer thickness, and the width shall be at least 150 mm.

(f) General

The construction of culverts shall commence at one end of the culvert, the position of which shall be fixed as shown on the Drawings or as prescribed by the Engineer.

Units which have been deformed or cracked, or which are not constructed to the required lines, levels and grades or which become displaced in the process of the work during the defects liability period shall be removed and replaced by the Contractor at their own expense.

Prefabricated units shall be lifted and handled by means of approved lifting devices only. Lifting eyes shall be caulked with a suitable mortar after the units have been installed.

The Contractor shall exercise due care not to damage, overstress or displace any prefabricated culverts with their own traffic or compaction equipment. Where loads exceeding those prescribed in the appropriate statutory provisions are likely to pass over completed culverts, the Contractor shall provide additional cover over the culverts to ensure that design stresses on the culverts will not be exceeded.

All concrete work shall be carried out in accordance with the provisions of SERIES 6000.

When the Contractor is required to supply and install culverts at a slope exceeding 1:4, the work shall be carried out as specified in CLAUSE 2216.

2211 BACKFILLING OF PREFABRICATED CULVERTS

After the culverts have been firmly laid on the required bedding as described in CLAUSE 2210, backfilling shall be carried out as follows:

(a) Material for Backfilling

The material used for the backfilling of those portions of culverts subject to traffic loads shall be selected material of at least subbase quality or such other lower quality as may be permitted by the Engineer. Where the excavated material is not of adequate quality, selected material shall be imported for this purpose. The Contractor shall in advance, ascertain from the Engineer as to which portions will require selected-quality material for backfilling.

In the case of concrete pipe culverts on Class B bedding and metal culverts the backfilling material shall be thoroughly tamped in under the flanks of the culverts to provide a uniform bedding all to the Engineer's satisfaction. Metal culverts shall be temporarily ballasted during backfilling to prevent them from lifting.

(b) Backfilling

Backfilling alongside and over all culverts shall be placed at or near the optimum moisture content of BS-Heavy and compacted in layers not exceeding 150 mm after compaction, or less if required, to a density of at least the density required for the material in adjoining layers of fill, subgrade and subbase. The density of backfilling in excavations made in natural ground shall be at least 93% of BS-Heavy density.

Backfilling shall be carried out simultaneously and equally on both sides of a culvert to prevent unequal lateral forces from occurring.

Where the Engineer so directs, metal culverts with large diameters or spans or multi-barrel culverts shall be constructed by the embankment method as defined in SUB-CLAUSE 2204. In such cases, the backfilling shall be carried out to the same standard as described above, simultaneously and equally on both sides of the culvert and placed over the culvert until the minimum specified cover is obtained. The width of backfill on each side of the culvert, after completion, shall be at least equal to the diameter (or span) of one of the openings of the culvert.

Metal culverts shall be backfilled symmetrically to prevent distortion of the units, and the Contractor shall also ensure that the required cover as specified is in place to allow construction equipment to pass over it without causing damage.

(c) Backfilling with Concrete

Whenever specified or as may be instructed by the Engineer, the backfilling shall consist of concrete placed between the side of the culvert and the excavation up to the top of the culvert.

(d) Backfilling With Soil-Cement

When specified or ordered by the Engineer, the backfilling of culverts shall be done using a wet or a stiff mixture of soil-cement in lieu of compacted gravel or lean concrete. A wet mixture of soil-cement shall consist of an approved soil or gravel mixed with at least 5% of a common cement complying with the requirements of US 310-1:2001/EAS 18-1, BS EN 197-1:2011 or equivalent standard on approval of the Engineer and only sufficient water to give a consistency that will permit the soil-cement to be placed with vibrators, so that all voids between the pipes and the sides of excavations and between culverts in the case of multi-barrel culverts will be properly filled. A stiff mixture of soil-cement shall contain 3% of a common cement complying with the requirements of US 310-1:2001/EAS 18-1, BS EN 197-1:2011 or equivalent standard on approval of the Engineer and just sufficient water for it to be placed and compacted like ordinary backfill material. The height to which the soil-cement backfill shall be taken shall be as prescribed by the Engineer or as shown on the Drawings, and any remaining backfill shall be carried out as described above with a granular material.

The aggregate used for soil-cement shall preferably be a sandy material but may contain large particles up to 38 mm. It shall not have a Plasticity Index exceeding 10%. Detrimental percentages of silt or clay shall be avoided and the aggregate shall be obtained from an approved source.

The soil-cement shall be mixed on the Site with suitable concrete mixers, and the water and cement contents shall be carefully controlled. The material shall be placed and then thoroughly compacted so that all voids are filled as described above. At culvert ends, stones shall be packed to prevent the soil-cement from flowing beyond the required limits.

Soil-cement shall not be used for backfilling corrugated metal culverts.

(e) Haulage

When haulage is paid for in accordance with the Special Specifications, a free haul distance determined according to SUB-CLAUSE 1602 (c) shall apply in respect of all imported materials used for backfilling the culverts. No overhaul shall be paid on any cement, water or concrete aggregates used.

2212 INLET AND OUTLET STRUCTURES, CATCH PITS AND MANHOLES

Inlet and outlet structures for prefabricated culverts as well as catch pits and manholes shall be constructed in accordance with the details shown on the Drawings.

(a) Excavation and Backfilling

The specifications given elsewhere in this Section for excavating and backfilling the culverts shall apply with changes as required to inlet and outlet structures, catch pits and manholes.

No backfilling of a concrete structure may be done for a period of at least seven days after the structure has been completed, unless otherwise specified or directed by the Engineer.

(b) Concrete Work

Concrete work shall be carried out in accordance with the provisions of SERIES 6000 and the Drawings.

(c) Brickwork

Bricks shall be engineering bricks conforming to the requirements of, BS EN 772-3:1998, BS EN 772-7:1998 or equivalent.

The limit for water absorption in the 24-hour immersion test shall be 8%.

Brickwork shall be built in English bond in a mortar consisting of one part cement and six parts sand, or in stretcher bond where its thickness does not exceed 115 mm. It shall be well and regularly bonded without any false headers. All bricks shall be unbroken, except where required as closers. Bricks shall be well wetted before laying and each brick shall be exceeding 10 mm in thickness. All joints shall be filled solid with mortar, and joints for exposed faces shall be pointed as the work proceeds.

Where pipes enter brickwork they shall be thoroughly caulked into the wall and rendered with mortar.

(d) Plaster

Where the plastering of brickwork is required, all joints shall be well raked out and the brick face thoroughly wetted before plaster is applied. Plaster shall not be less than 12 mm or more than 20 mm thick. Plaster finish shall be smooth and even and shall not show any trowel marks. Unless otherwise specified, all plaster shall be finished with a steel trowel. Plaster shall consist of one part of cement to four parts of approved fine sand.

(e) Manhole Covers, Grid Inlets Etc.

Manhole covers and frames, grid inlets and other metal accessories shall be supported and/or manufactured in accordance with the details shown on the Drawings. Road and pavement manhole covers and frames shall comply with the requirements of BS 7903:2020 and BS EN 124 or equivalent and shall be of the size and type indicated.

Before fixing manhole covers and frames they shall be dipped in an approved preservative and gratings and frames painted with two coats of bituminous paint. The manhole frame shall be set firmly in a cement mortar to leave the covers flush with the final surface. Manhole covers shall be installed in such a way to mitigate vandalism.

(f) Prefabricated Concrete Chambers and Shafts

Prefabricated chambers and shafts shall be constructed from non-pressure concrete pipes that comply with the requirements of BS 5911-1:2021 or equivalent. Pipes

with ogee joints shall be provided unless otherwise specified. The pipes shall be to the diameters specified. All chambers and shafts shall be installed with the spigot ends pointing upwards and shall be bedded in mortar thoroughly caulked to ensure watertight joints.

(g) Benching

All benching shall be rendered in 20 mm granolithic plaster and finished smooth and true with a steel trowel. Corners shall be rounded to dimensions shown on the Drawings.

(h) Prefabricated Inlet and Outlet Structures

Where specified for use, prefabricated inlet and outlet structures shall be manufactured in accordance with the dimensions shown on the Drawings. The units shall be laid and jointed generally as specified for prefabricated concrete pipe culverts.

(i) Prefabricated Energy Dissipaters in Outlet Structures

Where shown on the Drawings, the Contractor shall supply and install in the outlet structures, prefabricated reinforced concrete energy dissipaters of Class 25/20 concrete with dimensions as shown on the Drawings. All concrete work shall comply with the requirements of SERIES 6000.

2213 REMOVAL OF EXISTING WORK

Where shown on the Drawings or directed by the Engineer existing inlets and outlets to pipe culverts shall be demolished and debris or rubbish disposed of in an approved waste site as directed by the Engineer. Existing pipes shall be removed where necessary and saved for later use. All such work shall be carried out to prevent damage being done to former work which is to be retained.

The Contractor's attention is directed to the provisions of SECTION 3200, which specify any structures that have to be removed as part of the clearing and grubbing operations, the removal of which will therefore not be measured and paid for under this Section.

Pipes shall be carefully removed from existing culverts and thoroughly checked.

Undamaged pipes shall be reused in the Works where indicated by the Engineer. Pipes which cannot be reused shall remain the property of the Employer and shall be stacked within the road reserve or where directed by the Engineer.

2214 JOINING NEW WORK TO OLD

Where partial demolition is required for extension work to existing structures, the contact face shall be cut to predetermined lines and levels, any loose and fragmented material shall be removed and projecting steel cleaned and bent as directed by the Engineer. Where partial demolition is not required, but extension work only, the contact surface shall be roughened and cleaned of all dirt and loose particles.

If dowels are required, they shall be installed in holes drilled into the existing structures, in accordance with the details shown on the Drawings and secured by means of an approved type of epoxy resin grout.

Fresh concrete shall be bonded to the old concrete in accordance with the requirements specified in SECTION 6400.

Reinforced or plain concrete removed in the process of partial demolition shall be measured and paid for under ITEM 22.12 and the installation of dowels and those

surfaces treated with an epoxy bonding compound will be paid for separately but no separate payment will be made for any other work described above, the cost of which shall be deemed to be included in the rates bid for the concrete supplied for extensions to the existing structures.

2215 SERVICE DUCTS

Where required the Contractor shall construct service ducts for the easy installation and maintenance of existing, new and future cables and other services. Services ducts shall be constructed from one or more of the following materials:

- Normal duty PVC pipes in accordance with BS 4660:2022 and BS EN 1401-1:2019+A1:2023 or equivalent.
- Pitch-fibre pipes in accordance with BS 2760:1973 or equivalent.
- Fibre-cement pressure pipes in accordance with BS EN 512:1995 or equivalent. Class C pipes shall be used unless other types are specified.
- Reinforced-concrete pipes in accordance with BS 5911-1:2021 or equivalent.

Where required, the pipes shall be cut length-wise and accurately into two halves. The actual type of pipe required shall be in accordance with the Specifications. The pipes shall be installed in the required positions, and an accurate record shall be kept regarding the depth, position and number of pipes installed in each duct. Pipes shall be laid at the grades shown on the Drawings to facilitate flushing with water and shall, where required, be encased in concrete or soil-cement.

The width of excavation for service-duct trenches shall be equal to the nominal inside diameter of the pipe, plus 150 mm on each side of the duct. Where ducts consist of two or more units, the minimum spacing between the units shall be 75 mm, and the 150 mm side clearance specified above shall apply to the outside units of the group.

Below the carriageway, the depth of excavation shall accommodate a minimum cover of 1.0 m above the upper side of the installed services duct.

All pipes shall be joined with watertight couplings made from the same materials as the pipe. Fibre-cement couplings shall be of rubber-ring type.

Split pipes shall normally be used only for providing ducting for existing services that cannot be severed and threaded through the ducts. The pipes shall be accurately cut longitudinally into two halves and the opposite halves shall be matched as sawn. Split pipes shall be placed around the service as required, firmly bound by steel straps and finally encased in concrete if required.

Excavating, laying and bedding the pipes shall be in accordance with the Specifications for prefabricated culverts with any modifications as may be necessary or specified here.

Duct ends shall be provided with suitable conical wooden stoppers to prevent dirt from entering the ducts. Two strands, 2.5 mm in diameter of galvanised steel wire shall be threaded through each unit and shall extend 2 m beyond each end and firmly wedge into position with the wooden stoppers.

The end of each duct shall be marked with a marker block constructed to the details shown on the Drawings. Each duct marker block shall be at least 50 mm proud of the finished surface level.

2216 CULVERTS ON STEEP GRADIENTS

Where culverts are constructed on gradients exceeding 1:4, they shall be referred to as inclined culverts. Inclined culverts shall be constructed from the type of unit required, normally either circular concrete pipe units or metal culvert units as described in CLAUSE 2203.

Particular care shall be taken to protect excavations against stormwater damage. The trenches shall be excavated down to firm ground, and backfilled with selected gravel or concrete if it is necessary to over-excavate for obtaining a firm floor.

After the outlet structures have first been completed, the culvert units shall be laid in the normal manner by starting from the lower end and placing successive units firmly against each other to prevent subsequent movement. The lower unit shall be securely cast into the outlet structure, and metal culverts shall be provided with the necessary anchor bolts at both inlet and outlet structures and also at all thrust and anchor blocks.

Thrust and anchor blocks shall be constructed from concrete as required in accordance with Drawings and details furnished by the Engineer. Anchor bolts, straps and other anchoring devices required at anchor and thrust blocks shall be provided.

The backfilling of trenches shall be done in horizontal layers starting at the lower end.

2217 STORMWATER DUCTS, TREMIES AND OTHER CLOSED CONDUITS

The specifications given in this Section for culverts, including the method of measurement and payment, shall apply with changes as required to the construction of storm water ducts, tremies or any other closed conduits constructed from the prefabricated units described in CLAUSE 2203, whether intended for drainage or for any other purpose.

No distinction will be made in the Bill of Quantities between the construction of culverts as defined in SECTION 1100 and that of the other closed conduits described above, all being classed as culverts.

Tremies constructed from prefabricated units shall be classed as inclined culverts where laid to a grade steeper than 1:4.

2218 MEASUREMENT AND PAYMENT

ITEM	UNIT
22.01 EXCAVATION:	
(a) EXCAVATING SOFT MATERIAL SITUATED WITHIN THE FOLLOWING DEPTH RANGES BELOW THE SURFACE LEVEL:	
(i) 0 m UP TO 1.5 m	CUBIC METRE (m ³)
(ii) Exceeding 1.5 m AND UP TO 3.0 m	CUBIC METRE (m ³)
(iii) Exceeding 3.0 m AND UP TO ... (PER INCREMENT OF 1.5 m)	CUBIC METRE (m ³)
(a) EXTRA OVER SUB-ITEM 22.01 (a) FOR EXCAVATION IN ROCK AS DEFINED IN CLAUSE 3603, IRRESPECTIVE OF DEPTH:	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material excavated within the specified widths over the lengths and depths authorised by the Engineer in each case. Excavation in excess of the widths specified or

authorised by the Engineer shall not be measured for payment.

The quantity of material within each depth range shall be measured and paid for separately.

When measuring excavation for the removal of existing culverts, the volume occupied by the culvert shall not be subtracted from the calculated volume of excavation.

In the case of manholes, catch pits and inlet and outlet structures, the dimensions for determining the volume of excavation shall be the neat outside dimensions of the structure, plus an allowance of 0.5 m of working space around the structure.

The bid rates shall include full compensation for all excavation, temporary timbering, shoring and strutting, for preparing the bottom of the excavation for the culvert beds, the disposal of excavated material unsuitable for backfilling, keeping excavations safe, dealing with any surface or subsurface water, and for any other operations necessary for completing the work as specified.

No haulage will be paid.

<u>ITEM</u>	<u>UNIT</u>
22.02 BACKFILLING:	
(a) USING EXCAVATED MATERIAL	CUBIC METRE (m ³)
(b) USING IMPORTED SELECTED MATERIAL	CUBIC METRE (m ³)
(c) EXTRA OVER SUB-ITEMS 22.02 (a) AND (b) FOR SOIL CEMENT BACKFILLING (PERCENTAGE OF CEMENT INDICATED)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material in place after compaction. The quantity shall be calculated from the leading dimensions of the backfilling as specified or as authorised by the Engineer.

If excavations were carried out in excess of the dimensions authorised by the Engineer, the quantity of backfilling will nevertheless be based on the authorised dimensions. The volume occupied by the culvert shall be subtracted when calculating the volume of backfilling.

The bid rates shall include full compensation for backfilling under, alongside and over conduits, for watering, and for compacting the backfill material to the specified density. The bid rate for SUB-ITEM 22.02 (b) shall, in addition, include full compensation for supplying selected material of subbase quality from approved sources, including a free haul determined according to SUB-CLAUSE 1602 (c) in cases where haulage is paid for in accordance with the Special Specifications.

The bid rate for SUB-ITEM 22.02 (c) shall be additional to the rates bid for SUB-ITEMS 22.02 (a) and (b) and shall include full compensation for all incidentals required for the complete backfilling with soil-cement as specified.

<u>ITEM</u>	<u>UNIT</u>
22.03 CONCRETE PIPE CULVERTS:	
(a) ON CLASS A BEDDING (TYPE AND DIAMETER INDICATED)	METRE (m)
(b) ON CLASS B BEDDING (TYPE AND DIAMETER INDICATED)	METRE (m)
(c) ON CLASS C BEDDING (TYPE AND DIAMETER INDICATED)	METRE (m)
(d) ON CLASS D BEDDING (TYPE AND DIAMETER INDICATED)	METRE (m)

The unit of measurement for concrete pipe culverts shall be the metre of culvert laid as shown on the Drawings or ordered by the Engineer. The length shall be measured along the soffit of the culvert.

The bid rates shall include full compensation for providing, testing, loading, transporting and unloading the culverts, for providing and placing the fine-grained material, where required, and for the installation, laying and jointing of the culverts, as specified. The bid rate shall also include jointing with existing pipes where culverts have to be extended. Any concrete required for the jointing or for bedding, haunching and surround will be paid for separately under ITEM 22.07.

Should it be inevitable for a section to be cut off from a concrete pipe unit of standard length, the full standard length of the unit shall be measured for payment. No additional compensation for cutting and disposing of such section will be paid.

Upon payment, differentiation shall be made between the various types and sizes of culverts and between the culverts placed on A, B, C and D classes of bedding.

<u>ITEM</u>	<u>UNIT</u>
22.04 METAL CULVERTS:	
(a) SIZE, WALL THICKNESS AND TYPE INDICATED	METRE (m)
(b) CUTTING OFF BEVELLED AND/OR SKEW ENDS (SIZE AND TYPE INDICATED)	NUMBER (no.)
(c) ANCHOR BOLTS	NUMBER (no.)

The unit of measurement shall be the metre of culvert laid, the number of cuts made and the number of anchor bolts installed as shown on the Drawings or ordered by the Engineer.

In the case of a metal pipe, the culvert length shall be measured along the pipe centre line. In the case of a metal pipe arch, the culvert length shall be measured along the bottom of the pipe arch. In both cases, the length of bevelled and/or skew ends shall be included.

The bid rates shall include full compensation for providing, testing, loading, transporting and off-loading the culverts, for providing and placing fine-grained material where required for the installation of culverts, and for installing, laying and jointing the culverts as specified. Upon payment, a differentiation shall be made between the various types and sizes of culverts and also between culverts with differing wall thicknesses. The bid rate shall also include for jointing with existing pipes where culverts have to be extended. Any concrete required for the jointing will be paid for separately under ITEM 22.07.

Payment shall be made separately for the cutting of bevelled and/or skew ends, and the bid rate shall include full compensation for all work in connection with the cutting of ends.

The bid rate per anchor bolt shall include full compensation for procuring, providing and installing the bolts.

<u>ITEM</u>	<u>UNIT</u>
22.05 PORTAL AND RECTANGULAR CULVERTS:	
(a) COMPLETE WITH PREFABRICATED FLOOR SLABS (SIZE AND TYPE INDICATED)	METRE (m)
(b) WITHOUT PREFABRICATED FLOOR SLABS (SIZE AND TYPE INDICATED)	METRE (m)

The unit of measurement for prefabricated portal or rectangular culverts shall be the metre of culvert laid as shown on the Drawings or as directed by the Engineer.

The length shall be measured along the soffit of the culvert.

The bid rates shall include full compensation for supplying, testing, loading, transporting and off-loading all culverts, providing and placing the fine-grained material where required for installing the culverts, and installing, laying and jointing the culverts as specified, including cutting them on the site, and waste.

Payment will be made separately for floor slabs of cast in situ concrete.

Payment shall distinguish between the different sizes and types of culverts and between culverts installed with or without prefabricated floor slabs.

<u>ITEM</u>	<u>UNIT</u>
22.06 EXTRA OVER ITEMS 22.03 AND 22.04 FOR CONSTRUCTING INCLINED CULVERTS STEEPER THAN 1:4.	METRE (m)

The unit of measurement shall be the metre of culvert installed at a grade steeper than 1:4 as specified in CLAUSE 2216.

The bid rate shall include full compensation for additional or more difficult work of any nature in regard to laying, excavating and backfilling as may be required for installing the culverts at a grade steeper than 1:4.

<u>ITEM</u>	<u>UNIT</u>
22.07 CAST IN SITU CONCRETE AND FORM WORK:	
(a) IN CLASS A BEDDING, SCREEDS, HAUNCHES AND ENCASING FOR PIPES, INCLUDING FORMWORK, (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)
(b) IN FLOOR SLABS FOR PORTAL OR RECTANGULAR CULVERTS, INCLUDING FORMWORK AND CLASS U2 SURFACE FINISH (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)
(c) IN INLET AND OUTLET STRUCTURES, CATCH PITS, MANHOLES, THRUST AND ANCHOR BLOCKS, EXCLUDING FORMWORK BUT INCLUDING CLASS U2 SURFACE FINISH (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)
(d) FORMWORK OF CONCRETE UNDER SUB ITEM 22.07 (C) ABOVE (CLASS OF FINISH INDICATED)	SQUARE METRE (m ²)
(e) IN CONCRETE LININGS FOR THE INVERTS OF METAL CULVERTS, INCLUDING FORMWORK AND CLASS U2 SURFACE FINISH (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)

The unit of measurement for cast in situ concrete shall be the cubic metre of concrete in place. Quantities shall be calculated from the dimensions shown on the Drawings or as authorised. No deduction in volume measured for payment shall be made for the volume of any reinforcing steel, inserts and pipes or conduits under 150 mm in diameter embedded in the concrete.

Measurement of formwork shall be by the square metre as specified in SECTION 6200.

The bid rate for cast in situ concrete shall include full

compensation for procuring and furnishing all the materials, storing the materials, providing all plant, mixing, transporting, placing and compacting the concrete, forming the inserts, construction of joints, curing and protecting the concrete, repairing defective surfaces, and finishing the concrete surfaces as specified. Payment shall distinguish between the different classes of concrete.

No separate payment shall be made for any formwork required for concreting in SUB-ITEMS 22.07 (a), (b) and (e) and the Contractor's rates for concrete shall include full compensation for formwork.

Payment for formwork for concreting in SUB-ITEM 22.07 (c) shall be made under SUB-ITEM 22.07 (d) as specified in SECTION 6200.

No separate payment shall be made for the construction of joints in culvert floor slabs or at inlet and outlet structures, and the bid rates for concrete shall include full compensation for forming the joints complete in accordance with the details shown on the Drawings.

<u>ITEM</u>	<u>UNIT</u>
22.08 CONCRETE BACKFILL FOR CULVERT (CLASS INDICATED)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of concrete backfill. The quantity shall be calculated from the dimensions of the excavation as specified or as may be authorised by the Engineer, minus the volume taken up by the culverts, irrespective of whether the actual excavation to be backfilled exceeds the specified or authorised dimensions.

Payment shall be made as for concrete in ITEM 22.07 (a) above.

<u>ITEM</u>	<u>UNIT</u>
22.09 PREFABRICATED CONCRETE INLETS AND OUTLETS TO CULVERTS (SIZE AND TYPE INDICATED)	NUMBER (no.)

Prefabricated concrete inlets and outlets for concrete pipe culverts shall be measured per inlet or outlet, complete in position.

The bid rate shall include full compensation for procuring, providing, loading, transporting, off-loading and installing the inlets or outlets as specified.

<u>ITEM</u>	<u>UNIT</u>
22.10 STEEL REINFORCEMENT:	
(a) MILD STEEL BARS	TONNE (t)
(b) HIGH-TENSILE STEEL BARS	TONNE (t)
(c) WELDED STEEL FABRIC	KILOGRAMME (kg)

Measurement and payment for steel reinforcement shall be made as specified in SECTION 6300.

<u>ITEM</u>	<u>UNIT</u>
22.11 DOWELS FOR JOINING OLD AND NEW CONCRETE	KILOGRAMME (kg)

The unit of measurement shall be the kilogram of steel dowels installed.

The bid rate shall include full compensation for supplying all materials, all cutting, drilling and grouting, and any other operation or item necessary for the proper execution of the work.

<u>ITEM</u>	<u>UNIT</u>
22.12 REMOVING EXISTING CONCRETE:	
(a) PLAIN CONCRETE	CUBIC METRE (m ³)
(b) REINFORCED CONCRETE	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of existing concrete removed.

The bid rates shall include full compensation for all demolition and for loading, transporting and disposing of the products of demolition, including a free haul determined according to SUB-CLAUSE 1602 (c).

Payment shall distinguish between plain and reinforced concrete. For the purpose of this item, reinforced concrete shall be defined as concrete containing at least 0.2% of steel reinforcement measured by volume. Plain concrete shall, for the purpose of this item, be deemed to include stone masonry and brickwork.

The bid rates shall also include full compensation for cutting straight grooves of the specified depth at joint positions where shown on the Drawings.

<u>ITEM</u>	<u>UNIT</u>
22.13 REMOVING AND RE-LAYING EXISTING PIPES (SIZE AND TYPE OF BEDDING INDICATED)	METRE (m)

The unit of measurement shall be the metre of existing pipe removed and re-laid.

The bid rate shall include full compensation for lifting, loading, transporting, off-loading, and laying pipes according to the Specifications. No haulage will be paid.

Payment for any excavation and backfilling required for the removal and relaying of existing pipes shall be made separately under ITEMS 22.01 and 22.02.

Where existing pipes are used in diversions, they shall not be measured for payment under this item, and payment therefore shall be made only if provided in SECTION 1500 and included in the Bill of Quantities.

<u>ITEM</u>	<u>UNIT</u>
22.14 REMOVING AND STACKING EXISTING PREFABRICATED PIPES (ALL SIZES)	METRE (m)

The unit of measurement shall be the metre of existing prefabricated culverts removed and stacked.

The bid rate shall include full compensation for lifting, loading, transporting to stack, off-loading, and stacking the prefabricated culverts.

Payment for any excavation and backfilling required for removing, transporting and stacking the existing prefabricated culverts shall be made separately under ITEMS 22.01 and 22.02. No haulage will be paid.

<u>ITEM</u>	<u>UNIT</u>
22.15 TREATING SURFACES WITH EPOXY RESIN FOR JOINING NEW TO OLD CONCRETE (TYPE OF EPOXY RESIN SPECIFIED)	LITRE (l)

The unit of measurement shall be the litre of epoxy-resin compound used at the specified rate of application.

The bid rate shall include full compensation for providing

and applying the epoxy-resin compound.

<u>ITEM</u>	<u>UNIT</u>
22.16 PROTECTIVE MASTIC ASPHALT COATING FOR CORRUGATED METAL CULVERT UNITS (STATE WHETHER TO BE APPLIED BY BRUSH OR BY SPRAY GUN)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of protective coating applied as specified and as directed by the Engineer. When both inside and outside surfaces are treated, both surfaces shall be measured.

The bid rate shall include full compensation for procuring and furnishing the mastic asphalt, applying the material, and for all other additional work and incidentals required for providing the protective coating as specified.

<u>ITEM</u>	<u>UNIT</u>
22.17 MANHOLES, CATCH PITS, PRECAST INLET AND OUTLET STRUCTURES COMPLETE:	
(a) MANHOLES (TYPE AND STANDARD DEPTH INDICATED)	NUMBER (no.)
(b) CATCH PITS (TYPE AND STANDARD DEPTH INDICATED)	NUMBER (no.)
(c) PRECAST INLET AND OUTLET STRUCTURES (TYPE INDICATED)	NUMBER (no.)
(d) EXTRA OVER OR LESS THAN SUB-ITEM 22.17 (a) FOR VARIATIONS IN THE DEPTHS OF MANHOLES FROM THE STANDARD DEPTH DESIGNATED FOR BIDDING PURPOSES	METRE (m)
(e) EXTRA OVER OR LESS THAN SUB ITEM 22.17 (b) FOR VARIATIONS IN THE DEPTHS OF CATCH PITS FROM THE STANDARD DEPTH DESIGNATED FOR BIDDING PURPOSES	METRE (m)

The unit of measurement, in the case of SUB-ITEMS 22.17 (a), (b) and (c) above, shall be the complete unit as shown on the Drawings, including all concrete, brickwork, covers, frames, grids and other accessories.

The bid rates shall include full compensation for procuring, furnishing and installing, and laying where applicable, the complete units except for excavation and backfilling, which shall be measured separately. The bid rate shall also include full compensation for connecting up to and building any conduits into the walls of the various structures.

The unit of measurement in the case of SUB-ITEMS (d) and (e) above shall be the metre of increased or decreased depth of the manhole or catch pit measured in relation to the standard depth furnished for bidding purposes.

The bid rates per metre shall be an adjustment to the compensation for the standard item, payable either as an increased compensation to the Contractor in the case of an increased depth, or as a decrease in compensation in the case of a decreased depth in relation to the standard depth.

Where the above items of work cannot be conveniently standardised for payment according to complete units, the various types of work and items of material provided shall be measured separately in accordance with ITEMS 22.19 to 22.22 and such other items as may be necessary.

Concrete and formwork shall be measured and paid for under SUB-ITEMS 22.07 (c) and (d) respectively, excavation under ITEM 22.01 and backfilling under ITEM

22.02.

<u>ITEM</u>	<u>UNIT</u>
22.18 BRICKWORK:	
(a) 115 mm THICK	SQUARE METRE (m ²)
(b) 230 mm THICK	SQUARE METRE (m ²)
(c) 345 mm THICK	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of brickwork built, calculated from the leading dimensions of the brickwork. Areas in walls occupied by conduits, shall not be included in the areas measured, and corners and intersections common to more than one brick wall shall be measured only once.

The bid rates per square metre shall include full compensation for the brickwork complete as specified, including pointing and the building in of conduits.

<u>ITEM</u>	<u>UNIT</u>
22.19 PLASTER:	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of plaster work provided.

The bid rate shall include full compensation for raking out joints in the brickwork and applying a 1:4 plaster, as specified, to all surfaces where required.

<u>ITEM</u>	<u>UNIT</u>
22.20 BENCHING:	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of benching, measured in plan, constructed in Class 20/19 concrete with granolithic rendering.

The bid rate shall include full compensation for procuring and furnishing all materials, placing the concrete benching and rendering with the specified granolithic rendering.

<u>ITEM</u>	<u>UNIT</u>
22.21 ACCESSORIES:	
(a) MANHOLE COVERS INCLUDING FRAMES (DESCRIPTION)	NUMBER (no.)
(b) INLET GRIDS INCLUDING FRAMES (DESCRIPTION)	NUMBER (no.)
(c) STEP IRONS (DESCRIPTION)	NUMBER (no.)
(d) ETC. FOR OTHER ACCESSORIES	NUMBER (no.)

The unit of measurement shall be the number of each type of accessory delivered and installed.

The bid rates shall include full compensation for procuring, furnishing and installing the accessories.

<u>ITEM</u>	<u>UNIT</u>
22.22 ANCHORS FOR PIPES (DESCRIPTION)	NUMBER (no.)

The unit of measurement shall be the number of complete anchors installed, including straps, bolts, etc., but excluding any concrete work, which shall be measured under SUB-ITEMS 22.07 (c) and (d).

The bid rate shall include full compensation for procuring, providing and installing the anchors.

<u>ITEM</u>	<u>UNIT</u>
22.23 SERVICE DUCTS:	
(a) ORDINARY PIPES (TYPE AND DIAMETER INDICATED)	METRE (m)
(b) SPLIT PIPES (TYPE AND DIAMETER INDICATED)	METRE (m)

The unit of measurement shall be a metre of service duct laid.

The bid rates shall include full compensation for procuring, providing, and laying the pipes, including end stoppers, draw wires and complete installation, but shall exclude excavation, backfilling, and encasing with concrete, which shall be measured for payment under the appropriate items of payment of this Section.

<u>ITEM</u>	<u>UNIT</u>
22.24 DUCT MARKER BLOCKS (TYPE INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of marker blocks installed, and the bid rate shall include full compensation for manufacturing, delivering and installing the marker blocks, complete as shown on the Drawings.

<u>ITEM</u>	<u>UNIT</u>
22.25 HAND EXCAVATION TO DETERMINE THE POSITIONS OF EXISTING SERVICES	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material excavated within the lengths and widths authorised by the Engineer and the depth required to expose the service. Excavation in excess of the authorised dimensions shall not be measured for payment.

The bid rate shall include full compensation for all excavation, backfilling, compacting to 90% of BS-Heavy density, disposing of any surplus excavated material, keeping the excavations safe, dealing with any surface or subsurface water, taking special care to ensure that services are not damaged in any way and any other operation necessary for completing the work. The bid rate shall also include all haulage of material. Any damage to a service caused by the Contractor shall be repaired at their own costs, to the satisfaction of the Owner of the service and the Engineer.

No distinction will be made between the various types of services to be exposed or the depths to which excavations are taken.

<u>ITEM</u>	<u>UNIT</u>
22.26 REINSTATING TRENCHES CROSSING ROADS:	
(a) IMPROVED SUBGRADE LAYERS	SQUARE METRE (m ²)
(b) SUBBASE LAYERS	SQUARE METRE (m ²)
(c) BASE COURSE LAYERS	SQUARE METRE (m ²)
(d) BITUMINOUS SURFACING (INCLUDING TACK COAT)	SQUARE METRE (m ²)
(e) KERBING	METRE (m)

The unit of measurement for SUB-ITEMS 22.26 (a) to (d) shall be the square metre of the layer reinstated where instructed by the Engineer.

The unit of measurement for SUB-ITEM 22.26 (e) shall be the metre of kerbing replaced due to trench excavations

where instructed by the Engineer.

Any reinstatement required beyond the agreed or instructed dimensions owing to damage caused by the Contractor will not be measured for payment.

The appropriate Sections of the Specifications shall also be applicable to the reinstatement of the trenches.

The bid rates shall include full compensation for procuring, furnishing, placing, compacting and finishing all materials, providing all labour and constructional plant, cutting and preparing the edges of the existing surfacing, and protecting and maintaining the completed reinstatement as specified.

<u>ITEM</u>	<u>UNIT</u>
22.27 PREFABRICATED REINFORCED CONCRETE SKEW END UNITS FOR CONCRETE CULVERTS CONSTRUCTED AT A SKEW ANGLE (TYPE AND DIMENSIONS OF UNIT AND CLASS OF BEDDING INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of each type and size of prefabricated reinforced-concrete skew end unit provided and installed, irrespective of the angle of skew.

The bid rates shall include full compensation for providing, testing, loading and unloading the units, constructing the prescribed class of bedding, except Class A bedding, and for installing, laying and joining the units, complete as specified and in accordance with the details shown on the Drawings. Concrete in Class A bedding, haunching and surrounds shall be paid for under SUB-ITEM 22.07 (a).

SERIES 2000: DRAINAGE

SECTION 2300: CONCRETE KERBING, CONCRETE CHANNELLING, OPEN CONCRETE CHUTES, AND CONCRETE LININGS FOR OPEN DRAINS

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2301 SCOPE

This Section covers the construction of concrete kerbing and channelling, open concrete chutes, concrete linings for open drains and grouted stone pitching for drains at the locations and to the details as shown on the Drawings or as directed by the Engineer.

2302 MATERIALS

(a) Concrete

All concrete work shall be carried out in accordance with the requirements of SECTIONS 6200, 6300 AND 6400.

(b) Kerbing and channelling

Prefabricated kerbing and channelling shall comply with the requirements of BS EN 1339:2003 and BS EN 1340:2003 or equivalent. Cast in situ kerbing and channelling shall be class C30 or be of the class of concrete as indicated in drawings or specifications.

i) Cast In-Situ

Cast in situ concrete kerbs and channels kerbs shall comply with the minimum required performance class as specified in BS EN 1340:2003.

TABLE 2302/1: MINIMUM REQUIREMENTS FOR TEST SPECIMENS OF IN-SITU CONCRETE KERBS, CHANNELS AND EDGE DETAILS

Property	Minimum required performance/class when tested in accordance with BS EN 1340:2003
Bending strength	Class 2
Slip/skid resistance	Unpolished skid resistance value (USRV) of 45
Durability (bending strength)	Class 2
Weathering resistance	Class 3
Abrasion	Class 4

ii) Pre-Cast Kerb And Channel

Precast concrete kerbs and channels kerbs shall comply with the minimum required performance class as specified in BS EN 1340:2003.

TABLE 2302/2: MINIMUM REQUIREMENTS FOR PRECAST CONCRETE KERBS, CHANNELS, EDGINGS AND QUADRANTS

Property	Minimum Required Performance/Class when tested in accordance with BS EN 1340:2003
Bending Strength	Class 2
Slip/Skid Resistance	Unpolished Skid Resistance Value (USRV) of 45
Durability (Bending Strength)	Class 2
Weathering Resistance	Class 3
Abrasion	Class 4

(c) Joint Sealant

- Cold-applied joint sealant shall be a two-part polysulphide sealing compound conforming to the requirements of BS EN ISO 11600:2003+A1:2011.
- Polyurethane-based joint sealants shall comply with the requirements of SANS 1077:1984 or equivalent.
- Silicone-based joint sealants shall comply with the requirements of the Special Specifications.

(d) Bedding Material

The material on which concrete kerbs and channels are to be bedded shall consist of crushed stone, cinders, slag, sand or other approved porous material with a maximum particle size of 14 mm.

Concrete may also be prescribed as bedding material, in which case it shall comply with the requirements of SECTION 6400.

(e) Stone

Stones for pitching shall be sound, tough and durable, without any stones less than 200 mm in minimum dimension, except that smaller pieces or spalls may be used for filling spaces between the large stones. The shapes of the rocks or stones shall be so as to form a stable protective layer of the required thickness. Rounded boulders shall not be used on slopes steeper than 2:1 unless grouted.

The Aggregate Crushing Value (ACV) of the Stones shall be less than 30%. All stone intended for use on a particular pitching job shall be subjected to the prior approval of the Engineer.

2303 TYPES OF STRUCTURES

Kerbing shall include barrier kerbs, mountable and semi-mountable types. All these elements may be prefabricated units or constructed in a continuous operation using slipforms. Channelling may be cast in situ, prefabricated units or else of slipform construction. Chutes may be either prefabricated units or cast in situ, the concrete lining of open channels shall be cast in situ only, except that side slabs may be precast. Downpipes shall be prefabricated units.

2304 CONSTRUCTION

(a) Excavation, and Preparation of Bedding

i) Kerbs and Channels

Trenches for kerbs and channels shall be excavated to the required depth and all unsuitable

material shall be removed and replaced with a layer of approved bedding material at least 75 mm thick. The bedding shall be compacted and accurately shaped to the required grade. No concrete or precast concrete unit shall be placed on uncompacted or disturbed material.

ii) Concrete Linings

The excavation work for open drains shall be executed and paid for in accordance with the provisions of SECTION 2100.

The excavations shall then be neatly trimmed to the lines and levels specified so as to permit the accurate construction of the concrete linings. All loose material shall be compacted to a density of not less than 90% of BS-Heavy density.

Where the in-situ material is unsuitable, the Engineer may order that it be removed to the required depth and replaced with selected material compacted to a density of 90% of BS-Heavy density.

Where excavations for open drains are in rock, over-break shall be backfilled as ordered, either with mass concrete or with selected natural gravel or soil compacted to a BS-Heavy density of at least 90%.

iii) Chutes

Excavations for chutes shall be neatly trimmed. All loose material shall be thoroughly compacted, and where over-break occurs in rock material, the excavations shall be backfilled with mass concrete. If required by the Engineer, the excavations shall be taken deeper to accommodate a concrete screed cast to act as a working platform for the construction of the chutes.

(b) Prefabricated Concrete Kerbing and Channelling

Prefabricated concrete kerbing and channelling shall be laid on the approved bedding with close joints filled with cement mortar of class M 20 as specified in BS EN 998-2 not exceeding 10 mm in thickness and neatly pointed with a pointing trowel. The exposed faces of kerbs and edging shall be constructed true to line and elevation. Kerbing around curves shall first be laid along the full curve length before the joints are filled, unless otherwise allowed by the Engineer. Kerbs shall be temporarily propped during construction.

Unless otherwise instructed by the Engineer, prefabricated concrete kerb units shall be 1.0 m in length, except at curves at road junctions, where they shall be 0.3 m in length.

Prefabricated concrete kerbs shall be laid with a Class C25 cast in situ concrete support behind the kerbs in accordance with the details shown on the Drawings.

(c) Prefabricated Concrete Chutes on Side Slopes of Fills and Cuts

Prefabricated concrete chutes shall be manufactured in accordance with the dimensions shown on the Drawings, and the units shall fit neatly into each other as shown. The bottom unit shall rest against the outlet structure or footing as shown on the Drawings.

The units shall be laid true to line and grade from the bottom up so that each unit fits neatly into the previous one.

A transition section shall be constructed at the inlet to lead the water into the chute as shown on the Drawings.

(d) Slip-Form Kerbing

Slip-form kerbs and channels shall be placed on an approved bedding by a continuous process with an approved machine. Contraction joints shall be sawn at intervals shown on the Drawings or prescribed by the Engineer in a manner so as not to cause the concrete to spall at the joint. The concrete shall be cured in accordance with the requirements of CLAUSE 6409.

The kerbs and channels shall be constructed true to line and elevation and shall have a neat appearance. Where transverse cracks occur, the Contractor shall replace the entire section between the contraction joints at their own cost.

(e) Cast-In Situ Kerbs and Channels

Forms for kerbs and channels shall be accurately set to line and elevation and shall be firmly held in position during the placing of the concrete. Stops and jointing material at the ends of sections shall be accurately placed so as to ensure that joints between adjacent sections are truly perpendicular to the surface of the concrete and at right angles to the edge of the road.

After concrete has been placed in the forms, it shall be tamped and worked until the mortar entirely covers any exposed faces. Exposed faces shall then be finished to smooth and even surfaces and edges shall be rounded to the radii shown on the Drawings.

Forms shall be removed from any concrete surface that will be exposed, within a period of 24 hours of the concrete having been placed. Minor defects shall be repaired with a cement mortar mixture of class M 20 as specified in BS EN 998-2. Plastering shall not be permitted on exposed faces and all rejected portions shall be removed and replaced at the Contractor's expense. When completed, the sections shall be cured in accordance with the requirements specified in CLAUSE 6409.

The completed kerbs and channels shall be true to line and elevation and shall have an even and neat appearance.

(f) Cast In-Situ Chutes on Cut Slopes

Cast in-situ concrete chutes on cut slopes, together with the inlet and outlet structures, shall be constructed in accordance with the Drawings. The class of concrete shall be as indicated on the Drawings.

Where required by the Engineer, a concrete screed shall first be cast on excavations that cannot be trimmed accurately. The screed shall be accurately finished to the level of the underside of the chute floor slab and allowed to set before the floor slab is cast. Where the material being excavated cannot be accurately trimmed or where the chute sides have to extend above the surface of cut slopes, the outer faces of the sides shall be cast against formwork.

(g) Concrete-Lined Open Drains

The exposed surfaces of the concrete linings of open drains shall be given a Class U2 surface finish as defined in CLAUSE 6209. Concrete shall be cured in accordance with the requirements of CLAUSE 6409.

Sealed joints in concrete shall be in accordance with the details indicated on the Drawings and the provisions of SECTION 6600. Cold joints shall be painted with a coat of approved bituminous emulsion containing 60% of pure bitumen by mass, or with an approved anti-adhesive before any adjoining slabs are cast.

Expansion joints shall be made in accordance with the Drawings.

Where required, the surfaces on which concrete lining is to be cast shall, after having been trimmed, be covered with polyethylene sheeting of 0.15 mm thick and all joints in the sheeting shall be overlapped by at least 150 mm.

Concrete-lined open drains should be prepared by excavating, shaping and thoroughly compacting using appropriate equipment as determined by the Engineer.

(h) Backfilling

After completing the concrete work, the spaces at the backs of kerbs shall be backfilled with approved material to pavement or road shoulder level. Spaces adjoining chutes shall be backfilled level with the side slope. Such backfill shall be placed in layers not exceeding 150 mm, or less as required, and each layer shall be compacted to 90% of BS-Heavy density at or around optimum moisture content before the succeeding layer is placed thereon.

Where kerbs and channels are laid after construction of the base, the spaces between the concrete and adjoining base shall be backfilled with premixed bituminous material.

(i) Construction Sequence

i) Where Kerbs and Channelling are Constructed Before the Base Course:

In this case, slip-form units or cast in situ units may be constructed. During working and construction of the base, precautionary measures shall be taken to prevent the concrete work from being damaged or shifted.

ii) Where Kerbs and Channelling are Constructed After the Base Course:

The base shall be constructed wider than the specified width, after which a neat trench shall be dug for the kerbing or channelling. Any over-excavation shall be filled with concrete cast simultaneously with the kerbs and channelling.

iii) Where Kerbs and Channelling are Constructed After the Asphalt Surfacing:

The asphalt surfacing shall be constructed wider than the specified width and shall be cut back accurately with a mechanical saw to a marked line to give a neat joint line between the kerbs or channelling and the asphalt layer. The base shall then be removed to the required depth.

Any concrete spilt onto the asphalt surface shall be removed. Where so required by the Engineer, the Contractor shall, without any additional compensation paint emulsion over the stained surface.

(j) Protection

During transportation and laying, care shall be taken to protect all precast units against chipping or breakage.

Concrete kerbing and channelling as well as any other structures adjacent to the road shall be protected against staining by bitumen being sprayed or premix being placed. Where bitumen is to be sprayed, all such work shall be completely covered with polyethylene sheeting at least 0.25 mm thick, specially reinforced paper or other approved material, properly secured to prevent the sheeting from lifting during windy conditions. Any work stained by bitumen shall be broken down and replaced, unless all such bitumen is completely removed so as not to show any stains. Painting over stained concrete is strictly prohibited.

(k) Cutting Existing Bituminous Surfacing and

Pavement Layers

Where the Engineer instructs kerbing, channelling or concrete-lined drains to be constructed against existing bituminous surfacing, the full depth of the bituminous surfacing, and the base and subbase, if necessary, shall be accurately cut with a mechanical saw to the required line before the kerbing, channelling or concrete-lined drain is constructed. The edge shall be vertical for kerbing and channelling. The concrete shall then be placed directly against the cut edge without formwork. All material outside the cut edge shall be removed to the required depth before the concrete is placed. The debris shall be disposed of at a dumping site to be provided by the Contractor subject to the approval of the Engineer. The bituminous surfacing shall be protected and kept clean to the Engineer's satisfaction.

2305 INLET AND OUTLET STRUCTURES AND TRANSITION SECTIONS

Transition sections on kerbing, kerbing-channelling combinations and concrete-lined open drains shall be constructed to the same standards and by the same methods as described for the uniform sections, but with the required modifications. Sections may be either precast or cast in situ units.

Inlet and outlet structures may be either precast or partially precast concrete units or of cast in situ concrete.

Where shown on the Drawings or instructed by the Engineer, the Contractor shall supply and install in the outlet structures energy dissipaters consisting of prefabricated reinforced concrete blocks of Class 20/20 concrete of the dimensions shown on the Drawings or listed in the Bill of Quantities. All concrete work shall comply with the requirements of SERIES 6400.

Components such as grids, covers and frames shall be in accordance with the details shown on the Drawings and the requirements of SUB-CLAUSE 2212 (e).

2306 CONSTRUCTION TOLERANCES AND SURFACE FINISH

(a) Concrete Kerbing and Channelling

Concrete kerbing and channelling shall be constructed to within the following dimensional and alignment tolerances:

i) Horizontal Alignment

The maximum deviation of edges, centre line, or vertical surfaces from the specified position shall be 25 mm.

Further to the above, the maximum deviation of edges, centreline or vertical surfaces from the specified alignment, shall be 1:500 when taken over any section exceeding 10 m in length.

ii) Vertical Alignment and Level

The inside edge of channelling shall nowhere be above the finished road nor more than 10 mm below the finished road level. The invert level of channels and open drains and the top of kerbing shall nowhere deviate by more than 10 mm from the required level and nowhere shall channels or drains have adverse grade.

iii) Trueness of Exposed Surfaces

When tested with a 3 m straight-edge, no surface irregularities shall exceed 6 mm.

iv) Cross-Sectional Dimensions

All cross-sectional dimensions shall be within 6 mm of the specified dimensions except that the

underside of channelling may extend up to 25 mm below the level at which it would have the required thickness.

(b) Concrete-Lined Open Drains and Concrete Chutes

Concrete-lined open drains and concrete chutes shall be constructed to within the following tolerances:

i) Horizontal Alignment

The maximum deviation from the true position of the edges or centre line shall be 25 mm.

ii) Vertical Alignment

The invert level of concrete-lined open channels shall nowhere deviate by more than 25 mm from the required level and nowhere shall the open drain inverts have an adverse grade.

iii) Trueness of Exposed Surface

When tested with a 3 m straight edge, no exposed surface shall show surface irregularities exceeding 10 mm.

iv) Cross-Sectional Dimensions

All cross-sectional dimensions shall be within 10 mm of the specified dimensions and the average thickness of a floor or side slab shall not be less than the specified thickness when considering any complete slab or slab sections with a surface area of 10 m² or more and disregarding a thickness exceeding 10 mm of the specified thickness.

(c) Surface Finish

All unformed exposed concrete surfaces shall have a Class U2 surface finish, and all formed exposed concrete surfaces shall have a Class F2 surface finish as defined in CLAUSE 6207.

(d) Grouted Stone Pitching in Lined Open Drains

Grouted Stone Pitching in lined open drains shall be constructed within the following tolerances:

i) Horizontal Alignment

The maximum deviation from the true position of the edges or centre line shall be 25 mm.

ii) Vertical Alignment

The invert level of concrete lined open channels shall nowhere deviate by more than 25 mm from the required level and nowhere shall the open drain inverts have an adverse grade.

iii) Trueness of Exposed Surface

When tested with a 3 m straight edge, no exposed surface shall show surface irregularities exceeding 20 mm.

iv) Cross-Sectional Dimensions

All cross-sectional dimensions shall be within 10 mm of the specified dimensions and the average thickness of a floor or side slab shall not be less than the specified thickness when considering any complete slab or slab sections with a surface area of 10 m² or more and disregarding a thickness exceeding 10 mm of the specified thickness.

2307 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
23.01 CONCRETE KERBING (CLASS OF CONCRETE AS INDICATED ON DRAWINGS, STATE WHETHER PREFABRICATED OR CAST IN SITU AND CLASS OF CONCRETE):	
(a) (DESCRIPTION OF TYPE WITH REFERENCE OF DRAWING)	METRE (m)
(b) ETC. FOR OTHER TYPES	METRE (m)

<u>ITEM</u>	<u>UNIT</u>
23.02 CONCRETE KERBING – CHANNELLING COMBINATION (CLASS OF CONCRETE AS INDICATED ON DRAWINGS):	
(a) (DESCRIPTION OF TYPE WITH REFERENCE OF DRAWING)	METRE (m)
(b) ETC. FOR OTHER TYPES	METRE (m)

The unit of measurement shall be the metre of concrete kerbing, or a combination kerbing and channelling, complete as constructed, measured along the front face of the kerb.

The bid rate for each metre of concrete kerbing and/or kerbing channelling combination shall include full compensation for the necessary excavation and preparation of bedding, backfilling, formwork, finishing and for procuring, furnishing and installing all materials, kerbing and channelling and protecting it against staining, supporting the kerbs with in-situ cast concrete and filling and painting all joints, all complete as specified.

<u>ITEM</u>	<u>UNIT</u>
23.03 CONCRETE CHUTES (TYPICAL DESIGNS):	
(a) (DESCRIPTIONS OF TYPE WITH REFERENCE TO DRAWING. STATE WHETHER PREFABRICATED OR CAST IN SITU AND CLASS OF CONCRETE	METRE (m)
(b) ETC FOR OTHER TYPES	METRE (m)

The unit of measurement shall be the metre of completed chute as constructed, including any overlap measured along the slope as laid but excluding transition sections and inlet and outlet structures measured separately.

The bid rate per metre shall include full compensation for procuring, furnishing and installing the completed chutes as specified and all excavation and the preparation of bedding, backfilling, formwork and finishing required.

<u>ITEM</u>	<u>UNIT</u>
23.04 CAST IN SITU CONCRETE CHUTES (MEASURED BY COMPONENTS):	
(a) CONCRETE (CLASS INDICATED)	CUBIC METRE (m ³)
(b) FORMWORK (SURFACE FINISH INDICATED)	SQUARE METRE (m ²)

Measurement and payment for formwork and concrete shall be as specified in SECTIONS 6200 and 6400 except that payment for excavation and gravel or soil backfilling shall be deemed to be included in the rates bid for concrete and shall not be measured and paid for separately.

<u>ITEM</u>	<u>UNIT</u>
23.05 INLET, OUTLET, TRANSITION AND SIMILAR STRUCTURES (TYPICAL DESIGNS):	
(a) (DESCRIPTION OF STRUCTURE, TYPE, ETC, WITH REFERENCE TO DRAWING AND CLASS OF CONCRETE)	NUMBER (no.)
(b) ETC. FOR OTHER TYPES	NUMBER (no.)

The unit of measurement and payment shall be the number of completed units of each type of structure constructed, and payment shall include full compensation for all formwork, concrete, excavation, trimming and backfilling, including such accessories as grids, etc as may be specified on the Drawings.

<u>ITEM</u>	<u>UNIT</u>
23.06 INLET, OUTLET, TRANSITION AND SIMILAR STRUCTURES (MEASURED BY COMPONENTS):	
(a) CONCRETE (CLASS INDICATED)	CUBIC METRE (m ³)
(b) FORMWORK (SURFACE FINISH INDICATED)	SQUARE METRE (m ²)
(c) OTHER COMPONENTS	NUMBER (no.)

The measurement and payment for formwork and concrete shall be as specified in SECTIONS 6200 and 6400, except that excavation, trimming and backfilling shall not be measured and paid for separately, the cost of which shall be deemed to be included in the rates bid for concrete.

The unit of measurement for other components such as grids shall be the number of each type of component installed. The bid rates shall include full compensation for procuring, furnishing and installing the components, including any painting or protective coating required in the Special Specifications or as shown on the Drawings.

<u>ITEM</u>	<u>UNIT</u>
23.07 TRIMMING OF EXCAVATIONS FOR CONCRETE- LINED OPEN DRAINS:	
(a) IN SOFT MATERIAL AS DEFINED IN CLAUSE 3603	SQUARE METRE (m ²)
(b) IN ROCK AS DEFINED IN CLAUSE 3603	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of excavation trimmed to receive concrete lining.

The bid rates shall include full compensation for all labour, constructional plant, material and other additional work and incidentals necessary for trimming the excavations for open drains to the standard of finish required for the construction of concrete linings. All excavation, including the removal of unsuitable ground and backfilling with suitable material, shall be measured and paid for under SECTION 2100. Payment shall distinguish between trimming in soft material and trimming in rock material as defined in CLAUSE 3603. No extra payment shall be made in respect of any soil or gravel backfilling, additional concrete or mass-concrete backfilling required on account of overbreak or unavoidable unevenness of the excavations in difficult ground, the cost of which shall be deemed to be included in the bid rates for trimming in rock material.

<u>ITEM</u>	<u>UNIT</u>
23.08 CONCRETE LINING FOR OPEN DRAINS:	
(a) CAST IN SITU CONCRETE LINING (CLASS OF CONCRETE AND TYPE OF OPEN DRAIN INDICATED)	CUBIC METRE (m ³)
(b) CLASS U2 SURFACE FINISH TO CAST IN SITU CONCRETE (TYPE OF OPEN DRAIN INDICATED)	SQUARE METRE (m ²)

Measurement of and payment for concrete shall be as specified in SECTION 6400, but the bid rate shall include full compensation for making arrangements for finishing, procuring, installing all materials and painting open joint surface as specified.

The unit of measurement for surface shall be the square metre of finished surface.

The bid rate for surface finish shall include full compensation for all labour, constructional plant, material and other additional works as and when required and incidentals required for trimming the concrete lining specified.

<u>ITEM</u>	<u>UNIT</u>
23.09 FORMWORK TO CAST IN SITU CONCRETE LINING FOR OPEN DRAINS (CLASS F2 SURFACE FINISH):	
(a) TO SIDES WITH FORMWORK ON THE INTERNAL FACE ONLY	SQUARE METRE (m ²)
(b) TO SIDES WITH FORMWORK ON BOTH INTERNAL AND EXTERNAL FACES (EACH FACE MEASURED)	SQUARE METRE (m ²)
(c) TO ENDS OF SLABS	SQUARE METRE (m ²)

Measurement of and payment for formwork shall be as specified in SECTION 6200. Formwork under SUB-ITEM 23.09(a) shall be measured and paid for only when the side slope of the slabs exceeds 1:2 and the slabs cannot be constructed without formwork even when a stiff concrete mix is used. When the Contractor elects to use precast side slabs, payment will be made for formwork as if cast in situ concrete had been used.

<u>ITEM</u>	<u>UNIT</u>
23.10 SEALED JOINTS IN CONCRETE LININGS OF OPEN DRAINS (DESCRIPTION OF TYPE WITH REFERENCES TO DRAWING)	METRE (m)

The unit of measurement shall be the metre of completed joint of each size and type.

The bid rate shall include full compensation for the supply of all materials and for all labour, formwork and incidentals necessary for sealing the joint as shown on the Drawings or set out in the Special Specifications.

<u>ITEM</u>	<u>UNIT</u>
23.11 CONCRETE SCREED OR BACKFILL BELOW CHUTES (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of concrete screed or backfill as may be instructed by the Engineer to be placed below chutes.

The bid rate shall include full compensation for furnishing, procuring and placing the concrete in screed or backfill.

<u>ITEM</u>	<u>UNIT</u>
23.12 STEEL REINFORCEMENT:	
(a) MILD STEEL BARS	TONNE (t)
(b) HIGH TENSILE STEEL BARS	TONNE (t)
(c) WELDED STEEL FABRIC	TONNE (t)

Measurement and payment shall be in accordance with the provisions of SECTION 6300.

<u>ITEM</u>	<u>UNIT</u>
23.13 POLYETHYLENE SHEETING (0.15 mm THICK) FOR CONCRETE- LINED OPEN DRAINS	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of area covered with polyethylene sheeting.

The bid rate shall include full compensation for procuring, furnishing and installing the polyethylene sheeting, including wastage and overlap.

<u>ITEM</u>	<u>UNIT</u>
23.14 CUTTING BITUMINOUS PAVEMENT LAYERS FOR CONCRETE KERBING, CHANNELLING OR CONCRETE-LINED DRAINS	METRE (m)

The unit of measurement shall be the metre of bituminous surfacing and pavement layers cut where instructed by the Engineer, irrespective of the depth cut. The various layers shall not be measured separately for payment.

The bid rate shall include full compensation for all labour, constructional plant and materials required for cutting the surfacing and pavement layers to the required depth, removing and disposing of the debris and protecting and keeping the surfacing clean, all as specified.

<u>ITEM</u>	<u>UNIT</u>
23.15 PRECAST CONCRETE BLOCKS IN OUTLET STRUCTURES	NUMBER (no.)

The unit of measurement shall be the number of precast concrete blocks provided and installed as shown on the Drawings or directed by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
23.16 SIDE DRAIN CROSSINGS (SPECIFY GRADE AND DIMENSIONS OF THE SLAB)	
(a) PEDESTRIAN CROSSING	NUMBER (no.)
(b) VEHICULAR CROSSING	NUMBER (no.)

The unit of measurement shall be the number of pedestrian/ Vehicular crossings constructed in accordance with the Drawings.

The bid rate shall include full compensation for furnishing all materials (specified grade of concrete, Steel Reinforcement/ Mesh etc.) and labour including excavation, trimming, backfilling, and removing any surplus excavated material.

<u>ITEM</u>	<u>UNIT</u>
23.17 REINFORCED CONCRETE COVERED DRAIN:	
(a) CAST IN SITU REINFORCED CONCRETE DRAINS (CLASS OF CONCRETE AS INDICATED) INCLUDING FORM WORK AND U2 SURFACE FINISH	CUBIC METRE (m ³)

<u>ITEM</u>	<u>UNIT</u>
(b) CAST IN SITU REINFORCED CONCRETE DRAIN COVERS (CLASS OF CONCRETE AS INDICATED) INCLUDING U2 SURFACE FINISH	CUBIC METRE (m ³)

The measurement and payment for formwork and concrete shall be as specified in SECTIONS 6200 and 6400, however reinforcement shall be paid under Pay ITEM 23.12. Except that excavation, trimming and backfilling shall not be measured and paid for separately, the cost of which shall be deemed to be included in the rates bid for concrete. The bid rates shall include full compensation for procuring, furnishing and installing the components such as grids, including any painting or protective coating required in the Special Specifications or as shown on the Drawings.

<u>ITEM</u>	<u>UNIT</u>
23.18 PRECAST REINFORCED CONCRETE EROSION CHECK DAM	
(a) REINFORCED CONCRETE EROSION CHECK DAM (CLASS OF CONCRETE AS INDICATED) INCLUDING U2 SURFACE FINISH	CUBIC METRE (m ³)

The measurement for formwork and concrete shall be as specified in SECTIONS 6200 AND 6400, however reinforcement shall be paid under PAY ITEM 23.12. Except that excavation, trimming and backfilling shall not be measured and paid for separately, the cost of which shall be deemed to be included in the rates bid for concrete. The bid rates shall include full compensation for procuring, furnishing and installing the components including any painting or protective coating required in the Special Specifications or as shown on the Drawings.

SERIES 2000: DRAINAGE

SECTION 2400: ASPHALT AND CONCRETE BERMS

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2401 SCOPE

This Section covers the construction of asphalt or concrete berms at the outer edge of paved shoulders. Berms shall be cast in situ in moulds or by means of a suitable machine to the dimensions shown on the Drawings or as directed by the Engineer.

2402 MATERIALS

(a) Bituminous Binder

Bituminous binder shall be penetration-grade bitumen or mix-grade bituminous emulsion as may be prescribed by the Engineer. Spray-grade emulsion may be used as a primer and tack coat.

The various bituminous materials shall comply with the following specifications:

- Penetration-grade bitumen: US EAS 982-1
EN 12591:2009
- Bituminous emulsions: AASHTO M 140-20
M 208-18
US EAS 982-3:2020
US EA 982-4:2020
BS 434-1:2011+A1:2016

(b) Asphalt

Asphalt containing penetration-grade bitumen shall comply with the requirements of SECTION 4200. The aggregate grading shall lie between the limits indicated in TABLE 4202/13 for a fine continuously graded mix.

The material of asphalt which contains mix-grade bitumen emulsion shall comply with the requirements of the Special Specification.

The grading of the aggregate shall be subject to the prior approval of the Engineer.

(c) Concrete

All concrete work shall be carried out in accordance with the details shown on the Drawings and the requirements of SECTION 6400.

2403 COMPOUNDING, MIXING AND TRANSPORTING ASPHALT MIXES

(a) Compounding the Mixtures

Asphalt containing penetration grade bitumen shall contain by mass of the dry aggregate, 7% by total weight of 50/70 or 70/100 penetration grade bitumen or as specified, and 1% of active filler.

Asphalt containing mix-grade bitumen emulsion shall

contain by mass of the dry aggregate, 7% of net bitumen. The asphalt mix shall be in accordance with the requirements of the Special Specifications.

The composition of the asphalt mix shall in all cases be subject to the prior approval of the Engineer.

(b) Contractor's Mixing Plant

The Contractor's mixing plant shall be in accordance with the requirements of CLAUSE 4205.

(c) Mixing, Transporting And Placing

Asphalt with penetration-grade bitumen shall be mixed, transported and placed in accordance with the requirements of SECTION 4200, and asphalt with mix-grade bitumen emulsion in accordance with the requirements of the Special Specification.

2404 PREPARING THE BERM FOUNDATION

If shown on the Drawings, the prime coat sprayed onto the base and shoulders shall extend over a wider area to allow space for the berms to be placed.

Where the Engineer so instruct that berms shall be constructed, the specified width of the base projecting beyond the sides of the paved shoulders shall be thoroughly cleaned. The shoulder material adjacent to the base shall be compacted and trimmed to the upper level of the base and all loose material removed.

A prime coat consisting of bitumen-emulsion shall be applied at a rate of 0.40 l/m² onto that part of the berm foundation falling outside the paved surface of the road. In the case of asphalt berms, a tack shall be applied at a rate as specified in the drawings or to the limits as specified in SUB-CLAUSE 4206 (c) (iv) over the entire berm foundation. The tack coat shall be left to break before the berm is placed.

2405 PLACING

When the berms are placed, proper care shall be taken at all times to ensure that the toe of the berm does not encroach on the side of the carriageway or shoulder by more than 25 mm.

(a) Placing by Hand

The mixture shall be placed and shaped in situ in a rigid portable mould to form a trapezoidal kerb of the dimensions indicated on the Drawings.

In the case of asphalt berms, the mixture shall be thoroughly compacted to form a hard unyielding berm, true to level shape and line with the specified tolerances. The moulds may be removed as soon as the material has cooled to air temperature, or in the case of a cold asphalt mix as soon as it has hardened.

(b) Placing by Machine

A machine of approved design may be used for placing the berm. In general, machine-placed work will not require any additional compaction. In areas where, in the opinion of the Engineer, the compaction is inadequate, the machine shall be weighted with additional mass, or other measures shall be taken to ensure that adequate compaction is obtained.

(c) Placing Under Guardrails

Should the berm be placed first, the holes for the guardrail posts shall be excavated with care to prevent damage being done to the berm. Where chutes are required against fills, the berm shall be discontinued for the width of the top of the chute and finished to form a proper inlet for the water into the chute, as indicated on

the Drawings.

(d) General Requirements

The berms shall be placed true to level, shape and line. All berms deviating more than 10 mm from the specified line when measured at the inner edge of either their crests or their bases, or of which the height or width, measured at the crest, varies by more than 5 mm from the specified height or width, will be rejected and shall be removed and replaced at the Contractor's own expenses.

The surface of concrete berms placed by machine, and all unformed surfaces, shall be given a Class U2 finish, and formed surfaces a Class F2 finish. Joints shall be provided at 3 m intervals in all concrete berms either by casting in alternate sections or by cutting machined-placed sections. All such joints shall be neatly formed and finished so as not to leave any irregularities or loose concrete at the joints.

2406 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
24.01 ASPHALT BERMS:	
(a) PLACED WHERE THERE ARE NO GUARDRAILS (TYPES OF ASPHALT AND BINDER INDICATED)	METRE (m)
(b) PLACED AT EXISTING GUARDRAILS (TYPES OF ASPHALT AND BINDER INDICATED)	METRE (m)

The unit of measurement shall be the metre of asphalt berm placed as specified.

The bid rates shall include full compensation for procuring, furnishing, mixing and placing the material and all other work necessary for completing the asphalt berms as specified.

The prime and tack coats shall be paid for under ITEM 24.03.

<u>ITEM</u>	<u>UNIT</u>
24.02 CONCRETE BERMS:	
(a) PLACED WHERE THERE ARE NO GUARDRAILS (CLASS OF CONCRETE INDICATED)	METRE (m)
(b) PLACED AT EXISTING GUARDRAILS (CLASS OF CONCRETE INDICATED)	METRE (m)

The unit of measurement shall be the metre of concrete berm placed as specified.

The bid rates shall include full compensation for procuring, furnishing, mixing and placing the material and all other work necessary for completing the concrete berms as specified. The prime coat shall be paid for under ITEM 24.03.

<u>ITEM</u>	<u>UNIT</u>
24.03 PRIME AND TACK COATS:	
(a) PRIME COAT:	
(i) UNDER ASPHALT BERMS (SPECIFY TYPE OF BINDER/ EMULSION AND BINDER CONTENT)	SQUARE METRE (m ²)
(ii) UNDER CONCRETE BERMS (SPECIFY TYPE OF BINDER/ EMULSION AND BINDER CONTENT)	SQUARE METRE (m ²)
(b) TACK COAT (SPECIFY TYPE OF BINDER/ EMULSION AND BINDER CONTENT)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of completed prime coat or tack coat applied in accordance with the Specifications.

The bid rates shall include full compensation for procuring and providing all material and for mixing and applying the adhesive and primer complete as specified, including cleaning, compacting and trimming the coat being primed.

Payment shall be made under this item for the coat if, as instructed by the Engineer, it is applied in a separate strip independently from the prime coat of the road or shoulder surface.

If applied as an integral part of the prime coat of the road or shoulder surface by the prime coat being sprayed over a wider area to provide space for the berms, payment for the prime coat will not be made under this item.

<u>ITEM</u>	<u>UNIT</u>
24.04 TRANSITION SECTIONS FOR NEW JERSEY TYPE OF RAILS	NUMBER (no)

The unit of measurement shall be the number of completed asphalt transition sections constructed to the details shown on the Drawings.

The bid rate shall include full compensation for procuring, providing, mixing and placing all material and for all labour, formwork and incidentals required for constructing complete transition sections as specified.

SERIES 2000: DRAINAGE

SECTION 2500: PITCHING, STONEMASONRY AND PROTECTION AGAINST EROSION

CONTENTS:

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2501 SCOPE

This Section covers the furnishing of materials and the construction of a protective covering in stone pitching, cast in situ concrete pitching, bricks or prefabricated concrete blocks on exposed surfaces such as earth slopes, as well as heavier protective layers in the form of riprap and the construction of stone masonry for walls, all as shown on the Drawings or ordered by the Engineer.

The construction of check dams in the roadside ditches will be required on steep grades where the in-situ material is very erodible. Therefore, at locations designated by the Engineer, the Contractor will build masonry check dams in the roadside ditches as instructed by the Engineer.

2502 MATERIALS

(a) Stone

i) Pitching

Stone for pitching shall be sound, tough and durable, without any stones less than 200 mm in minimum dimension, except that smaller pieces or spalls may be used for filling spaces between the large stones. The shapes of the rocks or stones shall be so as to form a stable protective layer of the required thickness. Rounded boulders shall not be used on slopes steeper than 2:1 unless grouted.

The Aggregate Crushing Value (ACV) of the Stones shall be less than 30%. All stone intended for use on a particular pitching job shall be subjected to the prior approval of the Engineer.

ii) Riprap

Stone for riprap shall be hard field or quarry stone not susceptible to disintegration or excessive weathering on exposure to the atmosphere or water. It shall be free from soft material such as sand, clay, shale or organic material and shall not contain an excessive quantity of elongated stones.

The required size of the stone will depend on the "critical mass" specified. At least 50% by mass of the material comprising the riprap shall consist of stones with a mass heavier than the critical mass, and not more than 10% by mass of the material shall consist of stones with a mass of less than 10% of the critical mass or more than 5 times the critical mass.

(b) Cement

Cement shall be common cements that comply with the

requirements of US EAS 18-1:2017, BS EN 197-1:2011 or equivalent standard on approval of the Engineer.

(c) Sand

i) Sand for Concrete

Sand for concrete, cement slurry and cement mortar shall comply with the requirements of AASHTO M6 or equivalent.

ii) Sand Bedding

Sand for bedding used for paving blocks shall not contain any deleterious impurities and shall comply with the grading requirements in TABLE 2502/1.

TABLE 2502/1: GRADING REQUIREMENTS FOR BEDDING SAND

Sieve size (mm)	% Passing
10	100
5	95-100
2.36	80-100
1.18	50-85
0.600	25-60
0.300	10-30
0.150	5-15
0.075	0-10

iii) Sand for Joints

Sand used for being brushed into the joints between pavement blocks shall all pass through a 1.18 mm sieve, and between 10 and 15% of it shall pass through a 0.075 mm sieve.

(d) Paving Blocks

Paving blocks shall comply with the requirements of US 65:2002, , BS EN 1338:2003 or equivalent for Class 25 paving blocks where paving blocks are made from concrete, and bricks used as paving blocks shall be facebrick units which shall comply with the requirements of BS EN 772-3:1998, BS EN 772-7:1998, SANS 227:2007 or equivalent. Engineering units may also be used instead of facebrick units.

The surface texture and colour of all units shall be uniform.

Paving blocks for sidewalks shall be square prefabricated concrete blocks, 450 mm x 450 mm x 50 mm in size or the shapes, dimensions and colours of precast concrete paving blocks shall be as provided in the drawings or Special Specifications and fabricated from Class 30 concrete. As to appearance, the blocks shall comply with the requirements of US 65:2002, BS EN 1338:2003 or equivalent. The upper surface shall have an approved pattern to provide proper skid resistance.

Precast concrete paving blocks shall be chamfered and conform to BS EN 1338:2003, meeting the required performance class in TABLE 2502/1.

TABLE 2502/1: REQUIRED FOR CONCRETE BLOCK PAVING

Property	Minimum required performance/class when tested in accordance with BS EN 1338:2003
Tensile splitting strength	The characteristic tensile splitting strength T shall not be less than 3.6 MPa. None of the individual results shall be less than 2.9 MPa, nor have a failure load less than 250 N/mm of splitting length
Slip/skid resistance	Unpolished skid resistance value (USRV) of 45
Durability – strength	No less than the characteristic tensile splitting strength
Durability – slip/skid resistance	Not less than the initial slip/skid resistance
Abrasion resistance	Class 4
Weathering resistance	Class 3

Concrete grass blocks shall consist of concrete slabs or a precast panel system of the dimensions and colours of precast concrete paving and blocks shall be as provided in the drawings or Special Specifications and fabricated from Class 30 concrete, with openings through the slab totalling at least 20% of the surface area.

The precast panels, when tested for minimum characteristic bending strength, water resistance and abrasion resistance shall be in accordance with BS EN 1339:2003.

(e) Concrete

Concrete work shall be carried out in accordance with the provisions of SECTIONS 6200, 6300 and 6400.

(f) Wire

Wire for pitching kept in position by wires shall consist of 4 mm diameter galvanised wire, which complies with the requirements of BS 1052:1980 or equivalent.

(g) Permeable Material for Filter Layer

Permeable material for filter layers shall comply with the requirements specified for permeable material for subsoil drains in CLAUSE 2104.

(h) Geotextile Fabric

Synthetic-fibre filter fabric shall be of the grade and type specified in the Bill of Quantities or Special Specifications and shall comply with the requirements of SECTION 2700.

(i) Erosion Check Dam

The Erosion Check dams shall be constructed using Stone Masonry.

2503 STONE PITCHING

(a) Plain Stone Pitching

The area shall be prepared by excavating, shaping and trimming necessary for pitching and by thoroughly compacting the area by using appropriate equipment as determined by the Engineer to prevent subsequent settlement. A trench shall be excavated as directed by the Engineer along the toe of any slopes to be pitched or along the unprotected edge of the pitching in the beds of streams. Two pitching methods follow, and the method to be adopted shall be decided on by the Engineer.

i) Method 1

Commencing at the bottom of the trench, the stones shall be laid and firmly bedded into the slope and against adjoining stones. The stones shall be laid with their longitudinal axes at right angles to the slope and with staggered joints. The stones shall be well compacted into the bank or surface to be protected and the spaces between the larger stones shall be filled with spalls of approved pitching stone securely rammed into place.

Placing of rock by dumping shall not be allowed.

ii) Method 2

The technique and requirements laid down in Method 1 shall also apply to Method 2, except in the following aspects:

- No small stones or spalls shall be used to fill in spaces between larger stones.
- Simultaneously with the placing of stones, topsoil shall be introduced between individual stones, and sufficiently rammed so as to provide a firm bonded structure. The topsoil shall be provided to the full depth of the stone pitching at any point.
- Rooted grass or tufts of grass shall then be planted in the soil between stones and watered immediately and copiously and thereafter at regular intervals until the grass has been established.

Whichever of the above two methods is adopted, the finished surface of the pitching shall present an even, tight and neat appearance with no stones varying by more than 25 mm from the specified surface grades or lines. The thickness of the pitching, measured at right angles to the surface, shall not be less than 200 mm.

(b) Grouted Stone Pitching

The work shall be done in accordance with all the requirements specified for plain pitching in SUB-CLAUSE 2503 (a) above, except that the stone shall be thoroughly cleaned of adhering dirt or clay, moistened and embedded in freshly laid cement mortar of class M15 as specified in BS EN 998-1:2016. Any spaces between the stones shall be filled with cement grout of the same composition as the mortar. The mortar and the grout shall be placed in a continuous operation for any day's run at any one location. The grout shall be worked into the pitching to ensure that all spaces or voids between the stones will be completely filled with grout to the full depth of the stone pitching. Grout spilt onto the exposed surface of the stone shall be removed while still soft, and the joints between stones shall be neatly finished.

The grouted pitching shall be cured with wet sacking or other approved wet cover for a period of not less than four days after grouting, and shall not be subjected to loading until adequate strength has been developed. Where required, weep holes shall be formed in the pitching.

The finished surface of the pitching shall present an even, tight and neat appearance with no stones varying by more than 20 mm from the specified surface grades or lines. The thickness of the pitching, measured at right angles to the surface, shall not be less than 200 mm.

(c) Wired and Grouted Stone Pitching

The area to be pitched shall be prepared as described in SUB-CLAUSES 2503 (a) and 2503 (b). A concrete bed (Class 15 concrete) with a thickness of at least 75 mm shall then be placed. The stone pitching shall be of

stones with a minimum dimension of 200 mm, which shall be laid while the concrete is still fresh. Openings between stones shall be filled with cement grout as described in SUB-CLAUSE 2503 (b), and care shall be taken not to spill the grout onto the finally exposed surfaces of the stones. Grout spilt onto the exposed surface of the stone shall be removed while still soft and the joints between stones shall be neatly finished.

Curing shall be done as described for grouted stone pitching in SUB-CLAUSE 2503 (b).

The completed pitching shall have an even compacted appearance and nowhere may the surface deviate by more than 25 mm from the specified lines and grades.

2504 RIPRAP

(a) General

Riprap shall consist of a course of large rock placed on bank slopes and toes in stream and riverbeds and at other localities where protection of this type may be required.

Two types of riprap are specified here, viz. one type where the rocks are individually packed, which is designated as packed riprap, and the other type where the rock is dumped and then spread by machines, which is designated as dumped riprap.

The surface of areas to receive riprap shall be neatly trimmed to line and level and all loose material compacted. The perimeters of riprap areas shall be protected by the construction of either rock-filled trenches, walls or other structures as may be required. Perimeter trenches shall normally be backfilled with rock of the same size and quality as that used in the construction of the adjoining riprap, but any voids shall be filled with similar stone and the entire backfill shall be well compacted.

(b) Filter Bed

The filter bed shall consist of a layer or layers of permeable material placed on the prepared surface to the required thickness and each layer shall be finished to an even surface and thickness. Compaction of pervious material will not be required. Care shall be taken not to mix various grades of filter material nor to disturb material already placed when subsequent layers or riprap are being placed.

When the use of synthetic-fibre filter fabric is required, the material shall be placed on the prepared surface on the filter bed, depending on the instructions. The overlap between adjacent sheets shall be 150 mm unless otherwise specified. Care shall be taken not to damage the filter fabric when subsequent layers are being placed, nor to expose the filter fabric to the sun for periods exceeding three days before it is covered.

(c) Packed Riprap

Packed riprap shall be constructed from rocks placed individually to stagger the joints and so as to be firmly bedded in the prepared surface. The spaces between larger stones shall be filled with spalls or smaller stones securely rammed into place. On inclined surfaces the rock shall be laid in long horizontal strips starting from the bottom, and not in strips up the slope.

The completed riprap shall present a tight and even surface. Local surface irregularities of the riprap shall not exceed 150 mm.

(d) Dumped Riprap

Dumped riprap shall be constructed by dumping the stone on the prepared surface, spreading it by bulldozer

or other suitable earth-moving equipment, and trimming it to the required lines and levels. The material shall be placed in a manner that will prevent the segregation of the smaller and larger stones and the top layer shall be tight with a minimum of voids.

2505 STONE MASONRY WALLS

(a) General

Stone masonry walls may be plain packed stone walls with dry joints or otherwise mortared stone walls with stones bedded in cement mortar as indicated on the Drawings, as specified or as may be approved by the Engineer.

The minimum mass of each stone used shall be 10 kg and its minimum dimension 75 mm.

(b) Plain Packed Stone Walls

A foundation trench shall be excavated down to rock or to material with an adequate bearing capacity at a minimum depth of 300 mm below ground level. Larger selected stones shall be used for the foundation layer. Flat and stratified stones shall be laid with the largest dimension in the horizontal plane. Stones shall be packed individually to stagger the joints and to provide a minimum of voids, and shall be firmly bedded against adjoining stones. The spaces between the larger stones shall be filled with spalls securely rammed into place. The larger stones shall not bear on the spalls used for filling the voids. The top and ends of the wall shall be neatly finished with selected coping stones.

The appearance of the completed wall shall present an even and tight surface.

(c) Cement-Mortared Stone Walls

The walling shall be constructed as specified in SUB-CLAUSE 2505 (b) above, with the exception that the stones shall be wetted and set in cement mortar of class M 15 as specified in BS EN 998-2:2016. The exposed parts of the stones on the wall faces shall be cleaned of all mortar by washing or wire brushing. The mortar shall be flush pointed to the satisfaction of the Engineer, who may require a capping and end treatment of the same mortar.

Weep holes shall be provided as prescribed and shall be cleaned of mortar or any other clogging material that may have entered during construction.

The walling shall be protected from the elements and kept moist for a minimum period of four days after completion.

2506 SEGMENTAL BLOCK PAVING

(a) General

The underlying layers for surfaces to be pitched shall be constructed as specified or as indicated on the Drawings. Where no specified requirements have been set in respect of the underlying layers, the top layer shall be mechanically compacted to at least 90% of BS-Heavy density down to at least 150 mm from the top. During this process the top layer shall be trimmed to the required grades and levels.

Where specified or required by the Engineer the prepared surface shall be treated with approved environmentally compatible herbicide and ant poison before the layer of sand for bedding is placed.

(b) Sand for Bedding

A layer of sand for bedding shall be placed on top of the prepared surface, and when still loose, accurately floated

to an uncompacted thickness of 30 mm (± 5 mm) so as to afford the correct level to the pavement after compaction. Sand for bedding shall be placed immediately before the paving blocks are laid and shall not be compacted before the blocks have been laid.

(c) Laying the Paving Blocks

The pattern for laying the paving blocks shall be that as shown on the Drawings or approved or prescribed by the Engineer. Unbroken blocks shall first be laid and filler pieces afterwards. Filler pieces shall be neatly sawn or hewn to fit exactly into the space to be filled. Spaces of less than 25% of a full-sized block may be filled with 25 MPa concrete. The joints between blocks shall be sized between 2 and 6 mm and the top faces of blocks shall be flush. After the paving blocks have been laid, the pavement shall be compacted by two passes of a suitable vibrating-plate compactor operating at a frequency of 65 to 100 Hz and a low amplitude. Its plate surface shall be 0.2 to 0.4 m² and shall develop a centrifugal force of 7 to 16 kN.

After compaction of the pavement as described above, joint sand shall be spread and brushed into the joints until the joints have been properly filled. Any surplus sand shall then be broomed off and the pavement shall then be subjected to two further passes by the plate vibrator.

(d) Edge Beams

Concrete edge beams or any such other edge supports shall be constructed onto the supporting layer in accordance with the details shown on the Drawings, and shall be constructed and left to cure before any paving blocks are laid.

(e) Paving Blocks for Sidewalks

Paving blocks for sidewalks shall be laid in the same way as that described above for paving blocks, also on a bed of sand and joints shall be filled with sand. In this case the width of the joints between the stones shall be strictly in accordance with the dimensions shown on the Drawings and the pavement shall be fully compacted before the joints are filled.

(f) Concrete Grass Blocks

Concrete grass blocks of the size specified or shown on the Drawings shall be placed on areas prepared for grassing as specified in SECTION 5600. The holes in the blocks shall be filled with topsoil, and grassed with grass cuttings or hydro-seeding as specified in SECTION 5600.

(g) Finishing Requirements

i) Segmental Block Paving

The completed paving shall be even and neat, flush with the kerb or edge beam and may not lie below the side of the kerbing. The final surface levels shall nowhere deviate by more than 15 mm from the specified levels and planes, and no irregularities exceeding 10 mm may occur during testing with a 3 m straight-edge.

ii) Grass Block Pavement

The completed grass-block pavement shall have a neat and even appearance. The final surface of the pavement may nowhere deviate by more than 15 mm from the specified levels and planes.

with the requirements of SERIES 6000.

Prior to placing the concrete, the surface shall be watered and kept damp until the concrete has been placed. The type of concrete used shall, unless otherwise specified, be Class 20 and the concrete shall be accurately laid in alternate panels to the lines and levels indicated, after which the remaining panels shall be similarly placed. Accurately set-up guides shall be used to achieve the required line and slope. The concrete shall be thoroughly compacted and finished to a Class U2 surface finish as defined in CLAUSE 6209.

Where indicated, the concrete pitching shall be contained by concrete edge beams being constructed as described in CLAUSE 2506 (d).

The concrete pitching shall be cured for at least seven days and no traffic shall be allowed to move across the pitching before the specified 28-days strength has been reached.

The final surface may nowhere deviate by more than 25 mm from the specified levels and planes and no irregularities exceeding 10 mm occur during testing with a 3 m straight edge.

2508 MEASUREMENT AND PAYMENT

ITEM	UNIT
25.01 STONE PITCHING:	
(a) PLAIN PITCHING	
(i) METHOD 1	SQUARE METRE (m ²)
(ii) METHOD 2	SQUARE METRE (m ²)
(a) GROUTED STONE PITCHING (SPECIFY THICKNESS)	SQUARE METRE (m ²)
(b) WIRED AND GROUTED STONE PITCHING (TOTAL THICKNESS INDICATED)	SQUARE METRE (m ²)

The unit of measurement for pitching shall be the square metre of each type of pitching in place.

The bid rate for each type of stone pitching shall include full compensation for furnishing all materials, making all excavations excluding trench and bulk excavations, compacting and trimming the excavated surfaces, forming and cleaning the weep holes, placing stones and grouting or wiring and grouting where applicable, grassing and watering (applicable to Method 2) and for all other work necessary for completing the pitching as specified. The bid rate for grouted stone pitching on a concrete bed shall also include full compensation for the concrete bed.

Excavations for foundation trenches and concrete edge beams and the construction of the concrete edge beams will be paid for separately.

2507 CAST IN SITU CONCRETE PITCHING

The areas where cast in situ concrete pitching is to be constructed, shall be trimmed and prepared as described in CLAUSE 2506 for block paving. The areas shall also be treated with an environmentally compatible herbicide and ant poison if required. The concrete shall comply

<u>ITEM</u>	<u>UNIT</u>
25.02 RIPRAP:	
(a) PACKED RIPRAP (CRITICAL MASS OF STONES INDICATED)	CUBIC METRE (m ³)
(b) DUMPED RIPRAP (CRITICAL MASS OF STONE INDICATED)	CUBIC METRE (m ³)
(c) FILTER BACKING (SUB-CLAUSE 2104(a)(ii) AND 2504(b) CONSISTING OF:	
(i) CRUSHED STONE	CUBIC METRE (m ³)
(ii) FILTER SAND OBTAINED FROM BORROW PITS	CUBIC METRE (m ³)
(d) SYNTHETIC FIBRE FILTER FABRIC (TYPE, CLASS AND GRADE STATED)	SQUARE METRE (m ²)

The unit of measurement for riprap and filter layer (SUB-ITEMS 25.02 (a), (b) and (c) above) shall be the cubic metre of riprap or filter layer in place and shall include rock used in trench backfill. The unit of measurement for SUB-ITEM 2502 (d) shall be the square metre of filter fabric laid as specified, including overlaps.

The bid rates for SUB-ITEMS 25.02 (a), (b) and (c) shall include full compensation for preparing the surfaces, including excavation (but excluding excavation for trenches and bulk excavations) and for the furnishing, transporting, handling and placing of riprap or filter layers. The bid rate for SUB-ITEM (d) shall include full compensation for procuring and furnishing the filter fabric and for laying it as specified, including wastage. Collectively the rates shall also include full compensation for all other incidentals necessary for completing the work as specified in SECTION 2700.

<u>ITEM</u>	<u>UNIT</u>
25.03 STONE MASONRY WALLS:	
(a) PLAIN PACKED STONE WALLS	CUBIC METRE (m ³)
(b) CEMENT-MORTARED STONE WALLS	CUBIC METRE (m ³)
(c) EROSION CHECK DAMS	CUBIC METRE (m ³)

The unit of measurement for stone masonry walls shall be the cubic metre of actual walling constructed and accepted.

The bid rate for each type of stone wall shall include full compensation for furnishing all materials, trimming the areas, placing the stones and cement-mortared masonry where necessary, and all other work necessary for completing the walls in accordance with the Specifications. Excavation of foundation trenches will be paid for separately.

<u>ITEM</u>	<u>UNIT</u>
25.04 CONCRETE PITCHING AND BLOCK PAVING:	
(a) CAST IN SITU CONCRETE PITCHING (CLASS OF CONCRETE AND THICKNESS OF PITCHING INDICATED)	SQUARE METRE (m ²)
(b) SEGMENTAL BLOCK PAVING (TYPE AND THICKNESS INDICATED)	SQUARE METRE (m ²)
(c) PREFABRICATED CONCRETE GRASS BLOCKS	SQUARE METRE (m ²)
(d) PREFABRICATED CONCRETE PAVING BLOCKS FOR SIDEWALK	SQUARE METRE (m ²)

PAVEMENT (THICKNESS INDICATED)

The unit of measurement shall be the square metre of each type constructed.

The bid rates shall include full compensation for furnishing all material, all excavation (but excluding bulk excavation and excavation for foundation trenches and edge beams), compacting and trimming all the excavated areas, providing a sand bedding (SUB-ITEMS 25.04 (b) and (d)), laying and compacting the paving blocks (SUB-ITEMS 25.04 (b) and (d)), laying concrete grass blocks (SUB-ITEM 25.04 (c)), topsoiling and grassing, (SUB-ITEM 25.04 (c)), constructing concrete pitching, including normal formwork and the shaping of surfaces (SUB-ITEM 25.04 (a)), making and cleaning weepholes (SUB-ITEM 25.04 (a)) and for all other work necessary for completing the work as specified.

<u>ITEM</u>	<u>UNIT</u>
25.05 CONCRETE EDGE BEAMS (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)

The unit measured shall be the cubic metre of concrete in edge beams constructed as instructed.

The bid rate shall include full compensation for furnishing all materials and labour, including formwork as necessary, placing concrete and shaping all surfaces and all excavations required (in all classes of material).

<u>ITEM</u>	<u>UNIT</u>
25.06 PROVISION OF HERBICIDE AND ANT POISON:	
(a) PROVISION OF MATERIALS	PRIME COST SUM
(b) CONTRACTOR'S OVERHEADS AND PROFIT AS A PERCENTAGE OF SUB-ITEM 25.06 (a)	PER CENT (%)

Payment under the prime cost sum for providing environmentally compatible ant poison and herbicide and the Contractor's cost and profit in this respect shall be made in accordance with the provisions of the General Conditions of Contract, but, in addition, the Contractor's bid rate for costs and profit shall include full compensation for applying the chemicals as specified.

<u>ITEM</u>	<u>UNIT</u>
25.07 FOUNDATION TRENCHES	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material excavated for foundation trenches irrespective of the class or depth of material. The quantity shall be calculated according to the dimensions shown on the Drawings or as instructed by the Engineer.

The bid rate shall include full compensation for the excavation of the foundation trenches irrespective of the class or depth of material complete as specified, or as shown on the Drawings or as instructed by the Engineer.

SERIES 2000: DRAINAGE

SECTION 2600 : GABIONS

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2601 SCOPE

This Section covers the construction of gabion walls and aprons for constructing retaining walls, lining channels, revetments, bridge and culvert protections, protection of road embankments and other anti-erosion structures.

Gabions shall be flexible galvanised steel-wire wire-mesh cages packed with rock.

2602 MATERIALS

(a) Rock

Rock used as filling for cages shall be clean, hard, un-weathered boulders or rock fragments. No rock fragment shall exceed the maximum size given in TABLE 2602/1, and at least 85% of the rocks shall be of a size equal to or above the average least dimension size in TABLE 2602/1.

The minimum density of rock shall be 2,300 kg/m³, but the Contractor must get approval from the Engineer to use lower density rock.

TABLE 2602/1: ROCK SIZES

Depth of cage (m)	Rock size according to the largest dimension of rock	
	Average least dimension (mm)	Maximum (mm)
0.2	125	150
0.3	125	200
0.5	125	250
1.0	125	250

(b) Wire

All wire for making the gabions and for tying during the construction of the gabions shall comply with the following requirements:

i) Tensile Strength:

350-500 N/mm² as per EN 10223-3.

ii) Coating:

All the wire shall be heavily zinc coated in accordance with the provisions of BS EN 10244-2:2023. The minimum mass of the coating shall be according to BS EN 10244-2:2023, see TABLE 2602/2 below:

TABLE 2602/2: WIRE COATING

	Mesh wire diameter (mm)						
	2.0	2.2	2.4	2.7	3.0	3.4	3.9
Coating (gr/m ²)	215	230	230	245	255	265	275

iii) Elongation:

Elongation shall be not less than 10% as per EN 10223-3.

(c) PVC-Coated Wire

The gabions of PVC-coated mesh shall be of an acknowledged make which shall be subject to approval by the Engineer.

(d) Galvanising

All wire used in the making of gabions shall be galvanised in accordance with the provisions of BS 1052:1980 or equivalent for Class A heavy galvanised mild-steel wire.

(e) Wire Mesh

Wire mesh shall comply with the requirements of BS 4483:2005 or equivalent.

(f) Geotextile Filter Fabric

Geotextile filter fabric shall comply with the requirements of SECTION 2700.

2603 CONSTRUCTING GABION CAGES

(a) General

Gabion cages shall be made from wire mesh of the size and type and seldage as specified below. The cages shall be subdivided into cells by wire mesh diaphragms and will be of two types.

i) Boxes which are generally used for the construction of gabion walls. These boxes are subdivided into cells by diaphragms spaced at 1.0 m intervals. No diaphragms are required for a box of which the length does not exceed 1.5 m. The standard sizes of gabions are as shown in TABLE 2603/1 below:

TABLE 2603/1: GABION SIZES

Mesh type (mm)	Wire diameter	Sizes
80x100	2.7 mm	Length: 1.5-2-3-4 m
		Width: 1 m
		Height: 0.5-1 m

ii) Mattresses which are generally used as single-layer aprons only in revetments, channel linings, etc and in which the maximum width shall be subdivided by diaphragms into cells with a width of 1.0 m as specified in the Bill of Quantities.

The standard sizes of mattresses are as shown in TABLE 2603/2 below:

TABLE 2603/2: MATTRESS SIZES

Mesh type (mm)	Wire diameter	Sizes
60x80	2.2 mm	Length: 3-4-5-6 m
		Width: 2 m
		Height: 0.17-0.23-0.30 m
50x70	2.0 mm	Length: 3-4-5-6 m
		Width: 2 m
		Height: 0.15-0.20-0.25 m

Other sizes of gabion boxes and mattresses may be supplied, provided that the Engineer's prior permission has been obtained.

The cut edges of all mesh used in the construction of gabions, except the bottom edge of diaphragms and end

panels, shall be selvaged with wire as specified in TABLE 2603/3.

(b) Selvages

The cut edges of all mesh used in the construction of gabions, except the bottom edges of diaphragms and end panels, shall be selvaged with wire having a diameter as specified in TABLE 2603/3. The selvedge wire and the wire used for lacing operation must have the same technical specification of the mesh wire. The combination of the diameters of mesh wire, selvedge wire and lacing wire shall be as specified in TABLE 2603/3.

TABLE 2603/3 DIAMETER OF MESH WIRE, SELVEDGE WIRE AND LACING WIRE

Mesh wire diameter (mm)	2.0	2.2	2.4	2.7	3.0
Selvedge wire diameter (mm)	2.4	2.7	3.0	3.4	3.9
Lacing wire diameter (mm)	2.0	2.2	2.2	2.2	2.2

Where the selvedge is not woven integrally with the mesh but has to be tied to the cut ends of the mesh, it shall be attached by tying the cut ends of the mesh to the selvedge, so that a force of not less than 8.5 kN applied in the same plane as the mesh at a point on the selvedge of a mesh sample of 1.0 m in length will be required to separate it from the mesh.

(c) Diaphragms and End Panels

The diaphragms and end panels shall be selvaged on the top and vertical sides only. The end panels shall be attached by the cut ends of the mesh wires at the bottom of the panel being twisted around the selvedge on the base of the gabion. Similarly, the diaphragms shall be attached by the cut ends of the mesh being twisted to the twisted joints of the mesh in the base of the gabion. In each case the force required to separate the panels from the base shall be not less than 6 kN/m.

(d) Binding and Connecting Wire

Sufficient binding and connecting wire for all the tying to be done during construction of the gabions as specified in CLAUSE 2604 below, shall be supplied with the gabion cages. The diameter of the wire shall be 2.2 mm.

(e) Tolerances

The tolerance on the specified diameter of all wire shall be $\pm 2.5\%$. The length of the cages shall be subject to a tolerance of $\pm 10\%$ and the width of the cages shall be subject to a tolerance of $\pm 5\%$ and the depth of the cages shall be subject to a tolerance of $\pm 5\%$.

2604 CONSTRUCTING GABIONS

(a) Preparing the Foundation and Surface

The surface on which the gabion cages are to be laid prior to being filled with rock shall be levelled to the depth shown on the Drawings or as directed by the Engineer so as to present an even surface. If necessary, cavities between rock protrusions shall be filled with material similar to that specified in SUB-CLAUSE 2602 (a). Where required, a foundation trench along the toe of the revetment or wall shall be excavated to the dimensions shown on the Drawings or indicated by the Engineer.

(b) Filter Fabric

One layer of Grade 3 filter fabric shall be placed where indicated on the Drawings or ordered by the Engineer.

The material shall be placed in accordance with the instructions, in strips with a minimum overlap of 300 mm at the joints and shall be properly fastened to prevent any movement or slipping while the gabions are being placed.

(c) Assembly

The methods of constructing, stretching, placing in position, wiring and filling the gabions with rock shall generally be in accordance with the manufacturer's instructions which have been approved by the Engineer, but nevertheless sufficient connecting wires shall be tensioned between the vertical sides of all the outer visible cells to prevent the deformation of boxes as they are being filled with stone.

It is essential that the corners of gabion cages be securely wired together to provide a uniform surface and ensure that the surface does not resemble a series of blocks or panels.

The layout and the tolerances for the layout of the boxes shall be as shown on the Drawings or as instructed by the Engineer.

(d) Rock Filling

i) Boxes in Retaining Walls

Particular care shall be taken in packing the visible faces of gabion boxes, where only selected stone of the specified size shall be used so as to obtain an even-faced finish. The boxes shall be filled in layers to prevent deformation and bulging. Boxes shall be filled to just below the level of the wire braces, after which the braces shall be twisted to provide tension. Care must be taken to ensure that consecutive layers of cages are filled evenly to a level surface ready to receive the next course.

ii) Mattresses Used in Revetments and Aprons

The gabion mattresses forming aprons and revetments shall be filled with random stones being packed in the first layer and selected stones being used for the top layer so as to resemble normal stone pitching.

2605 MEASUREMENT AND PAYMENT

	ITEM	UNIT
26.01	FOUNDATION EXCAVATION AND BACKFILLING:	
(a)	IN SOLID ROCK AS DEFINED IN CLAUSE 3603	CUBIC METRE (m ³)
(b)	IN ALL OTHER MATERIAL THAN ROCK AS DEFINED IN CLAUSE 3603	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of each class of excavation made in accordance with the authorised dimensions.

The bid rates shall include full compensation for excavating in each class of material, including unavoidable overbreak, the trimming of trenches and compacting the trench inverts, backfilling and compacting the backfill, and the disposing of surplus excavated material.

No haulage will be paid.

	ITEM	UNIT
26.02	SURFACE PREPARATION FOR BEDDING THE GABIONS	SQUARE METRE (m ²)

The unit of measurement for levelling and preparing surfaces for receiving the gabions shall be the square

metre to the neat dimensions of revetments, aprons or wall foundations.

The bid rate shall include full compensation for excavating, filling any cavities with rock and levelling the ground surface so as to be ready for receiving the gabion cages for retaining walls, aprons and revetments.

<u>ITEM</u>	<u>UNIT</u>
26.03 GABIONS:	
(a) GALVANISED GABION BOXES (DIMENSIONS OF BOX AND MESH SIZE INDICATED)	CUBIC METRE (m ³)
(b) PVC-COATED GABION BOXES (DIMENSIONS OF BOX AND MESH SIZE INDICATED)	CUBIC METRE (m ³)
(c) GALVANISED GABION MATTRESSES (DIMENSIONS OF MATTRESS, MESH SIZE AND DIAPHRAGM INDICATED)	CUBIC METRE (m ³)
(d) PVC-COATED GABION MATTRESSES (MESH SIZE AND DIAPHRAGM SPACING INDICATED)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of the rock-filled cages and the quantity shall be calculated from the dimensions of the gabions indicated on the Drawings or prescribed by the Engineer, irrespective of any deformation or bulging of the completed gabions.

The bid rates shall include full compensation for supplying all the materials, including rock fill, wire-mesh cages, tying and connecting wires, loading, transporting and off-loading, the assembling and filling of the cages, and any other work necessary for constructing the gabions.

<u>ITEM</u>	<u>UNIT</u>
26.04 FILTER FABRIC (TYPE AND GRADE INDICATED)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of area covered with filter fabric placed in position.

The bid rate shall include full compensation for supplying the filter fabric, cutting, placing, joining, overlapping/wastage and securing the material in position as specified in SECTION 2700.

SERIES 2000: DRAINAGE

SECTION 2700: FILTER FABRIC, DRAINAGE COMPOSITE AND GEOSYNTHETICS

CONTENTS:

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2701 SCOPE

This Section covers the geotextile filter fabrics and drainage composites to be used in drainage systems such as surface drainage, drainage trenches, perforated pipes wrap, retaining wall backfill and vertical drainage where the function of the geotextile filter fabric is to allow the water to go through preventing the fine soil particles to enter the drainage system (filtration) that can be obtained by the use of filling gravel material or synthetic core (drainage composite).

2702 MATERIALS

(a) Geotextile for Drainage Applications

The geotextile used as a filter (as filter itself or as filter of the drainage composite) shall meet the mechanical and hydraulic properties listed in TABLE 2703/2 and the following general requirements:

- The geotextile shall be a "non-woven" type
- The raw material of the filament yarns shall be produced with a mixture of polypropylene and polyethylene where the polyethylene content will not exceed 30% of the overall mass and will be used as external revetment of each filament.
- The geotextile will be manufactured and supplied according to a certified quality control process.
- The geotextiles shall be rolled in a UV resistant package and it will be itself resistant to wearing out, rotting, solvents, acids, alkalis, bacteria and other microorganisms and to any chemical reaction occurring in standard natural soils.
- Geotextiles can be easily transported and installed. During transportation and storage, the geotextile rolls shall be kept wrapped to avoid damage. Each geotextile roll shall be labelled and marked for identification during quality control of the product.

(b) Drainage composites

In drainage applications a drainage composite can be used to replace the drainage system composed by granular material and filter. The drainage composite shall meet the mechanical and hydraulic properties listed in TABLE 2703/2 and the following general requirements:

- i) Drainage composite shall be a laminated filter drain composed of two layers of the above-described geotextile which is used as a filter separated by a high-density polyethylene net.
- ii) The three components (nonwoven-net-nonwoven) shall be bonded together over the entire surface by thermal lamination.

- iii) The filters will be larger than the core width to guarantee (at least at one side) an overlap to prevent the intrusion of fine soil into the drainage core.
- iv) The geo-composite will be manufactured and supplied according to a certified quality control process.

2703 CHARACTERISTICS AND STANDARD TESTING PROCEDURES

(a) Geosynthetics

To ensure quality of materials testing may be specified to verify compliance with the specified requirements. TABLE 2703/1 details various test methods that may be used to verify compliance with specified properties.

TABLE 2703/1: GENERIC SPECIFICATION TESTS (GEOSYNTHETICS)

Property	Test method
Degradation	ASTM D5819-22
Endurance	ISO 13437:2019
Abrasion	ASTM D4157-13(2022) & D4158-08(2020) ASTM D4886-22 ISO 13427:2014
Ultraviolet degradation	ASTM D4355/D4355M-21 ASTM G155-21 ASTM G154-23 ASTM D1435-20 ASTM D5970/D5970M-16(2021) ASTM D7238-20
Temperature degradation	ASTM D1388-23 ASTM D746-24
Chemical degradation	ASTM D543-21 ASTM D5322-23 ASTM D5496-15(2020)

(b) Geotextiles

i) Drainage Application

TABLE 2703/2 lists test standards for geotextiles. Any other standard meeting the basic requirements stated here can be accepted at the discretion of the Engineer provided that the Contractor has provided the Engineer with the manufacturer's test certificate.

The locations of the geotextiles employed for drainage function shall be shown in the Drawings or as directed by the Engineer. The required mechanical and hydraulic properties of the geotextile conform to the minimum property requirements as specified in TABLE 2703/2.

In addition to the properties given in TABLE 2703/2. The filter geotextile shall be unaffected by chemical materials and will be resistant to all natural occurring soil alkalis and acids (pH range 2-13)

The geotextile shall remain wrapped in a black polyethylene wrapper to protect it from the harmful effects of UV-rays. During the placement the temporary exposure to the light shall not exceed 10 hours.

TABLE 2703/2: TESTS/PROPERTIES FOR NON-WOVEN GEOTEXTILE FILTERS FOR DRAINAGE APPLICATIONS

Test	Test Standard	Minimum Requirement
Wide width strip tensile (kN/m)	BS EN ISO 10319:2015	8.0
Elongation (%)	BS EN ISO 10319:2015	Max 30
CBR Puncture resistance (N)	BS EN ISO 12236:2006	1500
Trapezoidal tear resistance (N)	ASTM D4533/D4533M-15(2023)	300
Permeability -10 cm head (l/m ² xsec)	BS EN ISO 12958	90
Pore Size (µm)	BS EN ISO 12956:2020	100

The Engineer reserves the right to reject any geotextile material they consider unsuitable for the Works.

In addition to that, the Engineer reserves the right to take samples of the geotextile during the course of the work and subject them to the tests they deem necessary in a suitably equipped laboratory on behalf of the Contractor.

(c) Geocomposites

i) Drainage Composite

The purpose of usage and application locations of the Geocomposites employed for the drainage function shall be stated in designs and shall be used if the engineer approves. The required mechanical and hydraulic properties of the Geocomposite selected at the end of the design phase shall be stated and the Geocomposite shall meet the minimum property requirements as specified in the TABLE 2703/3

Type A drainage composite shall be used for vertical applications as retaining walls or in flat applications where the vertical loading is limited to 60 kPa. Type B shall be used in flat applications exceeding the 60 kPa.

In addition to the properties given in TABLE 2703/3, the drainage composite elements shall be unaffected by chemical materials and will be resistant to all naturally occurring soil alkalis and acids (pH range 2-13).

The Geocomposite shall remain wrapped in a black polyethylene wrapper to protect it from the harmful effects of UV-rays. During the placement the temporary exposure to the light shall not exceed 10 hours.

The performance of the filter geotextiles of the drainage composite will comply with the specification limits indicated in CLAUSE 2703.

TABLE 2703/3: TESTS FOR NON-WOVEN FILTERS OF GEOCOMPOSITE

Test	Test Standard	Minimum Requirements	
		Type A	Type B
Tensile breaking load (kN/m)	BS EN ISO 10319:2015	16	20
CBR Puncture resistance (N)	BS EN ISO 12236:2006	2700	3400
Compressive strength at 10% compression (kN/sqm)	ASTM D1621-16(2023)	150	193
Water flow – hydraulic gradient = 1.0 hard/hard (l/sec/m)	BS EN ISO 12958-1:2020		
Water Flow (m/sec)			
20 kPa			0.52
200 kPa			0.41
300 kPa			0.31
400 kPa			0.27

(d) Quality Control

For the purpose of quality control of the geo-synthetics to be used, the number of rolls to be tested out of the total number of rolls supplied shall be in accordance with ASTM D4354-12(2020) and 5 test samples shall be taken from each test roll and tested in the main direction. If the average value of the results of five tests satisfies the specifications limits, the geo-synthetic material shall be accepted otherwise rejected. If one or more rolls fall below the specification limits, the procedure defined above shall be repeated by resampling. If the average test results of the resampled roll exceed the specification limits, the Geosynthetics of the batch shall be accepted.

(e) Construction Methods

When the use of geosynthetics is required at specified locations in projects, the Geosynthetics should not be damaged during transportation, placement and compaction of the granular fill material (if required by the application) in/on which the Geosynthetics will be placed. In case of damage, the damaged sections will be repaired in a way approved by the Engineer either by patching or by replacement of the damaged section with new material.

2704 MEASUREMENT AND PAYMENT

Measurement and payment for geotextile filter fabric will be according to the relevant pay ITEMS included in SECTIONS 2500 and 2600.

SERIES 3000

SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

CONTENTS OF THE GENERAL SPECIFICATIONS:

<i>SERIES 1000</i>	<i>GENERAL</i>
<i>SERIES 2000</i>	<i>DRAINAGE</i>
<i>SERIES 3000</i>	<i>SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE</i>
<i>SERIES 4000</i>	<i>BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT</i>
<i>SERIES 5000</i>	<i>ANCILLARY ROADWORKS</i>
<i>SERIES 6000</i>	<i>STRUCTURES</i>
<i>SERIES 7000</i>	<i>TOLERANCES, TESTING AND QUALITY CONTROL</i>
<i>SERIES 8000</i>	<i>DAYWORKS</i>

APPENDICES

SERIES 3000

SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

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3200 REMOVAL OF EXISTING STRUCTURES	3000-5
3300 BREAKING UP EXISTING PAVEMENT LAYERS	3000-7
3400 BORROW PIT AND QUARRY ACQUISITION AND EXPLOITATION	3000-11
3500 SELECTING AND UTILISING MATERIAL FROM BORROW PITS AND CUTTINGS	3000-13
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CONTENTS OF THE GENERAL SPECIFICATIONS:

SERIES 1000 GENERAL

SERIES 2000 DRAINAGE

SERIES 3000 SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SERIES 4000 BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

SERIES 5000 ANCILLARY ROADWORKS

SERIES 6000 STRUCTURES

SERIES 7000 TOLERANCES, TESTING AND QUALITY CONTROL

SERIES 8000 DAYWORKS

APPENDICES

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

**SECTION 3100: CLEARING,
GRUBBING AND REMOVAL OF
TOPSOIL**

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3101 SCOPE

This Section covers clearing of the Site, grubbing and removal of top soil for depth and disposal of materials resulting from clearing and grubbing necessary for construction of the Works covered by the Contract, in accordance with these Specifications.

3102 DESCRIPTION OF WORKS

(a) General

No clearing and grubbing shall be done unless approved by the Engineer. The Contractor shall note that, in order to avoid re-clearing, the clearing and grubbing may have to be done at the last practicable stage of construction.

Ground levels shall be taken prior to and after clearing and grubbing and removal of topsoil. Levels taken prior to clearing and grubbing shall be the base level and will be accordingly used for assessing the depth of clearing and grubbing and computation of quantities of any unsuitable material to be removed or suitable material to be reused. The levels taken subsequent to clearing and grubbing shall be the base level for computation of earthworks in embankments and cuttings.

The Contractor shall take all necessary precautions to prevent damage to structures and other private or public property.

Any unauthorised damage to or interference with private or public property including trees shall be made good to the satisfaction of the Engineer and the owner at the Contractor's sole expense.

(b) Area to be Cleared, Grubbed and Removed of Topsoil

The area to be cleared, grubbed and removed of topsoil shall extend 1 metre beyond the top of the slope in cuts and 3 metres beyond the toe of the slope of embankments in accordance with the Drawings or as directed by the Engineer. Topsoil shall only be stripped within the road prism unless otherwise instructed by the Engineer. The Engineer may also designate additional areas to be cleared, which shall not necessarily be limited to those mentioned above.

The shoulders on each side of existing carriageways are included in the clearing and grubbing, but not the existing carriageway itself. However, Clearing and grubbing on the existing shoulders is not required where there is no vegetation.

Felling of trees should be parallel to the road and controlled to avoid blocking the road and damaging other trees. No trees that fall between the extent of works and the limits of clearing and grubbing shall be removed without the written authorisation of the Engineer.

Individual trees designated by the Engineer shall be left standing and uninjured.

Within built up areas clearing and grubbing shall be strictly limited to the extent of cut or fill as shown in the Drawings or as directed by the Engineer. No private property e.g. buildings, crops, signs, fences etc shall be removed, relocated or altered without the authorisation of the Engineer.

(c) Clearing and Grubbing

Clearing shall consist of the removal of all trees with girth less than 300mm, bushes, shrubs and other vegetation, rubbish, fences and all other objectionable material, including the disposal of all material resulting from the clearing and grubbing. Clearing shall also include the removal of all rocks and boulders of up to 0.15 m³ in size that are exposed or lying on the surface.

Clearing shall include complete removal and disposal of structures that obstruct, encroach upon or otherwise obstruct the work, and which can be cleared by means of equipment proposed by the contractor and approved by the Engineer, including existing bridge structures and removal of foundations to a depth of one metre below the bed level shown on the Drawings. This also includes the removal of signposts; the demolition and removal of paved ditches; and the demolition and removal of any other masonry or concrete structures that obstruct the work. Clearing shall also include the removal of loose pavement materials, road signs, right-of-way markers, kilometre stones, guideposts and other incidentals. On instruction by the Engineer, these items shall be carefully removed to ensure they are not damaged. All signs and markers etc., shall remain the property of the Employer. They shall be cleaned, loaded, transported to a designated storage area, offloaded and neatly stacked.

Structures which cannot be cleared by reasonable means in the opinion of the Engineer shall be broken down in accordance with the requirements of the Special Specifications.

Clearing shall include removal of mounds and nests from termites, ants or other insects or burrowing animals. Such removal shall be carried out by excavation to the required depth as directed by the Engineer, and subsequent application of approved pesticides in the case of ants and termites. No additional payment will be made for removal of such nests, but backfilling and compaction with approved fill materials will be paid as ordinary earthworks fill under the relevant pay item. Application of approved pesticides will be paid for separately.

Stumps and roots of any size, including matted roots, in the roadway shall be removed at least to the depth which is the larger of the following:

- 600 mm below the finished road level;
- 100 mm below the ground level after removal of topsoil; and
- 300 mm below the top of improved subgrade or formation level.

All stumps and roots, including matted roots, shall be removed to a depth of at least 300 mm below the formation level (top of improved subgrade).

The cavities resulting from the grubbing shall be backfilled with approved material and compacted to comply with the Specifications for the relevant layer.

The Contractor during his site clearance and other operations, shall ensure that the site is well drained and existing water courses are maintained except where this is a direct and unavoidable result of the permanent works.

(d) Removal of Topsoil

Top soil shall be removed up to a depth of 150mm during clearing and grubbing. Clearing and grubbing done in excess of 150mm depth by the Contractor shall be made good by the Contractor at his own cost to the satisfaction of the Engineer, prior to execution of earthworks. Where clearing and grubbing is to be done to a level beyond 150mm, due to site considerations, as directed by the Engineer, the extra quantity shall be measured and paid for separately. Topsoil will be used in topsoiling embankment slopes and in rehabilitating existing roads in accordance with Section 5700. Further topsoil shall be used in landscaping other areas at the direction of the Engineer. Surplus topsoil shall only be removed to spoil at the direction of the Engineer. The rates for removal of topsoil shall include all haulage. The Contractor shall adhere to the requirements of CLAUSE 1213 unless indicated otherwise in the special specifications.

Once the Engineer has directed the removal of cut and spoil, it shall be immediately taken to designated stockpile areas or dumpsites approved by the Engineer. The Contractor shall manage the excavation, storage, transport, reuse and disposal of spoil to minimize impacts and meet other environmental and social requirements as stipulated in SECTIONS 1700 and 1800 of these Specifications. Spread subsoil shall be de-compacted before covering with topsoil so as to promote sufficient aeration, drainage and root growth.

(e) Conservation of Topsoil

If not used immediately, the topsoil shall be transported and deposited in stockpiles or spoil banks provided by the Contractor at their own expense and at locations approved by the Engineer. The cost of stripping and disposal of topsoil shall be included in the price bid for clearing, grubbing and removal of topsoil.

(f) Conservation of Vegetation and Cutting of Trees

Where provided for in the Special Specifications, certain designated plants and trees encountered in the road reserve shall be carefully protected by the Contractor. They shall then include in their bid rates for clearing and grubbing full compensation for omitting or the careful removal and planting of the plants in a protected and fenced-off area, and, on completion of the road, the replanting of the plants in suitable positions in the road reserve in accordance with the Engineer's instructions. The Contractor's attention is in this respect specifically drawn to SECTION 1700.

In the cases where cutting of trees has been approved by the Engineer they shall be cut in sections from the top downwards. The branches of trees to be left standing shall be trimmed so as to leave a 7 m clearance above the carriageway.

Where clearing and grubbing would involve the cutting down of indigenous forest containing a significant number of trees with a trunk diameter exceeding 200 mm, the Contractor shall inform the officials of the Forestry Department before commencing with clearing and grubbing of such areas so as to enable that Government Department either to salvage any usable timber or to identify the trees before they are removed by the Contractor.

(g) Disposal of Material

Material obtained from clearing, grubbing and removal of topsoil, shall be disposed of as approved by the Engineer, in stockpiles for later use in the case of topsoil, borrow pits or other suitable places and covered up with soil or gravel in the case of other debris. The burning of material will only be permitted with the prior written approval of the Engineer. All statutory provisions with regard to air pollution shall be carefully observed.

All tree trunks and branches in excess of 150 mm in diameter shall be cleared of secondary branches, sawn

into suitable lengths and stacked at sites indicated by the Engineer. Such timber shall not be used by the Contractor and shall remain the property of the Employer unless otherwise agreed on with the Engineer.

(h) Re-Clearing of Vegetation

When portions of the road reserve or other areas have been cleared in accordance with the Specifications, but vegetation grows again in the course of time during construction, the Engineer may, if he considers it necessary, order that the area be re-cleared. No additional payment will be made for such re-clearing.

Such re-clearing of areas previously cleared includes the removal and disposal of grass, shrubs and other vegetation in the same manner as for the first clearing operation and may be instructed by the Engineer once deemed necessary.

3103 MEASUREMENT AND PAYMENT

No payment will be made for the moving of soil or gravel material which may be inherent in or unavoidable during the process of clearing.

Clearing, grubbing and removal of topsoil required for quarries, borrow areas and any other natural material sources, for haul roads and all temporary construction will not be measured for payment.

<u>ITEM</u>		<u>UNIT</u>
31.01	CLEARING, GRUBBING AND REMOVAL OF TOPSOIL IN ACCORDANCE WITH CLAUSE 3102.	
(a)	CLEARING AND GRUBBING AND REMOVAL OF TOP SOIL FOR AVERAGE DEPTH NOT EXCEEDING 150MM	HECTARE (ha)
(b)	REMOVAL OF TOPSOIL IN EXCESS OF 150MM DEPTH	
(i)	REMOVAL OF TOPSOIL AND STOCKPILING FOR RE-USE	CUBIC METRE (m ³)
(ii)	DISPOSAL OF SURPLUS STOCKPILED TOPSOIL (PROVISIONAL)	CUBIC METRE (m ³)

The unit of measurement for SUB-ITEM 31.01 (a), clearing and grubbing, shall be the hectare (to the nearest 0.1 ha) designated by the Engineer and cleared of the vegetation cover and grubbed and in accordance with these Specifications, all to the satisfaction of the Engineer.

The unit of measurement for SUB-ITEM 31.01 (b), Removal of Topsoil as specified or instructed by the Engineer, shall be the cubic meter measured in the stockpile or spoil area. Topsoil otherwise wasted will not be paid for.

The bid rate shall include full compensation for all work necessary for the clearing of the surface, any necessary de-watering, removal of topsoil to the depth as specified or as instructed by the Engineer after removal of the vegetation cover, the removal and grubbing of trees and tree stumps (except large trees and stumps as defined below), cutting of branches, backfilling of cavities, demolishing and disposal of buildings and structures (except for removal of drainage structures as provided for in SECTION 2200), and the removal, transporting and disposal or conservation of material all as specified in this SECTION 3100. The Contractor's attention is drawn to SUB-CLAUSE 3102 (d) for further explanation of the work included under this pay item.

<u>ITEM</u>	<u>UNIT</u>
31.02 REMOVAL AND GRUBBING OF LARGE TREES AND TREE STUMPS:	
(a) GIRTH EXCEEDING 300 mm UP TO AND INCLUDING 1.0m	NUMBER (no.)
(b) GIRTH EXCEEDING 1.0 m UP TO AND INCLUDING 2.0 m	NUMBER (no.)
(c) GIRTH EXCEEDING 2.0 m UP TO AND INCLUDING 3.0 m	NUMBER (no.)
(d) GIRTH EXCEEDING 3.0 m	NUMBER (no.)

The girth of trees or stumps shall be measured at the narrowest point of the tree or stumps in the first metre of its height above ground level. For stumps less than one meter above ground level, measurement of the girth shall be taken at the top of the stump. Trees and stumps with a girth exceeding 300mm shall be measured individually and classified according to the size in increments as indicated above.

The bid rates shall include full compensation for all work necessary for the clearing and grubbing of trees and stumps with a girth exceeding 300mm, the backfilling of holes with suitable material to required compaction and the removal and disposal of material, all as described in this SECTION 3100.

Where construction is carried out through plantations or where the number of trees with a girth exceeding 300mm renders individual measurement impractical, the Special Specifications may provide that the clearing and grubbing of trees in such areas be measured in hectares. If this method of measurement is used, the areas where it applies will be shown on the Drawings or stated in the Special Specifications. Where the Special Specifications provide for the cleaning and grubbing of large trees per hectare in such specific cases, the bid price shall include full compensation for all work as described in connection with individual trees above.

<u>ITEM</u>	<u>UNIT</u>
31.03 APPLYING APPROVED PESTICIDES TO ANT AND TERMITE NESTS	LITRES (l)

The unit of measurement for applying approved pesticides to ant and termite nests shall be the litres as instructed by the Engineer applied in accordance with these Specifications.

The bid rate shall include full compensation for all work necessary for applying approved pesticides to ant and termite nests.

<u>ITEM</u>	<u>UNIT</u>
31.04 REMOVAL AND STORAGE OF SELECTED VEGETATION	
(a) COST OF REMOVAL, STORAGE, PROTECTION AND REPLANTING IN A PROTECTED AND FENCED-OFF AREA OF SELECTED VEGETATION	PROVISIONAL SUM
(b) CONTRACTOR'S PROFIT AND OVERHEADS AS A PERCENTAGE OF SUB-ITEM 31.04 (A)	PERCENT (%)

This item provides for a provisional sum for the removal, storage, protection and replanting of vegetation approved by the Engineer as part of the clearing and grubbing work.

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

**SECTION 3200: REMOVAL OF
EXISTING STRUCTURES**

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3204	REMOVAL OF BRIDGES, CULVERTS AND OTHER DRAINAGE STRUCTURES	3000-5
3205	REMOVAL OF PIPE CULVERTS	3000-5
3206	REMOVAL OF CONCRETE ENTRANCES, KERBS, ETC.	3000-5
3207	REMOVAL OF UTILITIES	3000-5
3208	REMOVAL OF EXISTING BUILDING STRUCTURE	3000-6
3209	MEASUREMENT AND PAYMENT	3000-6

3201 SCOPE

This Section covers the demolition, disconnection, dismantling, removal or part removal, disposal and storage of different components of buildings, bridges, drainage structures, retaining walls, wells, service ducts, foundations, fencing, walls, kerbs, existing pavements, abandoned pipelines, guard rails, manholes, disused public utilities and any other obstructions which are not designated or permitted to remain; except for the obstructions to be removed and disposed of under other items in the Contract.

This Section also covers the cleaning of existing drainage structures designated to remain as part of the Works and includes cleaning, removal and disposal of materials related to the existing structure.

3202 GENERAL

The Contractor shall remove and dispose of all buildings, foundations, bridges, drainage structures and other obstructions within the limits of the Works, except items designated to remain and utilities and obstructions to be removed under other provisions of this Contract. Refer also to SECTION 3100.

All existing structures designated as salvage material shall be removed, without damage, in sections or pieces that may be readily transported, and shall be stored by the Contractor at locations specified in the Special Specifications. Unusable perishable material shall be destroyed. Non-perishable material, waste concrete and masonry shall as far as practicable be placed in slopes of embankments. Any broken concrete or masonry that cannot be used in construction, and all other materials not considered suitable for use elsewhere, shall be disposed of by the Contractor. In no case shall any discarded materials be left in windrows or piles adjacent to or within the Site. The manner and location of disposal of materials shall be subject to the approval of the Engineer and shall not create an unpleasant or objectionable view. When the Contractor is required to locate a disposal area outside the Site at their own expense, they shall obtain and file with the Engineer, permission in writing from the property occupier for the use of their property for this purpose.

Basements or cavities left by structure removal shall be filled to the level of the surrounding ground and, if they are within the roadbed, the backfill shall be compacted in

accordance with the relevant requirements in this Specification.

Existing utilities through, at or near existing structures shall be protected and/or relocated as directed by the Engineer.

**3203 REMOVAL OF GROUTED STONE SIDE
DITCHES**

Existing grouted stone side ditches shall be preserved as far as feasible, in accordance with the instructions of the Engineer. However, where necessary, they shall be totally or partially removed, as directed by the Engineer, and if required the salvaged stones shall be stockpiled where directed by the Engineer.

**3204 REMOVAL OF BRIDGES, CULVERTS AND
OTHER DRAINAGE STRUCTURES**

Bridges, culverts, and other drainage structures shall not be removed until satisfactory arrangements have been made to accommodate traffic, the flow of water as well as the stability of the ground.

Unless otherwise indicated, the existing substructures shall be removed down to the natural stream bottom and those parts outside the stream shall be removed 300 mm below the natural ground surface. Portions of existing structures within the limits of a new structure shall be removed to accommodate the construction of the proposed structure.

Bridges designated as salvage material shall be dismantled without damage and match marked. Structures designated to become the property of the Contractor shall be removed from the Site.

Blasting or other operations necessary to remove existing structures or obstructions, which may damage new construction, shall be completed prior to placing the new work.

3205 REMOVAL OF PIPE CULVERTS

Pipe culverts, and other drainage structures shall not be removed until satisfactory arrangements have been made to accommodate traffic and the flow of water.

Due care must be taken during the process of dismantling salvage material to avoid damage. Sections of pipe lost from storage or damaged by negligence shall be replaced at the Contractor's expense. Pipes shown on the Drawings or directed by the Engineer to be plugged shall be left in place and the ends plugged.

**3206 REMOVAL OF CONCRETE ENTRANCES,
KERBS, ETC**

All concrete pavement, kerbs, channels, buildings, foundations, slabs, etc. designated for removal shall be disposed of by the Contractor at approved dump sites at a maximum haul distance of 10 km as ordered by the Engineer, unless otherwise specified.

Concrete designated for use as riprap shall be broken down into pieces not exceeding 30 kg and stockpiled at designated locations for use on the project.

3207 REMOVAL OF UTILITIES

The removal of existing utilities required to permit orderly progress of work will be accomplished by local agencies, unless otherwise provided for in the Special Specifications or shown on the Drawings. Whenever a telephone or telegraph pole, pipeline, conduit, sewer, Electrical Pole, Electrical Line, Solar Street Lighting or other utility is encountered and must be removed or relocated, the Contractor shall advise the proper local authority or owner to arrange for its removal/relocation.

3208 REMOVAL OF EXISTING BUILDING STRUCTURES

The removal of existing buildings shall be in accordance with the instructions of the Engineer. However, as required, they shall be totally or partially removed, as directed by the Engineer, and if required the salvaged material shall be stockpiled & disposed of by the Contractor at approved dump sites at a maximum haul distance of 10 km as ordered by the Engineer, unless otherwise specified.

Concrete designated for use as riprap shall be broken down into pieces not exceeding 30 kg and stockpiled at designated locations for use on the project.

3209 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
32.01 REMOVAL OF EXISTING STRUCTURES:	
(a) REMOVAL OF EXISTING PIPE CULVERTS OF ANY SIZE	LINEAR METRE (m)
(b) REMOVAL OF REINFORCED CONCRETE IN BRIDGES, BOX CULVERTS AND SLABS INCLUDING HEADWALLS, WING WALLS AND APRONS	CUBIC METRE (m ³)
(c) REMOVAL OF PLAIN CONCRETE AND MASONRY IN BRIDGES AND CULVERTS INCLUDING ABUTMENT, HEADWALLS, WING WALLS AND APRON	CUBIC METRE (m ³)
(d) REMOVAL OF STEEL STRUCTURES	TON
(e) REMOVAL OF KERB AND CHANNEL	LINEAR METRE (m)
(f) REMOVAL OF EXISTING GROUTED STONE PITCHING	SQUARE METRE (m ²)
(g) REMOVAL OF STONE/ BRICK MASONRY BOUNDARY WALL BUILDINGS	SQUARE METRE (m ²)
(h) REMOVAL OF FENCING (SPECIFY TYPE)	LINEAR METRE (m)

The unit of measurement for the removal of existing pipe culverts shall be the linear metre of pipe acceptably removed, as directed by the Engineer.

The unit of measurement for the removal of reinforced or plain concrete in bridges and culverts shall be the cubic metre of concrete acceptably removed, as directed by the Engineer.

The unit of measurement for removal of steel structures shall be the metric Ton of steel acceptably removed, and stockpiled as directed by the Engineer.

The unit of measurement for removal of kerb and channel shall be the number of linear metres of kerb and channel acceptably removed, as directed by the Engineer.

The unit of measurement for removal of grouted stone pitching shall be the square metres of surface of grouted stone side ditch acceptably removed, as directed by the Engineer.

The unit of measurement for the removal of stone/ brick masonry boundary wall buildings shall be the square metres acceptably removed, as directed by the Engineer.

The tendered rate for removal of pipe culverts shall include full compensation for all materials, labour, equipment, tools and incidentals necessary to complete the work for demolishing of pipes of any size and type including any concrete bedding and surround, removing and disposing of all materials including supply and

compaction of material for backfilling. Removal of concrete and masonry in headwalls, wing walls and apron will be paid for separately under ITEMS 32.01 (b) and 32.01 (c) as applicable.

The tendered rate for removal of reinforced or plain concrete and masonry in bridges and culverts shall include full compensation for all materials, labour, equipment, tools and incidentals necessary to complete the work for demolishing the bridge and culverts, removing and disposing of all materials including supply and compaction of material for backfilling.

The quantities, determined as provided above for kerb, channel and grouted stone pitching shall be paid at the rate per unit of measurement, respectively, for each of the particular pay items, included in the Bill of Quantities which price and payment shall be full compensation for all materials, labour, equipment, tools and incidentals necessary to complete the work of demolishing, removing, disposing or stockpiling, as applicable, including supply and compaction of material for backfilling.

<u>ITEM</u>	<u>UNIT</u>
32.02 REMOVAL OF EXISTING BUILDING STRUCTURES:	
(a) ARRANGE AND PAY FOR REMOVAL OF EXISTING BUILDING STRUCTURES: OF ANY DIMENSION	PROVISIONAL SUM (PS)
(b) CONTRACTORS' OVERHEADS AND PROFIT AS A PERCENTAGE OF SUB-ITEM 32.02 (a)	PERCENT (%)

The percentage inserted by the Contractor under SUB-ITEM 32.02 (b) shall include full compensation for all the Contractor's responsibilities in respect of services (including the Contractor's costs and overheads in making the arrangement and for co-ordinating the work and effecting payment) as specified in CLAUSE 3208.

The Provisional Sum shall be for reimbursement of the net cost for arranging the removal or alteration of all existing buildings, fences, etc. before any excavation or other work likely to affect the existing structure is commenced. Payment is subject to the agreement of the Engineer, and upon production of receipts

The percentage inserted by the Contractor shall be for the Contractor's overheads and costs in making the arrangement, for co-ordinating the work and effecting payment.

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

**SECTION 3300: BREAKING UP
AND RECYCLING EXISTING
PAVEMENT LAYERS**

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3301 SCOPE

This Section covers the breaking up and excavation of existing pavement layers by conventional means or by milling, selecting the material, and the removal thereof to spoil dumps or to stockpiles for later reprocessing or recycling.

3302 SELECTING THE MATERIAL

Where directed by the Engineer, the Contractor shall remove the layers of the existing pavement, taking care not to damage the existing kerbs and/or gutters, if any. In case of damage to the existing kerbs or gutters due to the Contractor's negligence, they shall be replaced to the satisfaction of the Engineer at the Contractor's expense.

Material from existing pavements may only be used for purposes approved by the Engineer. The material shall be so excavated that material from the various pavement layers, or materials of different types, will not be mixed unless so permitted by the Engineer.

3303 CLASSIFYING THE MATERIAL

Material from existing pavements shall be classified as follows for excavation and processing purposes:

(a) Existing Bituminous Material

Existing bituminous material shall be asphalt or other bituminous seal or DBM base course material removed separately from the pavement at the instruction of the Engineer. Where underlying material is broken down or excavated together with bituminous materials, the mixture will not be classified as bituminous material.

(b) Non-Cemented Material

Non-cemented material shall be existing pavement material that has not been treated with a chemical stabilizing agent to result in a cementing action, and which can be made usable for pavement material by ripping and breaking it up with tracks of the bulldozer.

(c) Cemented Material

Cemented material is classified as existing pavement materials made from gravel or crushed stone, that have been treated with a chemical stabilizing agent to result in a cementing action and that cannot be ripped and made usable for pavement material by the method described in SUB-CLAUSE 3303 (b). Unless specified as such in the Special Specifications, cemented material will not be

classified as concrete.

(d) Concrete

Concrete is classified as reinforced or un-reinforced concrete when specified as such in the Special Specifications or as decided by the Engineer.

(e) Milled Material

Milled material shall be bituminous material or cemented material excavated with an approved milling machine. Milled material will be classified as such only when milling is specified or ordered by the Engineer. Payment will distinguish between milling of asphalt, concrete and cemented material where so specified in the Bill of Quantities.

3304 EQUIPMENT

(a) General

The equipment to be used for the conventional breaking-up and excavation of existing pavement layers will be determined by the size and depth of the pavement section to be processed or excavated, taking into consideration the fact that work may have to be carried out in restricted areas. Only approved cutting or sawing equipment may be used for cutting or sawing the pavement layers. The equipment shall be capable of cutting the pavement layers to the specified depth in one operation without fragmenting the material, and in straight lines within the required tolerances.

(b) Milling Equipment

Only approved milling equipment may be used. The equipment shall be capable of milling asphalt and/or cemented material to the prescribed depth in one operation over the width specified in the Special Specifications. The milling depth shall be controlled electronically.

The direction and speed of the milling machine and the speed of rotation of the milling drum shall be adjustable so as to obtain the required grading of the milled material. The machine shall be capable of making a neat vertical cut at the outer edges when milling the layer and to leave the floor of the cut level and with a uniform texture.

Unless otherwise specified in the Special Specifications, the milling machine shall be equipped with a self-loading conveyor belt, which can be easily removed and installed and adjusted for slope and direction.

3305 CONSTRUCTION

(a) General

Where all or a part of the existing surfacing material is to be reprocessed together with the underlying layer, the surfacing shall be properly broken down and mixed through the full depth of the existing base material to the satisfaction of the Engineer. Fragments of bituminous material shall be broken down to sizes not exceeding 40 mm.

Where specified in the Special Specifications or ordered by the Engineer, the existing bituminous material shall first be removed before the underlying layers are broken up.

Bituminous material may be milled out or otherwise broken up and removed to stockpile sites approved for recycling or to spoil sites, whichever is required. The exposed surface shall be cleaned to the satisfaction of the Engineer after removal of the bituminous material.

The existing pavement material shall be broken down to the specified depth and removed, or reprocessed in place, whichever may be required. The underlying layers may not be damaged, and material from one layer may

not be mixed with that of another layer. Where such mixing occurs or where the material is contaminated in any other way by the actions of the Contractor, they shall remove such material and replace it with other approved material, all at their own cost.

Where a layer or layers require to be broken down over part of the pavement width only, the limit of the work shall be clearly demarcated and which limit shall not be exceeded by the Contractor by more than 100 mm. Pavement layers broken down outside the specified limits shall be repaired by the Contractor at their own cost, to the satisfaction of the Engineer.

Where so ordered by the Engineer, asphalt and cemented layers shall be cut or sawn through to the specified depth along the measured limit with approved equipment. Payment will be made for sawing only where specified on the Drawings or ordered, in writing, by the Engineer.

Payment will not be made for sawing or cutting work where the existing layer requires removal by milling.

Where existing roads have to be widened, the existing pavement layers shall be cut back to a firm, well compacted or cemented material. Material so broken up, if acceptable, may be used together with imported material in the widening process provided the mixture consistently meets all requirements for the material type specified for the layer in question.

Where pavement layers are broken down over a section of the road width or where pavement layers are widened, the Engineer may order, the various pavement layers be excavated in benches in accordance with their instructions. No additional payment will be made for excavating benches.

Where underlying layers are still structurally sound and are included as structural layers in the new design Drawings, care must be taken not to break them up during removal of the surfacing or underlying layers.

(b) Milling

i) Preparing the Pavement Surface

Before milling may be commenced, the pavement surface shall be clean and free from soil or other deleterious material. Where only part of the pavement is to be milled out, the milling area shall be properly demarcated. Milling may not exceed the required width by more than 50 mm. Payment will not be made for milling beyond the required width, and such additional milling shall be backfilled with approved material in accordance with the provisions for the specified pavement material at the cost of the Contractor.

ii) Trial Milling

Where ordered by the Engineer, the Contractor shall execute trial milling on the various materials to be milled. During the trial work, the Contractor will be expected to vary the direction and speed of the milling machine, the speed of rotation of the milling drum, and also the milling depth, in order to obtain milled material of the required grade. No payment will be made for trial milling.

iii) Asphalt

Where the asphalt and/or the cemented base must be reused, the asphalt shall be removed separately. Where the asphalt consists of layers of various mixes or grades, the Engineer may instruct the separate removal of the layers to different stockpiles. Where the milled material is not conveyed directly by conveyor belt and then loaded, and the Engineer so approves, the material shall first be cut into windrows and then loaded. During loading, the floor of the excavation or the

underlying material shall not be damaged.

The milled material shall be inspected and classified in accordance with the various types of asphalt and its suitability for recycling. Different stockpiles shall be used for the different types of material as ordered by the Engineer. Contamination of the asphalt with underlying material will not be permitted, and the Contractor shall adjust the depths of milling in accordance with the thickness of the layer.

iv) Cemented Material

Unless otherwise specified milled cemented material to be reprocessed on the road shall first be windrowed with a view to inspecting the underlying surface for any patches of poor or unsuitable material. Where unsuitable material is encountered in the floor of the excavation, such material shall first be removed by further milling (where the underlying layer also consists of the cemented material), or by other approved methods, all to the satisfaction of the Engineer. The unsuitable material shall be replaced with approved material of the required type, which shall be placed in accordance with the specifications for the relevant underlying layer.

Where in the opinion of the Engineer, it may be necessary, they may instruct the Contractor to taper the ends or edges of a milled excavation. No additional payment will be made for tapering the ends or edges of a milled excavation.

v) Coring of Cemented Material

Where existing cemented layers are to remain as a structural layer in the new pavement the Engineer may instruct the Contractor to drill cores from the layer and have them tested for compressive strength in accordance with the provisions of BS EN 12504-1:2019 or equivalent. The number of cores to be drilled out and the drilling locations will be determined on site by the Engineer.

vi) General

The floor of the milled excavation shall have an even texture and any loose patches or patches of unsuitable material shall be remedied in accordance with the instructions of the Engineer. Payment for removing and replacing unsuitable material and remedying loose patches shall be as specified elsewhere.

The floor of an excavation shall comply with the requirements of the surface level, grade and regularity for the layer that it will form in the new pavement.

Payment for milling will not distinguish between various types of milled material and between various milling depths unless such distinction is given in the Bill of Quantities.

(c) Sawing or Cutting

Where required in the opinion of the Engineer, diamond blade sawing or cutting shall be employed if necessary to achieve the required edge finish of milled layers. No additional payment will be made for sawing or cutting unless deemed necessary and approved by the Engineer.

(d) Treatment of Pavement Excavation Floor

The floor of any pavement excavation, whether or not excavated by milling, shall be treated and paid for as specified in the relevant sections of the Specifications.

(e) Scarification of Existing Pavement

Wherever shown on the Drawings or directed by the

Engineer, the existing pavement surfacing and base course material or part of the existing base layer shall be scarified, watered and recompacted. The depth of scarification and density of compaction shall be according to the Drawings and the Specifications.

Unless specified otherwise existing bituminous surfacing shall, if located within 1.0 m of new pavement surface, be scarified by such method and to such depth that will ensure that any lumps of surfacing are not more than two-thirds of the specified scarification depth and ensure that a homogeneous mix is obtained.

3306 STORING RECOVERED PAVEMENT MATERIAL

Excavated pavement material intended for reprocessing but which cannot be reprocessed in place or, in the opinion of the Engineer, cannot be windrowed next to the excavation, nor placed in position directly at any other place, and material intended for recycling or reprocessing in a plant, shall be transported to approved stockpiles with the written permission of the Engineer.

Stockpile sites for material intended for recycling or reprocessing in a plant shall be set out at the corresponding mixing or crushing plant or at such other locations as approved by the Engineer.

The stockpile site shall be cleaned, and all loose stones, vegetation and other materials which may cause contamination shall be removed. The site shall be graded smoothly with an adequate slope to ensure proper drainage. Where so instructed by the Engineer, the surface shall be watered and compacted to a depth of at least 150 mm to a density of 90% of BS Heavy density.

The compacted surface shall be firm without any loose patches. Where asphalt is recovered for recycling, the Engineer may order the surface to be chemically stabilised to a depth of 150 mm. Upon completion, this surface shall be swept clean.

Stockpile sites shall be sufficiently large to allow the placing of stockpiles of different types of material or types of recovered asphalt without the stockpiles overlapping or the limits of the prepared site being exceeded. The enlargement of the stockpile site after the stockpiles have already been placed will not be permitted without the approval of the Engineer.

Stockpiles of milled material shall be made in a manner that prevents segregation and undesirable consolidation or changes in moisture content. Adequate approved covers shall be provided as required in the opinion of the Engineer to prevent them from undesirable wetting or drying, or being contaminated by dust.

Upon completion of the work, the stockpile sites shall be broken up in accordance with the instructions of the Engineer.

The stockpiling of excavated material will not be paid for directly, but full compensation therefore shall be included in the rates for the various items of work in which the stockpiled material will be used. Separate payment will not be made for the preparation of storage sites.

3307 REUSE OR RECYCLING OF RECOVERED PAVEMENT MATERIAL

Reuse or Recycling of existing pavement is the process in which existing pavement materials are reclaimed and reused after processing for either surfacing or repaving or reconstruction of pavement depending upon the condition of the existing pavement, nature of the reclaimed materials, method of reprocessing and the treatment that the pavement requires. Preferably, cold process reclamation shall be adopted where existing pavement materials are reclaimed by cold milling, breaking or ripping. The recycling process shall be

achieved either by in-place recycling or in-plant recycling method.

(a) Reclaimed Bituminous Material

The reclaimed bituminous material in a defined proportion shall be used in the production of bituminous binder course or bituminous base course subject to homogeneous mix satisfying the requirements stated in SECTION 4200. In addition, reclaimed bituminous material shall be mixed in proportion with suitable virgin material for the Sub-base layer & Base layer subject to homogeneous mix satisfying the requirements stated in SECTION 3700.

(b) Reclaimed Granular Material

The reclaimed granular material shall be mixed in proportion with suitable virgin material for the Sub-base layer & Base layer subject to a homogeneous mix satisfying the requirements stated in SECTION 3700.

(c) Reclaimed Cemented/ Concrete Material

The reclaimed cemented/ concrete material shall be mixed in proportion with suitable virgin material for Sub-base & Base layer subject to a homogenous mix satisfying the requirements stated in SECTION 3700.

3308 MEASUREMENT AND PAYMENT

(a) General

i) Material to be Reprocessed

Direct payment will be made for breaking up and excavating or milling of existing pavement material that is to be reprocessed and reused, when:

- a. The material is excavated or milled out in accordance with the provisions of the Special Specifications or upon the written instruction of the Engineer.
- b. Bituminous surfacing or other bituminous pavement layers are removed separately from the underlying material in accordance with the Special Specifications or the written instructions of the Engineer.

ii) Material from an Existing Pavement Which is Not Reprocessed

Existing gravel pavement material, or existing bituminous material not intended for reprocessing, may be spoiled or be used in other layers or items of work where approved by the Engineer. Payment for the excavation of pavement material to be spoiled will be made directly under ITEM 36.01 (a). Dumping shall only occur on approval of the Engineer at an approved waste site.

Where used for other purposes full compensation for excavating shall be included in the rates bid for the various pavement layers and items or work in which the material is used.

iii) Measurement for Excavating Existing Pavement Material and Underlying Fill

Where payment is made separately for the excavation of existing pavement material and underlying fill, the quantity will be calculated in accordance with the authorised horizontal dimensions of the excavated layer and the average depth of excavation. The average depth of excavation will be determined in accordance with the test holes made or cores drilled at intervals not exceeding 10 m, and which are so distributed over the surface that a realistic estimate of the depth can be obtained.

the specified depth irrespective of individual pavement layer thicknesses, mixing with imported materials if required, shaping, and compacting the material as specified.

<u>ITEM</u>	<u>UNIT</u>
33.01 EXCAVATING OR MILLING OF MATERIAL FROM AN EXISTING PAVEMENT:	
(a) GRANULAR MATERIAL	CUBIC METRE (m ³)
(b) BITUMINOUS MATERIAL	CUBIC METRE (m ³)
(c) CEMENTED MATERIAL	CUBIC METRE (m ³)
(d) CONCRETE (INDICATE WHETHER REINFORCED OR UN- REINFORCED)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material excavated or milled from the existing pavement using approved equipment and methodology.

The bid rate shall include full compensation for excavating or milling the material from the existing pavement irrespective of layer thickness, for loading, transporting, off-loading, and placing the material in approved spoil dumps or stockpiles as directed by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
33.02 SAWING OR CUTTING CONCRETE, ASPHALT OR CEMENTED PAVEMENT LAYERS:	
(a) BITUMINOUS MATERIAL	LINEAR METRE (m)
(b) CEMENTED MATERIAL	LINEAR METRE (m)
(c) CONCRETE (INDICATE WHETHER REINFORCED OR UN- REINFORCED)	LINEAR METRE (m)

The unit of measurement shall be the linear metre of sawcut calculated in accordance with the authorised length of sawcut.

The bid rate shall include full compensation for all material and sawing or cutting costs and for all incidentals for cutting or sawing the pavement in accordance with the instructions of the Engineer.

<u>ITEM</u>	<u>UNIT</u>
33.03 DRILLING AND TESTING CORES FROM CONCRETE, ASPHALT OR CEMENTED PAVEMENT LAYERS:	
(a) BITUMINOUS MATERIAL	NUMBER (no.)
(b) CEMENTED MATERIAL	NUMBER (no.)
(c) CONCRETE (INDICATE WHETHER REINFORCED OR UN-REINFORCED)	NUMBER (no.)

The unit of measurement shall be the number of cores drilled on the instructions of the Engineer.

The bid rate shall include full compensation for setting out the core locations, for drilling the cores and testing their strength in the laboratory as specified.

<u>ITEM</u>	<u>UNIT</u>
33.04 SCARIFICATION AND RECOMPACTION OF EXISTING PAVEMENT LAYERS	
(a) SCARIFY (STATE SCARIFICATION DEPTH AND DENSITY OF COMPACTION)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of existing pavement materials scarified to the specified depth using approved equipment and methodology.

The bid rate shall include full compensation for scarification of the existing pavement materials to (add

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

**SECTION 3400: BORROW PIT
AND QUARRY ACQUISITION
AND EXPLOITATION**

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3401 SCOPE

This Section covers the work involved in obtaining borrow materials for work under this contract, including negotiations with Owners or Legal Occupants of the land on which borrow areas and quarry sites are situated.

**3402 NEGOTIATIONS WITH LANDOWNERS,
AUTHORITIES AND LEGAL OCCUPANTS
OF LAND**

As specified in CLAUSE 1215 it is entirely the Contractor's own responsibility to obtain and pay all royalties in respect of all land required by the Contractor outside the road reserve for opening of borrow pits and quarries, including access roads and land for stockpiling topsoil (that will be used for reinstating the Borrow area). Such provision of land shall be considered part of the Contractor's general obligations as defined in SECTION 1300.

Nevertheless, the approval of the Engineer must be sought before entry upon the land.

In all cases, the Contractor shall be required to make all necessary arrangements with local authorities and owners or legal occupants of the land and to pay the cost of compensation. For this purpose, the Contractor shall liaise with the Regional Administration and/or the appropriate district authority and advise these authorities and the Engineer of the intention to commence work of any kind in borrow areas and quarry sites.

The attention of the Contractor is drawn to the provisions of CLAUSE 1214 as regards their activities on private land.

The Contractor shall observe all the legal provisions and the provisions of SECTION 1700 the Specifications in respect of their activities at borrow pits and quarries and when finishing off the borrow pits and quarry areas.

**3403 ACCESS TO BORROW PITS AND
QUARRIES**

The Contractor shall satisfy itself that all necessary negotiations have been made with the Owner or Legal Occupants of the land on which any borrow area or quarry site is situated, prior to the entry upon such land.

The Contractor shall notify the affected Owners or Legal Occupants of land both verbally and in writing at least seven days before prospecting for materials.

The Contractor shall give the Engineer at least thirty days' notice of their intention to enter a borrow area or quarry and shall not enter thereon until compensation, if necessary, to owners or legal occupants is effected and the approval of the Engineer has been given.

The Contractor shall demonstrate compliance with the Environmental, Social Management and Monitoring Plan and provisions of SECTIONS 1700 AND 3405.

**3404 OBTAINING BORROW OR QUARRIED
MATERIALS**

(a) General

Any borrow pit and quarry plans included in the Soils and Materials Report or any other report issued by the Employer are issued for information purposes and supplied in good faith only and do not form part of the Contract Documents. Borrow pit and quarry site information given, if any, is to describe the location and possible quality of potential material sources. Any assessment and conclusions made by the Contractor based on the information provided are at his/ her own risk.

The Contractor shall make his own investigations in view of dedicated borrow pits for:

- i. Fills;
- ii. Subgrade; and
- iii. Subbase.

All borrow pits shall be approved by the Engineer whether they are mentioned in the Soils and Materials Report or not. The borrow materials for permanent works, as practicable, may come from the road reserve by widening the road prism. When the road reserve is used, the excavation after borrowing materials should not be below the adjacent roadbed level in fills or 50 cm below the bottom of cuts (bottom of drains levels).

If the closest edge of a borrow area is at least 20 m beyond the toe of embankments or beyond the top of cuts, this borrow pit can be deeper since the drainage is fully ensured to avoid stagnant water for environmental, health and safety reasons.

Borrow materials shall be obtained from approved sources of supply listed and described on the borrow area plans that may have been provided, or from such other sources as may from time to time be identified and tested by the Contractor and approved by the Engineer. Borrow pit material complying with the requirements of the Specifications for the use for which the material is intended, shall be selected from these approved sources. Such selection shall take into account that the specified requirements apply to the material on the road after processing.

The Contractor shall be responsible for locating and obtaining all the construction materials he requires and shall be responsible for carrying out all materials investigations regarding the location and use of borrow pits and quarries. The responsibility for ensuring that all construction materials used on the project conform to the specified requirements remains with the Contractor and the Engineer will only carry out quality acceptance control tests on materials after they have been delivered to the site for use in the Works.

(b) Borrow Area and Quarry Site Plans

If, at any time during construction, it appears that the quality or quantity of material available in a borrow pit or quarry is inadequate or insufficient, the Contractor shall locate and make use of other borrow or quarry areas approved by the Engineer, irrespective of whether or not

such other areas are shown on the plans for borrow pits or quarries.

Materials required for the construction of pavement layers shall be stockpiled in heaps within the borrow area or as directed by the Engineer. The Contractor shall in their programme of works allow for the necessary period for testing and approval of stockpiled materials before it may be incorporated in the permanent works.

No separate payment shall be made regarding such stockpiling of materials.

(c) Use of Borrow or Quarry Materials

Payment will not be made for moving the Contractor's plant from one location to another at any of the individual sources.

The Contractor shall search for and test all possible sources from which they intend to obtain material. This shall include sources designated by the Engineer within an economic haulage distance, or sources mentioned in the information provided whether or not the information form part of the Contract Documents. The Contractor shall excavate the necessary trial holes, take such samples and conduct or have conducted such tests as are deemed to be necessary by the Engineer. The Contractor shall submit the results in a report with sufficient details and sketches to the Engineer to satisfy them that the quality and quantity of the material available in the proposed area are acceptable for the intended use, all at the Contractor's own expense.

The Contractor shall plan their exploitation of the borrow pits or quarries in such a manner that the various types of materials extracted can be selected and utilised without contamination or admixture of unsuitable material.

(d) Borrow Material Obtainable from the Road Prism

Where suitable sources of materials are available in existing cuttings and side drains, such materials may be used for the Works if approved by the Engineer.

Approval of a borrow pit and its material product(s) by the Engineer will not alleviate the Contractor of his /her obligation to make full and effective use of all suitable materials available from the cut operations on site.

Should the Contractor spoil excavated material of a quality suitable for use in the construction of the pavement (including fill) and use borrow materials instead of suitable material(s) obtained from the cut operation within the road prism, the quantity of fill material measured shall be reduced by the quantity spoiled from cut operations. Material required for the construction of pavement layers may be stockpiled in heaps within the road reserve. All stockpiles shall be as instructed by the Engineer. No separate payment shall be made in regard to such stockpiling.

3405 OPENING AND WORKING BORROW PITS

(a) Excavating Borrow Material

The Contractor's attention is drawn to the provisions of CLAUSE 1702 regarding the provision of an Environmental Management Plan.

Prior to working borrow pits and quarries, the area shall be cleared and grubbed and topsoil stripped and stockpiled for subsequent reinstatement. Any overburden shall be removed and stockpiled separately.

All opening and working of borrow pits shall be undertaken in a manner that prevents contamination or undesirable mixing of materials.

Where any borrow pit contains different types of materials which require mixing to produce a suitable

product, the materials shall be excavated and handled by use of methods approved by the Engineer.

The Contractor shall take all precautionary measures so as to avoid contamination of the suitable material by the inclusion of clayey or otherwise unsuitable material from the floor of the borrow pit, the overburden, any unsuitable layers, or areas beyond the approved limits of the borrow area. During loading, any hard oversize material that will not break down during processing on the road shall be excluded as far as is practicable.

During borrow operations, and especially when excavating material near the floor and outer boundaries of the borrow areas, the Contractor shall plan their operations so as to reduce, insofar as is possible, the amount of earth moving work that will be necessary for finishing-off the borrow pits. Indiscriminate excavation without due regard being had to the desired final shape of the borrow pit will not be permitted.

The material in borrow pits shall be blasted or ripped and excavated in a manner that will ensure the effective breaking-down of the material in the borrow pit before it is loaded. Rippable material that tends to break into large blocks shall be cross-ripped.

Material required for the construction of pavement layers shall be stockpiled in heaps within the borrow area. All stockpiles shall be of maximum size and shape as instructed by the Engineer. The Contractor shall in his /her programme of works allow for the necessary period for testing and approval of stockpiled gravel before it may be used on the road.

No separate payment shall be made regarding such stockpiling of materials.

(b) Control at Borrow Pit

The Contractor shall be responsible for controlling their operations at every borrow pit where material is being excavated to ensure compliance with all the requirements of the Specifications.

The Contractor shall carry out sufficient tests on the material being excavated from the borrow pit to satisfy themselves that the quality of the material will comply with the specific requirements for the particular layers for which it will be used. If required for the proper control of quality, in the opinion of the Engineer, the materials shall be stockpiled prior to loading and tests of the stockpiles carried out as required.

If there is any doubt concerning the quality of the borrow material being excavated at any time, the Contractor shall notify the Engineer immediately, and in any case before such material is brought onto the road. The results of all tests carried out by the Contractor shall be submitted without delay to the Engineer. The Engineer may, after further testing or inspection if necessary, approve the use of the material in the borrow area, or they may order the borrow pit to be finished off and abandoned. Any such approval by the Engineer does not indemnify the Contractor with regard to their obligations to fulfil all requirements of the Specifications in respect of the quality of materials for earthworks or pavement layers.

(c) Protecting Borrow Pits and Quarries

Borrow pits and quarries shall be continuously protected against the ingress of surface water, and the Contractor shall construct such temporary banks as may be required for diverting surface water, and, insofar as possible, their operations shall be planned in such a way that the borrow pit and quarry will be self-draining. Where this is not possible, borrow pits and quarries shall be dewatered by pumping. The Contractor shall be solely responsible for keeping borrow areas and quarry sites dry and ensuring that borrow material is sufficiently dry when required for use.

(d) Access Roads

The Contractor shall obtain the Engineer's prior approval for the siting of junctions of access roads with existing roads and shall comply with the Engineer's conditions of access particularly regarding clearance of obstructions to provide adequate sight lines, temporary drainage or culverts and the provision of signs and traffic control in addition to proper regular maintenance.

The provision of access roads shall not be measured for payment.

(e) Private Access Roads

Where private roads are to be used as access roads, the Contractor shall after consultation with the Owner or Authority having control of such road, carry out any repairs, alterations or additions to such roads as may be required to bring them to an acceptable condition suitable for traffic. Where materials from a borrow pit or quarry are hauled on private access roads, such roads shall be maintained properly to the satisfaction of the Engineer during borrow and quarry operations. No additional payment will be made for this work, and full compensation for maintaining private access roads used as haul roads will be regarded as being included in the bid rates and paid for in the various items of work where the materials are used.

3406 REINSTATING BORROW AND QUARRY AREAS AND HAUL ROADS**(a) Borrow and Quarry Areas**

On completion of their operations in borrow and quarry areas, the Contractor shall reinstate the entire area so as to blend it with the surrounding area and to permit the re-establishment of vegetation. For this purpose, the borrow area shall be shaped to even contours without any slopes being steeper than 1:3, except where the Engineer so permits in specified cases. In such cases the Contractor shall, if so instructed by the Engineer, construct berms and contour banks to prevent erosion.

Spoil from clearing and grubbing operations together with overburden shall be removed from the stockpile and spread over the borrow area. Material excavated under SUB-ITEM 36.01 (a) (excluding perishable or combustible material) may also be spread if approved by the Engineer. Topsoil shall then be removed from the stockpile and spread evenly. Where there is insufficient topsoil, the area shall be scarified along contours to reduce erosion.

The shaping and reinstatement of the borrow pit shall be done in such a manner that the borrow pit will be properly drained wherever practicable, and, where required, the Contractor shall place earth banks to divert surface water from the borrow area. If so directed, the borrow and quarry area shall be fenced off and provided with gates as specified in SECTION 5300, and topsoiled and/or hydro-seeded as specified in SECTION 5600.

The reinstatement of the borrow and quarry areas shall be to the entire satisfaction of the Engineer and the Contractor shall submit to the Engineer a signed certificate from the Landowner, or Legal Occupants of land or relevant Government Agency stating that the finishing-off complies with all necessary legal provisions. The Contractor's attention is drawn to the provisions of CLAUSE 1214 in this respect.

Should the Contractor fail to comply with the requirements for reinstating quarry and borrow areas, the Engineer shall assess the cost of carrying out the works by a third party to be deducted from the Contractor and advise the Employer accordingly.

(b) Haul Roads

Unless otherwise specified or instructed by the Engineer all haul roads shall be obliterated and their surfaces

scarified, earth banks shall be constructed to prevent erosion, and all damaged fences and other structures shall be reinstated.

Where materials from a borrow pit or quarry are hauled on private access roads, such roads shall be restored to their original condition to the satisfaction of the Engineer when operations at the borrow pit and quarry are completed, unless otherwise specified.

No additional payment will be made for obliteration, or restoration respectively, of haul roads or access roads to borrow pits or quarries. Full compensation for this work is regarded as being included in the bid rates and paid for elsewhere.

Should the Contractor fail to comply with the requirements of restoration for haul roads to their original conditions, the Engineer shall assess the cost of carrying out the works by a third party to be deducted from the Contractor and advise the Employer accordingly.

3407 DISPOSAL OF BORROW OR QUARRY MATERIAL

The Contractor shall not have the right to use material obtained from borrow pits or quarries for any purpose other than for the execution of this Contract. They shall not dispose of any such material whether processed or not either by sale or donation to any person without the authorisation of the Employer.

3408 MEASUREMENT AND PAYMENT

No separate measurement and payment will be made for procuring and providing borrow or quarry material, but it will be regarded as an obligation on the part of the Contractor to be covered by the contract prices paid for the various items of work for which the material is used as prescribed in these Specifications.

Such bid rates related to procuring and providing borrow or quarry material shall also include full compensation for all obligations, costs, activities and work as prescribed in SECTION 1200, including all necessary de-watering as well as for all supervision, labour, plant, tools and incidentals required, including all costs as may be necessary for conducting control tests on all materials, draining and protecting all borrow or quarry areas, and concluding all negotiations with Owners or Legal Occupants of land (except negotiations that are conducted by the Employer themselves) as specified. Separate payment will not be made for clearing, grubbing, stripping topsoil and removing overburden prior to utilising borrow pits and quarries. Nor will separate payments be made for reinstatement. The bid rates for procuring and utilising materials obtained from borrow pits and quarries shall include the Contractor's costs in complying with all such requirements.

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

**SECTION 3500: SELECTING AND
UTILISING MATERIAL FROM
BORROW PITS AND CUTTINGS**

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3501 SCOPE

This Section describes the selection of materials from borrow pits and cuttings for the various purposes for which they are required in the Works, stockpiling the materials excavated but which cannot be dumped directly where required, breaking down the material during the excavation process when it is processed on the road, or when special processing for breaking-down by crusher is required, controlling the moisture content, placing and compacting the soil and gravel layers and constructing the rock fills.

In addition, this Section describes the treatment of material recovered from existing pavements, and construction in restricted areas during rehabilitation work.

Unless inconsistent with the context, the provisions of SECTION 3500 relating to borrow pits or the material obtained from borrow pits shall apply with changes as required to such places where material is recovered from an existing road, and to the material recovered from an existing road respectively.

3502 SELECTING AND STOCKPILING MATERIALS

The Contractor shall use materials strictly in accordance with the purpose for which they have been approved. During their activities in borrow pits or cuttings, they shall ensure that approved materials are not polluted with unsuitable material or that approved materials are not unnecessarily wasted.

Unless otherwise directed by the Engineer, the Contractor shall so plan their activities that materials excavated from borrow area stockpiles, insofar as is possible, can be transported directly to and placed at the point where it is to be used. However, where utilisation of materials in this manner is impracticable, or if so instructed by the Engineer, materials shall be temporarily stockpiled for later loading and transportation to where it will be used. If, in the opinion of the Engineer, materials need to be stockpiled for the purpose of quality control or for mixing to become sufficiently homogenous, the Contractor shall carry out stockpiling as required to ensure proper quality control and to meet the Specifications consistently.

Stockpiling areas and maximum height and extent of

stockpiles shall be approved by the Engineer. Before any stockpiling of material may be done, the site shall be cleaned, and all material that may cause pollution shall be removed. The Contractor shall not use contaminated material. After the stockpiled material has been removed, the site shall be reinstated as closely as possible to its original condition, and the surface shall be lightly scarified to promote vegetation growth.

No separate payment will be made in regard to stockpiling of materials.

3503 BREAKING DOWN OVERSIZE MATERIALS

(a) Material from Cuts or Borrow Pits

The material from cuttings and borrow pits shall be broken down in the cuttings or borrow pits, alternatively in the road, to the maximum size specified for the respective layer where it will be used.

Spoil material need be broken down only sufficiently for convenient loading and transporting, but the Engineer may require sufficient material to be broken down to a maximum size of 500 mm with a view to effectively trimming the spoil areas.

Material intended for crushing need only be broken down sufficiently to permit acceptance by the crusher.

In order that the material can be broken down to the appropriate sizes, the Contractor shall adjust and control their blasting, ripping, excavating and other operations so that the desired result can be achieved as effectively as possible.

Care shall be taken not to load oversized material and to bring it onto the road. The Contractor shall, at their own cost remove such oversized material from the road or break it down further to the required size on the road.

If, in the opinion of the Engineer, the working methods of the Contractor are such that unnecessarily large quantities of oversized material are produced, the Contractor shall change their methods in order to produce less oversize material, and the material shall be broken down to the sizes as specified for each layer by using equipment suited to this purpose. The Contractor shall be at liberty to employ any methods and equipment they may prefer, but where any difference of opinion may arise in regard to the practicability of the breaking-down process or the suitability of the methods and equipment employed by the Contractor, the Engineer may require use of grid-rollers, pad-foot rollers or other equipment giving similar effect as a grid roller to be used on the road. The results so obtained will then serve as the norm of the degree to which the breaking-down shall be attained by any alternative methods. No separate payment will be made for breaking down material to the required size.

Where surplus oversize material is available and the Engineer so agrees, the Contractor, instead of breaking down any oversized materials may spoil it. The Engineer may also require oversize materials to be used for other purposes, such as for rock fills or rip-rap.

Any oversized material still remaining after processing in accordance with any of the processes described above shall be removed from the road.

The Contractor's attention is drawn to the risk of causing excessive breakdown of the finer fraction of the materials and thereby altering the properties of the material by inappropriate working methods or equipment. Any material which does not meet the requirements of these Specifications after compaction shall be replaced or made good on the Contractor's expense.

(b) Existing Cemented Layers

Existing cemented layers to be broken down and reprocessed may be reprocessed either on the road, or it may be hauled to a crusher for processing, whichever is specified or required by the Engineer.

(c) Crushing and Screening

Where the material intended for use in pavement layers cannot be suitably broken down by the methods set out herein, the Contractor shall use alternative sources or apply crushing or screening or both, as required to meet the Specifications. The crushing plant shall be capable of breaking down oversized material to the maximum size specified for the layer concerned.

No separate payment will be made for crushing or screening material to the required size unless specifically allowed for in the Special Specifications and the Bill of Quantities.

(d) Disposing of oversized Materials

All oversized materials removed from the road and all excess material removed from the road shall be disposed of at the Contractor's cost or may be used in the Works for other suitable purposes on the approval of the Engineer.

The bid rates for constructing all pavement layers shall include full compensation for the removal of oversized material without any additional payment being made to the Contractor.

Excavated material which is either unsuitable for use in the Works; or oversized; or is surplus to requirements, shall be disposed of in specially designated areas identified by the Contractor and approved by the Engineer. If necessary, the area shall be cleared and grubbed in accordance with the requirements of SECTION 3100 prior to the surplus soil or rock being deposited; spread in layers; and compacted to the approval of the Engineer. After compaction, the surface and slopes of the finished disposal area shall be trimmed to the satisfaction of the Engineer.

3504 CONTROLLING THE MOISTURE CONTENT OF MATERIALS

The Contractor shall take all necessary precautions to prevent material in borrow pits, excavations, stockpiles and unprocessed material on the road from becoming excessively wet as a result of rain or groundwater or storm water. Therefore, the excavation of borrow pits and cuttings shall be so planned and executed as to prevent the damming-up of water in the borrow pits or cuttings, and the Contractor shall also provide the necessary temporary drainage for this purpose.

Material that is too dry shall be mixed thoroughly with water until the required moisture content for compaction is achieved.

During the rainy season the Contractor shall take all necessary precautions to prevent material from becoming excessively wet. The methods may include, but are not restricted to, the following: spreading on the road with a proper cross slope and temporarily rolling with a flat-wheeled roller in order to improve water run-off, covering of stockpiles with tarpaulins, applying special measures to prevent water from damming up against material heaps or windrows.

Where material is too wet, for whatever reason, to comply with the requirements in regard to moisture content during compaction, the Contractor shall correct the moisture content of the material until it is adequately dry for compaction, by drying out the material, alternatively mixing with approved dry material, spoiling and replacing with drier approved material, or applying treatment with lime or cement.

No separate payment will be made in regard to measures for keeping material dry, nor for any measures for correcting the moisture content, nor for the addition of stabiliser for the purpose of using wet material. The Contractor themselves shall decide and submit their proposed method of work for the approval of the Engineer.

3505 LAYER THICKNESSES AND SPREADING OF MATERIALS**(a) General**

All material shall be placed in the correct quantity, and to the required grade, line and thickness, in a manner which prevents segregation and contamination of any kind.

The thickness of layers compacted in one operation shall not exceed the maximum that the equipment and method of operation can process to meet the requirements of the Specifications in terms of tolerances and density to the full depth of the layer.

The thickness of layers compacted in one operation shall not be less than the minimum that the equipment and method of operation can process without lamination unless special precautions are taken on the approval of the Engineer.

(b) Fill and Improved Subgrade Layers (G15, G7, DR)

The maximum layer thickness for fill or improved subgrade layers made of soils or gravel (G15, G7), compacted in one operation, shall be 200 mm (compacted thickness).

For rock fill (DR) the maximum compacted layer thickness shall be 1 metre except in areas where compaction plant is not accessible or is impracticable to use in the opinion of the Engineer.

The maximum particle size for all fill and improved subgrade layers shall not exceed one third of the compacted layer thickness. In order to prevent the layer thicknesses from being determined by the presence of isolated large fragments, the Contractor shall remove such isolated fragments as directed by the Engineer.

Where a new layer is constructed on an existing or already constructed fill or improved subgrade layer and the new layer will be less than 100 mm in compacted thickness, the existing layer shall be scarified to such a depth as will give a layer thickness after compaction of not less than 100 mm of the new plus the scarified material together. No additional payment will be made for this operation.

(c) Pavement Layers

The layer thickness shall comply with the requirements as indicated on the Drawings and in the Special Specifications or as directed by the Engineer.

Spreading material in restricted areas shall be done in a manner approved by the Engineer to comply with the required levels, grade, line and density to the full depth of the layer.

Where the thickness of any existing pavement layer requires to be supplemented and the thickness of the added material after compaction will be less than 100 mm, the existing layer shall be scarified to a depth that will give a layer thickness of at least 100 mm after compacting together the loosened existing and added material. In the case of gravel or crushed aggregate base course, the Engineer may direct the existing layer to be broken down to its full depth.

3506 COMPACTION OF MATERIALS

(a) General Requirements

Compaction shall be carried out in a series of continuous operations covering the full width of the layer concerned according to the Drawings. The Contractor shall reduce the length or width of any layer compacted in any single operation if the proper compaction or finish of such layer is not being achieved in the opinion of the Engineer.

The method of work, type of compaction equipment to be used and the amount of rolling to be done, shall be such as to ensure that the specified density and finish are obtained without damage being done to adjacent or lower layers or structures. During compaction the layer shall be maintained to the required shape and cross-section, and all holes, ruts and laminations shall be removed or repaired to the satisfaction of the Engineer.

Suitable equipment and methods acceptable to the Engineer shall be used in restricted areas so that the required densities will be obtained throughout the thickness of the layer. If necessary, the layers shall be placed in thicknesses that are less than the specified layer thickness.

Rock fill material shall be compacted with vibratory rollers to achieve a good mechanical interlock of the rock and the maximum compaction of the finer material in the spaces between the rock. The type of vibratory roller used, the operating speed, the number of passes and the layer thicknesses shall be determined after field trials and the proposed method shall be to the satisfaction of the Engineer.

(b) In-Place Reworking of Pavement Layers

Where so specified or instructed by the Engineer, and the material in any existing layer complies with the requirements for the new layer, the Contractor shall scarify the layer to the specified depth, add extra approved material if necessary, and reprocess the layer in place. Reprocessing includes watering, mixing, and compaction of the layer to the level, grade line, finish and density specified for the layer concerned. Payment will be made as determined for the respective pavement layers.

3507 DRAINAGE AND PROTECTION

The compacted layers shall be adequately drained and shaped to prevent water from standing on or along or causing damage to the completed work. Windrows shall be removed to facilitate the drainage of water from the surface.

No material for a subsequent layer may be placed if the underlying layer has been softened by excessive moisture and requires repair in the opinion of the Engineer.

3508 MEASUREMENT AND PAYMENT

No separate measurement and payment will be made for procuring and providing borrow material, selection, stockpiling and breaking down material from borrow pits and cuttings, nor for placing materials, adding water, drying, mixing and compacting the layers. It will be regarded as an obligation on the part of the Contractor to be covered by the contract prices paid for the various items of work for which the material is used as prescribed in these Specifications.

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

SECTION 3600: EARTHWORKS

- **RF** Rock Fill shall consist of predominantly blasted or crushed angular rock with fine material filling the voids between the rock particles to form a dense layer with minimum voids between the rocks and shall comply with grading limits provided under TABLE 3609/1.

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3601 SCOPE

This Section covers work in connection with the construction of cuts and fills, the removal to spoil of material unsuitable for use or surplus materials not required for fill, the construction and compaction of fills and improved subgrade layers with cut material from the road prism or borrow material from approved borrow pits, the compaction of the roadbed and finishing of cuts and fills, up to the stage where fills are ready for the placing of the pavement layers. The section also covers the widening of existing cuttings, fills and roadbeds.

This Section covers the requirements for the following types of material:

- **G15** natural gravel/soils with minimum CBR value of 15
- **G7** natural gravel/soils with minimum CBR value of 7
- **DR** Dump Rock consists of predominantly blasted or crushed angular rock (other than argillaceous rock), well graded. Dump Rock used in the uppermost 2.5 m of fill shall comply with the grading limits in TABLE 3602/2.

3602 MATERIALS

(a) General

Any test results provided in design documents such as the Materials Report, read in conjunction with these Specifications, may give a preliminary indication as to the purpose for which the cut material may be used as well as the treatment, if any, which the roadbed shall receive. Any test results or recommendations of method of work in the Material Report are solely for information. The Contractor shall undertake their own assessment and any tests required and submit their proposed methods of work and test results of all material they intend to use for the approval of the Engineer.

The material types (G15, G7, DR) given in the Drawings denote the minimum quality for a particular use in the Works, either specified in the Drawings or as instructed by the Engineer. In the cases where a minimum quality of earthworks material is not specified, the following guidelines shall apply and the Engineer's instruction shall be the standard to which materials quality control is applied:

Material type Typical use

G15	Upper improved subgrade layers and fill
G7	Lower improved subgrade layers and fill
DR	Fill in Swamp Area
RF	Rock Fill Embankment (Other than Swamp Area)

Irrespective of the minimum required quality specified or the above guidelines the highest quality of approved earthworks material available at economical haul distances, complying with the requirements of the Specifications and Drawings, shall be selected for fill or improved subgrade layers. Rock fill / Dump Rock materials (RF/DR) complying with the requirements of the Specifications shall be the preferred material type unless otherwise specified or directed by the Engineer.

(b) Material Requirements for Fill and Improved Subgrade Layers

Materials for earthworks shall be non-expansive soils or dump rock meeting the requirements given in TABLES 3602/1 and 3602/2.

TABLE 3602/1: REQUIREMENTS FOR FILL AND IMPROVED SUBGRADE LAYERS

Material properties	Material class	
	G15	G7
1) *CBR (%) BS 1377-2:2022	Minimum 15 after 4 days soaking	7 after 4 days soaking
CBR-swell (%) BS1377-2:2022	Maximum 1.5	Maximum 2
2) Plasticity index (%) BS1377-2:2022	Maximum 20	Maximum 25
Max. particle size BS1377-2:2022	1/3 of the compacted layer thickness but not > 75 mm.	
Maximum Compacted Layer Thickness	200 mm compacted thickness placed in one operation	
Minimum Compacted Layer Thickness	100 mm compacted thickness placed in one operation	
1. *CBR values are measured at the specified field density for the respective layer.		

TABLE 3602/2: REQUIREMENTS FOR DUMP ROCK (DR) IN FILL

Material Class: DR (Dump Rock)				
Depth within DR fill	Below 300 mm		Upper 300 mm	
Grading to BS EN 13383-2:2019	Dimension / Size (mm)	Percentage Passing	Sieve size (mm)	Percentage Passing
	500	100	75	100
	300	50 - 70	Crusher Run	
	20	0 - 5		
Maximum Los Angeles Coefficient (to EN 1097-2: 2022)	50		50	
Maximum Compacted Single Layer Thickness	1000 mm		200 mm	

3603 EXCAVATIONS

(a) Classification

i) General

This SUB-CLAUSE 3603 (a) sets out the criteria and assessment methods to classify all excavations for measurement and payment. The classification is valid for excavations of cuts, for structures, drains, services and for removal of unsuitable materials or any other excavations measured and paid for separately.

ii) Classification Criteria

The excavation of material shall be classified in accordance with TABLE 3603/1 for purposes of measurement and payment. Payment will be made for rock excavation only if one of the methods described under rock excavation is actually used for loosening the material.

TABLE 3603/1 CLASSIFICATION OF MATERIALS FROM CUT EXCAVATIONS

Classification	Description
Rock excavation	Rock excavation shall be excavation in material that requires drilling and blasting or the use of hydraulic or pneumatic jackhammers to be loosened sufficiently for loading and transportation.
Common excavation	Common excavation shall be excavation in all material other than rock as defined above, whether the material is suitable for use in the works, or to be spoiled and paid for as common excavation to spoil. The classification includes excavation in earthworks, or any pavement layers of an existing pavement not covered by a separate item in the Bill of Quantities regardless of the nature of the material excavated, other than rock excavation.

iii) Classification Assessment

The Engineer shall decide under which one of the above classes any excavation shall be classified for purposes of payment. In the event of a disagreement between the Contractor and the Engineer, the Contractor shall, at their own cost, make available such mechanical plant as required by the Engineer in order to determine whether or not the material can reasonably be removed. The decision of the Engineer as to the classification shall be final and binding.

The Contractor shall immediately inform the Engineer if and when the nature of the material

being excavated changes to the extent that a new classification for further excavation is warranted. Failure on the part of the Contractor to advise the Engineer thereof in good time shall entitle the Engineer to classify, at their discretion, such excavation as may have been executed in material of a different nature.

iv) Boulders

Individual boulders greater than one cubic metre in volume shall be classified as rock when their nature and size are such that, in the opinion of the Engineer, they cannot be removed without recourse to one of the methods described under rock excavation in TABLE 3603/1. Where a portion of excavation contains 50% or more by volume of boulders of this order, such portion shall be considered as rock excavation throughout.

(b) Dimensions of Cuts

The dimensions of cuts shall be in accordance with the details of the Drawings and may further be defined or amended during the course of construction by instructions from the Engineer. The Contractor shall obtain instructions beforehand from the Engineer regarding the slope of the sides of cuttings and the depth to which cuttings are to be taken, including the dimensions of any in situ treatment of cuts that may be required below the formation level. Cuts in soils shall be trimmed to a smooth finish to prevent the initiation of slope erosion.

In rock cuts, the rock shall be removed to the level that will permit the construction of the subbase layer, unless otherwise instructed.

The Contractor shall take proper care when excavating cuts not to loosen any material outside the specified cut line, whether by ripping, blasting or by other means. Care shall also be taken not to undercut any slopes, and proper control shall at all times be exercised by regular survey checking and by using batter poles at close intervals.

All cuts made outside the specified cut line or below the specified level without the approval of the Engineer shall be backfilled with approved material, compacted to the satisfaction of the Engineer and re-trimmed, all at the Contractor's own expense and in accordance with SECTION 7400.

The Engineer may, when they consider it necessary, instruct the Contractor to widen existing, completed or partly completed cuttings either uniformly or by altering the slope of the sides of the cutting, or by cutting benches, or in any other way.

(c) Utilisation of Excavated Material

i) General

As far as practical in the opinion of the Engineer, the material resulting from cuts, widening of cuts or other excavations in the road reserve shall be utilised for construction of earthworks or pavement

layers depending on their quality. The Engineer's approval to use any material does not indemnify the Contractor with regard to their obligations to fulfil all requirements of the Specifications in respect of the quality of materials for earthworks or pavement layers.

The Contractor shall plan their operations in such a manner that all cut material may be used to the best advantage of the Employer. This would mean that no material shall be unnecessarily spoiled, borrowed or hauled. The Contractor shall neither borrow nor spoil any material without the Engineer's approval and without satisfying the Engineer that this is necessary and the most economical method of constructing the Works.

Material which will not be used in the pavement or earthworks due to quality or other reasons may be stockpiled for future use as topsoil or side fill as required by the Engineer.

ii) Conservation of Topsoil

Topsoil encountered in excavations shall be conserved as described in SECTION 3100 where directed by the Engineer. No additional payment will be made for the conservation of topsoil.

3604 PREPARATIONS OF THE ROADBED

(a) Shaping and Compaction of The Roadbed on Suitable Material

The existing ground beneath embankments prior to their construction or the ground at the bottom of cuttings prior to construction of pavement layers shall have a density not less than 90% of the maximum dry density in case of embankment or 95% of the maximum dry density in case of subgrade, determined in accordance with BS 1377-2:2022.

In-situ material that is classified as suitable material but with a density not less than 90% of the maximum dry density in case of embankment or 95% of the maximum dry density in case of subgrade, determined in accordance with BS 1377-2:2022 shall be scarified to a minimum depth of 200mm, watered and re-compacted to the specified density.

(b) Removing Unsuitable Material

Materials from swamps, marshes and bogs, organic soils, debris from maintenance/ dismantling works, or material that is sufficiently wet and soft to prevent it from being trafficked or excavated, complying with any of the following properties shall be treated as unsuitable material.

- i. Organic soils such as peat materials from swamps, marshes and bogs that contain an excessive number of logs, tree stumps and other perishable material falling below A-line of plasticity chart classified as OL, OI, OH, or Pt and tested in accordance with BS 1377-2:2022 and BS 1377-3:2018+A1:2021;
- ii. Debris from maintenance/ dismantling works, contaminated material from erosion of previous maintenance works;
- iii. Material having a liquid limit exceeding 50% and plasticity index exceeding 25%; (Depth of material to be replaced shall be determined by Swell Pressure test results obtained from third party testing);
- iv. Material having a 4 days soaked CBR value less than 3% achieved at 90% MDD determined by BS 1377-2:2022.
- v. Materials with salts resulting in leaching in the embankment.

vi. Any material that is sufficiently wet and soft to prevent it from being trafficked or excavated by normal bulk earth-moving equipment; and

vii. However, the Engineer may, at his sole discretion, instruct other types of materials that he considers unsuitable to be removed and paid for as unsuitable. Other unsuitable materials include trash, rubble, wood, debris, non-regulated industrial waste, etc.

(c) Expansive Soil

An expansive soil is defined as a type of soil that undergoes a large change in the volume with change in water content. The strength of expansive soil is very high in a dry state, but with an increase in water content, the strength reduces rapidly.

If the soil falls into any of the categories as given in CLAUSE 3604 (b), Activity of the soil shall be checked. The Activity of soil is an indication of the swelling and shrinkage characteristics of the soil.

Any roadbed material that the Engineer considers to be of a quality that would be detrimental to the performance of the completed road shall be removed to such widths and depths as instructed, and shall be disposed of as prescribed. The excavated spaces shall then be backfilled with approved material and compacted according to the Specifications.

For roadbed material that the Engineer considers to have high swelling potential the Contractor shall carry out plasticity and hydrometer tests according to BS 1377-2:2022 and determine the Activity defined as:

$$\text{Activity} = \frac{PI}{(C - 10\%)}$$

Where:

PI = Plasticity Index

C = Percentage of clay size finer than 0.002 mm, where C>10

Material with very high swelling potential as defined in TABLE 3604/1 shall be considered detrimental for the performance of the completed road and must be replaced or stabilised in accordance with SECTION 3800 or covered by geo-grid or similar crack arresting measures as instructed by the Engineer.

TABLE 3604/1: SOILS WITH HIGH SWELLING POTENTIAL

Percent Clay Sizes (<0.002 mm)	Very High Swelling Potential
10	Activity >7
20	Activity >3
30	Activity >2
40	Activity >1.5
50	Activity >1.1
60	Activity >0.9
70	Activity >0.7
80	Activity >0.6
90	Activity >0.5

The soil exhibiting very high swelling potential shall be tested for the swelling pressure test. The swell potential and swell pressure of a soil specimen can be determined by any of the three methods specified by ASTM D4546-21.

(d) Wet Material

The Engineer may order that roadbed material which is too wet to provide a stable platform for the construction of the embankment be removed to such widths and depths as they may instruct and be replaced with approved dry material and compacted according to the Specifications. Payment for this work will only be made if

the Engineer is satisfied that the high moisture content is not a result of inappropriate or insufficient measures by the Contractor to protect the roadbed from getting wet and that drying of the material could not be done with reasonable efforts and within a reasonable time, all in the opinion of the Engineer.

No payment will be made for replacing material, should the material become unstable after exposing it to traffic (public or construction traffic).

(e) Preparing and Compacting the Roadbed

i) Compaction

Unless otherwise instructed by the Engineer the roadbed shall be scarified, watered and compacted to a density and depth according to the Drawings and the Specifications or as directed by the Engineer. If necessary, roadbed material may have to be temporarily bladed off to windrow in order to achieve the necessary depth of compaction. No separate payment will be made for any such operations or alternative techniques to achieve the specified depth and degree of compaction. The Contractor shall carry out field trials as required by the Engineer to show that their proposed method and equipment for processing and compaction of the roadbed give the desired result in accordance with the Specifications and to the satisfaction of the Engineer.

ii) Adjustment of Levels

Where any additional material has to be imported to obtain the required level and layer thickness, and where the thickness of the layer of imported material would be less than the specified layer thickness after compaction, then the roadbed material shall be scarified, the necessary imported material placed, and this combined material mixed and compacted to the full specified depth of the layer. No separate payment will be made for such operations.

Rock or hard material

Wherever shown on the Drawings or as may be directed by the Engineer, the roadbed shall be treated in situ by undesirable formations of hard or rocky materials being broken down in order to achieve a uniform standard of subgrade compaction and strength, or to prevent water-logging and improve drainage.

After ripping or blasting, the material shall be processed as follows:

- Where the Engineer instructs the Contractor to rip the in-situ material, the whole of the material shall be sized by rolling or breaking until the maximum dimension of any clod or spall is not more than one-third of the thickness of the layer in order to achieve a uniform standard of subgrade compaction corresponding to maximum dry density as determined by BS 1377-2:2022 and strength. The thickness of the layer after compaction shall be 250 mm.
- Where the Engineer instructs the Contractor to blast the in-situ material, the whole of the material shall be processed as directed by the Engineer.
- Remove all loose rock from the surface.
- Excavation in solid rock shall be minimum 250mm below the bottom level of the sub-base unless otherwise agreed with the Engineer.
- Rock shall be undercut neatly to the required elevation and sections as shown on the Drawings or as directed by the Engineer.

- Transverse and longitudinal profile checked by cross section template shall be accurate to the Specifications.
- All rock surfaces shall be prepared so that water cannot accumulate at any point. The excess cut material shall be placed in embankments or disposed of at the direction of Engineer.
- A layer of upper Improved Subgrade G15 material to be laid after the bed level is achieved. The fill material shall be a minimum of 250 mm compacted in accordance with 95% of the maximum dry density as determined by BS 1377-2:2022.
- The unit of measurement for the compacted fill material shall be paid as a cubic meter under relevant pay ITEM 36.02 (a) in accordance with the Drawings or as directed by the Engineer. The quantity measured shall be computed by the method of average end areas from levelled cross-sections. The levelled cross-sections shall be prepared from the ground line prior to the construction of the fill after corrections for the instructed depth of the removal of loose rock and the instructed depth of any excavation and preparatory roadbed treatment specified or ordered by the Engineer.

In both cases surplus material arising from bulking after treatment in place shall be removed and disposed of, or utilised elsewhere, as directed by the Engineer.

(f) Draining and Protecting the Roadbed

The Contractor shall take all necessary precautions to ensure that the roadbed is kept drained. In the cases where the roadbed needs to be kept moist due to the presence of expansive soils they shall carry out watering and timely dumping and spreading of the following layers as required to the satisfaction of the Engineer. No separate payment will be made for any such operations or adjustments of schedules to fulfil such requirements.

Waterlogged roadbed, such as saturated material overlying less pervious strata, shall first be drained by the installation of all permanent surface or subsoil drainage shown on the Drawings, or as directed by the Engineer, before any other construction may be started on these sections. Such drains shall be constructed, measured and paid for in accordance with the requirements of SECTION 2100.

(g) Expansive Soils Treatments

The overburden/load on the expansive soil should be calculated. If this load/overburden on the swelling soil is greater than the swelling pressure of the soil then no treatment is required. The difference of swelling pressure and overburden/load on the expansive soil below the ground level shall be countered/neutralised by providing sufficient overburden pressure i.e. either raising the height of embankment or by increasing the depth of replacement below Ground Level with a suitable backfill material.

After the excavated material has been replaced with non-expansive material in 250mm lifts and compacted to 95% of MDD in accordance with BS 1377-2:2022, the road shall be brought to finished level, with a side slope of 1:2 or as indicated in the Drawing. All other requirements for pavement layers shall be complied with as specified. The stockpiled expansive soil excavated as directed shall be utilized in turfing the slopes and be paid under relevant pay ITEM 56.03 (c) as topsoil obtained from within the road reserve.

The excavated area shall be backfilled with a non-expansive material having the following properties:

- Plasticity index 10-25 %;

- Liquid Limit 25-45 %;
- Material passing the 75µm sieve less than 15 %; and
- CBR value greater or equal to 5% and compacted to a density of 93% of Heavy MDD in accordance with BS 1377-2:2022.

If so specified in the Special Specification or directed by the Engineer particular remedial measures shall be taken to reduce the risk of future damage to the road caused by swelling or shrinkage of expansive roadbed material. If cost considerations prohibit full replacement of the expansive soils, the remedial measures should aim at providing nearest possible constant moisture content over the full width of the carriageway below the embankment. The remedial measures may include one or more of the following:

- Replace the upper layer of the expansive soil, i.e. the zone where the largest proportion of the volumetric changes takes place, this shall be done with respect to swelling pressure to be counteracted;
- Provide wider paved shoulders to move the zone of seasonal changes in moisture content further away from the roadway;
- Provide embankment with a minimum height of about 1 m and with side slopes of 1:4 or flatter,
- Provide an impermeable membrane in the full embankment width under the pavement and a sandy drainage layer on top of the membrane; and
- Chemical stabilisation, normally by use of Cement /lime/Fly Ash, to counteract volumetric changes in the expansive soils, but although this is technically possible it requires careful appraisal of the associated construction costs as well as the potential practical problems in admixing stabilisers into deep layers of clayey soils.

(h) Capping or Selected Layers

Where shown on the Drawings or as instructed by the Engineer, a capping or selected layer(s) shall be constructed over weak or poor-quality sub-grade in cut or fill situations using material complying with the requirements as specified except that it shall have a minimum CBR of either 7% for lower capping layer and 15% for upper capping layers as defined in the Drawings. The capping layer shall be constructed in accordance with the requirements as specified.

Where any additional material has to be imported as a capping layer to achieve the required subgrade strength and level, this material shall be placed and compacted to a minimum 93% or 95% of modified AASHTO density as required in accordance with AASHTO T 180-22 and the layer thickness as specified.

Where the specified layer thickness is less than the thickness required to achieve the specified compacted density, strength and thickness (normally 150mm) then the underlying material shall be scarified; the necessary imported material placed; and this combined material mixed and compacted to the full specified depth of the layer to achieve the required level and density.

The capping or selected layer shall be considered as a relatively inexpensive option to strengthen the sub-grade and may also be used to protect the road formation during construction.

(i) Protection of Earthworks

This Clause covers all work in connection with the protection of earthworks (including, excavations, embankments, slopes, roadbed and/or subgrade) from the effects of weather.

The compacted layers of fill and the bottom of excavations shall be adequately drained and shaped to prevent free water from standing on or scouring the completed layer(s) or the in-situ material. Any windrows

or ridges, which will impede the free drainage of water, shall be removed from the surface. No fill material for a succeeding layer shall be placed if the underlying layer has been softened by excessive moisture.

All permanent drains, plus additional necessary temporary drains, shall be constructed as soon as possible to protect the earthworks. Ruts, potholes and other damaged sections of earthworks and slopes, shall be rectified. Drains shall be constructed so as to avoid damage to embankments from erosion.

Any runnels or erosion channels, that develop during the Contract period, shall be backfilled with suitable materials, and the areas reinstated. The Contractor shall not allow erosion to develop on a large scale before effecting repairs and all erosion damage shall be repaired as soon as possible.

3605 EMBANKMENTS

(a) General

Embankments shall be constructed to comply with all requirements in the Specifications and Drawings or as further instructed or amended by the Engineer in respect of dimensions of embankments, installation of subsoil drainage or other structures, work method, such as benching or roadbed preparation. Before the start of construction, the Contractor shall submit plans showing their proposed method of work, the selection of materials, the method of compaction, and any other matter that may affect the construction of the embankment or sequence of operations.

All material used for the construction of embankments shall meet the requirements of CLAUSE 3602 and shall be selected so that the minimum required quality of material is used in the respective positions of the embankment according to the Drawings and the Specifications. The density of embankment layers shall comply with the requirements of CLAUSE 3606. Materials with properties given in CLAUSE 3604(b) shall be considered unsuitable for embankment construction.

Embankment shall be placed in successive layers parallel to the final road surface, and the construction of wedge-shaped layers shall be restricted to the bottom layers of embankment where this may be unavoidable on account of cross-fall, the tapering out of embankments, or the superelevation of the final road surface.

(b) Materials for Earthworks Layers

Materials for earthworks layers shall meet the requirements as set out in CLAUSE 3602 in respect of the specified respective material types given in the Drawings or as directed by the Engineer. The better soil qualities shall be selected where alternative fill materials all meet the minimum material requirements. In the situation where material quantities are limited, the better-quality materials shall be used in the upper layers. Dump Rock shall in the cases where instructed by the Engineer be the type of material for earthworks. Under special conditions, such as where a near impermeable material is desirable, the Engineer may instruct that Dump Rock is not to be used in the earthworks.

(c) Benching

Where the natural cross-fall of the roadbed or existing or already constructed embankments exceeds 1:6, the fills shall be bonded to the roadbed by means of benches excavated in the roadbed or existing embankment. Where the existing fill is loose on the outside and shows inadequate compaction, benches shall be cut back further than may be necessary to accommodate construction equipment until adequately compacted material is found.

Benches in rock shall be jagged to give sufficient resistance to slippage.

The dimension of benches as well as the extent to which existing fills have to be cut back to form benches shall be subject to the Engineer's approval. The benches shall be wide enough to accommodate sufficiently effective compaction equipment.

The measurement and payment for benching will be made under the normal payment items for fills and no additional payments will be made for benching.

(d) Constructing Pioneer Layers on Unstable Ground

Where fill is to be constructed across waterlogged or soft ground exhibiting excessive movement under normal compaction equipment and haulage trucks, and such conditions preclude the effective compaction of the bottom fill layers, the Engineer may direct that a pioneer layer be constructed on the unstable ground. This layer shall be constructed by placing suitable coarse material in a uniform layer with a thickness sufficient to provide a stable working platform for constructing the further fill layers which are to be compacted to a controlled density.

Where dump rock has been used as a pioneer layer, the pioneer layer should be compacted (pushed into the underlying material) by tracking with heavy equipment such as dozers, tracked excavators or loaded dump trucks until there is no discernible movement. The pioneer layer shall then be blinded with rock material to fill up the voids within and shall be vibrated using a heavy vibrating compactor until there is no discernible movement.

Payment for the pioneer layer and blinding material will be paid for under SUB-ITEMS 36.02 (h) and (j) respectively

(e) Sand Filter Blankets and Geotextiles

Sand, which for the purposes of this requirement is specified as non-plastic sand with not less than 95% passing through the 4.75 mm sieve, but with no more than 20% passing through the 0.075 mm sieve, shall be compacted to 100% of density. Should more than 20% pass through the 0.075 mm sieve, the sand shall be compacted to 95% of modified AASHTO density.

To ensure effective filtration, the geotextile's apparent opening must be carefully chosen based on the soil's effective particle size

At the bottom of fills, and sometimes at intermediate levels, the construction of sand filter blankets may be required to facilitate the drainage of fills and to separate layers of materials where there is a risk of undesirable infiltration of fine material into the coarse material. Sand filter blankets shall be constructed in accordance with the details on the Drawings and shall consist of a layer of selected sand with suitable grading to provide effective drainage and to prevent the infiltration of fill or roadbed material into the sand filter blanket.

The sand filter material shall meet the requirements given in SUB-CLAUSE 2104 (a) (ii), however the requirements with reference to the slot size of drainage pipes shall only apply where drainage pipes are to be constructed adjacent to the sand filter material.

The surface on which the sand filter blankets are to be constructed, shall be smooth and even and the sand shall be spread evenly to the required thickness and be given a light compaction with suitable rollers. The final surface of the sand filter blanket shall be finished off true to line and level. The Engineer may require the layers immediately below and above the filter blanket to be constructed from selected soil or gravel.

Geotextiles, where specified, shall meet the requirements given in TABLE 3605/1. The fabric shall not be exposed to direct sunlight for prolonged periods and shall be protected from mechanical damage during installation and construction.

Separate payment for the construction of sand filter blankets or specially selected gravel to be placed in conjunction with the construction of sand filter blankets will only apply as an extra over rate to the layer in question on the approval of the Engineer.

TABLE 3605/1: REQUIREMENTS FOR GEOTEXTILES (SWAMP TREATMENT)

Aggregate placed adjacent to the geotextile		Geotextile, weight per area of the geotextile material (g/m ²)	
Aggregate type	Maximum particle size, d _{max}	Placed on firm, dry subsoil 1)	Placed on soft, wet subsoil 2)
Gravel, sand or graded, crushed material:	Maximum 50 mm	Minimum 140	Minimum 200
Sorted crushed rock:	Maximum 200 mm	Minimum 200	Minimum 320
Dump rock (DR), unsorted:	-	Minimum 320	Special reinforcement shall be considered
1) Dry subsoil refers to moisture contents below OMC of BS-Light according to BS 1377: PART 2 2022.			
2) Soft, wet subsoil is silty or clayey materials in waterlogged areas or as defined by the Engineer.			

(f) Placing of Rock Fill (DR)

Rock material containing particles larger than two thirds of the compacted layer thickness shall not be used in the fill unless otherwise authorised by the Engineer.

The Contractor shall, by the judicious planning of the operation by selecting the smaller sized material for placing in the thinner fill layers, avoid unnecessary spoiling of the larger sized rock material and shall ensure its fullest practicable utilisation in fills.

(g) Construction of High Fills

The Contractor shall make allowance for all required measures, special techniques and scheduling of work to prevent the development of excessive pore pressure and to ensure the stability of high fills during and after construction where such measures are required in accordance with the Special Specifications or as directed by the Engineer. No separate payment will be made for any special measures taken in conjunction with the construction of high fills.

(h) Constructing Rock Protection at the Toes of Fills

Where required, the toes of fills shall be protected against erosion by special rock protection, which shall be installed as shown on the Drawings and as further directed by the Engineer, by the outer part of the toes of fills being constructed from assorted boulders and/or blasted rock, as described below.

The rock protection shall be constructed simultaneously with the rest of the fill and shall consist of selected durable rock material varying in size between 150 mm and 750 mm. If required, a layer of approved geotextile filter shall be installed at the interface between the normal fills and the rock protection.

The outer part of the rock protection shall consist of larger boulders properly bedded by means of smaller fragments so as to form a stable interlocking rip-rap surface. The rock protection shall otherwise be constructed and compacted as rock fill as described in the SPECIFICATIONS.

(i) Widening of Fills

Where existing fills are to be widened, the existing fill slope and the roadbed onto which the new fills are to be constructed shall be cleared and grubbed as instructed by the Engineer. The clearing and grubbing shall be done in accordance with the provisions of SECTION 3100. The new roadbed shall be treated in accordance with CLAUSE 3604.

Where existing fills are required to be widened or where already constructed fills are required to be widened or flattened, it shall be done by bench construction in order to form a bond. The benches shall not be deeper than the layer thickness prescribed for constructing the widening, depending on whether or not un-compacted fill material occurs in the side of the existing fill. The benches shall extend into the properly compacted portion of the original fill material to the satisfaction of the Engineer.

All suitable material from the benches shall be used in the construction of the widened section of the fill. Unsuitable material shall be removed as instructed by the Engineer. Benches shall be compacted together with the fill widening during the construction of the fill.

Where existing fill consists of rock, the new fill (widened part) section shall consist of rock fill unless otherwise approved by the Engineer.

Where required in accordance with the Special Specifications, or as instructed by the Engineer, special measures shall be taken to prevent differential settlements where high fills are being widened. Such measures may include the use of material from the existing fill in the construction of the widened part of the new fill or alternative measures as directed by the Engineer. If specified in the Drawings or as instructed by the engineer, for the construction of the combined upper layers, where it is required as specified or as instructed by the Engineer to mitigate differential settlement between existing road embankment and the new widened section; a multi-axial geogrid of minimum tensile strength 30 KN/m shall be applied above the section to straddle across the interface of the existing embankment and the new widened section. A single layer or more as specified shall be applied to such a width as to anchor over the existing embankment to the extent of at least 1m or 0.7H (where H is the height of the widened embankment elevation. The geogrid shall extend through the entire layer of the widened embankment. Where multiple layers are used, they should be placed in such a way as to coincide with the layers of compaction; as specified multiples or as required by the engineer. Unless otherwise stated in the Special Specifications and the Bill of Quantities, no additional payments will be made for employing such techniques in the widening of fills, and payment will be made under the normal payment items for fills.

(j) Embankment Construction in Swamps

i) General

The design Drawings for embankment in swamps should contain the details of subsurface profile at the swamp location showing the thickness of soft strata, consistency of soil, strength parameters, type of treatment to be done, depth of treatment to be done, extent of treatment, anticipated settlement, anticipated time for settlement to be completed, maximum anticipated depth of water above ground level, type of fill to be used. The

construction methodology of embankment shall be submitted by the Contractor for approval of the Engineer. This shall be supplemented by any additional geotechnical investigations instructed by the Engineer in accordance with SECTION 7100. Different ground improvement methods and techniques that can be used are given in SECTION 3600A.

In swamp locations settlements are expected, to help in maintaining the final top width, in addition to the designed cross-section can be an extra width of 1.00m–2.00m up to the G7 top level followed by maintenance of the design cross-section can be constructed.

The construction in swamps must ensure a well-functioning drainage structure within the swamp to give a proper guide on the level of water within the swamp. It is essential that construction works at swamps is carried out as early as possible in order to allow settlement and consolidation to take place before construction of pavement layers. The pavement layers shall be placed only after the settlement vs time graph becomes asymptotic and there is no further settlement is observed.

Construction methodology of embankment shall be submitted by the Contractor for approval of the Engineer. The construction methodologies shall involve: total excavation of the compressible soils, displacement of the soft material with rock fill, pre-loading with higher embankment, installation of vertical drains or combination of pre-loading and vertical drains, incorporation of geosynthetics and geotextiles.

Construction of embankments across swamps and other waterlogged or low-lying areas will require special techniques to prevent differential settlements especially where the existing embankment is to be widened.

Two different techniques may be employed when constructing the embankments across swamps and wetlands as directed by the Engineer:

- In shallow swamps where tracked earthmoving plants can operate without getting stuck, the soft material shall be removed by a tracked earthmoving plant and immediately be replaced with G7 material.

Where filling takes place under the water table, the fill materials shall be selected, well-draining sandy and gravelly materials, having a maximum percentage passing the 0.075 mm sieve of 15 % and a maximum Plasticity Index of 25%. This layer is to be constructed by dumping and spreading successive loads of material in a uniform layer thickness just sufficient to provide a stable working platform for the construction of further fill layers above the water table which are to be compacted according to the Specifications. The stable working platform shall be compacted using light compaction equipment which will give the most effective compaction without over-stressing the material. Light hauling equipment shall be used when driving on top of this stable platform as instructed by the Engineer.

The fill placed under the water table cannot be compacted to the normally required density for fill, and will be allowed to settle under the dead weight of the embankment, until the movements in the surface of the embankment have diminished.

- In swamps where the above technique cannot be used due to the thickness of the soft and unsuitable material, the embankment shall be

constructed using the displacement method. In this method the excavation of soft and unsuitable materials shall be done by a tracked excavator, followed by end-tipping G7 material up to a height above the water-table which can provide a stable working platform for the construction of further fill layers up to the top of the embankment. The end-tipping of the G7 material shall be done before soft or unsuitable material flows into the excavation for the embankment. The inflow could possibly be reduced by excavating outside the boundary of the material to be backfilled.

The stable working platform shall be compacted using light compaction equipment which will give the most effective compaction without over-stressing the material. Light hauling equipment shall be used when driving on top of this stable platform as instructed by the Engineer.

The fill material under the water table shall be selected, well-draining sandy and gravelly materials, having a maximum percentage passing the 0.075 mm sieve of 5 % and a maximum Plasticity Index of 6%. It is not expected that it will be possible for the excavator to excavate all soft materials as similar ground will be flowing into the excavation. However, as the soft material has a very low strength, which has been further reduced by the excavation operation, the soil is expected to be displaced by the dead weight of the embankment.

The operation shall move along the existing embankment and displace the soft and unsuitable material in an outgoing direction. Displacement without excavation by the excavator will not be permitted due to the risk of leaving highly compressible material below the embankment soil.

The fill above the water table shall be compacted according to the Specifications, whereas the fill placed under the water table cannot be compacted to the normally required density for fill, and will be allowed to settle under the dead weight of the embankment.

The slope of the embankment sides in swamps where this technique is employed shall be increased to 1 in 4.

After construction of the embankment, the Contractor shall carry out auger drillings through the constructed embankment and into the in-situ subsoil below the fill at intervals not exceeding 40 square metres. The Engineer may at their discretion instruct further auger drillings at no additional cost. The findings shall satisfy the Engineer that all soft materials such as peat and soft clay have been excavated/displaced by the embankment soil. Any sections not constructed to the satisfaction of the Engineer shall be reworked.

Swamps can be classified as either seasonal or permanent. Methods/Techniques for the construction of embankments in swamps are suggested below.

ii) Seasonal Swamps

Seasonal swamps can be defined as swamps where there is no standing water during the dry season. Construction at these locations, and other waterlogged areas should, preferably be carried out during the dry season. The Contractor at his own expense shall keep the whole of the Works free from water and shall provide all dams, cofferdams, pumps, piles, shoring, temporary

drains, sumps etc. necessary for this purpose prior to taking up of work in a seasonal swamp location.

Case 1: Soft Material (Not Encountered)

All material used for the construction of embankments in seasonal swamps shall meet the requirements of CLAUSE 3602 and shall be selected so that the minimum required quality of material is used in the respective positions of the embankment according to the Drawings and the Specifications. The density of embankment layers shall comply with the requirements of CLAUSE 3606.

Embankment shall be placed in successive layers parallel to the final road surface, and the construction of wedge-shaped layers shall be restricted to the bottom layers of embankment where this may be unavoidable on account of cross-fall, the tapering out of embankments, or the superelevation of the final road surface.

Case 2: Soft Material (Encountered) Without Water Table

If required the soft material shall be removed to the depth as specified in the Drawings or as directed by the Engineer with the help of tracked earthmoving equipment. After removal of soft material to the required depths, a minimum of 250 mm thick pioneer layer shall be laid to facilitate the movement of equipment. The stable working platform shall be compacted using light compaction equipment which will give the most effective compaction without over-stressing the material. Light hauling equipment shall be used when driving on top of this stable platform as instructed by the Engineer. If and as specified in the Drawings a single or multiple layer geo-grid layer in accordance with SECTION 3600A or as instructed by the Engineer shall be laid above the pioneer layer or at the bottom of fill to uniformly distribute the load to the ground.

Further, material of desired quality as specified in the Drawings/ Specifications shall be dumped, spread in successive loads in a uniform layer thickness and compacted sufficiently to provide a stable working platform for the construction of further fill layers above the water table to meet the requirements of CLAUSE 3602.

Case 3: Soft Material (Encountered) With Water Table

If in case filling has to be done below water table after removal of soft material, use of Dump rock (DR) shall be preferred as desired quality of material to be used. The rock must be compacted (pushed into the underlying material) by tracking with heavy equipment such as dozers, tracked excavators or loaded dump trucks. Dumped rock Compaction should continue until there is no discernible movement. More rock can then be dumped and similarly compacted until one reaches 300 mm above the anticipated water level. "Crusher run" material shall then be placed on the top of dumped rock so that voids in the top of the dumped rock are filled. This shall be vibrated into the underlying voids using a heavy vibrating compactor until there is no discernible movement. If indicated in the Drawings a non-woven geotextile layer shall be laid over the crusher run material. Any fill required in excess of the Rock fill would be done using proposed fill material as stipulated in the contract document. If and as specified in the Drawings a single or multiple layer geo-grid layer in accordance with SECTION 3600A or as instructed by the Engineer shall be laid above the pioneer layer or at the bottom of fill to uniformly distribute the load to the ground.

The fill placed under the water table cannot be compacted to the normally required density for fill, and will be allowed to settle under the dead weight of the embankment, until the movements in the surface of the embankment have diminished.

iii) Permanent Swamps

Permanent swamps can be defined as swamps where there is standing water throughout the year when there is a well-functioning drainage system in place.

- In shallow swamps where tracked earthmoving equipment can operate without getting stuck, dewatering shall be carried out as directed by the Engineer. The soft material shall be removed by tracked earthmoving equipment. After the removal of soft soil, a pioneer layer will be laid to facilitate the movement of equipment. If indicated in the Drawings a geogrid layer shall be laid at the top of the pioneer layer to uniformly distribute the load of embankment fill to the ground. Immediately G15/dumped rock material shall be placed and compacted to the required density. This G15/dumped rock should be laid up to the water level. If G15 material is used then Stone pitching should be done along the slope up to 0.60 m above the high-water level. The embankment above the high-water level shall be constructed using G7 material.

Filling takes place under the water table, the fill materials shall be selected, well-draining sandy and gravelly materials, having a maximum percentage passing the 0.075 mm sieve of 15 % and a maximum Plasticity Index of 25%. This layer is to be constructed by dumping and spreading successive loads of material in a uniform layer thickness just sufficient to provide a stable working platform for the construction of further fill layers above the water table which are to be compacted according to the Specifications. The stable working platform shall be compacted using light compaction equipment which will give the most effective compaction without over-stressing the material. Light hauling equipment shall be used when driving on top of this staple platform as instructed by the Engineer.

The fill placed under the water table cannot be compacted to the normally required density for fill, and will be allowed to settle under the dead weight of the embankment, until the movements in the surface of the embankment have diminished.

In swamps where the above technique cannot be used due to the thickness of the soft and unsuitable material, the embankment shall be constructed using the displacement method. In this method the excavation of soft and unsuitable materials shall be done by a tracked excavator, followed by end-tipping G7 material up to a height above the water-table which can provide a stable working platform for the construction of further fill layers up to the top of the embankment. The end-tipping of the G7 material shall be done before soft or unsuitable material flows into the excavation for the embankment. The inflow could possibly be reduced by excavating outside the boundary of the material to be backfilled.

When using G15/G7. There is a need to add an extra 1m both sides up to at least 0.5 m above the existing ground surface for proper compaction or as guided by the engineer

The stable working platform shall be compacted using light compaction equipment which will

give the most effective compaction without over-stressing the material. Light hauling equipment shall be used when driving on top of this staple platform as instructed by the Engineer.

The fill material under the water table shall be selected, well-draining sandy and gravelly materials, having a maximum percentage passing the 0.075 mm sieve of 5% and a maximum Plasticity Index of 6%. It is not expected that it will be possible for the excavator to excavate all soft materials as similar ground will be flowing into the excavation. However, as the soft material has a very low strength, which has been further reduced by the excavation operation, the soil is expected to be displaced by the dead weight of the embankment.

- In swamps where the above technique of dewatering cannot be used due to the larger depth of standing water, the embankment shall be constructed using the displacement method.

The first operation is to remove as much poor material (such as black cotton soil) as possible using a large-tracked excavator. Ideally, all poor material should be removed down to a more stable material. However, this may not be possible given the limitations of the machinery being used. When widening an existing embankment, care must be taken not to destabilise the existing road structure by excavating too close to it.

The second operation is to tip the Rock fill. No compaction will be possible until the top level of the rock is near the water level. The rock must then be compacted (pushed into the underlying material) by tracking with heavy equipment such as dozers, tracked excavators or loaded dump trucks. Compaction should continue until there is no discernible movement. More rock can then be dumped and similarly compacted up a top level nominally 0.3 m above the anticipated water level with a well-functioning drainage system in place. Payment for this rock will be made under SUB-ITEM 36.02 (i).

The third operation is to blind the rock with a "crusher run" material so that voids in the top of the rock fill are filled. This shall be vibrated into the underlying voids using a heavy vibrating compactor until there is no discernible movement. Further crusher run material can then be dumped and similarly compacted until the top level is nominally 0.6 m above the high-water level. Payment for this crusher run will be made under SUB-ITEM 36.02 (j). There is no specified grading for this material other than a maximum particle size of 75 mm. The Contractor shall submit a sample of the proposed material to the Engineer for approval prior to use.

If indicated in the Drawings a non-woven geotextile filter fabric may be laid on the blinded rock prior to filling or pavement construction. Payment for this geotextile will be made under SUB-ITEM 36.02 (k). The embankment above the crusher run material shall be constructed using G7 material.

The operation shall move along the existing embankment and displace the soft and unsuitable material in an outgoing direction. Displacement without excavation by the excavator will not be permitted due to the risk of leaving highly compressible material below the embankment soil.

The fill above the water table shall be compacted according to the Specifications, whereas the fill placed under the water table cannot be compacted to the normally required density for fill, and will be allowed to settle under the dead weight of the embankment.

The slope of the embankment sides in swamps where this technique is employed shall be increased to 1 in 4.

After construction of the embankment, the Contractor shall carry out boreholes at 100m intervals or minimum one borehole in the swamp less than 100m along the road through the constructed embankment and into the in-situ subsoil below the fill. The Engineer may at their discretion instruct further drilling at no additional cost.

The findings shall satisfy the Engineer that all soft materials such as peat and soft clay have been excavated/displaced by the embankment soil. Any sections not constructed to the satisfaction of the Engineer shall be reworked.

In order to minimise differential settlements in the finished road surface, the widening of embankments shall be carried out well in advance of placing the pavement layers on that particular section. This is expressly important where the new road will be placed partly on a newly constructed embankment and partly on the existing road embankment. In such cases the existing embankment shall be cut to the top of the adjacent rock level and a new embankment (widened part) shall be constructed up to this level. After this operation adequate waiting period should be provided to consume the anticipated settlement of this new embankment (widened part). After completion of settlements of new embankment (widened part), If specified in the Drawings or as instructed by the engineer, for the construction of the combined upper layers, where it is required as specified or as instructed by the Engineer to mitigate differential settlement between existing road embankment and the new widened section; a multi-axial geogrid of minimum tensile strength 30 KN/m shall be applied above the section to straddle across the interface of the existing embankment and the new widened section. A single layer or more as specified shall be applied to such a width as to anchor over the existing embankment to the extent of at least 1m or 0.7H (where H is the height of the widened embankment elevation). The geogrid shall extend through the entire layer of the widened embankment. Where multiple layers are used, they should be placed in such a way as to coincide with the layers of compaction; as specified multiples or as required by the engineer.

Embankment fill material shall be placed full width according to normal and approved construction methods over both the existing and widened embankment foundation. The existing embankment material shall where possible be used for this filling operation and be compacted according to the Specifications.

Widening of the embankments through the swampy areas shall be performed as early as possible and be completed within 12 months of Notice to Commence. The time gap between finishing the embankment up to the underside of improved subgrade layers and placement of improved subgrade layers and pavement layers will depend on the rate of settlement in the surface. To monitor this rate of settlement, the Contractor shall, unless otherwise instructed by

the Engineer, erect settlement gauges and piezometers. No compensation will be paid to the Contractor for a delay in time of up to four months between finishing the embankment and commencement of the pavement layers on that particular section.

If the Engineer assesses that there is a risk of settlements of fills, he may direct the Contractor to pre-load the fills for the estimated settlement period, without the grant of an additional construction period. The program of works should consider this possibility.

The rates for construction of the embankment fill is deemed to include all extra cost relating to the special techniques used in constructing the embankment across swampy areas, use of material from the existing fill in the construction of the widened part of the new fill and any other measures directed by the Engineer except excavation for widening of the embankment as specified in CLAUSE 3610.

(k) Preloading

Road embankment fills constructed over potentially compressible and weak ground require special construction procedures to be implemented to ensure their stability both during and post-construction. These may include slow construction or staged construction possibly with surcharge loading, generally in advance of adjacent conventional roadworks. Preload monitoring is the process of measuring settlements, pore pressures and other parameters in order to ensure stability is maintained during construction by providing time for settlement and pore pressure dissipation.

Monitoring can consist of:

- Measurement of settlement of the fill embankment relative to the surrounding surface,
- Pore water pressures in underlying materials subject to load,
- Load cells/ earth pressure cells encompassed within constructed fill (e.g. Gloetzel cells),
- Ongoing monitoring of the embankment side slopes with inclinometers.

At least 90% consolidation shall be achieved in the embankment before placement of the pavement layers.

(l) Construction of Fill Near Structures (Excluding Structural Backfill)

At all embankments adjoining uncompleted structures such as bridges and large culverts, where the construction of the embankment and the backfilling behind the structure cannot be done simultaneously, the embankment shall be so constructed that the longitudinal slope of the surface of the embankment at all stages will form a continuous plane sloping towards ground level at the structure at a gradient not exceeding 10%. When the structure is completed, the remaining portion of the embankment shall be similarly completed simultaneously with the backfilling behind the structure, while the backfill behind the structure is being maintained at the same elevation as the adjoining embankment.

3606 COMPACTION OF EARTHWORKS

(a) General Requirements

i) Moisture Content

The moisture content of earthwork at the time of compaction shall not be higher than the optimum moisture content (OMC) measured at BS-Heavy compaction for earthwork layers and roadbed. The corresponding lowest allowed moisture content shall be 75% of OMC. SUB-CLAUSE 3605 (d) shall apply if the natural moisture content of the roadbed is too high and drying it back could not be done with

reasonable efforts and within a reasonable time, all in the opinion of the Engineer.

Dry compaction techniques shall not be employed unless prescribed in the Special Specifications or directed by the Engineer.

The Engineer may instruct that expansive soils are given treatment such as watering to maintain natural moisture content and timely dumping and spreading of the following layers. They may also instruct compaction to be omitted on such soils as they find it appropriate.

ii) **Density**

The minimum required compacted density of earthworks shall be as given in TABLE 3606/1.

(b) **Compaction Method Specification**

The Engineer may at their own discretion allow compaction to be carried out in accordance with a method specification instead of density control in cases where material characteristics or site conditions in their opinion make compaction density control inappropriate. Trials shall be undertaken to the full satisfaction of the Engineer in order to establish the required type of equipment, processing method and number of roller passes. The outcome of the trials shall be satisfactory to the Engineer for a method specification to be employed. All costs for undertaking such trials shall be carried by the Contractor.

The use of a compaction method specification may at the Engineer's discretion be discontinued at any time they find it necessary for contractual or technical reasons.

(c) **Proof Rolling**

Proof rolling of any earthworks layer or roadbed using loaded trucks or suitable rollers shall be carried out as required by the Engineer. The equipment and method of operation shall be as directed by the Engineer and the Contractor shall make all required equipment available for proof rolling at any time as required by the Engineer.

(d) **Side Fill and Spoil Dumps**

Spoil material for side fill shall be spread in successive layers of maximum 300 mm loose thickness, shaped and given a smooth surface and compacted by bulldozers or other heavy plant to the satisfaction of the Engineer. Where required by the Engineer the same procedure shall be followed in the case of spoil dumps

(e) **Dynamic Cone Penetration Test**

The Dynamic Cone Penetration Test which consists of a 20mm diameter, 60° cone into the soils by an 8Kg weight dropped through a height of 575mm can also be used as a guide in compaction control. The undrained shear strength correlations as given by Brink et al (1982) are summarised in Table 3602/2 with cohesive soils being clays and non-cohesive soils being the sands..

TABLE 3606/1: COMPACTION REQUIREMENTS FOR EARTHWORKS

Layer and typical material type specified	Minimum dry density, lower specification limit 1), BS 1377-2:2022
Upper improved subgrade layer, G15 material or better, for layers less than 150 mm below the formation level	95% of BS-Heavy
Lower improved subgrade layer, G7 material or better, for layers from 150 mm to 300 mm below the formation level	93% of BS-Heavy
Fill or improved subgrade layers using rock fill (DR)	Compaction method specification shall apply
Roadbed compaction to 150 mm depth after clearing, grubbing and removal of topsoil or other unsuitable material, where the roadbed level is:	
less than 150 mm below the formation level	97% of BS-Heavy
150 mm to 300 mm below the formation level	95% of BS-Heavy
300 mm to 600 mm below the formation level	93% of BS-Heavy
more than 600 mm below the formation level	100% of BS-Light
1) Refer to SUB-CLAUSE 7203 (c)	

TABLE 3606/2: UNDRAINED SHEAR STRENGTH CORRELATIONS WITH DPL TEST

Sandy Materials		
Description	SPT 'N' (blows per 300mm)	Dynamic Probe Light (DPL). (mm per blow)
Very Loose	<5	>75
Loose	5 – 10	30 – 75
Medium Dense	10 – 30	12.5 – 30
Dense	30 – 50	5 – 12.5
Very Dense	>50	2 -5
Clayey Materials		
Very Soft	<2	>110
Soft	2 – 4	55 – 110
Firm	4 – 8	30 – 55
Stiff	8 -15	15 – 30
Very Stiff	15 - 30	7 – 15

3607 PROTECTING THE EARTHWORKS AND STRUCTURES

During construction all earthworks shall be kept well drained and protected at all times as specified in SECTION 1200. All windrows shall be cut away after construction

to prevent the concentrated flow of water on completed earthworks layers, but, where necessary, flat berms shall be constructed to prevent the undue erosion of fill slopes. All permanent drains shall be constructed as soon as possible, together with sufficient additional temporary drains as may be necessary to protect the road prism,

and shall be maintained in a good working order. Ruts, potholes, soft spots or any other damage developing in the earthworks after completion shall be repaired, and the damaged portions shall be reshaped and re-compacted to the satisfaction of the Engineer at the Contractor's own cost.

All erosion and flood damage to slopes shall be promptly repaired as specified in SECTION 1200.

Side drains discharging water from cuts and all other drains shall be constructed in such a way that damage to the earthworks by erosion is avoided.

Proper precautions and temporary measures shall be taken in all cases to ensure that the method or procedure by which the fills are constructed will not impose loads on structures, especially on uncompleted structures, which may damage or overstress such structures.

3608 FINISHING THE SLOPES

(a) General

This section covers all work in connection with the trimming and finishing of slopes both to embankments and cuttings, the dimensions of which shall be in accordance with the cross-sections and details shown in the Drawings, or as instructed by the Engineer.

Except in solid rock, the tops and bottoms of all slopes including the slopes of drainage ditches shall be rounded as indicated on the Drawings or as ordered by the Engineer. Slopes at the junctions of cuts and fills shall be adjusted and warped to flow into one another or into the natural ground surfaces without any noticeable break.

When so directed by the Engineer, adjustments to the slopes shall be made in order to avoid damage being done to standing trees and to harmonise with existing landscape features. The transition to such adjusted slopes shall be gradual.

Cut and fill slopes shall be finished to a uniform appearance without any noticeable break that can be readily discerned from the road. The degree of finish required for all fill slopes and for cut slopes flatter than 1:4 shall be that normally obtainable by motor grader or hand-shovel operations.

The slopes of cuts and fills that are designated for grassing shall, after finishing, be prepared for grass planting and/or for topsoil for grass planting as specified in SECTION 5600.

All trimming of cut slopes shall be completed before any work on the subbase is commenced inside such cuttings.

All loose rocks, stones, and other material shall be removed from the slopes. The final surface of slopes shall have a rough surface suitable for subsequent grassing; or which will allow the natural vegetation to grow as described in the Contract.

(b) Cut Slopes

i) Cuts in Soils

The slopes of cuttings shall be trimmed to neat lines and to a standard that is generally attainable with proper care and workmanship in the type of material concerned. All loose rocks, stones and nests of loose material shall be removed, especially in solid-rock cuts, which must be completely free from such material. The final surface of batters must be absolutely smooth to prevent initiation of slope erosion unless alternative methods for grassing or the establishment of natural vegetation are instructed by the Engineer.

ii) Cuts in Rock

Cuts in rock shall be cleared of all loose stones to the satisfaction of the Engineer.

(c) Fill Slopes

Fill slopes shall be finished to neat lines with all loose rocks and un-compacted material removed. The degree of finish required shall depend on the nature of the material used for the fill slope but shall be as smooth as is consistent with the material involved and good workmanship to the satisfaction of the Engineer.

3609 ROCK FILL

Rock fill shall be free-draining and well-graded complying with the grading shown in TABLE 3609/1.

TABLE 3609/1: GRADING REQUIREMENTS FOR ROCK FILL

Maximum Size	% Passing
500 mm	100
200 mm	20-75
75 mm	10-30
20 mm	5-25

Argillaceous rocks such as clay, shale and marl; and amygdaloidal or vesicular basalts shall not be used in rock fill. Rock fill shall apply to materials consisting predominantly of hard, durable, angular rock fragments interspersed with finer material to fill the voids and facilitate mechanical interlock of the rock. Tabular, flaky or elongated particles shall not be used. If naturally occurring gravel, cobbles and/or boulders are used then they shall be crushed so that particles have at least one (1) broken surface.

The material shall be deposited, spread and levelled in layers extending to the full width of the embankment by a dozer. Each layer shall be compacted by a minimum of eight (8) passes of a vibrating roller with a static weight of 8 – 10 tonnes.

Rock fill shall not be used in the top 400 mm of an embankment.

For rock fill embankment slopes steeper than 1V:1.5H, the outer layer shall comprise hand-placed interlocking fragments between 200 mm and 500mm dimensions.

(a) Constructing Toes for Rock Fill Embankments

Where required, rock fill embankments shall have a toe constructed that is keyed into the underlying natural ground at the foot of the embankment through the construction of a trench backfilled with interlocking rock material. The dimensions of the trench shall be as shown on the Drawings, or as directed by the Engineer; but should be of nominal 2 m depth and 5 m width.

The toe shall be constructed simultaneously with the rest of the embankment and shall consist of selected rock material varying in size between 150 mm and 500 mm. If shown on the Drawings, a layer of synthetic-fibre filter material and a sand blanket shall be installed at the interface between the rock fill embankment and the toe at the foot of the embankment. Care shall be taken not to damage or tear such material.

The outer part of the toe shall consist of larger boulders properly bedded by means of smaller fragments so as to form a stable interlocking surface.

If placing with mechanical construction equipment is impractical, the equipment shall be supplemented by manual labour to select, bar and place keystones in between the larger boulders until the correct placement is achieved and the rocks are firmly interlocked.

3610 SIDEFILL

Side fill is the portion of imported material within the road prism which lies outside the fills, shoulders, sub-base and base; and is contained within such surface slopes as shown on the Drawings or as directed by the Engineer.

Construction of side fills for fill-flattening shall be carried out after completion of the fill for the road prism. The construction of the fill flattening using unsuitable or expansive soil/material shall be as indicated on the Drawing or as approved by the Engineer. In order to minimize the permeability of side fill and loose flattening of the slope, the Contractor shall remove any boulders, logs, tree stumps and other perishable materials. The road prism side slope shall be trimmed before placing the side fill or fill-flattening material. Attempts to verify density of the materials by processing and compaction are not required, however compaction mechanism shall be devised by the Contractor and approved by the Engineer so as to prevent loose fill flattening which could result ingress of water into the road prism or erosion of the flattening fill.

If insufficient material for side fills is available, the Contractor shall obtain additional material from ditch excavations or from nearby pits of similar materials without creating standing water or undermining the surrounding area all in accordance with the instructions of the Engineer.

The Contractor shall obtain specific approval from the Engineer for processing, supplying and placing of material for side fill for fill-flattening using material that is unsuitable for other purposes.

3611 LABORATORY AND SITE TRIALS

Laboratory and site trials shall be in accordance with SERIES 7000.

3612 CONSTRUCTION TOLERANCES AND TESTING

Construction tolerances and testing shall be in accordance with SERIES 7000.

3613 MEASUREMENT AND PAYMENT

The Engineer and Contractor shall jointly survey the ground surface after the topsoil strip has been completed but before removal of any unsuitable material or roadbed preparation. This survey may be carried out by taking cross-sections at 20 m intervals, or closer where needed, and should include changes of slope such as side ditches. Alternatively, the survey may be taken using a total station instrument in which case the data does not have to be recorded at fixed intervals. These data shall be entered in the road design software to produce a 'stripped digital terrain model' which shall be used in calculating bulk earthworks quantities. No additional payment will be made to the Contractor and their rates are deemed to include these provisions.

<u>ITEM</u>	<u>UNIT</u>
36.01 EXCAVATIONS:	
(a) COMMON EXCAVATION TO SPOIL	CUBIC METRE (m ³)
(b) EXCAVATION IN SWAMPS OR WETLANDS TO SPOIL	CUBIC METRE (m ³)
(c) ROCK EXCAVATION	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material removed as specified to be spoiled on the instruction of the Engineer, measured in its original position and computed by the method of average end areas from levelled cross-sections taken prior to excavating the cut, measured along the ground line. Measurements of common excavation to spoil shall exclude materials already paid for as removal of topsoil

under ITEM 31.01, or under other bill items, and shall only be applicable either for material deemed by the Engineer to be unsuitable for the Works or surplus material not required for fill or improved sub-grade construction.

"Common Excavation to Spoil" shall include material other than "Rock Excavation", which is surplus based on the total theoretical cut and fill volumes for the project, including material specified or instructed by the Engineer to be spoiled. It shall include unsuitable material excavated below stripped ground level in fill areas or below the design excavation level in cut (the underside of improved subgrade layers where these are to be placed, or formation level where improved subgrade layers are not required). The conversion of the fill volume to an equivalent cut volume shall assume a compaction factor of 1.15 or as determined by the Engineer.

"Excavation in Swamps or Wetlands to Spoil" shall include material excavated according to the special methods described in SUB-CLAUSE 3605 (j) when so agreed with the Engineer. Quantities shall be measured in its original position and computed by the method of average end areas from levelled cross-sections taken prior to excavating into the material below the water level as directed by the Engineer. Final levels after excavation/displacement shall be determined either by levelling or the approved profile established by the auger measurements, as directed by the Engineer.

Excavation from within the road prism being used for embankment construction shall not be paid for under ITEM 36.01 but only be paid for as fill under ITEM 36.02 measured in its final compacted position.

No excavation in excess of that indicated on the Drawings or as directed by the Engineer shall be paid for, notwithstanding any tolerances in workmanship allowed.

The bid rates for excavation shall include full compensation for excavation as classified, any necessary de-watering, loading, off-loading and disposing of the material as specified. The bid rate shall also include full compensation for working in confined locations and/or with small quantities such as could be encountered in excavating pockets of unsuitable material. The bid rate shall further include full compensation for the temporary storage of spoil material next to borrow areas and for the subsequent loading, transporting, offloading and spreading of spoil material within the borrow areas and for reinstating the temporary storage site. No overhaul will be paid for transporting away the excavated material.

In case the material is used in pavement layers or earthworks, overhaul may be paid for as prescribed in SECTION 1600 when, and only when, payment of overhaul is prescribed in the Special Specifications. In such case the material measured for payment of overhaul shall be the compacted material in the respective pavement or earthworks layer for which overhaul is paid.

<u>ITEM</u>	<u>UNIT</u>
36.02 FILL AND IMPROVED SUBGRADE LAYERS:	
(a) MINIMUM G15 QUALITY MATERIAL IN THE UPPER IMPROVED SUBGRADE LAYER	CUBIC METRE (m ³)
(b) MINIMUM G7 QUALITY MATERIAL IN THE LOWER IMPROVED SUBGRADE LAYER	CUBIC METRE (m ³)
(c) FILL USING ROCK	CUBIC METRE (m ³)
(d) CROSS FILL	CUBIC METRE (m ³)

<u>ITEM</u>	<u>UNIT</u>
(e) SIDE FILL COMPACTED BY DOZERS AS SPECIFIED	CUBIC METRE (m ³)
(f) EXTRA OVER SUB-ITEM 36.02 (a) TO (e) FOR CONSTRUCTION OF SAND BLANKET	CUBIC METRE (m ³)
(g) CLASS DR DUMPED ROCK TO PIONEER LAYER	CUBIC METRE (m ³)
(h) CLASS DR DUMPED ROCK FILL IN SWAMPS	CUBIC METRE (m ³)
(i) CRUSHER RUN IN UPPER 0.3 M	CUBIC METRE (m ³)
(j) GEOTEXTILE (STATE TYPE AND GRADE)	SQUARE METRE (m ²)
(k) GEOGRID (STATE TYPE AND GRADE)	SQUARE METRE (m ²)
(l) CONSTRUCTION OF SURCHARGE EMBANKMENT (DIMENSIONS AND QUALITY OF MATERIALS AS APPROVED BY THE ENGINEER)	CUBIC METRE (m ³)
(m) INSTALLATION OF VERTICAL DRAINS	METRES (M)
(n) INSTALLATION OF MONITORING INSTRUMENTS (SETTLEMENT PLATES, PIEZOMETERS)	NUMBER
(o) CONDUCT OF THE MONITORING	DAY
(p) REMOVAL OF SURCHARGE EMBANKMENT	CUBIC METRE (m ³)

The unit of measurement for sub-items (a) to (g) shall be the cubic metre of material measured in the compacted fill according to the Drawings or as directed by the Engineer. The quantity measured shall be computed by the method of average end areas from levelled cross-sections. The levelled cross-sections shall be prepared from the ground line prior to the construction of the fill after clearing and grubbing and after corrections for the instructed depth of the removal of topsoil and the instructed depth of any excavation and preparatory roadbed treatment specified or ordered by the Engineer. Filling to compensate for excavation of unsuitable material in excess of that instructed by the Engineer will not be paid for. The Contractor's tendered rate shall include (add an additional 300 mm of rock fill that penetrated the soft ground).

Where the roadbed has been lowered due to subsidence under fills, or the roadbed levels are lowered due to the roadbed preparation, the quantities shall be adjusted to make allowance for such lowering, at the sole discretion of the Engineer. The Contractor shall lodge such request without delay, and they shall submit the required supporting evidence to the Engineer. Where the Engineer is satisfied that significant lowering is occurring, they shall decide to what extent, if any, the lowering will be compensated for in the measurement of earthworks fill. Such adjustment of quantities shall only be considered where a total lowering due to subsidence and processing of the roadbed is in excess of 100 mm. The Contractor shall allow in their rates for such lowering of up to 100 mm.

That part of the fill placed in excess of the cross-sections shown on the Drawings or as directed by the Engineer, will not be paid for irrespective of the tolerances in workmanship allowed under the Contract.

Measurement and payment of fill shall not distinguish between alternative methods of processing and compaction of the materials.

The bid rates shall include full compensation for procuring, excavating, any necessary de-watering, loading, furnishing, placing, preparing, processing, shaping, watering, mixing, and compaction of the materials to the densities according to the Specifications.

The bid rate for SUB-ITEMS 36.02 (a) to (d) shall also include full compensation for filling in confined locations and/or with small quantities such as those that could be encountered in backfilling where pockets of unsuitable material have been excavated.

When payment for overhaul is specified in the Special Specifications, the rate shall include a free haulage distance as defined in SECTION 1600.

When payment for overhaul is not specified in the Special Specifications, the rate shall all transportation of the material.

Earthworks layers, except rock fill, shall be paid for as cross fill where the material on the instruction or approval of the Engineer is taken from cuts in the road reserve and placed in embankments at a distance of 50 m or less from its original position, measured along the centreline of the road. The unit of measurement for cross fill shall be the cubic metre of material measured in the compacted embankment according to the Drawings or as directed by the Engineer. No distinction shall be made for the earthworks layer in which cross fill is used, i.e. whether in improved subgrade layers or common fill.

The unit of measurement for dumped rock in pioneer layers and fill to swamps shall be tonne. The measured quantity shall be determined from weighbridge printouts as described in SUB-CLAUSE 1302 (a). The bid rates shall include excavation of the material, either from the road prism or quarry, haulage, placing and compaction in accordance with all the requirements of CLAUSES 3605 and 3606 for this material. Where the material is obtained from the road prism, the bid rate shall also allow for haulage via a quarry for weighing, or for provision and use of a portable weighbridge which can produce printouts.

The measurement of SUB-ITEMS 36.02 (k) and 36.02 (l) shall be the square metre of area covered. Bid rates shall include full compensation for supplying the material, cutting, placing, joining, overlapping and securing the material in position including any wastage.

<u>ITEM</u>	<u>UNIT</u>
36.03 ROADBED PREPARATION AND COMPACTION OF MATERIAL:	
(a) COMPACTION TO 97% OF BS-HEAVY DENSITY	CUBIC METRE (m ³)
(b) COMPACTION TO 95% OF BS-HEAVY DENSITY	CUBIC METRE (m ³)
(c) COMPACTION TO 93% OF BS-HEAVY DENSITY	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of roadbed material prepared and compacted as specified in SUB-CLAUSE 3604 (b)(i). The quantity shall be computed in accordance with the authorised dimensions of the completed layer.

The tendered rates shall include full compensation for shaping, scarifying, mixing of in-situ and imported material if required, any necessary de-watering and preparing and compaction of the material as specified. For payment purposes a distinction will be made between compaction to a percentage of BS-Heavy density.

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

**SECTION 3600A: EARTH
LATERAL SUPPORT SYSTEMS
AND GROUND IMPROVEMENT
WORKS**

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3601A SCOPE

This Section covers techniques used as Lateral Support systems like Sheet Piling and Diaphragm Wall. The Section also covers ground improvement techniques like Geotechnical Grouting, Jet Grouting, Compaction Grouting, Dynamic Compaction, Rapid Impact Compaction, Vibration Compaction / Vibro-flotation, Underpinning, Pre-load Monitoring, Basal reinforcement and prefabricated vertical drains.

3602A GENERAL

(a) Method Statements

The Contractor shall prepare detailed method statements for each facet of the work describing key aspects such as construction methodology, key plant, materials, personnel as well as any programme constraints of the envisaged construction process.

Method statement shall be prepared and submitted at least 30 days to the Engineer for approval prior to commencement of activity. The onus lies with the Contractor to ensure that the information is obtained and that associated activities are completed expeditiously to avoid any delays in the commencement, continuation and completion of the required works. No permanent works shall be commenced until the Engineer's approval has been accorded for the relevant method statement. The Contractor shall, however, remain responsible for all work-methods, materials, plant and equipment used, notwithstanding acceptance by the Engineer.

The Contractor shall be required to construct trials and the testing thereof as specified herein and shall make due allowance therefore in his programme. Allowance shall also be made to allow for the Engineer's assessment of constructed works, procedures followed, and materials and plant utilised and test data. Production, Execution and Procurement related to any works shall not be permitted until it is accepted by the Engineer and the Contractor possesses the necessary experience, plant and equipment to carry out the works as specified in the Drawings, Special Specifications or as instructed by the Engineer.

It should be noted that work shall only be performed by personnel listed by the Contractor. If personnel changes need to be made during the project, works shall be suspended until replacement personnel are approved by the Engineer. Time lost due to incomplete submissions, unacceptable submissions, or obtaining approval of replacement personnel will not be considered as cause for extension of time or delay claims. All costs associated with incomplete, replacement, or unacceptable

submissions shall be at the Contractor's cost.

The commencement of works shall only commence when the Engineer has given written acceptance of designs for which the Contractor is responsible for, the Contractor's method statements, and approval of plant and equipment.

Once approved in writing by the Engineer, these shall become the method statement for the execution of work. Notwithstanding, the Engineer may require revision from time to time if circumstances during construction arise that warrant change.

(b) Sheet Piling

Sheet piling is the construction of an embedded wall achieved by combining individual steel or precast concrete sheet piles linked together and driven either to refusal, or pre-determined depth into the ground to provide lateral support and / or an impermeable barrier. Each sheet pile has a pair of clutches that allow the male of one sheet to interlock with the female of another. The resultant structural wall forms an integral part of the overall lateral support system and is designed either as a cantilever to provide a primary method of support, or to act as a support system against which braced or tie-back forces are mobilised.

(c) Diaphragm Walls

Diaphragm walls are cast in situ concrete walls, generally reinforced, using under-slurry techniques. Diaphragm walls are necessary:

- In very unstable soil profiles beneath the water table where continuous support and watertight joints are required to prevent mudflows, piping and erosion of soils
- To provide support and/or water retention allows earlier subsurface excavations.
- In conditions where deeper than normal cantilever support may be required, for example, where the wall acts as a cantilever only, or where a very deep initial excavation is required before the first braced or tie-back support can be installed.

Diaphragm walls require a large site area. They are not suited to small or shallow basement excavations.

Wall widths from 600 mm to 1500 mm can be formed using diaphragm walls, to depths greater than 60 m. The resultant structural wall forms an integral part of deep lateral support and should be designed either as a cantilever to provide primary support or water retention/dewatering, or to act as a support system against which braced or tie-back forces are mobilised. Cantilever is generally effective between 4.0 and 6.0 m; bracing up to 10 m, and anchored walls to 25 m and higher.

(d) Geotechnical Grouting

Geotechnical grouting is the process in which the remote placement of a cementitious, pumpable material in the ground or rock is indirectly controlled by adjusting its rheological characteristics (constituents, mix proportions, strength, physical properties, etc.) and by the manipulation of the placement parameters (pressures, volume and flow, rate) all to achieve the requisite Engineering performance.

The two broad methods covered in these specifications are:

- Displacement grouting (jet grouting and compaction grouting)
- Non-displacement grouting (fissure grouting, contact grouting, gravity grouting, permeation grouting, penetration grouting and curtain grouting).

Contact grouting is done to fill the cavities/voids between concrete and rock mass on account of the shrinkage of

concrete and uneven over breaks. Consolidation grouting is done to strengthen the surrounding rock mass by filling up the open joints, fissures, cracks etc. Curtain grouting involves the construction of a narrow excavation and filling it with concrete or by the creation of a thin grout curtain by pressure grouting holes at closely spaced intervals, each grout pillar intersecting the adjacent grout pillar.

(e) Jet Grouting

Jet grouting is the process whereby in situ materials are eroded by high velocity grouts and mixed therewith to form soilcrete columns. These specifications cover the construction of soilcrete columns for ground improvement purposes to meet the project objectives as described in the Drawings, or as described in the Special Specifications or as instructed by the Engineer. The works are of a highly specialised nature and shall only be carried out by a Contractor who has the necessary experience, expertise and plant and equipment to carry out the works.

Generally, the process of constructing soilcrete columns comprises the drilling of a hole through the material to be treated to the required depth, the erosion of the surrounding material by high velocity jetting with cementitious grout (possibly using air and also water to facilitate the process) and the simultaneous rotation and withdrawal of the drill string to form the soilcrete columns. Surplus materials need to be continuously removed from the platform. The plant and equipment required need to be matched to meet the demands during execution to meet the continuity requirements of this technique. Positioning, resourcing and good maintenance are similarly essential in achieving the desired product.

The Contractor shall construct trial columns and shall allow for the Engineer's assessment of these columns. Further objectives are the determination of the rotation and withdrawal rates of the monitor required to achieve the specified minimum diameter of the columns. Exposure of the completed trial columns after the specified curing period to ascertain whether the soilcrete columns meet the specified requirements regarding diameter and uniformity shall generally be required as well as the execution of tests and measurements for quality assessment purposes.

The commencement of the production columns may only commence when the Engineer has given his written acceptance of the designs for which the Contractor is responsible in terms of drawing and Specifications, the Contractor's method statements, approval of plant and equipment, spoil disposal arrangements and the Contractor's successful installation and testing of the trial column.

(f) Compaction Grouting

Compaction grouting is the in-situ soil compaction process whereby the density or bearing capacity of soils is improved by the injection of a thick cementitious grout under pressure. The technique is frequently employed to address settlement under existing foundations and for the ground improvement for new structures and embankments.

The injected grout forms an enlarged bulb or series of bulbs while displacing the soils thereby increasing its density. Generally, the aim is to form columns of grout bulbs from the surface or just below an existing foundation to such depth that competent materials /conditions are encountered.

The grout is pumped through driven or drilled in grout pipes and the compaction grouting can be performed from the top down (downstage grouting) or from the bottom up (upstage grouting). With downstage grouting the uppermost bulb is formed first and after the initial set has taken place the grout pipe is drilled through the bulb

to a lower stage where the next bulb is created. With upstage grouting the bulbs are formed as the grouting tube is withdrawn in typically 500 mm increments.

(g) Dynamic Compaction (DC)/ Dynamic Replacement

Dynamic Compaction (DC) is the process whereby the density of in-situ soil is improved by dropping a large weight or pounder from great height onto the soil to be compacted. Depth of improvement is typically 6.0–8.0 m.

Shock of the falling weight may cause damage to nearby structures/services and potential impacts must be determined.

Dynamic replacement is a technique whereby in situ soft/loose soils are displaced by stone columns driven into the soils by dynamic compaction. It is used in very soft cohesive material with high moisture contents making compaction by conventional means impossible. The columns of stone are driven by a pounder as in Dynamic Compaction

(h) Rapid Impact Compaction (RIC)

Rapid Impact Compaction (RIC) of in situ soils is achieved by repeatedly dropping a large weight or pounder of between 9 and 12 tonnes from a height varying from 1.0 to 1.5 m, at a high frequency (about 40 blows per minute, depending on machinery employed), onto ground to be compacted. Depth of improvement is typically 3.0 to 5.0 m.

RIC is carried out by impacting blows on a grid, triangular (3 prints) or square (either 4 prints or a 5-print sequence in which one is located in the middle of the 4). Ram size varies from 1.0 to 1.5 m diameter and grid size varies from 2.0 to 4.0 m. Up to 50 blows per imprint may be required to achieve the specified densification.

Material may either be compacted as is or stone columns may be constructed by placing selected stone at regular intervals in the created voids and continuing compaction thereon driving stone into the substrata. The Stiffness of these stone columns needs to be controlled.

(i) Vibration Compaction

Vibration Compaction is the process whereby in-situ soils are compacted by vibrating immersion probes inserted into the soil to increase relative density, stiffness and strength thereby reducing settlement as well as improving resistance to liquefaction. Vibration may have either horizontal or vertical amplitude and brings soil particles into a state of suspension allowing for their rearrangement and densification. Water jets assist penetration of the vibrator into the ground and rearrangement of soil particles. The Degree of soil improvement is largely dependent on grading of soil, natural resonant frequency and the level of energy available. Vibration compaction consists of:

- Vibro-compaction is a technique, designed to induce compaction of granular materials at depth. The basic principle behind the process is that particles of non-cohesive soils can be rearranged by means of vibration.
- Vibro-replacement is a technique derived by further developing the vibro-compaction process. Soils such as pure silts or mixed deposits of silt, and/or sand are improved by lateral displacement initially induced by probe insertion and further densified by the addition of coarse aggregate to create a stone column. Soil improvement relies on higher stiffness and shear strength of stone columns which act compositely with the surrounding soil.

(j) Underpinning

Underpinning is the process of staunching settlement of a structure post-construction. Underpinning may be

accomplished by extending existing foundations in depth or in area to a more supportive substratum or distributing load across a greater area, supplementing the support by providing additional piles or micro-piles or by ground improvement beneath existing footings.

Underpinning may be necessary when:

- Original foundations have insufficient bearing capacity/stability. Properties of material supporting the foundation may have changed (possibly through seepage or soil particle distribution or pore water dissipation),
- Geotechnical characteristics misdiagnosed during investigation/design,
- Construction of nearby/adjacent structures necessitates excavation of existing foundations,
- To increase depth or load capacity of the structure It is more economical to upgrade the present structure's foundation than to construct a new one,
- Earthquake, flood, drought or other natural causes have caused the structure to move, thereby requiring additional work in the form of underpinning.

(k) Preload Monitoring (Stability Monitoring of Fills Under Construction)

Preload monitoring of fills under construction shall be carried out in accordance with Subclause 3605 (k).

(l) Basal Reinforcement

Basal reinforcement may be required where soft deep deposits below fills make removal uneconomical or over undermined areas and karst regions where soft or voided zones require bridging. This basal reinforcement usually comprises geo-synthetics in the form of polymeric or steel reinforcement to prevent embankment distress. The tensile capacity of the geo-synthetic in conjunction with the fill above can be used in the repair/bridging of sinkholes or undermined areas. Void sizes up to 5.0 m may be treated (provided the fill thickness is at least 2.0 m thick) but specialised applications are necessary for larger voids.

Where the void or soft zone size exceeds 5.0 m, steel cables are usually used in conjunction with a ring beam and appropriate matting to ensure material retention.

Basal reinforcement can also be addressed employing other sophisticated techniques included in this and other sections of the specifications, e.g. piling, compaction grouting, jet grouting, etc.

(m) Prefabricated Vertical Band/ Wick Drains

Prefabricated drains are vertical drains comprising pre-manufactured long cylindrical composite having cusped cores wrapped in a geotextile filter jacket. They are installed in very soft to stiff clays to provide a drainage path for accelerating the consolidation settlements. These are installed in a grid pattern either in a square or triangular shape.

3603A MATERIALS

(a) General

All materials used in the works described hereunder shall meet the relevant standards specified herein or as specified in the Drawings, Special Specifications or as instructed by the Engineer and shall be subject to the approval of the Engineer. The Contractor shall submit product certificates, conformance documentation related to the specifications, test results as required together with samples of materials and where applicable, materials designs that he proposes to use in the construction of the works to the Engineer for his acceptance/approval at least Two (02) weeks prior to execution of works or as stated in Special Specifications.

Due allowance shall be made for obtaining materials, re-

submissions and re-designs, all to the required/ approved standards, methods and practices in attending to these requirements. Particular attention shall be paid to the early submission of materials, concrete and grout mix designs where parameters at various ages may be specified. No consideration for extension of the contract period will be entertained for delays incurred in meeting these requirements.

(b) Cement

Cement used for concrete shall be any of the following:

- i. Common cements complying with the requirements of EAS 18-1:2017, BS EN 197-1:2011 or equivalent standard on approval of the Engineer.
- ii. Sulphate-resistant Portland cement conforming to the requirements of BS EN 197-1:2011, but only where shown on the Drawings or instructed by the Engineer.

In pressurised concrete members or units, the use of Portland blast-furnace cement will not be permitted. A 50/50 mixture of Portland cement and ground granulated blast-furnace slag may be used only if authorised in the Special Specifications or by the Engineer, in writing.

(c) Aggregates

Both coarse aggregate (stone) and fine aggregate (sand) shall comply with the requirements of BS EN 1367-4:2008 or equivalent, subject to the following:

- i. The drying shrinkage of both the fine and coarse aggregate when tested in accordance with BS EN 1367-4:2008 or equivalent shall not exceed the following limits:
 - For use in prestressed concrete, concrete bridge decks and slender columns the shrinkage of both fine and coarse aggregate shall not exceed 130% of that of the reference aggregate.
 - For use in other reinforced concrete members the shrinkage of the fine aggregate shall not exceed 175%, and that of the coarse aggregate 150% of that of the reference aggregate.
 - For use in mass concrete substructures and unreinforced concrete head walls and wing walls, the shrinkage of both the fine and coarse aggregate shall not exceed 200% of that of the reference aggregate.

Where there is any doubt about the shrinkage characteristics of aggregates, the Contractor shall submit a certificate from an approved laboratory that gives the shrinkage characteristics of the aggregate.

The drying shrinkage of concrete samples made from each of the required three concrete mixtures for preparing the compressive-strength and flexural-strength samples shall not exceed 0.04%.

- ii. The flakiness index of the stone as specified in BS 812-105.1:1989 shall not exceed 35%.
- iii. Aggregates shall not contain any deleterious amounts of organic materials such as grass, timber or similar materials and shall be free from clay, shale, pyrites and all other impurities.
- iv. Where there is any danger of a particular combination of aggregate and cement giving rise to a harmful alkali-aggregate reaction, the particular combination shall be tested in accordance with BS 812-123:1999, and, where the result points to such reaction, either the aggregate or the cement or both shall be replaced so that an acceptable combination may be obtained.
- v. The fineness modulus of the fine aggregate shall not vary by more than ± 0.2 from the approved modulus.

- vi. The coarse part of aggregate shall be roughly cubical in shape and free from excess flat and/or elongated particles.

(d) Boulders

Boulders used in concrete shall comply with the following:

- The boulders shall be clean, durable and inert.
- The aggregate crushing value may not exceed 25%.
- The weight of each boulder shall be between 15 kg and 55 kg.
- No dimension of any boulder shall be less than 150 mm or exceed 500 mm.

(e) Water

Water for use in mixing concrete and mortar and for curing and related purposes shall be obtained from a source approved by the Engineer and shall comply with the requirements of BS EN 1008:2002.

Water shall be clean, fresh and free from detrimental concentrations of acids, alkalis, salts, sugar and other organic or chemical substances that could impair the durability and strength of the concrete or the embedded steel. The Contractor shall prove the suitability of the water by way of tests conducted by an approved laboratory. For reinforced and prestressed concrete, the chloride content of the mixing water shall not exceed 500 mg/l when tested in accordance with BS 6068-2.37:1990, SANS 5202/ SABS SM 202 or equivalent.

(f) Steel Bars

Steel reinforcing bars shall comply with the requirements of US EAS 412, BS 4449:2005+A3:2016 or equivalent on the approval of the Engineer unless otherwise noted on the Drawings. For each consignment of steel reinforcement delivered on the site, the Contractor shall submit a certificate issued by a recognised testing authority to confirm that the steel complies with the specified requirements.

(g) Welded Steel Fabric

Welded steel fabric shall comply with the requirements of AASHTO M 336M/M336-24 or equivalent on approval of the Engineer. The grade of wire shall be W4 in accordance with AASHTO M 336M/M336-24 or equivalent on approval of the Engineer unless otherwise noted on the Drawings. The grid shall be 100 mm x 100 mm unless otherwise noted on the Drawings.

(h) Mechanical Couplers

All mechanical couplers used shall be subject to the approval of the Engineer. The tensile properties determined on a test sample that consists of reinforcing bars butt-jointed by a mechanical coupler shall comply with the requirements as given in the Special Specifications.

(i) Admixtures

Admixtures shall not be used in concrete without the approval of the Engineer who may require that tests be conducted before the admixtures are used to prove their suitability. Admixtures, if their use is allowed, shall comply with the following requirements:

- Admixtures shall be used only in liquid form and shall be batched in solution in the mixing water by a mechanical batcher capable of dispensing the admixture in quantities accurate to within 5% of the required quantity.
- All admixtures shall comply with the requirements of ASTM C494/C494M-24 or AASHTO M 194M/M194-23 and shall be of an approved brand and type.

- Air entraining agents shall comply with the requirements of ASTM C260/C260M-10a(2016) or AASHTO M 154M/M154-24.
- Admixtures shall not contain any chlorides.

(j) Curing Agents

Curing agents shall be tested in accordance with ASTM C156-20 and shall comply with the requirements of ASTM C309-19, except that the loss of water within 72 hours shall not exceed 0.40 kg/m². Only approved curing agents shall be used.

Curing agents shall be clear or pigmented as specified or required by the Engineer. A certificate from an approved testing laboratory stating that the curing compound complies with the specified requirements shall be submitted to the Engineer.

Irrespective of the above specifications being met, the curing compound shall be the type that can be applied to a wet surface without loss of stability or impairment of its water retention properties.

(k) Bentonite Slurry

Bentonite slurry is a viscous mixture of approximately 4% - 6% bentonite powder by mass with water and is of such consistency that soil and other heavy particles mixed with this bentonite slurry during excavation are held in suspension and do not settle to the pile base.

Bentonite shall either be of sodium origin or calcium derivation and checked for required thixotropic properties, quality, moisture content, grading and sand content.

(l) Sheet Piling

Sheet pile sections are available in ordered lengths. Recommended maximum lengths, as dictated mainly by handling and driving requirements as given in TABLE 3604A/1:

TABLE 3604A/1: RECOMMENDED SHEET PILE LENGTHS

Moment of Inertia of Section cm ⁴ per metre width	Maximum recommended length in metres	Typical wall thickness (mm)	Typical section half depth (mm)
4110	6		
13513	14		
23885	18	10,0	150
39831	23	10,5	220
49262	24	13,0	220
92298	26	19,0	230

Sheet pile lengths may be successfully extended by specialist welding of sections or shortened by cutting. Length changes must ensure that no damage or distortion occurs to adjacent piles.

Steel sheet pile sections manufactured from various grades of steel in accordance with EN10249-1-1995 shall comply with the requirements given in TABLE 3604A/2 for cold-formed U and Z sections:

TABLE 3604A/2: STEEL GRADES

Grade of steel	Minimum yield strength R _{eh} (MPa)	Tensile strength R _m (MPa)	Former UK reference
S 235 JRC	235	340 – 470	40B
S 275 JRC	275	410 – 560	43B
S 355 JRC	355	490 – 630	50C

In hard driving conditions it may be necessary to increase the pile section size to achieve the required

penetration and/ or adopt a higher grade of steel. The Engineer's approval shall be obtained before orders for any sheet pile sections are placed.

Piles shall be stacked on site in accordance with the manufacturer's recommendations. The Contractor shall ensure that operations involving loading, transporting, offloading, handling, stacking and pitching the piles, are carried out in a manner that shall prevent damage to them or their coatings. The Engineer shall be immediately informed of any damage and the Contractor shall submit proposals for remedial measures, the cost of which shall be borne by the Contractor. Lifting holes shall not be burned or drilled through sheet pile without prior approval by the Engineer and shall be made good after use. The same pile sections; lengths and steel grades shall be stored in different stacks clearly marked or colour-coded to avoid placement errors.

Driving caps for diesel hammers shall be manufactured from cast steel and have an arrangement of guiding grooves for the different sheet pile sections on its lower side. A wooden or plastic/composite dolly (cushion) shall be fitted into recesses on top of the driving cap.

Walers, tie-rods and ground anchors shall be as specified in the Drawings or Special Specifications.

(m) Diaphragm Wall

Materials to be used for the Diaphragm Wall shall be pursuant to those that are described in SECTION 2904 (a) above.

(n) Geotechnical Grouting

The Contractor is responsible for the design of the grout. Typical grout types are listed below.

(o) Cement/Water Grouts

Cement to be used for the Diaphragm Wall shall be pursuant to those that are described in section 2904 a). Depending on the grouting method employed, the Engineer may allow or specify the use of certain additives such as bentonite to reduce bleeding, improve penetration, to vary viscosity or to improve pumpability of the grout. Where large cavities are to be filled, the Engineer may allow or specify the use of fillers, sands or gravels provided specified performance criteria are met. These shall be free of deleterious materials and meet criteria for use as aggregates in concrete as detailed in SECTION 6000.

Water for grout shall comply with SECTION 3604A (a).

i) Bentonite/Blended Cement Grouts

Bentonite grouts, either neat, or blended with cement, are finer than pure cement grouts but do not develop the same strengths.

ii) Chemical Grouts

Chemical grouts enable better penetration than cement or bentonite-based grouts. These include:

- Sodium Silicate,
- Acrylamides,
- Ligno-sulphonates,
- Phenoplasts,
- Aminoplasts,
- Specialty grouts.

Specialised grouts such as epoxy resins, polyurethanes and resin silicates may be used in specialist applications and shall be detailed in Drawings or Special Specifications.

All grout materials shall be stored under a roof and protected from weather and contamination.

(p) Jet Grouting

Materials for the cementitious grout used in jet grouting shall be pursuant to those that are described in SECTION 3604A (a).

(q) Compaction Grouting

Materials for the cementitious grout used in compaction grouting shall be pursuant to those that are described in SECTION 3604A (a).

i) Sand

Sand shall be clean, non-plastic, non-angular and well-graded particles sized from 0.06 – 2.0 mm.

ii) Bentonite

Bentonite shall be OCMA grade (Oil Companies Material Association) and comply with API 13A.

(r) Dynamic Compaction

Materials for backfilling of craters or depressions created by dynamic compaction shall, unless otherwise specified in the Drawings or Special Specifications meet the requirements for G15 material. However, where stone columns are required, dump rock/ blast rocks shall be used as specified below:

i) To Increase Stiffness of In-Situ Soils:

- UCS greater than 40 MPa but less than 75 MPa,
- Maximum size 300 mm,
- Percentage passing the 0.075 mm sieve less than 5 %

ii) To Increase Stiffness and Provide Drainage for Dissipation of Excess Pore Pressures

- UCS greater than 100 MPa,
- Maximum size 300 mm,
- Percentage passing the 0.075 mm sieve less than 5%.

Dump rock for stone columns shall be obtained from a suitable source, approved by the Engineer. It shall be unweathered, sound and durable. Mudrock, shales and other rapid weathering rock types shall not be used.

(s) Rapid Impact Compaction

Materials for the Rapid impact compaction used shall be pursuant to those that are described in SECTION 2904 (a).

(t) Vibration Compaction

Crushed stone to be used for replacement material shall be manufactured/ crushed from approved unweathered, sound durable rock, with grading of material in a range from 8.0 mm to 40 mm and a specific gravity greater than 2.4.

(u) Underpinning

Materials for underpinning shall consist of:

i) Concrete

All concrete used for underpinning purposes shall comply with the requirements given in SECTION 6400 of the standard Specifications unless otherwise specified in the Drawings, Special Specifications or as directed by the engineer.

Any other materials used shall be pursuant to those that are described in SECTION 2904 (a).

ii) Chemical Grouts

Chemical grouts may include but not be limited to:

- Sodium Silicate,
- Acrylamides,
- Ligno-sulphonates,

- Phenoplasts,
- Aminoplasts.

iii) Specialty Grouts

Specialised grouts such as epoxy resins, polyurethanes and resin silicates may be used in specialist applications as detailed in the Drawings or Specification.

iv) Micropiles

Materials for micropiles shall be as specified in the Drawings or Special Specifications or as directed by the Engineer.

(v) Preload Monitoring

i) Filter Sand for Piezometers

Filter sand used to fill voids between drilled hole sides and piezometer porous element surrounds shall be clean, siliceous sand from an approved source and of size 0.06 to 2.0 mm with less than 5 % smaller than 0.425 mm and less than 5 % greater than 1.18 mm. The sand shall also comply with the requirements described in SECTION 2904 (a).

ii) Bentonite Pellets for Seals

Bentonite pellets for seals shall be as specified in the Drawings or Special Specification or as directed by the Engineer.

(w) Basal Reinforcement

i) Geogrid

Reinforcement

The reinforcement geotextile shall be manufactured using long-chain, synthetic polymers, composed at least 95 percent by mass of polyolefins or polyesters. Form the geotextile, including selvages, into a stable network such that the filaments or yarns retain their dimensional stability relative to each other.

Furnish reinforcement geogrid shall be manufactured as a regular network of integrally-connected longitudinal and transverse polymer tensile elements with a geometry that permits significant mechanical interlock with the backfill. Provide a geogrid composed of fibres or ribs that are at least 95 percent by mass polypropylene, polyethylene, or polyester. The geogrid structure must remain dimensionally stable under construction stresses and have a high resistance to damage during construction, to ultraviolet degradation, and to chemical and biological degradation encountered in the soil being reinforced. Conform to TABLES 2703/8 and TABLE 2703/9. Property values represent MARV (that is average test results of any roll in a lot sampled for

conformance or quality assurance testing must meet or exceed the minimum specified values).

The nominal long-term strength (T_{al}) is based on:

$$T_{al} = T_{ult}/RF$$

where $RF = RF_{ID} \times RF_{CR} \times RF_D$.

RF_{ID} , RF_{CR} , and RF_D values must be substantiated by evaluation of independent test results by Highway Innovative Technology Evaluation Centre (HITEC), AASHTO National Transportation Product Evaluation Program (NTPEP), or an equivalent third-party report. Provide a copy of the report to the CO. Determine RF_{ID} , RF_{CR} , and RF_D according to the following:

- RF_{ID} : Determine the reduction factor for installation damage from the results of full-scale construction damage tests conducted according to ASTM D5818-22. Conduct the tests with a soil having the same maximum particle size, D_{50} , and angularity as the soil to be used for construction. Tests using coarser soils (same or larger maximum particle size and D_{50}) may be an acceptable substitution. The CO will make the final determination as to whether the test data based on the substitute soil is acceptable. Interpolation of RF_{ID} will not be allowed, the results for the coarser soils will be used. The Contractor may elect to perform a test using project specific fill, placement, and compaction techniques and equipment to determine the RF_{ID} . Use a default value of 3.0 if no installation damage testing has been conducted. The minimum value for RF_{ID} is 1.1.
- RF_{CR} . Determine the creep reduction factor according to one of the following:
Conventional creep testing according to ASTM D5262-21; or
A combination of Stepped Isothermal Method (SIM) according to ASTM D6992-16(2023) and conventional creep testing. If testing has not been conducted, default values for RF_{CR} are 2.5 for polyester polymer, and 5.0 for polypropylene or polyethylene polymer.
- RF_D . For polypropylene or polyethylene geosynthetics conforming to the requirements of TABLE 3604A/3, a default reduction factor of 1.1 may be used for RF_D . For polyester geosynthetics conforming to the requirements of TABLE 3604A/3, a default reduction factor of 1.15 may be used for RF_D if the soil has a pH between 5 and 8; and a reduction factor of 1.3 may be used if the soil pH is between 3 and 5 or between 8 and 9.

TABLE 3604A/3: REINFORCEMENT GEOTEXTILE AND GEOGRID POLYMER REQUIREMENTS

Polymer Type	Property	Test Method	Specifications
Polypropylene and polyethylene	Thermo-oxidation resistance	ENV ISO 13438, Method A (polypropylene) or Method B (polyethylene)	Minimum 50% retained strength after 28 days (polypropylene) or 56 days (polyethylene)
Polyester	Hydrolysis resistance	Inherent Viscosity Method ASTM D4603-18 & GRI ⁽¹⁾ GG8	Minimum number average molecular weight (M_n) of 25,000
	"	GRI ⁽¹⁾ GG7	Maximum carboxyl end group (CEG) of 30
All polymers	Ultraviolet stability	ASTM D4355/D4355M-21	Minimum 70% retained strength after 500 hours of exposure
	Mass per unit area	ASTM D5261-10(2018)	Minimum 8 oz/yd ² (270 g/m ²)

Polymer Type	Property	Test Method	Specifications
	Percent post-consumer recycled material by mass	Certification of material used	Maximum 0%
(1) Geosynthetic Research Institute.			

TABLE 3604A/4: REINFORCEMENT GEOTEXTILE AND GEOGRID STRENGTH REQUIREMENTS

Property	Test Method ASTM	Units	Specifications ⁽¹⁾⁽²⁾					
			Type I	Type II	Type III	Type IV	Type V	Type VI
Ultimate strength (⁽³⁾ T _{ult})	D4595/D4595M-24 or D6637/D6637M-15(2023) ⁽⁴⁾	(kN/m)	29.2	43.8	58.4	73.0	87.6	116.8
Nominal long-term strength (T _{al})	See Note (5)	(kN/m)	(4.6	21.9	29.2	36.5	43.8	58.4
Note: (1) For reinforcement geotextile, also meet the Class 1 strength requirements in TABLE 3604A/4 and the ultraviolet stability requirements in TABLE 3604A/3. (2) The specified strength is in the principal direction of reinforcement (that is perpendicular to the wall or slope face) (3) Based on MARV. (4) ASTM D4595/D4595M-24 is for reinforcement geotextile and ASTM D6637/D6637M-15(2023) is for Geogrid (5) See the nominal long-term strength (T _{al}) formula above								

(x) Stabilization**i) Geogrid**

The geogrid shall be manufactured using long-chain synthetic polymers composed of at least 95 percent by mass of polyolefins, polyesters, or polyamides. Fabricate the geogrid into a stable network such that the ribs, filaments, or yarns retain their dimensional stability relative to each other, including selvages.

Property values, with the exception of maximum opening size, represent MARV (that is average test results of any roll in a lot sampled for conformance or quality assurance testing must meet or exceed the minimum specified values). The value for maximum opening size represents the maximum average roll value shall confirm to TABLE 3604A/5.

ii) Geotextile

Property values, with the exception of apparent opening size (AOS), in these specifications represent minimum average roll value (MARV) in the weakest principal direction (that is average test results of any roll in a lot sampled for conformance or quality assurance testing must meet or exceed the specified values). Values for AOS represent maximum average roll values. The geotextiles and geotextile filter shall conform to Table 3604A/6.

TABLE 3604A/5: STABILIZATION GEOGRID REQUIREMENTS

Property	Test Method	Specifications ⁽¹⁾
Minimum opening size	N/A ⁽²⁾	13 mm
Maximum opening size	N/A ⁽²⁾	75 mm
Tensile strength at 2% strain	ASTM D6637/D6637M-15(2023)	9.2 kN/m
Tensile strength at 5% strain	ASTM D6637/D6637M-15(2023)	19 kN/m
Ultimate tensile strength	ASTM D6637/D6637M-15(2023)	30 kN/m
Junction strength	GRI ⁽³⁾ GG2	330 N
Ultraviolet stability	ASTM D4355/D4355M-21	50% retained strength after 500 hours of exposure
Note: (1) Strength values are in the weaker principal direction. (2) Direct measure with a caliper. (3) Geosynthetic Research Institute.		

TABLE 3604A/6: SEPARATION AND STABILIZATION GEOTEXTILE AND GEOTEXTILE FILTER REQUIREMENTS (1)

Strength and Durability Properties							
Property	Test Method ASTM	Units	Class 1		Class 2		
Type of Geotextile			Woven	Nonwoven	Woven	Nonwoven	
Elongation at break	D4632/D4632M-15a(2023)	%	< 50	≥ 50	< 50	≥ 50	
Minimum grab strength	D4632/D4632M-15a(2023)	(N)	1420	890	1110	710	
Minimum sewn seam strength	D4632/D4632M-15a(2023)	(N)	1290	800	980	620	
Minimum tear Strength	D4533/D4533M-15(2023)	(N)	490	360	400	240	
Minimum puncture strength	D6241-22a	(N)	2760	1910	2220	1380	
Minimum ultraviolet stability	D4355/D4355M-21	%	50% retained strength after 500 hours of exposure				
Hydraulic Properties							
Property	Test Method ASTM	Units	Type A	Type B	Type C	Type D	Type E
Minimum permittivity	D4491/D4491M-22	s ⁻¹	0.7	0.5	0.2	0.1	0.1
Maximum apparent opening size (AOS)	D4751-21a	Sieve size (mm)	0.425	0.425	0.250	0.425	0.212
(1) Do not use woven slit film geotextile.							

(1) Do not use woven slit film geotextile.

iii) Cellular confinement Systems (Geocell)

The contractor shall furnish a flexible honeycomb three-dimensional structure fabricated from light stabilized polyethylene plastic. Conform to the properties given in TABLE 3604A/7 and TABLE 3604A/8.

TABLE 3604A/7: CELLULAR CONFINEMENT SYSTEM REQUIREMENTS

Property	Test Method	Minimum Requirement
Functional longevity		120 months min
Cell area		200 to 300 cm ²
Sheet thickness	ASTM D751-19	1.24 to 1.26 mm
Density	ASTM D792-20	0.941 to 0.960 g/cm ³
Carbon black content	ASTM D1603-20	1.5 to 2.5 percent
Environmental stress-cracking	ASTM D1693-21	2000 hours min.

TABLE 3604A/8: CELLULAR CONFINEMENT SYSTEM REQUIREMENTS

Property	Requirements				
Nominal cell depth (mm)	50	75	100	150	200
Cell joint Strength (minimum)N	.500	700	1000.	1400	2000

(y) Prefabricated Vertical drain/ Wick drains

A prefabricated Geocomposite drain composed of a drainage core and a nonwoven geotextile that permits inflow from both sides. Geocomposites that only permit inflow from one side may only be used directly against a concrete surface. Furnish geotextile and drainage core manufactured from long-chain synthetic polymers composed of at least 95 percent by mass of polypropylene, polyester, polyamide, polyvinyl chloride, polyolefin, or polystyrene. Build the core up in thickness by columns, cones, nubs, cusps, meshes, stiff filaments, or other configurations. Fabricate the core in sheets, panels, or rolls of adequate strength to resist installation stresses and long-term loading conditions.

Property values, with the exception of fungi resistance, in these specifications represent MARV in the weakest principal direction (that is average test results of any roll in a lot sampled for conformance or quality assurance testing must meet or exceed the specified values).

Furnish a nonwoven encapsulating geotextile meeting the requirements of TABLE 3604A/9. Firmly attach the encapsulating geotextile to the core at the manufacturing plant, so that folding, wrinkling, or other movement cannot occur during handling or after placement. Use a non-water-soluble adhesive, heat sealing, or other methods recommended by the geotextile manufacturer. Do not use adhesive on areas of the geotextile where flow is intended to occur.

If heat sealing is used, do not weaken the geotextile below the required strength values. Extend the geotextile beyond the core length on all sides sufficiently to encapsulate the core and collector pipe Conform to TABLE 3604A/9.

TABLE 3604A/9: GEOCOMPOSITE MATERIAL PREFABRICATED VERTICAL DRAIN REQUIREMENTS

Property	Test Method	Units	Specifications		
			Sheet Drain	Strip Drain	
			Type A	Type A	Type B
Transmissivity (flow rate) (1)	ASTM D4716/4716M-22	(m ³ /sec/m)	0.0010	0.0031	0.0041
Compressive strength at yield	ASTM D1621-16(2023)	(kPa)	690	340	340
Applied normal compressive stress	ASTM D4716/4716M-22	(kPa)	100	10	10
Hydraulic gradient	ASTM D4716/4716M-22	dimensionless	1.0	0.1	0.1
Fungi resistance	ASTM G21-15(2021)e1	–	No visible growth		

3604A MEASUREMENT AND PAYMENT

The tendered rate for each pay item shall include full compensation for providing, operating, maintaining and decommissioning upon completion, of all the construction equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the pay item as specified, unless otherwise stated.

<u>ITEM</u>	<u>UNIT</u>
36.01A ESTABLISHMENT ON SITE	
(a) SHEET PILING	LUMP SUM
(b) DIAPHRAGM WALLS	LUMP SUM
(c) GEOTECHNICAL GROUTING	LUMP SUM
(d) JET GROUTING	LUMP SUM
(e) COMPACTION GROUTING	LUMP SUM
(f) DYNAMIC COMPACTION	LUMP SUM
(g) RAPID IMPACT COMPACTION	LUMP SUM
(h) VIBRATION COMPACTION	LUMP SUM
(i) UNDERPINNING	LUMP SUM
(j) PRELOADING	LUMP SUM
(k) BASAL REINFORCEMENT	LUMP SUM

The tendered lump sum for site establishment for items above shall include full compensation for establishing all necessary plant, equipment and services on site to carry out the works as specified including all work in preparing the works area for construction activities and subsequent removal from site of all such plant and equipment including all temporary works such as access roads, staging, platforms and such like. The tendered rate for preload monitoring shall include the establishing on site of all the necessary equipment and material as specified required for the installation of the specified monitoring instruments and for the removal thereof on completion of the works. The provision of boreholes in which instruments are to be installed, and the supply of the specified instruments and accessories as may be required, shall be paid for separately.

The work will be paid for by way of a lump sum, 50 % of which shall be payable when all major necessary equipment is on site, trials (if any) are completed and the first production work started. The second instalment of 25 % is payable after half the specified work is complete. The final instalment shall be payable after all work is complete, all equipment has been removed and the site restored as specified in the Specifications or to the satisfaction of the Engineer.

<u>ITEM</u>	<u>UNIT</u>
36.02A MOVING TO AND SETTING UP EQUIPMENT AT SECTIONS OR SITES TO BE DEFINED	
(a) SHEET PILING	NUMBER (no.)
(b) DIAPHRAGM WALLS	NUMBER (no.)
(c) GEOTECHNICAL GROUTING	NUMBER (no.)
(d) JET GROUTING	NUMBER (no.)
(e) COMPACTION GROUTING	NUMBER (no.)
(f) DYNAMIC COMPACTION	NUMBER (no.)
(g) RAPID IMPACT COMPACTION	NUMBER (no.)
(h) VIBRATION COMPACTION	NUMBER (no.)
(i) UNDERPINNING	NUMBER (no.)
(j) PRELOADING	NUMBER (no.)
(k) BASAL REINFORCEMENT	NUMBER (no.)

The unit of measurement shall be the number of positions to which equipment is moved and set up in a position to execute the works as described in the Specification or as provided in the Bill of Quantity. The quantity measured shall be the number of setups at designated works positions inclusive of approved trial works positions as well as any additional positions as may be instructed by the Engineer.

The tendered rates shall include full compensation for all costs involved in moving to and setting up required equipment at each works position. Multiple setups at the same hole shall only be measured and paid for once. Tendered rates shall also include all costs in setting-up equipment and subsequent decommissioning thereof.

<u>ITEM</u>	<u>UNIT</u>
36.03A SETTING OUT OF WORKS AT POSITIONS	
(a) SHEET PILING	NUMBER (no.)
(b) DIAPHRAGM WALLS	NUMBER (no.)
(c) GEOTECHNICAL GROUTING	NUMBER (no.)
(d) JET GROUTING	NUMBER (no.)
(e) COMPACTION GROUTING	NUMBER (no.)
(f) DYNAMIC COMPACTION	NUMBER (no.)
(g) RAPID IMPACT COMPACTION	NUMBER (no.)
(h) VIBRATION COMPACTION	NUMBER (no.)
(i) UNDERPINNING	NUMBER (no.)
(j) PRELOADING	NUMBER (no.)
(k) BASAL REINFORCEMENT	NUMBER (no.)

The unit of measurement shall be the number of positions set out by a registered surveyor as per Specifications or as instructed by the Engineer. Payment will not be made for re-setting out of treatment positions lost for whatever reason.

The tendered rate shall include all labour, plant, equipment, materials and all incidentals required.

<u>ITEM</u>	<u>UNIT</u>
36.04A SHEET PILE DRIVING (INDIVIDUAL SHEET PILE TYPE OR SHEET PANEL EXTENT TO BE SPECIFIED)	SQUARE METRE (m ²)

The unit of measurement shall be the net square metre of sheet piles installed.

The tendered rate shall include full compensation for the supply of sheet piles to the site; correct handling and storage of sheet pile elements, driven installation and for all labour, plant and equipment required for installation to depths as specified in the Drawings, Specification or as instructed by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
36.05A SHEET PILE EXTRACTION	SQUARE METRE (m ²)

The unit of measurement shall be the area of the pile sheet extracted.

The tendered rate shall include full compensation for sheet piles extracted, handling and storage; and ultimate removal from site inclusive of all labour, plant and equipment required for these works specified in the Drawings, Specification or as instructed by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
36.06A SHEET PILE AND DIAPHRAGM WALL SUPPORTS (TYPE AND MATERIAL AS SPECIFIED)	
(a) PROPS	No.
(b) ANCHORS	No.
(c) TIE-BARS	No.

The unit of measurement shall be the number of props or anchors or tie-bars (including designed deadman anchorages).

The tendered rate shall include full compensation for installation to details as specified in Drawings, or as specified in the Special Specifications or as instructed by the engineer, including all labour, plant, materials and equipment required.

<u>ITEM</u>	<u>UNIT</u>
36.07A GROUTING (CEMENT)	
(a) GEOTECHNICAL GROUTING	KILOGRAM (kg)
(b) JET GROUTING	KILOGRAM (kg)
(c) COMPACTION GROUTING	KILOGRAM (kg)
(d) EXTRA OVER FOR ITEM 36.07A (a),(b) &(c)	KILOGRAM (kg)

The unit of measurement shall be kilograms (kg) of cement actually utilised for grouting as specified and approved by the Engineer.

The tendered rates shall include for all labour, plant, equipment, materials, delivery, storing, mixing, pumping, injection and all incidentals required. No payment will be made for any wastage or for rejected batches. Only verified quantities will be accepted for measurement and payment.

The rate shall include quality control measures, testing of materials, monitoring and supervision of the works and daily records of all items as per industry's best practice.

<u>ITEM</u>	<u>UNIT</u>
36.08A GROUTING (FILLERS AND ADDITIVES)	
(a) SAND	KILOGRAM (kg)
(b) BENTONITE	KILOGRAM (kg)
(c) OTHER FILLERS (SPECIFY)	KILOGRAM (kg)

The unit of measurement shall be the kilograms (kg) of filler/additive actually utilised for grouting as specified and approved by the Engineer.

Tendered rates shall include all labour, plant, equipment, materials, delivery, storage, mixing, pumping, injection and all incidentals required. No payment will be made for any wastage or for rejected batches. Only verified quantities will be accepted for measurement and payment.

The rate shall include quality control measures, testing of materials, monitoring and supervision of the works and daily records of all items specified in as specified in the Specifications or as instructed by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
36.09A DRILLING OF HOLES	
(a) FOR GEOTECHNICAL/COMPACTION GROUTING (DIAMETER AND INCLINATION AS INDICATED)	METRE (m)
(b) FOR JET GROUTING TO SPECIFIED DEPTHS (DEPTH RANGES AND INCLINATIONS TO BE SPECIFIED)	METRE (m)
(c) EXTRA OVER FOR DRILLING THROUGH REINFORCED CONCRETE	METRE (m)

The unit of measurement for pay ITEM 36.09A (a & b) shall be the metre of hole actually drilled and re-drilled. No differentiation will be made for different drilling methods (e.g. rotary, percussion, rotary percussion or vibratory drilling), unless otherwise specified.

The unit of measurement for pay ITEM 36.09 (c) shall be the metre of drilling through reinforced concrete.

The tendered rate shall include full compensation for drilling holes of appropriate diameter including, drilling aids, drilling materials and disposal of all waste products on completion thereof. Casings/sleeves shall be measured and paid for separately. The tendered rate shall also include all labour, plant, equipment and materials to carry out the drilling as required.

<u>ITEM</u>	<u>UNIT</u>
36.10A INSTALLATION OF CASING (DIAMETER AND INCLINATION INDICATED)	METRE (m)

The unit of measurement shall be the metre of temporary casing installed.

The tendered rate shall include full compensation for supplying the indicated diameter casing, installation thereof and for subsequent removal and shall include all labour, plant and equipment required for this. No extra time will be granted for installation and removal of temporary casing.

<u>ITEM</u>	<u>UNIT</u>
36.11A INSTALLATION OF STANDPIPES FOR GEOTECHNICAL GROUTING	NUMBER (NO.)

The unit of measurement shall be the number of standpipes installed.

The tendered rate shall include full compensation for supply, installation, securing in position of approved standpipes complete with suitable couplings for the attachment of grout hoses.

<u>ITEM</u>	<u>UNIT</u>
36.12A INJECTION GROUTING (TYPE INDICATED)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of grout actually injected into the fissure/cavity /void/material.

The tendered rate shall include full compensation for the mixing, storing, pumping and placement of the approved grout and shall include for all labour, materials, quality control measures, the testing of materials, monitoring and supervision of the works the daily recording of results, injection parameters, production and other record keeping and reporting all as specified in the Specifications.

<u>ITEM</u>	<u>UNIT</u>
36.13A CONCRETE PLACED BY TREMIE UNDER SLURRY IN DIAPHRAGM WALLS (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre (m³) of concrete placed by tremie under bentonite slurry for the construction of diaphragm walls.

The tendered rate shall include full compensation for supplying and storing all material, providing all plant, mixing, transporting and placing the concrete by tremie methods.

<u>ITEM</u>	<u>UNIT</u>
36.14A PARTIAL EXCAVATION OF PANELS	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre (m³) of material excavated for inspections and testing adjacent to panels and removed to stockpile for backfilling operations or to spoil.

The tendered rate shall include full compensation for the excavation to expose the panels and shall include the backfilling thereof as specified. The rate shall include all labour, plant and equipment required for such removal and backfilling as required by the Contract, or as instructed by the Engineer. No overbreak shall be paid for excavation beyond the theoretical excavation boundaries.

<u>ITEM</u>	<u>UNIT</u>
36.15A CEMENT, ADDITIVES, BENTONITE, AGGREGATE AND FILLERS	
(a) CEMENT	KILOGRAM (kg)
(b) BENTONITE	KILOGRAM (kg)
(c) FINE/COARSE AGGREGATE (SPECIFY)	KILOGRAM (kg)
(d) OTHER FILLERS (SPECIFY)	KILOGRAM (kg)

The unit of measurement shall be the kilogram of materials actually utilised for diaphragm wall construction as specified and approved by the Engineer.

The tendered rates shall include for all labour, plant, equipment, materials, delivery, storing, mixing, pumping, placement and all incidentals required. No payment will be made for wastage or rejected batches. Only verified quantities will be accepted for measurement and payment.

The rates shall include quality control measures, testing of materials, monitoring and supervision of the works, daily records of all items specified in the Contract.

<u>ITEM</u>	<u>UNIT</u>
36.16A BENTONITE SLURRY RE-USE	CUBIC METRE (m ³)

The unit of measurement shall be the volume of bentonite slurry pumped for re-use.

The tendered rate for re-used bentonite slurry shall be for full compensation of pumping from completed panels to storage; cleaning and removal of sand from used slurry to design standards; storage and pumping to new panel positions. Rates shall include all plant; labour and equipment necessary for this process. All activities associated with bentonite slurry re-use shall be to the requirements of the Contract Documentation, or as instructed by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
36.17A STEEL REINFORCEMENT	TONNE (T)

The unit of measure for steel bars shall be the ton of reinforcing steel in place in accordance with the Drawings or as authorised.

The tendered rate shall be for full compensation in procuring the steel, bending, cage reinforcement construction, pitching and installation and shall include all plant required for reinforcement cage installation; labour and equipment necessary.

<u>ITEM</u>	<u>UNIT</u>
36.18A EXPOSING TOPS OF SELECTED CONCRETE PANELS	NUMBER (no.)

The unit of measurement shall be the number of concrete panel tops exposed for inspection, measurement and testing.

The tendered rate shall include all plant, excavating the material around selected panels as well as backfilling of excavations with suitable approved material in 150 mm layers compacted to the required density.

<u>ITEM</u>	<u>UNIT</u>
36.19A CORING OF CONCRETE PANELS	
(a) SETTING UP AT COMPLETED PANELS	NUMBER (no.)
(b) DRILLING AND CORE RECOVERY (SIZE INDICATED)	METRE (m)
(c) PROVISION OF CORE BOXES	NUMBER (no.)
(d) EXTRA OVER FOR INCLINED DRILLING	METRE (m)

The unit of measurement shall be per set-up at coring positions selected and pointed out by the Engineer; length of core actually recovered; the provision of core boxes capable of accommodating a minimum 7.5 m of core, and for inclined drilling into panel sides.

The tendered rate shall include for establishment; labour, plant, delivery, core storage, monitoring, drilling supervision, core logging, removal of samples for laboratory testing, and demobilisation shall be included in the above rates tendered.

<u>ITEM</u>	<u>UNIT</u>
36.20A EXTRA OVER ITEMS 36.07A AND 36.08A	
(a) FOR STAGE GROUTING (SPECIFY UP OR DOWNSTAGE)	NUMBER (no.)
(b) FOR JET GROUTING OF WIDENED SECTIONS OR MUSHROOM HEADS (POSITION AND WIDTH TO BE SPECIFIED)	NUMBER (no.)

The unit of measurement for ITEM 36.20A (a) shall be the number stages grouted to required pressures. The tendered rate shall include full compensation for all additional costs of managing each stage.

The unit of measurement for ITEM 36.20A (b) shall be the number of widened sections or mushroom heads constructed as specified. The tendered rate shall include

full compensation for all additional costs for this operation.

<u>ITEM</u>	<u>UNIT</u>
36.21A EXPOSING TEST JET GROUTED COLUMNS	NUMBER (no.)

The unit of measurement shall be the number of columns exposed for inspection, measurement and testing.

The tendered rate shall include all plant, excavating the material around the column and trimming of the column as well as backfilling of excavations with suitable material in 150 mm layers compacted to required density.

<u>ITEM</u>	<u>UNIT</u>
36.22A CORING OF JET GROUTED COLUMN	
(a) SETTING UP OVER COMPLETED JET GROUTED COLUMN	NUMBER (no.)
(b) DRILLING AND CORE RECOVERY (SIZE INDICATED)	METRE (m)
(c) PROVISION OF CORE BOXES	NUMBER (no.)

The unit of measurement shall be per setup over a completed, cured column as instructed by the Engineer.

The unit of measurement for drilling and recovery of core samples using appropriate methods and equipment of indicated size.

<u>ITEM</u>	<u>UNIT</u>
36.23A REMOVAL OF JETTING AND DRILLING SPOIL	CUBIC METRE-KILOMETRE (m ³ -Km)

The unit of measurement shall be the cubic metre of spoil hauled over the distance covered.

The tendered rate shall include the loading, transport and all other costs in hauling the spoil material to the approved spoil site.

<u>ITEM</u>	<u>UNIT</u>
36.24A PERFORMING DYNAMIC COMPACTION OVER (SPECIFY DISTANCE) UTILIZING A (INDICATE MASS) TONNE POUNDER	
(a) PRIMARY PRINTS	BLOWS
(b) SECONDARY PRINTS	BLOWS
(c) IRONING PRINTS	BLOWS

The unit of measurement will be the number of blows imparted at a compaction point. Differentiation is made between primary phase, secondary phase and ironing phase works.

The tendered rate will include full compensation for carrying out the specified dynamic compaction in full compliance with the specifications at designated compaction points including the ongoing vibration measurement and monitoring as specified and for the placement of dump rock during the construction of stone columns. Separate payment shall be made for the procurement of dump rock.

<u>ITEM</u>	<u>UNIT</u>
36.25A VARIATION IN NUMBER OF BLOWS	
(a) PRIMARY PRINTS	BLOWS
(b) SECONDARY PRINTS	BLOWS
(c) IRONING PRINTS	BLOWS

The unit of measurement in respect of increase or decrease in the number of blows imparted in the execution of dynamic compaction at designated compaction points as instructed or approved by the

Engineer.

Differentiation is made between primary phase, secondary phase and ironing phase works. Where the actual no of blows varies from the specified nominal blows, adjustment of compensation will be made either:

- As a payment to the Contractor in respect of any authorised increase in quantities which exceed those specified nominal no of blows (including tolerances), where such increase has been specified by the Engineer or
- As a refund to the Employer in respect of the decrease in quantities which are less than those specified nominal no of blows (including tolerances), irrespective of whether such decrease results from an authorised decrease in the number of blows, or from unauthorised reductions on the part of the Contractor.

Payment for a prescribed rate of blows shall be based on the actual no of blows, provided that this does not exceed the prescribed number of blows including any tolerance specified in the Special Specifications. If the actual no of blows is above the prescribed rate of blows, no additional payment shall be made above the allowed tolerance limit. If the actual no of blows is below the prescribed rate of blows payment shall be based on the actual blows regardless of any tolerance allowed. Notwithstanding the above, the Engineer shall be fully entitled to reject work which has not been constructed in accordance with the specifications. The Employer shall be refunded for any decrease in the specified number of blows at the same rate per unit of measurement as the quoted rate for additional Blows required by an increase in (add the number of blows

<u>ITEM</u>	<u>UNIT</u>
36.26A IMPORTING G15 QUALITY MATERIAL FROM APPROVED SOURCES	CUBIC METRE (m ³)

The unit of measure shall be the cubic metre of imported G15 quality material.

The tendered rate shall include full compensation for procuring, stockpiling, watering to compaction moisture content for processing as backfill in craters formed by dynamic compaction or for the construction of a capping layer or for general layer works, levelling and finishing of compacted areas. The quantity shall be taken as 70% of the volume transported to the site as measured in trucks. Only full, struck-off loads arriving on site shall be paid for.

<u>ITEM</u>	<u>UNIT</u>
36.27A IMPORTING DUMP ROCK FOR FORMING STONE COLUMNS BY DYNAMIC COMPACTION FROM APPROVED SOURCES	CUBIC METRE (m ³)

The unit of measure shall be the cubic metre of dump rock as specified for forming stone columns by dynamic compaction.

The tendered rate shall include full compensation for the procuring, stockpiling and placement during the construction process. The quantity shall be taken as 70 % of the volume transported to the site as measured in trucks.

<u>ITEM</u>	<u>UNIT</u>
36.28A IMPORTING CRUSHED ROCK FOR VIBRATORY REPLACEMENT FROM APPROVED SOURCES	CUBIC METRE (m ³)

The tendered rate shall include full compensation for the procuring, stockpiling, and the placement in craters formed by vibrocompaction/ vibroflotation.

The quantity shall be taken as 70% of the volume

transported to site as measured in trucks. Only full, struck-off loads arriving on site shall be paid for.

<u>ITEM</u>	<u>UNIT</u>
36.29A WATER ACCEPTANCE TESTING (PERMEABILITY TESTS AS SPECIFIED)	NUMBER (no.)

The unit of measurement shall be the number of tests carried out as instructed by the Engineer in accordance with the Contract Documentation.

The tendered rate shall include full compensation for establishing approved equipment on site and all costs incurred in carrying out the tests by competent persons plus record keeping and reporting.

<u>ITEM</u>	<u>UNIT</u>
36.30A PLATE LOAD TESTS	NUMBER (no.)

The unit of measurement shall be the number of plate load tests carried out as specified in the instructions of the Engineer.

The tendered rate shall include full compensation for the provision of the testing equipment on site for the duration of the works, for the carrying out of the tests by competent persons and for the provision of the test data as specified in the Contract.

<u>ITEM</u>	<u>UNIT</u>
36.31A ESTABLISHMENT ON SITE FOR	
(a) DCP TESTING (DEPTH INDICATED)	LUMPSUM
(b) CPT TESTING (DEPTH INDICATED)	LUMPSUM
(c) DPSH TESTING (DEPTH INDICATED)	LUMPSUM

The tendered lump sum shall include full compensation for the establishment and removal from the site of all the plant and equipment required to carry out the testing as specified inclusive of all preparatory work that may be required and all operations for which the cost does not vary with the actual amount of testing carried out.

The lump sum rate shall include full compensation for the provision of all the resources inclusive of water and electrical power for carrying out the tests as specified.

This work will be paid for by way of a lump sum, 50 % of which will become payable when all the equipment is on site, trials (if any) are completed and the first tests successfully conducted. The second instalment of 25 % of the lump sum will be payable after half the total number of tests are completed and the final instalment of 25 % after all the testing work is complete, the results accepted by the Engineer and the equipment has been removed from the site.

<u>ITEM</u>	<u>UNIT</u>
36.32A DCP, CPT AND DPSH TESTING	
(a) DCP TESTING (DEPTH INDICATED)	NUMBER (no.)
(b) CPT TESTING (DEPTH INDICATED)	NUMBER (no.)
(c) DPSH TESTING (DEPTH INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of tests carried out as specified in the instructions of the Engineer.

The tendered rate shall include full compensation for the setting up of the equipment at each designated testing point, the execution of the tests by competent persons as specified as well as the provision other the test results in an approved format within 24 hours of testing.

<u>ITEM</u>	<u>UNIT</u>
36.33A CONTINUOUS SURFACE WAVE TESTING (CSW)	NUMBER (no.)

The unit of measurement shall be the number of tests

carried out on the instruction of the Engineer.

The tendered rate shall include full compensation for the provision of the testing equipment on site for the carrying out of the tests by competent persons and for the provision of the test data, all as specified.

<u>ITEM</u>	<u>UNIT</u>
36.34A MONITORING OF INSTRUMENTS AND EARTHWORKS BY SURVEY	MONTH

The unit of measurement shall be the period over which the Contractor shall have in his employ a suitably-qualified and experienced surveyor equipped with all the necessary survey equipment to carry out the monitoring as specified.

The tendered rate shall include for all labour, materials, calibrations and other items required to complete the works as specified.

<u>ITEM</u>	<u>UNIT</u>
36.35A SUPPLY AND INSTALL ROD SETTLEMENT GAUGES	NUMBER (no.)

The unit of measurement shall be the number of rod settlement gauges supplied and installed.

The tendered rate shall include the supply and installation of the base plates and extension rods (number indicated) as specified, the marking and protection thereof. The tendered rate shall also include all labour, materials, periodic installation of extension rods required as well as the recording and reporting of settlement results.

<u>ITEM</u>	<u>UNIT</u>
36.36A SUPPLY AND INSTALL STANDPIPE PIEZOMETERS	NUMBER (no.)

The unit of measurement shall be number of standpipe piezometers supplied and installed.

The tendered rate shall include for supply and installation of standpipe piezometers as specified as well as the labelling, survey and the protection thereof. The tendered rate shall also include for all labour, materials, reading equipment and all incidentals required for the measurement of water levels, the recording and for the reporting of the results as specified, Boreholes in which piezometers are installed shall be measured separately.

<u>ITEM</u>	<u>UNIT</u>
36.37A SUPPLY AND INSTALL PNEUMATIC PIEZOMETERS (LENGTH INDICATED)	NUMBER (no)

The unit of measurement shall be the number of pneumatic piezometers supplied and installed.

The tendered rate shall include for supply and installation of pneumatic piezometers as specified, labelling, survey and protection thereof. The tendered rate shall also include all labour, materials, tubing, cabling, couplings, manifolds, readout and recording, unit cabinets and incidentals required for measurement of water levels, recording, processing and for reporting of results as specified. Boreholes in which piezometers are installed shall be measured separately.

<u>ITEM</u>	<u>UNIT</u>
36.38A SUPPLY AND INSTALL INCLINOMETER MONITORING SYSTEMS (LENGTH INDICATED)	METRE (m)

The unit of measurement shall be metres of inclinometer tubing installed.

The tendered rate shall include the supply and

installation of the tubing, the labelling and survey and the protection thereof as specified

The tendered rate shall also include all the labour, materials, tubing, cabling, inclinometer torpedo and readout unit and all incidentals required for the measurement of displacement of the installed tubing, processing and for the reporting of the results as specified.

Boreholes in which inclinometers (put or) piezometers are installed shall be measured separately.

<u>ITEM</u>	<u>UNIT</u>
36.39A SUPPLY AND INSTALL PRESSURE MEASURING LOAD CELLS (TYPE AND MAKE SPECIFIED)	NUMBER (no.)

The unit of measurement shall be the number of load cells of the specified type installed in the earthworks during construction.

The tendered rate shall also include all the labour, materials, tubing, cabling, and loadcells, readout unit and all incidentals required for the measurement of earth pressures during construction and for the processing and reporting of the results as specified.

<u>ITEM</u>	<u>UNIT</u>
36.40A SUPPLY AND INSTALL GEO- SYNTHETIC FOR BASAL REINFORCEMENT	SQUARE METRE (m ²)

The unit of measurement shall be the square metre (m²) of geo-synthetic placed as specified.

The tendered rate shall include for the procurement, transport, storage and placement of the specified geo-synthetic, measured in place inclusive of all labour, incidentals and materials.

<u>ITEM</u>	<u>UNIT</u>
36.41A SUPPLY AND PLACEMENT OF 125 MM PROTECTION LAYER	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre (m³) of approved material.

The tendered rate shall include for the supply, transport and placement as specified, of approved material inclusive of all labour, plant and incidentals required, therefore.

<u>ITEM</u>	<u>UNIT</u>
36.42A SUPPLY AND INSTALLATION OF PREFABRICATED VERTICAL DRAINS	RUNNING METRE (m)

The unit of measurement shall be the running metre (m) of approved material.

The tendered rate shall include for the supply, transport and placement as specified, of approved material inclusive of all labour, plant and incidentals required, therefore.

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

SECTION 3600B: SOIL NAILING

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3601B SCOPE

The soil nailing system is the method whereby slopes or excavations are stabilised by reinforcing the soil in-situ with closely spaced tensile inclusions which are fully bonded high yield steel bars which are introduced into the soil mass to produce a zone of reinforced ground. Soil nails are installed sub-horizontally so that the shear resistance along a potential failure plane is improved by the reinforcing elements acting in tension.

The section covers soil nailing as required for construction of the Works covered by the Contract, in accordance with the relevant Specifications.

3602B GENERAL

Generally, utilized soil nail installation Methods in practice are as follows:

(a) Drilled and Grouted Soil Nail

Drilled and grouted soil nail (or simply grouted nail), are approximately 75 mm to 200 mm diameter nail hole drilled in the soil mass to be retained, followed by placing a steel reinforcement bar (tendon) and grouting of the drilled hole.

(b) Driven and Grouted Soil Nail

Driven soil nail is mechanically driven into the ground and grout is inserted through it.

(c) Driven Soil Nail

Driven soil nail is mechanically driven into the ground.

3603B MATERIALS

(a) General

The design of soil nail shall be done by guidelines given in BS EN 14490:2010 or FHWA0-IF-03-017. The contractor shall submit a detailed construction methodology for approval by the Engineer before the commencement of works.

(b) Reinforcement Bar (Nail or Tendon)

The reinforcing element (tendon) shall be high yield stress deformed bars compliant with the requirements of BS 4449:2005+A3:2016 or equivalent on the approval of the Engineer unless otherwise noted on the Drawings, with a minimum characteristic tensile strength of 500 MPa or higher which may be threaded at one end. Minimum recommended diameter of reinforcement bar (tendon) is 16 mm.

Steel wire steel strand shall comply at least with the requirements of BS 5896:2012.

(c) Welded Steel Fabric

Welded steel fabric shall comply with the requirements of BS EN 10080:2005 or equivalent on approval of the Engineer. Steel fabric reinforcement shall be Grades B500A, B500B or B500C conforming to BS EN 10080:2005 and BS 4483:2005. Steel fabric reinforcement shall be cut and bent in accordance with BS 8666:2020. Steel fabric reinforcement shall have a minimum nominal bar size of 6 mm (8 mm for Grade B500A) Steel fabric reinforcement shall be delivered to site in flat mats or pre-bent

Welded Steel fabric shall be designated with the following information:

- Designation of the product form (welded fabric);
- Number of this European standard;
- Nominal dimensions of the product (dimensions of the wires, dimensions of the sheet, pitch of wires, overhangs); and
- Technical classes of the steel.

(d) Nail Head

The nail head shall comprise of following main components: the bearing-plate, hex nut, and washers; and the headed-stud. The bearing plate with a central hole (with diameter greater than reinforcement bar) shall be of minimum 250 MPa grade steel, typically square in shape with 200 to 250 mm side dimension and 19 mm thickness. Washers and nuts shall be made of steel with a grade consistent with that of the nail bar commonly of 500 MPa or higher. Nuts may be tightened with a hand-wrench. The headed-stud connection may consist of four headed studs welded near the four corners of the bearing plate to provide anchorage of the nail head into the permanent facing. For temporary walls, the bearing plate shall be on the outside face of the shotcrete facing.

(e) Grout

Grout for soil nails is required for filling the annular space between the nail bar and the surrounding ground, and for shotcreting of the temporary facing. Grout for soil nail walls shall be commonly a neat cement grout with the water/cement ratio typically ranging from 0.4 to 0.5. Other additives and admixtures may be added to improve the impermeability and strength, with the approval of the Engineer. The size of the particles and the consistency of the grout must be suited to the passageways it must follow. Neat grout will not flow freely into holes smaller than about three times the largest cement particle. Except in large cavities where thick mortar can be placed, the sand should pass through a 28-mesh sieve and have a large portion passing the 50-mesh and 100-mesh sieves. The proportions of Ordinary Portland cement to sand will depend upon the size of the spaces to be filled and will vary from a neat grout to about 1:1 mix. The amount of water to be added depends upon the consistency required.

Grout shall have a minimum 28 days characteristic strength as specified in the Drawings. For filling up nail holes, grout shall be pumped shortly after the nail bar is placed in the drill hole to reduce the potential for hole squeezing or caving. In solid nail bar applications, the grout may be injected by tremie methods through a grout pipe, which is previously inserted to the bottom of the drill hole, until the grout completely fills the drill hole.

Where necessary and approved by the Engineer, additives and admixtures may be added to Portland cement grout mixtures for improving impermeability and strength, delaying the setting time, increasing flowability and minimizing segregation and shrinkage.

(f) Centralizers

Centralizers are devices made of polyVinyl Chloride (PVC) or other synthetic materials that are installed at various locations along the length of each nail bar to

ensure that a minimum thickness of grout completely covers the nail bar. Centralizers shall be installed at regular intervals, typically not exceeding 2.5 m, along the length of the nail and at a distance of about 0.5 m from each end of the nail.

(g) Couplers

Bar coupler if required, shall develop the full ultimate tensile strength of the bar as certified by the manufacturer.

(h) Facing Types

Soil nails have two types of facing:

i) Temporary Facing

Temporary facing shall be constructed by providing reinforcement in the form of welded wire mesh throughout the wall face, and by additional bearing plates and waler bars (rebars of smaller lengths placed in the vicinity of nail head) at the nail heads; which is, subsequently shotcreted. Overall temporary facing thickness shall vary from 75 mm to 200 mm.

ii) Permanent Facing

Permanent facing may be constructed as cast-in-place reinforced cement concrete, precast concrete or any suitable material to achieve the desired strength and aesthetics. Reinforcement in the permanent facing may be adopted in the form of welded wire mesh or reinforcement bars in either direction. Permanent facing shall be connected to the temporary facing by means of headed-studs (usually four numbers per plate) welded on the bearing plates installed during the construction temporary facing. Minimum thickness of permanent facing shall not be less than 200 mm.

(i) Drainage Measures

i) Short Term Drainage Measures

Surface water and groundwater must be controlled both during and after construction of the soil nail wall. A surface water interceptor ditch, excavated along the crest of the excavation and lined with concrete, is a recommended element for controlling surface water flows. Additionally, if ground water impacts are temporary or localized, suitable dewatering measures may be taken for lowering the groundwater table.

ii) Long Term Drainage Measures

Long term drainage shall be provided by means of the drainage system comprising of:

- Vertical geo-composite drain strips placed suitably along the face of the wall;
- Weep holes in the form of perforated PVC pipes of typical diameter as 50-100 mm and 300- 600 mm length, placed through the face at the location of expected localised seepage;
- Provision of horizontal or slightly inclined drainpipes of typical diameter 50 mm installed at the locations where it is necessary to control the groundwater pressures imposed on the retained soil mass;
- Installation of a permanent interception ditch behind the wall at its crest to prevent surface water runoff from infiltrating behind the wall or flowing over the wall edge;
- Provision of a vegetative protective cap/cover to reduce or prevent water infiltration into the soil

(j) Corrosion Protection

Corrosion potential of the soil must be evaluated for all

permanent soil nail walls and, in some cases, for temporary walls. Corrosion protection measures:

- Specify a minimum grout cover of 25 mm between the reinforcement nail bar and the soil or as directed by the Engineer;
- Recommend epoxy coating of minimum thickness 0.4 mm on the nail bars shall be applied by the manufacturer prior to shipment of nails to the construction site, which is, subsequently to be encased in grout cover; and
- Adopt other site-specific suitable corrosion protection measures as directed by the Engineer.

3604B CHARACTERISTICS AND STANDARD TESTING PROCEDURES

(a) Field Pullout Testing

Field pull out testing of soil nails shall be conducted:

- To verify that the nail design loads can be carried without excessive movements and with an adequate safety factor for the service life of the structure, and
- To verify the adequacy of the contractor's drilling, installation, and grouting operations prior to and during construction of production soil nails.

(b) Types of Field Pull Out Tests

Depending upon the type of test being performed, the maximum test load, the load increments, and the time that each load increment is held shall be determined. To prevent chances of explosive failure of the steel, in no case, shall the soil nail tendon be stressed to more than 80% of its minimum ultimate tensile strength for 415 grade steel, or more than 90% of the minimum yield strength for 500 grade steel.

(c) Verification or Ultimate Load Test

A verification test on soil nail shall be performed:

- To determine the ultimate bond capacity (if carried to pull-out failure);
- Verify the design bond factor of safety; and
- To determine the soil nail load at which excessive creep occurs. Verification tests are generally conducted on non-production "sacrificial" nails as a first order of work prior to construction.

The criterion for acceptance in verification test shall be as detailed below::

- No pull-out failure shall occur at 200 percent of the design load where pull out failure is defined as the load at which attempts to further increase the test load increments results in continued pullout movement of the tested nail; and
- The total measured movement (L) at the test load of 200 percent of design load shall exceed 80 percent of the theoretical elastic movement of the unbonded length (from back of the reference plate to the top of the grout length). This is expressed as

$$L \geq L_{min}$$

$$L_{min} = 0.8 \times \frac{P \times L_u}{E \times A}$$

Where:

L_{min} = minimum acceptable movement

P = Maximum applied test load

A = Cross-sectional area of the nail bar

E = Young's modulus of steel

L_u = Unbonded length

waler bars with all leads and lifts as per the detailed drawing and technical specification.

(d) Proof Test

A proof test shall typically be performed on a specified number of the total number of production soil nails installed. Typically, successful proof tests shall be performed on 5% of the production nails in each row or a minimum of 1 test per row. Proof tests provide information necessary to evaluate the ability of production soil nails to safely withstand design loads without excessive structural movement or long-term creep over the structure's service life. The acceptance criterion requires no pull-out failure during the loading and the displacement (L) under 150% of the design load should exceed the minimum acceptable movement (L_{min}).

(e) Creep Test

Creep tests shall generally be performed as part of a verification or proof test to ensure that nail design loads can be safely carried throughout the structure's service life. In such a test, soil nail displacement shall be measured at a constant load over a specified period of time. The deflection-versus-log-time results shall be plotted on a semi-log graph, before comparing with the acceptance criteria presented in the construction specification. Acceptance criteria shall typically require that creep movement between the 1-minute and 10-minute readings, at maximum test load, should be less than 1 mm or that the creep movement between the 6 minute and 60-minute readings must be less than 2 mm at maximum test load.

3605B MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
36.01B NAIL SOIL STABILIZATION SYSTEM	
(a) PROVIDING AND FIXING OF GALVANISED THREADED SOIL NAIL INCLUDING BOLTS	METRE (m)
(b) PROVIDING AND LAYING OF (SPECIFY THICKNESS AND GRADE) SHOTCRETE FACIA INCLUDING WIRE MESH AND WALLAR BARS:	SQUARE METRE (m ²)

The unit of measurement for Nail Soil Stabilization System shall be the metre of Nail Drilled/ Driven as shown on the Drawings or directed by the Engineer. The length shall be measured along the Nail from the base plate to tip of the Nail.

The bid rates shall include full compensation for providing, testing, loading, transporting, unloading and placing the Nail soil stabilization system. The rate includes supplying, drilling (in hard/soft soil/rock), flushing of drill holes and grouting of bars having minimum yield strength, at a defined pattern and spacing, diameter and length as per design/ drawing and specification. The rates also include validation from pull out test at the site including flushing of drilled holes as per approved methodology using necessary equipment, tools, plants, staging/ working platform, labour and material.

The unit of measurement for Nail Soil facing shall be the Square metre of shotcrete facia to the desired thickness as shown on the Drawings or directed by the Engineer.

The bid rates shall include full compensation for providing, and placing Nail soil Facing (shotcrete Facia) of specified thickness and reinforcement using necessary equipment, tools, plants, staging, working platform, labour, all materials and equipment required for grouting under high pressure using fine cement, cement-sand and shrink, compensating grout mixture, admixtures. Shotcrete facia including wire mesh and

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SECTION 3600C: ROCKFALL NETTING

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3601C SCOPE

The section covers rockfall netting as required for construction of the works covered by the Contract, in accordance with these Specifications.

3602C MATERIALS

(a) General

For rock slopes with higher boulder size and loose surficial layer, cable panels secured by grouted anchor bars shall be laid over the slope which by higher self-weights prevents the movement of top loose layers. Different types of cable panels that are generally used for rockfall protection works are:

- Cable Panels with high strength knots
- Cable Panels with high strength clips

The minimum mass of galvanised high grade corrosion prevention using Zinc-Aluminium coating of the wire rope shall comply with BS EN 10244-2:2023 in conformance with class B or class A. The minimum tensile strength of the simple rock fall netting varies depending on the mesh opening size and the diameter of the wire used.

(b) Cable Panel with High Strength Knots

These shall be panels made of steel cable mesh panels made with only one steel cable, laced or woven to form rhomboid mesh. The intersection points shall be reinforced with high strength knots to resist an eventual static or dynamic stress that can deform the panel. The reinforcements shall be made of double steel wire knots with a wire diameter of 3 mm, mechanically intersected during the production phase on each side of the panel (double binding with two separate wires).

- Mesh Shape: Rhomboidal
- Mesh size: 250 mm x 250 mm,
300 mm x 300 mm,
400 mm x 400 mm.

Note: 60 mm x 60 mm can be used in combination with the above

- Wire rope characteristics:
Wire rope construction (As per ISO 2048):

- 8 mm: 6 x 7
- 10 mm: 6 x 19
- 12 mm: 6 x 19

Tensile Strength: 80 kN/m to 200 kN/m.

- Type of connection at the junction of cables:
Double binding knot on both sides with high

strength 3 mm diameter galvanised steel wire.

- Junction Strength:

Junction tearing/rupture strength: 20 kN - 24 kN;
Pull-apart strength ranges: 10 kN - 11.5 kN

(c) Cable Panel with High Strength Clips

The square woven and diagonally woven cable nets manufactured are fabricated using galvanized steel cable. At the intersections, horizontal and vertical chords shall have a tucked joint fixed with special clamps, which provides an extra dimensional stability.

- Mesh Shape: Square
- Mesh size: 300 mm x 300 mm

- Wire rope characteristics:

Wire Rope Diameter: 8 mm

Wire Rope Construction (As per ISO 2048):

8 mm: 6 x 19

Tensile Strength: Minimum Value 120 kN/m.

- Type of connection at the junction of cables:

Steel clips with zinc electroplate coating.

- Junction Strength:

Junction tearing/rupture strength: 12 kN - 15 kN
Junction pull-apart strength: 7 kN - 9 kN

(d) Ring Nets

Ring net shall be a mesh with excellent elastic deformation which ensures the gentle and regular transmission of the dissipation energy through interlocked rings. The ring panels combine high strength features of the wire rope with extreme flexibility and dynamic impact resistance capacity. The ring shall be made by seven loop bindings, each one obtained by looping a single steel wire. Each ring shall be connected with 4 contiguous rings (4-point connection) or 6 contiguous rings (6-point connection).

- Mesh Shape: Ring Shaped
- Size: 350 mm

- Wire Rope Characteristics:

Ø wires: 3 mm,
3.5 mm,
4 mm.

- Class A zinc coated (As per BS EN 10244-2:2023).
Tensile Strength: 180 kN/m to 200 kN/m

(e) Reinforced Mesh

Reinforced mesh shall be a woven geocomposite made from steel wire and ropes assembled together during the production of simple rockfall netting. Depending on the direction in which the ropes are inserted in the mesh, the mesh can be Mono-oriented or Bi-oriented

i) Mono-Oriented Reinforced Mesh:

Steel ropes of 8 mm Ø shall be used in place of the conventional selvage wire and shall be inserted longitudinally in the woven mesh at approximate distances of 0.3 m, 0.5 m, 1.0 m, 1.5 m and 3.0 m.

ii) Bi-Oriented Reinforced Mesh:

Steel ropes of 8 mm Ø shall be used in place of the conventional selvage wire and shall be inserted longitudinally in the woven mesh at an approximate distance of 1.0 m, 1.5 m, 3.0 m. Steel ropes shall also be inserted in the cross direction through the mesh at an approximate distance of 1.0 m, 1.5 m, 2.0 m, 3.0m centre-to-centre during production.

Mesh Size:	8 x 10, 10 x 12.
Tensile Strength:	40 kN/m to > 170 kN/m.

The Rate for shall include full compensation for providing, and placing rock fall netting along with installing of anchors as per specification, Drawings and as directed by the engineer. The rate shall also include using necessary equipment, tools, plants, staging, working platform, labour, all materials and equipment required for grouting using fine cement, cement-sand and shrink, compensating grout mixture, admixtures.

(f) Simple Rock Fall Netting

Simple Rockfall Netting shall consist of a mechanically woven double-twisted wire mesh with hexagonal mesh opening size and tolerance in accordance with BS EN 10223-3:2013.

The netting shall be supplied in the form of rolls, which are used to prevent rocks and debris from falling onto roads, or any other area that needs protection.

Mesh Size:	8 x 10 10 x 12
Wire Mesh Ø:	Mesh wire 2.7 mm to 3.0 mm.
Tensile Strength:	32 kN/m to > 60 kN/m.

(g) Single Twist Mesh

Single Twist mesh shall be made of steel wire with high ultimate strength which is used to cover the slope posing rockfall problems. Single twist mesh can have high deformations that can lead to the stripping of anchors and could cause global failure of the system. Also, in case of accidental breakage of a single wire, the entire mesh unravels exposing the threat of rockfall. Hence higher maintenance may be required in case of a single twist mesh

Shape:	diamond
Mesh Size:	8.3 cm x 14.3 cm
Wire Ø:	2 mm, 3 mm 4 mm diameter
Tensile Strength:	Minimum 100 kN/m.

In case of single twist mesh, on breakage of a single wire, the whole mesh gets unravelled very easily and hence the use shall be restricted to very low hazard locations.

3603C STANDARD TESTING PROCEDURES

The contractor shall submit a detailed construction methodology for approval by the engineer before the commencement of works. The tests shall be carried out as per the guidelines given in ASTM A975-23.

3604C MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
36.01C WIRE MESH FOR ROCK FALL PROTECTION	
(a) PROVIDING, PLACING AND INSTALLATION (SPECIFY TYPE, SHAPE, MESH SIZE, WIRE DIAMETER, MINIMUM TENSILE STRENGTH)	SQUARE METRE (m ²)
(b) PROVIDING AND LAYING OF (SPECIFY THICKNESS AND GRADE) SHOTCRETE FACIA INCLUDING WIRE MESH AND WALLAR BARS:	SQUARE METRE (m ²)

The unit of measurement for Rockfall netting shall be the Square metre of netting along with the installation) of anchors as shown on the Drawings or directed by the Engineer.

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**SECTION 3600D: ROCKFALL)
BARRIER**

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3601D SCOPE

The section covers Rockfall barrier as required to be carried out under the Contract or as directed by the Engineer.

3602D GENERAL

Rockfall protection catchment fences to intercept and contain falling rocks, consisting of components such as mesh panels, supporting cables and steel posts used to prevent rocks and debris from falling onto roads.

The Rock fall Barrier system shall be able to withstand the impact of a rock block/debris flow with energy levels of minimum 500/1000/2000/3000/5000/8000 Kilo Joules. The Rock fall Barrier system shall include:

- Primary Interception Net (in case of lower capacity barriers) — Cable Nets/ Steel Wire Ring Nets/ Reinforced Mesh/special proprietary mesh;
- Additional Interception Net (in case of higher capacity barriers) — Simple rockfall netting/Reinforced Mesh/Chain link mesh;
- Detachable Base plates;
- Posts;
- Post foundations;
- Cable or Wire ropes;
- Energy Dissipaters / Braking systems;
- Cable anchor foundations;
- Cable anchors;
- Other necessary accessories for constructing the system.

3603D MATERIALS

(a) General

The retaining Interception Panels along with the additional retaining layer of simple rockfall netting are to be placed on the down slope side of the barrier. Posts act independently of the Interception Nets. The system shall be so designed that even if a post is hit by a falling block and damaged, the adjacent posts should be able to take the additional forces, ensuring that the catching performance of the Rock fall Barrier system is not compromised. The Primary and any additional Interception panels made of Cable Panels/Steel Wire Ring Nets panels and simple rockfall netting respectively shall be continuous. During an impact, the system should ensure that the energy of the falling rock/debris is dissipated and prevented from moving any further. The supporting cables/network shall have energy dissipaters/braking systems that should be able to help dissipate the impact energy by deformation and not by friction, thereby guaranteeing a better and longer lasting

performance.

(b) Material Specification

The height of the Rockfall Barrier System shall vary between 2 m to 8 m. The height and the orientation of the barrier to be provided at each location shall be determined by the Project Engineer.

i) Primary Interception Net

The Primary Interception Net shall be made of cable panels/Ring nets/special proprietary mesh.

ii) Additional Interception Net

The Additional Interception Net (where used) shall be made of simple rockfall netting of types as explained in rockfall netting SECTION 3600C.

The different components such as the energy dissipation devices, the foundation posts, base plate and the cable anchors etc., vary for the different energies of the barrier and for different manufacturers. While implementing the rockfall barrier for dealing with the rockfall problem, it must be ensured that the system as a whole should be in compliance with (EAD 340059-00-0106) — Guideline for European Technical Approval of Falling Rock Protection Kits".

iii) Post Foundation and Cable Anchor Foundation:

The Contractor with the help from the specialist provider of Rock Fall system shall submit working Drawings for the post foundation and cable anchor foundations based on the geological conditions, evaluation of the sub surface layers by drilling and study of the local conditions. Different foundation typologies can be provided, according to the real soil or rock characteristics and parameters. This design assumption has to be carefully verified during the construction stage, to check the real on-site conditions, before the acceptance of the data contained in this report. All metallic parts must be galvanized according to the relevant regulations and the anchors shall be effectively protected against corrosion in aggressive environmental conditions. For example, chemical reactions related to the presence of water and chemical substances. Attention must be paid in the construction stage, to adopt the proper solution to protect the grout-ground lateral surface, because this interface can become the way for rainfall water to flow, and this condition could damage the anchoring system and therefore decrease the effectiveness of the foundations.

3604D STANDARD TESTING PROCEDURES

The contractor shall submit a detailed construction methodology for approval by the engineer before the commencement of works.

The Rock fall Barrier shall be capable of absorbing 500/1000/2000/3000/5000/8000/8500 Kilo Joules of Kinetic energy. Certification of the test results of the test program and approved by a reputed Institute/University (including situated abroad) as per the instructions provided in ETA (EAD 340059-00-0106) — Guideline for European Technical Approval of Falling Rock Protection Kits" shall be evidenced to the Engineer-In-Charge by the Manufacturer/Supplier of the Rock fall Barrier system. Confirmation of the certification shall be proved by the provision of ETA code sheet on independent check of the EOTA website made by the Project Engineer.

3605D MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
36.01D ROCKFALL BARRIER	
(a) PROVIDING & FIXING OF ROCKFALL BARRIER (SPECIFY HEIGHT, SPACING OF POST)	METRE (m)

The unit of measurement for Rock Fall Barrier shall be the metre of Barrier length as shown on the Drawings or ordered by the Engineer. The length shall be measured along.

The bid rates shall include full compensation for providing, testing, loading, transporting, unloading and placing entire components of the Rockfall barrier like energy dissipation devices, the foundation posts, base plate and the cable anchors etc. The rate includes supplying, Drilling/Excavation (in hard/soft soil/rock) for foundation trenches, preparation of foundation, at a defined pattern and spacing, as per design/drawing and specification.

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SECTION 3600E:SHOTCRETE

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3601E SCOPE

This Section covers the supply and application of shotcrete to rock and soil cut faces, soil nail faces, slope stabilization and slope remediation, and other areas as directed by the Engineer. It includes the supply and application of shotcrete by either dry or wet-mix methods and for reinforcement included in shotcrete layers.

3602E GENERAL

The contractor shall submit a detailed construction methodology for approval by the Engineer before the commencement of works.

3603E MATERIALS

(a) Cement

Cement shall comply with the requirements of US EAS 18-1:2017 (CEM I or II), AASHTO M 85-24.

(b) Aggregates

Aggregate shall conform to the requirements of SECTION 6402.

(c) Water

Potable water shall be used for batching of shotcrete.

(d) Admixtures

Shotcrete admixtures shall comply with SERIES 6000 and shall be submitted to the Engineer together with the proposed mix design for approval prior to commencement of work. Admixtures shall have no deleterious effects on reinforcement or shotcrete, and shall not contain any chlorides, nitrates, sulphides or sulphites. Where more than one admixture is included in the shotcrete mixture, they shall be chemically compatible. Approval of the shotcrete admixture shall be subject to satisfactory demonstration of suitability of the proposed shotcrete mixture through the construction of trial panels and acceptable quality assessments conducted on a minimum of three test panels representing three independently batched shotcrete mixes.

(e) Fibres

All steel fibres for concrete shall comply with BS EN 14889-1:2006; all polymer fibres shall comply with BS EN 14889-2:2006 or ASTM D7508/D7508M-20. All fibres shall be submitted to the Engineer for approval prior to the commencement of work.

The fibres shall not cause blockage of hoses used for shotcrete. Long fibres shall not exceed 70 per cent of the minimum internal diameter of the pipes and hoses used, unless it has been proven that longer fibres can be used without blockages.

(f) Reinforcement

All reinforcement shall comply with SECTION 6302. Reinforcement type and description shall be welded steel fabric mesh, unless otherwise specified in the Drawings or as directed by the Engineer.

(g) Compressive Strength, Ultimate Flexural Strength and Energy Absorption Capacity

The Contractor shall be responsible for design of the shotcrete mix in order to produce shotcrete that complies with the requirements for each class of shotcrete.

Minimum ultimate flexural strength requirements shall be as shown in Drawings or as directed by the Engineer.

The minimum energy absorption capacity of fibre-reinforced shotcrete shall be as specified in the special specifications or as indicated on the Drawings. Energy absorption capacity shall be determined from a slab specimen, tested at 28 days in accordance with BS EN 14488-5:2006.

(h) Drainage Systems, Geopipe Collectors and Weep Holes

Weep hole material shall be U-PVC pipes.

Water collection pipes shall be perforated. The size of perforations in perforated pipes shall in all cases be 8.0 mm in diameter plus or minus 1.5 mm, and the number of perforations per metre shall not be fewer than twenty-six for 100 mm pipes and fifty-two for 150 mm pipes. Perforations shall be spaced in two rows for 100 mm pipes and in four rows for 150 mm pipes. Slotted pipes shall have a slot width of 8.0 mm with a tolerance of 1.5 mm. Arrangement of slots shall be subject to approval by the Engineer, but the total slot area shall not be less than that specified for perforations. Installed pipes shall protrude 20 mm beyond the surface of the final shotcrete layer and have their inner slotted section end wrapped with a single layer of approved geotextile.

Pipes without slots or perforations required for transporting water from the drainage system to the point of discharge shall be U-PVC.

Geo-composite/ Geo-synthetic drains shall be of type as specified in the specifications or as shown in the Drawings. Strip or band drains generally 150 mm wide geo-synthetic which discharge into weep holes installed through shotcrete lining are commonly specified. Such shall be detailed on the Drawings where these drain types are specified.

These materials shall be protected against sunlight and mechanical damage during storage and installation. Geo-synthetics shall be non-woven, spun or thermic-bonded filament consisting of more than 85 % by mass of polypropylene, polyester or other approved material and manufactured for civil engineering applications by a recognized manufacturer.

In special applications requiring particular drainage measures, shotcrete may require application over vegetation, matting or other bonded open- structured Geo-synthetic. Geo-synthetic requirements shall be specified in the specifications and as shown in the Drawings.

3604E CONSTRUCTION EQUIPMENT

(a) General

Plant used for shotcreting shall be based on proven technology within the industry and shall be in good working order. Plant shall be inspected, serviced and calibrated at regular intervals and tested to ensure system functionality, efficiency and accuracy all to Engineer's satisfaction.

(b) Spraying Equipment

The delivery hoses and nozzles shall be such as to ensure a uniform mix and supply of mix ingredients to the mixing nozzle, thereby obtaining correct consistency and a uniform discharge rate from the nozzle. Hoses shall be blown clean before any work is stopped.

i) Dry-Mix Process

Air operating pressure supply at the gun outlet shall be greater than 240 kPa, and shall, as a minimum, be capable at all times of maintaining a discharge nozzle velocity of 90 to 120 m/sec. Water added at the nozzle shall be supplied at a uniform pressure of 100 kPa greater than air pressure at the nozzle.

Supply of water to the mixing nozzle shall be such that a pressure of greater than 400 kPa or as dictated in the approved method statement can be maintained.

ii) Wet-Mix Process

The air compressors and delivery hose lines shall be of adequate capacity and size to provide a pressure of greater than 240 kPa at the nozzle for 25 mm nozzles and proportionally greater for larger nozzles or as given in the approved method statement.

3605E TESTING**(a) Compressive Strength**

For determining compressive strength, characteristic cylinder strength, determined from cores extracted from test panels, using 75 mm diameter, 150 mm high cylinders shall be prepared in accordance with SANS 3001-CO2-2 and tested in accordance with SANS 3001-CO2-3 at a sample age of 28 days. For particular uses, it may be necessary to specify compressive strength at ages earlier or later than 28 days, or after storage under special conditions. In assessing strength, other sizes of specimens and other curing regimes shall be used provided that relationship to those standardized is established and documented.

(b) Flexural Strength

Ultimate flexural strength shall be determined from beam specimens cut from test panels, tested at 28 days in accordance with SANS 5864.

(c) Energy Absorption Capacity

Energy absorption capacity shall be determined from a test panel slab specimen, tested at 28 days, in accordance with BS EN 14488-5:2006.

3606E MEASUREMENT AND PAYMENT**(a) General**

The tendered rate for each pay item shall include full compensation for providing, operating, maintaining and decommissioning upon completion, of all the construction equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the pay item as specified, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

ITEM**UNIT**

36.01E ESTABLISHMENT ON SITE LUMP SUM

The tendered lump sum shall include full compensation for establishing on site all plant and equipment, scaffolding, platforms, materials and personnel necessary to carry out the specified work and for the removal from site of all such plant and equipment including all temporary works such as access roads, staging, platforms and such like on completion of the works.

ITEM**UNIT**

36.02E SURFACE PREPARATION FOR SHOTCRETING SQUARE METER (m²)

The unit of measurement shall be the square metre of face/slope cleared of all loose or unwanted material, including indicated vegetation, and manually trimmed to designed lines and levels as specified.

The tendered rate shall include full compensation for trimming all material, and for all equipment, labour and other incidentals necessary to complete the specified work.

ITEM**UNIT**

36.03E SUPPLY AND INSTALLATION OF REINFORCEMENT

(a) WELDED STEEL MESH FABRIC	SQUARE METER (m ²)
(b) FIBRE (STATE TYPE)	KILOGRAMME (Kg)
(c) OTHER SPECIAL REINFORCEMENT (STATE TYPE)	SQUARE METER (m ²)

The unit of measurement for steel mesh shall be the net square metre of reinforcement actually incorporated into shotcrete. Measurement shall be based on square metres of soil and or rock slope covered with mesh and measured on the plane of the slope. No overlaps of mesh and or reinforcement system shall be measured.

The unit of measure for fibre shall be the mass in kilograms of fibre actually used, as determined by the kilogram of fibre per cubic metre of shotcrete specified.

The tendered rate shall include full compensation for supply and installation, including all equipment, plant, materials, labour and incidentals necessary to carry out the specified work and including specifically supply and installation of pins, earth spikes, soil nails/ rock bolts, wire ties, gun nails and any other approved fastenings for the completion of the work as specified.

ITEM**UNIT**

36.04E SHOTCRETE	
(a) FLASH/ BASE COAT (SPECIFY THICKNESS)	SQUARE METRE (m ²)
(b) INTERMEDIATE COAT (SPECIFY THICKNESS)	SQUARE METRE (m ²)
(c) FINAL COAT (SPECIFY THICKNESS)	SQUARE METRE (m ²)
(d) DENTAL SHOTCRETE	CUBIC METRE (m ³)

The unit of measurement shall be the net square metre of face measured in the plane of the cutting face, which is protected by shotcrete of specified nominal thickness, installed as specified. No separate allowance shall be made for an uneven surface when measuring the area over which shotcrete is applied.

The unit of measurement for dental shotcrete shall be the cubic metre of shotcrete of measured batch volume, agreed with the Engineer and installed in accordance with the specifications.

The tendered rate shall include for everything necessary to carry out specified work as specified. and shall include safe access for the Engineer to any portion of the cut face or slope.

<u>ITEM</u>	<u>UNIT</u>
36.05E EDGE FINISHING OF SHOTCRETE	LINEAR METRE (m)

The unit of measurement shall be the linear metre of perimeter where shotcrete is required to be finished off as detailed in the Drawings, all as specified.

The tendered rate shall include full compensation for excavation and spoiling of material from trenches, bending of mesh or reinforcement, application of shotcrete irrespective of volume involved as well as all equipment, labour, transport and other incidentals necessary to complete the specified work.

<u>ITEM</u>	<u>UNIT</u>
36.06E GEO-PIPE COLLECTORS/ WEEP HOLES	
(a) PIPE (SPECIFY TYPE, DIAMETER AND CLASS)	LINEAR METRE (m)

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

**SECTION 3700: PAVEMENT
LAYERS OF NATURAL OR
MECHANICALLY MODIFIED
GRAVEL MATERIALS**

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3701 SCOPE

This Section covers the construction of subbase, base course, shoulders and gravel wearing course from natural gravel or partially crushed gravel.

This Section covers the requirements for the following types of material:

- GW natural gravel material for wearing course and unpaved shoulders with minimum soaked CBR value of 25%;
- G80 natural gravel with minimum soaked CBR value of 80%;
- G60 natural gravel with minimum soaked CBR value of 60%;
- G45 natural gravel with minimum soaked CBR value of 45%;
- G30 natural gravel with minimum soaked CBR value of 30%.

3702 MATERIALS

(a) General

Gravel material shall be obtained from approved sources. Any test results provided in design documents such as the Materials Report, read in conjunction with these Specifications, may give a preliminary indication as to the purpose for which cut or borrow material may be used as well as the treatment, if any, which the roadbed shall receive. Any test results or recommendations of the method of work in the Materials Report are solely for information. The Contractor shall undertake their own assessment and any tests required and submit their proposed methods of work and test results of all material they intend to use for the approval of the Engineer.

The material type (G80, G60, G45, G30, GW) given in the Drawings denotes the minimum quality for a particular use in the Works, either specified in the Drawings or as instructed by the Engineer. In the cases where a minimum quality of earthworks material is not specified, the following guidelines shall apply and the Engineer's instruction shall be the applied standard to which materials quality control is applied:

(b) Material Type and Typical Use

- GW Gravel wearing course and gravel shoulders
- G80 Base course
- G60 Base course, low traffic roads
- G45 Subbase
- G30 Subbase

Irrespective of the minimum required quality specified or the above guidelines, the highest quality of approved gravel for pavement layers available at economical haul distances, complying with the requirements of the Specifications and Drawings, shall be selected for fill, improved subgrade and the individual pavement layers.

(c) Soluble Salts

The Contractor shall discard the material or fulfil all requirements for appropriate construction techniques and timing of operations to the satisfaction of the Engineer if assessments of soluble salt contents in base course or subbase materials show deleterious values. Such assessments are only required where the pavement is going to receive a bituminous seal as the only surfacing. No additional payment will be made for any measures taken, or for any alterations of the material utilisation, due to the presence of soluble salts in materials or construction water.

(d) Grading Modulus (GM), Grading Coefficient (GC) and Shrinkage Product (SP)

Wherever grading modulus (GM) is referred to the value shall be calculated as follows:

$$GM = \left[3 - \left(\frac{\%pass2mm + \%pass0.425mm + \%pass0.075mm}{100} \right) \right]$$

Wherever Grading Coefficient (GC) is referred to the value shall be calculated as follows:

$$GC = \frac{((\%pass28mm - \%pass2mm) \times \%pass5mm)}{100}$$

Where:

- % pass 26.5 mm is the percentage of material passing the 26.5 mm sieve size (N.B. 26 mm or 28 mm standard sieve size can be substituted without significant error);
- % pass 2 mm is the percentage of material passing the 2 mm sieve size (N.B. 2.36 mm standard sieve size can be substituted without significant error);
- % pass 4.75 mm is the percentage of material passing the 4.75 mm sieve size.

Shrinkage Product (SP) is referred to the value calculated as follows:

$$SP = LS \times (\% \text{ pass } 0.425 \text{ mm})$$

Where LS is Linear Shrinkage as determined according to BS 1377-2:2022.

(e) Gravel Wearing Course (GW) and Unpaved Shoulders

Materials for unpaved shoulders and gravel wearing course layers of GW materials as specified on the Drawings shall meet the requirements given in TABLE 3702/1.

(f) Material Requirements for Natural Gravel Base Course (G80)

Materials for base course layers of G80 materials as specified on the Drawings shall meet the requirements given in TABLE 3702/2.

(g) Material Requirements for Natural Gravel Base Course (G60) for Low Traffic Roads

Materials for base course layers of G60 materials as specified on the Drawings shall meet the requirements given in TABLE 3702/3.

specified on the Drawings shall meet the requirements given in TABLE 3702/4.

(h) Material Requirements for Natural Gravel Subbase (G45)

Materials for subbase layers of G45 materials as

(i) Material Requirements for Natural Gravel Subbase (G30)

Materials for subbase layers of G30 materials as specified on the Drawings shall meet the requirements given in TABLE 3702/5.

TABLE 3702/1: REQUIREMENTS FOR LAYERS OF GRAVEL WEARING COURSE GW MATERIALS

Material properties	Material class GW
CBR: BS 1377-2:2022	
CBR (%)	Minimum 25 after 4 days soaking ¹⁾
Grading and Shrinkage Limits 2)	
% passing the 37.5 mm sieve	Minimum 95
Shrinkage product, SP	Minimum 120, Maximum 400 ³⁾
Grading coefficient, GC	Minimum 16, Maximum 34
Single Compacted Layer Thickness (in mm)	Minimum 100 - Maximum 200
1) CBR values shall be measured at 95% of MDD for BS-Heavy compaction. For minor gravel roads the required CBR value may be reduced to 15 on the approval of the Engineer. 2) It is emphasized that the Atterberg limits shall be measured according to BS 1377-2:2022. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer. All grading parameters must be normalised for 100% passing 37.5 mm. 3) In built up areas the maximum SP value shall be 270 or as directed by the Engineer in order to minimise dust problems.	

Table 3702/2: REQUIREMENTS FOR BASE COURSE LAYERS OF G80 MATERIALS

Material properties	Material class G80	
	General requirements	Calcrete or other pedogenic materials
CBR: BS 1377-2:2022		
CBR (%)	Minimum 80 after 4 days soaking 1)	
CBR-swell (%)	Maximum 0.5 measured at BS-Heavy compaction	
Atterberg limits: 2)		
Max Liquid limit BS 1377-2:2022	30	35
Max Plasticity Index BS 1377-2:2022	8	10
Max Linear Shrinkage BS 1377-2:2022	4	5
Grading: BS 1377-2:2022		
Sieve size (mm)	Grading limits (% passing sieve)	The largest particles d_{max} shall be maximum $\frac{1}{2}$ of compacted layer thickness but not > 50 mm. Grading modulus, GM shall be minimum 2.0
63	100	
37.5	80 – 100	
20	60 – 95	
5	30 – 65	
2	20 – 50	
0.425	10 – 30	
0.075	5 – 15	
Particle strength: BS 812-111:1990		
Minimum TFV _{dry}	80 kN	
Ratio dry to soaked value of TFV	TFV _{soaked} shall be minimum 60% of the corresponding TFV _{dry} value	
Single Compacted Layer Thickness (in mm)	Minimum 100 – Maximum 200	
1) CBR values shall be measured at the minimum specified field density for the layer in accordance with TABLE 3704/1. 2) It is emphasized that the Atterberg limits shall be measured according to BS 1377-2:2022. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.		

TABLE 3702/3: REQUIREMENTS FOR BASE COURSE LAYERS OF G60 MATERIALS

Material properties	Material class G60	
	General requirements	Calcrete or other pedogenic materials
CBR: BS 1377-2:2022		
CBR (%)	Minimum 60 after 4 days soaking 1)	
CBR-swell (%)	Maximum 1.0 measured at BS-Heavy compaction	
Atterberg limits: 2)		
Max Liquid Limit BS 1377-2:2022	35	40
Max Plasticity Index BS 1377-2:2022	10	12
Max Linear Shrinkage BS 1377-2:2022	5	6
Grading: BS 1377-2:2022		
Sieve size (mm)	Grading limits (% passing sieve)	The largest particles d_{max} shall be maximum 1/2 of compacted layer thickness but not > 50 mm. Grading modulus, GM shall be minimum 2.0
63	100	
37.5	80 – 100	
20	60 – 95	
5	30 – 65	
2	20 – 50	
0.425	10 – 30	
0.075	5 – 15	
Particle strength: BS 812-111:1990		
Minimum TFV _{dry}	50 kN	
Ratio dry to soaked value of TFV	TFV _{soaked} shall be minimum 60% of the corresponding TFV _{dry} value	
Single Compacted Layer Thickness (in mm)	Minimum 100 – Maximum 200	
1) CBR values shall be measured at the minimum specified field density for the layer in accordance with TABLE 3704/1. 2) It is emphasized that the Atterberg limits shall be measured according to BS 1377-2:2022. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.		

TABLE 3702/4: REQUIREMENTS FOR SUBBASE LAYERS OF G45 MATERIALS

Material properties	Material class G45	
	General requirements	Calcrete or other pedogenic materials
CBR: BS 1377-2:2022		
CBR (%)	Minimum 45 after 4 days soaking 1)	
CBR-swell (%)	Maximum 0.5 measured at BS-Heavy compaction	
Atterberg limits: 2)		
Max Liquid Limit BS 1377-2:2022	40	45
Max Plasticity Index BS 1377-2:2022	14	16
Max Linear Shrinkage BS 1377-2:2022	7	8
Grading: BS 1377-2:2022		
Requirements:	Grading modulus, GM shall be minimum 1.5	
Single Compacted Layer Thickness (in mm)	Minimum 100 – Maximum 200	
1) CBR values shall be measured at the minimum specified field density for the layer in accordance with TABLE 3704/1.		
2) It is emphasised that the Atterberg limits shall be measured according to BS 1377-2:2022. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.		

TABLE 3702/5: REQUIREMENTS FOR SUBBASE LAYERS OF G30 MATERIALS

Material properties	Material class G30	
	General requirements	Calcrete or other pedogenic materials
CBR: BS 1377-2:2022		
CBR (%)	Minimum 30 after 4 days soaking 1)	
CBR-swell (%)	Maximum 1.0 measured at BS-Heavy compaction	
Atterberg limits: 2)		
Max Liquid limit BS 1377-2:2022	45	45
Max Plasticity Index BS 1377-2:2022	16	18
Max Linear Shrinkage BS 1377-2:2022	8	9
Grading: BS 1377-2:2022		
Requirements:	Grading modulus, GM shall be minimum 1.2	
Single Compacted Layer Thickness (in mm)	Minimum 100 – Maximum 200	
1) CBR values shall be measured at the minimum specified field density for the layer in accordance with TABLE 3704/1.		
2) It is emphasised that the Atterberg limits shall be measured according to BS 1377-2:2022. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.		

3703 CONSTRUCTIONS

(a) Requirements Applying Prior to Placing of the Layer

No pavement layer shall be placed until approval is obtained from the Engineer and the underlying layer is placed, compacted and finished in accordance with the Specifications and is tested and found acceptable to the full satisfaction of the Engineer. Before placing any pavement layer the underlying layer shall be inspected and proof rolled as required by the Engineer in order to establish whether there is any damage, wet spots or other defects. Any such defect shall be rectified to the satisfaction of the Engineer before the next layer is placed.

(b) Processing to Improve Quality

The Contractor may elect to crush, screen or mix materials from different sources or undertake other processing of materials to meet the specified material requirements. No additional payment will be made for any such processing unless stated in the Special Specifications and the Bill of Quantities.

(c) Shoulders

Where the shoulders and the base course are to be constructed from the same material, they shall be constructed simultaneously.

Where the base course is to be constructed from a different material than the shoulders, the shoulders shall first be constructed and then neatly cut to the required line to provide lateral support for the base course. Care shall be taken not to contaminate the base course material with the shoulder material. Where the base course is made of a bituminous mix, the base course may however be constructed before the shoulders. Work shall be so constructed that the road will be adequately drained at all times by means of sufficient drainage pipes passing through the shoulders. The Contractor shall not start constructing the final bituminous surfacing of any part of the road before they have completed the shoulders of such section to the satisfaction of the Engineer.

Shoulder material shall be spread, broken down as required, watered, mixed and compacted in accordance with the Specifications, and shall be compacted to a density of not less than that specified in TABLE 3704/1 or as directed by the Engineer.

(d) Subbase and Base Course Materials

Subbase or base course materials respectively shall be spread, broken down as required, watered, mixed and

compacted in accordance with the Specifications, and shall be compacted to a density of not less than that specified in TABLE 3704/1 or as directed by the Engineer.

3704 COMPACTION REQUIREMENTS

(a) General Requirements

The minimum required compacted density for pavement layers made of natural gravel shall be as given in TABLE 3704/1.

TABLE 3704/1: COMPACTION REQUIREMENTS FOR PAVEMENT LAYERS MADE OF NATURAL GRAVEL

Layer and typical material type specified	Minimum dry density, lower specification limit, BS 1377-2 :2022
Base course layers, G80 or G60 material or better	98% of BS-Heavy
Subbase course layers, G45 or G30 material or better	95% of BS-Heavy
Gravel wearing course or unpaved shoulders GW material	

Unless otherwise specified in the Special Specifications, the compaction requirements shall comply with acceptance criteria according to the statistical method specified in SECTION 7200.

(b) Compaction Method Specification

The Engineer may at their own discretion allow compaction to be carried out in accordance with a method specification instead of density control in cases where material characteristics or site conditions in their opinion makes compaction density control inappropriate. Trials shall be undertaken to the full satisfaction of the Engineer in order to establish the required type of equipment, processing method and number of roller passes. The outcome of the trials shall be satisfactory to the Engineer for a method specification to be employed. All costs for undertaking such trials shall be carried by the Contractor.

The use of a compaction method specification may at the Engineer's discretion be discontinued at any time they find it necessary for whatever reason.

3705 MAINTENANCE OF EXISTING GRAVEL ROADS

(a) General

Maintenance of existing gravel road surfaces shall be classified as one or more of the following operations:

- i. Shaping existing gravel roads
- ii. Ripping and processing existing gravel roads
- iii. Re-gravelling existing gravel roads

(b) Shaping Existing Gravel Roads

Shaping existing gravel roads is paid for per square metre in SUB-ITEM 37.04 (a). No payment shall be made for shaping existing gravel roads on sections where regravelling or ripping and processing is carried out. Shaping existing gravel roads comprises the following operation carried out to the satisfaction of the Engineer:

- i. Bringing loose material back to the road from the slopes and ditches if instructed by the Engineer.
- ii. Shaping by motor grader, or equivalent equipment approved by the Engineer.

(c) Ripping and Processing Existing Gravel Roads

Ripping and processing existing gravel roads is paid for per square metre in SUB-ITEM 37.04 (b) and comprises the following operations:

- i. Ripping of the existing road to a depth of minimum 100 mm as required by the Engineer.
- ii. Bringing loose material back to the road from the slopes and ditches if instructed by the Engineer.
- iii. Mixing, breaking of lumps, removal of oversize particles and watering as required to make a homogenous material having suitable moisture content at or around the optimum moisture content of BS-Heavy density.
- iv. Shaping and finishing to the correct grade and crossfall and compaction to the requirements in CLAUSE 3704.

(d) Regravelling Existing Gravel Roads

Regravelling comprises the following operation, paid for per cubic metre in SUB-ITEM 37.03 (b).

- i. Addition of gravel wearing course material to an existing road.
- ii. Processing as specified in CLAUSES 3703 and 3704 for GW material by mixing, breaking of lumps, removal of oversize particles and watering as required to make a homogenous material having suitable moisture content at or around the optimum moisture content of BS-Heavy density.
- iii. Shaping and finishing to the correct grade and crossfall and compaction to the requirements in CLAUSE 3704.

Ripping of the existing surface shall be carried out as required on the approval of the Engineer wherever the compacted layer thickness will not reach minimum 75 mm, or as instructed by the Engineer for other reasons. Ripping shall be carried out to a depth of minimum 100 mm as required by the Engineer. In such cases additional payment per square metre in SUB-ITEM 37.04 (b) will apply.

Ripping and reprocessing in addition to regravelling may be required due to the application of thin layers of imported gravel, poor shape of the existing road or whatever other reason as deemed necessary by the Engineer.

(e) Materials and Compaction

The gravel wearing course material, and respectively the combination of imported and scarified material, shall meet the requirements for material class GW as given in

CLAUSE 3702. Where the compacted layer thickness will exceed 200 mm the compaction shall be carried out in two operations. Each layer shall be shaped to the specified grade and compacted to the required density in accordance with CLAUSE 3704 before the succeeding layer is placed.

3706 PROTECTION AND MAINTENANCE

The compacted layers shall be adequately drained and shaped to prevent water from standing on or along or causing damage to the completed work. Windrows shall be removed to facilitate the drainage of water from the surface.

No material for a subsequent layer shall be placed if the underlying layer has been softened by excessive moisture and requires repair in the opinion of the Engineer.

3707 CONSTRUCTION TOLERANCES

Construction tolerances and testing shall be in accordance with SERIES 7000.

3708 LABORATORY AND SITE TRIALS

Laboratory and site trials shall be in accordance with SERIES 7000.

3709 MEASUREMENT AND PAYMENT

ITEM	UNIT
37.01 NATURAL GRAVEL FOR BASE COURSE:	
(a) NATURAL GRAVEL CLASS G80	CUBIC METRE (m ³)
(b) NATURAL GRAVEL CLASS G60	CUBIC METRE (m ³)

ITEM	UNIT
37.02 NATURAL GRAVEL FOR SUBBASE:	
(a) NATURAL GRAVEL CLASS G45	CUBIC METRE (m ³)
(b) NATURAL GRAVEL CLASS G30	CUBIC METRE (m ³)
(c) NATURAL MATERIAL CLASS G15	CUBIC METRE (m ³)

ITEM	UNIT
37.03 NATURAL GRAVEL FOR GRAVEL WEARING COURSE AND UNPAVED SHOULDERS:	
(a) NATURAL GRAVEL CLASS GW USED FOR UNPAVED SHOULDERS FOR BITUMINOUS PAVEMENTS	CUBIC METRE (m ³)
(b) NATURAL GRAVEL CLASS GW USED FOR GRAVEL WEARING COURSE	CUBIC METRE (m ³)

The quantity of natural gravel shall be the number of cubic metres completed in place compacted to the depths and widths shown on the Drawings or as directed. The quantity shall be measured by the cross-section area shown on the construction Drawings times the station length. Where gravel wearing course material, GW, is placed on an existing gravel road the measurement of levels before the start of the operation shall form the basis for calculating the cubic metre quantities. In the cases where gravel wearing course material is not to be compacted on the approval of the Engineer, the quantity shall be measured as cubic metres in the un-compacted state.

The quantity measured under ITEM 37.02 (c) when chemically stabilised shall be the compacted volume of the finished stabilised layer.

The bid rates shall include full compensation for procuring, breaking down, placing, compacting, testing and proof rolling the material including the protection and maintenance of the layer, all as specified.

When payment for overhaul is allowed for in accordance with the Special Specifications, the rates shall include the free haulage distance as defined in SECTION 1600. When GW materials are used as unpaved shoulders for paved roads the corresponding free haul distance shall be as for natural gravel subbase material.

When payment for overhaul is not allowed for in the Special Specifications, the rates shall include all transportation of the material.

<u>ITEM</u>	<u>UNIT</u>
37.04 MAINTENANCE OF EXISTING GRAVEL ROADS:	
(a) SHAPING EXISTING GRAVEL ROADS WITHOUT SCARIFICATION OF THE SURFACE	SQUARE METRE (m ²)
(b) SCARIFICATION, MIXING, WATERING AND COMPACTION	SQUARE METRE (m ²)

The quantity paid for in SUB-ITEM 37.04 (a) shall be the square metres calculated as the horizontal distance along the centreline times the distance between the shoulder breakpoints in accordance with the cross-section Drawings or as directed by the Engineer.

Imported gravel wearing course material shall be paid for under SUB-ITEM 37.03 (b). Material brought in from the side shall be paid for as crossfill under ITEM 36.02 in the cases where the material on the instruction or approval of the Engineer is taken from cuts in the road reserve and placed in embankments at a distance of 50 m or less from its original position, measured along the centreline of the road.

The operation of bringing loose material back to the road from the slopes and ditches on the approval or instruction of the Engineer shall be included in the respective rate in ITEM 37.04 and will not be measured for payment per cubic metre as crossfill or imported fill or gravel.

The bid rates for SUB-ITEM 37.04 (a) shall include full compensation for shaping the existing road by motor grader as specified.

The bid rates for in SUB-ITEM 37.04 (b) shall include full compensation for ripping the existing road by approved equipment, breaking of lumps, removal of oversize particles and watering as required to make a homogenous material having suitable moisture content at or around the optimum moisture content of BS-Heavy compaction and shaping of the layer to the required grade and crossfall as specified including the protection and maintenance of the layer, all as specified.

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

**SECTION 3800: MODIFICATION
AND STABILISATION**

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3801 SCOPE

This Section covers the modification or stabilisation of materials used in the construction of the roadbed and/ or subgrade; sub-base and road base; by modification of the naturally available gravel material/ soil by mixing through the addition of soil binder or crushed stone aggregate or chemical agents and by stabilisation using stabilising agent such as cement or lime or other commercially available stabilizers etc.

The term Modification may be adopted to improve engineering properties such as load bearing capacity (CBR strength), plasticity index, grading or other properties of a natural material. Such improvements may be achieved by the addition of natural gravel/ soil material or treatment with suitable chemical agents, in which the parent material retains its granular nature (not becoming a cemented material).

The term Stabilisation is used to denote materials for which the addition of a stabilising agent causes cementing action and associated strength gain. The generic term "stabilising agent" used in this section denotes stabilising agents such as cement or lime or other commercially available stabilizers etc where specified conditions are applicable to either method.

It includes the furnishing, spreading and mixing-in of the chemical or stabilising agent and compaction including and provision of a curing treatment.

Technical suitability of a treatment (fitness-for-purpose) shall be evaluated as follows:

(a) Modification

Modified materials shall be natural gravels blended or mixed with other materials without occurrence of cementing action with resultant material remaining unbound.

Modified materials shall be classified by classes G30, G45, G60, G80 and shall meet specification requirements in SECTIONS 3600 or 3700 unless otherwise approved by the Engineer

(b) Stabilisation

Stabilised materials in which cementing action occurs are classified according to their minimum unconfined compression strength (UCS)

This section covers the requirements for the following types of material classified according to their minimum unconfined compression strength (UCS):

- **C4.5** stabilised material with a minimum UCS value of 4.5 MPa
- **C3.0** stabilised material with a minimum UCS value of 3.0 MPa
- **C1.5** stabilised material with a minimum UCS value of 1.5 MPa
- **C1.0** stabilised material with a minimum UCS value of 1.0 MPa
- **C0.7** stabilised material with a minimum UCS value of 0.7 MPa
- **CM:** modified material with a minimum UCS value of 0.5 MPa.

UCS value is measured after 7 days airtight curing and 7 days soaking in water at $27 \pm 2^\circ\text{C}$ in accordance with BS 1924-2:2018. The compaction degree of the specimens shall be 97% MDD.

Full compliance details for stabilised materials are set out in TABLE 3802/2 and TABLE 3802/3.

3802 MATERIALS

(a) Material to be Stabilised/ Modified

Material to be stabilised/ modified shall be any naturally occurring cohesive or non-cohesive soil or processed material, the properties of which can be permanently improved by the process of stabilisation/ modification to comply with the requirements of these Specifications for the relevant materials for roadbed and/ or subgrade, sub-base and road base.

Materials considered for stabilisation shall have a minimum grading coefficient of uniformity of 5.

(b) Roadbed and/ or Subgrade Stabilisation:

Roadbed and/ or subgrade materials shall be considered for stabilisation to strengthen a weak soil and restrict the volume change potential of a highly plastic (expansive) or compressible soil.

The thickness, depth or zone of the roadbed or subgrade that shall be selected for material stabilisation/ improvement shall be as shown on the Drawings or as instructed by the Engineer. Where a thin zone or short length of roadbed or subgrade is subject to improvement, removal and replacement shall be the preferred alternative unless a suitable replacement soil is not economically available.

(c) Stabilised/ Modified Sub-base and Road Base Material

The stabilisation/ modification of materials for use as sub-base and road base shall provide a permanent improvement to the un-treated materials to meet the requirements of these Specifications.

(d) Soil Binder/ Crushed Stone Material for Modification

Natural gravel or soil material used as a binder for modification shall be classified nominally by CBR strength after 4 days soaking as required for all materials specified in SECTIONS 3600 and 3700.

Crushed stone materials used for modification shall meet other properties for cleanliness, strength, durability and soundness as specified in the project Special Specifications or as directed by the Engineer.

In all cases approval for use as a binder material shall be subject to the Engineer's discretion based on results from trial sections, and compliance of the modified parent material with specified requirements.

Binder material approved for modification shall comply with SECTION 3600, 3700, 3900 or applicable Special Specifications as the case may be.

The binder material shall be as specified in the Drawings or BOQs or as in Special Specifications.

(e) Stabilising Agents

The stabilising agent shall be either one or more of the following agents specified on the Drawings, in the Bill of Quantities or in the Special Specifications or as ordered by the Engineer.

i) Hydraulic Road Binder

Hydraulic road binders shall comply with the requirements of US EAS 981:2020, and road lime shall comply with US 288:2000 or AASHTO M 216-22 or equivalent standard on approval of the Engineer.

ii) Cement

Cement shall comply with the requirements of US EAS 18-1:2017 (CEM I or II), AASHTO M85 or equivalent standard on approval of the Engineer. The use of rapid-hardening cement shall not be permitted.

iii) Blast-Furnace Cement

Blast-furnace cement may be used if specified in the Special Specifications, and shall comply with the requirements of US EAS 18-1:2017 (CEM III), AASHTO M240M/M 240 or equivalent standard on approval of the Engineer.

iv) Other Stabilising Agents

Other stabilising agents such as fly-ash or liquid ionic stabiliser or other commercially available stabilizers may be used if allowed for in the Special Specifications or if instructed by the Engineer.

(f) Selection of Stabiliser

The most suitable type of stabiliser to use for a particular type of soil /bound / unbound layers shall be as given in the Special Specifications, or as directed by the Engineer whereby TABLE 3802/1 may be used as guidance.

(g) Requirements for Stabilisation

i) Durability for lime stabilisation

In order to ensure that an irreversible stabilisation reaction occurs, the amount of stabiliser added shall not be less than the initial consumption of lime (ICL) as determined according to BS 1924-2:2018 plus 1%.

The durability test of stabilised material shall satisfy minimum requirement of 12 cycles when determined according to AASHTO T 135-22 or ASTM D559/D559M-15(2023).

ii) Material Requirements

The requirements for materials before and after treatment are given in TABLE 3802/2. The Grading Modulus (GM) is defined in SUB-CLAUSE 3702 (d).

(h) Purchase and Storage of Stabilisers

From the time of manufacture to the time of use, all stabilising agents shall be kept under proper cover and be protected from moisture.

Consignments of these materials shall be used in the same sequence as that in which they are delivered at the Works. Stock which have been stored on the Site for periods longer than three (3) months shall not be used in the Works, unless authorised by the Engineer.

TABLE 3802/1: PRELIMINARY SELECTION OF STABILIZER¹

Particle Size (BS 1377-2:2022)	More than 25% passing 75 µm size (BS 1377-2:2022)			Less than 25% passing 75 µm size (BS 1377-2:2022)		
	Plasticity Index (PI)	PI < 10	10 < PI < 20	PI > 20	PI < 6 and PI x % pass. 75 µm < 60	PI < 10 PI > 10
Cement and Cementitious blends	Usually suitable	Doubtful	Usually suitable	Usually not suitable	Usually suitable	Usually suitable
Lime	Doubtful	Usually suitable	Usually suitable	Usually not suitable	Usually suitable	Usually suitable
Bitumen#	Doubtful	Doubtful	Usually suitable	Usually not suitable	Usually suitable	Usually not suitable
Bitumen/ Blends#	Usually suitable	Doubtful	Usually suitable	Usually not suitable	Usually suitable	Usually Doubtful
Granular	Usually suitable	Usually not suitable	Usually not suitable	Usually suitable	Usually suitable	Doubtful
Dry Powder Polymers	Usually suitable	Usually suitable	Usually not suitable	Usually suitable	Usually suitable	Usually not suitable
Other proprietary chemical products*	Usually not suitable	Usually suitable	Usually suitable	Usually not suitable	Usually suitable	Usually suitable
¹ Reference: Guide to Pavement Technology Part 4D: Stabilised Materials (AUSTROADS)						
# Generally used in Foamed Bitumen Stabilisation/ Emulsion Stabilization						
* Should be considered as broad guidelines only. Refer to product specific information before approval.						

TABLE 3802/2: REQUIREMENTS FOR MATERIALS IN CEMENTED LAYERS

Material properties		Material class			
		C1.5	C1.0	C0.7	CM
After stabilisation:					
Minimum CBR (%) for stabilised materials ⁴⁾		80	60	45	30
Minimum UCS (MPa) BS 1924-2:2018 ¹⁾		1.5	1.0	0.7	0.5
Before stabilisation:					
Soaked CBR (%) at 97% MDD of BS-Heavy, BS 1377-2:2022		Minimum 30	Minimum 20	Minimum 20	(no requirement)
Plasticity index (%), BS 1377-2:2022 ³⁾		Maximum 20	Maximum 25	Maximum 25	Maximum 35
Aggregate strength TFV_{dry} , BS 812-111:1990		Minimum 50 kN	(no requirement)	(no requirement)	(no requirement)
Grading modulus (GM), BS 1377-2:2022		Minimum 1.5	Minimum 1.2	Minimum 1.0	(no requirement)
Organic content BS 1377-3:2018+A1:2021		Maximum 0.5%	Maximum 1.0%	Maximum 1.0%	Maximum 2.0%
Sulphate (SO ₃) content BS 1377-3:2018+A1:2021		Maximum 0.25%			
Max. particle size BS 1377-2:2022		1/3 of compacted layer thickness but not > 65 mm.			
Single Compacted Layer Thickness (in mm)		Minimum 100 – Maximum 200			
Durability Test (AASHTO T 135-22 or ASTM D559/D559M-15(2023)) ²⁾		Loss of Weight of Stabilized Material (Maximum 14%)			
1)	2)	3) The Unconfined Compression Strength (UCS) shall be measured after 7 days airtight curing and 7 days soaking in water at $27 \pm 2^{\circ}\text{C}$ in accordance with BS 1924-2:2018. The compaction degree of the specimens shall be 97% MDD. For each source of material to be stabilized, the Unconfined Compression Strength (UCS) shall also be determined on specimens cured airtight for 14 days. The ratio of UCS measured after 7 days curing and 7 days soaking and the UCS measured on specimens cured for 14 days shall not be less than 75%. A lower ratio might be a result of too high sulphate content. The laboratory UCS shall be at least 1.5 times min. field UCS stipulated in the contract. 4) The durability test of stabilised material shall satisfy the minimum requirement of 12 cycles when determined according to AASHTO T 135-22 or ASTM D559/D559M-15(2023) 5) It is emphasised that the Atterberg limits shall be measured according to BS 1377-2:2022. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer. 6) CBR for the stabilized layer shall only be checked if apparatus for determining UCS is not available in the list of project equipment.			

TABLE 3802/3: REQUIREMENTS FOR MATERIALS IN CEMENTED LAYERS (BASE LAYERS)

Material properties	Material class	
Minimum UCS (MPa) BS 1924-2:2018 1)	C3	C4.5
Uniformity Coefficient	Minimum 6	
Max Liquid limit BS 1377-2:2022	Maximum 30	
Plasticity index (%), BS 1377-2:2022 2)	Maximum 10	
Aggregate strength TFV_{dry} , BS 812-111:1990	Minimum 80 kN	
Grading modulus (GM), BS 1377-2:2022	Minimum 2	
Organic content BS 1377-3:2018+A1:2021	Maximum 0.5%	
Sulphate (SO ₃) content BS 1377-3:2018+A1:2021	Maximum 0.25%	
Max. particle size BS 1377-2:2022	1/3 of compacted layer thickness but not > 65 mm	
Single Compacted Layer Thickness (in mm)	Minimum 150 – Maximum 200	
Durability Test (AASHTO T 135-22 or ASTM D559/D559M-15(2023)) 2)	Loss of Weight of Stabilized Material (Maximum 14%)	
Grading: BS 1377-2:2022		
Sieve size (mm)	Percentage passing each sieve size (%)	
75.0	100	
53.0	80-100	
26.5	55-90	
9.5	35-65	
4.75	25-55	
2.36	20-40	
0.425	10-35	
0.075	3-10	
1) The unconfined compression strength (UCS) shall be measured after 7 days airtight curing and 7 days soaking in water at 27 ± 2°C in accordance with BS 1924-2:2018. The compaction degree of the specimens shall be 97% MDD. For each source of material to be stabilised the unconfined compression strength (UCS) shall also be determined on specimens cured airtight for 14 days. The ratio of UCS measured after 7 days curing and 7 days soaking and the UCS measured on specimens cured for 14 days shall not be less than 75%. A lower ratio might be a result of too high sulphate content. The laboratory UCS shall be at least 1.5 times min. field UCS stipulated in the contract.		
2) The durability test of stabilised material shall satisfy the minimum requirement of 12 cycles when determined according to AASHTO T 135-22 or ASTM D559/D559M-15(2023)		
3) It is emphasised that the Atterberg limits shall be measured according to BS 1377-2:2022. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.		
4) CBR for the stabilized layer shall only be checked if apparatus for determining UCS is not available in the list of project equipment.		

3803 CONSTRUCTIONS

(a) For Stabilisation

i) Preparing the Layer

The material to be stabilised shall be prepared broken down and placed as specified in SECTIONS 3600, 3700 and 3900, and given at least one pass with a flat wheel roller. The material shall be damp.

ii) Applying and Mixing in The Stabilising Agent

Mixing of gravel and soils with stabiliser and water in a stationary or portable plant and laying with pavers shall be the preferred method. Where specified in the Special Specification this method shall be adhered to unless otherwise approved by the Engineer.

Where mixing on the road is employed, the stabilising agent shall be spread uniformly over the full area of the prepared layer at the prescribed rate of application by means of an approved type of mechanical spreader in a continuous process, or it may be spread by other methods such as motor grader or by hand. Any equipment and method to be used shall be approved by the Engineer.

Immediately after the stabilising agent has been

spread, it shall be mixed with the loose gravel for the full depth of treatment. Care shall be taken not to disturb the compacted layer underneath, nor to mix the stabilising agent below the desired depth. Mixing shall be continued for as long as necessary and repeated as often as required to ensure a thorough, uniform and intimate mix of the soil or gravel and the stabilising agent over the full area and depth of the material to be treated and until the resulting mixture is homogeneous and of uniform appearance throughout.

Mixing shall be done by grader, disc harrow, rotary mixer or equivalent plant approved by the Engineer, working over the full area and depth of the layer to be stabilised by means of successive passes of the equipment.

Mixing may also be done in central batch-mixing plants, but the Contractor will not be entitled to payment for additional overhaul or incidentals resulting from such procedure, unless such mode of operation has been prescribed in the contract.

iii) Watering

Immediately after the stabilising agent has been properly mixed with the soil or gravel, the moisture content of the mixture shall be determined, and the

required amount of water shall be added.

Each application or addition of water shall be well mixed with the gravel or soil so as to avoid the concentration of water near the surface or the flow of water over the surface of the layer.

Particular care shall be taken to ensure satisfactory moisture distribution over the full depth, width and length of the section being stabilised and to prevent any portion of the work from getting excessively wet after the stabilising agent has been added.

Any portion of the work that becomes too wet after the stabilising agent has been added and before the mixture has been compacted, will be rejected, and such portions shall be allowed to dry out to the required moisture content and shall then be scarified, re-stabilised, re-compacted and again finished off in accordance with the requirements specified herein, all at the expense of the Contractor.

The water supply and watering equipment shall be adequate to ensure that all the water required will be added and mixed with the material being treated within a short enough period to enable compaction and finishing to be completed within the period specified in SUBCLAUSE 3803 (g).

iv) Compaction

During compaction the layer shall be continuously bladed by a motor grader, and loss of moisture by evaporation shall be corrected by further light applications of water.

During compaction of the stabilised layers, the Contractor shall lightly harrow or scarify the crust before final rolling if so, required by the Engineer, in order to prevent the formation of laminations near the surface of the layer. Final rolling shall be done with equipment that will give a smooth surface finish which conforms to the surface tolerances specified. Low patches on the surface may not be filled after compaction. The minimum compaction requirements shall be as specified for the particular layer in the various SECTIONS of these Specifications.

A sufficient number of compacting units shall be employed on the work to ensure that, from the time the stabilising agent is first applied to the layer, the mixing process, watering, compacting, shaping and final finishing will be completed within the periods specified in SUBCLAUSE 3803 (vi).

v) Finishing at Junctions

Any finished portion of the stabilised layer adjacent to new work, which is used as a turn-round area by equipment in constructing the adjoining section, shall be provided with a protective cover of soil or gravel of at least 100 mm thick over a sufficient length to prevent damage to work already completed. When the adjoining section is being finally finished, such cover shall be removed to permit the making of a smooth vertical joint at the junction of the different sections. Material in the vicinity of the joint that cannot be processed satisfactorily with normal construction equipment shall be mixed and compacted by hand or with suitable hand-operated machines.

vi) Curing the Stabilised Work

The stabilised layer shall be protected against rapid drying-out for at least seven days following completion of the layer.

The methods of protection may be any one or more of the following:

- a. The stabilised layer shall be kept continuously wet or damp by watering at frequent intervals. This method will be permitted for up to a maximum period of 24 hours, but one of Methods (b.) or (c.) shall be applied as soon as the moisture content of the stabilised layer so permits. Work which is not kept continuously wet or damp but is subjected to consecutive wet-dry cycles, may be rejected by the Engineer should they consider the layer to have been adversely affected.
- b. The stabilised layer shall be covered with the material required for the following layer while the stabilised layer is still in a wet or damp condition. The material forming the protective layer shall be watered at such intervals as may be required to keep the stabilised layer continuously wet or damp, and in dry weather this shall be done at least once in every 24 hours.
- c. The stabilised layer shall be covered with a curing membrane consisting of a spray-grade emulsion or cutback bitumen applied at the rate specified or instructed by the Engineer. The provisions of SECTION 4100 shall apply with changes as required to the application of a curing membrane. Cutback bitumen may be used instead of bitumen emulsion if trials show no adverse effect to the stabilised layer, such as loosening of the surface, and the result is to the full satisfaction of the Engineer.

No additional payment will be made for curing as described above, except that the application of a curing membrane when specified or ordered by the Engineer shall be paid for separately under SECTION 4100.

vii) Construction Limitations

For stabilised layers, the stabilising agent shall be applied only to an area of such size that all processing, watering, compacting and finishing can be completed within the period given in TABLE 3803/1.

TABLE 3803/1: CONSTRUCTION LIMITATIONS

Stabilising Agent	Material Class	Maximum time for completion after stabilising agent comes in contact with the material to be stabilised
Cement	C4.5, C3, C1.5, C1.0, C0.7 and CM	4 hours
Lime	C1.5, C1.0, and C0.7	8 hours
Lime	CM	48 hours
Other Stabilizing Agents/ Proprietary Products	C4.5, C3, C1.5, C1.0, C0.7 and CM	As per the Manufacturer's Recommendation

No stabilisation shall be applied when the moisture content of the material to be stabilised exceeds the optimum moisture content by more than 2% of the dry mass of material. No stabilisation shall be done when weather conditions may adversely affect the stabilising operations in the opinion of the Engineer. Excessive drying out or rain falling on the working area during the process of stabilisation

may be sufficient cause for the Engineer to order any affected areas to be reconstructed at the Contractor's own cost.

No traffic or any equipment not actually used for processing the layer may be allowed to pass over the freshly spread stabilising agent. Only equipment required for curing or priming may be allowed over the treated layers during the specified curing period. Where water spraying equipment causes damage to the layer, the Contractor shall carry out watering by side-spraying tankers travelling off the stabilised layer or alternative methods employed to the satisfaction of the Engineer.

viii) Quality of Materials and Workmanship

The Contractor shall keep detailed records of the quantities of stabilising agent applied to the road and the volume of material stabilised, and shall make these records available to the Engineer. They shall also monitor the rate of application when using bulk spreading equipment, by taking a canvas patch or tray test every 200 metres or as required by the Engineer.

All spreader equipment shall be calibrated and approved by the Engineer before use on the road.

The requirements for testing compaction control shall be in accordance with SERIES 7000.

ix) Compaction Requirements

The minimum required compacted density for pavement layers made of modified or stabilised material shall comply with TABLE 3704/1 or TABLE 3606/1 as may be the case.

x) Defective Work Or Materials

Any material or work that does not comply with the requirements specified shall be removed and replaced with new materials or be repaired as specified to comply with the specified requirements if the Engineer permits.

xi) Trial Sections

Before the Contractor commences with the stabilisation or mechanical modification of any layer, he shall demonstrate by constructing a trial section that the equipment and procedure he proposes to use will result in the layer(s) complying in every way with the specifications.

The trial section shall be at least 2,000 m² in area and shall be constructed in its position in the pavement. Only when such a trial section has been satisfactorily constructed and accepted will the Contractor be permitted to proceed with further stabilised layer or mechanical modification work. Once approval has been obtained the mixing process and equipment used shall remain unaltered unless otherwise approved by the Engineer.

In the event of the trial section being unsuccessful the Contractor shall remove the trial section when instructed to do so by the Engineer.

The trial section shall be paid for separately only when it complies with all the requirements of these Specifications and has been approved by the Engineer.

(b) For Modification

The material to be treated shall be prepared, broken down and spread to the required loose thickness all as specified in SECTIONS 3600, 3700 and 3900. Thereafter, an approved binder material shall be spread over the prepared material at the required rate and the materials

shall be dry mixed by means of motor graders, ploughs and other suitable equipment, until the binder material is uniformly mixed with the material being treated. Thereafter, the mixed materials shall be watered, mixed and compacted as described in CLAUSE 3803.

3804 PROTECTION AND MAINTENANCE

The Contractor shall protect and maintain the completed layer at their own expense until the subsequent layer is applied. Maintenance shall include the immediate repair of any damage to or defects in the layer and shall be repeated as often as is necessary. Repairs shall be so made as to ensure an even and uniform surface to be restored after completion of the repair work.

Any completed section of base/ subbase works approved by the Engineer must be covered by a subsequent course within fourteen days of completion.

No traffic shall be allowed to travel on the finished base/ subbase course.

Where it is not feasible for traffic to use deviations, primer/ curing membrane shall be applied and allowed to cure for a practicable duration (4 to 6 hours) in opinion of the Engineer followed by application of a binding layer of aggregate before opening to traffic. The Contractor shall make all these arrangements at their own expense.

3805 CONSTRUCTION TOLERANCES

Construction tolerances and testing shall be in accordance with SERIES 7000.

3806 LABORATORY AND SITE TRIALS

Laboratory and site trials shall be in accordance with SERIES 7000.

3807 MEASUREMENT AND PAYMENT

(a) General

The curing membrane, where required, shall be paid for under SECTION 4100. The stabiliser agent shall in all cases be paid for separately under ITEM 38.03. The process of stabilisation may be paid for in one of the two alternative ways given below, as specified in the Special Specifications and the Bill of Quantities:

- As an **extra-over** rate for admixture of the stabiliser and curing, where all costs for furnishing the natural gravel layer including compaction have been paid for already under SECTION 3600 or SECTION 3700 of these Specifications as relevant, or
- as a payment for the **full cost** of providing the material to be stabilised, admixture of stabiliser, compaction and curing, however at a separate payment for the stabiliser.

(b) Payment as an Extra-Over Rate

	<u>ITEM</u>	<u>UNIT</u>
38.01	STABILISATION; EXTRA-OVER THE RELEVANT PAY ITEM FOR STABILISING MATERIALS ALREADY PAID FOR UNDER SECTION 3600 OR SECTION 3700	
(a)	EARTHWORKS MATERIALS	CUBIC METRE (m ³)
(b)	PAVEMENT MATERIALS	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of stabilised material, the quantity of which shall be determined in accordance with the authorised dimensions of the layers treated as instructed by the Engineer.

The bid rates for stabilisation under ITEM 38.01 shall be paid as an extra-over the rate bid for constructing the un-stabilised layers. The bid rate for chemical stabilisation

shall therefore include full compensation for spreading and mixing the stabilising agent, curing the stabilised sections, any extra water required, and all supervision, labour, equipment, tools and incidentals (extra over those provided for in the rates bid for constructing the un-stabilised layer) necessary for completing the specified work, but excluding the cost of supplying the stabilising agent. No distinction shall be made in respect of the type of stabilising agent used or the time for curing.

(c) Payment as a Full Cost Rate

<u>ITEM</u>	<u>UNIT</u>
38.02 STABILISATION, PAYMENT FOR FULL COST OF PROVIDING:	
(a) STABILISED LAYER, MATERIAL CLASS C 4.5	CUBIC METRE (m ³)
(b) STABILISED LAYER, MATERIAL CLASS C 3	CUBIC METRE (m ³)
(c) STABILISED LAYER, MATERIAL CLASS C1.5	CUBIC METRE (m ³)
(d) STABILISED LAYER, MATERIAL CLASS C1.0	CUBIC METRE (m ³)
(e) STABILISED LAYER, MATERIAL CLASS C0.7	CUBIC METRE (m ³)
(f) STABILISED LAYER, MATERIAL CLASS CM	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of stabilised material, the quantity of which shall be determined in accordance with the authorised dimensions of the layers provided and treated as instructed by the Engineer.

The bid rates for stabilisation under ITEM 38.02 shall include full compensation for providing the material to be stabilised, breaking down, placing, spreading and mixing the stabilising agent, curing the stabilised sections, any extra water required, and all materials, supervision, labour, equipment, tools and incidentals compacting, testing the material including the protection and maintenance of the layer, but excluding the cost of supplying the stabilising agent

When payment for overhaul is allowed for in the Special Specifications and included in the Bill of Quantities, the rates shall include a free haulage distance as defined in SECTION 1600.

When payment for overhaul is not allowed for in the Bill of Quantities, the rates shall include all transportation of the materials.

(d) Payment for the Stabiliser Agent

<u>ITEM</u>	<u>UNIT</u>
38.03 STABILISER AGENTS:	
(a) ROAD LIME	TONNE (t)
(b) COMMON CEMENT	TONNE (t)
(c) BLAST-FURNACE CEMENT	TONNE (t)
(d) OTHER STABILISING AGENT (STATE TYPE)	TONNE (t)

The unit of measurement shall be the tonne of stabilising agent. When mixtures of slag and cement or lime are used, the quantity of each constituent shall be measured separately and not the mixture as a whole.

The quantity shall be determined in accordance with the authorised rate of application within the layer concerned.

The bid rates shall include full compensation for providing the stabilising agent at the Works irrespective of the rate of application specified or ordered by the Engineer. The rate for milled blast-furnace slag shall

include full compensation for premixing the blast-furnace granulated slag with other stabilising agents in the required proportion.

(e) Payment for Modification

<u>ITEM</u>	<u>UNIT</u>
38.04 MODIFICATION TO PRODUCE CRUSHED ROCK STONE AGGREGATES OF SIZES RANGING FROM 0-37.5 mm	
(a) EXTRA OVER SUB-ITEMS 38.05 (A) AND 37.02 (B)	CUBIC METRE (m ³)
(b) EXTRA OVER SUB-ITEMS 38.05 (A) AND 37.02 (C)	CUBIC METRE (m ³)
(c) EXTRA OVER SUB-ITEMS 38.05 (B) AND 37.02 (B)	CUBIC METRE (m ³)
(d) EXTRA OVER SUB-ITEMS 38.05 (B) AND 37.02 (C)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of compacted modified material.

The bid rate for modification under ITEM 38.04 shall be paid extra-over the rates bid for the materials used in producing the modified layer. The bid rate shall include full compensation for all additional work involved in mixing the materials and compaction to the density specified in TABLE 3704/1. The measured quantity shall be the compacted volume of the finished modified layer.

<u>ITEM</u>	<u>UNIT</u>
38.05 BINDER MATERIAL USED FOR MODIFICATION	
(a) CRUSHED ROCK STONE AGGREGATES OF SIZES RANGING FROM 0-37.5 MM	CUBIC METRE (m ³)
(b) OTHER (STATE TYPE)	Cubic Metre (m ³)

The bid rate for the binder material under ITEM 38.05 used in modification shall include full compensation for procuring, transporting, placing, watering and compacting the material to the density specified in TABLE 3704/1.

**SERIES 3000: SITE CLEARANCE,
EARTHWORKS AND PAVEMENT LAYERS OF
GRAVEL OR CRUSHED STONE**

**SECTION 3900: CRUSHED
AGGREGATE ROAD BASE AND
SUBBASE**

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3901 SCOPE

This Section covers the procuring, furnishing and placing of approved crushed aggregate base course layers in accordance with the requirements of these Specifications.

The primary material shall be Crushed Rock (CRR) and Crushed Stone (CRS) for crushed aggregate road base and subbase layers. However, crushed cement concrete or milled bituminous material or excavated granular material as reclaimed from existing pavement structure, shall be utilised as partial supplement or replacement material to CRR and CRS material such that a homogeneous mix that satisfies the desired specification requirement is achieved.

This Section covers the requirements for the following types of material:

- **CRS** crushed stone made from stones, boulders, oversized material from borrow pits or quarried rock compacted to a percentage of the maximum dry density of the material at BS-Heavy compaction, with normal requirements for workmanship during construction
- **CRR** crushed, fresh, quarried rock compacted to a percentage of the maximum dry density of the material at BS-Heavy compaction, with enhanced requirements for workmanship during construction

3902 MATERIALS

(a) Source of Material, Crushing and Screening

i) General

The aggregate used for crushed aggregate course shall contain no contamination or deleterious material such as decomposed rock, clay or shale. The Contractor shall take all necessary measures to prevent segregation of the material, including watering during crushing and screening and any other measures required in the opinion of the Engineer.

ii) CRS Class of Crushed Aggregate

Crushed aggregate class CRS shall be made of hard, durable and un-weathered fragments made by the crushing of stones, boulders, oversize from borrow pits or quarried rock. Minimum 50% by mass of particles larger than 5 mm shall have at

least one fractured face. Maximum 30% by mass of material passing 5 mm can be approved as soil fines.

iii) CRR Class of Crushed Aggregate

Crushed aggregate class CRR shall be made of hard, durable and unweathered fragments made by the crushing of fresh quarried rock or boulders of minimum 0.3 m diameter. Single stage crushing shall not be allowed and all particles shall be crushed material; no soil fines shall be allowed. If the multi-stage crushing does not directly and continuously provide materials complying with the grading requirements specified in TABLE 3902/2, the crushed material shall be screened into a sufficient number of fractions and reconstituted and mixed thoroughly in a pug mill or by other suitable means to ensure compliance with the grading requirements.

iv) Reclaimed Material

CCSB Class of Crushed Cement Concrete

Crushed Cement Concrete is made by crushing dismantled cement concrete in slabs to a size not exceeding 75 mm and utilised as a partial supplement or replacement to CRR and CRS material. These materials shall meet the requirements in either TABLE 3902/1 or TABLE 3902/2.

RAP Class of Reclaimed Asphalt/ Bituminous Pavement material

Reclaimed Asphalt/ Bituminous material from milling existing pavement bituminous layer shall be utilised as a particle supplement or replacement to CRR and CRS material. Milling of existing bituminous pavement layers shall be utilised as particle supplement or replacement to CRR or CRS material. The materials shall typically be produced through milling operations, which involve the grinding and collection of the existing bituminous pavement materials. RAP shall be pulverised using full-size recycler, or portable asphalt recycling machines. RAP can be stockpiled for use on other roads or processed immediately and reused in situ. These materials shall meet the requirements in either TABLE 3902/1 or TABLE 3902/2.

Reclaimed Granular Material

Reclaimed granular material from excavated existing pavement granular material shall be utilised as particle supplement or replacement to CRR and CRS material. These materials shall meet the requirements in either TABLE 3902/1 or TABLE 3902/2.

(b) Soluble Salts

The Contractor shall discard the material or fulfil all requirements for appropriate construction techniques and timing of operations to the satisfaction of the Engineer if assessments of soluble salt contents in base course materials show deleterious values. Such assessments are only required where the pavement is going to receive a bituminous seal as the only surfacing. No additional payment will be made for any measures taken, or for any alterations of the material utilisation, due to presence of soluble salts in materials or construction water.

(c) Material Requirements – Class CRS

Materials for subbase and course layers of class CRS crushed aggregate as specified on the Drawings shall meet the requirements given in TABLE 3902/1.

(d) Material Requirements – Class CRR

Materials for subbase and course layers of class CRR

crushed aggregate as specified on the Drawings shall meet the requirements given in TABLE 3902/2.

TABLE 3902/1: REQUIREMENTS FOR CLASS CRS CRUSHED AGGREGATE ROAD BASE COURSE/ SUBBASE COURSE

Material properties	Material class: CRS	
Atterberg limits: 1)		
Max Plasticity Index BS 1377-2:2022	8	
Max Linear Shrinkage BS 1377-2:2022	4	
Grading: BS 1377-2:2022		
Sieve size (mm)	Grading limits - CRS (% passing sieve) 2)	
	Coarse type	Fine type
50	100	
37.5	90-100	100
28	75-95	90-100
20	60-90	65-95
10	40-75	40-70
5	29-65	29-52
2	20-45	20-40
1.18	17-40	15-33
0.425	12-31	10-24
0.075	5-12	4-12
Single Compacted Layer Thickness (in mm)	Minimum150 - Maximum 200	Minimum100 - Maximum 150
Particle strength and shape:		
Aggregate strength TFV_{dry} , BS 812-111:1990	110 kN	
Ratio dry to soaked value of TFV BS 812-111:1990	TFV_{soaked} shall be minimum 60% of the corresponding TFV_{dry} value	
Maximum flakiness index BS EN 933-3:2012	35%	
1) It is emphasised that the Atterberg limits shall be measured according to BS 1377-2:2022. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.		
2) The base course material on the road after final compaction shall comply with the above grading limits.		

TABLE 3902/2: REQUIREMENTS FOR CLASS CRR CRUSHED AGGREGATE ROAD BASE COURSE/ SUBBASE COURSE

Material properties	Material class: CRR	
Atterberg limits: 1)		
Max Plasticity Index BS 1377-2:2022	6	
Max Linear Shrinkage BS 1377-2:2022	3	
Grading: BS 1377-2:2022		
Sieve size (mm)	Grading limits - CRR (% passing sieve) 2)	
	Coarse type	Fine type
37.5	100	
28	87-97	100
20	75-90	87-97
10	52-68	62-77
5	38-55	44-62
2	23-40	27-45
1.18	18-33	22-38
0.425	11-24	13-27
0.075	4-12	5-12
Single Compacted Layer Thickness (in mm)	Minimum 100 - Maximum 150	Minimum 75 - Maximum 150
Particle strength and shape		
Minimum TFV _{dry} BS 812-111:1990	110 kN	
Ratio of dry to soaked value of TFV BS 812-111:1990	TFV _{soaked} shall be minimum 75% of the corresponding TFV _{dry} value	
Maximum flakiness index BS EN 933-3:2012	35%	
1) It is emphasised that the Atterberg limits shall be measured according to BS 1377-2:2022 Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.		
2) The base course material on the road after final compaction shall comply with the above grading limits.		
3) Where DBST is adopted as a wearing course, CRR/CRS Fine Type is recommended, while CRR/CRS Coarse type is recommended for AC Wearing course.		
4) For heavily trafficked roads, a CRR base course is recommended.		

3903 CONSTRUCTION

(a) Preparation of the Subbase/ Subgrade

No base/Subbase course shall be placed until approval is obtained from the Engineer and the subbase/ Subgrade is placed, compacted and finished in accordance with the Specifications and is tested and found acceptable to the full satisfaction of the Engineer. Before placing the base course/ Subbase, the subbase / Subgrade shall be inspected and proof rolled as required by the Engineer in order to establish whether there is any damage, wet spots or other defects. Any such defect shall be rectified to the satisfaction of the Engineer before the next layer is placed. Pre-tipping of material prior to subbase processing shall be over a maximum distance of 300m.

(b) Shoulders

Bitumen surfaced shoulders made with the same base course material as the carriageway shall be the preferred method for the construction of shoulders. Where the shoulders are nevertheless to be constructed with a different material than the carriageway, or where any other obstruction such as kerbstones could impair drainage of the base course, all work shall be so constructed that the base course will be adequately drained at all times during and after construction by means of sufficient drainage pipes through the obstructions or by the use of freely draining materials passing through shoulders. The Contractor shall not start constructing the base course of any part of the road before they have ensured sufficient drainage through the shoulders to the satisfaction of the Engineer.

(c) Spreading and Mixing

Crushed aggregate complying with the requirements specified above shall be placed in quantities sufficient to ensure that the completed layer will comply with all the requirements in regard to layer thickness, level, cross-section and density. Segregation of the aggregates during spreading shall be prevented by an appropriate choice of working method to the satisfaction of the Engineer. Allowance shall be made for sufficient extra material to enable the layer to be properly trimmed.

The maximum compacted thickness of any layer of crushed aggregate course compacted in one process shall be as specified in TABLE 3902/1 and TABLE 3902/2.

The dumps of material shall be spread out to a flat-surfaced layer with a thickness that will be suitable for mixing. The required quantity of water shall then be added and the material mixed until a homogeneous mixture is obtained.

CRR crushed aggregate material shall, unless otherwise specified in the Special Specifications, be laid by an approved type of self-propelled mechanical spreader and finisher capable of laying to the required widths, thicknesses, profile, camber or cross-fall, without causing segregation, dragging or other defects.

(d) Compaction

i) General

After mixing, the crushed aggregate material shall be placed to the correct thickness and level and thoroughly compacted by suitable equipment so that the specified density is obtained throughout the entire layer.

The finally compacted layer shall be free from surface laminations, portions exhibiting segregation of the fine and coarse aggregate, corrugations, or other defects that may adversely affect the performance of the layer.

ii) Compaction Requirements

The minimum required compacted density for pavement layers made of crushed aggregate shall be as given in TABLE 3903/1. The Contractor's attention is drawn to the high-density requirements for class CRR materials and the required high standards of workmanship necessary to achieve these on site.

TABLE 3903/1: COMPACTION REQUIREMENTS FOR BASE COURSE OF CRUSHED AGGREGATE

Material class specified	Minimum dry density, lower specification limit, BS 1377-2:2022
CRS	98% of BS-Heavy
CRR	102% of BS-Heavy

The Engineer may, if so specified in the Special Specifications, allow that nuclear method in accordance with SUBCLAUSE 7114 (c) to be used for control of density and moisture content.

Compaction method specifications shall not be used for compaction control of crushed aggregate base course.

iii) Processing of Class CRR Materials

Class CRR shall be slushed as described herein to achieve the required field density. After completion of the compaction described above, short sections of the surface shall be thoroughly watered, rolled and slushed by means of steel-wheeled rollers with a mass of not less than 12 tonnes each, or with pneumatic-tyre rollers. The process shall continue until all excess fines are brought to the surface. The grout thus formed shall be uniformly broomed over the surface with stiff brooms to correct any areas still deficient in fines. Thereupon the excess fines shall be broomed from the surface of the layer. This process shall continue until all excess fines in the mixture have been brought to the surface of the layer and its specified density has been reached. Excess fines and loose aggregate shall then be swept from the surface while the surface is still damp. The layer shall then receive final rolling with pneumatic-tyre rollers and the layer shall then be allowed to dry out. During slushing operations, care shall be taken not to roll the surface out of shape.

The slushing process shall be carried out on each section in one continuous process, and each section shall be completed before the next is proceeded on.

The completed layer shall be firm and stable with a closely-knit surface of aggregate exposed in mosaic and free from nests of segregated material, laminations or corrugations.

Excess crushed aggregate shall not be spread over the shoulders or side fills, but shall be loaded and removed from the road. It shall not be re-used unless it has been re-screened, re-tested and again approved for use. It shall not be mixed with approved material unless screened, tested and again approved for use on its own.

3904 PROTECTION AND MAINTENANCE

The Contractor shall protect and maintain the completed layer at their own expense until the surfacing is applied. Maintenance shall include the immediate repair of any damage to or defects in the layer and shall be repeated as often as is necessary. Repairs shall be so made as to ensure an even and uniform surface is restored after completion of the repair work.

The primed base course shall be covered by the bituminous surfacing as soon as it is practical but within a period of no more than 30 days.

No traffic shall be allowed to travel on the finished base course before application and curing of the bituminous emulsion prime coat.

Where it is not feasible for traffic to use deviations, primer shall be applied and allowed to cure for a practicable duration (2 to 4 hours) in opinion of the Engineer followed by application of a binding layer of aggregate before opening to traffic. The Contractor shall make all these arrangements at their own expense.

3905 CONSTRUCTION TOLERANCES AND TESTING

The completed crushed aggregate layer shall comply with construction tolerances and testing requirements specified in SERIES 7000.

3906 LABORATORY AND SITE TRIALS

Laboratory and site trials shall be in accordance with SERIES 7000.

3907 MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
39.01	CRUSHED AGGREGATE FOR ROAD BASE	
(a)	CRUSHED AGGREGATE CLASS CRS (COARSE TYPE)	CUBIC METRE (m ³)
(b)	CRUSHED AGGREGATE CLASS CRS (FINE TYPE)	CUBIC METRE (m ³)
(c)	CRUSHED AGGREGATE CLASS CRR (COARSE TYPE)	CUBIC METRE (m ³)
(d)	CRUSHED AGGREGATE CLASS CRR (FINE TYPE)	CUBIC METRE (m ³)
(e)	CRUSHED AGGREGATE CLASS CRS (STATE % OF RECLAIMED MATERIAL AND STATE TYPE)	CUBIC METRE (m ³)
(f)	CRUSHED AGGREGATE CLASS CRR (STATE % OF RECLAIMED MATERIAL AND STATE TYPE)	CUBIC METRE (m ³)

The quantity of crushed aggregate shall be the number of cubic metres completed in place compacted to the depths and widths shown on the Drawings or as directed. The quantity shall be measured by the cross-sectional area shown on the construction Drawings times the station length.

The bid rates shall include full compensation for procuring, crushing/ breaking into particles, mixing, placing, compacting, slushing as required and testing the material including the protection and maintenance of the layer, all as specified.

The bid rate shall also include full compensation for the provision and erection of the crusher ready for crushing, its later dismantling and removal after completion of the crushing operations, and the work involved in opening the quarry, including clearing, establishing a working face, and finishing-off the quarry area upon completion of the operations.

The rates shall include all transportation of the material; no overhaul will be paid.

SERIES 4000

BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

CONTENTS OF THE GENERAL SPECIFICATIONS:

<i>SERIES 1000</i>	<i>GENERAL</i>
<i>SERIES 2000</i>	<i>DRAINAGE</i>
<i>SERIES 3000</i>	<i>SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE</i>
<i>SERIES 4000</i>	<i>BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT</i>
<i>SERIES 5000</i>	<i>ANCILLARY ROADWORKS</i>
<i>SERIES 6000</i>	<i>STRUCTURES</i>
<i>SERIES 7000</i>	<i>TOLERANCES, TESTING AND QUALITY CONTROL</i>
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APPENDICES

SERIES 4000

BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

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CONTENTS OF THE GENERAL SPECIFICATIONS:

SERIES 1000	GENERAL
SERIES 2000	DRAINAGE
SERIES 3000	SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE
SERIES 4000	BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT
SERIES 5000	ANCILLARY ROADWORKS
SERIES 6000	STRUCTURES
SERIES 7000	TOLERANCES, TESTING AND QUALITY CONTROL
SERIES 8000	DAYWORKS

APPENDICES

SERIES 4000: BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

SECTION 4100: PRIME AND BITUMINOUS CURING MEMBRANES

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4101 SCOPE

This Section covers the application of a bituminous prime coat to a prepared pavement layer. This Section also covers the application of a bituminous curing membrane to a prepared pavement layer made of a cemented material.

4102 GENERAL

The Contractor shall submit samples of the bituminous material that he proposes to use, together with the manufacturer's certified test report stating source, characteristics and all laboratory test results as specified in US EAS 982-2:2020, US EAS 982-3:2020, and US EAS 982-4:2020 and written approval shall be obtained before supplying such material to Site. The Contractor is advised to initiate this process in due time before the intended start date for use of the material. The actual choice of material to be used shall be based on the trial sections.

The Contractor shall require the manufacturer or producer of the bituminous material to furnish material subject to the requirements and all other pertinent requirements of the Contract. Only satisfactory materials, so demonstrated by tests, shall be acceptable.

The furnishing of the manufacturer's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance. All such test reports shall be subject to verification by testing samples of materials received for use on the project.

4103 MATERIALS

(a) Material for Priming

The priming material shall be one of the following as specified or directed by the Engineer, complying with the given relevant material specification or equivalent standards approved by the Engineer:

- i. Cutback bitumen complying with US EAS 982-2:2020
 - o MC-30
 - o MC-70
- ii. Bitumen emulsion (Cationic/ Anionic) complying with US EAS 982-3:2020 or US EAS 982-4:2020
 - o CSS-1 and CSS-1h
 - o SS-1 and SS-1h

- o CMS-2 and CMS-2h
- o MS-1, MS-2 and MS-2h
- o CRS-1 and CRS-2
- o RS-1 and RS-2
- iii. Bitumen emulsion (Cationic) complying with BS EN 13808:2013
 - o C50 and C60
- iv. Other appropriate proprietary product containing or not containing solvents (Only to be used when specified in the contract with manufacturers' test certificates compliant with the Special Specifications)

(b) Aggregate for Blinding

The aggregate used for blinding the primed surface shall consist of crushed rock or river sand, with 100% passing the 6.3 mm sieve and should not have more than 10% passing the 2.36 mm sieve. The aggregate shall be clean and shall contain no clay, loam or other deleterious matter and shall have no excessive contents of fines in the opinion of the Engineer.

(c) Material for Bituminous Curing Membranes

Bituminous Curing Membranes laid on cemented pavement layers shall be made of one of the following, complying with the given relevant material specification or equivalent standards approved by the Engineer:

- i. Cutback bitumen complying with US EAS 982-2:2020
 - o MC-30
 - o MC-70
- ii. Bitumen Emulsion (Cationic/ Anionic) complying with US EAS 982-3:2020, US EAS 982-4:2020
 - o CSS-1 and CSS-1h
 - o SS-1 and SS-1h
 - o CMS-2 and CMS-2h
 - o MS-1, MS-2 and MS-2h
 - o CRS-1 and CRS-2
 - o RS-1 and RS-2
- iii. Bitumen emulsion (Cationic) complying with BS EN 13808:2013
 - o C55 and C60
- iv. Other appropriate Proprietary product containing or not containing solvents (Only to be used when specified in the contract with manufacturers' test certificates compliant with the Special Specifications)

Bitumen Emulsion shall comply with the relevant requirements of US EAS 982-3:2020, US EAS 982-4:2020 or equivalent standards approved by the Engineer.

4104 EQUIPMENT

(a) General

The following equipment shall be available and in good working order:

- **Self-Propelled bitumen distributor;** and hand spray equipment.
- **Water sprinkler;** The water sprinkler shall have efficient spray equipment, capable of spraying a uniform film of water over the whole area to be primed.
- **Rotary broom;** The rotary broom shall be height adjustable, self-propelled or a towed type supplied together with a suitable pneumatic tyre towing vehicle. The minimum bristle length allowed shall be 70% of the initial length.
- **Other equipment;** such as compressors, hand brooms, reinforced paper for joints, string, nails and all other ancillary equipment as required to carry out the operation efficiently and neatly.

(b) Equipment for Storage and Heating Bituminous Materials

Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. The circulating system for the bituminous

material shall be designed to ensure proper and continuous circulation during the operating period. Storage tanks shall have sufficient capacity to provide for continuous operation.

Provision shall be made for measuring and sampling from the storage tanks. All heating or storage tanks shall be fitted with working thermometers. The storage tanks shall be calibrated and equipped with a device whereby the Engineer may determine the amount of bituminous material on hand at any time.

The equipment for heating bituminous materials shall be of adequate capacity to heat the material properly by circulating steam or hot oil through the coils and/or the jacket of a tank or by circulating the bituminous material around a system of heated coils or pipes or other approved means.

The heating device shall be so constructed that it will prevent the direct flame from a burner from striking the surface of the coils, pipes or jacket through which the bituminous material is circulated. The heating device shall be operated in such a manner as to prevent damage to the bituminous material. The use of any equipment for the agitation of bituminous material to aid in heating will be prohibited if it damages or in any way changes the characteristics of the bituminous material or introduces free steam or moisture into the tank containing the bituminous material.

(c) Bitumen Distributors

i) General

The distributor vehicle shall be a self-propelled vehicle mounted distributor of nominal tank capacity not less than 2,000 nor more than 20,000 litres, equipped with a spray bar with a width of not less than 3.5 metres, nor more than 6.0 metres.

The spray rate of the bitumen must be controlled by one of the following methods:

Type A:	Controlling the pressure constant in the spray bar and precisely controlling the speed of the vehicle.
Type B:	Using a metering bitumen pump, precisely controlling the speed of the pump to give constant output and precisely controlling the speed of the vehicle.
Type C:	Using a metering bitumen pump driven at a speed proportional to the road speed of the vehicle, the vehicle being controlled to within 5% of a predetermined speed.

The exhausts of all motors on the vehicle shall be directed so that fumes do not reach driver or operator and there is no danger of sparks from the exhausts coming into contact with fumes or materials coming from the overflow pipe or any other inflammable material.

Self-propelled distributors shall have sufficient engine torque to maintain the steady speeds required for any application rate between 0.4 and 2.7 litres per square metre on an ascending grade of 10% when fully laden.

Self-propelled distributors shall be equipped with a guide arm with a suitable pointer and chain, to assist the sprayer driver in following the correct line. The guide arm shall be mounted on the driver's side of the vehicle, forward of and in full view of the driver and shall be marked and numbered relative to the spray bar nozzles.

ii) Distributor Tanks

[1] Construction

The tank shall be structurally sound, securely attached to and positively located on the distributor vehicle. No part of the tank or its fittings shall leak when filled with hot bitumen.

[2] Insulation

The tank shall be covered with suitable non-combustible insulation of adequate thickness. The insulating material shall be firmly secured so that it does not move in use and protected by a strong waterproof sheathing.

[3] Circulatory System

A system capable of circulating and thoroughly mixing the contents over the full length of the sprayer tank shall be provided.

[4] Dipstick

The tank shall be provided with a dipstick of rigid construction. It must be mounted in the centre of the tank, must hang from a 'T' piece so that wear can be detected and must not touch the bottom of the tank. A guide shall be provided to hold the dipstick in a vertical position as it is withdrawn and surging of bituminous material as the dipstick is lowered. The dipstick shall be graduated in litres, in increments not more than 50 litres. Where the spacing between any two markings is less than 10 mm, an alternative method of indicating the load quantity shall be provided.

The dipstick shall be marked at the level below which heating equipment shall not be used; this level shall be at least 150 mm above the highest part of the heating tubes or elements.

iii) Heating Equipment

The distributor shall be provided with heating tubes and burners capable of maintaining the material in the tank at a steady temperature of up to 190°C and also of raising it from 135°C to 175°C in not more than 4 hours when the ambient temperature is 15°C to 20°C and the tank is fully loaded. The heating tubes shall have a slight upward slope away from the burners. No part of the tubes or their flues shall pass through the vapour space above the bituminous material. Flue outlets shall be fitted with spark arresters. The burners and their controls shall be so arranged as to avoid the necessity for the operator to be directly behind the heating tubes when operating the burners.

A legible red warning sign shall be attached near the burners bearing the wording:

"This burner equipment must not be operated while the vehicle is loading or unloading or is in transit or when the level of bitumen in the tank is below the warning mark on the dipstick".

Alternative methods of heating the bituminous material, with or without heating tubes, may be applied on approval of the Engineer, provided the above levels of performance are achieved.

iv) Thermometers

The tank shall be fitted with a thermometer located so as to accurately indicate the temperature of the material as it is sprayed. A second thermometer shall be fitted as close as possible to the heating line, near the other end of the tank. The thermometers shall be of dial type, located so that they can be read conveniently without parallax error. The thermometer dials shall read in increments of not more than 5°C and shall include a range of at least 70°C to 200°C over a scale distance based on 0-200°C of at least 150 mm. The thermometer assemblies shall be

readily removable for checking and shall be accurate to within $\pm 5^{\circ}\text{C}$.

v) Speed Control

Distributors shall be fitted with a dial type road speed indicator. The speed indicator shall be positioned near the driver's line of sight to the guide arm. The dial indicator shall be mounted so that it can be read without parallax error by the driver of the distributor.

The speed indicator shall comply with the requirements for an Industrial class 1.5 tachometer to BS 3403:1972. The indicator scale shall be calibrated in suitable metric units, marked in increments corresponding to a change in speed of not more than 5%, with not less than 3 mm spacing between such markings. The road speed indicator shall be operated from a separate retractable wheel attached to the distributor. The tyre of the wheel shall be at least 300 mm diameter and constructed of either solid rubber or permanently inflated rubber.

For Type C distributors a revolution counter or speedometer operated by the transmission may be substituted, provided that the mounting and accuracy of the instrument comply with this clause.

vi) Pumping System

[1] General Requirements

The pumping system, comprising the pump and its associated valves and pipe network, shall be capable of the following operations:

- Loading and unloading bituminous materials:
- It shall be possible to empty the tank by either the distributor's own pump or by gravity flow.
- Mixing bituminous materials in the tank by circulation:

The circulation pipe inside the tank shall have suitably designed orifices so that the flow of bituminous material into each baffled compartment is proportional to the volume of the compartment divided by the total volume of the tank.

The pump shall have sufficient capacity when operating on the tank circulate mode to show turbulent mixing in each baffled compartment. The mixing efficiency shall initially be assessed by observation through the manhole when the tank is at least 30% full.

[2] Pump Output

The pump outlet shall have a steady non-pulsating discharge. Where flat fan type spray nozzles are used, the design and operating procedures of the distributor shall be such that, when the spray bar is used to apply any application rate on spray width within the limits specified the total spray output shall meet the following requirements, without recourse to pump system adjustments while spraying.

Type (A) and Type (B) distributors shall be operated so that the mean spray output per nozzle for any width of spray shall not differ by more than 5 percent from the optimal value recommended by the distributor manufacturer.

Type (C) distributors shall be operated in accordance with a spraying table that defines the vehicle speeds for all application rates and the pump speeds for all bar widths which correspond to the optimal output per spray nozzle recommended by the manufacturer.

For type (B) and type (C) distributors, the total pump outputs shall be delivered through the spray nozzles, for all spray widths.

For all distributors, spraying any particular spray width in the operating range, the pump output measured over any 60 second period shall not vary by more than $\pm 2.5\%$ from the mean output over three such 60 second periods spraying the same width, where the controls are moved and then reset and the level of binder in the tank is varied between each measurement.

[3] Pump Drive

The binder pump drive shall be capable of driving the pump without appreciable pulsation or vibration. Where a separate engine drives the pump, the engine shall be capable of controlling the spray pump shaft revolutions within $\pm 2.5\%$ of the predetermined spraying speed within the full operating range.

In the case of type (C) sprayers (single engine for propulsion and spraying), the transmission between the engine and the pump shall be capable of being adjusted to different ratios.

[4] Strainers

A strainer must be provided in the pump suction line and/or the pump output line. It must be easily removable for cleaning and designed so that all the bitumen flow will pass through it. The maximum mesh orifice size shall be not greater than 3 mm and the total area of the orifices shall not be less than seven times the cross-sectional area of the pipe in which the strainer is fitted.

[5] By-pass and Relief Valves

Where a by-pass valve is used for controlling the pressure and the discharge from the sprayer, it shall be capable of smoothly and uniformly varying the quantity of material by-passed in order to maintain the required pressure in the spray bar. It shall be capable of by-passing not less than 25% of the maximum output of the pump.

Means shall be provided to prevent excessively high pressures, due to blockages or other causes, from damaging the pumping system. Where relief valves are used, they shall be set to a pressure not less than 80% more than the recommended spraying pressure. Provision shall be made for checking the operating pressure of these valves.

vii) Spraying Equipment

[1] Pump Revolution Counter

A revolution per minute counter of an approved type shall be fitted to show the speed of the pump shaft. The instrument shall be calibrated in revolutions per minute and marked at intervals of not more than 5% of the full operating range which shall occupy a scale distance of not less than 150 mm. The instrument shall comply with the requirements for an Industrial Class 1.5 tachometer to BS 3403:1972.

[2] Pressure Gauge

A pressure gauge complying with BS EN 837:1998 'Bourdon Tube Pressure and Vacuum Gauges Part 2 Metric Units' shall be fitted.

Type (A) distributors (constant pressure type) shall be fitted with an Industrial Class I gauge of not less than 100 mm nominal size.

All other types of distributors shall be fitted with an Industrial Class I or II gauge of not less than 100 mm nominal size.

The gauge shall be fitted so as to measure the pressure in the spray bar and shall be mounted so that it is protected from heat and vibration in accordance with BS 837-1:1998.

[3] Spray Bar**a. Length:**

The length of the spray bar, defined as the distance between centres of the two extreme end nozzles, shall comply with the requirements of SUB-CLAUSE 4104 (c) (i).

b. Circulation and Check Valves:

The bar shall be of the fully circulating type, in which the bituminous material is pumped from the tank through the full length of the spray bar in use, and returned to the tank while the valves controlling the individual spray nozzles are closed. The spray nozzles in the bar shall be controlled by a linkage or other means that shall open or close the check valves of all nozzles equally, simultaneously, and fully, and which shall be capable of being operated by an operator positioned at the rear of the vehicle with a clear view of all parts of the spray bar. A check valve shall be provided for each nozzle for at least the 10 nozzles nearest one end of the spray bar. For the remainder of the bar, two spray nozzles may be controlled by a single check valve if desired. Each check valve shall be readily disconnected from the master control and operated independently.

c. Extensions and Transverse Slew:

Spray bars fitted to self-propelled distributors shall be fitted with readily removable or foldable extension sections to enable the bar to be reduced to less than 2.5 m and shall be capable of spraying when shortened. These bars shall also be capable of being moved at least 400 mm transversely while spraying, such movement being readily controlled by an operator at the rear of the vehicle. Operation of the transverse movement control shall not cause any associated rotating movements of the bar. Any associated vertical movements shall be less than ± 5 mm.

The spray bar shall be mounted on the sprayer in such a manner that the nozzle tips are maintained within plus and minus 10% of the optimum height recommended by the distributor manufacturer irrespective of the loading of the sprayer. The maximum height of the bar shall in no case exceed 325 mm.

Hinged extensions and bar height adjustments shall incorporate positive stops and locks, non-positive adjustment means such as chains, cables or pneumatic or hydraulic rams shall not be deemed sufficient.

[4] Spray Nozzles**a. General**

Spray nozzles shall be of the flat fan (slot) type and apart from any approved special end nozzles shall be of similar construction and interchangeable. Nozzles shall be mounted with their flow axes vertical and so that all nozzle tips are within 3 mm of a straight line parallel with the rear axle of the vehicle. The nozzles shall be spaced at intervals of not more than 110 mm and no spacing shall vary more than ± 1.5 mm from the mean spacing. All nozzles except end nozzles must be mounted with the slots in the nozzles at the same horizontal angle. At least 1 spare nozzle shall be carried for every 5 mounted on the spray bar.

The construction and mounting of the sprayer shall be such that all nozzles are positively and rigidly set and maintained. Plain screwed connections must not be used unless supplemented by some positive locking device, mark or approved adjustment tool or gauge to ensure that the correct alignment is maintained.

b. End Nozzles:

An end nozzle or other approved means shall be provided to reduce the cut off spray taper at the road shoulder edge of the spray bar to comply with SUBCLAUSE 4104 (c) (viii). Where used, three such end nozzles (1 spare, 2 on the spray bar) shall be carried on the distributor.

[5] Hand Spray Equipment

Approved hand spray equipment shall be provided. This equipment shall be suitable for operation at a pressure of 6.0 bar but must be capable of withstanding a minimum test pressure of 20 bar and a temperature of 205°C.

viii) Performance Requirements**[1] Definitions****a. Sprayed width:**

The sprayed width of spray shall be the whole width of the spray.

b. Effective width:

The effective width of spray shall be the sprayed width less the permitted spray taper widths specified below.

c. Spray taper width:

The spray taper width shall be the portion of spray fan width, at either edge of the sprayed width that is overlapped by a lower number of spray fans than an equivalent sprayed width within the effective width.

d. End nozzle taper:

The spray taper width shall be deemed to be 150 mm when an end nozzle or an approved equivalent is used.

e. End taper without an end nozzle:

The spray taper width shall be deemed to be 200 mm when an end nozzle or an approved equivalent is not used.

[2] Rate of Application

Distributors shall be capable of applying bituminous material evenly and uniformly to the road surface at any required temperature not exceeding 190°C and at any rate of application required in the range 0.4 to 2.7 litres per square metre.

The distributor shall be capable of achieving these spray rates at vehicle speeds not exceeding 25 km/hr.

[3] Transverse Distribution

a. Within the range of application rates stated above, transverse uniformity requirements, specified in terms of the amounts of bituminous binder applied to successive 50 mm widths, are as follows:

b. The amount of bituminous material sprayed onto any width of 50 mm within the effective width shall not differ by more than 20% from the average application over the effective width.

c. The mean amount of bituminous material sprayed onto any four adjacent widths of 50mm shall not differ by more than 12% from the average application over the effective width.

- d. The effective width shall be divided into three approximately equal sections. The mean amount of bituminous material per 50 mm width sprayed on any one section shall not vary by more than five percent from that on any other section.
- e. End Nozzle Taper:
The amount of bituminous binder sprayed onto any 50 mm width within the end nozzle taper shall be less than 120% of the average application over the effective width. In addition, the mean amount of bituminous material sprayed onto the 3 adjacent 50 mm widths immediately outside the effective width shall be greater than 50% of the average application over the effective width.
- f. End Taper without an end Nozzle:
The mean amount of bituminous material sprayed onto the four adjacent 50 mm widths within this taper shall be between 40% and 60% of the average application over the effective width. In addition, the amount of bituminous material on each 50 mm width, within the taper, shall be less than the amount on the adjacent 50 mm width that is closer to the effective width.

[4] Longitudinal Distribution

Within the range of application rates stated above, longitudinal uniformity requirements specified in terms of the amounts of bituminous binder applied to 50 mm lengths are as follows:

- a. The effective length shall be the full sprayed length less 500 mm from each end.
- b. The full intensity of spray application shall be reached or cut-off within a length of travel of the sprayer not exceeding 500 mm.
- c. The amount of binder sprayed onto any length of 50 mm within the effective length shall not differ by more than 10% from the average binder application over the effective length.

[5] Uniformity of spray

In the case of self-propelled distributors, the application rates and uniformity requirements specified above shall be met when any set of six or more adjacent nozzles are operated up to and including the full bar width.

[6] Calibration and Check of Distributors

All distributors shall be calibrated and checked to demonstrate compliance with this specification before being used on the Work. The calibration testing of the distributor will be done by the Contractor in the presence of the Engineer by the method prescribed by the manufacturer and/or as directed by the Engineer.

When the test results confirm compliance of the Equipment with this Specification the Contractor shall submit a written record of the calibration testing to the Engineer for approval.

A certificate of approval will be given to the distributor operator by the Engineer, showing the record of the calibration and check. This certificate shall be kept in the distributor at all times and shall be available to the Engineer or Inspector in charge at each location where the distributor is used. This certificate may be revoked at any time due to unsatisfactory performance of the distributor and will be returned only when satisfactory repairs or adjustments have been made. Failure to present the certificate will necessitate a re-check and if deemed necessary, a re-calibration of the distributor before it can be used on the Works.

The Contractor shall furnish at their own expense all necessary equipment, materials and assistance necessary for the calibration.

The operation of the distributor will be checked by the Engineer the first time it is used and as often as they deem it necessary thereafter, and when the operation is found to be satisfactory, a new certificate will be issued by the Engineer.

4105 WEATHER AND OTHER LIMITATIONS

(a) General

The Engineer's decision on whether or not to apply the curing membrane or prime coat under specific conditions shall be final.

(b) Prime Coat

No prime coat shall be applied under the following adverse conditions;

- During foggy or wet conditions;
- When rain is imminent;
- When wind is blowing sufficiently hard to cause uneven spraying;
- When the surface of the layer is visibly wet, i.e. More than damp;
- When the temperature of the surface immediately prior to commencing with the application of the prime is below, or in the opinion of the engineer, likely to fall below 10°C;
- Before sunrise;
- After sunset;
- When at any position the moisture content of the base layer is more than 50% of the optimum moisture content as determined by the engineer
- When the layer is soft, i.e. Sponging under load;

(c) Curing Membranes for Cemented Layers

No curing membrane shall be applied under the adverse conditions as decided by the Engineer. Curing membranes shall be applied within the time limits given in the Special Specifications for the respective layer and type of cemented material.

4106 PREPARATION OF THE LAYER TO BE PRIMED OR TO RECEIVE A BITUMINOUS CURING MEMBRANE

Prior to prime coat application, the Contractor shall carry out the necessary field trials to allow the Engineer to check the methods of surface preparation and the performance of the pressure distributor and to establish the exact rate of application and the application temperatures of the bituminous material.

No longer than 24 hours before spraying, the layer to be sprayed with prime coat shall be cleaned by heavy mechanical brooming or hand brooming in case of inaccessible places. The brooming shall clean the surface of dust and foreign matters and leave the coarse aggregate standing proud of the surface. The brooming shall be carried out in such a manner so that the surface is not damaged.

A light spray of water, sufficient to dampen the surface, shall be uniformly applied to the layer immediately before the application of the primer. If the water is over applied the layer shall be allowed to dry until a uniform damp surface is obtained.

Before any material is applied, the layer to be sprayed shall be checked by the Engineer for compliance with the surface and other requirements specified. Any sections not complying with the specified requirements shall be corrected as specified or directed by the Engineer.

4107 APPLICATION OF THE PRIME COAT OR BITUMINOUS CURING MEMBRANE

A minimum of 1.0 m of reinforced paper or other suitable approved material shall be used at all joints at the beginning and end of all sprays in order to obtain a neat start and cut-off.

The temperatures for storage and spraying shall be in accordance with TABLE 4107/1.

All cutback bitumen stored in a heated condition shall be stored in a container with a properly functioning circulation system and having a securely fitting lid.

The rate of application of Prime Coat and Bituminous Curing Membrane for tendering purposes may be assumed to be 1.0 l/m². The final rate of application shall be decided and agreed on by the Engineer after the Contractor has completed and documented trial sections. The pay ITEM 41.04 pertaining to variation in Binder content to be utilized in BOQ/ Item rate Contracts only.

TABLE 4107/1: TEMPERATURES FOR STORING AND SPRAYING PRIME OR CURING MEMBRANES

Type of Prime or Curing Membrane	Maximum Storage Temperature (°C)		Spraying Temperature Range (°C)
	Up to 24 hrs	Over 24 hrs	
Cut-back Bitumen: MC-30 MC-70	65 80	40 50	45-60 60-80
Bitumen Emulsions (all types)	ambient	ambient	ambient above 10°C

The total width of primed surface shall be 150 mm wider than the specified width of the final surfacing and the edges of the prime shall be parallel to the centreline of the road or as prescribed by the Engineer.

The bituminous material shall be applied in one or more lanes evenly over the full effective width and length and allowed to cure until traffic can pass over the surface without the wheels picking up the bituminous material. All traffic shall be kept off the surface until this condition is obtained.

Where no convenient detour is available for traffic, operation shall be confined to one half the roadway width at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage to the primed area.

Where it is not feasible for traffic to use deviations, the bituminous material shall be applied and allowed to cure for as long as is practicable in the opinion of the Engineer before a blinding layer of aggregate is applied. Care shall be exercised in this operation to avoid the aggregate being applied too soon after spraying the bituminous material. Where practicable, two to four hours shall elapse as directed by the Engineer. Any "caking" of aggregate which may take place and cause problems during the surfacing process and all loose aggregate shall be removed before the final surfacing is commenced.

The rate of application of blinding material shall be 0.0035 m³/m² unless otherwise directed by the Engineer

If the bituminous material is applied in more than one strip, allowance shall be made for the overlapping of strips by 100 mm. No additional payment will be made for the overlapping strips.

Care shall be taken to protect all kerbing and guttering, guard rails and channelling from the bituminous material by covering them with a suitable protective material when spraying. The Contractor shall, at their own cost, replace

all soiled items, that cannot be properly cleaned. Painting the soiled surfaces will not be accepted as a suitable remedial measure.

4108 MAINTENANCE AND OPENING TO TRAFFIC

The Contractor shall maintain the prime coat until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amounts; any excess shall be blotted using blinding material.

All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying.

If it is desired to pass traffic on the sprayed surface to facilitate accommodation of traffic or for access management a blinding layer has to be applied. Where a blinding layer has been applied to the sprayed surface, the Contractor shall maintain the blinding layer and the sprayed surface during the period when the surface is opened to traffic and shall repair all damage caused to the blinding layer or the sprayed surface by such traffic at no additional payment

If it is desired to pass traffic for a period in order to reveal any weak spots in the pavement, the rate of application of prime coat may be increased as ordered by the Engineer and the treated areas shall be blinded with rock crusher dust or coarse sand at the approximate rate of 0.004 m³/m².

The Contractor shall provide proper traffic control in order that vehicles may pass without damage to the primed area. The Contractor shall ensure that the primed surface is not excessively damaged by weather or traffic prior to the application of the next layer. Major patching of the primed surface will not be acceptable and damaged sections of the prime and base gravel shall be reworked and re-primed at the Contractor's expense.

The primed surface shall be inspected and repaired, if necessary, prior to the next layer being placed if the surface has been opened to traffic.

Where no convenient detour is available for traffic, operation shall be confined to one half the roadway width at a time. The Contractor shall provide proper traffic control in order that traffic may proceed without damage to the primed area.

4109 TOLERANCES

The actual spray rates measured at spraying temperature shall not deviate from the required spray rate as specified or agreed by the Engineer by more than 0.03 l/m². The average spray rate, calculated over any area of the work determined by the Engineer, shall not be less than the required spray rate. No payment shall be made for any material sprayed in excess of the specified spray rate.

The rate of application for the bituminous material shall be checked by weighing test trays before and after application.

The sprayed surface shall nowhere be narrower than (the specified width).

4110 TESTING

The Contractor shall give the Engineer at least 24 hours' notice of their intention to apply prime or curing membranes so that the actual spray rates can be verified and approved by the Engineer.

Unless otherwise agreed in advance the Contractor shall only spray when the Engineer or their representative is present and approval of the Engineer has been obtained.

4111 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
41.01 PRIME COAT:	
(a) MC-30 CUT-BACK BITUMEN	LITRE (l)
(b) MC-70 CUT-BACK BITUMEN	LITRE (l)
(c) BITUMEN EMULSION (STATE)	LITRE (l)
(d) CERTIFIED PROPRIETARY PRODUCT (STATE NAME)	LITRE (l)

<u>ITEM</u>	<u>UNIT</u>
41.02 BITUMINOUS CURING MEMBRANE:	
(a) MC-30 CUT-BACK BITUMEN	LITRE (l)
(b) MC-70 CUT-BACK BITUMEN	LITRE (l)
(c) BITUMEN EMULSION (STATE TYPE)	LITRE (l)
(d) CERTIFIED PROPRIETARY PRODUCT (STATE NAME)	LITRE (l)

The unit of measurement shall be the litre of bituminous material measured at spraying temperature and sprayed as specified at the rate of application specified or approved by the Engineer.

The area of bituminous prime coat or curing membrane application shall be measured by length along the centreline of the road multiplied by the width as shown on the plans or as directed by the Engineer.

The bid rates shall include full compensation for supplying the bituminous material, cleaning and watering the layer to be sprayed as required, applying the bituminous material and maintaining the sprayed surface as specified.

<u>ITEM</u>	<u>UNIT</u>
41.03 AGGREGATE FOR BLINDING:	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of aggregate for blinding applied at the approved rate over the area of prime coat as instructed by the Engineer.

The bid rate shall include full compensation for procuring, furnishing and applying the aggregate for blinding where directed by the Engineer, and for maintenance of the blinding layer as specified.

<u>ITEM</u>	<u>UNIT</u>
41.04 BITUMINOUS BINDER VARIATIONS:	
(a) MC-30 CUT-BACK BITUMEN	LITRES (l)
(b) MC-70 CUT-BACK BITUMEN	LITRES (l)
(c) BITUMEN EMULSION (STATE TYPE)	LITRES (l)
(d) CERTIFIED PROPRIETARY PRODUCT (STATE NAME)	LITRES (l)

The unit of measurement of bituminous binder in respect of an increase or a decrease in the specified rates of application above or below the rate of application for tendering purposes shall be the litres measured at spraying temperature.

Payment for variations shall be made as specified in CLAUSE 1212.

**SERIES 4000: BITUMINOUS LAYERS, SEALS
AND CONCRETE PAVEMENT**

**SECTION 4200:BITUMINOUS
BASE COURSE, BITUMINOUS
BINDER COURSE AND
BITUMINOUS CONCRETE
SURFACING**

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4201 SCOPE

This Section covers all the work in connection with the construction of bituminous base courses, binder courses and asphalt concrete surfacing for new roads, pavement rehabilitation, widening or maintenance. It includes the procuring and furnishing of aggregate and bituminous binder, addition of additives / fibres mixing at a central mixing equipment, alternatively on the road, spreading and compaction of the mixture, all as specified for the construction of:

- (i) Continuously Graded Asphalt Concrete Surfacing
 - Marshall Mixes: AC20, AC14, AC10
 - Superpave Mixes: 19.0mm, 12.5mm, 9.5mm Nominal Size
- (ii) Hot Mixed Bituminous Base Course
 - Marshall Mixes: DBM40, DBM30
 - Superpave Mixes: 37.5mm, 25.0mm Nominal Size
- (iii) Cold Mixed Bituminous Base Course
 - Foam based Mix (FBMIX)
 - Bitumen Emulsion based Mix (BEMIX)
 - Stone Matrix Asphalt (SMA) 19mm, 13mm, 9.5mm Nominal Size)

This Section also covers the recycling of bituminous materials by reprocessing recovered materials, adding fresh aggregate, bituminous binders and other agents for obtaining a bituminous mix, which will comply with the specified requirements and placing the recycled material. The provisions of SECTION 4200 shall apply throughout to recycled bituminous materials, except where explicitly specified otherwise.

Recycled Asphalt Pavement (RAP) can be successfully used in hot-mixes in predefined quantities.

For In-Place Recycling, the following four types of pavement materials are likely to be considered (individually or in combination):

- i. A thick layer of asphalt concrete and other bituminous material
- ii. Thin layer of surface dressing (SD) along with lime stabilised base course
- iii. Thin layer of surface dressing (SD) along with crushed stone base course
- iv. Unbound granular layer.

The processed recycled material in case of in place / in plant produced shall act as the base course of the pavement system and requires a surface course above it.

4202 MATERIALS

(a) General

Coarse and Fine aggregate shall be clean and free from decomposed materials, vegetable organic matter and other deleterious substances and shall meet all relevant requirements in the Specifications.

The coarse and fine aggregate shall be produced by crushing of rock obtained by blasting of hard solid rock formation. The crushing shall be by multi-stage equipment in order to produce aggregates of angular shape.

All materials shall be handled and stockpiled in a manner that will prevent contamination, segregation or damage. Stocks of cement and lime shall be rotated in a manner whereby it is used in the order in which it has been received. Aggregate shall be stocked to have an angle of repose not more than 40° at the base. Stockpile height shall be maintained at around 3m or to the satisfaction of the Engineer. Stocks of proprietary additives/ fibres shall be in a manner specified by the manufacturer and approved by the Engineer.

The Contractor shall, as often as necessary test and control the materials produced by themselves or the materials received by themselves from suppliers to ensure that the materials always comply with the specified requirements.

The Contractor will not be expected to construct layers in which the compacted layer thickness is less than one and a half times the maximum aggregate size.

(b) Bituminous Binders

i) General

The various bituminous binders specified shall comply with the relevant specifications as stated in TABLE 4202/1, 4202/2, 4202/3, 4202/4 and 4202/5 or equivalent standards according to the Special Specifications and on the approval of the Engineer:

ii) Conventional Bituminous Binders

Specifications for conventional bituminous binders used for hot mix asphalt shall comply with the requirements of Table 4202/1.

TABLE 4202/1: SPECIFICATIONS FOR CONVENTIONAL BITUMINOUS BINDERS

Type of binder	Specification
Penetration Grade Bitumen	US EAS 982-1:2020 or ASTM D946/D946M-20
Performance Grade Bitumen	US EAS 982-5:2020 or AASHTO M332-23
Cutback Bitumen	US EAS 982-2:2020 or ASTM D2026/D2026M-15(2021), ASTM D2027/D2027M-19 ASTM D2028/D2028M-15(2021)
Bitumen Emulsions, Anionic	US EAS 982-3:2020 ASTM D977-20 AASHTO M140-20
Bitumen Emulsions, Cationic	US EAS 982-4:2020 or ASTM D2397/D2397M-20 or AASHTO M208-18

- Penetration Grade Bitumen Classification 35/50, 40/60, 50/70, 80/100
- Performance Grade Bitumen Designation Classification PG 46, PG 52, PG 58, PG 64, PG 70, PG 76, PG 82
- Cutback bitumen classification RC, MC, SC
- Bitumen Emulsions Anionic/Cationic classification CSS, SS, CMS, MS, CRS, RS, C
- Penetration Index (PI) values range from -3 to +7: Higher PI (>0): Less temperature susceptible, better for extreme climates
Lower PI (<0): More temperature susceptible

iii) Modified Binders (Based on TG1, 5th Edition, 2020 from SABITA/ US EAS 982-5:2020)

Modified bituminous binders shall be divided into the following two broad compositional groups:

- Homogenous Binders
- Non-homogenous Binders

The generic binders classified in TABLE 4202/2 are suitable for pre-mixed asphalt surfacing.

TABLE 4202/2: CLASSIFICATION FOR MODIFIED BINDERS FOR HOT MIX ASPHALTS

Modified Binder Class	Compositional Group	Application
A-E1	Homogenous	Hot Mix Asphalt - Elastomer Modified
A-E2	Homogenous	Hot Mix Asphalt - Elastomer Modified
A-P1	Homogenous	Hot Mix Asphalt - Plastomer Modified
A-R1	Non-homogenous	Hot Mix Asphalt - Rubber Modified
A-R2	Non-homogenous	Hot Mix Asphalt - Rubber Modified

The properties of the modified binder classes shown in TABLE 4202/2 are specified in TABLES 4202/6 and 4202/7

In case of Non-homogeneous (heterogeneous) modified binders, the bitumen-rubber binder shall comply with the following requirements:

[1] Base Bitumen

The bituminous binder used in the production of the bitumen-rubber shall be 50/70, 70/100 or 160/200 penetration-grade bitumen respectively or a blend of any two or all three grades to

provide a product with the required viscosity properties.

[2] Rubber

The rubber shall be obtained by processing and recycling rubber tyres. The ground rubber should be free from fabric, steel cord and other contaminants. A maximum of 4% (by mass of rubber) calcium carbonate, or talc, may be added to the rubber crumbs to prevent the rubber particles from sticking together. At the time of use the crumbs shall be free flowing and dry and comply with the requirements of TABLE 4202/3.

TABLE 4202/3 RUBBER CRUMBS

Sieve Analysis:		Test Method
Sieve size (mm)	Percentage passing by mass	
1.18	100	MB 14 (SABITA TG1 - 5 th Edition)
0.600	40-70	
0.075	0-5	
Fibre length	6 mm (maximum)	-
Bulk density (kg/m ³)	300-400	MB 16 (SABITA TG1 - 5 th Edition)

[3] Extender Oils

If considered appropriate during manufacture, these highly aromatic oils, are added to the bitumen prior to the addition of the rubber crumbs and shall comply with the requirements of TABLE 4202/4.

TABLE 4202/4: EXTENDER OILS

Property	Requirements
Flash point (min.)	180°C
% by mass of aromatic, unsaturated hydrocarbons (min.)	55%

[4] Diluent (Thinner)

The diluent shall be a petroleum hydrocarbon distillate (typically kerosene). Cutter is not recommended.

[5] Bitumen-Rubber Blend

The bitumen-rubber blend shall comply with the requirements of TABLE 4202/5. This table serves as a guideline only so as to ensure compliance of the final blended product in line with TABLE 4202/7.

Prior to commencement of the work, the supplier shall state in writing the percentage of rubber and the blending/ reaction temperature he/ she intend to use for his/ her specific product. The actual percentage of rubber shall not deviate by more than 1.0% from the stated value and the actual reaction temperature shall not deviate by more than 10% from the stated value.

TABLE 4202/5: BITUMEN-RUBBER BLEND

Property	Requirements
Percentage Rubber by Mass of Total Blend	18% - 24%
Percentage Extender Oil by Mass of Total Blend	3% (max)
Percentage of Diluent by Mass of Total Blend	7% (max)
Blending / Reaction Temperature	170°C - 210°C
Reaction Time	45 minutes (min)

A continuous record of both percentage rubber added and reaction temperatures shall be kept on site by the Contractor.

The bitumen-rubber binder shall comply with the requirements of TABLE 4202/7: Requirements for Rubber Modified Binders for Hot Mix Asphalt.

The Contractor shall provide the Engineer with time-temperature ratios in regard to the above properties of his / her specific product before work may start in order to determine the final process and the acceptance limits. TABLE

4207/2: Temperature Requirements for Asphaltic Mixes with Modified Binders, may be used as a reference.

The Contractor shall provide the performance record for three recent projects of the materials he/she intends to use in order to assess the successful use of the materials. The information shall include mean values obtained for the prescribed tests as well as any relevant comments. This information shall be submitted at the bidding stage.

TABLE 4202/6: REQUIREMENTS FOR POLYMER MODIFIED BINDERS FOR HOT MIX ASPHALT

Property	Unit	Test Method (As provided in TG 1 unless indicated otherwise)	Class		
			A-E1	A-E2	A-P1
Before Ageing					
Softening Point*	°C	MB-17	55-65	65-85	63–73
Elastic recovery @ 15°C	%	MB-4	> 50	> 60	30–50
Dynamic Viscosity @ 165°C	Poise	MB-18	≤ 0.6	≤ 0.6	≤ 0.55
Storage Stability @ 160°C	°C	MB-6	≤ 5	≤ 5	≤ 5
Flash Point	°C	ASTM D92-18	≥ 230	≥ 230	≥ 230
After Ageing with Rolling Thin Film Oven (RTFOT) to ASTM D2872-22					
Mass Change	%	MB-3	≤ 1.0	≤ 1.0	≤ 1.0
Softening Point	°C	MB-17	≥ 53	≥ 63	≥ 61
Elastic Recovery @ 15°C	%	MB-4	> 40	> 50	NA
*The prescribed test method is based on not using stirrers although it has been reported that the use of stirrers has shown no difference in test results. For refereeing purposes, no stirrer should be used.					

*The prescribed test method is based on not using stirrers although it has been reported that the use of stirrers has shown no difference in test results. For refereeing purposes, no stirrer should be used.

TABLE 4202/7: REQUIREMENTS FOR RUBBER MODIFIED BINDERS FOR HOT MIX ASPHALT

Property	Unit	Test method	Class	
			A-R1	A-R2
Softening Point*	°C	MB-17	55-65	65-80
Dynamic Viscosity @ 190°C	Poise	MB-13	20-50	- NA-
Dynamic Viscosity @ 170°C	Poise	MB-13	- NA-	10-40
Compression Recovery (5 minutes)	%	MB-11	>80	>70
Compression Recovery (1 hour)			>70	>70
Compression Recovery (24 hours)			- NA-	- NA-
Resilience @ 25°C	%	MB-10	13-40	10-40
Flow @ 60°C	Mm	MB-12	10-50	0-40

*The prescribed test method is based on not using stirrers although it has been reported that the use of stirrers has shown no difference in test results. For refereeing purposes, no stirrer should be used.

In case modifiers are used in the conventional performance grade bitumen (Example: any organic material of suitable manufacture that is used in virgin or recycled condition and that is dissolved, dispersed or reacted in asphalt binder to enhance its performance), the classification of bitumen should be carried out based on Multiple Stress Creep Recovery (MSCR) Test as per AASHTO M 332-23. The same test can also be used to verify the presence of a modifier in the bitumen.

The selection of type of bitumen should be based on location (climatic condition) of the project and expected loading pattern. TABLE 4202/8 may be referred as guidance for asphalt grade selection criteria. However, the grade of binder proposed for a particular project shall be mentioned in the Special Specifications. Moreover, guidance for the selection of bitumen grade shall be obtained from MS-2 7th Edition as it comprises specifications for Marshall as well as Superpave Mix.

TABLE 4202/8: GUIDANCE FOR ASPHALT GRADE SELECTION CRITERIA

PENETRATION GRADE BITUMEN			
Lowest Daily Mean Air Temp, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20 °C	20 to 30 °C	More than 30 °C
More than -10 °C	70/100	50/70	40/60
-10 °C or lower	70/100	70/100	50/70
PERFORMANCE GRADE BITUMEN			
Selection of Performance Grade Binder shall be based on Multiple Stress Creep Recovery (MSCR) Test as per AASHTO M 332-23.			
MODIFIED BITUMEN			
To be used only in surfacing layers with the approval of the engineer to improve rutting potential, reduce temperature susceptibility and improve performance.			

The Type and grade of bituminous binders to be employed for the specific project shall be described in the Special Specifications.

Representative test certificates showing all relevant properties of the adhesion agent/antistripping agent and bitumen shall be submitted for approval by the Engineer.

Such certificates shall be submitted minimum 28 days prior to proposed use or as required by the Engineer to conduct further testing of the materials. Samples of the materials shall be submitted together with the test results if required by the Engineer. New test certificates and samples shall be provided for approval in the event of changes in type or source of adhesion agent / antistripping agent, bitumen grade, crude oil source, refinery equipment or refinery method or as deemed necessary by the Engineer.

iv) Additional Requirements for Foamed Bitumen

In addition to the general requirements stated in this SUB CLAUSE foamed bitumen shall meet the following requirements when tested using TG-2, 2021. In addition, the requirements for bitumen shall comply with BSM 1 Protocol of Manual 39 'Laboratory Testing Protocols for Binders and Asphalt', SABITA.

The Expansion Ratio (ratio of the volume of the bitumen in a foamed state and in an un-foamed state) shall not be less than 10. The Half Life (from the time the foam is ejected into atmospheric pressure until the time the foam volume has decreased to half its maximum volume) shall not be less than 6 seconds.

If necessary, appropriate quantities of foaming agent can be used to achieve minimum foaming characteristics. Prior approval from the Engineer shall be obtained before using the foaming agent.

v) Pre-Construction Binder Investigations

The Contractor shall immediately after signing of contract, prepare pre-construction binder investigations, including:

- a. Identification of a capable and independent bitumen testing laboratory for comparative testing of binders
- b. Collection of samples of potential bitumen
- c. Documentation of sample origin, including:
 - ♦ The refinery (name of owner(s) and full address)
 - ♦ Date, and time of sampling.
 - ♦ Point of sampling, (tank number, flow line valve, truck, drum, etc.)
 - ♦ Person responsible for sampling.
 - ♦ Production data:
 - Manufacturing method (direct vacuum distillation, propane precipitation, etc.)
 - Feed stock data
 - Batch ID No.
 - Composition of product (raw materials, additives, etc.)
 - Product characteristics (penetration, softening point, etc.)
 - Storage temperature

The sample should be accompanied with a signed certificate from the manufacturer with the above-mentioned information and a declaration that the sample to be tested is representative of their production and that a corresponding product will be available to the project during the construction period.

- d. Prepare a bitumen testing programme according to the present Specifications.
- e. The Contractor shall test the bitumen samples in accordance with this

Specification and send the results to the Engineer for their approval.

(c) Aggregates

i) Marshall Mixes

The aggregates employed for all the asphaltic pavement layers using Marshall Mix Design when tested shall conform to the following requirements unless otherwise stated in the individual clauses:

[1] Cleanliness

The Sand Equivalent of the fine aggregate shall be minimum 45 when tested in accordance with AASTHO T176. The plasticity index when tested in accordance with BS 1377-2:2022 shall be less than 4%. Linear Shrinkage when tested in accordance with BS 1377-2:2022 should be less than 2%.

[2] Particle Shape

The flakiness index when tested in accordance with BS EN 933-3:2012 shall be less than 25%.

[3] Aggregate Strength

- The AIV of coarse aggregate shall not be more than 25 when determined in accordance with BS 812-112:1990.
- The Aggregate Crushing Value (ACV) shall not be more than 25 when determined in accordance with BS 812-112:1990.
- TFV of the coarse aggregate used in asphalt concrete surfacing, when determined in accordance with BS 812-111 or equivalent shall not be less than 110 kN. The wet/dry strength ratio shall not be less than 75%.

[4] Absorption

The water absorption of the coarse aggregate shall not exceed 2% by mass, when tested in accordance with BS EN 1097-3:1998 or equivalent,

[5] Soundness

The sodium soundness when tested in accordance with AASTHO T 104-22 shall be less than 12% or Magnesium test <18%.

[6] Coating and Stripping Test

The minimum retained coating of the aggregates when tested in accordance with AASTHO T 182-84 (2002)/ IS 6241 shall be greater than 95%. In case if the retained coating is less than 95 % than suitable antistripping agent shall be used.

[7] Bitumen Affinity

The aggregate shall have good affinity with bitumen - hydrophilic aggregates may be acceptable only where protection from water can be guaranteed or a suitable adhesion agent like an antistripping agent, Cement, Lime etc. can be used. The aggregate shall conform to the requirements as stated in Table 4202/9.

TABLE 4202/9: SPECIFICATION FOR BITUMEN AFFINITY OF AGGREGATE FOR HOT MIX ASPHALT

Test	Properties	Test Method
Retained Indirect Tensile strength	> 80% (at 7%VIM)	AASHTO T 283-22
Rolling Bottle Test	> 95%	BS EN 12697-11:2020

[8] Polished Stone Value (PSV)

The polished stone value (PSV) when tested in accordance with BS EN 1097-8:2020 or equivalent shall be at least 50, unless otherwise specified or approved by the Engineer.

[9] Abrasion

The Aggregate Abrasion Value AAV of coarse aggregate shall not be more than 15 and not more than 12 for very heavy traffic Sections when determined in accordance with BS EN 1097-2020.

[10] Petrographic Test

Various minerals are found in aggregate namely pyrite, dolomite, lazurite, etc. depending on project location. Hence to ascertain the presence of minerals in the aggregate, a petrographic test in accordance with BS EN 932-3:2022 shall be carried out.

(d) Fine Aggregates for Bituminous Mixes

- Cleanliness; Sedimentation or Decantation Percentage passing 0.075 mm sieve, Wearing courses: < 8% for sand fines < 17% for crushed rock fines Other layers: < 22%
- Sand Equivalent (material passing 4.75 mm sieve): Traffic: Light (< T3): Wearing Course> 35%, Road base> 45%. Medium/Heavy: Wearing Course> > 40%, Road base >50%
- Plasticity Index (material passing 0.425 mm sieve) < 4
- Durability: Soundness Test (3) five cycle; Magnesium: < 20% Sodium: < 15%

ii) Superpave Mixes

The aggregates employed for all the asphaltic pavement layers using Superpave Mix Design when tested shall conform to the following requirements unless otherwise stated in the special specifications:

[1] Coarse Aggregate Angularity (CAA)

The Coarse Aggregate Angularity (CAA) shall have a minimum value for coarse aggregate angularity tested as per ASTM D5821-13(2017) based on traffic level and position within the pavement as per TABLE 4202/10. In the format XX / YY denoted in the table, XX denotes percent of the coarse aggregate that has one fractured face and YY denotes the percent that has two or more fractured faces.

[2] Fine Aggregate Angularity (FAA)

The Fine Aggregate Angularity (FAA) shall have a minimum value for fine aggregate angularity

tested as per ASTM D4791-19 based on traffic level and position within the pavement as per TABLE 4202/10.

[3] Flat and Elongated Particles (F&E)

The flat and elongated particles is the percentage by mass or by particle count of coarse aggregates that have a maximum-to-minimum dimension ratio greater than 5:1 or as specified by the Engineer. Maximum values for flat and elongated particles specified in AASHTO M 323-22 are given in TABLE 4202/10.

[4] Clay Content (SE Value)

The clay content/ sand equivalent of the fine aggregate when tested in accordance with AASHTO T 176:2022 shall comply with the minimum properties as specified in TABLE 4202/6.

[5] Toughness

Resistance of coarse aggregate to abrasion and mechanical degradation using Los Angeles Abrasion test AASHTO T 96-22 and Micro-Deval test AASHTO T 327-22. The maximum allowable loss value in case of Los Angeles Abrasion test is typically a range from 25 to 45 percent based on traffic levels as per TABLE 4202/10.

[6] Soundness

The sodium soundness when tested in accordance with AASHTO T 104-22 shall have a maximum value based on traffic levels as per TABLE 4202/10.

[7] Deleterious Material

Deleterious materials to be defined as per AASHTO T 112-23 and limiting criteria as per TABLE 4202/10.

[8] Petrographic Test

Various minerals are found in aggregate namely pyrite, dolomite, lazurite, etc. depending on project location. Hence to ascertain the presence of minerals in the aggregate, a petrographic test in accordance with BS EN 932-3:2022 shall be carried out.

TABLE 4202/10: SUPER PAVE AGGREGATE REQUIREMENT

Design ESALs (In millions)	CAA (%), min.		FAA (%), min.		SE (%), min.	F&E (%), min.	LA abrasion (%), max.	Soundness (%), max.	Deleterious material
	≤ 100 mm	> 100 mm	≤ 100 mm	> 100 mm					
< 3	75/ -	50/ -	40	40	40	10	40	20	<4
3 - 10	85 / 80	60/ -	45	40	45	10	30	15	<3
10 - 30	95 / 90	80/ 75	45	40	45	10	30	15	<2
≥ 30	100/100	100/100	45	45	50	10	25	<10	<1

iii) Stone Matrix Asphalt (SMA)

The coarse aggregates shall consist of crushed rock retained on a 2.36 mm sieve, whereas fine aggregates (passing 2.36 mm sieve and retained on 0.075 mm sieve) shall consist of 100 percent crushed, manufactured sand resulting from crushing operations. The fine aggregates shall be non-plastic and the Sand Equivalent Test value for these shall not be less than 50.

Mineral filler shall consist of finely divided mineral matter such as stone dust and/or hydrated lime. The filler shall be inert material free from organic impurities and shall have PI < 4. The Plasticity index requirement will not apply if the filler is hydrated lime. The filler shall be graded within the limits indicated in TABLE 4202/11.

TABLE 4202/11: GRADING LIMITS FOR FILLER

IS Sieve (mm)	Cumulative % Passing by Weight of Total Aggregate
0.6	100
0.3	95-100
0.075	85-100

In case the SMA mixture fails to satisfy the requirement of the Moisture Susceptibility Test (AASHTO T 283-22), at least 2 percent by total weight of aggregate of hydrated lime shall be used as filler and the percentage of fine aggregate reduced accordingly.

iv) Cold Mixed Bituminous Base Course

The aggregate shall be natural gravel, crushed material or approved material milled-off existing pavement layers. Unless otherwise approved by the Engineer the material shall be placed in stockpile prior to mixing with bitumen. Aggregate shall be stocked to have an angle of repose not more than 40° at the base. Stockpile height shall be maintained around 3m or to the satisfaction of the engineer.

All operations to produce, stockpile and lay bituminous base course and shall be carried out in a manner that ensures a homogeneous mixture with even distribution of additives, bitumen and water without segregation or contamination or excessive variations in moisture contents within the material. All the aggregate shall be free from lumps, soft or unsound particles, clay or other deleterious material.

The aggregates shall be free of organic matter and the flakiness index shall not exceed 35%.

Unless otherwise approved by the Engineer the aggregate shall be screened into a minimum of two fractions before use. Minimum one fraction shall be free of fines within a tolerance of maximum 5% passing the 2.0 mm sieve. The fractions shall be combined to achieve the required grading uniformly throughout the production of bituminous base. The mix design shall be based on laboratory tests of parallel sets of representative samples with a minimum of 5 different bitumen contents respectively. The mix design shall adequately show test results that can be expected on material produced within the tolerances given. The mix design shall give one moisture content and one bitumen content for the proposed mix recipe.

[1] Aggregate Strength

The TFV of the coarse aggregate used in cold mixed bituminous base course, when determined dry in accordance with BS EN 1097-2:2020 or equivalent, shall not be less than:

- 110 kN for Traffic Load greater than 1×10^6 esa's
- 80 kN for Traffic Load less than 1×10^6 esa's

The appropriate Traffic Load Class shall be as given in the drawings or Special Specifications. Where such information is not given, the decision of the Engineer shall apply. The wet strength shall not be less than 75% of the dry strength.

[2] CBR Soaked 4 days

When tested in accordance with BS 1377-2:2022 or equivalent, the CBR value shall not be less than 30% before admixture of bitumen.

[3] Plasticity Index

When tested in accordance with BS 1377-2:2022 or equivalent, the plasticity index before admixture of bitumen shall not be more than:

- FB MIX material: 14%
- BE MIX material: 8%

(e) Fibres as Stabilizer Additive for SMA mixes

Only pelletized cellulose fibres shall be utilized as stabilizer additive. The contractor shall submit the manufacturer's test certificate along with the source during the approval of Job mix formula.

The fibres dosage rate is minimum 0.3 percent by weight (on loose fibre basis) of the total mix. The dosage rate shall be confirmed so that the bitumen drain down does not exceed 0.3 percent when the designed mix is tested in accordance with ASTM D6390-11(2017). The cellulose fibres shall be protected from moisture and contamination prior to incorporating them into the SMA.

The cellulose fibres to be used in pellets shall meet the

following requirements given in TABLE 4202/12.

TABLE 4202/12: CELLULOSE FIBRE REQUIREMENTS

Maximum Fibre Length	8 mm
Ash Content	Maximum of 20 percent non-volatile
Oil Absorption	More than 4 times of the fibre weight
Moisture Content	Less than 5 percent by weight

(f) Requirements for Asphalt Concrete and Stone Matrix Asphalt Surfacing Courses

The grading of the combined aggregate including any filler added in a working mix shall be within the limits stated in TABLES 4202/10 - 4202/17 for the respective mixes.

The approved grading shall be designated as the target grading. The mean grading of each lot of the working mix (minimum of 6 tests per lot) determined from samples obtained in a stratified random sampling procedure, shall conform to the approved target grading within the tolerances specified in CLAUSE 4213.

The type of bitumen shall be conventional binders such as penetration grade 40/60 or 50/70, or Modified Binders or Performance Grade Asphalt as specified in the Special Specifications, or as directed by the Engineer.

The bitumen content given in the tables is for bidding purposes. The exact percentage to use shall be determined after the Engineer's approval of the mix design and result of field trials and the bitumen content shall thereafter be within the acceptance limits specified in CLAUSE 7205.

TABLE 4202/13: GRADING LIMITS FOR COMBINED AGGREGATE AND NOMINAL MIX PROPORTIONS FOR ASPHALT CONCRETE SURFACING EMPLOYING MARSHALL MIX DESIGN.

Sieve Size (mm)	Asphalt Concrete, Continuously Graded		
	AC20	AC14	AC10
28	100	-	-
20	80-100	100	-
14	60-80	80-100	100
10	50-70	72-94	85-100
5.0	36-56	54-72	62-80
2.36	28-44	42-58	44-60
1.18	20-34	34-48	36-50
0.600	15-27	26-38	28-40
0.300	10-20	18-28	20-30
0.150	5-13	12-20	12-20
0.075	2-6	6-12	6-12
Aggregate	95%	94.5%	94%
Bitumen Content for Bidding Purposes ASTM D2172/ D2172M-24	5%	5.5%	6%
Compacted Layer Thickness Range (in mm)**	50-65	40-50	30-40
**HMA Pavement Mix Type Selection Guide (Information Series 128)			

TABLE 4202/14: GRADING LIMITS FOR COMBINED AGGREGATE FOR A 19 MM NOMINAL SIZED ASPHALT CONCRETE SURFACING EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	19 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
25	100	-	-	-
19	90	100	-	-
12.5	-	90	-	-
9.5	-	-	-	-
4.75	-	-	-	-
2.36	23	49	34.6	34.6
1.18	-	-	22.3	28.3
0.600	-	-	16.7	20.7
0.300	-	-	13.7	13.7
0.075	2	8	-	-
*) The Restricted Zone forms a band through which the gradation may not pass.				
Bitumen Content for bidding purposes: 5.0%				
Compacted Layer Thickness Range (in mm): 50-75 mm				

TABLE 4202/15: GRADING LIMITS FOR COMBINED AGGREGATE FOR A 12.5 MM NOMINAL SIZED ASPHALT CONCRETE SURFACING EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	12.5 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
25	-	-	-	-
19	100	-	-	-
12.5	90	100	-	-
9.5	-	90	-	-
4.75	-	-	-	-
2.36	28	58	39.1	39.1
1.18	-	-	25.6	31.6
0.600	-	-	19.1	23.1
0.300	-	-	15.5	15.5
0.075	2	10	-	-
*) The Restricted Zone forms a band through which the gradation may not pass.				
Bitumen Content for bidding purposes: 5.5%				
Compacted Layer Thickness Range (in mm): 30 - 75				

TABLE 4202/16: GRADING LIMITS FOR COMBINED AGGREGATE FOR A 9.5 MM NOMINAL SIZED ASPHALT CONCRETE SURFACING EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	9.5 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
25	-	-	-	-
19	-	-	-	-
12.5	100	-	-	-
9.5	90	100	-	-
4.75	-	90	-	-
2.36	32	67	47.2	47.2
1.18	-	-	31.6	37.6
0.600	-	-	23.5	27.5
0.300	-	-	18.7	18.7
0.075	2	10	-	-
*) The Restricted Zone forms a band through which the gradation may not pass.				
Bitumen Content for bidding purposes: 6.0%				
Compacted Layer Thickness Range (in mm): 25 - 50				

TABLE 4202/17: COMPOSITION OF STONE MATRIX ASPHALT AS SURFACING COURSE

Sieve Size (mm)	13mm SMA	9.5mm SMA
19	100	-
12.5	90-100	100
9.5	50-80	70-95
4.75	20-25	30-50
2.36	16-24	20-30
1.18	-	21 max.
0.600	-	18 max.
0.300	-	15 max.
0.075	8-11	8-12
Compacted Layer Thickness Range (in mm) **		
37.5 - 50		
Bitumen Content for bidding purposes: 6.5%		
**HMA Pavement Mix Type Selection Guide (Information Series 128)		

(g) Requirements for Hot Mixed Bituminous Base and Binder Courses

The grading of the combined aggregate including any filler added in a working mix shall be within the limits stated in TABLES 4202/18 - 4202/21 for the respective mixes.

The approved grading shall be designated as the target grading. The mean grading of each lot of the working mix (minimum of 6 tests per lot) determined from samples obtained in a stratified random sampling procedure, shall conform to the approved target grading within the tolerances specified in CLAUSE 4213.

The type of bitumen shall be 40/60 or 50/70 penetration grade, or Performance Grade Asphalt as specified in the Special Specifications, or as directed by the Engineer.

The bitumen content given in the tables is for bidding purposes. The exact percentage to use shall be determined after the Engineer's approval of mix design and result of field trials and the bitumen content shall thereafter be within the acceptance limits specified in CLAUSE 7205.

TABLE 4202/18: GRADING LIMITS FOR DENSE BITUMEN MACADAM BASE COURSE AND BINDER COURSE EMPLOYING MARSHALL MIX DESIGN.

Sieve Size (mm)	DBM40 (% passing)	DBM30 (% passing)
50	100	-
37.5	95-100	100
28	70-95	90-100
20	-	70-95
14	56-76	58-82
10	53-70	52-73
5.0	39-56	40-56
2.0	24-40	24-40
1.18	19-35	19-35
0.425	9-25	9-25
0.300	7-21	7-21
0.075	2-9	2-9
Bitumen content for bidding purposes, ASTM 2172/2172M-24		4.0%
Bitumen Type, US EAS 982-1:2020, US EAS 982-5:2020, AASHTO M 332-23		4.5%
Bitumen Type, US EAS 982-1:2020, US EAS 982-5:2020, AASHTO M 332-23		40/60 or 50/70 penetration grade or according to the Special Specifications, or as directed by the Engineer.
Compacted Layer Thickness Range (in mm)**		100-150
75-100		
**HMA Pavement Mix Type Selection Guide (Information Series 128)		

TABLE 4202/19: GRADING LIMITS FOR A 37.5 MM NOMINAL SIZED ASPHALTIC BASE COURSE EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	37.5 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
50	100	-	-	-
37.5	90	100	-	-
25	-	90	-	-
19	-	-	-	-
12.5	-	-	-	-
9.5	-	-	-	-
4.75	-	-	34.7	34.7
2.36	15	41	23.3	27.3
1.18	-	-	15.5	21.5
0.600	-	-	11.7	15.7
0.300	-	-	10	10
0.075	0	6	-	-
*) The Restricted Zone forms a band through which the gradation may not pass.				
Bitumen Content for bidding purposes: 4.0%				
Compacted Layer Thickness Range (in mm): 100 -150				

TABLE 4202/20: GRADING LIMITS FOR A 25 MM NOMINAL SIZED ASPHALTIC BINDER/BASE COURSE EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	25 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
50	-	-	-	-
37.5	100	-	-	-
25	90	100	-	-
19	-	90	-	-
12.5	-	-	-	-
9.5	-	-	-	-
4.75	-	-	39.5	39.5
2.36	19	45	26.8	30.8
1.18	-	-	18.1	24.1
0.600	-	-	13.6	17.6
0.300	-	-	11.4	11.4
0.075	1	7	-	-
*) The Restricted Zone forms a band through which the gradation may not pass.				
Bitumen Content for bidding purposes: 4.5%				
Compacted Layer Thickness Range: 75 -100 mm				

TABLE 4202/21: COMPOSITION OF STONE MATRIX ASPHALT AS BINDER COURSE

Sieve Size (mm)	19mm SMA
25	100
19	90-100
12.5	50-88
9.5	25-60
4.75	20-28
2.36	16-24
1.18	-
0.600	-
0.300	-
0.075	8-11
Compacted Layer Thickness Range**: 50 mm - 62.5 mm	
Bitumen Content for bidding purposes: 6.0%	
**HMA Pavement Mix Type Selection Guide (Information Series 128)	

(h) Requirements for Cold Mixed Bituminous Base Course

In case of cold mixed bituminous base course, the grading

of the combined aggregate including any filler added in a working mix shall be within the limits stated in TABLE 4202/22 for the respective mixes. The approved grading shall be designated as the target grading. The mean grading of each lot of the working mix (minimum of 6 tests per lot) determined from samples obtained in a stratified random sampling procedure, shall conform to the approved target grading within the tolerances specified in SUB-CLAUSE 4213 (b).

TABLE 4202/22: GRADING LIMITS FOR COMBINED AGGREGATE FOR COLD MIXED BITUMINOUS BASE COURSE

Sieve size (mm)	FBMIX (%) passing)	BEMIX (%) passing)
37.5	100	100
28	80-100	80-100
20	60-95	60-95
10	42-78	35-70
5.0	30-65	25-50
2.0	20-50	18-35
0.425	10-30	10-25
0.075	5-15	5-8
Bitumen type *)	Foamed	Emulsion
*) Nominal consumption of bitumen (litres per m ³ of compacted material)	90	90
*) The nominal consumption of bitumen is for bidding purposes. The exact percentage of bitumen content shall be determined after the Engineer's approval of mix design and result of field trials. The type of bitumen shall be according to the Special Specifications or as specified by the Engineer.		

(i) Fillers

If the grading of the combined aggregates for asphalt surfacing mixes shows a deficiency in fines an approved filler may be used to improve the grading. Filler may consist of active filler as defined hereinafter or of inert material such as rock dust having the required grading necessary to improve the grading of the combined aggregates. In no instance shall more than 2% by mass of active filler be used in asphalt mixes. Inert filler such as rock dust used to improve grading shall not be subject to this limitation.

The Engineer may order the use of any active filler to improve the adhesion / anti-stripping properties of the aggregate. Active filler shall consist of milled blast furnace slag, hydrated lime, Portland cement (CEM I), Portland blast furnace cement fly-ash or a mixture of any of the above materials. Individual materials shall comply with the requirements of the relevant specifications for such material.

Active filler shall have at least 70% by mass passing the 0.075 mm sieve, all passing the 0.600 mm sieve and a bulk density in toluene falling between 0.5 and 0.9 g/ml. The voids in dry compacted filler shall be between 0.3% and 0.5%, when tested in accordance with BS 812-103.2:1989.

Active fillers for use in bituminous base courses shall be introduced to the mix prior to wetting with the binder. Only active filler added on the instructions of the Engineer, for the purpose of improving adhesion/ anti-stripping properties, will be paid for. No payment will be made for filler added to improve the grading.

(j) Asphalt Reinforcing

Asphalt reinforcing shall be of the type specified in the Special Specifications and shall be obtained from an approved manufacturer. Some common examples of such reinforcements are fibres (Ex. ACE XP Polymer™, FORTA-FI® or other proprietary products).

Where the use of reinforcing for asphalt has been

specified, the Contractor shall, at least three months before the material is to be used, submit samples of the type he/she intends to use, together with complete specifications of the material, as well as the manufacturer's instructions for use, to the Engineer for approval. Where the material does not carry the mark of an acknowledged standards authority, the Engineer may instruct the Contractor to have the material tested by an approved laboratory and to submit the results.

(k) Recycling of Bituminous Layers

For recycled asphalt the nominal mix ratios of recovered asphalt, new aggregate, new bituminous binders and active mineral filler to be used for bidding purposes shall be as specified in the Special Specifications.

i) Recovered Asphalt

The Engineer will test the existing asphalt in any part of the road and determine its suitability for recycling before removal. He/ she may instruct the Contractor to drill additional cores at specified points. Recovered asphalt intended for recycling shall be stored separately from other asphalt and the Engineer may also direct different types of asphalt to be stored separately.

The recovered asphalt shall be free from any underlying granular base material and other foreign matter.

Asphalt milled out shall be of a maximum size of 28 mm, unless another maximum size has been approved by the Engineer.

Asphalt not milled out shall be broken down in an approved manner so that it can be properly remixed in an equipment to the satisfaction of the Engineer. Mixes of recycled asphalt containing fragments of recovered asphalt exceeding 28 mm in size, will not be accepted.

Payment for recovered asphalt will distinguish between milled out and non-milled out material.

Samples shall be taken from the recovered asphalt intended for recycled mixes in the stockpile and shall be tested for grading and quality of the aggregate, binder content and properties of the binder.

ii) Bituminous Binders

The provisions of CLAUSE 4202 shall apply. The grade of new binder used in the recycled asphalt mix shall be such that the mix of new and residual binder will comply with the requirements of the Special Specifications. Whenever the use of reclaimed bituminous material in the recycled asphalt mix exceeds 10% of weight, the penetration value of the recovered binder, before mixing, should be more than 15. The type and amount of binder required to be added in the recycled asphalt mix, shall be determined after the Engineer's approval of mix design and result of field trials. Bitumen content shall thereafter be within the acceptance limits specified in CLAUSE 7205. Recycling agents such as blended oils/rejuvenators and other additives may not be used without prior approval by the Engineer.

In a case where Performance Grade Bitumen is specified, the selection of virgin binder can be referenced based on TABLE 4202/23.

TABLE 4202/23: SELECTION OF BITUMEN GRADE FOR RECYCLED MIX

Recommended Virgin Asphalt Binder Grade	RAP Percentage
No change in binder selection	< 15
Select a virgin binder one grade softer	15 to 25

than normal (e.g., select a PG 58-28 if a PG 64-22 would normally be used)	
Follow recommendations from blending charts as per MS-2 (7 th Edition)	> 25

iii) New Aggregate

New aggregate required for use in recycled asphalt mixtures shall comply with the requirements of CLAUSE 4202.

iv) Combined Aggregate

The aggregate mix obtained from new aggregate and the aggregate in the recovered asphalt including any mineral filler, an approved quantity of which may be added in accordance with CLAUSE 4202, shall comply with the requirements specified in the Special Specifications for the relevant recycled asphalt layer.

v) Storing Material for Recycling

The provision of CLAUSE 3306 shall apply to the storing of recovered asphalt.

In addition, the following requirements shall apply.

- Stockpiles of milled or crushed asphalt shall be shaped and formed in a manner that will prevent segregation as far as possible. The stockpiling of the recovered asphalt shall be done in a manner that will prevent consolidation as far as possible; and adequate covers shall be provided to prevent the ingress of water and contamination by dust.
- Recycling material shall be stocked to have an angle of repose not more than 40° at the base. Stockpile height shall be maintained around 3 m or to the satisfaction of the Engineer.
- The recovered asphalt that is placed in the stockpile(s) shall be tested, carefully controlled and recorded with regard to origin and material properties to ensure a consistent recycled end product.
- The preparation of stockpile sites and the stockpiling of recovered asphalt for recycling will not be paid for directly but full compensation therefore shall be included in the rates for the recycled asphalt.

(l) Hot In-Situ Surface Recycling

With regard to new binder, recycling additives, new asphalt, new aggregate or combinations of these materials, hot in-situ surface recycling shall comply with the requirements in the Special Specifications.

(m) Cold In-Situ Recycling

Cold in-situ pavement recycling shall comply with the requirements in the Special Specifications.

(n) Warm Mix Asphalt (WMA)

WMA is a generic term for various products and technologies that are incorporated into plant-produced hot mix asphalt to reduce the plant mixing, roadway paving and compaction temperatures while maintaining workability. They can also be used as compaction aids. There are many WMA technologies and products such as organic/chemical proprietary additives but not limited to Evotherm®, Zycotherm etc. which are already in use. Mixes using WMA technologies are produced and placed at temperatures 0-35°C lower than conventional hot mix. Use of WMA is said to reduce fuel consumption, emissions and improve compatibility of mixes.

4203 MIX DESIGN AND PROPERTIES OF MIXED MATERIALS

The Asphaltic mix design shall be carried out in accordance with the following standards or the latest edition (28 days prior to tendering):

Marshall Mix Design: Asphalt Institute Manual Series, MS-2; (7th Edition)

Superpave™ Mix Design: Asphalt Institute Manual Series, MS-2 (7th Edition)

TABLE 4203/1: DESIGN REQUIREMENTS FOR ASPHALT CONCRETE SURFACING-MARSHALL MIX DESIGN

Property Of Mixture and Laboratory Test Method			Asphalt Concrete, Continuously Graded, (AC20, AC14, AC10)	
			Conventional Binder	Polymer Modified Binder
Marshall Flow (mm)			2 – 4	2.5 - 4
Marshall Stability at Refusal Compaction (Newton), All Severely Loaded Areas*)			Minimum 9,000	Minimum 12,000
Marshall Stability (Newton)	2 x 75 blows	Traffic Loads	> 10 x 10 ⁶ esa's	Minimum 8,000
			1.5 – 10 x 10 ⁶ esa's	Minimum 7,000
	2 x 50 blows		< 1.5 x 10 ⁶ esa's	Minimum 6,000
Air Voids (%)			3 – 5	
Voids in Mineral Aggregate (%) @ 4% Air Voids		Asphalt Mix	AC 20	min. 13%
			AC 14	min. 14%
			AC 10	min. 15%
Voids Filled with Bitumen (%)		Traffic Loads	> 10 x 10 ⁶ esa's	65 – 75%
			1.5 - 10 x 10 ⁶ esa's	65 – 78%
			< 1.5 x 10 ⁶ esa's	70 – 80%
Requirement after Refusal Laboratory Compaction to BS 598-104:2005 (severely loaded areas only) *)			Air Voids shall be minimum 3%	
Indirect Tensile Strength (kPa) AASHTO T 283-22			Minimum 800 Tested at 25 °C	
Tensile Strength Ratio (TSR), ASHTO T 283			Minimum 80%	
PROPERTIES OF CORES POST CONSTRUCTION				
Core Voids (%)			Max. 8	
Compaction Requirement			Min. 96% of Marshall Density	
Indirect Tensile Strength (kPa) AASHTO T 283-22			Minimum 800 Tested at 25 °C	
Tensile Strength Ratio (TSR), AASHTO T 283-22			Minimum 80%	

(a) Properties of Mixed Materials

The Contractor shall, by conducting the necessary tests, prove to the satisfaction of the Engineer that they will be able to produce a mixture meeting the design requirements in TABLE 4203/1, 4203/3, 4203/4 or 4203/5 for the respective mixes, using the aggregate they propose to supply, within the grading limits specified.

Property Of Mixture and Laboratory Test Method	Asphalt Concrete, Continuously Graded, (AC20, AC14, AC10)	
	Conventional Binder	Polymer Modified Binder
*) The appropriate Traffic Load Class, and whether requirements for severely loaded areas apply to any location, shall be as given in the drawings or Special Specifications. Where such information is not given, the decision of the Engineer shall apply. Note: To ensure resistance towards bituminous deformation, wheel tracking test in accordance with EN 12697-22:2020 shall be conducted during mix design and the maximum Deformation slope shall be 1.0 mm/ 1000 cycles.		

In general, the Marshall Mix Design method shall be employed unless the Superpave™ method is particularly specified in the Special Specifications.

When the Superpave™ Mix Design has been specified then the compaction efforts shown in Table 4203/2 shall be employed for the different traffic classes. Guidance on typical roadway applications is provided in Table 6.4 of MS-2 (7th Edition).

TABLE 4203/2: SUPERPAVE™ MIX DESIGN, GYRATORY COMPACTION EFFORTS

Design Traffic (esa x 10 ⁶)	N _{initial}	N _{design}	N _{maximum}
< 0.3	6	50	75
0.3 - < 3	7	75	115
3 - < 30	8	100	160
≥ 30	9	125	205

TABLE 4203/3: DESIGN REQUIREMENTS FOR SUPERPAVE™ MIX DESIGN

Design ESALs (in millions)	Required Relative Density (% of Gmm)			VMA, % Min.					VFA Range, Percent1					Dust to Binder Ratio Range
				NMAS, mm					NMAS, mm					
	N _{initial}	N _{design}	N _{max}	37.5	25.0	19.0	12.5	9.5	37.5	25.0	19.0	12.5	9.5	
< 3	≤ 90.5	96	≤ 98	11.0	12.0	13.0	14.0	15.0	64-78	65-78	65-78	65-78	65-78	0.6-1.2
3 - 10	≤ 89.0	96	≤ 98	11.0	12.0	13.0	14.0	15.0	64-75	65-75	65-75	65-75	73-76	0.6-1.2
10 - 30	≤ 89.0	96	≤ 98	11.0	12.0	13.0	14.0	15.0	64-75	65-75	65-75	65-75	73-76	0.6-1.2
≥ 30	≤ 89.0	96	≤ 98	11.0	12.0	13.0	14.0	15.0	64-75	65-75	65-75	65-75	73-76	0.6-1.2
Indirect Dry Tensile Strength (kPa) AASHTO T 283-22				Minimum 800 tested at 25°C										
Tensile Strength Ratio (TSR), AASHTO T 283-22				Minimum 80%										
In case advanced Performance Tests are available (Reference Testing Matrix):														
Design ESALs (in millions)	Permanent Deformation Test ¹		Fatigue Cracking Test		Thermal Cracking Test									
	Conventional Mixes	Non-Conventional Mixes	Conventional Mixes	Non-Conventional Mixes	Conventional Mixes	Non-Conventional Mixes								
< 3	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required								
3 - 10	AMPT Flow Number ² FN ≥ 53 cycles	AMPT Flow Number ² FN ≥ 53 cycles	Not Required	Flexural Beam Fatigue ³	Not Required	ITC/ITS ⁴ T _{cr} ≤ T _{min,50%}								
10 - 30	AMPT Flow Number ² FN ≥ 190 cycles	AMPT Flow Number ² FN ≥ 190 cycles	Not Required	Flexural Beam Fatigue ³	Not Required	ITC/ITS ⁴ T _{cr} ≤ T _{min,98%}								
≥ 30	AMPT Flow Number ² FN ≥ 740 cycles	AMPT Flow Number ² FN ≥ 740 cycles	Not Required	Flexural Beam Fatigue ³	Not Required	ITC/ITS ⁴ T _{cr} ≤ T _{min,98%}								

¹ In some cases AMPT test can be replaced by repeated load tests (Ex: Hamburg Test) with the approval of the engineer.

² AMPT Flow Number Test carried out as per AASHTO T 378-22

³ Flexural Beam Fatigue Test carried out as per AASHTO T 321-22

⁴ Indirect Tensile Creep/Strength Test carried out as per AASHTO T 322-07 (2020).

In case advanced Pavement Tests are to be used in project implementation, requirements for performance

thresholds should be fixed on a project specific level and included in the Special Specifications.

TABLE 4203/4: DESIGN REQUIREMENTS FOR DENSE BITUMEN MACADAM BASE COURSES-MARSHALL MIX DESIGN

Property of Mixture and Laboratory Test Method			DBM40 & DBM30	
			Conventional Binder	Polymer Modified Binder
Marshall Flow (mm)			2 – 4	2.5 – 4
Marshall Stability (Newton), all severely loaded areas			Minimum 9000	Minimum 12,000
Marshall Stability (2x75 blows) (Newton)	Traffic Loads	> 10 x 10 ⁶ esa's	Minimum 7000	Minimum 8000
		< 10 x 10 ⁶ esa's	Minimum 6000	Minimum 7000
Air voids (%)			3 – 5	
Voids in Mineral Aggregate (%) @ 4% Air Voids			Min. 12%	
Compaction Levels	Traffic Loads	Severely loaded areas)	To refusal **)	
		> 10 x 10 ⁶ esa's	To refusal **)	
		<10 x 10 ⁶ esa's	2 x 75	
*) Severely loaded areas will only be identified during the detailed design, when information such as alignment, soil conditions and traffic volumes are determined, and therefore these areas should be identified in the Special Specifications.				
**) Requirement after refusal laboratory compaction to BS 598-104:2005: Air voids shall be minimum 3%				

Stone Matrix Asphalt (SMA) mixes should be designed using AASHTO M 325-08 (2021), 'Standard Specification for Stone Matrix Asphalt' and AASHTO R 46-22, 'Standard Practice for Designing Stone Matrix Asphalt'. The SMA mixture shall be compacted with 50 blows on each side using the Marshall procedure given in the Asphalt Institute MS-2. The designed mix shall meet the requirements given in TABLE 4203/5.

Table 4203/5: SMA Mix Requirements

Mix Design Parameters	Requirement
Air Void Content	3%– 5%
Bitumen Content	Min. 5.8%
Celluloid Fibres	0.3 % minimum by weight of total mix
Voids In Mineral Aggregate (VMA)	Min. 17%.
Voids In Coarse Aggregates (VCA) Mix,	Less than VCA (Dry Rodded)
Asphalt Drain Down, Percent ASTM D6390-11(2017)	Maximum 0.3
Indirect Tensile Strength (kPa) AASHTO T 283-22	Minimum 800 Tested at 25 oC
Tensile Strength Ratio (TSR), AASHTO T 283-22	Minimum 85%

TABLE 4203/6: DESIGN REQUIREMENTS FOR COMBINED AGGREGATE AND MIX PROPERTIES FOR COLD MIXED BITUMINOUS BASE COURSE

Property Of Mixture And Laboratory Test Method	FBMIX (% passing)	BEMIX (% passing)
Marshall Stability Tested at 40°C, (N) ASTM D6927-15	6000	4500
Marshall Flow Tested at 40°C, (mm) ASTM D6927-15	2 - 4	2 - 4
Minimum Elastic Modulus Tested at 29°C by Indirect Tensile Strength Method or alternative approved methods, (MPa) BS EN 12697-23:2017	1600	1200
Minimum Moisture Content at the time of laying, (%)	Mix Design Moisture less 1.5% points	
Maximum Moisture Content at the Time of Laying, (%)	Mix design moisture plus 0.5% points	
Minimum Compacted Field Density, (% of Marshall Dry Density).	96%	

Warm Mix Asphalt (WMA) is a generic term for various products and technologies that are incorporated into plant-produced hot mix asphalt to reduce the plant mixing, roadway paving and compaction temperatures while maintaining workability. This is added as an additive to the bitumen as 0.3% to 0.5% of the mass of bitumen to produce and place hot mixes at temperatures 0-35°C lower than conventional hot mix. The criteria and process for mix design comply with the standard Design procedure for applicable surfacing, base and binder coarse mixes.

4204 COMPOSITION OF MIXTURES FOR BITUMINOUS BASE COURSE AND SURFACING

The rates of application and mix proportions of bituminous binder, aggregates and fillers which are given in this SPECIFICATION are nominal rates and proportions and shall only be used for tendering purposes. The rates and proportions actually used shall be determined to suit the materials used and conditions prevailing during construction and any approved variation on a nominal mix in the bitumen content or active filler content shall be

the subject of an adjustment in payment for binder or active filler variations as described in CLAUSE 4215.

Before production or delivery of the bituminous material the Contractor shall submit samples of the materials, they propose to use in the mix, together with their proposed mix design as determined by an approved laboratory, to the Engineer in accordance with TABLE 7110/1, so that the Engineer may test the materials and confirm the use of the proposed mix if they are satisfied that it meets the specified requirements.

A mix design shall be submitted for the approval of the Engineer for each new material source the Contractor proposes to use or when significant changes in the material properties are encountered within a material source or as deemed necessary by the Engineer. Any proposed change of mix design for use in Permanent Works shall be notified to the Engineer for their approval minimum 7 days in advance of proposed use.

As soon as the materials become available the Contractor shall produce a working mix with the approved equipment in accordance with the design mix.

The working mix shall again be tested by themselves for compliance with the design requirements. Samples of the working mix shall also be made available to the Engineer, who will authorise the use of the working mix proportions finally approved for use. The Asphalt Concrete Surfacing shall be a material of different designation (TABLE 4203/1) and designed accordingly employing Marshall Mix Design methodology or SuperpaveTM Mix Design.

Having received source approval of the aggregates & bitumen from the Engineer, the Contractor shall make written proposals to the Engineer for the Job-Mix Formula at least 30 days before beginning production of bituminous mix.

These shall be based on Trial Mixes prepared by the Contractor in the Site Laboratory in the presence of the Engineer and all other mix design tests specified in this section.

The proposal shall further include information on storage, handling, mixing, paving and compaction temperatures.

The composition of the approved working mix shall be maintained within the tolerances given in TABLES 4213/1 and 4213/2.

The design of the bituminous mixes shall be in accordance with the relevant design guidelines and the mix properties and requirements.

4205 CONSTRUCTION EQUIPMENT

(a) General

The Contractor shall submit to the Engineer full details of the Construction Equipment they propose to use and the procedures they propose to adopt for carrying out the Permanent Works. The Engineer shall have access at all times to construction equipment for the purpose of inspection.

All equipment shall so be designed and operated to produce a mixture complying with the requirements of this specification. The construction equipment used in the mixing, transportation, laying, and compaction of bituminous materials shall be of adequate rated capacity, in good working order and subject to approval by the Engineer. Obsolete, worn-out or oil/fuel leaking plant will not be allowed on site.

Prior to the start of the work the Contractor shall supply the Engineer with copies of the manufacturer's handbooks and copies of check lists where applicable pertaining to the mixing, remixing and paving equipment's, containing details of the correct settings and adjustments of the equipment.

Any alteration that has been or is being made to any construction equipment, and which does not comply with the specifications of the manufacturer, shall be brought to the notice of the Engineer.

(b) Mixing Equipment

i) General

Mixing of the bituminous mixture shall be carried out in appropriate equipment acceptable to the Engineer.

ii) Stationery or Portable Mixing Equipment

Bituminous mixture shall be mixed by means of an approved-type mixer of proven suitability for producing a mixture complying with all the requirements of the Specifications.

The mixing equipment may be either automatically or manually controlled. Two control operators shall be provided.

The heating system of the tanks storing the binder shall be so designed that the binder will not be degraded during heating. A circulating system for the binder shall be provided which shall be of adequate size to ensure the proper and continuous circulation between storage tanks and mixer during the entire operating period.

Binder storage tanks shall be fitted with thermometers designed to provide a continuous record of the temperature of the binder in the tank. Copies of these records shall be supplied to the Engineer on a daily basis.

Satisfactory means shall be provided to obtain the proper amount of binder in the mix within the tolerances specified, either by weighing or volumetric measurements. Suitable means shall be provided for maintaining the specified temperatures of the binder in the pipelines, weigh buckets, spray bars and other containers or flow lines.

In the case of a drum type mixer, the system shall control the cold feeding of each aggregate fraction and of the filler by mass, by means of a load cell or another device regulating the feed automatically, and by immediately correcting any variation in mass which results from moisture or from any other cause. The cold feed shall be regulated automatically in regard to the binder feed so as to maintain the required mix proportion. For SMA mixes produced in a drum type mixer, a separate fibre feeding system shall be utilized that can accurately and uniformly introduce fibre into the drum at such a rate as not to limit the normal production of mix through the drum. At no time shall there be any evidence of fibre in the bag house/wasted bag house fines.

For SMA mixes produced in a batch plant, the fibre will be added directly into the weigh hopper above the pug mill. Adequate dry mixing time is required to disperse the fibre uniformly throughout the hot aggregate. Dry mixing time will be increased by 5 to 10 seconds. Wet mixing time shall be increased by at least 5 seconds.

In case of WMA mixes, the process and time of mixing the additives during the mixing process should be specified by the manufacturer and approved by the Engineer.

Suitable dust collecting equipment shall be fitted to prevent pollution of the atmosphere in accordance with the provisions of any local Act governing pollution.

The fuel chosen and control of the burner shall be such as to ensure the complete combustion of the fuel in order to prevent pollution of the atmosphere

and the aggregate.

iii) Recycling

In addition to the requirements set out in CLAUSE 4205 the mixing equipment shall be specially adapted to deal with recycling and any such adjustments shall be in accordance with the instructions of the manufacturer of the mixing equipment on the approval of the Engineer. The recovered asphalt portion of the mix shall not be exposed directly to the heating source whilst the feeding rate and proportioning shall be accurately controlled. Before work is commenced, the Contractor shall submit full details of their mixing equipment to the Engineer for their approval.

iv) Non-Homogeneous Modified Binders (Bitumen-Rubber)

In the event of on-site blending, adequate and suitable heating tanks and acceptable blending equipment shall be provided in addition to the mixing plant for conventional binder.

(c) Spreading Equipment, Pavers

All asphalt layers shall be paved by an appropriate type of self-propelled mechanical spreader of a type approved by the Engineer and shall be kept in a good running condition and adjusted correctly according to the manufacturer's specifications.

The pavers shall be equipped with a powerful tamper and vibrating screed. The pavers shall be capable of laying the material to widths, lines, grades cross-fall and thickness within the specified tolerances without causing separation, dragging or other surface defects.

All pavers used for laying Permanent Works shall be fitted with automatic electronic screed controls to maintain the required levels, cambers and cross-falls. Where skids are used, they shall be at least 9m long or as specified by the Engineer.

The paver shall be positioned in such a manner that the asphalt can be tipped from the trucks into the hopper without any spillage.

Where levelling beams on multiple skids or sliding beams are used they shall be at least 9 m long.

Other than WMA mixes, the mix at delivery to the paver shall be not more than 10°C below the discharge temperature at the mixing plant. The minimum temperature for the commencement of breakdown rolling shall be determined on trial sections.

Mix loads of temperatures less than the minimum temperature shall be disposed of.

If there is consistent failure to meet the temperature requirement, the paving operations shall be suspended until suitable measures are taken by the Contractor to ensure that the temperature requirements are met. Should the Engineer stop the works for any reason related to non-compliance with the specifications, there will be no compensation for any costs incurred by the Contractor as a result of such stoppage, nor will there be any extension of time granted as a result.

(d) Rollers, General Requirements

Compaction shall be done by means of approved flat steel wheeled, vibratory or pneumatic-Tyre rollers, sufficient in size and numbers to achieve the specified density through the entire depth of the layer. Minimum one roller shall be pneumatic Tyre with a weight of minimum 2.5 tonnes per wheel and not less than 18 tons total un-ballasted weight. The frequency as well as the amplitude of vibratory rollers shall be adjustable. Vibratory rollers shall be used only where there is no danger of damage being done to the layer, structures of bridge decks, or other layers.

It will be indicated in the Special Specifications whether vibratory compaction equipment may be used on bridge decks and what the constraining parameters will be. The rollers shall be self-propelled and in good working condition, free from backlash, faulty steering mechanisms and worn parts.

Rollers shall be equipped with adjustable scrapers to keep the drums clean and with efficient means of keeping the wheels wet to prevent mixes from sticking to the rollers. No leakage of any nature may occur in the rollers.

Rollers shall not be left stationary on a fresh mat, compacted or not.

(e) Binder Distributors

Where bituminous binders are to be sprayed onto areas before laying the asphalt is done, the binder distributors shall comply with CLAUSE 4104.

(f) Vehicles

All vehicles used for transporting asphalt shall be insulated. Delivery trucks should be fitted with rear spill trays to facilitate transfer of material to the paver without spillage.

All vehicles used for transporting asphalt shall be fitted with canvas for transport in excess of 10 km or when weather conditions demand such cover in the opinion of the Engineer. Such covers shall be securely fixed over the asphalt from the time of departure at the storage or mixing equipment until immediately prior to discharge of the asphalt into the paver.

(g) Construction Equipment for Recycled Asphalt

Construction equipment for producing, hauling and placing the recycled asphalt shall comply with the provisions of SUB-CLAUSE 4204 (a) to 4204 (f), as applicable, and subject to the following additional requirements:

The mixing equipment shall be capable of producing asphalt mixes with or without recovered material. Where necessary, the mixing equipment shall be specially adapted to deal with recycling, and any such adjustments shall be made in accordance with the instructions of the manufacturer. The equipment, with any necessary adjustments, shall be so designed, equipped and used that the measuring, heating and mixing of the material will give a uniform asphalt mix which complies with all the specified requirements in regard to temperatures within the limits necessary for properly placing and compacting the asphalt in accordance with the specified requirements. Before work is commenced, the Contractor shall submit full particulars of their mixing equipment to the Engineer.

(h) Recycling Train

In case of in-place recycling, a recycling train needs to be insured with basic components such as recycler, bitumen tanker and in case of cold mixes water/emulsion tanker. In case of foamed mixes, the recycler shall be a purpose-built machine capable of producing bitumen foam and supply water to the recycled material. The minimum requirements of a recycler shall be as below:

- Milling drum capable of milling bituminous pavement to a depth of 300mm.
- A level control system that maintains the depth of milling within the tolerance of 10mm of the recycling depth.
- A mixture chamber that enables mixing of the miller material with water and foamed bitumen in case of foamed bitumen mixes and with emulsion in case of bitumen emulsion mixes.

4206 GENERAL LIMITATIONS AND REQUIREMENTS AND THE STOCKPILING OF MIXED MATERIAL

(a) Weather Conditions

i) General

Bituminous material may be mixed and placed only under favourable weather conditions, and shall not be mixed or placed when rain is imminent or during wet conditions.

ii) Hot mixes (AC [Marshall & Superpave™ Mixes], DBM, SMA)

The following wind and temperature conditions are regarded as being suitable for paving work with hot mixed material:

While the air temperature is rising, work may be performed at temperatures of:

- 6°C with an allowable wind velocity of less than 25 km/h
- 10°C with an allowable wind velocity of less than 55 km/h, or for asphalt with a compacted thickness of less than 30 mm with an allowable wind velocity of less than 25 km/h.

With falling air temperatures, work must be stopped when the temperature reaches 6°C regardless of the wind velocity and may not be restarted before the temperature is definitely rising.

iii) Cold Mixes (FBMIX, BEMIX)

The Contractor's attention is drawn to the fact that cold mixed material is likely to be pervious until sealed. Damage to unsurfaced layers may occur in wet weather. Due allowance should be provided in the programme of works during rainy seasons, such that exposure of un-sealed layers is kept to a minimum. Time limits for the laying operation are given in SUB-CLAUSE 4212 (b). The time limits are applicable only in dry weather working conditions. Allowance for weather conditions in the programme of works may include reduction of these maximum time limits and/or complete stoppage of the laying operations in wet weather.

iv) SMA Mixes

Laying shall be suspended during the following weather and seasonal conditions:

- In presence of standing water on the surface;
- When rain is imminent, and during rains, fog or dust storm;
- When the base/binder course is damp;
- When the air temperature on the surface on which it is to be laid is less than 10°C for mixes with conventional bitumen and is less than 15°C for mixes with modified bitumen;
- When the wind speed at any temperature exceeds 40 km per hour at 2 m height.

v) Warm Mix Asphalt (WMA)

The use of Warm Mix Asphalt shall be preferred at locations with Cold Climatic Conditions, higher plant distances where keeping a control over laying temperature is difficult. Also, in places where environmental emission from hot mixes is a constraint as near heritage sites. The limitations for use of WMA are similar to as specified in Hot Mix Asphalt.

(b) Moisture Content

The mixing and placing of asphalt will not be allowed if the moisture content of the aggregate affects the uniformity of temperature or if free water is present on the working surface, or when the moisture content of the underlying layer, in the opinion of the Engineer, is too high.

No surfacing shall be placed unless the moisture content of the upper 50 mm of the base course is less than 50% of the optimum moisture content as determined by the Engineer. No overlay shall be placed immediately after a rainy spell on an existing partly cracked and/or highly permeable surfacing resulting in the trapping of moisture in the pavement structure. A minimum delay of 24 hours or such extended period as ordered by the Engineer shall apply.

(c) Surface Requirements

i) General

Any defects of the surface shall be made good and no bituminous material shall be laid until the surface has been approved by the Engineer.

ii) Correction of Base Courses, or Subbase in the Case of Bituminous Surfacing/ Binder Course or Base Course

The base course (after the prime coat has been applied) or the subbase, as the case may be, shall be checked for smoothness and accuracy of grade, elevation and cross section. Any portion of the base or subbase, as the case may be, not complying with the specified requirements, shall be corrected with asphalt at the Contractor's own expense, until the specified requirements are met. The Engineer may, however, in their sole discretion, allow minor surface irregularities to remain, provided they can be taken up in the following asphalt layer without adversely affecting that layer.

The bituminous material used for the correction of the base or subbase, shall be the same mixture as specified for the bituminous surfacing/ base, or as directed by the Engineer, and the maximum size of aggregate used shall be dictated by the required thickness of the correction in each case.

Notwithstanding these provisions for the correction of the base or subbase, the Engineer reserves the right to order the removal and reconstruction of the layer or of portions of the base and subbase layers not complying with the specified requirements, instead of allowing the correction of substandard work with asphalt material.

iii) Cleaning of the Surface

Immediately before applying the tack coat, or where there is no tack coat, before the application of the asphalt, the surface shall be cleaned of all loose or deleterious material by means of a rotary broom, and hand brooms, compressed air or as required to the satisfaction of the Engineer.

Where the prime coat (if any) has been damaged, it shall be repaired by hand brushing or spraying priming material over the damaged portions.

The prime coat shall be sufficiently dry before the tack coat and/or the asphalt may be applied. The Contractor's programme shall allow for delays that are a function of the type of prime, rate of application, base porosity and moisture content, and climatic conditions.

iv) Tack Coat

A tack coat shall be applied to the surface to be paved in accordance with the Specifications and Drawings or as instructed by the Engineer.

The binder used for tack coat shall be either bitumen emulsion (RS 1 or CRS1) complying with EAS 982-3 OR EAS 982-4. The use of cutback bitumen RC:70 as per EAS 982-2 shall be restricted only for emergency applications as directed by the Engineer. The type and grade of binder for tack coat shall be as specified in the special specifications or as directed by the Engineer.

Tack coat shall be applied at the spray rate of 0.2-0.3 kg/m² in case of bituminous surfaces and 0.25-0.3 kg/m² in case of primed granular surface. For bidding purposes, application spray rate of 0.25 kg/m² should be used.

The use of hand operated equipment for the application of tack coats shall be at the sole discretion of the Engineer.

Portions of kerbing and guttering, bridge kerb and railing which will be exposed, shall be protected in terms of SECTION 2300 when the tack coat is applied.

The tack coat shall not be applied more than 24 hours before the paving is done.

v) Preparation for Placing Overlays

The provisions of SECTION 4800 shall apply to any surface to be covered with overlays. The type of treatment to be applied, if any, will be specified in the Special Specifications or instructed in writing by the Engineer.

vi) Preparation where Asphalt Layers are to be Widened or Where Surfacing Over a Section of the Road Width Requires Replacement

The existing asphalt shall be removed as described in SECTION 3800, where applicable, or as instructed by the Engineer.

Where a road has to be widened, the overlay shall be cut back not less than 100 mm from the existing edge. Unless otherwise indicated on the Drawings or instructed by the Engineer. Asphalt joints may not fall within a wheel track.

(d) Storage

i) Hot Mixes (AC [Marshall & Superpave™ Mixes], DBM)

Mixing shall not be allowed to take place more than four hours before paving begins unless provision has been made for storage. Storage of mixed material will only be permitted in approved hoppers, which are capable of maintaining the temperature of the mix uniform throughout.

in any case storage will not be permitted for a period longer than 12 hours after mixing.

ii) Cold Mixes (FBMIX, BEMIX)

The material for use in Permanent Works shall not be laid on the same day as it is mixed unless otherwise approved by the Engineer.

The length of time for mixed material to remain in stockpile before laying shall not be more than 7 days after mixing. Should the Contractor propose to use material that has been stockpiled for longer than 7 days, then the Engineer may allow a trial section to be constructed. The Engineer may subsequently allow the material to be used in the Permanent Works if the outcome of the trial is to their satisfaction.

All equipment used for stockpiling and transportation of the mixture shall have buckets that are cleaned of all foreign material, fuel, lubricants or other contamination before use.

4207 PRODUCING AND TRANSPORTING THE MIXTURE

(a) Mixing and Storage Temperatures of Binder

Bituminous binders shall be stored at temperatures not exceeding those given in TABLE 4207/1 or the Special Specifications, and the aggregate and bituminous binders shall be heated at the mixing equipment to such

temperatures that the mixed product shall have a temperature within the range given in TABLE 4207/1.

TABLE 4207/1: TEMPERATURE RANGES FOR BITUMINOUS BINDERS

Bitumen Type, Pen. Grade	Max. Storage Temperature of Binder (°C)		Temperature Range of Mix (°C)
	Over 24 hrs	Under 24 hrs	Continuously Graded Mixes
40/60 Pen.	145	175	140-165
50/70 Pen.	135	175	135-160

TABLE 4207/2: TEMPERATURE REQUIREMENTS FOR ASPHALTIC MIXES WITH MODIFIED BINDERS

Binder Class	Short-term Handling		Storage		Mixing		
	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Min Temp (°C)	Max Holding Time (hrs)
A-E1 (SBR)	180	24	150	240	190	175	8
A-E1 (SBS)	180	24	150	240	180	170	12
A-E2	180	24	150	240	180	170	12
A-P1	180	24	150	240	170	150	24
A-R1	170	24	150	240	210	190	Refer Time/ Viscosity curve of SABITA TG1-5th Edition
A-R2	160	> 168	150	> 336	185	170	

TABLE 4207/3: MIXING, LAYING AND ROLLING TEMPERATURES FOR BITUMINOUS MIXES (DEGREE CELSIUS)

Bitumen Grade	Bitumen Temperature	Aggregate Temperature	Mixed Material Temperature	Laying Temperature	* Rolling Temperature
40/60 PEN	150-165	150-170	150-165	140 Min.	90 Min.
50/70 PEN	145-165	144-170	145-165	135 Min.	85 Min.

* Rolling must be completed before the mat cools to these minimum temperatures.

(b) Production of the Mixture

i) Hot Mixes Using Batch Equipment's

[1] Heating the Aggregate

The aggregate shall be dried and heated so that, when delivered to the mixer, its temperature shall be between 0°C and 20°C lower than the maximum temperature indicated in TABLE 4207/1 for the mixture. The moisture content of the mix shall not exceed 0.5%.

[2] Batching

Each fraction of the aggregate and binder shall be measured separately and accurately in the proportions by mass in which they are to be mixed. If filler is used, it shall be measured separately on a scale of suitable capacity and sensitivity. The error in the weighing apparatus used shall not exceed 2% for each batch.

[3] Mixing

The aggregate, filler and binder shall be mixed until a homogeneous mixture is obtained in which all particles are uniformly coated. Care shall be taken to avoid excessively long mixing times which can cause hardening of the binder.

ii) Hot Mixes using Drum-Type Mixer Equipment's

The aggregate and filler shall be accurately proportioned and conveyed into the drum-mixing unit. The calibrated amount of binder shall be sprayed onto the aggregates at the correct position so that no hardening of the binder shall take place. A homogeneous mixture and uniform coating of binder must be achieved and the moisture content of the asphalt mixture shall not exceed 0.5%. Once the final mix temperature has been agreed upon it may not be altered without the prior consent of the Engineer.

iii) SMA Mixes using Stationary Mixing Equipment

The SMA Mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregate. When penetration grade bitumen is used, the mix temperature shall range from 150°C to 165°C. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the abovementioned temperature range. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to ensure uniform quality of mix, the plant shall be calibrated from time to time.

Adequate dry storage will be provided for the mineral filler and provisions shall be made for proportioning the filler into the mixture uniformly and in the desired quantities. This is necessary because relatively large amounts of mineral filler are required in SMA mixes.

iv) Cold Mixes using Stationary, Portable Or In-Situ Mixing Equipment

Mixing of bituminous base for use in Permanent Works shall only be carried out in mixing equipment approved by the Engineer and on the basis of an approved mix design. Any proposed change of mix design for use in Permanent Works shall be notified to the Engineer for their approval minimum 7 days in advance of proposed use.

The length of time for storage of additives from the moment of mixing with hot bitumen until mixed with aggregates shall be limited to maximum 2 hours, unless otherwise approved by the Engineer. Such approval shall be subject to proof that adhesion properties are adequate at the time of mixing bitumen with aggregate.

(c) Transporting the Mixture

The mixture shall be transported from the mixing equipment to the Works in trucks complying with the requirements of CLAUSE 4205. Deliveries shall be made so that spreading and rolling of all the mixtures prepared for a day's run can be completed during daylight, unless artificial lighting, as approved by the Engineer, is provided. Any asphalt that has become unusable in the opinion of the Engineer due to rain or any other cause will be rejected. Hauling over freshly laid material is not permitted.

The mix at delivery to the paver shall be not more than 10°C below the discharge temperature at the mixing equipment. The minimum temperature for the commencement of breakdown rolling shall be determined on trial sections. Mix loads of temperatures less than the minimum temperature shall be disposed of.

If there is consistent failure to meet the temperature requirement the paving operations shall be suspended until suitable measures are taken by the Contractor to ensure that the temperature requirements are met. Should the Engineer stop the works for any reason related to non-compliance with the specifications, there will be no compensation for any costs incurred by the Contractor as a result of such stoppage, nor will there be any extension of time granted as a result.

Hauling equipment for bituminous mixes shall have isolated, tight, clean and smooth beds, which are periodically coated with a lime solution or other approved material to prevent adherence of the mix. All hauling units shall be equipped with a canvas or other approved type of cover which shall be used to cover the material upon loading at the mixing equipment and shall not be removed until the mix is discharged into the paver.

The Engineer may instruct that hauling equipment shall have an engine exhaust system blowing the gas vertical not to cause inconvenience to the paving crew.

(d) Recycled Asphalt

The provisions of SUB-CLAUSES 4207 (a) to 4207 (c) shall apply with changes as required.

At least four weeks before paving with recycled material will commence, the Contractor shall submit to the Engineer full particulars regarding the recycling methods they intend to use.

Where recovered asphalt material is taken from a stockpile, it shall be done by excavating from the pile over its full depth. Where segregated material is fed into the mixing equipment, the Engineer will have the right to order the work to cease and to instruct the Contractor to remix the stockpile, retest the mixed material and redesign the asphalt mixture all at their own cost.

4208 SPREADING THE MIXTURE**(a) General****i) The Paver, General**

The paver shall be kept in good working order, and adjustment of the screed tamping bars, feed screws, hopper feed, etc., shall be checked frequently to ensure uniform spreading of the mix.

If segregation or other imperfections occur, the spreading operations shall immediately be suspended until the cause is determined and corrected.

The asphalt plant mixing capacity, the asphalt haulage fleet, the operating speed of the asphalt paver, the number of rollers, etc shall be so coordinated to ensure continuous paving to avoid intermittent stopping of the paver.

Unless otherwise stated in the Special

Specifications the paver shall be equipped to provide automatic control of levels and cross section. In the case of asphalt binder and base construction, automatic control shall be run off guide wires and in the case of surfacing and overlays skids or guide wires shall be used.

ii) Workmanship

The bituminous layer shall be laid and compacted in one or more layers giving a total compacted thickness as specified.

The addition and removal of material behind the paver shall normally not be allowed and the paver shall be capable of spreading the mixture to the correct amounts that will provide the required compacted thickness and surface evenness without resorting to spotting, picking-up or otherwise shifting or disturbing the mixture.

Repairs to joint and isolated surface irregularities may be carried out by hand or other suitable methods, subject to approval of the Engineer.

In restricted areas, inaccessible to the paving equipment used, the mixture may be placed by hand or other means to obtain the specified results. Paving shall be carried out in a manner which will avoid segregation and that will allow control of levels.

Paving shall be carried out in accordance with good workmanship for such operations. This requirement includes, but is not restricted to, particular attention to the following:

- Paving shall commence at the bottom of the grades and the lower edges of super elevated curves
- Paving shall be done upgrade on grades steeper than 5%
- The paver shall be operated in a manner that provides the maximum possible degree of compaction exerted by the screed, evenly distributed across and along the layer.
- Spreading shall be so arranged that longitudinal joints do not coincide with joints in lower layers of asphalt base or surfacing.

The mixture shall be delivered continuously to the paver to avoid stop-go paving operations. The temperature of the mixture shall be controlled by measuring in a random pattern in the truck immediately before emptying, and shall not be less than the minimum temperature defined during the trial section.

The adjustment of the screed, tamping bars, feed screws, hopper feed, etc. shall be checked frequently to ensure uniform pre-compaction and spreading of the mixtures.

If segregation occurs, the spreading operations shall immediately be suspended until the cause is determined and corrected.

The pavers shall be equipped with 60° sloped side plates on the screed to confine and to form a stable and neat permanent outer shoulder edge.

iii) Weather

Paving shall stop when rain is imminent and compaction of all laid material shall be completed immediately.

iv) Hot Mixes, Special Requirements

The temperature of hot mixtures shall be controlled by measuring in a random pattern in the truck immediately before emptying, and shall not be more than 10°C below the minimum temperature specified for mixing in TABLE 4207/1.

v) SMA Mixes, Special Requirements

Bituminous material, with a temperature greater than 145°C, shall not be laid or deposited on bridge deck water-proofing systems, unless precautions against heat damage have been approved by the Engineer.

The minimum thickness of material laid in each paver pass shall be in accordance with relevant SUB-SECTION 4202.

vi) Cold Mixes: Special Requirements

No cold mixed bituminous base course material shall be laid unless the moisture content is within the specified limits. If the moisture content of stockpiled materials falls outside these limits, the Contractor may propose methods to bring the moisture content back to comply with the requirements.

The Engineer may then allow a Trial Section as described in CLAUSE 4211 to be constructed if the proposal is to their satisfaction. The Engineer may subsequently allow the material to be used in Permanent Works if the outcome of the Trial Section is to their satisfaction.

(b) Overlays

In the case of overlays, guide wires will be required during the placing of the mix if so specified in the Special Specifications. In all cases, including placing of levelling courses, the paver shall be provided with skid beams with electronically controlled equipment, which can ensure a constant crossfall and can even out local irregularities.

(c) Constrained Areas

In areas constrained by insufficient space, bituminous material shall be placed with the aid of smaller specially equipped pavers, hand tools, or other approved equipment.

All the relevant provisions in regard to temperature, mix composition, uniformity, etc., shall remain applicable, but layer thickness and control shall be such that the requirements for compaction and surface tolerances can still be attained.

(d) Recycled Asphalt

Where the average thickness of a completed asphalt layer exceeds the specified thickness, and/or recovered asphalt has been wasted indiscriminately, and, if in the opinion of the Engineer it has resulted in a deficiency of recovered material, the Contractor shall supplement such deficiency at their own cost with a quantity of similar or better material equal to the quantity wasted, as determined by the Engineer.

4209 JOINTS

All joints between adjacent sections of the work shall be made by cutting back the layer against which the material is to be placed unless otherwise approved by the Engineer. All loose and incompletely compacted material shall be removed. A cutting wheel shall be used for cutting longitudinal joints. All joints shall be cut vertically in full layer depth unless otherwise instructed by the Engineer.

Joints shall be either at right angles or parallel to the centre line, and joints in the final layer of the surfacing shall, where possible, correspond with the lane markings. Joints in lower layers shall be offset not less than 150 mm on either side of the edges of the traffic lanes.

Before a new layer is placed next to an existing layer, the cut edge of the existing layer shall be painted with a coat of bituminous emulsion /paving bitumen/cutback bitumen

of the same type and application rate as used for the tack coat.

Joints shall be neat and shall have the same texture and density as the remainder of the asphalt course. All joints shall be marked out with chalk lines prior to cutting. The outside edges of the completed asphalt course shall be trimmed along the shoulder, and parallel to the centre line, to give a finished width, as shown on the Drawings, within the tolerances specified.

Any fresh mixture spread accidentally onto existing work at a joint shall be carefully removed by brooming it back with stiff brooms onto the un-compacted work, so as to avoid the formation of irregularities at the joint. Whenever the paving operation is stopped due to lack of mixture, the Contractor shall form a proper joint as specified above, if so directed by the Engineer.

The paved pre-compacted "over height" after the screed shall be carefully determined on the trial sections (with e.g. 10, 20 and 30 mm over height) and properly implemented for satisfactory joint construction.

Joints shall have the same texture and density as the remainder of the asphalt course.

4210 COMPACTION

The mix shall be rolled immediately after it has been laid by vibratory, steel wheel and pneumatic-Tyre rollers in a sequence predetermined and approved during the laying of trial sections. Such rolling shall commence and be continued only for so long as it is effective and does not have any detrimental effect. The use of pneumatic-Tyre rollers for continuously graded non-homogeneous modified binders shall be assessed in the trial section.

As many rollers shall be used as are necessary to provide the specified pavement density and the required surface texture. During rolling of surfacing only, the roller wheels shall be kept moist with only sufficient water to avoid picking up the material.

After longitudinal joints and edges have been compacted, rolling shall start longitudinally at the sides and gradually progress towards the centre of the pavement, except on super-elevated curves, or where the area to be paved has a straight cross-fall, when rolling shall begin on the low side and progress to the higher side, uniformly lapping each preceding track, covering the entire surface. During breakdown rolling, the rollers shall move at a slow but uniform speed (not to exceed 5 km/h) with the drive roller nearest the paver, unless otherwise specified on account of steep gradients.

No movement of the asphalt layer shall occur under steel wheel rollers once the asphalt temperature has dropped to below 100°C. Three-wheeled steel rollers, with large diameter rear wheels are preferable to tandem rollers and may be used in conjunction with pneumatic Tyre rollers, provided pick-up of the asphalt on the wheels does not occur.

The sequence of rollers used in compaction is at the discretion of the Contractor provided the completed pavement shall have a density as measured on recovered cores equal to or greater than the nominal density specified in TABLE 7114/2 and assessed by the statistical method defined in SECTION 7200.

The Contractor shall utilise a calibrated nuclear gauge for process control during compaction operations. Notwithstanding this requirement, the acceptance control carried out for compaction by the Engineer shall still be based on cores taken from the compacted layer. The nuclear device shall:

- Be operated by a suitably trained technician.
- Comply with all the safety regulations of the relevant regulatory authority.

- Be certified to be suitably calibrated.

The portion of the trial section having the desired surface texture shall be designated as a reference for what is required in the permanent work.

The following requirements shall apply to rolling and compacting generally:

- The material shall not be excessively displaced in a longitudinal or transverse direction especially when changing gears, stopping or starting rollers.
- No cracks or hair cracks shall be formed and the bond with the underlying layer shall not be broken.
- The density shall be uniform over the whole area of the layer and extend over the full depth of the layer.
- Rollers shall not be left standing on the asphalt layer before it has been fully compacted.
- In restricted areas where the specified rollers cannot be used, compaction shall be carried out with hand-operated mechanical compaction equipment or approved smaller vibratory rollers. The prescribed density requirements remain applicable throughout, over the full layer thickness, irrespective of the method of compaction.

An adequate number of roller passes shall be used to provide the specified pavement density. The density shall be uniform over the whole area of the layer, as well as at the joints after approximately 10 cm back-cutting of tentative free edges.

The tyre pressure of pneumatic-Tyre rollers shall be adjusted to the maximum that the mixture can carry without excessive displacement of the asphalt layer. The total weight of pneumatic Tyre roller is distributed on each wheel depending on number of wheels. The load on a single tyre ranges from 1.0 – 3.0T. The tyre inflation pressure and wheel load influence the ground contact pressure which is depicted in TABLE 4210/1.

TABLE 4210/1: GROUND CONTACT PRESSURE FOR VARIOUS WHEEL LOADS & INFLATION PRESSURE.

Wheel Load (Tonne)	Inflation Pressure (KPa)					
	240	350	480	620	720	830
1.125	2.0	2.4	2.7	3.0	3.3	3.4
1.375	2.2	2.6	3.0	3.3	3.5	3.8
1.825	2.4	2.8	3.4	3.8	4.0	4.3
2.250	2.5	3.1	3.6	4.1	4.4	4.8
2.750	2.6	3.2	3.9	4.4	4.8	5.2
3.000	2.7	3.3	4.1	4.6	4.9	5.4

The Contractor shall, when necessary only employ approved slippage agents for the rollers. Diesel will under no circumstances be accepted.

In case of SMA mixes, the initial or breakdown rolling shall be done with 8-10 tonne static weight smooth-wheel rollers. The intermediate rolling shall be done with 8-10 tonne static weight or a vibratory roller. The Contractor shall demonstrate the efficiency of the equipment proposed to be used by carrying compaction trials. The procedure for site trials shall be submitted to the Engineer for approval. The finish rolling shall be done with 6 to 8 tonne smooth wheel tandem rollers. Rolling shall continue until the specified compaction is achieved. The density of the finished paving layer shall be determined by taking 150 mm diameter cores. The density of finished paving layer shall not be less than 94 percent of the average (sample size N=2) theoretical maximum specific gravity of the loose mix (G_{mm}) obtained on that day in accordance with ASTM D2041/D2041M-11. That is, no more than 6 % air voids shall be allowed in the compacted SMA mat.

The provisions of CLAUSE 4210 shall apply with changes as required, and with the approval of the Engineer, to

recycled asphalt and cold mixes.

4211 LAYING TRIAL SECTIONS

Laboratory trials shall be carried out by the Contractor and the Engineer on bituminous or recycled bituminous pavement materials which are to be used in the works in their natural state to establish a relationship between their specified end product requirements and properties which can be readily determined in the field for construction control purposes.

The Laboratory trials on mixed materials shall be submitted to the Engineer, at least one week before the Contractor proposes the site trials. Upon the laboratory trial is approved by the Engineer, the site trials shall be conducted.

Each site trial shall be at least 100 metres long unless otherwise specified and to the full construction width and shall be laid to the specified depth for the material. It may form part of the permanent works provided it complies with this Specification. Any areas that do not comply with this Specification shall be removed and a new trial shall be laid.

The Trial Section shall demonstrate that the materials, equipment and procedures proposed are adequate to achieve a bituminous layer in accordance with the Specifications and to the satisfaction of the Engineer.

In case of recycled cold mixes, the objective of the trial section is to establish appropriate equipment settings and subsequent recycling operations such that the resulting mix properties meet the mix design criteria. The following details shall be established during the construction of the trial section where in-place recycling operations are used:

- The forward speed of the recycler and the rate of rotation of the milling drum influence the degree of pulverisation of the pavement layer material. In order to attain the required gradation of the milled material, an appropriate combination of speed of recycler and milling drum needs to be established.
- Rolling sequence and compaction effort required to achieve the target density should be established.

The Engineer may require a number of different binder contents, and a number of different moisture contents in the case of cold mixed material, to be incorporated in one such trial section to verify the laboratory design recipe.

Cores extracted from the completed trial section and in locations determined in a stratified randomly sampled manner.

Only when such a trial section has been satisfactorily laid and finished and complies with the specified requirements will the Contractor be allowed to commence with construction of the permanent work. Should the trial fail, the Contractor shall perform additional trials at his own cost until a trial and the trial section report has been approved by the Engineer.

If the Contractor should make any alterations in the methods, processes, equipment or materials used, or if they are unable to comply consistently with the Specifications, the Engineer may require that further trial sections be laid before allowing the Contractor to continue with the permanent work. Any work that does not comply with the Specifications shall be removed or made good to comply with the Specifications to the satisfaction of the Engineer.

The trials shall be carried out with the agreement and in the presence of the Engineer. The Contractor shall prepare the surface on which to lay the trial section and shall also, if required by the Engineer, remove the trial section after completion and restore the surfaces on which it was constructed, at their own cost.

The Contractor shall for each trial section prepare a plan for the execution of the trial. It shall at least include the following subjects:

- Date and time, location, sketch of location, type of asphalt;
- Preparation of surface, spray rate of tack coat or prime coat and curing time;
- Mixing and paving temperature, cooling rate, infrared camera photos and locations for temperature control;
- Paving speed, tamper settings and type/angle of screed side plates;
- Illustrate intended rolling pattern for at least 3 levels of compaction efforts (medium, high and extra high) and describe methods to record and control number of passes and the rolling pattern actually used;
- Joint construction method, over height of the second paving lane, control of the over height;
- Core drilling and test programme for testing of the mix and the finished pavement. The programme shall include recovered binder and mix properties, wheel track rutting test; and
- Programme for instruction of every person involved in the trial section.

The activity plan for the trials shall be forwarded to the Engineer for approval not less than 7 working days before the planned trials.

The trial on each pavement layer shall be undertaken at least 21 days ahead of the Contractor proposing to commence full scale work on that pavement layer.

The Contractor shall assess back-cuttings and separately document that finished joints satisfy the compaction requirements by taking asphalt cores at a distance of 50 mm from joints and tentative free edges.

The trial sections shall include continuous measurements of asphalt temperatures to determine the rate of cooling and the time available for compaction.

The construction equipment and techniques as well as the mix properties applicable to the approved trial section shall not be changed without prior approval by the Engineer.

No payment shall be made for trial sections and the Contractor must allow for all costs in their rates.

The specification for laboratory trial and site trial in this Clause shall be read in conjunction with CLAUSE 7119 of this Specification.

4212 PROTECTION AND AFTERCARE

(a) General

The Contractor shall protect the bituminous base/ binder course and asphalt surfacing from all damage until the work is handed over to the Employer and they shall maintain the surfacing work until the date of substantial completion. Any damage occurring to the completed base/ binder or surfacing shall be made good by the Contractor at their own expense and to the satisfaction of the Engineer.

Traffic can under normal conditions be allowed onto the fresh layer immediately after compaction and when the paved mat has cooled to ambient temperature in its entire depth is completed unless otherwise directed by the Engineer.

(b) Special Requirements for Cold Mixed Base Course Material

Traffic can under normal dry conditions be allowed on the fresh layer immediately after the compaction is completed unless otherwise directed by the Engineer.

Where the base course is placed in more than one layer,

no more than 7 days shall elapse between completion of consecutive layers. No more than 14 days shall elapse from completion of the base course until the surface dressing is constructed.

The time limits in the above paragraph are applicable only in dry weather working conditions. The Contractor's attention is drawn to the fact that the material is likely to be pervious until sealed.

Damage to unsurfaced layers may occur in wet weather. Due allowance should be provided in the programme of works during rainy seasons, such that exposure of unsealed layers is kept to a minimum. This may include reduction of the above maximum time limits and/or complete stoppage of the laying operations in wet weather.

If the times specified above are not adhered to the Contractor shall place tack coat or priming in accordance with this Specification on approval of the Engineer without additional costs to the Employer.

Approved crusher dust or clean sand shall at no additional costs to the Employer be evenly spread at a rate of 0.005 m³/m² immediately following the spraying of tack coat.

Notwithstanding the above, construction of consecutive layers or surface dressing shall not be unduly delayed. In no case shall more than 90 days elapse since completion of the previous layer.

4213 CONSTRUCTION TOLERANCES AND FINISH REQUIREMENTS

(a) Construction Tolerances

Construction tolerances and finish shall meet all relevant requirements in SECTION 7300. The riding quality of the final layer shall be to the satisfaction of the Engineer or as specified in the Contract.

(b) Grading

The combined aggregate and filler grading shall not deviate from the approved target grading for the working mix by more than that given in TABLES 4213/1 and 4213/2 respectively for Asphalt Concrete surfacing and Bituminous base course / Bituminous Binder course materials and shall remain within the gradation band (minimum-maximum) as stated in relevant subsections of SECTION 4200. These deviations are intended to apply to individual specimens taken for quality control tests in accordance with SECTION 7000.

TABLE 4213/1: AGGREGATE GRADING TOLERANCES FOR ASPHALT CONCRETE SURFACING MATERIALS

Size of Aggregate: Material Passing The Following Sieves (Mm)	Permissible Deviation From The Approved Target Grading (%)
20	± 7.0
14	± 6.0
10	± 6.0
6.3	± 5.0
5	± 5.0
2.00	± 4.0
1.18	± 4.0
0.600	± 4.0
0.300	± 3.0
0.150	± 3.0
0.075	± 1.5

TABLE 4213/2: AGGREGATE GRADING TOLERANCES FOR BITUMINOUS BASE COURSE/ BITUMINOUS BINDER COURSE MATERIALS

Size of Aggregate: Material Passing The Following Sieves (Mm)	Permissible Deviation From The Approved Target Grading (%)
37.5	± 8.0
28	± 8.0
20	± 8.0
14	± 7.0
10	± 7.0
6.3	± 6.0
5	± 6.0
2.00	± 5.0
1.18	± 5.0
0.600	± 5.0
0.300	± 4.0
0.150	± 4.0
0.075	± 2.0

(c) Bitumen Content**i) Hot Mixed Material**

The bitumen content for asphalt concrete surfacing and bituminous base/ binder course materials shall not deviate from the bitumen content of the approved mix by more than the value given below:

Bitumen content tolerance per single test:

±0.3%

where the bitumen content is in per cent by the total weight of the mixture.

ii) Cold Mixed Material

The maximum accepted deviation in binder content of cold mixed bituminous base course material compared to that of the approved Mix Design is given in TABLE 4212/3.

TABLE 4213/3: ACCEPTANCE LIMITS FOR BINDER CONTENT FOR COLD MIXED BITUMINOUS BASE COURSE MATERIALS

Number Of Tests In Lot	Maximum Deviation From The Approved Binder Content (%)	
	Sample Mean	Single Values
4 or less	0.30	0.60
5	0.28	0.62
6	0.27	0.64
7	0.26	0.65
8	0.24	0.66
9	0.22	0.68
10 or more	0.20	0.70

The average amount of bituminous binder in the total length of any layer, calculated as the product of the bitumen contents obtained from single tests and the volume represented by each test, shall not be less than the amount ordered.

The average amount of bituminous binder for each day's production calculated from the checked weights of mixes shall not be less than the amount ordered.

(d) Mixing Temperature

The Permissible variation of mixing temperature in Plant mix from the Job mix formula should be within ± 10.0°C.

(e) Field Density

In case of in-situ recycled cold mixes, compacted layer

density shall not deviate from the target density by ± 3%.

4214 SAMPLING AND TESTING**(a) General**

All sampling and testing shall be carried out in accordance with sampling and testing standards laid down in these Specifications and standards of the Central Materials Laboratory or equivalent approved by the Engineer, and shall be carried out to adequately show compliance with the Specifications.

(b) Coring of Asphalt Layers

The Contractor shall provide suitable coring machines capable of cutting 100 mm or 150 mm diameter cores from the completed asphalt layers based on the bituminous compacted layer thickness.

The cost of extracting cores for process control in accordance with the Specifications shall be included in the Contractor's rates for the construction of asphalt pavement layers and will not be paid for separately.

Cores in the carriageway lanes shall be taken at the outer permanent edge, at the centre of the paved lane and at the longitudinal joint. Cores at the outer edges and at the joints shall be taken 50 mm from the edge after back-cutting as directed. Cores in the shoulders shall be taken 300 mm from the outer shoulder edge and 50 mm from the longitudinal joints to the carriageway pavement.

All core holes shall be neatly repaired with asphalt and compacted to the specified density. The core holes shall be filled with the same mix as used for the layer tested.

(c) Laboratory Testing

Testing shall be carried out by the Contractor at the site laboratory or an external laboratory approved by the Engineer. All operations of the testing shall be available for inspection by the Engineer at all times and the Contractor shall give notice well in advance of all testing as required by the Engineer. All test results shall at all times be available to the Engineer.

Testing and quality control of materials and workmanship shall be carried out in accordance with the relevant provisions for sampling, testing and acceptance given in SECTIONS 7100 AND 7200 of these Specifications.

All test results representative of Permanent Works shall meet the relevant requirements in the Specifications within the tolerances specified and shall be approved by the Engineer.

Test results (laboratory readings and measurements) as well as calculated results in digital form shall be submitted daily to the Engineer in continuously updated summary sheets.

4215 MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
42.01	BITUMINOUS CONCRETE SURFACING:	
(a)	ASPHALT CONCRETE SURFACING (STATE TYPE OF MIX, TYPE OF BITUMEN AND COMPACTED LAYER THICKNESS)	CUBIC METRE (m ³)
(b)	BITUMEN FOR ASPHALT CONCRETE SURFACING (STATE TYPE OF BITUMEN)	TONNES (t)

<u>ITEM</u>	<u>UNIT</u>
42.02 BITUMINOUS BASE/ BINDER COURSE:	
(a) HOT MIX (STATE TYPE OF MIX, TYPE OF BITUMEN AND COMPACTED LAYER THICKNESS)	CUBIC METRE (m ³)
(b) COLD MIX (STATE TYPE OF MIX, TYPE OF BITUMEN / EMULSION AND COMPACTED LAYER THICKNESS)	CUBIC METRE (m ³)
(c) BITUMEN FOR BITUMINOUS BASE/ BINDER COURSE MIXES (STATE TYPE OF BITUMEN)	TONNES (t)
(d) FOAM ASPHALT FOR COLD MIXES (STATE TYPE OF BITUMEN)	TONNES (t)
(e) BITUMEN EMULSION FOR COLD MIXES (STATE TYPE AND BITUMEN CONTENT)	TONNES (t)

The unit of measurement for bituminous mixes shall be the cubic metre of asphalt concrete or bituminous base course placed and compacted on the road as specified and to the specified thickness. The quantities shall be calculated as the product of the length instructed to be paved and the compacted cross-sectional area shown on the Drawings or instructed by the Engineer.

The bid rate for bituminous mixes shall include for procuring all materials, except the bitumen, which is paid for separately, for preparing the surface to the satisfaction of the Engineer, providing, heating, drying as required, mixing, transporting, laying and compacting the mix in accordance with the Specifications and to the satisfaction of the Engineer. The rate shall also include for trial sections, process control testing, protecting and maintaining the work as specified.

The bid rate for the bituminous mixes shall be valid irrespective of which bitumen is selected for the mixes.

The bitumen for bituminous mixes, produced and placed as specified and accepted by the Engineer, is measured by the tonne and paid for separately.

The Emulsion for Cold bituminous mixes, produced and placed as specified and accepted by the Engineer, is measured in litres of emulsion mix of specified type and bitumen content and shall be paid for separately.

The quantity shall be calculated from the approved recipe of the mix at the specified compacted density. A new mix design and recipe shall be prepared if, in the opinion of the Engineer, this is warranted due to variations in mix density or other material properties

No payment will be made for material wasted.

<u>ITEM</u>	<u>UNIT</u>
42.03 TACK COAT	
(a) BITUMEN EMULSION (STATE TYPE AND BITUMEN CONTENT)	KILOGRAMME E (KG)
(b) CUTBACK BITUMEN (STATE TYPE AND BITUMEN CONTENT)	KILOGRAMME E (KG)

The unit of measurement for tack coat shall be the litre of bitumen emulsion applied as specified. The Bituminous Emulsion/Cutback, produced and sprayed as specified and accepted by the Engineer, is measured in litres of emulsion mix of specified type and bitumen content and shall be paid for separately.

The quantity of tack coat (between asphalt layers) shall be calculated as the area in square metres specified to be coated multiplied by the approved spray rate in litres per square metre. The spray rate shall be verified by weighing of test trays before and after application.

The bid rate shall include for the cleaning the surface to the satisfaction of the Engineer, procuring, furnishing and application of the material as specified.

<u>ITEM</u>	<u>UNIT</u>
42.04 ADDITIVES (STATE TYPE)	
(a) BITUMEN MODIFIERS (STATE NAME AND TYPE)	KILOGRAMME (kg)
(b) ANTI-STRIPPING AGENTS (STATE NAME, DOSAGE AND TYPE)	KILOGRAMME (KG)
(c) WMA ADDITIVES (STATE NAME, DOSAGE AND TYPE)	KILOGRAMME (KG)
(d) REJUVENATORS (STATE NAME, DOSAGE AND TYPE)	KILOGRAMME (KG)
(e) SMA STABILIZER ADDITIVE FIBRES (STATE NAME, AND TYPE)	KILOGRAMME (KG)
(f) OTHER PROPRIETARY PRODUCTS (STATE NAME, DOSAGE AND TYPE)	KILOGRAMME (KG)

The quantity of additive shall be calculated as kilograms used in accordance with the recipe of the mix approved of the Engineer.

Additives shall be paid for separately only where these are specified or instructed by the Engineer. Additives shall include active filler to improve adhesion properties, but no separate payment will be made for filler added to improve the grading.

SERIES 4000: BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

SECTION 4300: GENERAL REQUIREMENTS FOR SEALS

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4301 SCOPE

This Section covers the materials, construction equipment, construction and requirements common to the construction of all seals detailed in these Specifications.

4302 MATERIALS

(a) Bituminous Binders

i) Conventional Bituminous Binders

Bituminous binders shall comply with TABLE 4202/1 (i) Conventional Bituminous Binders under the bituminous binder's subsection, CLAUSE 4202 of SECTION 4200.

The type and grade of bituminous binder to be used shall be as specified under the appropriate SECTION of these Specifications for each type of bituminous seal or in the Special Specifications.

ii) Non-Homogeneous (Heterogeneous) Modified Binders

If non-homogeneous modified binders are required, they shall comply with the requirements in the Special Specifications. Where applicable the following details will be indicated in the Special Specifications:

The bitumen-rubber binder shall comply with the following requirements:

[1] Base bitumen

The bituminous binder used in the production of the bitumen-rubber shall be a 60/70, 80/100 or 150/200 penetration-grade bitumen respectively, or a blend of any two or all three grades to provide a product with the required viscosity properties.

[2] Rubber

The rubber shall be obtained by processing and recycling pneumatic tyres. It shall be pulverised, free from fabric, steel cord and other contaminants. A maximum of 4% by mass of

fine particle size calcium carbonate, or talc, may be added to the rubber crumbs to prevent the rubber particles from sticking together. At the time of use the crumbs shall be free flowing and dry and comply with the requirements of TABLE 4302/1.

TABLE 4302/1: RUBBER CRUMBS

Sieve analysis:		Test Method
Sieve size (mm)	Percentage passing by mass	
1.18	100	BR6T Sabita *)
0.60	40-70	
0.075	0-5	
Other requirements:		
Natural rubber hydro-carbon content	30% (minimum)	BS 903 Parts B11 and B12
Fibre length	6 mm (maximum)	-
Relative density (kg/m³)	1100-1250	BR9T (Sabita) *)
*) Southern African Bitumen and Tar Association		

[3] Extender oils

The extender oil shall be petroleum derived material of high aromaticity and shall comply with the requirements of TABLE 4302/2.

TABLE 4302/2: EXTENDER OILS

Property	Requirements
Flash point	180°C
% by mass of saturated hydrocarbons	25% (max)
% by mass of aromatic, unsaturated hydrocarbons	50% (min)

[4] Diluent

The diluent shall be a distillate of hydrocarbons.

[5] Bitumen-rubber blend

The bitumen-rubber blend, including extender oil and/or diluent, it necessary, shall comply with the requirements of TABLE 4302/3.

TABLE 4302/3: BITUMEN-RUBBER BLEND

Property	Requirements
% rubber by mass of total blend	20% - 24%
% extender oil by mass of total blend	6% (max)
% of diluent by mass of total blend	7% (max)
Blending/Reaction temperature	170°C – 210°C
Reaction time	0.5 - 2 hours

Prior to commencement of the work, the supplier shall state in writing the percentage of rubber and the blending/reaction temperature they intend to use for their specific product. The actual percentage of rubber shall not deviate by more than 1.0% from the stated value and the actual reaction temperature shall not deviate by more than 10% from the stated value.

A continuous record of both percentage rubber added and reaction temperatures shall be kept on site by the Contractor.

The bitumen-rubber binder shall comply with the requirements of TABLE 4302/4.

TABLE 4302/4: BITUMEN-RUBBER BINDER

Property	Requirements	Test Method (or equivalent method on approval of the Engineer)
Minimum compression recovery: -after 5 minutes: -after 1 hour: -after 4 hours:	70% 70% 48-55%	BR3T (Sabita)
Ring-and-ball softening point	Minimum 55°C	BS EN 12591
Resilience	13%-35%	BR2T (Sabita)
Dynamic viscosity (Haake at 190°C)	20 35 cPas	BR5T (Sabita)
Flow (mm)	20 – 75	BR4T (Sabita)

The Contractor shall provide the Engineer with time-temperature ratios in regard to the above properties of their specific product before work may start in order to determine the final process and the acceptance limits.

The methods of testing bitumen-rubber material have been published in Manual 3 of the Southern African Bitumen and Tar Association (SABITA).

If a supplier uses a diluent, an ageing test may be required in which the binder is placed in an oven for 5 hours at 150°C, after which time it shall comply with the above Specifications.

The Contractor shall provide the performance record for three recent projects of the materials they intend to use in order to assess the successful use of the materials. The information shall include mean values obtained for the prescribed tests as well as any relevant comments. This information shall be submitted at the bidding stage.

The bitumen-rubber binder shall comply with the requirements of base bitumen, rubber, extender oils, diluent and bitumen-rubber blend as per CLAUSE 4202 (iii).

A continuous record of both percentage rubber added and reaction temperatures shall be kept on site by the Contractor.

iii) Homogeneous Cold Applied Modified Binders

If any polymer other than the elastomer polymers styrene-butadiene rubber (SBR) or styrene-butadiene-styrene (SBS) is required. The manufacture of cationic modified bitumen emulsions shall comply with the requirements in the Special Specifications. The modification of emulsions for fog-spray applications is not recommended.

Where applicable the following details will be indicated in the Special Specifications:

[1] Type Elastomer Polymer

Synthetic Styrene-Butadiene-Rubber SBR Latex or Styrene-Butadiene-Styrene SBS. Elastomeric Polymers. Unless otherwise specified SBR shall be used for bidding purposes.

[2] Grade base bitumen

70/100 penetration grade or 160/200 penetration grade. Unless otherwise specified 70/100 penetration grade shall be used for bidding purposes.

[3] Modified binder content

Unless otherwise specified 65% shall be used for bidding purposes. For steep inclines, and higher application rates it is advisable to use the higher binder content emulsion (as per TABLE 4302/5) to reduce runoff.

The aforementioned components together with polymer content will dictate the attributes attainable.

Unless otherwise specified, the properties of cationic modified bitumen emulsion containing SBR or SBS solids shall comply with the requirements in TABLE 4302/3.

A volatile solvent flux content of up to 3% mass by mass of the bitumen may be added to enhance emulsion performance with regard to prevailing climatic conditions.

Any expected change to specified values shall first be discussed with the Engineer prior to the addition of any such enhancer.

The properties of the recovered modified bitumen using a rotary vacuum evaporation method or simple evaporation method as described in CLAUSE 7108 shall be required to comply with the requirements of TABLE 4302/5.

If there is any discrepancy in the test results on recovered modified binder, then the results on recovered binder obtained from the rotary vacuum evaporation method shall be binding.

TABLE 4302/5: PROPERTIES OF POLYMER MODIFIED EMULSIONS FOR SURFACING SEALS

Property	Unit	Test method*	Class			
			SC-E1		SC-E2	
Binder content (m/m)	%	MB-22	65-68	70-73	65-68	70-73
Saybolt Furol viscosity @ 50°C	sec	MB-21	51-200	51-400	51-200	51-400
Residue on sieving (/100ml)	g	MB-23	For 710µm sieve ≤ 0.1			
			For 150µm sieve ≤ 0.5			
Particle charge		MB-24	positive		positive	
Sedimentation after 60 rotations		SANS 4001 BT3	nil		Nil	
Softening Point#	°C	MB-17	≥ 48		≥ 55	
Elastic Recovery @ 15°C#	%	MB-4	≥ 50		≥ 55	

*As provided in TG 2 unless indicated otherwise in the Special Specifications.

Tests on Recovered Binder Residue obtained as per MB-20.

iv) Homogeneous Hot-Applied Modified Binders (Summer Grades)

The requirements for hot applied polymer modified binders for surfacing seals any polymer other than the generic types are as listed in TABLE 4302/6 used for the manufacture of homogeneous hot-applied

modified binders will be indicated in the Special Specifications.

Where applicable the following details will be indicated in the Special Specifications:

- Generic type (elastomer) and type polymer.

- b. Grade base bitumen (70/100 or 160/200) required. The aforementioned components together with polymer content will dictate the attributes attainable.

v) Homogeneous Hot-Applied Modified Binders (Winter Grade)

Where applicable the requirements for homogeneous modified binders (winter grade) will be specified in the Special Specifications. The requirements for hot-applied modified binders are listed in TABLE 4302/6.

TABLE 4302/6: PROPERTIES OF HOT APPLIED POLYMER MODIFIED BINDERS FOR SURFACING SEALS

Property	Unit	Test method*	Class	
			S-E1	S-E2
Before Ageing				
Softening Point	°C	MB-17	50-70	60-80
Elastic recovery @ 15°C	%	MB-4	> 50	> 60
Dynamic Viscosity @ 165°C	Pa.s	MB-18	≤0.55	≤0.60
Storage Stability @ 180°C	°C	MB-6	≤5	≤5
Flash Point	°C	ASTM D92-18	≥230	≥230

Property	Unit	Test method*	Class	
			S-E1	S-E2
After Ageing (RTFOT)				
Mass change	%	MB-3	≤1.0	≤1.0
Elastic recovery @ 15°C	%	MB-4	>50	>60

(b) Aggregates

The aggregate shall consist of approved crushed stone or natural material complying with the relevant requirements set out for each type of seal and the grading, flakiness index and hardness and soundness shall be as specified for each nominal size of stone.

All aggregates shall be clean and free from dust and other deleterious materials.

The polished stone value (PSV) when tested in accordance with BS EN 1097-8:2020 or equivalent shall be at least 50, unless otherwise specified or approved by the Engineer.

The rolling bottle test when tested in accordance with BS EN 12697-11:2020 shall be at least 95%, unless otherwise specified or approved by the Engineer.

The degree of coating when measured in accordance with the test method shall be a minimum 60%.

The aggregates shall be washed when it is considered necessary by the Engineer or their appointed representative.

TABLE 4302/7: CATIONIC MODIFIED BITUMEN EMULSION

Polymer modifier	Required properties, grade of base bitumen	Minimum modified binder content (%)	Minimum viscosity at 50°C Saybolt Furol (sec.)	Maximum residue on sieving (g/100ml)	Particle charge	Sedimentation after 60 rotations
SBR	80/100 150/200	70 65	80 70	0.25 0.25	Positive Positive	Nil Nil
SBS	80/100 150/200	70 65	80 50	0.25 0.25	Positive Positive	Nil Nil
Test Method	-	ASTM D244-09(2017)	ASTM D244-09(2017)	BS EN 1097-8:2020		

TABLE 4302/8: RECOVERED MODIFIED BITUMEN

Polymer modifier	Required properties				Elastic recovery (%)		
	Grade of base bitumen	Mini-mum Softening point (°C)	Minimum dynamic viscosity at 135°C (Pa.s)	Mini-mum ductility at 10°C (mm)		at 5°C (%)	at 50°C (%)
SBR						90 90	100 100
SBS	80/100 150/200	60 47	1.2 1.0	500 500	55 60	90 90	100 100
Test Method	-	ASTM D36-06	ASTM D4402-06	DIN 52013	DIN 52013	DIN 52013	TMH method B11

Note: Modified binder is bitumen plus polymer. The dust content criteria shall be according to TABLE 4302/8 grade 2 stone for the adhesion test.

TABLE 4302/9: HOT-APPLIED MODIFIED BINDERS, REQUIRED PROPERTIES

Genetic type of modified binder		Required properties							
		Grade of base bitumen	Minimum Softening point (°C)	Minimum dynamic viscosity at 135°C (Pa.s)	Minimum ductility at 10°C (mm)	Minimum elastic recovery 10°C (%)	Maximum stability difference (°C)	Minimum adhesion	
								at 5°C (%)	at 50°C (%)
Plastomer polymer (EVA)		150/200	48	0.5	300	45	2	90	
Elastomer polymer	SBR	80/100	47	1.0	1000	55	2	90	100
	SBS	80/100	49	1.0	500	60	2	90	
	SBR	150/200	45	0.5	1000	55	2	90	
	SBS	150/200	47	0.5	500	60	2	90	100
Test Method	-	-	ASTM D36-06	ASTM D4402-06	DIN 52013	DIN 52013	DIN 52013	TMH 1 Method B11	

(c) Slurry**i) Filler for Slurry**

Common cements shall comply with the requirements of US EAS 18-1:2017, AASHTO M85-22 or equivalent standard on approval of the Engineer.

Road lime shall comply with the requirements of US 288:2001, AASHTO M 216-22, or equivalent (Lime for Soil Stabilisation).

Only one of the above materials shall be used throughout in order to prevent undesirable colour differences in the surface.

ii) Immersion Index

The immersion index of briquettes made with slurry aggregate and penetration-grade bitumen at the specified net bitumen content for the slurry shall be not less than 75.

(d) Hydrophilic Aggregates

Where hydrophilic or other aggregates that may cause problems are encountered, the Engineer may order that the stone chips be pre-coated, as described below, or that a fog spray be applied, as specified in SUB-CLAUSE 4403 (e).

(e) Pre-Coating**i) Pre-Coating of Aggregate for Stockpiling or for Immediate Use.**

The method to be employed for the pre-coating of chippings shall be described in the Special Specifications and be approved by the Engineer.

The wetting agent liquid antistripping agent/chemical adhesion agent approved by the Engineer shall be added to the pre-coating fluid at a rate of 0.5% of the volume of pre-coating fluid.

Base pre-coating fluid is a low viscosity bituminous based binder containing petroleum cutters. Wherever possible, the use of bitumen emulsion or diesel must be avoided as pre-coating fluid.

The mixture of aggregate and pre-coating fluid shall then be dumped on a site prepared as specified in CLAUSE 4306. This process shall be repeated until a stockpile of approximately 15 m³ to 20 m³ has been built up.

This stockpile shall then be turned over with the front-end loader until the aggregate is uniformly coated with the pre-coating fluid. At least three complete turnings of the stockpile may be required.

The time between the pre-coating and the placing of the aggregate shall not exceed the time given in the Special Specifications or agreed on by the Engineer and the Contractor. Before the aggregate is used,

the pre-coating fluids shall have set or dried sufficiently in the opinion of the Engineer.

All aggregates used with hot-applied homogeneous and non-homogeneous modified binders, shall be pre-coated.

Pre-coating stockpiles shall be covered to protect the chippings against rain and contamination.

ii) Pre-Coating Constraints

No pre-coating shall be applied where emulsion binders are used unless specifically specified or ordered by the Engineer.

4303 CONSTRUCTION EQUIPMENT**(a) General**

All construction equipment used on the Works shall be of an adequate rated capacity and in a good working condition.

All construction equipment that will be operated on the road during construction of the seal shall be free from any binder, fuel or oil leaks and no refuelling or servicing of any equipment will be allowed to take place while such equipment is on the road.

(b) Binder Distributors**i) General**

The binder distributor shall comply with all the provisions of CLAUSE 4103.

ii) Non-homogeneous Modified Binder

The binder distributor used for non-homogeneous modified binder shall be adapted to spray the rubber-modified binder satisfactorily. The Contractor shall provide proof by way of a test on the site that the binder distributor has sufficient reserve power to maintain the required constant speed up the steepest incline to which spray has to be applied, and to obtain a uniform distribution of the mix. The optimal spray-bar level shall be determined during testing, and the spray-bar level shall be adjusted accordingly before each spray. The uneven application of binder will be unacceptable. In addition to the requirements of CLAUSE 4103 the equipment shall be capable of heating the binder to 210°C.

(c) Chip Spreaders

The chip spreaders shall be capable of spreading stone of the specified size uniformly over widths varying between 2.4 m and 4 m and shall be capable of adjustment to permit variation of the rate of application within the specified tolerances, and uniform spreading in both the transverse and longitudinal directions.

At least two chip spreaders shall be provided, one of which shall be self-propelled.

Spreaders that are not self-propelled shall be of a type that can be attached quickly to the rear of trucks, and operated while backed over the stone chippings being spread.

(d) Rollers

Sufficient operational rollers of each of the following types shall be available on the Works to maintain the required tempo of work:

i) Pneumatic-Tyre Rollers

Pneumatic-Tyre rollers shall be of a self-propelled type equipped with smooth flat profile pneumatic tyres of uniform size and diameter. The mass of the roller shall not be less than 15 tonnes (unloaded).

The rollers shall be equipped with suitable devices for keeping the wheels wet and clean during operation.

The wheels of the roller shall be so spaced that one pass of the roller will provide one complete coverage equal to the rolling width of the machine.

The Engineer at their discretion may vary the total operating mass and tyre pressure. Individual tyre pressures shall not differ by more than 35 kPa from one another.

ii) Rubber-Soled Steel-Wheeled Rollers

Rubber-soled steel-wheeled rollers shall be self-propelled, and have a mass of between 6 and 8 tonnes. It shall be equipped with suitable devices for cleaning and moistening the wheels.

The wheels of the roller shall be so arranged as to give one complete coverage by one passage of the roller over a width equal to the rolling width of the roller.

iii) Steel-Wheeled Rollers

Steel-wheeled rollers shall be self-propelled three-wheel or tandem rollers of between 6 and 8 tonnes mass and shall be equipped with suitable devices for cleaning and moistening the wheels. The mass of the roller required shall be determined by the Engineer. No steel-wheeled rollers shall be used without the consent of the Engineer.

iv) Additional Requirements

The type and number of rollers shall be subject to the approval of the Engineer for each type of seal and the proposed programme.

No seal work shall continue if the required rollers are not on site or in an operational condition.

(e) Brooms

i) Drag Broom

The drag broom shall be of a size, type and mass that will enable the chips to be distributed evenly over the surface without dislodging any chips from the binder.

ii) Rotary Broom

An approved rotary broom, complete with towing vehicle fitted with smooth pneumatic tyres, shall be available at all times on the Works.

(f) Mixer for Slurry

A mobile mixer of a type approved by the Engineer shall be provided. It may be either a batch mixer or a continuous-type mixer. The paddles of the mixer shall be so designed as to ensure a complete blending of the constituents of the slurry.

For the rapid setting slurry types, the mixing and application of the slurry shall be done by a mixer designed to provide a rapid mixing time, and sufficient

agitation within the spreading system to prevent segregation or premature hardening. The mixer shall be capable of continuous mixing and application.

The purpose designed mixer for continuous type mixing of either conventional or rapid setting slurries, shall be equipped with precise metering systems to enable the various constituents to be combined continuously to the prescribed formulation.

No central mixing equipment will be allowed. Details of the type of mixer shall be submitted in advance of actual construction, for approval by the Engineer.

(g) Loader for Slurry

A loader, or equivalent capacity labour force where so required in the Special Specifications, compatible with the needs and capacity of the mixer unit shall be available at the stockpiling site.

(h) Spreader Box for Slurry

The type of spreader box used for spreading the slurry shall be submitted to the Engineer, in advance, for approval. The spreader box for rapid setting slurry shall be of a proven and approved type, fitted with a proven and approved device to ensure sufficient agitation within the spreader system.

The spreader box shall be so constructed as to distribute the weight onto metal skids in such a way that no damage shall be done to the surface when the box is in operation.

Soft rubber belting shall be attached to the framework in such a manner as to prevent slurry from being spilled past the sides of the spreader box when the box is in operation.

The spreader box shall be capable of spreading a uniform application of the slurry in adjustable widths from 1.5 m to 4 m, at specified rates, and it shall have efficient mechanical means of adjusting the rates and widths of application specified.

(i) Pre-coating Equipment

The pre-coating of chips may be done in any suitable equipment capable of uniformly coating the chips.

(j) Mass-Measuring Device

Where payment per tonne is specified, the Contractor shall keep available on the site as directed by the Engineer, a suitable gauged mass-measuring device. The device shall be provided with a printer for printing the mass, the time and the date. The printed data shall be submitted to the Engineer on a daily basis.

(k) Miscellaneous Equipment

Sufficient equipment for handling and hauling aggregate, binder and slurry, and blending units for non-homogeneous modified binders, shall be provided to ensure prompt and continuous placing and application of bituminous materials as specified. The Contractor shall have available all the necessary ancillary equipment and hand tools to carry out the work efficiently.

Suitable fire-fighting equipment for dealing with bitumen fires shall be available on site, together with suitable first aid equipment for dealing with bitumen burns. (Refer to SABITA Manual 8: Guidelines for the safe and responsible handling of bituminous products.)

The Engineer shall be entitled to request reserve equipment, should there be any doubt as to the efficiency or capability of the equipment provided.

4304 GENERAL LIMITATIONS AND REQUIREMENTS

(a) Weather Limitations

The minimum road-surface temperatures at which the spraying of the different types and grades of binder may be done are:

i) Conventional Binders:

- o Penetration grade bitumen:
- o 160/200 penetration-grade bitumen: 20°C
- o 70/100 penetration-grade bitumen: 25°C
- o Cutback grade bitumen MC800 / MC3000: 10°C
- o Bitumen emulsions: 10°C

ii) Non-Homogeneous Modified Binders:

- o Bitumen-rubber (spray application) 20°C
- o S-R1/ S-R2 Bitumen-rubber: 25°C

iii) Other Non-Homogeneous Modified Binders:

As set out in the Special Specifications.

iv) Homogeneous Cold Applied Modified Binders

SC-E1/ SC-E2 modified cationic emulsion: 10°C

v) Homogeneous Hot-Applied Modified Binders

S-E1/ S-E2 hot-applied modified binders: 25°C

vi) Other Homogeneous Hot-Applied Modified Binders

As set out in the Special Specifications.

vii) General

Whenever the temperature of the road surface falls below the aforesaid temperature for the binder in question, or, in the opinion of the Engineer, will probably fall below the required temperature before spraying the binder, no binder shall be sprayed.

No bituminous work shall be done during foggy or rainy weather, and, when a cold wind is blowing, the above temperatures shall be increased by 3°C to 6°C as directed by the Engineer.

Conventional slurry shall not be applied at an air temperature of less than 7°C when temperatures are rising, or less than 13°C when temperatures are dropping. Rapid setting slurry shall be sufficiently versatile to be laid in air temperatures of 4°C to 40°C, as well as capable of being laid under damp conditions.

During hot weather slurry operations shall be suspended when aggregate is being displaced by the spreader box or squeegees.

When the breaking process accelerates to such an extent that it renders the product unworkable to attain the required end result, for instance when the surface temperature is in excess of 60°C, or as otherwise prescribed by the Engineer, no sealing shall be done.

When strong winds are blowing which are likely to interfere with the proper execution of the work, no sealing, especially spraying of binder, shall be done.

(b) Moisture Content

No seal shall be placed unless the moisture content of the upper 50 mm of the base is less than 50% of the optimum moisture content as determined by the Engineer. No reseal shall be placed immediately after a rainy spell on an existing partly cracked and/or highly permeable surfacing resulting in the trapping of moisture in the pavement structure. A minimum delay of 24 hours or such extended period as ordered by the Engineer shall apply.

(c) Other Constraints

i. The following curing periods shall apply to the various treatments listed, prior to applying a seal/reseal unless otherwise given in the Special Specifications:

- o Texturing using fine slurries: 6 weeks
- o Rapid setting slurry (rut filling, etc.): 12 weeks
- o Crack sealing: 2 weeks
- o Repair of distressed patches: 6 weeks

ii. Unless otherwise agreed by the Engineer, and subject to the outcome of a trial section, the Contractor shall programme all spraying to cease each working day before the end of daylight.

(d) Preparation of Areas to be Sealed

i) General

The areas to be sealed shall be cleaned of all dust, dirt, dung, oil or any other foreign matter that may be deleterious to the seal.

ii) Newly Constructed Seals

Where newly constructed base or shoulder areas are to be sealed, the surfaces shall be checked for compliance with the surface tolerances and all other requirements specified. Any portions that do not meet these requirements shall first be either corrected or removed and reconstructed before they are sealed.

iii) Existing Surfaces to be Resealed

Existing roads that require resealing shall, if so specified or ordered by the Engineer, be given a pre-treatment in accordance with one or more of the methods described in SECTION 4800.

Any failures shall be repaired as set out in the Special Specifications.

(e) Demarcation of Working Area

i) New Work

The Contractor shall demarcate the area of the primed base to be sealed by means of setting out wire lines down each edge of the specified seal width.

ii) Reseal Work

Immediately before the tack coat or bituminous binder is sprayed, the centre line of the road shall be marked by a 3 mm thick sisal or hemp twine, secured by nails driven, at 15 m intervals on straights and 5 m intervals on curves, into the existing surface.

This twine shall be left in position during all subsequent operations.

4305 HEATING AND STORAGE OF BITUMINOUS BINDERS

(a) Conventional Binders

The temperature ranges between which bituminous binders are to be heated shall be as given in TABLES 4305/1 and 4305/2.

Binders stored in a heated condition shall be kept in a container with a securely fitting lid, the circulatory system of which is functioning properly.

The container shall be provided with a built-in thermometer.

Binders that have been heated above the maximum temperatures indicated in this table shall not be used and shall be removed from the site.

Every effort shall be made to maintain the binder temperature for spraying to within 5°C of the recommended temperature.

For single seals the temperature limits for 160/200 penetration-grade bitumen, cut back with the indicated amounts of kerosene in parts per 100 parts of bitumen by volume as described in SECTION 4400, shall be as set out in TABLE 4305/3.

TABLE 4305/1: MAXIMUM STORAGE TEMPERATURES, CONVENTIONAL BINDERS

Materials	Maximum storage temperature (°C)	
	Over 24 hours	Up to 24 hours
Pen. Grade Bitumens: -160/200 pen grade	115	165
-70/100 pen grade	125	175
Cut-Back Bitumen: MC-800	75	125
MC-3000	100	155
Bituminous Emulsions: 60%, to 70%	Air Temperature (all types)	60 (all types)

(b) Cutting Back Bitumen

Kerosene shall be used as the cutter where correction of viscosity is required or cutback bitumen is to be made on site from penetration grade bitumen. Allowance shall be made for quantities between 0 – 45% by volume of the total quantity hot sprayed bitumen, as directed by the Engineer. The Contractor's attention is drawn to the potential hazards involved in the cutting back operation and they shall take all necessary precautions to prevent fire.

The temperature of the bitumen shall not be higher than 140°C, when the kerosene is introduced.

TABLE 4305/2: HEATING AND SPRAYING TEMPERATURES, CONVENTIONAL BINDERS

Materials	Heating and Spraying Temperatures (°C)		
	Min	Max	Recommended
Pen. Grade Bitumens: 160/200	150	175	165
70/100	175	190	180 - 185
Cutback Bitumens: MC-800	110	135	125
MC-3000	135	155	145
Bituminous Emulsions: 60%, to 70%	Air temp. (all types)	60 (all types)	60 (all types)

The kerosene shall be sucked in measured quantities through the bitumen pump to the bottom of the tank and circulated with the bitumen for a minimum of 45 minutes. During this process all burners shall be shut off and no open flames shall be allowed near the distributor.

The power paraffin shall not be introduced into the distributor through the manhole, which shall be kept closed. Each distributor shall at all times have two fire extinguishers in good working order available.

TABLE 4305/3: TEMPERATURE LIMITS FOR CUTBACK BITUMEN

Proportion of kerosene (% of Total Volume of Mixed Binder)	Spraying Temperature	
	Lower Limit °C	Upper Limit °C
5%	140	155
10%	125	145
15%	105	125
20%	90	110

(c) Non-Homogeneous (Heterogeneous) Modified Binders

After completion of the bitumen-rubber reaction, the binder shall be cooled to below 160°C. The binder mixture may not be kept for more than 2 days. The mix may only be stored in tanks with circulation systems.

The spray and storing temperatures of the bitumen-rubber binder shall comply with the requirements given in TABLE 4305/4.

TABLE 4305/4: TEMPERATURE REQUIREMENTS FOR SEALS WITH MODIFIED BINDERS

Binder Class	Short-Term Handling		Storage		Mixing		
	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Min Temp (°C)	Max Holding Time (hrs)
S-R1	170	24	150	240	210	195	Refer Time/Viscosity curve of SABITA TG1- 5th Edition
S-R2	160	> 168	150	> 336	190	180	

Binder that has failed to meet the requirements for storage and handling shall not be used and shall be removed from the site.

(d) Other Non-Homogeneous Modified Binders

The Contractor shall comply with the requirements given in the Special Specifications with regard to the storage, heating and spraying temperatures, and with regard to the information to be provided in the bidding stage, unless otherwise approved by the Engineer.

(e) Homogeneous Cold Applied Modified

Modified bitumen emulsions may be stored at ambient temperature for long periods, provided that some circulation/mixing takes place from time to time. The spraying temperatures of these emulsions are the same as for conventional bitumen emulsions.

The spray and storing temperatures of the Polymer Modified Emulsion shall comply with the requirements given in TABLE 4305/5.

TABLE 4305/5: TYPICAL TEMPERATURE / TIME LIMITS FOR POLYMER MODIFIED EMULSIONS

Binder Class	Short-term Handling		Storage		Mixing		
	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Min Temp (°C)	Max Holding Time (hrs)
SC-E1/E2 with binder content of approximately 65% m/m	60	24	Ambient	>240	70	50	6
SC-E1/E2 with binder content of approximately 70 % m/m	60	24	Ambient	>240	80	50	6

(f) Homogeneous Hot Applied Modified Binders
The temperature limits for the storage and spraying of modified hot-applied binders shall be as set out in TABLE 4305/6 unless otherwise approved by the Engineer

Excessive temperature over extended periods will degrade all modified bitumen and negatively affect the properties of these binders.

TABLE 4305/6: TYPICAL TEMPERATURE/TIME LIMITS FOR POLYMER MODIFIED BINDER

Binder Class	Short-Term Handling		Storage		Mixing		
	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Min Temp (°C)	Max Holding Time (hrs)
S-E1 (SBS, SBR)	180	24	150	240	210	175	8
S-E1 (SBS)	180	24	150	240	185	175	12
S-E2	180	24	150	240	185	175	12

Modified binders stored in a heated condition shall be kept in a container having a properly functioning circulation system and a securely fitting lid.

Many long chain polymers have low shear stability and can be degraded by the action of a high shear rate pump such as a close tolerance gear pump. Any material damaged by handling shall not be used on the road and shall be removed from the site.

The Contractor shall comply with the requirements of the Special Specifications with regard to the storage, heating and spraying temperatures, and with regard to the information to be provided in the bidding stage, unless otherwise approved by the Engineer.

stockpiles shall be covered with tarpaulins or similar protective coverings.

During cooler periods the Engineer may order that stockpiles be covered with tarpaulins to ensure that the aggregate temperature remains compatible with the limiting temperature applicable to the specified binder type.

4306 STOCKPILING OF AGGREGATE

(a) General

Sites for the stockpiling of aggregates shall be prepared in such a manner that no grass, mud, dirt or other deleterious material will be included when the aggregates are loaded for use.

Access roads to stockpile sites shall be prepared and maintained in such a way that no dirt is conveyed by vehicle wheels onto the areas to be sealed or resealed whilst aggregate is being transported to or from the stockpiles.

Stockpiles shall be so sited that they will not be exposed to excessive contamination with dust arising from traffic on the road or access roads.

Aggregates contaminated to the extent that they contain more than the allowable percentage of material passing through the 0.425 mm sieve and 0.075 mm sieve shall not be used for sealing.

(b) Pre-Coating

Areas used for stockpiling pre-coated aggregate shall be so sited that dust deposited on the chips is prevented. Where necessary, temporary diversions and access roads in the immediate proximity shall at the Contractor's own cost be watered, sprayed with a suitable chemical dust suppressant, or sealed.

During the wet season when there is danger of the pre-coating fluid being washed off the aggregate, the

4307 CONSTRUCTIONS OF SEALS

(a) General

Adequate advance notice shall be given to the Engineer before the Contractor proceeds with any seal work.

(b) Single and Double Aggregate Seals

i) Application of binder coat and aggregate

A bituminous coat consisting of the type and grade of binder specified in these Specifications under each of the appropriate Sections for each type of bituminous seal, or in the Special Specifications, shall be sprayed on the properly cleaned and prepared base or existing surface over the full specified width of the seal.

Where the tank of the binder distributor could become empty during spraying against inclines, the spraying shall be done while the binder distributor is moving uphill. Should the Engineer be of the opinion that the Contractor is unable to place the sealant over the specified width in one movement, the Contractor shall execute the spraying and the distribution of the chips in strips. The spraying of adjacent strips shall overlap by 100 mm. Chips may not be placed on the 100 mm overlap before the adjacent strip has been sprayed. The adjacent strip may not be sprayed before the preceding strip, excluding the 100 mm overlap, has been covered satisfactorily with chips in compliance with the Specifications. Insofar as is practicable, the Contractor shall so place the strips that the joint between two adjacent chip applications shall fall on the centre line of the road.

Immediately after the binder has been sprayed, it shall be covered with clean, dry aggregate of the size given in these Specifications under each of the

appropriate Sections for each type of seal.

The actual rates of application of binder and aggregate to be used in the construction will be determined by the Engineer, after they have tested the aggregates the Contractor proposes to use for the seal and prior to any sealing being carried out.

The aggregate shall be applied uniformly by means of self-propelled chip spreaders, unless otherwise specified. In the case of single seals, the use of a self-propelled chip spreader shall be obligatory. The immediate application of the chips is of prime importance. The chip spreader shall be so operated that the tack coat shall be covered with aggregate before the wheels of the chip spreader or truck pass over the uncovered tack coat.

The quantity of bitumen sprayed in any single spray operation shall be governed by the quantity of aggregate, and the number of trucks available shall be sufficient to ensure the continuous application of stone behind the distributor. In addition, the available roller capacity at normal operating speed shall also govern the extent of the tack coat and aggregate that may be applied.

ii) Initial Rolling of Aggregate

Immediately after the aggregate has been applied, rolling shall be commenced. A self-propelled 15-tonne pneumatic-Tyre roller only shall be used in the case of single seals, and a steel-wheeled roller may also be used in the case of double seals on condition that excessive crushing of the aggregate shall not take place. Rollers shall operate parallel to the centre line of the road, from the shoulders inwards towards the crown of the road, until the entire surface has been covered at least three times with the wheels of the roller.

iii) Broom Drag and Final Rolling of Aggregate

After the bituminous binder has set-up sufficiently to prevent any aggregate from being dislodged, the surface shall be slowly dragged with a broom drag to ensure even distribution of the aggregate.

If there are areas that are deficient in stone chips, additional material shall be added by hand so as to leave a single layer of chips laying shoulder to shoulder. If there are areas with an excess of stone chips, such excess shall be removed by hand so as to leave a single layer of chips laying shoulder to shoulder.

The importance of applying only a single layer of chips is stressed. Every care shall be taken to avoid an over-application of stone.

After completing the spreading of the aggregate, the surface shall be rolled with a 15-tonne pneumatic-Tyre roller for three to four coverages.

Except in the case of single seals final rolling shall then be done with a steel-wheeled roller with a mass of 6 to 8 tonnes working parallel to the centre line of the road from the shoulders towards the crown of the road, until every portion of the surface concerned has been covered by at least two to four passes of the roller, provided that only a limited degree of crushing of the aggregate will take place, but if, in the opinion of the Engineer, general crushing occurs under the rollers, such rolling shall be stopped regardless of the number of passes completed by the roller.

The surface shall be well knit and have a uniform appearance free of roller-tyre marks; all aggregate contaminated by fuel, oil or grease shall be removed and replaced with clean aggregate.

iv) Joints Between Binder Sprays

In order to prevent overlapping at junctions of separate binder applications the previous work along the joint shall be covered with twin-reinforced building paper for a sufficient distance back from the joint to ensure that the sprayer is operating at the required rate before the untreated surface is reached, and also to prevent additional binder application onto the previously treated section. The same method shall be used to ensure a neat joint at the end of the run.

v) Protection of Kerbs, Channels, etc.

Kerbs, channels, guttering, manholes, guard rails, bridge railings and any other structures which may be soiled by bituminous binders during spraying operations shall be protected in terms of SECTION 2300 during spraying operations.

The Contractor shall replace at their own cost any items that have been soiled and cannot be cleaned entirely. The painting of soiled surfaces will not be accepted as a suitable remedy.

(c) Slurry Seals

Slurry seals shall be applied as specified in SECTION 4600.

4308 AREAS INACCESSIBLE TO MECHANICAL EQUIPMENT

Areas inaccessible to mechanical equipment shall be constructed as follows:

(a) Prime Coat/ Tack Coat

The prime/tack coat shall be applied to the area to be surfaced by hand spraying under the close supervision of an experienced person. The application of prime/tack coat shall be controlled in order to achieve a uniform application at the rate specified. The type of prime/tack coat material and the rate of application thereof shall be subject to the Engineer's approval.

Each area that is to be surfaced shall be screened off by means of fibre-reinforced paper, so that only the area to which the binder is to be applied will be exposed.

The binder shall be applied by means of a hand-spray lance which should form part of the bitumen distributor equipment complying with the requirements specified in SUB-CLAUSE 4303 (b), or by any other hand spray operation as approved by the Engineer.

(b) Binders for Surface Seals

Bituminous binders for surface seals shall be constructed by means of mechanical equipment, unless otherwise approved. Binders, and particularly bitumen-rubber binders, shall be applied using binder distributors that have been specially adjusted for accurately applying the binders in restricted areas in accordance with the specified requirements.

Hand-spray equipment may be used only with the written approval of the Engineer and then only in accordance with approved methods under the strict supervision of experienced personnel; and with equipment suitable for performing the work in accordance with the specified requirements.

(c) Aggregate Chippings

Aggregates used for surface seals in restricted areas shall be of the same size as the adjacent surfacing and shall be spread by hand. The chippings shall be rolled to the satisfaction of the Engineer with the most effective rollers that can be used in the area in question, and thereafter the excess chippings shall be removed by means of hand brooms. If a double surface treatment is required, the specified penetration spray shall be applied

and the second layer of chippings applied, rolled and broomed. Any specified fog spray of bitumen emulsion shall be applied within 48 hours

(d) Slurry

Where the surfacing layer consists of an application of aggregate with slurry, the slurry shall be applied to the surface of the layer constructed at a rate of between 0.003 and 0.004 m³/m² or as instructed by the Engineer. This shall be done at the same time as the final slurry application on the other portions of the work to obtain a uniform appearance.

(e) Bituminous Mixture

Where a premixed bituminous mixture is specified for surfacing in inaccessible areas as shown on the Drawings, or as instructed by the Engineer, a mixture shall be prepared consisting of the following components and proportions:

- 9.5mm nominal size aggregate 1 part
- 6.7mm nominal size aggregate 1 part
- Crusher sand 1 part

The aggregate and sand shall be mixed with a 60% stable-mix grade emulsion with the net quantity of bitumen between 75 and 90 l/m³ aggregate mix. The ingredients shall be mixed in a suitable concrete or other type of mixer with a suitable heating mechanism by gas flame or other means, while the mixer is rotating.

The aggregate and sand shall be placed in the mixer and heated to 100°C while mixing after which the bituminous emulsion shall be added. Mixing shall continue until the aggregate is uniformly coated with bitumen.

Prior to spreading the mixture, the surface shall be prepared by painting with one layer of bituminous emulsion which shall be allowed to dry. The mixture shall be placed in the areas to be sealed and screeded off in a layer of uniform thickness. After the emulsion has broken and the layer has attained sufficient stability, it shall be rolled with suitable compaction equipment.

The thickness of the layer shall be the same as that of the adjacent seal.

4309 RATES OF APPLICATION

Whenever the terms or quantity of bitumen, spray rate or application rate are used in these Specifications to specify the rate of application of the binder for conventional or homogeneous modified binder, they shall mean at spraying temperature.

All rates of application for seal works shall be properly designed by the Contractor and approved by the Engineer prior to any trial sections of the works.

All rates of application for seal works shall be documented daily and recorded on a spray record sheet.

All binders, aggregates, and slurry used in the various types of seals shall be applied at the rates of application as determined by the Engineer after tests on the materials proposed for use.

No payment will be made for bituminous binder applied in excess of the rate ordered unless, in the opinion of the Engineer, such overspray or any shortages can be satisfactorily corrected in the case of a first application by the adjustment of the application rate of a subsequent spray.

Unless otherwise specified, the nominal rates of application of bituminous binders given in further sections, and also the variations in application rate, shall be measured at spraying temperature.

The nominal rates of application are for bidding purposes only and will not necessarily be used in construction. The

actual rates of application to be used on the site shall in all cases be as instructed by the Engineer.

4310 DUST CONTROL

Any temporary diversions and construction roads shall be kept watered and damp, or sprayed with a suitable chemical dust suppressant, during all sealing operations and all dust shall be removed from surfaces before any binder, aggregate or slurry is applied.

The supply and application of water or chemical dust suppressants on temporary diversions will be paid for separately as specified in SECTION 1500, but payment for dust control on the haul and construction roads shall be included in the unit rates bid for the various types of seals used.

4311 OPENING TO TRAFFIC

The Engineer shall be responsible for determining when any sealing layer is to be opened to public traffic.

The road shall not be opened to traffic until the binder has set sufficiently to retain the aggregate, or in the case of slurry seals, the slurry has set sufficiently so as not to be picked up by the wheels of passing traffic.

The Contractor shall not allow any construction equipment, which is likely to cause damage, over the completed seal. The Contractor shall display speed restriction signs in accordance with Section 1500 and the instructions of the Engineer.

4312 DEFECTS

Where, in the opinion of the Engineer, any unacceptable loss of stone from, or bleeding of the road surface that occurs during the course of the Contract or during the maintenance period, and that can be attributed to the Contractor not observing any of the requirements of the Specifications, not using the correct rates of application, or to any other omission or fault on the part of the Contractor, the work shall be rejected, and any corrective work shall be at the Contractor's cost, including the supply, pre-coating, stockpiling at selected sites and later removal if not used, of any aggregate reserved for corrective work during the period of maintenance or thereafter.

The Contractor shall carry out an investigation to determine the reasons for the defective works and send a proposal on how the works should be repaired. No repair works shall be implemented prior to the Engineer's approval of the investigation of the cause of the defect and the Contractor's proposal to repair them.

4313 MAINTENANCE

The Contractor shall maintain the bituminous surface until the work is handed over to the Employer. Any damage done to the surface or any defects which may develop before the date of substantial completion shall be corrected by the Contractor at their own cost and to the requirements of the Engineer.

4314 TOLERANCES AND FINISH REQUIREMENTS

(a) Binder Spray Rates

The following terms are used for measuring binder spray rates:

i) Conventional Binders:

Conventional binders shall be measured at spraying temperature in litres per square metre.

ii) Modified Binders:

Whenever the terms "net bitumen" or "net quantity of bitumen" are used in these Specifications to specify the rate of application of the binder for

conventional or homogeneous modified binder (hot or cold), they shall mean viscosity grade (penetration-grade) bitumen net cold. Non-homogeneous modified binders, however, shall be specified at spraying temperature.

(b) Surface Tolerances, Rate of Application, Conditional Acceptance

The completed seal shall be free from corrugations or any other wave effect where depressions are preceded and followed by humps or ridges no matter how small the distance between the top of the hump to the bottom of the preceding or following depression.

The completed bituminous work shall comply with the requirements set out in SECTION 7300 regarding surface tolerances, finish and roughness as specified. The provisions of SECTION 7200 shall apply to conditional acceptance.

(c) Surface Appearance

The completed seal shall be of uniform texture without gaps or patches and shall be free from any loose aggregate or bitumen spillage.

Corrective work shall be carried out in such a manner as to blend in colour, texture and finish with adjacent work.

The completed seal should be an even mosaic of aggregates firmly held by the bitumen so that there is no stripping of the aggregates or bleeding and providing a good even skid resistant surface.

In double seal applications the aggregates should be matched to give the maximum mechanical interlock.

4315 MEASUREMENT AND PAYMENT

Measurement and payment will be made under the various sections where the different seals are described.

**SERIES 4000: BITUMINOUS LAYERS, SEALS
AND CONCRETE PAVEMENT**

**SECTION 4400: SINGLE
SURFACE DRESSINGS**

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4401 SCOPE

This Section covers the supply and furnishing of all materials for the repair of existing surfaces and for the construction of reseals, or new single seals.

The requirements of all relevant clauses of SECTION 4300 shall apply to this Section.

4402 MATERIALS

(a) Bituminous Binders

The bituminous binder shall consist of one of the following binders, whichever is specified in the Special Specifications or the Bill of Quantities or ordered by the

Engineer:

- 70/100 penetration-grade bitumen;
- 160/200 penetration-grade bitumen,
- 65% - 70% spray-grade emulsion;
- MC-3000 cut-back bitumen;
- Modified binder and emulsions as specified in CLAUSE 4302.

i) Bitumen Coats

The specified bituminous binders shall comply with the conditions of SECTION 4300.

ii) Fog Spray

Fog spray, when specified, shall be 30% or 60% spray grade emulsion of anionic or cationic type, as specified or ordered by the Engineer.

iii) Pre-Coating Fluid

Pre-coating fluid, when pre-coating of aggregate is specified, shall be bitumen emulsion, or alternative approved types, as specified or ordered by the Engineer. The pre-coating fluid shall comply with the requirements as given in SUB-CLAUSE 4302 (e)

(b) Aggregate

Aggregate for surface dressing shall consist of clean, tough, durable fragments of crushed stone free from any deleterious matter and shall comply with the requirements given in TABLES 4402/1 and 4402/2.

TABLE 4402/1: GRADING LIMITS AND REQUIREMENTS FOR CHIPPINGS

Sieves (mm):	Chipping, nominal size of aggregates, (% passing)			
	20 mm	14 mm	10 mm	7 mm
25	100			
20	85-100	100		
14	0-30	85-100	100	
10	0-5	0-30	85-100	100
6.3	-	0-5	0-30	85-100
5	-	-	0-5	0-30
2.36	-	-	-	0-5
Fines: 0.425	< 0.5	< 1.0	< 1.0	< 1.5
Dust: 0.075	< 0.3	< 0.5	< 0.3	< 1.0

TABLE 4402/2: REQUIREMENTS FOR CHIPPINGS

Aggregate Properties	Chipping, nominal size of aggregates			
	20 mm	14 mm	10 mm	7 mm
Maximum Flakiness index BS EN 933-3:2012	20	25		30
Minimum strength, TFV dry. BS EN 1097-2:2020	*) For AADT > 1000: 160 kN			
	*) For AADT < 1000: 120 kN			
Ratio dry to soaked value of TFV. BS EN 1097-2 :2020	TFVsoaked shall be minimum 75% of the corresponding TFVdry value			
Sodium Sulphate Soundness (AASHTO T 104-22)	Max 12 %			
Polished Stone Value (BS 812 or SANS Method 848)	At least 50			
The percentage of friable particles, clay lumps and other deleterious matter shall not exceed 1% as determined by AASHTO T 112-23. Content of washable particles of mineral origin, in % by mass shall not exceed 2.5% when tested with ASTM C117-17.				
*) The appropriate traffic volume that applies to any location, shall be as given in the Drawings or Special Specifications. Where such information is not given, the decision of the Engineer shall apply.				

(c) Average Least Dimension (ALD)

The ALD of the chippings shall be determined by the following method:

- A sieve analysis is first carried out on a sample of the chippings and the results are plotted on a large-scale grading curve. The median size of chipping is then determined as that theoretical sieve size through which 50 percent of the material will pass.
- The flakiness index is determined.
- Then using FIGURE 4402/1 the median size is marked on scale A and the flakiness index on scale C. A straight line is drawn between the two marks and the ALD is read off on scale B.

The ALD of the chippings when determined as described above shall meet the requirements of TABLE 4402/3.

FIGURE 4402/1: FIGURE FOR THE DETERMINATION OF THE AVERAGE LEAST DIMENSION

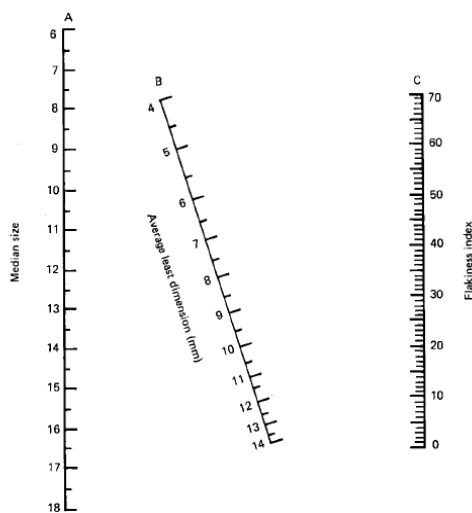


TABLE 4402/3: ALD REQUIREMENTS FOR CHIPPINGS

Nominal size of aggregate (mm)	ALD Requirement (mm)
20	11 – 15
14	8 -10
10	5 - 6.5
7	2 – 4

4403 CONSTRUCTION

(a) Preparation of the Surface

Surface treatment shall not commence until the existing surface has been repaired of any defects and cleaned to the satisfaction of the Engineer by the use of brooms, water, compressed air or any other method required to give a satisfactory result.

Kerbs, channels, guttering, manholes, guard rails, bridge railings, and any other structures that may be soiled by bituminous binders during spraying operations shall be covered with suitable plastic sheeting during spraying operations.

The sheeting shall be kept firmly in position by soil, stones or adhesive tape in such a manner that it will not lift or be blown away during windy conditions but will keep the areas to be protected fully covered.

The use of paper bags, sand or other materials will not be permitted in lieu of plastic sheeting and the Contractor shall replace at their own expense any items that have

been soiled and cannot be cleaned entirely. The painting of soiled surfaces will not be acceptable as a suitable remedy.

(b) Application of Binder and Aggregate**i) General**

The bitumen coat and aggregate, of the types and sizes specified in the Special Specifications, or ordered by the Engineer, shall be applied as specified in SUB-CLAUSE 4307 (b).

The Contractor shall demonstrate the suitability of the application rates together with construction equipment and methods by carrying out trial sections for the approval by the Engineer.

The Trial sections shall be carried out on surfaces identical to those used in the permanent works and shall include at least 3 different binder and aggregate application rates covering the range of application rates determined according to both publications mentioned above. Each combination of application rates shall be spread over a trial length of minimum 25 m.

Chip spreaders shall be checked and calibrated before starting any trial or permanent work and further when required by the Engineer.

ii) Nominal Rates of Application

The nominal rates given are for information only. The application rates for which payment is calculated, are given in the Bill of Quantities. If, however, no application rates are given in the Bill of Quantities, then the rates in TABLE 4403/1 shall be used for bidding purposes.

TABLE 4403/1: NOMINAL RATES OF BINDER AND AGGREGATE APPLICATION, SINGLE SURFACE DRESSING

Nominal size of aggregate (mm)	Nominal rates of application	
	Binder hot spray rate (l/m ²)	Aggregate spread rate (kg/m ²)
20	1.80	19
14	1.50	14
10	1.10	11
7	0.80	7

iii) Actual Rates of Application

The actual rates of application for use on site on any part of the Works, shall be as determined on site, on approval of the Engineer.

The difference in actual rates of application compared to the rates for bidding purposes are paid for separately in variation rates measured in tonnes and litres (hot sprayed) for aggregate and binder respectively, as specified in CLAUSE 4404.

Mechanical Brooming of chippings after spreading to effect redistribution will not be permitted. Any excess of chippings shall be removed by hand and any insufficiently chipped area shall be chipped by hand to obtain adequate coverage.

(c) Initial Rolling

Initial rolling shall be carried out as specified in SUB-CLAUSE 4307 (b).

The main rolling shall be carried out with self-propelled pneumatic-tyre rollers having a wheel load of more than 2 tonnes.

The tyres shall be smooth and the tyre pressure shall be minimum 0.4 N/mm². The number and capacity of rollers shall be sufficient to ensure that rolling does not lag behind spreading. As a minimum 2 pneumatic rollers

shall be used for each chip spreader.

Rolling shall begin immediately after the chippings have been spread and, in no case, later than 2 minutes after the application of the binder. Rolling shall continue until all chippings are firmly embedded into the binder.

The number of passes shall be as agreed with the Engineer, but as a rule, all chippings shall receive at least six passes of the pneumatic tyre roller on the first day. Excessive rolling resulting in the crushing of chippings shall be avoided.

The roller speed shall not exceed 8 km/hr, unless otherwise agreed with the Engineer.

The road shall not be opened to traffic until the binder has attained sufficient viscosity to prevent the chippings from being whipped off.

(d) Final Rolling

Any areas deficient in aggregate shall have additional material added so as to leave the carpet with a single layer of chippings laying shoulder to shoulder. It is essential to ensure that only one layer of chippings is applied and every care shall be taken to avoid over-application of chippings.

The final rolling shall be done with a pneumatic-tyre or a rubber-soled steel-wheeled roller only, applying a minimum of four coverages.

The finished surface shall be well-knit and have a uniform appearance free of roller-tyre marks. All aggregate contaminated by oil, fuel or grease shall be removed and dumped in an approved waste site and replaced by clean aggregate. All loose aggregate shall be broomed off the surface with a rotary broom or hard brooms as directed by the Engineer.

(e) Fog Spray

If stated in the Special Specifications, or if so directed by the Engineer, a fog spray of 60% or 30% anionic or cationic emulsion shall be applied to the surface of the aggregate by means of a pressure distributor at the required rate.

(f) Blinding

If stated in the Special Specifications, or if so directed by the Engineer, a light blinding layer of natural or crusher sand shall be applied by the Contractor to prevent chippings from being picked up by traffic. The blinding layer shall be spread evenly over the full indicated surface. Should it be required by the Engineer, the layer shall be spread evenly by means of hand brooms.

(g) Pre-Coating of Aggregate

If stated in the Special Specifications, the aggregate shall be pre-coated with a pre-coating fluid as specified in SUB-CLAUSE 4302 (e).

(h) Protection of the New Surface

Vehicle speed shall be restricted to a maximum of 30 km/hr until there is sufficient adhesion to ensure that chippings will not be dislodged by fast moving vehicles.

4404 MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
44.01	SINGLE (INDICATE TYPE OF BINDER AND HOT SPRAYED APPLICATION RATE IN LITRES PER SQUARE METRE):	
(a)	USING 7 mm AGGREGATE	SQUARE METRE (m ²)
(b)	USING 10 mm AGGREGATE	SQUARE METRE (m ²)

	<u>ITEM</u>	<u>UNIT</u>
(c)	USING 14 mm AGGREGATE	SQUARE METRE (m ²)
(d)	USING 20 mm AGGREGATE	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of completed and accepted seal.

The bid rates shall include full compensation for furnishing all materials, marking the centre or reference lines, spraying of binder, spreading of aggregate, rolling and all other incidentals necessary for completing the work as specified.

	<u>ITEM</u>	<u>UNIT</u>
44.02	SINGLE SEALS. BITUMINOUS BINDER VARIATIONS:	LITRES (l)
(a)	160/200 PENETRATION GRADE BITUMEN	LITRES (l)
(b)	70/100 PENETRATION GRADE BITUMEN	LITRES (l)
(c)	MC3000 CUTBACK BITUMEN	LITRES (l)
(d)	BITUMEN EMULSION (STATE TYPE AND COMPOSITION)	LITRES (l)
(e)	PRE-COATING FLUID (STATE TYPE)	LITRES (l)
(f)	OTHER TYPES OF MODIFIED BITUMEN/ EMULSION (STATE TYPE AND COMPOSITION)	LITRES (l)

The unit of measurement of bituminous binder in respect of an increase or a decrease in the specified rates of application shall be the litres measured at spraying temperature.

Payment for variations shall be made as specified in CLAUSE 1212.

	<u>ITEM</u>	<u>UNIT</u>
44.03	SINGLE SEALS. AGGREGATE VARIATIONS:	
(a)	USING 7 mm AGGREGATE	TONNE
(b)	USING 10 mm AGGREGATE	TONNE
(c)	USING 14 mm AGGREGATE	TONNE
(d)	USING 20 mm AGGREGATE	TONNE
(e)	USING SAND	TONNE

The unit of measurement shall be the tonne of increased or decreased aggregate applied, as compared to the amounts required at the specified nominal rate of application.

Payment for variations shall be made as specified in CLAUSE 1212.

	<u>ITEM</u>	<u>UNIT</u>
44.04	APPLICATION OF FOG SPRAY:	
(a)	USING 60% SPRAY-GRADE EMULSION	LITRE (l)
(b)	USING 30% SPRAY-GRADE EMULSION	LITRE (l)

The unit of measurement shall be the litre of emulsion sprayed as specified and measured at the spraying temperature.

The bid rate shall include full compensation for furnishing the material and applying the fog spray as specified.

<u>ITEM</u>	<u>UNIT</u>
44.05 PRE-COATING THE AGGREGATE (INDICATE TYPE OF PRE-COATING FLUID AND RATE OF APPLICATION IN LITRES PER TONNE OF AGGREGATE)	TONNE

The unit of measurement for the pre-coating of aggregate shall be the tonne of aggregate so treated and used on the surfacing in quantities according to drawings or as instructed by the Engineer.

The bid rate shall include full compensation for furnishing the equipment and pre-coating fluid and pre-coating the aggregate as specified, including the handling, stockpiling and protecting of the stockpiles against inclement weather.

<u>ITEM</u>	<u>UNIT</u>
44.06 ADDITION OF APPROVED WETTING AGENT TO THE BINDER (STATE TYPE AND NOMINAL APPLICATION RATE PERCENT OF BINDER):	KILOGRAMS (kg)

The bid rate shall include full compensation for providing, handling the material, storing and introducing it into the mix, including any equipment required, for the work.

<u>ITEM</u>	<u>UNIT</u>
44.07 AGGREGATE FOR BLINDING:	
(a) NATURAL SAND	TONNE
(b) CRUSHER SAND	TONNE

The unit of measurement shall be the tonne of sand according to drawings or as instructed by the Engineer.

The bid rate shall include full compensation for providing the material and applying the blinding coat complete as specified, and, should it be required, stockpiling the sand at an approved locality.

SERIES 4000: BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

SECTION 4500: DOUBLE SURFACE DRESSINGS

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4501 SCOPE

This section covers the supply and furnishing of all materials for the construction of a bituminous double seal for resealing or new construction. The seal shall be constructed using different sizes of aggregates, whichever is shown in the Bill of Quantities.

The requirements of all relevant clauses of SECTION 4300 shall apply to this SECTION.

4502 MATERIALS

(a) Bituminous Binders

The bituminous binder shall consist of one of the following binders, whichever is specified in the Special

Specifications or the Bill of Quantities or ordered by the Engineer:

- 70/100 penetration-grade bitumen;
- 160/200 penetration-grade bitumen,
- 65% - 70% spray-grade emulsion;
- MC-3000 cut-back bitumen;
- Modified binder and emulsions as specified in CLAUSE 4302.

i) Bitumen Coats

The specified bituminous binders shall comply with the conditions of SECTION 4300.

ii) Fog Spray

Fog spray, when specified, shall be 30% or 60% spray grade emulsion of anionic or cationic type, as specified or ordered by the Engineer.

iii) Pre-Coating Fluid

Pre coating fluid, when pre-coating of aggregate is specified, shall be bitumen emulsion, or alternative approved types, as specified or ordered by the Engineer. The pre-coating fluid shall comply with the requirements as given in SUB-CLAUSE 4302 (e)

(b) Aggregate

Aggregate for surface dressing shall consist of clean, tough, durable fragments of crushed stone free from any deleterious matter and shall comply with the requirements given in TABLES 4502/1 and 4502/2.

TABLE 4502/1: GRADING LIMITS AND REQUIREMENTS FOR CHIPPINGS

Sieves (mm):	Chipping, nominal size of aggregates, (% passing)			
	20 mm	14 mm	10 mm	7 mm
25	100			
20	85-100	100		
14	0-30	85-100	100	
10	0-5	0-30	85-100	100
6.3	-	0-5	0-30	85-100
5	-	-	0-5	0-30
2.36	-	-	-	0-5
Fines: 0.425	< 0.5	< 1.0	< 1.0	< 1.5
Dust: 0.075	< 0.3	< 0.5	< 0.3	< 1.0

TABLE 4502/2: REQUIREMENTS FOR CHIPPINGS

Aggregate Properties	Chipping, Nominal Size Of Aggregates			
	20 mm	14 mm	10 mm	7 mm
Maximum Flakiness Index (%) BS EN 933-3:2012	20	25		30
Minimum Strength, TFV dry (kN) BS EN 1097-2:2020	*) For AADT ≥ 1000: 160			
	*) For AADT < 1000: 120			
Ratio Dry to Soaked Value of TFV (%) BS EN 1097-2:2020	TFV _{soaked} shall be minimum 75 of the corresponding TFV _{dry} value			
Sodium Sulphate Soundness (%) (AASHTO T 104-22)	Max 12 %			
Polished Stone Value (%) (BS 812 or SANS Method 848)	At least 50			
The percentage of friable particles, clay lumps and other deleterious matter shall not exceed 1% as determined by AASHTO T 112-23. Content of washable particles of mineral origin, in % by mass shall not exceed 2.5% when tested with ASTM C117-17.				
*) The appropriate traffic volume that applies to any location, shall be as given in the Drawings or Special Specifications. Where such information is not given, the decision of the Engineer shall apply				

(c) Average Least Dimension (ALD)

The ALD of the chippings shall be tested by the following method:

- A sieve analysis is first carried out on a sample of the chippings and the results are plotted on a large-scale grading curve. The median size of chipping is then determined as that theoretical sieve size through which 50 percent of the material will pass.
- The flakiness index is determined.
- Then using FIGURE 4502/1 the median size is marked on scale A and the flakiness index on scale C. A straight line is drawn between the two marks and the Average Least Dimension is read off on scale B.

The ALD of the chippings when tested as described above shall meet the requirements of TABLE 4502/3.

FIGURE 4502/1: FIGURE FOR THE DETERMINATION OF THE AVERAGE LEAST DIMENSION

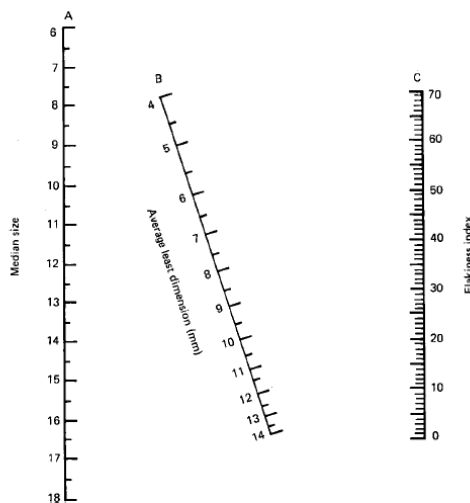


TABLE 4502/3: ALD REQUIREMENTS FOR CHIPPINGS

Nominal Size of Aggregate (mm)	ALD Requirement (mm)
20	11 - 15
14	8 - 10
10	5 - 6.5
7	2 - 4

4503 CONSTRUCTION

(a) Preparation of the Surface

Surface treatment shall not commence until the existing surface has been repaired of any defects and cleaned to the satisfaction of the Engineer by the use of brooms, water, compressed air or any other method required to give a satisfactory result.

Kerbs, channels, guttering, manholes, guard rails, bridge railings, and any other structures that may be soiled by bituminous binders during spraying operations shall be covered with suitable plastic sheeting during spraying operations.

The sheeting shall be kept firmly in position by soil, stones or adhesive tape in such a manner that it will not lift or be blown away during windy conditions but will keep the areas to be protected fully covered.

The use of paper bags, sand or other materials will not

be permitted in lieu of plastic sheeting and the Contractor shall replace at their own expense any items that have been soiled and cannot be cleaned entirely. The painting of soiled surfaces will not be acceptable as a suitable remedy.

(b) Nominal Rates of Application of Binder and Aggregate

The bitumen coat and aggregate, of the types and sizes given in the Special Specifications, or ordered by the Engineer, shall be applied as specified in SUB-CLAUSE 4307 (b).

The Contractor shall demonstrate the suitability of the application rates together with construction equipment and methods by carrying out trial sections for the approval by the Engineer.

The trial sections shall be carried out on surfaces identical to those used in the permanent works and shall include at least 3 different binder and aggregate application rates covering the range of application rates determined according to both publications mentioned above. Each combination of application rates shall be spread over a trial length of minimum 25 m.

Chip spreaders shall be checked and calibrated before starting any trial or permanent work and further when required by the Engineer.

Nominal rates of application of binder and aggregate are given in TABLES 4503/1 and 4503/2. The given nominal rates of application of binder and aggregate are for information only. The application rates for which payment shall be calculated, are given in the Bill of Quantities. If, however, no application rates are given in the Bill of Quantities, then the rates in TABLES 4503/1 and 4503/2 shall be used for bidding purposes.

(c) Actual Rates of Application of Binder and Aggregate

The actual rates of application for use on site on any part of the Works, shall be as determined on site, on approval of the Engineer. The difference in actual rates of application compared to the rates for bidding purposes are paid for separately in variation rates measured in tonnes and litres (hot sprayed) for aggregate and binder respectively, as specified in CLAUSE 4504.

Brooming of chippings after spreading to effect redistribution will not be permitted. Any excess of chippings shall be removed by hand and any insufficiently chipped area shall be chipped by hand to obtain adequate coverage.

(d) First Layer of Double Surface Dressings**i) Nominal Rates of Binder and Aggregate**

The nominal rates of binder and aggregate shall be as given in TABLE 4503/1 for the first layer of double surface dressings.

TABLE 4503/1: FIRST LAYER OF DOUBLE SURFACE DRESSINGS. NOMINAL RATES OF BINDER AND AGGREGATE APPLICATION

Nominal size of aggregate (mm)	Nominal rates of application			
	Binder, hot bitumen (l/ m ²)			Aggregate (kg/m ²)
	AADT			
	<200	200 - 1000	>1000	
20	1.8	1.5	1.2	19
14	1.4	1.1	1.0	14

ii) Rolling

Initial rolling shall be carried out as specified in SUB-

CLAUSE 4307 (b). Any areas deficient in aggregate shall have additional material added so as to leave the carpet with a single layer of chippings laying shoulder to shoulder.

It is essential to ensure that only one layer of chippings is applied and every care shall be taken to avoid over-application of chippings.

(e) Second Layer of Double Surface Dressings

i) Nominal Rates of Binder and Aggregate

The bituminous binder specified by the Engineer shall be applied and followed by the second layer of aggregate of the size specified in the Special Specifications or as ordered by the Engineer.

The nominal rates of binder and aggregate shall be as given in TABLE 4503/2 for the second layer of double surface dressings.

The second application of binder shall preferably take place within 48 hours of the application of the first coat when penetration grade bitumen is used for the first coat and not less than ten days of the application of the first coat when cutback bitumen is used in the first coat.

TABLE 4503/2: SECOND LAYER OF DOUBLE SURFACE DRESSINGS. NOMINAL RATES OF BINDER AND AGGREGATE APPLICATION

Nominal size of aggregate (mm)	Nominal rates of application			Aggregate (kg/m ²)
	Binder, hot bitumen (l/ m ²)			
	AADT			
	<200	200 - 1000	>1000	
10	1.2	1.0	0.9	11
7	0.9	0.8	0.7	7

(f) Fog Spray Applied to First Layer

If specified in the Special Specifications, or if so directed by the Engineer, a fog spray of 60% or 30% anionic or cationic emulsion shall be applied to the surface of the first layer of aggregate by means of a pressure distributor at the required rate.

(g) Blinding

If specified in the Special Specifications, or if so directed by the Engineer, a light blinding layer of natural or crusher sand shall be applied by the Contractor to prevent chippings from being picked up by traffic.

The blinding layer shall be spread evenly over the full indicated surface. Should it be required by the Engineer, the layer shall be spread evenly by means of hand brooms.

(h) Initial Rolling of Second Layer

Initial rolling of the second layer of aggregate shall be carried out as specified in SUB-CLAUSE 4307 (b). The final rolling shall be done with a pneumatic-tyre or a rubber-soled steel-wheeled roller only, applying a minimum of four coverages.

The finished surface shall be well-knit and have a uniform appearance free of roller-tyre marks. All aggregate contaminated by oil, fuel or grease shall be removed and dumped in an approved waste site and replaced by clean aggregate.

All loose aggregate shall be broomed off the surface with a rotary broom or hard brooms as directed by the Engineer.

The main rolling shall be carried out with self-propelled pneumatic-tyre rollers having a wheel load of more than 2 tonnes.

The tyres shall be smooth and the tyre pressure shall be minimum 0.4 N/mm². The number and capacity of rollers shall be sufficient to ensure that rolling does not lag behind spreading. As a minimum 2 pneumatic rollers shall be used for each chip spreader.

Rolling shall begin immediately after the chippings have been spread and, in no case, later than 2 minutes after the application of the binder. Rolling shall continue until all chippings are firmly embedded into the binder.

The number of passes shall be as agreed with the Engineer, but as a rule all chippings shall receive at least six passes of the pneumatic tyre roller. Excessive rolling resulting in the crushing of chippings shall be avoided.

The roller speed shall not exceed 8 km/hr, unless otherwise agreed with the Engineer.

The road shall not be opened to traffic until the binder has attained sufficient viscosity to prevent the chippings from being whipped off.

(i) Broom Drag and Final Rolling of Second Layer
Dragging and final rolling of the second layer of aggregate shall be carried out as specified in SUB-CLAUSE 4307 (b).

Mechanical Brooming of chippings after spreading, to effect redistribution will not be permitted. Any excess of chippings shall be removed by hand and any insufficiently chipped area shall be chipped by hand to obtain adequate coverage.

The road shall not be opened to traffic until the binder has attained sufficient viscosity to prevent the chipping from being whipped off. Vehicle speed shall be restricted to a maximum of 30 km/hr until there is sufficient adhesion to ensure that chippings will not be dislodged by fast moving vehicles.

(j) Fog Spray Applied to Second Layer

When required by the Special Specifications or if so directed by the Engineer in writing, a fog spray of 30% or 60% bitumen emulsion shall be applied to the surface of the second layer of aggregate by means of a pressure sprayer at the rate of application specified by the Engineer.

(k) Pre-Coating of Aggregate

If stated in the Special Specifications, the aggregate shall be pre-coated with a pre-coating fluid as specified in SUB-CLAUSE 4302 (e).

(l) Protection of the New Surface

Vehicle speed shall be restricted to a maximum of 30 km/hr until there is sufficient adhesion to ensure that chippings will not be dislodged by fast moving vehicles.

4504 MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
45.01	DOUBLE SURFACE DRESSING USING:	
(a)	20 mm AND 10 mm AGGREGATE IN 1 ST AND 2 ND LAYER RESPECTIVELY (STATE TYPE OF BINDER AND HOT BINDER APPLICATION RATE FOR EACH LAYER IN LITRES PER SQUARE METRE)	SQUARE METRE (m ²)
(b)	14 mm AND 7 mm AGGREGATE IN 1 ST AND 2 ND LAYER RESPECTIVELY (STATE TYPE OF BINDER AND HOT BINDER APPLICATION RATE FOR EACH LAYER IN LITRES PER SQUARE METRE)	SQUARE METRE (m ²)

The quantity of bituminous binder and the quantity of aggregates specified to be applied including agreed variation in application shall be determined in accordance BS 1707:2018 or equivalent as guided by the Engineer.

The unit of measurement shall be the square metre of completed and accepted surface treatment.

The bid rate shall include full compensation for furnishing all materials, marking the centre line or reference lines, spraying of binder, spreading of aggregate, rolling, removing of dust or deleterious material, supplying of water and spraying of haul roads and construction roads, trimming the edges of the completed surface, and all other incidentals necessary for completing the work as specified, except the application of a fog spray and pre-coating of aggregate, which shall be paid for separately.

	<u>ITEM</u>	<u>UNIT</u>
45.02	BITUMINOUS BINDER VARIATION:	
(a)	160/200 PENETRATION GRADE BITUMEN	LITRES (l)
(b)	70/100 PENETRATION GRADE BITUMEN	LITRES (l)
(c)	MC3000 CUTBACK BITUMEN	LITRES (l)
(d)	BITUMEN EMULSION (STATE TYPE AND COMPOSITION)	LITRES (l)
(e)	PRE-COATING FLUID (STATE TYPE)	LITRES (l)
(f)	OTHER TYPES OF MODIFIED BITUMEN/ EMULSION (STATE TYPE AND COMPOSITION)	LITRES (l)

The unit of measurement of bituminous binder in respect of variations in the specified rates of application shall be a litre, measured at spraying temperature.

Payment for variations shall be made as specified in CLAUSE 1212.

	<u>ITEM</u>	<u>UNIT</u>
45.03	AGGREGATE VARIATION:	
(a)	20 mm NOMINAL SIZE AGGREGATE	TONNE
(b)	14 mm NOMINAL SIZE AGGREGATE	TONNE
(c)	10 mm NOMINAL SIZE AGGREGATE	TONNE
(d)	7 mm NOMINAL SIZE AGGREGATE	TONNE

The unit of measurement with respect to variations in application of aggregate shall be the tonne of aggregate specified on site by the Engineer minus the tonne of aggregate calculated from application rates given in TABLES 4503/1 and 4503/2 and already paid for in ITEM

45.01.

Payment for variations shall be made as specified in CLAUSE 1212.

	<u>ITEM</u>	<u>UNIT</u>
45.04	APPLICATION OF FOG SPRAY CONSISTING OF BITUMEN EMULSION (STATE TYPE AND PERCENTAGE BITUMEN CONTENT IN THE EMULSION)	LITRES (l)

The unit of measurement shall be the litre of emulsion sprayed as specified and measured at the application temperature.

The bid rate per litre of emulsion shall include full compensation for procuring and furnishing the binder and applying the fog spray as specified.

	<u>ITEM</u>	<u>UNIT</u>
45.05	PRE-COATING SECOND APPLICATION OF AGGREGATE (STATE TYPE OF PRE-COATING FLUID AND APPLICATION RATE IN LITRES PER TONNE)	TONNE

The unit of measurement for the pre-coating of aggregate shall be the tonne of aggregate so treated and used on the surfacing at the specified application rates according to drawings or as directed by the Engineer.

The bid rate shall include full compensation for furnishing the equipment and materials and pre-coating the aggregate as specified, including the handling, Stockpiling and protecting the stockpiles against inclement weather.

	<u>ITEM</u>	<u>UNIT</u>
45.06	ADDITION OF APPROVED WETTING AGENT TO THE BINDER (STATE TYPE AND NOMINAL APPLICATION RATE PERCENT OF BINDER):	KILOGRAMS (kg)

The bid rate shall include full compensation for providing, handling the material, storing and introducing it into the mix, including any equipment required, for the work.

	<u>ITEM</u>	<u>UNIT</u>
45.07	AGGREGATE FOR BLINDING:	
(a)	NATURAL SAND	TONNE
(b)	CRUSHER SAND	TONNE

The unit of measurement shall be the tonne of sand according to drawings or as instructed by the Engineer.

The bid rate shall include full compensation for providing the material and applying the blinding coat complete as specified, and, should it be required, stockpiling the sand at an approved locality.

SERIES 4000: BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

SECTION 4600: OTTA SEALS, SAND SEALS, SLURRY AND CAPE SEAL

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4601 SCOPE

This SECTION covers the supply and application of all materials used for constructing Otta Seals, Sand Seals Slurry Seals and Cape Seal. The requirements of all relevant clauses of SECTION 4300 shall apply to this Section.

This Section covers the construction of a seal consisting of the application of a tack coat, spreading of 20 mm or 14 mm aggregate, a further application of bituminous binder coat and the application of the slurry in one or two coats.

4602 MATERIALS

(a) Cape Seal Construction and After Construction

This section covers the supply and furnishing of all materials for the construction of a bituminous cape seal for resealing or new construction. The cape seal shall be constructed by combination of a single chip seal followed by a slurry seal on top. The cape seal shall consist of a single 14 mm or 20 mm chip seal penetrated with a binder and covered with a slurry seal. If 20 mm aggregate is used, the slurry seal shall be applied in two layers.

i) Binders

The bituminous binders shall consist of one of the binders stipulated in CLAUSE 4502, 4302, or whichever is specified in the Special Specifications or the Bills of Quantities or instructed by the Engineer. Binder applications shall be split into two as tack coat and penetration coat.

ii) Aggregates

The quality of aggregate shall conform to TABLE 4502/1 and TABLE 4502/2. The selection of size of aggregate shall depend on the traffic using the road and, on the texture, required for appropriate skid resistance.

For : <10,000 elv/lane/day 14mm;
>10,000 elv/lane/day 20mm; and
elv is equivalent light vehicles and 1 heavy vehicle is equal 40 light

vehicles.

(b) Binder

For sand seals, slurry seals and Tack Coat for Cape Seal the following grades of binder shall be used as set out in the Special Specifications or the Bill of Quantities or as ordered by the Engineer:

- MC-800 cut-back bitumen
- MC-3000 cut-back bitumen
- 60%, 65%, or 70% spray-grade emulsion
- Modified binder and emulsions as specified in SECTION 4202 and 4302.

For the construction of Otta seal surfacing and Single Otta seal with sand capping and emulsion based Otta seals, bituminous binders shall comply with the requirements of SECTIONS 4200 and 4300 for asphalt surfacing and seals respectively.

Otta seal should be constructed using soft binders and binders that take a long time to harden producing better performing Otta seal surfacing. Soft penetration grade cutback binders are recommended in TABLE 4602/1.

TABLE 4602/1: TYPES OF BINDERS FOR OTTA SEAL SURFACING

AADT at Time of Construction	Type of Bitumen		
	Open Grading	Medium Grading	Dense Grading
>1000	N/A	150/200 pen grade	MC3000 MC800
100-1000	150/200 pen grade	150/200 pen grade	MC3000 MC800
<100	150/200 pen grade	MC 3000	MC 800

The second application of binder in case of Cape Seal shall consist of either 30% or 60% spray-grade emulsion, whichever is specified in the Project Specifications or the Schedule of Quantities or as ordered by the Engineer.

The binder used for slurry shall be an anionic stable-grade emulsion (60% bitumen).

(c) Aggregate

i) Sand seal

The aggregate for sand seal shall be crusher dust clean river sand free from lumps of clay or any other deleterious matter. The grading shall conform to TABLE 4602/2.

TABLE 4602/2: GRADING LIMITS FOR SAND SEAL

Sieve Size (mm)	Percentage Passing Sieve (% by mass)	
	Natural River Sand	Crusher Dust
10	100	100
5	85 – 100	85 – 100
1.18	20 – 60	20 – 80
0.425	0 – 30	-
0.300	0 – 15	-
0.150	0 – 5	0 - 30

The sand shall be screened or washed as required to ensure compliance with the Specifications.

ii) Slurry Seal

The aggregate for slurry seal shall be approved crusher sand obtained from a parent rock having a TFCV value of not less than 110 kN or a mixture of

such crusher sand and an approved clean natural sand, where the mixture does not contain more than 25% of natural sand. The aggregate shall be clean, tough, durable, angular in shape, and shall comply with the grading requirements given in TABLE 4602/3.

TABLE 4602/3: GRADING LIMITS FOR SLURRY SEALS

Sieve Size (mm)	Percentage Passing Sieve (% by mass)	
	Fine Type	Coarse Type
10		100
5	100	85-100
2	90-100	50-90
1.18	60-90	32-70
0.425	32-60	20-44
0.150	10-27	7-20
0.075	4-12	2-8

iii) Otta Seal

The aggregate for Otta seal surfacing shall be graded crushed stone or graded natural aggregate obtained through sieving of natural gravels.

The aggregate shall be free from contamination with organic materials, clays, salts, mud and other deleterious materials which may affect the bonding with the binders. The aggregate can be fine grained or coarse and this is defined by the nominal maximum sizes. The coarse grained Otta seal has aggregate with a nominal maximum size of 19 mm and the fine grained Otta seal has aggregate with a nominal maximum size of 14 mm.

Otta seal with a fine aggregate cure more easily and should be used in the case where traffic is low.

The decomposed aggregate will get crushed during rolling or under the action of traffic. The grading specifications for the aggregate should be carried out using AASHTO sieves are given in TABLE 4602/3 AND 4602/4.

TABLE 4602/4: GRADING LIMITS FOR OTTA SEAL AGGREGATE

AASHTO Sieve size (mm)	Overall Requirement	Open Grading	Medium Grading	Fine Grained
		AADT < 100	100 < AADT < 1000	LVRs
	% Passing			
25	100	100	100	
19	100	100	100	
16	80-100	80-100	84-100	100
13.2	52-100	52-82	68-94	55-100
9.5	36-98	36-58	44-73	33-70
6.7	20-80	20-40	29-54	20-52
4.7	10-70	10-30	19-42	12-40
2.0	0-48	0-8	3-18	5-25
1.18	0-38	0-5	1-14	2-18
0.425	0-25	0-2	0-6	1-15
0.075	0-10	0-1	0-2	0-13

TABLE 4602/5: PROPERTIES OF OTTA SEAL AGGREGATE

Test	Requirement
Los Angeles Abrasion	Max 35%
Sodium Sulphate Soundness	Max 10%
Magnesium Sulphate Soundness	Max 12%
Flakiness Index	Max 30%
Wet and dry strength ratio	Min 60%
Water Absorption	Max 1%

Unless guided by the Special Specifications or

directed by the Engineer the aggregate shall be sieved through a 20 mm sieve to remove the oversize aggregate and through a 5 mm sieve to remove the fines.

The content of fines passing a 0.075 mm sieve should not exceed 10% by mass under normal circumstances or 13 % by mass where the gravel has high silt content and no better material can be obtained. The ACV or TFC tests give an indication of this and should not be greater than 30 or 80kN respectively.

Aggregates with weathered surfaces tend to roll inside the binder coating and should be avoided. When used for Otta seal a sand seal capping should always be applied on top of the Otta seal surfacing to prevent this phenomenon from occurring in order to increase durability of the Otta seal surfacing

4603 SAND SEAL CONSTRUCTION AND AFTER CARE

(a) Equipment

The following equipment shall be readily available on the site:

- Pneumatic-Tyre Rollers;
- A Rotary Broom;
- A Drag Broom; and
- Mechanical Aggregate Spreaders if spreading by hand is not used.

(b) Preparation of Surface Before Application of Seal

The road shall be cleaned of all loose or deleterious material to the satisfaction of the Engineer before the sand seal is applied.

The surface of the base shall be watered, rolled and swept until a smooth fine texture has been achieved. The base course shall then be primed in accordance with the provisions of SECTION 4100, or as instructed by the Engineer.

(c) Binder Application Rate for Sand Seal

The nominal rate of application of binder for bidding purposes shall be 1.2 litres per square metre of MC 3000 cutback bitumen measured at spraying temperature. The exact spray rate shall be determined on site on approval of the Engineer.

(d) Application of Sand Seal

i) General

Granular base courses of non-calcareous materials do not normally require a prime, unless otherwise directed by the Engineer. Base courses of calcrete or coral material shall always be primed.

ii) Application of surfacing

The binders, of the type and grade required, and the aggregates, of the size specified in the Bill of Quantities or ordered by the Engineer, shall be applied in accordance with the provisions of SECTION 4300.

iii) Rolling

Rolling shall begin immediately after the aggregate has been spread after the application of the binder. Rolling shall continue until all aggregate is firmly embedded into the binder.

The rolling shall be carried out with self-propelled pneumatic tyre rollers having a wheel load of more than 2 tonnes. The tyres shall be smooth and the tyre pressure shall be minimum 0.4 N/mm².

The number and capacity of rollers shall be

sufficient to ensure that rolling does not lag behind the spreading of aggregate. A minimum of two pneumatic tyre rollers shall be used for the rolling operations.

The number of passes shall be as agreed with the Engineer, but as a rule, all aggregates shall receive at least six passes of the pneumatic tyre roller.

The roller speed shall not exceed 8 km/hr, unless otherwise agreed with the Engineer.

iv) Subsequent Trafficking

The road should be opened to traffic immediately after the sealing operations are completed, but a maximum speed limit of 50 km/h should be enforced during the initial period after construction. The Engineer may direct even trafficking of the sealed area and channelling of the traffic may be required for certain periods. Aggregate that has been dislodged by traffic during the immediate post construction period shall be broomed back into the exposed areas, as directed by the Engineer.

v) Aftercare

After 2 - 3 weeks of trafficking the excess aggregate shall be swept off the road surface. If natural gravel is used with a fairly high content of fines, the period may be extended to 6 weeks or as directed by the Engineer.

4604 SLURRY CONSTRUCTION AND AFTER CARE

(a) Condition of Surface

The surface shall be cleaned to remove all dust, mud, leaves, etc., and shall have a uniform closely knit appearance, with edges trimmed correctly to the specified width.

(b) Composition of Slurry

The slurry shall consist of a mix of the grade of slurry aggregate ordered by the Engineer and specified in SUB-CLAUSE 4302 (b) together with a 60% stable-grade emulsion, filler and water in the proportions as directed by the Engineer. The following proportions shall apply for bidding purposes only:

- Slurry aggregate (saturated volume): 1 m³
- Stable-grade emulsion: 260 litres
- Cement: 0.01 m³
- Water (as directed by the Engineer): approximately 235 litres

If specified in the Special Specifications, the composition of the slurry shall be based on the following mass proportions for bidding purposes:

- Slurry aggregate (dry 100)
- Stable-grade emulsion 20
- Cement 1-15
- Water +15

The saturated volume of slurry shall be determined by applying a correction for bulking of moist aggregate.

(c) Mixing of Slurry

i) General

A mixer of a type approved by the Engineer shall be provided in a good working order capable of producing a uniform slurry of the constituent materials. It may either be a batch mixer or a continuous-type mixer. Hand mixing may be used if the result is satisfactory to the Engineer.

Material which, in the opinion of the Engineer, is not properly mixed or in which the emulsion shows

signs of having broken during mixing shall not be applied to the road and shall be removed from the site.

ii) Batch Mixer

The slurry shall be mixed in an approved type of mixer as specified in SUB-CLAUSE 4303 (f).

All the constituents of the slurry shall be accurately proportioned and due care and attention shall be given to the sequence in which the ingredients are introduced into the mixer and to the period of mixing. Mixing shall be continued until the materials in each batch are thoroughly blended.

iii) Continuous Mixer

Aggregate and filler contained in separate bins shall be fed through metering devices at controlled rates to the mixer. Water and bitumen emulsion contained in separate tanks shall similarly be pumped to the mixer at controlled rates through metering devices. The mixing of the slurry shall be at a suitable rate adjusted to ensure complete blending of the ingredients and uniformity of mix.

(d) Application of Slurry

Before slurry is applied, the road surface shall be thoroughly cleaned and lightly sprinkled with water but no free water shall be present on the surface when the slurry is applied. The nominal rate of application of slurry shall be in accordance with drawings or as directed by the Engineer. The slurry shall be applied in two layers in the case application rates of 0.008 m³/m² or larger, or as directed by the Engineer.

The nominal rates of application given in the Bill of Quantities are intended for bidding purposes only and the actual rates of application on the site shall be as directed by the Engineer. When the slurry is applied in two layers, the first layer of slurry shall be struck off level with the tops of the stones in the aggregate layer so that, after application, the tops of the stones will be just visible.

The second layer of slurry shall not be applied until the first layer has dried. If required by the Engineer, the Contractor shall open the road to traffic before the second layer of slurry is applied. The surface shall be well rolled with a pneumatic-tyre roller. The second layer shall be applied only after sufficient time has been allowed for the first layer to cure. The Engineer will decide on the time necessary for proper curing, which will in any case be not less than 24 hours.

The surface shall be thoroughly cleaned of all dust, dirt or foreign materials before the second layer of slurry is applied. For seals using 14 mm nominal sized chipping the slurry shall be applied in one layer only. The slurry shall also be struck off so that the tops of the stone chipping will be just visible after the emulsion has set and cured.

Where slurry is spread by hand, the squeegee squad shall be allowed to complete the spreading of each batch discharged onto the road, using squeegees, before the next is discharged.

Where spreading is carried out by means of the spreader box, the slurry shall be discharged into the spreader box by means of a chute, which shall be so directed that an even supply of slurry is maintained against the full width of the strike-off blade of the spreader box. Areas where an excess of slurry has been applied by the spreader box shall be corrected by squeegees being used immediately after the passage of the spreader box.

Should breaking of the emulsion, segregation of the mix or formation of lumps occur during the application of the slurry, the slurry operations shall be discontinued at once and any defective material removed from the road. Successive strips of slurry shall overlap transversely by

not less than 25 mm nor more than 150 mm. Any overlapping on the longitudinal joints and any omitted areas shall be rectified with squeegees.

The Contractor shall ensure that either edge of the road surface is finished to the specified widths and lines. All stones dislodged in the process of applying the slurry shall be removed on the same day on which the slurry seal has been applied. All spillage of slurry or excess slurry shall be neatly removed from the road and buried in an approved waste site.

If the slurry is spread with a spreader box, a moist burlap drag shall be drawn behind the spreader box to ensure an overall even texture.

If applied by hand, the slurry shall be worked from side to side and criss-cross with the aid of squeegees so as to fill as many spaces as possible. In this case the final layer of slurry shall be struck off flush with the tops of the stone chippings so as to leave the chippings to be visible after the emulsion has stiffened and hardened.

The work must be so programmed, that the two half road widths of slurry shall be applied on two successive days to complete a full road width section in two days.

Any damage to the slurry seal by rain or traffic before the slurry has cured shall be rectified by the Contractor at their own expense.

4605 CONSTRUCTION REQUIREMENTS FOR OTTA SEALS

(a) General

The primed base on which the Otta seal is to be constructed shall be cleaned to remove excessive dust, debris and deleterious materials. Water shall be sprinkled on the surface to reduce surface tension and aid the even distribution of the binder.

(b) Equipment

The Contractor shall ensure that the full complement of equipment is made available and in good working order. The equipment shall include the binder distributor for applying the binder. This can be self-propelled or tractor towed binder tank with a hand lance.

The aggregate shall be spread using a chip spreader or labour in the case where labour-based methods are used.

The compaction shall be carried out using pneumatic rollers with a minimum weight of 12 tonnes. Smaller rollers may be used for fine grained Otta seals, grit seals and sand capping.

Power brooms shall be used to clean the primed surface of the base, to broom back aggregate dislodged by traffic and to remove unbound aggregate once the Otta seal has fully cured.

The Contractor shall ensure that the equipment is in good working order and is also approved for use on the permanent works by the Engineer.

(c) Aggregate

The aggregate should be slightly moist and if it is completely dry, water shall be sprinkled on the stockpile of aggregate while churning with a front-end loader. This should be carried out within 2 hours of application of the aggregate on the road. Care shall be taken to avoid wetting of the aggregate and should this happen, the aggregate shall be spread to dry in order to reduce the moisture. The condition of the aggregate shall be checked and approved by the Engineer.

4606 CONSTRUCTION OF SINGLE AND DOUBLE OTTA SEAL

(a) General

The construction of a single and double Otta seal involves the preparation of the primed base, setting out the area to be primed using strings or small stones lined up along the centreline and edges, heating and application of the binder, application of the aggregate rolling and aftercare.

(b) Binder Application

The application rates for the binders are given in TABLE 4606/1 and shall be applied with a tolerance of ± 5 .

TABLE 4606/1: BINDER APPLICATION RATES FOR OTTA SEAL SURFACING, SAND CAPPING AND GRIT

Type of Otta Seal	Open	Medium	Dense	
			AADT < 100	AADT > 100
Double				
1st layer	1.7	1.8	1.8	1.7
2nd layer	1.6	1.4	2.0	1.9
Single	1.8	1.9	2.1	2.0
Maintenance Reseal	1.7	1.8	2.0	1.8

The binders shall be heated to the temperatures stipulated in this Specification and applied in accordance with procedures given in SECTION 4300.

(c) Application of Aggregate

The aggregate shall be applied immediately after spraying the binder i.e., when the binder is still hot. The chip spreader shall be adjusted to deliver an even application of the aggregates without segregation of the different particle sizes. The application rates of the aggregate are given in TABLE 4606/2.

TABLE 4606/2: AGGREGATE APPLICATION RATES FOR OTTA SEAL SURFACING, SAND CAPPING AND GRIT

Type of Seal	Aggregate Application Rates (m ² /m ³)		
	Open Grading	Medium Grading	Dense Grading
Otta Seals	63-77	63-77	50-63

The Contractor shall continually check the application rate of the aggregate using a tray test and record the values for the Engineer's approval.

Areas that may be deficient of aggregate or may have excess aggregate shall be corrected by hand.

(d) Rolling

Rolling is a critical activity in the application of Otta seals. Rolling shall commence immediately after the aggregate is applied. A minimum of 12 passes of the roller shall be applied on the first day. The rolling shall be continued for an extra 3 to 5 days applying 8 passes of the roller each day during the hottest part of the day.

Care shall be taken to avoid excessive crushing of the aggregate

(e) Curing and Aftercare

The section shall be opened to traffic on the 3rd day of rolling and the speed of the traffic shall be controlled to a maximum of 40 km/h. The traffic shall also be channelled to run on the whole width of the carriageway. Traffic aids the curing of Otta seal.

The contractor shall ensure that the curing is uniform and

the Engineer shall check for the gradual migration of the binder to the surface. Should the traffic be too low to effect adequate curing, the Engineer may order the Contractor to apply more passes of the roller. This is called compensatory rolling. Aggregate that is whipped off the surface by traffic shall be broomed back for at least 2 weeks.

Once the surfacing is fully cured the loose aggregate shall be swept off the carriageway.

(f) Application of Second Layer

The second layer shall only be applied after the first layer has been fully cured.

The absolute minimum curing period for the first and second application layer shall be 7 days but subject to the surface having a ball penetration result of less than 2.5mm.

4607 CONSTRUCTION OF EMULSION BASED OTTA SEAL

(a) General

The aggregate shall be as specified in SECTION 4602 and TABLE 4602/3 AND 4602/4. However, the fine grained Otta aggregate of nominal maximum size of 14 mm is preferred. All conditions stipulated in this Specification and SECTION 4300 shall apply.

(b) Application of Tack Coat

The binder application rates shall be such that the residual binder after the emulsion has broken conforms to TABLE 4606/1 considering the proportion of water in the emulsion.

The binder shall be applied in spilt applications. 30 % as a tack coat and 70 % for the seal coat. The tack coat shall be applied followed immediately by the application of aggregate. The tolerance limits for the application rate shall be ± 5 %.

(c) Application of Aggregate

The application of the aggregate shall follow immediately after the application of the tack coat. The aggregate shall be spread evenly using a chip spreader or by labourers when the labour-based method is used. Areas that are deficient in aggregate or have excess aggregate shall be corrected by hand or hard brooms.

(d) Application of Seal Coat

After the aggregate is spread evenly the seal coat shall be applied constituting the remaining 70% of the design binder application. The tolerance limit shall be ± 5 %. The emulsion shall be left to break before rolling can commence.

(e) Rolling

Rolling shall be carried out using pneumatic or steel drum rollers in non-vibratory mode, or a combination of both. The Contractor shall ensure that the emulsion has broken before rolling.

The roller(s) shall have capability to wet the wheels to avoid picking up the surfacing during compaction. A minimum of 6 passes shall be applied and care shall be taken to avoid excessive crushing during the rolling.

(f) Curing and Aftercare

The surface shall be left to cure for 48hrs before allowing normal traffic on the road. Once cured the surfacing shall be neat and impervious with the aggregate forming a mosaic packing on the surface.

4608 CAPE SEAL CONSTRUCTION AND AFTER CARE

(a) Construction Before Slurry Application

i) Application of Tack Coat and Aggregate

The binder of the type and grade required, and the aggregate of the size specified in the Schedule of Quantities or ordered by the Engineer, shall be applied as specified in SUB-CLAUSE 4307 (b) at the rates as ordered by the Engineer.

The nominal rates of application given in TABLE 4609/1 shall be used for the purposes of tendering.

TABLE 4609/1: RATES OF APPLICATION

Nominal Size of Aggregate (mm)	Nominal rates of application for tender purposes	
	Binder (litres of tar or net bitumen per m ²)	Aggregate (m ³ per m ²)
14	0.6	0.009
20	1.2	0.013

ii) Initial Rolling

Initial rolling shall be carried out as specified in SUB-CLAUSE 4307 (b).

iii) Broom Drag and Final Rolling of Aggregate

Dragging and final rolling of aggregate shall be carried out as specified in SUB-CLAUSE 4307 (b).

iv) Second Application of Bituminous Binder

The required binder shall be sprayed at the rate prescribed by the Engineer. This shall be done at least two days after application of the tack coat and the aggregate if bitumen is used in the tack coat, and at least 14 days in summer and 21 days in winter after application of the tack coat and the aggregate if tar is used in the tack coat.

For tender purposes a nominal rate of 0.33 /m² (net bitumen) shall be used for 14 mm aggregate and for 20 mm aggregate.

(b) Slurry

i) Condition of Surface

The surface shall be rolled once with a light flat-wheeled roller early in the morning on the day of sealing to depress any loose stones that may have been displaced.

The surface shall be cleaned to remove all dust, mud, leaves, etc., and shall have a uniform closely knit appearance, with edges trimmed correctly to the specified width.

ii) Timing of Slurry Application

The slurry shall be applied only after the final spray has cured or dried out (which usually takes at least two days).

iii) Composition of Slurry

The slurry shall consist of a mix of the grade of slurry aggregate ordered by the Engineer and specified in SUB-CLAUSE 4302 (b) together with a 60% stable-grade emulsion, filler and water in the proportions as directed by the Engineer. The following proportions shall apply for tendering purposes only:

- Slurry aggregate (saturated volume): 1 m³
- Stable-grade emulsion: 260 Lit.
- Cement: 0.01 m³
- Water (as directed by the Engineer) approx.: 235 litres.

If specified in the Project Specifications, the composition of the slurry shall be based on the following mass proportions for tender purposes:

- Slurry aggregate (dry): 100
- Stable-grade emulsion: 20
- Cement: 1 - 1.5
- Water: ± 15

The saturated volume of slurry shall be determined by applying a correction for bulking of moist aggregate, as described in ITEM 46.03.

iv) **Mixing of Slurry**

A mixer of a type approved by the Engineer shall be provided in a good working order capable of producing a uniform slurry of the constituent materials. It may either be a batch mixer or a continuous-type mixer. Material which, in the opinion of the Engineer, is not properly mixed or in which the emulsion shows signs of having broken during mixing shall not be applied to the road.

[1] **Batch Mixer**

The slurry shall be mixed in an approved type of mixer as specified in SUB-CLAUSE 4303 (f). All the constituents of the slurry shall be accurately proportioned and due care and attention shall be given to the sequence in which the ingredients are introduced into the mixer and to the period of mixing. Mixing shall be continued until the materials in each batch are thoroughly blended.

[2] **Continuous Mixer**

Aggregate and filler contained in separate bins shall be fed through metering devices at controlled rates to the mixer. Water and bitumen emulsion contained in separate tanks shall similarly be pumped to the mixer at controlled rates through metering devices. The mixing of the slurry shall be at a suitable rate adjusted to ensure complete blending of the ingredients and uniformity of mix.

v) **Application of Slurry**

Before slurry is applied, the road surface shall be thoroughly cleaned and lightly sprinkled with water but no free water shall be present on the surface when the slurry is applied.

The slurry shall be applied in two layers in the case of 20.0 mm chippings and in one layer in the case of 14.0 mm chippings, unless otherwise specified in the Project Specifications or ordered by the Engineer.

The nominal rate of application of slurry shall be as follows for a seal using:

- 14.0 mm aggregate: 0.006 m³/m² one layer
- 20.0 mm aggregate: 0.008 m³/m² total for two layers

If specified in the Project Specifications, the nominal rate of application of the slurry on a mass basis shall be taken as:

- 14.0 mm aggregate: 7.5 kg/m²
- 20.0 mm aggregate: 9.5 kg/m²

The rate of application of slurry shall be measured in cubic metres of fine aggregate (saturated volume) contained in the slurry applied, per square metre of surfacing.

The nominal rates of application given above are intended for tendering purposes only and the actual rates of application on the site shall be as directed by the Engineer.

When the slurry is applied in two layers, the first layer of slurry shall be struck off level with the tops of the stones in the aggregate layer so that, after application, the tops of the stones will be just visible.

The second layer of slurry shall not be applied until the first layer has dried. If required by the Engineer, the Contractor shall open the road to traffic before the second layer of slurry is applied. The surface shall be well-rolled with a pneumatic-tyred roller. The second layer shall be applied only after sufficient time has been allowed for the first layer to cure. The Engineer will decide on the time necessary for proper curing, which will in any case be not less than 24 hours.

The surface shall be thoroughly cleaned of all dust, dirt or foreign materials before the second layer of slurry is applied.

For seals using 14.0 mm nominal sized chippings, the slurry shall be applied in one layer only. The slurry shall also be struck off so that the tops of the stone chippings will be just visible after the emulsion has set and cured. Where slurry is spread by hand, the squeegee squad shall be allowed to complete the spreading of each batch discharged onto the road, using squeegees, before the next is discharged.

Where spreading is carried out by means of the spreader box, the slurry shall be discharged into the spreader box by means of a chute, which shall be so directed that an even supply of slurry is maintained against the full width of the strike-off blade of the spreader box. Areas where an excess of slurry has been applied by the spreader box shall be corrected by squeegees being used immediately after the passage of the spreader box. Should breaking of the emulsion, segregation of the mix or formation of lumps occur during the application of the slurry, the slurry operations shall be discontinued at once and any defective material removed from the road. Successive strips of slurry shall overlap transversely by not less than 25 mm nor more than 150 mm. Any overlapping on the longitudinal joints and any omitted areas shall be rectified with squeegees.

The Contractor shall ensure that either edge of the road surface is finished to the specified widths and lines. All stones dislodged in the process of applying the slurry shall be removed on the same day on which the slurry seal has been applied. All spillage of slurry or excess slurry shall be neatly removed from the road and buried in an approved waste site.

If the slurry is spread with a spreader box, a moist burlap drag shall be drawn behind the spreader box to ensure an overall even texture. If applied by hand, the slurry shall be worked from side to side and crisscrossed with the aid of squeegees so as to fill as many spaces as possible. In this case the final layer of slurry shall be struck off flush with the tops of the stone chippings so as to leave the chippings to be visible after the emulsion has stiffened and hardened.

The work must be so programmed, that the two half road widths of slurry shall be applied on two successive days to complete a full road width section in two days.

Any damage to the slurry seal by rain or traffic before the slurry has cured shall be rectified by the Contractor at his own expense.

4609 MEASUREMENT AND PAYMENT

ITEM	UNIT
46.01 APPLICATION OF SAND SEAL:	
(a) BINDER (STATE TYPE)	LITRE (l)
(b) EMULSION (STATE TYPE AND COMPOSITION)	LITRE (l)

- (c) SAND CUBIC METRE (m³)

The unit of measurement of binder shall be the litre, measured at spraying temperature. The unit of measurement for the sand shall be the cubic metre of sand applied to the road as specified.

The bid rate for binder shall include full compensation for procuring and furnishing the material and applying the binder, including all preparatory work to the surface prior to application of the binder.

The bid rate for sand shall include full compensation for supplying the sand, washing, screening and preparing the sand, applying the sand as specified, as well as brooming the sand back onto the surface as often as is required.

ITEM	UNIT
46.02 APPLICATION OF SLURRY (STATE NOMINAL APPLICATION RATE IN CUBIC METRE PER SQUARE METRE):	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of completed and accepted slurry seal according to drawings or where directed by the Engineer.

The bid rate shall include full compensation, inter alia, for furnishing all materials, marking the centre line or reference lines, spraying of binder, spreading of aggregate, rolling, removing of dust or deleterious material, supplying of water and spraying of haul roads and construction roads, trimming the edges of the completed surface, and all other incidentals necessary for completing the work as specified.

The bid rates shall include full compensation for procuring and furnishing the material including all preparatory work to the surface prior to application of the seal.

ITEM	UNIT
46.03 VARIATION IN THE RATE OF APPLICATION OF THE SLURRY:	CUBIC METRE (m ³)

The unit of measurement for slurry variations shall be the cubic metre of saturated fine aggregate.

Payment for variations shall be made as specified in CLAUSE 1212.

Every load of fine aggregate used for the slurry shall be struck off with a straight edge at the stockpile, and the volume shall then be measured, and corrected for bulking.

The following method shall be used for calculating the corrected volume of fine aggregate when determining the application rate of slurry:

- The volume of a truck hopper filled with fine aggregate shall be carefully measured in cubic meters (A m³).
- A representative sample of aggregate shall be obtained from the conveyor belt feeding the mixer. 1000 ML of the sample shall be placed in a plastic measuring cylinder and dropped ten times through a height of 50 mm onto a wooden table, after which the volume of aggregate in the cylinder shall then be measured in ML (B ML).
- The sample in the cylinder shall then be saturated with water and water shall be added until it covers the aggregate by 50 mm. The mixture shall be shaken well, and the cylinder containing the aggregate and water placed on a horizontal surface allowing the aggregate to settle until the liquid above the aggregate clears sufficiently for a reading

to be taken of the volume of the saturated aggregate, in ML (C ML).

- The saturated volume of the aggregate in the hopper of the truck shall be calculated from the following formula, and payment for the slurry application variations shall be made in accordance with this formula:

True (saturated) volume carried by the truck hopper;

$$A \{ (1 - 0.72) \times [(B - C) / C] \}$$

For Otta Seals; and Grit Seal, the unit of measurement shall be the square metre of surfacing completed in accordance with the Specifications to the nominal thickness indicated on the Drawings or to the instruction of the Engineer. The bid rate shall include full compensation for procuring and furnishing all materials, heating the binder, mixing, transporting, placing and compaction of the material, and the provision and application of the surfacing. The rate shall also include full compensation for variations in thickness within the specified tolerance for bridge deck levels and for cleaning of the surface to the satisfaction of the Engineer, the application of a tack coat.

ITEM	UNIT
46.04 AGGREGATE FOR OTTA SEAL, AND GRIT SEAL USING	
(a) 19 MM FOR FIRST THE LAYER (STATE TYPE OF AGGREGATE AND BINDER AND RATE OF APPLICATION)	SQUARE METRE (m ²)
(b) 14 MM AGGREGATE IN SINGLE OTTA SEAL OR AS A SECOND LAYER IN DOUBLE OTTA SEAL (STATE TYPE OF AGGREGATE AND BINDER AND APPLICATION RATE PER SQUARE METRE)	SQUARE METRE (m ²)
(c) 9 MM NOMINAL MAXIMUM SIZE AGGREGATE FOR GRIT SEAL OVER THE SINGLE OTTA SEAL (STATE TYPE OF AGGREGATE AND BINDER AND APPLICATION RATE PER SQUARE	SQUARE METRE (m ²)

The unit of measurement shall be the square metre. The bid rate shall include compensation for the cleaning of the primed base, acquisition of the aggregate through machine or hand crushing or sieving of natural gravel, placement, rolling and curing.

ITEM	UNIT
46.05 BITUMINOUS SINGLE SEAL WITH:	(d)
(a) 20 MM AGGREGATE AND SLURRY (STATE TYPE AND GRADE OF BINDER)	SQUARE METRE (m ²)
(b) BITUMINOUS SINGLE SEAL WITH 14 MM AGGREGATE AND SLURRY (STATE TYPE AND GRADE OF BINDER)	SQUARE METRE (m ²)

The unit of measurement for the complete bituminous single seal with aggregate and slurry shall be the square metre.

The tendered rates shall include full compensation, for furnishing all materials, demarcating the working area, spraying the binders, spreading the aggregates, rolling, mixing and applying the slurry, and all other incidentals necessary for completing the work as specified, including the watering of haul and construction roads in and about the site.

ITEM	UNIT
46.06 BITUMINOUS VARIATION	BINDER LITRES (l)

(PENETRATION GRADE
BITUMEN/ CUTBACK BITUMEN/
BITUMEN EMULSION (STATE
TYPE AND COMPOSITION))

Variations: The unit of measurement shall be in litres of variations in the binder application on site compared to the rate stipulated in the Bill of Quantities.

<u>ITEM</u>	<u>UNIT</u>
46.07 AGGREGATE VARIATION:	
(a) 20 MM NOMINAL SIZE AGGREGATE	CUBIC METRE (m ³)
(b) 19 MM NOMINAL SIZE AGGREGATE (GRIT)	CUBIC METRES (m ³)
(c) 14 MM NOMINAL SIZE AGGREGATE	CUBIC METRES (m ³)
(d) 9 MM NOMINAL SIZE AGGREGATE (GRIT)	CUBIC METRES (m ³)
(e) SAND FOR SAND CAPPING	CUBIC METRES (m ³)

The unit of measurement shall be in cubic metres and is the difference between the rate given in the Bill of Quantities and the rate applied on site with the Engineer's approval.

SERIES 4000: BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

SECTION 4700: SURFACING OF BRIDGE DECKS

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4701 SCOPE

This Section covers the construction of a bituminous surfacing on bridge decks as shown on the Drawings or ordered by the Engineer.

4702 MATERIALS

Bituminous binders and aggregate shall comply with the requirements of SECTIONS 4200 AND 4300 for asphalt surfacing and seals respectively.

4703 PREPARATION OF SURFACE

Before the surfacing is constructed, the concrete deck shall be thoroughly cleaned by washing and brushing to remove all loose material. After drying, a bridge Water Proofing System shall be applied. Further, a tack coat consisting of 30% bituminous cationic emulsion shall be applied to the surface at a rate of 0.4 l/m². The tack coat shall then be allowed to dry before surfacing is laid.

After drying, a Bridge Deck Waterproofing System should be utilized so as to prevent the ingress of water into the bridges. There are two types of bridge deck waterproofing systems, namely sheet and liquid (sprayed):

- Sheet Systems: Polymer Modified Bituminous sheets bonded to the bridge deck, using torch application, hot mopping asphalt, or through self-adhesion. Construction practices of these proprietary products are to be provided by the manufacturers and approved by Engineer prior to execution.
- Liquid (Sprayed) Systems: Liquid applied membrane shall be made of polyurethane, acrylic, polyurea, polyester or other polymer derivatives with a thickness not less than 2 mm, and may consist of one or more components. The liquid applied membrane may be air or chemically cured.

4704 TYPE AND THICKNESS OF SURFACING

The type and nominal thickness of the surfacing shall be as indicated on the Drawings and specified in the Bill of Quantities. Bituminous wearing coat shall comprise of the following types:

Type 1: Continuously graded asphalt concrete surfacing 40-50 mm thick laid in a single layer

Type 2: Stone Matrix Asphalt 40-50 mm thick laid in a single layer

Before commencing with the construction of the surfacing, the actual levels of the bridge deck shall be determined by means of accurate levelling. The levels and grades to which the surfacing is to be constructed shall be as shown on the Drawings or as indicated by the

Engineer. If the levels of the concrete deck as constructed by the Contractor deviate by more than the specified tolerances from the specified levels, they shall construct a levelling layer at their own cost. The nominal size of the aggregate in the levelling layer shall be 10 mm.

4705 CONSTRUCTION

Irrespective of the type of seal applications on the road on both sides of the bridge, asphalt surfacing shall be constructed in accordance with SECTION 4200, and seals in accordance with SECTION 4300.

Overlay on the existing wearing coat on bridge decks shall not be permitted. In case the wearing coat is damaged, it shall be repaired or replaced. The milling of wearing coat shall be as per SECTION 3300 of these Specifications.

4706 SURFACE TOLERANCES

The completed surfacing shall comply with the requirements for base of CLAUSE 7115 in respect to surface tolerances for grade, smoothness, cross section and width.

4707 MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
47.01	SURFACING ON BRIDGE DECK (STATE TYPE AND THICKNESS)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of surfacing completed in accordance with the Specifications to the nominal thickness indicated on the Drawings or to the instruction of the Engineer.

The bid rate shall include full compensation for procuring and furnishing all materials, heating the binder and aggregate, mixing, transporting, placing and compaction of the material, and the provision and application of the surfacing. The rate shall also include full compensation for variations in thickness within the specified tolerance for bridge deck levels and for cleaning of the surface to the satisfaction of the Engineer and the application of a tack coat.

	<u>ITEM</u>	<u>UNIT</u>
47.02	WATER PROOFING LAYER	SQUARE METRE (m ²)

SERIES 4000: BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

SECTION 4800: TREATMENT OF SURFACE DEFECTS, PATCHING, REPAIRING EDGE-BREAKS AND CRACK SEALING

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4801 SCOPE

This Section covers the work in connection with the treatment of existing road surfaces prior to the application of a seal or asphalt surfacing, patching of potholes, repairing edge breaks, crack sealing and other specialist repairs.

Provision is made for treating existing seals exhibiting any of the following defects:

- The existing surface is deficient in binder.
- Marked differences in texture occur over the surface.
- The existing surface is open-textured.
- The surface is uneven on account of potholes, bumps, slacks, etc.
- Edges require trimming and/or repairs.

Patching shall be any work to existing pavement layers (and in exceptional cases to fills and the roadbed) with the purpose of repairing local failures, and which is carried out in an area having a width of less than 1.0 m, or a length of less than 25 m or an area of less than 100 m². This does not include the repair of edge breaks, pre-treatment of the road surface, or the rehabilitation of concrete pavements.

Patching of a Pothole involves excavating the existing failed sections and reconstructing the excavated fills and pavement layers with the specified pavement material.

Compensation for work in restricted areas shall not be applicable to patching and repairing edge breaks.

The general requirements for seals given in SECTION 4300 shall apply to this SECTION.

4802 MATERIALS

The material shall comply with the requirements specified for the various types of material in the appropriate sections of the Specifications and the Special Specifications.

The following grades of binder may be used. The actual type or grade used shall be as specified in the Special Specifications or the Bill of Quantities or as ordered by the Engineer.

(a) Binder for Fog Spray (Treatment Type 1)

65%-70% cationic or anionic spray-grade bituminous emulsion.

(b) Tack-Coat Binder (Treatment Type 2)

65%-70% cationic or anionic spray-grade bituminous emulsion.

(c) Slurry Binder (Treatment Type 3)

65%-70% stable grade bituminous emulsion.

(d) Binder for Asphalt Skim Coat (Treatment Type 4)

70/100 penetration grade bitumen.

(e) Screed (Treatment Type 5)

Bitumen emulsion shall be used for the tack coat, and the binder for the asphalt shall be an approved grade of penetration grade bitumen unless otherwise specified.

(f) Binder for Asphalt used in Reconstructing Pavement Edges

65%-70% stable grade bituminous emulsion for tack coat and 70/100 penetration-grade bitumen in asphalt.

(g) Rubber Pellets

Rubber pellets for crack sealing shall be obtained by processing rubber tyres. The rubber shall be granulated and free from fibres, steel wire and other impurities. The rubber crumbs shall pass through a 2.00 mm sieve.

(h) Primer Seal

The recommended primer is medium cutback MC30/ MC70.

(i) Binders for Crack Treatment

Stable-grade bitumen emulsion or bitumen rubber shall be used as modified binders/emulsions (*based on TG1, 5th edition, 2020 from SABITA/ US EAS 982-5:2020*) for the following generic homogeneous and non-homogeneous modified binder classes for crack sealing material.

- C-E1: Crack Sealant – Hot Applied Elastomer Modified
- CC-E1: Crack Sealant – Emulsion Elastomer Modified (Suitable only for 2-4mm cracks)
- C – R1: Crack sealant – Hot Applied Bitumen Rubber
- C – R2: Crack sealant – Hot Applied Bitumen Rubber

The property requirements of the modified crack sealant classes are shown in TABLE 4802/1 and typical temperature/time limits are shown in TABLE 4802/2.

TABLE 4802/1: PROPERTY REQUIREMENTS FOR MODIFIED CRACK SEALANTS

Property	Unit	Test method (TG2)	Class			
			C-E1	CC-E1	C-R1	C-R2
Softening Point	°C	MB-17	≥ 80	≥ 70*	55-65	
Elastic Recovery @ 150°C	%	MB-4	≥ 80	≥ 50*	-	
Dynamic Viscosity @ 190°C	dPa.s	MB-13	-	-	20-40	
Dynamic Viscosity @ 170°C	dPa.s	MB-13				10-40
Dynamic Viscosity @ 165°C	Pa.s	MB-18	≤ 0.65			
Dynamic Viscosity @ 25°C	Pa.s	MB-18		≤ 0.8		
Resilience @ 25°C	%	MB-10			13-40	10-40
Flow	Mm	MB-12			15-70 (at 60°C)	0-40 (at 70°C)
Binder content (m/m)	%	MB-22		≥ 55		

*Values to be determined on the residue after recovery of the binder by evaporation method MB-20

TABLE 4802/2: TYPICAL TEMPERATURE/TIME LIMITS FOR MODIFIED CRACK SEALANTS

Binder Class	Short-Term Handling / Transportation		Storage		Application/Spraying/ Asphalt Mixing/ Asphalt Binder Feed		
	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Max Holding Time (hrs)	Max Temp (°C)	Min Temp (°C)	Max Holding Time (hrs)
C-E1	160	24	n/a	Indefinite	170	150	8
CC-E1	Ambient	> 240	Ambient	> 240	Ambient	Ambient	> 240
C-R1	165	24	-	-	190	180	Refer Time/ Viscosity curve of SABITA TG2
C-R2	160	> 168	150	336	185	170	

(j) Herbicide

Herbicide shall be a non-selective environmentally compatible herbicide approved by the Engineer.

i. Special spraying equipment with 2 mm nozzle openings and provided with spare nozzles.

ii. Special heating equipment appropriate for cleaning cracks, and custom-built applicators for applying sealants to cracks.

4803 CONSTRUCTION EQUIPMENT

All equipment shall be suitable for the specified use and working areas and shall be capable of obtaining the specified results.

(a) Plaining Machine

The machine shall be of a design which will be suitable for plaining the existing surfacing in order to remove any irregularities and to leave an even surface without tearing the underlying material. An approved milling machine may be used.

Before plaining may start, the Contractor shall demonstrate to the Engineer that the machine is capable of executing the work in accordance with the Special Specifications.

(b) Patching and Repairing Edge Breaks

Only approved cutting or sawing equipment may be used for cutting or sawing asphalt layers. The equipment shall be capable of cutting asphalt layers to depths of 200 mm in one operation without fragmenting the material, and in straight lines within the required tolerances.

The following items of construction equipment shall also be available and in good working order:

- A vibratory roller having a mass approximately equal to that of a Bomag 765 or similar vibratory roller, with an adjustable amplitude and frequency of vibration.
- A mobile compressor capable of producing at least 3 m³/minute compressed air at 750 k-Pa.
- Appropriate paving breakers.
- Manually operated pneumatic compactors as required.
- Appropriate concrete mixers.

(c) Crack Sealing

Over and above the equipment normally used for surface treatments, the following additional equipment shall be available for crack sealing:

4804 TREATMENT OF SURFACE DEFECTS

Before any treatment is carried out, the area to be treated shall be cleaned and prepared and any major failures shall be repaired as specified in the Special Specifications.

(a) Treatment Type 1

This treatment shall be applied where the existing surface is deficient in binder.

The treatment shall consist of the application of a fog spray of the specified grade of emulsion to the existing surface by means of a pressure distributor at the rates of application as directed by the Engineer, in widths that may vary from 0.5 m to 4.0 m.

(b) Treatment Type 2

This Treatment, or a sand seal as specified in SECTION 4600, is intended for application where marked differences in texture occur in the existing surfacing, in order to obtain a uniform texture before resealing.

A tack coat of the specified type and grade of emulsion shall be applied to the surface as specified in SUB-CLAUSE 4307 (b) followed by an application of double-washed crusher sand. The crusher sand shall be the medium grade specified for slurry in CLAUSE 4302, but shall be on the coarse side of the grading envelope.

The nominal rates of application shall be:

- Emulsion 0.7 litres net bitumen per m²
- Aggregate 0.004 m³/m²

The actual rates of application shall be as instructed by the Engineer.

It can be anticipated that spraying and spreading will have to be carried out in narrow bands varying in width from 0.5 m to 4.0 m. The emulsion shall be allowed to break before the aggregate is applied.

As soon as the aggregate has been applied, the

distribution thereof shall be corrected by light hand brooming or by means of a light broom drag.

Rolling shall be carried out as specified in SUB-CLAUSE 4307 (b). Any excess aggregate remaining on the road after it has been opened for two days or more shall be removed.

(c) Treatment Type 3

This treatment shall be used when an existing surface treatment, which is open-textured or exhibits cracking, requires treatment with bituminous slurry.

Prior to Treatment with a slurry, the surface shall be sprayed with a tack coat at the rate prescribed by the Engineer.

A distinction shall be made in respect of the payment for the following two methods of construction:

- Where the slurry can only be applied by hand methods or where the Engineer so directs or where it is specified that the slurry shall be applied by hand methods.
- Where the slurry can be applied mechanically with a spreader box.

The slurry shall be prepared, mixed and applied as specified in SUB-CLAUSES 4604 (b), (c), and (d), with the following exceptions:

- Slurry to be applied by hand may be mixed in a suitable concrete mixer.
- When applied by hand with brooms or rubber squeegees, the slurry shall be worked into cracks and other open areas until a sound, uniform surface is obtained.

The slurry shall, in the case of application by spreader box, be applied in a single layer at a nominal rate, for bidding purposes, of 0.004 m³/m².

(d) Treatment Type 4

This treatment is intended for use where the road surface is uneven or contains slacks, bumps or minor rutting caused by deformation of the pavement layers, but not by failure of these layers.

The surface to be treated shall, after having been cleaned and prepared, be given a tack coat of bitumen emulsion at rates directed in the field by the Engineer.

Asphalt shall consist of a medium or fine-grade asphalt surfacing mix manufactured as specified with 6% of 70/100 penetration-grade bitumen and 1.0% active filler. The actual composition of the mix shall be as dictated by the required thickness of the asphalt layer, or as directed by the Engineer.

The asphalt shall be applied as specified in SECTION 4200 in thicknesses varying between 6 mm and 25 mm depending on the nature of the irregularities that occur so that the final surface will conform to the surface tolerances for cross section and smoothness as specified in CLAUSE 4213. Where the thickness of asphalt required exceeds 25 mm, it shall be laid in separate layers each not exceeding 25 mm thickness.

If the final surfacing shows signs of ravelling, disintegration, or an uneven surface, the surface shall be given a Type 3 Treatment or removed and replaced, all at the Contractor's cost.

(e) Treatment Type 5

This treatment is used where the road surface is uneven and where depressions, humps or small grooves occur, which, in the opinion of the Engineer, are the result of the deformation of the pavement layers, but not of structural failure of the pavement.

Where both plaining and screeding are specified, the

screed shall be placed after the plaining has been completed. Where milling is required, it shall be done in accordance with the requirements of CLAUSE 4803.

The existing surface shall be swept clean or cleaned by other approved methods to be free from dust, soil, gravel, loose stones or any other undesirable material. A tack coat of stable-grade bitumen emulsion shall then be applied at a rate prescribed by the Engineer.

The bituminous material used for the screed shall be asphalt or coarse slurry as specified in the Special Specifications.

4805 PATCHING

(a) Demarcation

The Engineer will demarcate any failed areas to be repaired, and shall instruct the Contractor in regard to the repair work to be done.

The Contractor shall give adequate notice to the Engineer of their intention to commence with repair work on any specific section of the road so that the Engineer will have sufficient time to demarcate the areas to be patched and repaired.

In addition to their specified responsibilities for the accommodation of traffic, the Contractor shall also be responsible for traffic accommodation during the demarcation work.

(b) Excavating Pavement Material

In addition to the provisions of this SECTION the various provisions of SECTIONS 3200, 3400, 3500, 3600, 3800, 4100 AND 4200 amongst others shall apply with changes as required.

Unless otherwise instructed by the Engineer, the patching shall have a neat rectangular shape. The existing material shall be excavated and removed to the full specified depth. Asphalt layers and surfacing shall be cut with approved sawing equipment.

Excavation for patching shall be cut with side slopes of approximately 60° to the horizontal.

Where required, excavation shall be done with approved milling equipment in accordance with SECTION 3800.

Excavated material from each pavement layer shall be placed in separate stockpiles adjacent to the patch. The stockpiled material shall be re-used or spoiled in an approved manner in accordance with the Engineer's instructions. Stockpiled material shall not be spoiled next to the road.

After completion of the excavation to the specified depth, the Engineer shall be afforded the opportunity to examine it. Where required, the floor of the excavation shall be compacted to the specified density for the layer concerned.

(c) Backfilling Excavations

- i. Excavations shall be backfilled with pavement material as specified in the Special Specifications or as ordered by the Engineer, and the backfilling shall be compacted and finished to the required levels. The requirements for material quality, density and finish specified in other appropriate Sections shall remain applicable. Untested material from the sides of the road shall not be used.

Stabilised materials shall be mixed in concrete mixers or by other approved equipment.

- ii. Unless otherwise specified in the Special Specifications, the base shall be backfilled in accordance with the following requirements:

- The base material shall be placed in a concrete mixer, and water shall be added to moisten the material.
 - A suitably diluted 60% stable grade anionic bitumen emulsion shall be added at the specified rate.
 - Portland cement shall be added at a rate of 1.0% by mass to the dry aggregate before adding water, unless otherwise specified.
 - During mixing the fluid content (water plus emulsion) shall not exceed the optimum fluid content (optimum moisture content + percentage residual bitumen) of the base. Mixing shall continue until a uniform mix of the base material and the emulsion is obtained.
 - The Contractor shall place and spread the stabilised material by hand in layers of appropriate thickness. Each layer shall be compacted with a hand-operated self-propelled vibratory roller to the specified density. The process of placing, spreading and compacting shall be repeated until the required total thickness of base is obtained. The stabilised materials shall be placed at a fluid content not exceeding the optimum fluid content for the base course. The finished surface of patching shall be a minimum of 2 mm and a maximum of 5 mm above the adjacent existing pavement.
- iii. When backfilling with asphalt is specified in the Special Specifications, the asphalt mix specified for Treatment Type 4 above shall be used. The mix shall be well compacted by means of a suitable vibratory roller or compactor and shall be finished neatly to the required line and levels.

(d) Restrictions

Unless otherwise instructed in writing by the Engineer, the excavation, backfilling and all patching work, complete as specified, for any patch shall be carried out and completed on the same day. Special attention shall be given during patching to controlling and protecting traffic, as specified.

4806 REPAIRING EDGE BREAKS

This treatment is intended for use where trimming and/or repair of the edges of the surfaced area is required, including restoring the road edges to the true edge lines of the original road or to such other edge line as may be required.

Where the existing edge of the surfacing is sound but exceeds the required width by more than 150 mm, the excess surfacing shall be cut back to the required width keeping it parallel to the centre line of the road.

Where the edges of the surfacing have broken away or where the surfacing is narrower than the required new width, the existing broken edges shall be cut back until a sound edge can be obtained.

Where the edge of the surfacing, as cut back, requires building up to bring it to the required width, all material between the edge of the surfacing and the line to which the surfacing has to be built up, shall be removed to a depth of 60 mm below the final road surface or until firm material is found, and the surface so enclosed shall be cleaned, watered and primed at a rate of 0.6 l/m² with a 60% stable grade emulsion diluted with three parts of water to one part of emulsion. The enclosed surface may also be compacted with suitably sized vibratory rollers to ensure a sound surface.

The edges shall then be built up with the asphalt specified for Treatment Type 4 and shall be well compacted by means of a suitable vibratory roller or

compactor. The built-up edges shall be finished neatly to the required line and levels.

4807 CRACK SEALING

(a) General

The types of cracks treated will be specified in the Special Specifications. The Engineer will instruct the Contractor regarding the type of treatment to be used in the various cases.

(b) Preparation

The cracks shall be blown clean with compressed air, and all foreign and loose material shall be removed from the cracks.

(c) Cracks Narrower than 3 mm

Cracks narrower than 3 mm shall be treated with an emulsion or by means of resealing the surface.

(d) Cracks 3 mm and Wider

After the primer has been applied, anionic stable grade emulsion shall be mixed with synthetic modifiers, as set out in the Special Specifications, and applied by means of pneumatic spraying equipment or other approved equipment at the rate given in the Special Specifications.

Where the cracks are to be rolled, the Contractor, in accordance with the Special Specifications or the prescriptions of the Engineer, shall treat the cracks as described below.

Where "Volcano" cracks occur and require to be flattened, in accordance with the Special Specifications or the prescriptions of the Engineer, the Contractor shall treat the cracks as follows:

- The cracks shall initially be treated for cleaning out and priming the crack as described above.
- The surface on either side of the crack shall be sprayed with an approved rejuvenator for a width of 300 mm on either side of the crack and allowed to soften the existing surface.
- The crack shall then be filled with cold rubber slurry which shall be worked in with rubber squeegees. Any excess slurry shall be removed from the sides of the crack.
- Once the emulsion has broken, the crack can be rolled with a pedestrian vibratory roller until a smooth finish is obtained.

For other cracks, the instructions of the Engineer shall be implemented. Cracks shall be treated with cold rubber slurry, hot bitumen rubber, or any other approved sealant.

Where, in the opinion of the Engineer, the above treatments are not suitable for the existing cracks, the Contractor shall treat the cracks in accordance with the instructions of the Engineer.

i) Rubber Slurry

The rubber slurry mixture shall be proportioned as follows (by volume):

- 10.0 parts of rubber crumbs
- 4.5 parts of 60% anionic stable grade bitumen emulsion
- 0.2 parts of Portland cement
- parts of SBR (net rubber) (anionic emulsified rubber)

Water may be added to improve workability. The mixture shall be neatly worked into the cracks by rubber squeegees. Excess slurry shall be removed from the surface as soon as the emulsion has broken.

ii) Bitumen Rubber

Bitumen rubber may be used only where the Contractor is able to convince the Engineer that they are able to mix, heat and apply the material satisfactorily.

The bitumen rubber shall be mixed on the site or at another approved locality on condition that the Contractor is able to propose efficacious methods for controlling both the mixing process and the end product.

Approved heating equipment and mechanical equipment for mixing and applying the mixture shall be used.

The rubber content of the mix shall be at least 25% by mass of the total bitumen-rubber mix.

iii) Other Sealants

Other approved sealants shall comply with and be applied in accordance with the requirements of the Special Specifications.

(e) Restrictions

Cracks may be sealed only where the temperature of the road surface exceeds 10°C.

Crack sealing may not be done within three days after rain has fallen on the site, unless otherwise instructed by the Engineer.

The Contractor shall note that a single application of crack sealant is usually insufficient and that the application will have to be repeated.

4808 PRIMER SEAL

The primer seal is the application of primer binder to a prepared pavement which is then covered with chippings as a temporary treatment prior to applying the sprayed seal.

The binder used for primer seal is more viscous than primer and less viscous than normal binder. The binder shall penetrate the pavement as well as bind the chippings.

The recommended primer is medium cutback MC30/ MC70. The basic application rate of primer binder at 15°C is specified in Table 4808/1. The average total allowance for primer binder application shall be +0.2 to

+0.3 L/m². The size of chipping and application rate of chipping based on traffic volume is specified in TABLE 4801/1.

TABLE 4808/1: BASIC RATE FOR PRIMER BINDER (CUTBACK BITUMEN) AND RATE FOR CHIPPINGS

Chipping Size (mm)	Basic Primer binder Application Rate at 15°C (L/m ²) of mixture			Chipping Application Rate (m ² /m ³)
	Vehicle / Lane / Day			
	< 300	300 – 2000	> 2000	
7	1.3	1.2	1.1	150-190
10	1.4	1.3	1.2	120-150
14	1.5	1.4	1.3	90-100

The absolute minimum curing period shall be 7 days but subject to the surface having a ball penetration result of less than 2.5 mm.

4809 CRACK PREVENTION COURSES

The work shall consist of providing one or two coats of an elastomeric rubber membrane known as Stress Absorbing Membrane (SAM) over a cracked surface, followed by a covering of aggregate chips. Modified binder in accordance with SECTION 4202, to be specified as per the requirements of the contract.

The requirement of the aggregates shall be as specified in SUB-CLAUSE 4302. Precoated aggregates may also be utilised with the approval of the engineer.

The rate of spread of binder and aggregate shall be as given in TABLE 4809/1 or as per the Contract.

The base on which the SAM is to be laid shall be prepared, in accordance with these specifications and as directed by the Engineer. The surface shall be thoroughly cleaned either by using a mechanical brush or any other equipment/method approved by the Engineer. Dust removed in the process shall be blown off with compressed air.

The application temperature for the modified binder shall be 160°-170°C. The surface on which the binder is to be applied shall be dry.

Where a two coat SAM is required, the second coat shall be applied within 90 days of the first coat.

TABLE 4809/1: QUANTITY OF MATERIALS REQUIRED FOR 10 M² OF ROAD SURFACE FOR STRESS ABSORBING MEMBRANE

Sr. No.	Type and Width of Crack	Specification of SAM to be Applied	Quantity of Binder Kg / 10m ²	Quantity of Chipping
1	Hair Cracks and Map Cracks up to 3mm Width	Single Coat SAM or 2 nd Coat of Two Coat SAM	8-10	0.10 m ³ of 5.6 mm chips
2	Map Cracks or Alligator Cracks 3 mm to 6 mm Width	Single Coat SAM	10-12	0.11 m ³ of 5.6 mm chips
3	Map Cracks or Alligator Cracks 3 mm to 6 mm Width	Two Coat SAM		
		1 st Coat	12-14	0.12 m ³ of 5.6 mm and 11.2 mm chips in 1: 1 ratio
		2 nd Coat	8-10	0.10 m ³ of 5.6 mm chips
4	Cracks above 9 mm Width and Cracked Area above 50%	Two Coat SAM		
		1 st Coat	14-16	0.12 m ³ of 11.2 mm chips
		2 nd Coat	8-10	0.10 m ³ of 5.6 mm chips

4810 OPENING TO TRAFFIC

The road shall be left open to traffic for such period as the Engineer may direct before further surface treatment work is carried out.

4811 JOINTS AND THE PROTECTION OF KERBS

The requirements of SUB-CLAUSE 4307 (b) regarding joints between sprays and the protection of kerbs, channels, etc., shall be observed.

4812 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
48.01 TREATMENT TYPE 1 (FOG SPRAY):	
(a) BITUMEN EMULSION (STATE TYPE AND BINDER CONTENT)	LITRE (l)

The unit of measurement for Treatment Type 1 (fog spray) shall be the litre of bituminous emulsion sprayed at application rates as instructed by the Engineer, measured at spraying temperature.

The bid rates shall include full compensation for cleaning and preparing the existing surface, for furnishing the material and applying the fog spray and for all other incidentals necessary for completing the work as specified.

<u>ITEM</u>	<u>UNIT</u>
48.02 TREATMENT TYPE 2: (APPLICATION OF SAND SEAL):	
(a) BINDER (STATE TYPE)	LITRE (l)
(b) SAND	CUBIC METRE (m ³)

The unit of measurement of binder shall be the litre, measured at spraying temperature. The unit of measurement for the sand shall be the cubic metre of sand applied to the road as specified.

The bid rates shall include full compensation for procuring and furnishing the material and applying the binder, including all preparatory work to the surface prior to application of the binder.

The bid rate shall include full compensation for supplying the sand, washing, screening and preparing the sand, applying the sand as specified, as well as brooming the sand back onto the surface as often as is required.

<u>ITEM</u>	<u>UNIT</u>
48.03 TREATMENT TYPE 3: (SLURRY) (STATE NOMINAL APPLICATION RATE IN CUBIC METRE PER SQUARE METRE):	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of completed and accepted slurry seal according to drawings or where directed by the Engineer.

The bid rate shall include full compensation, inter alia, for furnishing all materials, marking the centre line or reference lines, spraying of binder, spreading of aggregate, rolling, removing of dust or deleterious material, supplying of water and spraying of haul roads and construction roads, trimming the edges of the completed surface, and all other incidentals necessary for completing the work as specified.

The bid rates shall include full compensation for procuring and furnishing the material including all preparatory work to the surface prior to application of the seal.

<u>ITEM</u>	<u>UNIT</u>
48.04 VARIATION IN THE RATE OF APPLICATION OF THE SLURRY:	CUBIC METRE (m ³)

The unit of measurement for slurry variations shall be the cubic metre of saturated fine aggregate.

Payment for variations shall be made as specified in CLAUSE 1212.

<u>ITEM</u>	<u>UNIT</u>
48.05 TREATMENT TYPE 4: (ASPHALT SKIM COAT):	
(a) TACK COAT USING BITUMEN EMULSION (STATE TYPE AND BINDER CONTENT)	LITRE (l)
(b) CONTINUOUSLY-GRADED ASPHALT	TONNE (t)

The unit of measurement for the tack coat shall be the litre of emulsion applied, measured at spraying temperature. The unit of measurement for asphalt shall be the tonne of asphalt laid according to the Specifications.

The bid rate for tack coat shall include full compensation for procuring, furnishing and applying the tack coat and demarcating the areas to be sprayed, and for all incidentals necessary for completing the work as specified.

The bid rate for asphalt shall include full compensation for procuring, furnishing and mixing all the materials required for applying the asphalt, and for all transport and other incidentals necessary to complete the work as specified.

<u>ITEM</u>	<u>UNIT</u>
48.06 TREATMENT TYPE 5: (SCREED):	
(a) TACK COAT USING BITUMEN EMULSION (STATE TYPE AND BINDER CONTENT)	LITRE (l)
(b) CONTINUOUSLY-GRADED ASPHALT (SPECIFY GRADE)	TONNE (t)
(c) COARSE GRADE SLURRY	CUBIC METRE (m ³)

The unit of measurement for the tack coat shall be the litre of emulsion applied, measured at spraying temperature. The unit of measurement for asphalt shall be the tonne of asphalt laid according to the Specifications. The unit of measurement for coarse grade slurry shall be the cubic metre of aggregate mix used in the slurry.

The bid rate for tack coat shall include full compensation for procuring, furnishing and applying the tack coat and demarcating the areas to be sprayed, and for all incidentals necessary for completing the work as specified.

The bid rate for asphalt shall include full compensation for procuring, furnishing and mixing all the materials required for applying the asphalt, and for all transport and other incidentals necessary to complete the work as specified.

The bid rate for slurry shall include full compensation for all materials, equipment and labour for producing and applying the slurry, irrespective of the number of applications required to attain the required thickness.

<u>ITEM</u>	<u>UNIT</u>
48.07 SAWING ASPHALT OR CEMENTED PAVEMENT LAYERS FOR PATCHING:	
(a) CONTINUOUSLY-GRADED ASPHALT:	
(i) NOT EXCEEDING 50 mm	SQUARE METRE (m ²)
(ii) EXCEEDING 50 mm BUT NOT EXCEEDING 100 mm	SQUARE METRE (m ²)
(iii) EXCEEDING 100 mm	SQUARE METRE (m ²)
(b) CEMENTED PAVEMENT LAYERS TO AN AVERAGE DEPTH:	
(i) NOT EXCEEDING 50 mm	SQUARE METRE (m ²)
(ii) EXCEEDING 50 mm BUT NOT EXCEEDING 100 mm	SQUARE METRE (m ²)
(iii) EXCEEDING 100 mm	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of saw cut area calculated in accordance with the authorised length of saw cut and the average saw depth measured after excavation of the material.

The bid rate shall include full compensation for all equipment, labour supervision, materials, transport and for all incidentals for sawing the asphalt and the cemented pavement layers, complete as specified and prescribed by the Engineer.

<u>ITEM</u>	<u>UNIT</u>
48.08 EXCAVATION IN EXISTING PAVEMENTS FOR PATCHING IN:	
(a) ASPHALT LAYERS	CUBIC METRE (m ³)
(b) CEMENTED LAYERS	CUBIC METRE (m ³)
(c) OTHER LAYERS (SPECIFY TYPE)	SQUARE METRE (m ²)

The unit of measurement shall be the cubic metre of material excavated from the existing pavement. The quantity shall be computed in accordance with the authorised dimensions of the excavation.

The bid rate shall include full compensation for demarcating the excavation, excavating the material, placing the excavated material in temporary stockpiles and spoiling of material in the stockpiles where ordered by the Engineer, including haul over a free-haul distance of 1.0 km, complete as specified.

<u>ITEM</u>	<u>UNIT</u>
48.09 BACKFILLING OF EXCAVATIONS FOR PATCHING WITH:	
(a) CHEMICALLY STABILISED PAVEMENT MATERIAL (SPECIFY THE PAVEMENT MATERIAL AND THE STABILISING AGENT) FOR A PATCH WITH A SURFACE AREA:	
(i) NOT EXCEEDING 5 m ²	CUBIC METRE (m ³)
(ii) EXCEEDING 5 m ² BUT NOT EXCEEDING 100 m ²	CUBIC METRE (m ³)
(iii) EXCEEDING 100 m ²	CUBIC METRE (m ³)
(b) BASE COURSE MATERIAL STABILISED WITH BITUMINOUS EMULSION (SPECIFY THE EMULSION) FOR A PATCH WITH A SURFACE AREA:	

<u>ITEM</u>	<u>UNIT</u>
(i) NOT EXCEEDING 5 m ²	CUBIC METRE (m ³)
(ii) EXCEEDING 5 m ² BUT NOT EXCEEDING 100 m ²	CUBIC METRE (m ³)
(iii) EXCEEDING 100 m ²	CUBIC METRE (m ³)
(c) CONTINUOUSLY GRADED ASPHALT FOR A PATCH WITH A SURFACE AREA:	
(i) NOT EXCEEDING 5 m ²	TONNE (t)
(ii) EXCEEDING 5 m ² BUT NOT EXCEEDING 100 m ²	TONNE (t)
(iii) EXCEEDING 100 m ²	TONNE (t)

The unit of measurement for ITEMS 48.09 (a) and (b) shall be the cubic metre of the specified chemically or bitumen stabilised pavement material placed in accordance with the specified requirements.

The quantities will be computed in accordance with the dimensions of the filling.

The unit of measurement for ITEM 48.09 (c) shall be the tonne of bituminous mix placed in accordance with the specified requirements.

The quantities will be computed in accordance with the dimensions of the filling and the density of the compacted bituminous mix.

The bid rates shall include full compensation for compacting the floor of the excavation, providing all the material, irrespective of its origin, including gravel (notwithstanding the provisions of SECTION 1600), for all mixing, placing, compacting and finishing as specified in this Section and other appropriate Sections of the Specifications, for all transport, work in restricted areas, and also for all machinery, equipment, labour, supervision and other incidentals for executing the work as specified.

The bid rate shall also include full compensation for chemical or bituminous stabilisation, including amongst others the provision and application of the stabilising agents and the bitumen.

<u>ITEM</u>	<u>UNIT</u>
48.10 EDGE BREAKS:	
(a) TRIMMING EDGES OF EXISTING SURFACING	METRE (m)
(b) RECONSTRUCTING EDGES FROM CONTINUOUSLY-GRADED ASPHALT	TONNE (t)

The unit of measurement for trimming edges shall be the metre of pavement edge cut back and trimmed as specified. The unit of measurement for reconstructing pavement edges shall be the tonne of continuously-graded asphalt furnished and compacted as specified.

The bid rate for trimming the edges shall include full compensation for cutting back the edges as directed, and removing and dumping of all excavated and loose material in an approved waste site.

The bid rate for reconstructing pavement edges shall include full compensation for compacting the surface on which the new edge is to be constructed and procuring, furnishing and mixing all materials and compacting and trimming the asphalt to the required lines and levels. It shall also include full compensation for applying a tack coat of emulsion to the surface to be treated.

The bid rates shall include full compensation for all transport, handling, labour, material and all incidentals necessary to complete all the work specified in the treatment of edge breaks.

<u>ITEM</u>	<u>UNIT</u>
48.11 CLEANING THE CRACKS WITH COMPRESSED AIR:	KILOMETRE (km)

The unit of measurement for cleaning the cracks with compressed air shall be the kilometre of road along which all the cracks have been blown clean.

The bid rate shall include full compensation for providing all equipment, labour, supervision and incidentals for blowing clean the cracks over the full width of the road to the satisfaction of the Engineer.

<u>ITEM</u>	<u>UNIT</u>
48.12 APPLYING BITUMINOUS BINDERS, AND SEALANTS FOR SEALING CRACKS:	
(a) MSP/1 OR SIMILAR PRIMER	LITRE (l)
(b) ANIONIC STABLE-GRADE EMULSION MIXED WITH SYNTHETIC MODIFIERS	LITRE (l)
(c) HOT BITUMEN RUBBER	LITRE (l)
(d) OTHER SPECIFIED AGENTS (TYPE INDICATED)	LITRE (l)

The unit of measurement shall be the litre of material applied as specified or as instructed by the Engineer.

The bid rates shall include full compensation for providing, mixing, heating (where required) and applying all the materials specified, and for all equipment, labour, supervision and incidentals for completing the work. No additional payment shall be made for multiple applications of material, and payment will not distinguish between the various types, widths or lengths of cracks.

<u>ITEM</u>	<u>UNIT</u>
48.13 COLD RUBBER-SLURRY FOR SEALING CRACKS	CUBIC METRE (m ³)

The unit of measurement for crack treatment with rubber slurry shall be the cubic metre of fine rubber crumbs used for preparing the mix.

The bid rate shall include full compensation for procuring and providing all the material, including emulsion synthetic modifiers, cement and water, and for mixing and applying the mixture, and for all equipment, labour, supervision, and incidentals for executing the work in accordance with the specifications.

Payment will not be made for redundant rubber pellets or redundant mixture or for mixture, which in the opinion of the Engineer has been wasted.

<u>ITEM</u>	<u>UNIT</u>
48.14 STRESS ABSORBING MEMBRANE	SQUARE METRE (m ²)

The unit of measurement for crack prevention course shall be the square metre of the area to be covered.

The bid rate shall include full compensation for procuring and providing all the material, including modified bitumen, aggregate, and for mixing and applying the mixture, and for all equipment, labour, supervision, and incidentals for executing the work in accordance with the specifications.

SERIES 4000: BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT

SECTION 4900: CONCRETE PAVEMENTS

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4901 SCOPE

This Division covers the construction of a surface course of Portland cement concrete, with or without reinforcement, and includes, inter alia, the specifications for materials, the placing and compacting of concrete, applying the surface texture, and constructing the joints.

4902 MATERIALS

(a) Cement

Cement shall comply with the requirements of US EAS 18-1:2017 (CEM I or II), AASHTO M85-22 or equivalent standard on approval of the Engineer.

Different brands of cement, or the same brand of cement from different mills, shall not be mixed.

The use of other cementitious binders may be allowed by the Engineer, provided that it can be proved by the Contractor that they perform similarly to the cements specified above.

Suitable means shall be provided for storing and protecting the cement against dampness. Cement which for any reason has become partially set or which contains lumps of caked cement will be rejected. The temperature of the cement at the time of delivery to the mixer shall not exceed 71°C.

(b) Water

Water for use in mixing concrete and mortar and for curing and related purposes shall be obtained from a source approved by the Engineer and shall comply with the requirements of BS EN 1008:2002.

Water shall be clean, fresh and free from detrimental concentrations of acids, alkalis, salts, sugar and other

organic or chemical substances that could impair the durability and strength of the concrete or the embedded steel. The Contractor shall prove the suitability of the water by way of tests conducted by an approved laboratory.

(c) Admixtures to Concrete

Admixtures shall not be used in concrete without the approval of the Engineer who may require that tests be conducted before the admixtures are used to prove their suitability. Admixtures, if their use is allowed, shall comply with the following requirements:

- Admixtures shall be used only in liquid form and shall be batched in solution in the mixing water by a mechanical batcher capable of dispensing the admixture in quantities accurate to within 5% of the required quantity.
- All admixtures shall comply with the requirements of ASTM C494/C494M-17 or AASHTO M 194M/M 194-23 and shall be of an approved brand and type.
- Air entraining agents shall comply with the requirements of ASTM C260-10 OR AASHTO M 154M/M 154-12 (2020).
- Admixtures shall not contain any chlorides.

The Contractor shall submit details of the nominated supplier and shall nominate the proprietary source, type and name for each admixture to be used. The Contractor shall furnish documentary evidence of the quality and chemical compatibility to the Engineer upon request at any stage of the work.

(d) Aggregates

Both coarse aggregate (stone) and fine aggregate (sand) shall comply with the requirements of BS EN 1367-4:2008 and BS EN 12620:2002+A1:2008 or equivalent, subject to the following:

- The drying shrinkage of both the fine and coarse aggregate when tested in accordance with BS EN 1367-4:2008 and equivalent shall not exceed 200% of that of the reference aggregate.

Where there is any doubt about the shrinkage characteristics of aggregates, the Contractor shall submit a certificate by an approved laboratory that gives the shrinkage characteristics of the aggregate.

The drying shrinkage of concrete samples made from each of the required three concrete mixtures for preparing the compressive-strength and flexural-strength samples shall not exceed 0.04%.

- The flakiness index of the stone as specified in BS 812-105.1:1989 shall not exceed 35%.
- Aggregates shall not contain any deleterious amounts of organic materials such as grass, timber or similar materials and shall be free from clay, shale, pyrites and all other impurities as shown in TABLE 4902/1.

TABLE 4902/1: MAXIMUM AMOUNT OF DELETERIOUS SUBSTANCES

Item	Maximum Percentage by Mass (%)	
	Fine Aggregate	Coarse Aggregate
Material Passing 0.075 mm sieve	2.0	1.0
Light-weight material	2.0	2.0
Organic matter	0	0
Clay lumps	1.0	0.5
Other deleterious substances	2.0	1.0

- iv. The fineness modulus of the fine aggregate shall not vary by more than ± 0.2 from the approved modulus.
- v. The coarse part of aggregate shall be roughly cubical in shape and free from excess flat and/or elongated particles.
- vi. In case of coarse aggregates, the weighted loss shall not exceed 12% in the Sodium Sulphate Soundness test (AASHTO T 104-22).
- vii. The Los Angeles abrasion value obtained from the AASHTO T 96-22 test shall not exceed 40%.
- viii. The water absorption of the coarse aggregate shall not exceed 2% by mass, when tested in accordance with BS 812-2:1995.

The combined gradation as per TABLE 4902/2 is given below:

TABLE 4902/2: COMBINED AGGREGATE GRADATION

Sieve Designation (mm)	Percentage by weight passing (%)
37.5	100
28.0	85-95
20.0	68-88
10.0	45-65
5.00	30-55
600 microns	8-30
150 microns	5-15
75 microns	0-5

(e) Materials for Joints

i) Joint Sealers

Hot-poured joint sealer shall conform to ASTM D3406-95 (2000). Cold-poured joint sealant shall be silicone type conforming to ASTM D5893/D5893M-16 (2021). Manufacturer's certificate shall be produced by the Contractor for establishing that the sealant is not more than six months old and stating that the sealant complies with the relevant standard.

ii) Preformed Expansion Joint Filler

Preformed fillers for joints shall conform to AASHTO M 33M/M 33-22, AASHTO M 153-20 TYPE-II, AND AASHTO M 213-22 and shall be punched to admit the dowels. This joint filler shall be used only at abutting structures.

The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint. When the use of more than one piece is authorised for a joint, the abutting ends shall be fastened securely, and held accurately to shape by stapling or other positive fastening.

The use of preformed, closed-cell, polyethylene foam backer joint filler shall conform to ASTM D 1751-18, TYPE I and shall be limited to vertical applications only.

iii) Preformed Elastomeric Compression Seals.

Preformed elastomeric compression seals used shall comply with the requirements of AASHTO M 220-84 (2012). The seals shall be manufactured in accordance with an extrusion process, from an elastomeric material consisting entirely of polychloroprene, which is subsequently vulcanized.

(f) Materials for Reinforcing Steel, Tie-Bars and Dowels

Reinforcing steel for concrete pavements shall be of the type, length, size, spacing, and quantity shown on the plans and shall meet the following requirements:

- All steel shall be clean and free from mill scale, loose rust or oil.

- Reinforcement steel may be either deformed steel bars or cold-drawn steel wire conforming to the following:
- Bar Mats that shall be cold-drawn steel wire or deformed steel bars from new billet steel conforming to AASHTO M 31M/M 31-22. All bars shall have the tensile requirement of Grade 300 or 400. Fabrication of bar mats using deformed steel bars shall be in accordance with ASTM A184/A184M-06. Bar mats fabricated using rolled cold-drawn steel wire shall be in accordance with ASTM A82-01.
- Welded Steel Wire Fabric conforming to AASHTO M55M/M 55-09 (2013). Wire fabric shall not be less than 1.5 metres in width and shall be shipped in sheets and not in rolls.
- Tie bars shall be deformed bars having tensile strength requirement of grade 500. Tie bars for use across joints shall have an epoxy coating conforming to ASTM A775/A775M-22 except that the thickness of the cured coating shall be 250 ± 50 microns.
- Dowel bars shall be plain, round bars having tensile strength requirement of grade 500. They shall be free from burring or other deformation restricting slippage in concrete. Dowel bars shall be coated with an approved material to break the bond between the steel and concrete.

(g) Curing Materials

Curing agents shall be tested in accordance with ASTM C156-20 or BS 7542:1992 and shall comply with the requirements of ASTM C309-19, except that the loss of water within 72 hours shall not exceed 0.40 kg/m². Only approved curing agents shall be used.

Curing agents shall be clear or pigmented as specified or required by the Engineer. A certificate from an approved testing laboratory stating that the curing compound complies with the specified requirements shall be submitted to the Engineer.

Irrespective of the above specifications being met, the curing compound shall be the type that can be applied to a wet surface without loss of stability or impairment of its water retention properties

Some other curing materials for Portland cement concrete which might be used with the approval of the Engineer include:

- Burlap cloth made from jute or kenaf shall conform to AASHTO M 182-05 (2021), Class 4.
- White polyethylene sheeting shall conform to ASTM C171-20 for white opaque polyethylene film.
- White burlap-polyethylene sheeting shall conform to ASTM C171-20.
- Waterproof paper shall conform to ASTM C171-20.

(h) Separation Membrane

Separation membranes, to be used between jointed reinforced concrete surface slabs or unreinforced concrete surface slabs and the sub-base, shall be impermeable plastic sheeting 125 microns thick. Before placing the separation membrane, the sub-base shall be swept clean of all the extraneous materials using air an compressor. The separation membrane shall be omitted when two layers of wax-based curing compound are used.

(i) Concrete Requirements

Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, fly ash, water- granulated blast- furnace slag, water, and chemical admixtures as proposed by the Contractor and approved by the Engineer to produce concrete of the specified strength and workability.

Mix design, manufacture, placing, compaction and

finishing of concrete shall be the responsibility of the Contractor.

i) Concrete Strength

Concrete shall have a minimum characteristic compressive strength after 28 days of 30 MPa.

ii) Proportions

The concrete shall contain the amount of cement as directed by the Engineer.

The water: cement ratio, including moisture on the aggregates, shall be not more than 0.50. This shall be maintained by use of chemical admixtures and or additional if necessary.

The concrete shall be uniformly plastic and workable. The consistency of the concrete shall be determined by the slump test in accordance with relevant standards. A slump value in the range of 25 ± 15 mm is reasonable for paving works but this may be modified depending upon the site requirement and will be approved by the Engineer

Where the Contractor wishes to use an air-entraining agent, the total air content in the freshly mixed concrete shall be $M \pm 1\%$, where M is the target value within the limits of 2% to 4%. Tests shall be conducted in accordance with ASTM C231/C231M-22.

The percentage of entrained air voids in the mix shall be from 3 to 6 per cent.

Where concrete is to be cast between fixed forms the nominal maximum size of the aggregate shall be 37.5 mm.

Where the Engineer has approved of the placement of concrete by means of a self-propelled slip-form paving machine, the mix design, slump and workability shall suit the machine proposed for use.

iii) Determining the Mix Proportions

The preliminary proportions of cement and aggregate required for producing concrete which complies with the requirements of these Specifications shall be determined by way of laboratory tests on concrete manufactured from the cement, coarse and fine aggregates, admixtures (if any) and water proposed for use in the Works.

At least sixty (60) days prior to the construction of the trial pavement as specified in CLAUSE 4917, the Contractor shall submit to the Engineer samples of all the components of the concrete proposed for use, plus a report by an approved testing laboratory showing the mix proportions proposed for each combination of material sources for the concrete. The report shall also show the following:

- o The results of tests on the specified properties of all components.
- o The relationship between the 28-day compressive strength and flexural strength of the concrete at each of at least three water cement ratios namely 0.48, 0.53 and 0.58.
- o The effect of the particular admixture (if any) proposed by the Contractor in regard to variations in admixtures, air content (if air entraining) and concrete setting and sawing times.
- o The effect of at least three water contents on concrete consistency.
- o In determining the relationship between compressive and flexural strength, the tests shall be based on not less than six compressive-strength specimens and six flexural-strength specimens for each water: cement ratio. All strength tests shall be

conducted in accordance with ASTM C39/C39M-21 AND ASTM C78/C78M-22.

iv) Changes in the Mix Proportions or the Materials

If during the progress of the work the requirements set out in SUB-CLAUSE 4902 (h) are not met by concrete manufactured from the materials or material mix proportions being used, the Contractor shall immediately cease producing such concrete and shall effect such changes to the mix proportions and/or materials as may be necessary in order to meet the requirements.

If during the progress of the work, the Contractor wishes to use materials or mix proportions other than those originally approved, or if the materials from the sources originally approved change in regard to properties, the Contractor shall, before proceeding with further work, submit adequate evidence to the Engineer that the new materials or combination of materials will produce concrete which complies with the requirements of SUB-CLAUSE 4902 (h) and will not bring about detrimental changes in the properties of the concrete.

Any such changes made shall be at the Contractor's expense, and no extra payment will be allowed by reason of such changes.

Where concrete is placed by hand and vibrated or finished with hand equipment, the requirements of SUB-CLAUSE 4902 (h) shall remain applicable irrespective of the size of the concrete panel or concrete patch placed. The mix proportions, however, shall be adjusted to promote hand placing, vibrating and finishing. Only if the Contractor has produced written proof to the Engineer that the requirements of SUB-CLAUSE 4902 (h) cannot be complied with under the specific circumstances, the Engineer may change the requirements at his own discretion.

v) Changes in Requirements

The Engineer shall have the power, at any time during the progress of the work, to order changes in the requirements set out in SUB-CLAUSE 4902 (j). In such cases, the Contractor shall be compensated in accordance with the terms of the General Conditions for the additional cost of materials or additional handling, placing and/or other costs, if any, entailed by such changes. If such changes result in savings, the Engineer shall recover such savings from the Contractor.

(j) Handling, Measuring and Batching Materials for Concrete

i) Storing the Materials

The storing of aggregates and cement to be carried out in accordance with SECTION 6403 of MOWT General Specifications.

Aggregates from different sources shall not be stockpiled together unless approved by the Engineer.

The fine aggregate and coarse aggregate shall be separately weighed into the hopper in the respective amounts set by the Engineer in the job mix approval.

The various types of admixtures shall be properly marked and stored separately.

ii) Transporting

When mixing of the concrete is to be done at the job site, materials shall be transported from the batching plant to the mixer in vehicles appropriate for the job.

In the dry batch process, bulk cement shall be transported to the roadside paver in watertight compartments carrying the full amount of cement

required for the batch; or, if permitted, between the fine and coarse aggregate.

Concrete shall be so transported to its final position that segregation or loss of any of the ingredients, or contamination will be prevented and that the mix is of the required workability at the point and time of placing.

Concrete shall be protected against rain, heat, direct sunlight and evaporation, by means of covers. No additional water may be added in transit or where delivered.

The time lapse from the moment when the cement and aggregate are intermingled up to the time of placing and compacting the concrete shall not exceed sixty (60) minutes when concrete is transported in truck agitators, and shall not exceed forty-five (45) minutes in mild weather or thirty (30) minutes when the concrete temperature is 30°C or higher when transported in ordinary trucks.

iii) Proportioning the Components

All components shall be accurately proportioned in approved automatic proportioning devices to within the following tolerances, and supplied separately at the mixing drums.

- o Aggregate: Each fraction within $\pm 3\%$ of the prescribed mass of the fraction in question.
- o Cement: $\pm 2\%$ of the prescribed mass of cement.
- o Water: $\pm 2\%$ of the prescribed volume or mass.
- o Admixtures: Admixtures shall be admixed in part of the mixing water after having been carefully measured in an automatic proportioning device capable of proportioning the admixture in quantities which will not deviate by more than 2% from the required quantities, and shall be done so as to spread the agent uniformly throughout the entire concrete mix during the mixing process.

Water for the mix may be measured by volume or by weight. Methods and equipment for adding air-entraining agent or other admixtures into the batch, shall be as recommended by the manufacturer.

iv) Batch Mixing

All concrete shall be mixed in mechanically operated batch mixers. The concrete may be mixed at the site of the work in a central-mix plant; in truck mixers when allowed, or in a roadside paver as instructed by the Engineer.

The mixing period shall be as directed by the Engineer, if necessary, to produce a homogeneous mass.

The capacity of batching and mixing plant shall be at least 25% higher than the proposed capacity of the paving equipment. Where the mixing plant is supplied with more than one drum, the same unit shall be used for proportioning the components.

The drums shall always be kept clean, and all build-up shall be removed. The total period between the times that the cement is placed in the drums until mixing starts shall not exceed 15 minutes.

No more concrete shall be mixed than can be placed, finished, and covered during daylight, unless the Engineer approves an artificial lighting system.

v) Transit-Mixing

The Contractor will be permitted to use appropriate truck mixers, which agitate previously mixed concrete in transit.

Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators. The time elapsing from the time water is added to the mix until the concrete is deposited in place shall not exceed sixty (60) minutes when hauled in truck mixers or truck agitators.

4903 PREPARING THE UNDERLYING LAYERS

(a) Preparation of Sub-base

The underlying layers shall be constructed in accordance with the Standard Specifications and the Special Specifications (if any) up to the level of the underside of the concrete slab.

The Contractor shall note the provisions regarding the construction tolerances for underlying pavement layers and shall make provision in his prices for any additional concrete, which may be necessary in respect of irregularities in the layer underlying the concrete pavement.

The sub-base shall be brought to reasonably close conformity to the lines, grades and typical sections as shown on the plans or as designated by the Engineer.

The sub-base shall include an area 900 mm in width extending beyond the edges of the road base or pavement unless shown otherwise on the Drawings.

When kerb and gutter is constructed contiguous with the pavement, the sub-base shall include an area 610 mm in width extending beyond the back of the curb and gutter.

The Sub-base shall be completed for at least 800 metres in advance of concrete placing operations when this distance is available.

(b) Conditioning of Sub-base

i) Compaction

The entire sub-base layer shall be thoroughly compacted. Any portion of the sub-base that is not accessible to a roller shall be compacted with hand tampers to obtain the density requirements for the material.

ii) Wetting the Sub-base

The sub-base shall be kept continuously wet for a period of at least one (1) hour before the concrete is placed. Immediately before the concrete is placed, the excess water shall be broomed off the road ahead of the paver so as to ensure that the sub-base will still be damp when the concrete is placed, but no puddles of water or deleterious matter shall be left on the road.

iii) Protection

Before placing any surfacing material on any section, open drains and drains along that section shall be completed to drain the water effectively. Until the sub-base has been checked and approved by the Engineer, no laying operation of the concrete slab should be commenced.

(c) Applying a Bituminous Prime Coat or Placing a Separating Membrane

Unless otherwise specified in the Specifications, a separating membrane shall be placed on the completed and approved sub-base or capping layer, or where shown on the Drawings, a bituminous prime coat shall be applied at a rate of application ordered by the Engineer.

Separation membranes, to be used between jointed reinforced concrete surface slabs or unreinforced concrete surface slabs and the sub-base, shall be laid flat without creases. Where an overlap of plastic sheets is necessary, this shall be at least 300 mm.

Before any pavement concrete is placed, the bituminous prime coat shall be checked and any areas having

deficient or poor coverage, or where the bituminous coating has been damaged, shall be repaired as directed by the Engineer. The sprayed surface shall then be thoroughly cleaned. The bituminous prime coat shall be dry before any reinforcing steel, tie bars, dowels or concrete may be placed.

4904 PLACING CONCRETE

(a) Compacting

The concrete shall be fully compacted by means of approved equipment and shall be free from honeycombing and planes of weakness. The average amount of air voids as measured in concrete cores shall not exceed 3% without air-entrainment when measured by ASTM C173/C173M-16.

Over-vibration resulting in segregation, surface laitance, or leakage (or any combination of these) will not be acceptable.

No paving in the downhill direction will be allowed if tearing of the concrete occurs. The Contractor shall take the necessary measures to the satisfaction of the Engineer to prevent tearing of the concrete for example by carrying out the paving in the uphill direction.

(b) Time for Placing and Compacting

The placing, compacting and finishing of the concrete shall be carried out as quickly as possible, and the operations shall be so arranged that in any transverse section of the pavement the concrete shall be fully compacted and finished within 2 hours of having been mixed. This time shall be reduced by 30 minutes for every 5°C by which the concrete temperature is above 20°C at the time of placing, unless otherwise permitted by the Engineer.

Unless adequate lighting facilities, approved by the Engineer, are provided beforehand by the Contractor, the placing of concrete pavement shall cease in good time so that the finishing operation can still be completed during daylight hours.

Paving operations shall be continuous, and the rate of paving shall be adjusted to suit the rate of delivery of the concrete and the width of concrete pavement strip to be placed in a single uninterrupted operation shall be as shown on the Drawings.

(c) Adverse Weather Conditions

i) Protection Against Rain and Hail

No concrete shall be placed during rainy weather. For the concrete to be properly protected against rain and hail before it has sufficiently hardened, the Contractor shall have available at all times frame-mounted waterproof covers for protecting the surface of the unhardened concrete. In addition, when slip forms are used, the Contractor shall also provide acceptable emergency protection for the slab edges.

When rain is imminent, all paving operations shall cease and the Contractor shall take the necessary steps to protect the unhardened concrete. The Contractor shall be responsible for the repair of any damage to the concrete that may occur. If the damage is limited to texture, it shall be retextured in accordance with the directions of the Engineer.

ii) Cold-Weather Paving

No concreting shall be done when the concrete temperature is below 5°C and the temperature is further falling.

iii) Hot-Weather Paving

When paving is done during hot weather and when the temperature of the fresh concrete can

be expected to exceed 25°C, the Contractor shall implement appropriate precautionary measures to place the concrete at the coolest temperature practicable. Besides, in adverse conditions like high temperature, low relative humidity, excessive wind velocity, imminence of rains etc., tents on mobile trusses may be provided over the freshly laid concrete for a minimum period of 3 hours as directed by the Engineer.

Paving operations shall cease when the concrete temperature as discharged at the paver exceeds 32°C.

iv) Responsibility for Protection

The Contractor shall be responsible for the quality and strength of the concrete placed and for its protection. Any concrete damaged by adverse weather (e.g. any combination of high ambient temperature, low humidity, wind, rain and hail) shall be removed and replaced at the Contractor's expense.

(d) Maintaining Continuity During Placing

The Contractor shall make adequate advanced arrangements for preventing delay in delivering and placing the concrete.

An interval of more than thirty (30) minutes between the placing of any two consecutive batches or loads of concrete shall constitute sufficient reason for the Engineer to have the paving operations stopped. The Contractor shall then, at his own expense, make a construction joint in the concrete already placed, at the location and of the type directed by the Engineer.

Paving operations shall be continuous, and the rate of paving shall be adjusted to suit the rate of delivery of the concrete.

(e) Width of Placing

The width of concrete pavement strip to be placed in a single uninterrupted operation shall be as shown on the Drawings or specified in the Special Specifications.

4905 SIDE-FORMS, RAILS AND GUIDE WIRES

(a) Side-Forms

Side-forms and rails shall be so designed, manufactured, set and supported that the completed concrete pavement will comply with the tolerance specified in series 7000 of these specifications.

Where the forms are tested with a 3m straightedge, the top edge shall not deviate by more than 3mm at any place; or the sides by more than 6mm. The sides shall not deviate by more than 3mm from the vertical. The height of the side-forms shall not be less than the nominal thickness of the concrete slab, less 15 mm; and the resulting opening between the side-forms and the layer on which it is supported shall be caulked with a stiff mortar consisting of one (1) part of rapid-hardening cement and three (3) parts of sand by volume and finished vertically on the inside. The mortar shall have hardened before any concrete may be cast against it.

The rails, side-forms and running surface shall be kept clean in front of the wheels of all paving equipment.

Side-forms shall not be removed before the concrete has hardened sufficiently to prevent damage being done to the sides and loosening of tie-bars or dowels, if any; and not earlier than six (6) hours after the completion of the construction of the slab. The side-forms shall also be removed in a timely manner to permit the sawing of transverse joints up to the edges of the concrete slab.

Projecting tie-bars and/or the concrete shall not be damaged during removal of the side-forms.

Before any side-forms may be ordered or brought onto the site, particulars regarding the side-forms shall have been approved by the Engineer.

(b) Rails

The wheels of spreading and finishing machines and frame-mounted covers shall not run directly on the top surface on the side-forms but on rails rigidly attached to the forms, unless the forms are specially made to double as rails.

(c) Electronic Control Systems

Where a slip-form paver is used, the alignment levels for placing the concrete shall be controlled automatically from guide wires by sensors attached at the four corners of the slip-form paving machine. The alignment and level of ancillary machines for finishing, texturing and curing shall be automatically controlled relative to the guide wires and to the surface and edges of the slab.

Guide wires shall be so designed, manufactured and fixed that the paver will be capable of producing a completed slab, which will comply with the tolerance specified in SERIES 7000 of these specifications.

Other control methods will also be considered, and should the Engineer be satisfied that they will produce satisfactory results, their use will have to be approved in writing.

(d) Inspection of Side-Forms, Guide Wires and Rails

Before any concrete may be cast, the Engineer shall approve all assembled side-forms, guide wires and rails. For this purpose, the Engineer shall be given sufficient notice and opportunity.

Approval by the Engineer will not relieve the Contractor of any of his obligations to construct the concrete slab in accordance with the specified dimensions and tolerances.

4906 PLACING, COMPACTING AND FINISHING WITH SIDE-FORMS

The paving train shall consist of several powered machines that spread, compact, finish, texture and cure the concrete in a continuous operation.

(a) Placing and Spreading

The concrete shall be spread uniformly by means of a purpose-made mechanical hopper spreader running on rails and capable of spreading the concrete uniformly to a specified level and to a uniform un-compacted density over the entire surface of the slab. The machines shall be capable of being rapidly adjusted for changes in slab thickness or cross fall.

(b) Compaction

The concrete shall be fully compacted by vibration or by a combination of mechanical surface vibration, internal vibration and tamping. The power supply to the vibrators shall cut out automatically as soon as the compaction equipment stops moving.

Suitable internal vibrators shall be used against the side-forms and at joint assemblies to ensure compaction throughout the pavement layer.

(c) Final Finishing

The surface of the concrete shall be finished smooth and true to grade and level by means of an initial finishing machine equipped with a transverse or oblique oscillating beam.

The final finish of the surface of the slab shall be carried out by a machine that incorporates twin oblique oscillating finishing beams. The beams in the case of

both machines shall be readily adjustable for both height and tilt. The leading beam shall be vibrated. The beam shall be supported on a carriage with two wheels on either side, at least four (4) metres apart in the longitudinal direction. The oscillating beams shall be of rectangular section, spanning the full width of the slab and each weighing not less than 170 kg/m.

Hand-finishing of the concrete surface shall be reduced to the absolute minimum and shall be used only to correct minor imperfections and marks on the surface.

Before the concrete starts setting, all pavement edges and the edges of joints shall be rounded off to the prescribed radius.

After finishing, the Contractor shall test the concrete surface with a straightedge of at least 3 m in length. Irregularities indicated by the straightedge shall be removed with a long-handled hand-operated scraping straightedge of at least 3m length. A gangplank shall be used when walking on the concrete.

The final finisher shall be able to finish the surface to the required level and smoothness as specified, care being taken to avoid bringing up of excessive mortar to the surface by overworking.

In case of damages during construction, the Contractor shall repair all damage at his own cost or as directed by the Engineer.

(d) Constructing the Concrete Pavement in More than One Contiguous Strip

Where concrete is placed adjacent to an existing pavement, that part of the paving equipment running on the existing pavement shall have flanged wheels on flat-bottom section rails weighing not less than 15 kg/m or by replacing the flanged wheels on that side of the machines by smooth flangeless wheels. Before the paving operation commences, the surface be thoroughly cleaned and brushed to remove all extraneous materials. The wheels shall run at a distance of not less than 300 mm from the edge of the pavement to prevent the pavement edge from spalling or cracking.

No equipment shall be run on the existing pavement until the concrete is strong enough to prevent damage from occurring, but in any case not earlier than fourteen (14) days after the construction of the slab.

Where visible cracks occur or any other damage is done to the pavement, further work involving the paver shall be suspended immediately.

In case of damages during construction, the Contractor shall repair all damage at his own cost or as directed by the Engineer.

4907 PLACING, COMPACTING AND FINISHING WITH SLIP-FORM EQUIPMENT

(a) General

Slip-form paving equipment shall be used for spreading, compacting, floating and finishing the concrete in a continuous operation and in such a manner that a minimum of finishing by hand will be required and a dense and homogeneous concrete to the proper level and grade will be produced.

(b) Placing and Spreading the Concrete

The concrete shall be deposited without segregation ahead of the paver across its whole width and to a height, which at all times is in excess of the required surcharge.

The deposited concrete shall be struck off to the necessary average and differential surcharge by means of a strike-off plate or screw auger device extending across the entire width of the slab. The strike-off equipment shall be capable of being rapidly adjusted for

changes in slab thickness or cross fall.

(c) Compacting and Finishing

The slip-form paver shall compact the concrete over the full paved width by means of internal vibration only or by a combination of internal and surface vibration. The vibration shall be variable with a maximum energy output of at least 2.5 kN per metre width of slab per 300 mm depth for a laying speed of up to 1.5 metres per minute or pro-rata for higher speeds.

The level and grades of the surface shall be automatically controlled within the prescribed tolerances by means of a sensing device running on guide wires as specified.

The consistency of the concrete shall be so controlled that the edge slump will not exceed the tolerance specified in SERIES 7000 of these specifications.

If approved by the Engineer, metal side-forms of sufficient thickness may be used to maintain the proper shape and line.

After the concrete has been finished by the finishing devices incorporated in the slip-form paving equipment, the surface of the concrete shall be checked by means of a straight-edge of not less than 3.0 metres in length. High spots indicated by the straightedge shall be removed by hand floats.

After the final finishing and texturing of the concrete, but before curing, the pavement edges shall be rounded to the prescribed radius.

(d) Constructing the Concrete Pavement in More than One Contiguous Strip

Except for the wheels, which are in the case of slip-form pavers to be replaced with rubber cushioned crawler tracks; the provisions of CLAUSE 4906 shall apply when concrete is being placed in more than one contiguous strip.

(e) Track Support

The Contractor shall at his own cost ensure that adequate track support is provided to suit the needs of the slip-form paver, either by extending the upper pavement layers or by providing alternative support layers.

4908 PLACING, COMPACTING AND FINISHING WITH HAND EQUIPMENT

(a) General

Where the slabs are too small or irregular, or the site is so restricted as to render the use of the methods described in CLAUSES 4906 AND 4907 impracticable, concrete shall be placed, compacted and finished by means of hand-guided twin vibratory beams and poker vibrators. If necessary, the consistency of the concrete shall be adjusted so as to be suitable for placing with hand-operated equipment.

(b) Forms

Side-forms complying with the requirements of CLAUSE 4905 shall be used.

(c) Placing, Spreading, Compacting and Finishing the Concrete

The concrete shall be placed and spread uniformly to a surcharge of about one-fifth more than the final pavement thickness and shall then be compacted, struck off and finished to the level of the side-forms.

The concrete shall be compacted by means of vibrating finishing beams. In addition, internal poker vibrators shall be used for slabs thicker than 150 mm. Where used, the pokers shall be inserted at points not more than 500 mm

apart over the whole area of the slab, and adjacent to side-forms or the edge of a previously constructed slab.

The surface shall be regulated and finished to the level of the side-forms or adjacent slabs by using twin vibrating beams. The beams shall be of metal with a contact surface at least 50 mm wide and a vibrating unit having a minimum centrifugal force of 4 kN with a frequency recommended by the manufacturer or an equivalent compactive effort. The vibrating beams shall be moved forward at a steady speed of 0.5 m to 1.0 m per minute while vibrating over the compacted surface, to produce a smooth finish.

The surface shall then be further smoothed by at least two passes of a scraping straightedge with a blade length of not less than 2.4 m.

The final surface finish of the concrete shall be affected by means of hand-operated floats. The finishing of the concrete surface shall be as specified in SECTION 6200 of these specifications.

4909 STEEL REINFORCEMENT

(a) General

Spacing of bars shall be as indicated on the Drawings or specified in the Special Specifications.

Laps in longitudinal bars shall not be less than 35 bar diameters or 450 mm, whichever is greater. In continuously reinforced concrete slabs, only one third of the laps may be in any one transverse section, except in single bay width construction where half the laps may be in any one transverse section. There shall be a minimum of 1.2 m longitudinally between groups of transverse laps or laps in prefabricated reinforcement sheets. Alternatively, the reinforcement may be butt welded.

Laps in any transverse reinforcement shall be a minimum of 300 mm.

Where prefabricated reinforcement sheets are used and longitudinal and transverse laps would coincide, no lap is required in the transverse bars within the lap of the longitudinal reinforcement. These transverse bars may be cropped or fabricated shorter so that the requirements for cover are met. Alternatively, prefabricated sheets incorporating splices (i.e. flying ends) may be used to provide nesting of reinforcement in both directions at lap positions. The lengths of the laps shall be the minimum values previously stated.

If the reinforcement is positioned prior to concreting, it shall be fixed on metal supports/chairs, spacers and retained in position at the required depth below the finished surface and distance from the edge of the slab so as to ensure that the required cover is achieved.

Reinforcement assembled on site shall be tied, or firmly fixed, at sufficient intersections to provide sufficient rigidity to ensure that the reinforcement remains in the correct position during construction of the slab.

Alternatively, when a reinforced concrete slab is constructed in two layers, the reinforcement in the form of prefabricated sheets may be placed on or into the bottom layer, which shall be spread and compacted to such a level that it will support the reinforcement without distortion at the required position in the slab. The sheets shall be tied together at overlaps and after the second layer has been spread and compacted, the reinforcement shall have the required cover.

When a reinforced concrete slab is constructed at maximum width of 6 m or more, the transverse reinforcement in the centre of the slab shall be a minimum of 12 mm nominal diameter bars at 600 mm centre to centre. This reinforcement shall be at least 600 mm longer than one third of the width of the slab and be lapped to other transverse reinforcement bars or sheets,

or be continuous across the whole width of each slab.

(b) Jointed Reinforced Concrete Slabs

The reinforcement shall be so placed that after compaction of the concrete, the cover below the finished surface of the slab is as indicated on the Drawings, with a tolerance of ± 10 mm for slabs less than 270 mm thick and ± 20 mm for slabs 270 mm thick or more.

The vertical cover between any longitudinal joint groove forming strip and any reinforcement shall be a minimum of 30 mm.

Any transverse bars shall be at right angles to the longitudinal axis of the carriageway. Any transverse reinforcement shall terminate at the specified distance from the edge of the slab and longitudinal joints as shown on the Drawings, with a tolerance of ± 25 mm. No longitudinal bar shall lie within 100 mm of a longitudinal joint. The reinforcement shall terminate 300 mm ± 50 mm from any transverse joint, excluding emergency construction joints.

(c) Continuously Reinforced Concrete Slabs

The reinforcement shall be positioned with the diameters and spacing shown on the Drawings. Except where otherwise shown on the Drawings, the longitudinal bars shall be parallel to the centreline of the road.

The reinforcement shall be positioned so that, after compaction of the concrete, it shall be at mid- depth of the specified thickness of the slab ± 25 mm. No longitudinal bar shall lie within 100 mm of a longitudinal joint. In reinforcement assembled on site, longitudinal bars shall be placed immediately above any transverse bars, which shall be at right angles to the longitudinal axis of the carriageway or as otherwise specified or shown on the Drawings.

Any transverse reinforcement shall terminate at the specified distance from the edge of the slab and longitudinal joints as shown on the Drawings, with a tolerance of ± 25 mm.

4910 SURFACE TEXTURE

(a) General

After the concrete has been placed, spread, compacted, finished and completed and before the curing membrane is applied, the surface of the concrete shall be provided with a surface texture.

The direction of texturing shall be at right angles to the longitudinal axis of the pavement.

The surface texture shall be applied and completed before the concrete is so hard that the surface will be torn and coarse aggregate unduly loosened during texturing.

(b) Equipment

The required texturing shall be effected by means of a machine which spans the full width of the concrete pavement and which is guided in regard to both level and direction by the rails in the case of side-form construction or by the paver guide wires in the case of slip-form construction.

i) Burlap Drag Equipment

Unless otherwise authorised by the Engineer, the burlap drag shall be attached to the front of the texturing machine or to an additional machine which spans the full width of the concrete pavement and is placed in such a way that the full width of the concrete pavement is covered in one operation and, when not in use, the entire drag can be lifted clear off the pavement.

The dimensions of the burlap drag shall be such that at least 1.0 m of the material is in contact with the

surface of the concrete pavement measured in the direction in which the drag is being moved. The burlap drag shall consist of at least two layers of 340 g/m² burlap with the bottom layer at least 150 mm longer than the top layer at the dragging end; however, at the discretion of the Engineer, the number of layers may be increased to four. The transverse threads of the trailing 150 mm to 300 mm of the burlap drag shall be removed.

ii) Tine Grooving Device (Grooving Comb)

The pavement shall be grooved by means of a metal tine grooving device. The tines shall be made from flat spring steel 0.6 mm in thickness and 3 mm in width, 125 mm in length and spaced at between 12 mm and 25 mm in an approved random pattern. The Engineer may, however, require a different random pattern or equal spacing of the tines during the course of the work, and provision shall be made to supply different sets of combs as required. The combs for applying the texturing shall be at least 3.0 m wide. It must also be possible to adjust the combs to a lower position in order to compensate for wear.

iii) Burlap-Drag-and-Grooved Texture

This texture shall be obtained by first applying a burlap-drag finish to the concrete surface and then by grooving it with a grooving comb.

The first pass of the burlap drag shall be made as soon as construction operations permit and before the wet sheen has disappeared from the surface. Burlap dragging shall be repeated until a gritty and uniform texture having the required depth of texture has been obtained.

Every morning the burlap drag shall be wetted and kept moist throughout the day. At the end of each day's pour, the burlap mats shall be cleaned or discarded and replaced with new burlap if cleaning is not possible.

After the concrete has hardened, all loose particles generated by the cutting of the grooves shall be broomed off the surface with stiff hand brooms or mechanically operated rotary brooms.

When measured with a suitable depth gauge, the grooves shall be not less than 2 mm and not more than 4 mm in depth.

The Engineer may permit the use of texturing equipment other than the grooving comb, provided that it produces a texture similar to that produced by the metal tines.

(c) Hand Texturing

Texturing the surface with hand-held brooms or combs shall be allowed only where the pavement is so small or irregular, or the site is so restricted as to make the use of the texturing machine impracticable, or in cases of mechanical breakdown of the texturing machine, in which case it may be used for the required texturing of concrete already placed. The brush or comb to be used then shall be of the same type and width used in the machine.

In order to ensure straight grooves, the comb shall be operated against a straight-edge placed at right angles to the pavement centreline.

The same requirements regarding groove dimensions or texture depth as for machine-texturing will apply.

4911 CURING

The exposed surfaces, including the sides of the slab, shall be treated immediately after the required texturing of the surface has been achieved and after the side formwork has been removed by the

application of a clear/ pigmented curing compound as specified in accordance with the directions of the manufacturer.

The curing compound shall be sprayed onto the surface at a rate of 0.35 litre/m² or as approved by the Engineer by means of a mechanical distributor capable of producing a fine fog-type of spray, which will not damage the surface of the concrete. The curing compound shall be applied in two layers with the distributor moving in opposite directions for the two applications. Coverage shall be uniform over the entire surface and the rate of application of the curing compound shall be carefully controlled.

During spraying operations, the curing compound shall be continuously stirred mechanically to keep the pigmentation in suspension. The spray nozzles shall be adequately protected against wind.

The curing membrane shall be maintained intact for at least seven (7) days after the concrete has been placed. Any damage to the curing membrane, caused by the Contractor's activities, shall be repaired by hand-spraying the affected areas.

Areas inaccessible to the mechanical distributor such as irregular shaped areas, or those with varying widths or shapes, shall be sprayed with curing compound by means of approved hand spraying equipment, at the specified rate of application.

4912 TRANSVERSE JOINTS

(a) General

Transverse joints shall be provided in unreinforced and jointed reinforced concrete slabs and shall be contraction, construction, expansion or warping joints at the spacing shown on the Drawings.

Transverse joints shall be straight within the following tolerances along the intended line of the joint (line transverse to the longitudinal axis of the carriageway):

- Deviations of the filler board or bottom crack inducer from the intended line of the joint shall not be greater than ± 10 mm;
- The best fit straight line through the joint groove as constructed shall not be more than 25 mm from the intended line of the joint;
- Deviations of the joint groove from the best fit straight line of the joint shall not be greater than 10 mm.
- Transverse joints on each side of a longitudinal joint shall be in line with each other and of the same type and width.

Concrete pavement layers shall be isolated from fixed structures by expansion joints; or earthworks or a granular layer over the structure; or by lengths of fully flexible pavement construction. At the interface of Concrete and flexible pavement, at least 3 m long reinforced buried transition slab shall be provided to give a long-lasting joint at the interface as per Drawings and as directed by the Engineer.

(b) Contraction Joints

Contraction joints shall consist of:

- A sawn joint groove;
- Dowel bars; and
- A sealing groove.

(c) Expansion Joints

Expansion joints shall consist of:

- A joint filler board;
- Dowel bars; and
- A sealing groove.

The filler board shall be positioned vertically within the prefabricated joint assemblies along the line of the joint and at such depth below the surface as will not impede the passage of the finishing beams on the paving machines.

The joint filler board together with the sealing groove shall provide a complete separation of adjacent slabs and any spaces around dowel bars and between the layers underlying the slab. The filler board shall be packed with a suitable compressible material after fixing the joint assembly.

(d) Warping Joints

Warping joints shall consist of:

- A sawn groove;
- Tie bars; and
- A sealing groove.

(e) Construction Joints

Construction joints made at the end of a working day in unreinforced concrete slabs and jointed reinforced concrete slabs shall be contraction joints. In the event of mechanical breakdown of the concreting machinery, or at the onset of adverse weather, emergency joints may be formed.

Emergency joints in unreinforced concrete slabs shall be contraction joints not less than 2.5 m from the preceding or succeeding joint position.

Emergency joints in jointed reinforced concrete slabs shall be not less than 2.5 m from the preceding or succeeding joint position. The stop end formwork shall be sufficiently rigid to ensure that dowel bars, tie bars or reinforcement will be held in position in compliance with the Specification, and placed in such a position that it permits the longitudinal reinforcement to project through the joint for a distance of at least 750 mm.

Construction joints in continuously reinforced concrete slabs at the end of the day or in an emergency shall not be constructed within 1.5 m of any lap in the longitudinal reinforcement. The stop-end formwork shall be sufficiently rigid to ensure that the longitudinal reinforcement and the tie bars, which project through the joint, are held in the correct position.

4913 LONGITUDINAL JOINTS

(a) General

Sawn or wet-formed longitudinal joints shall be provided in surface slabs at the positions as shown on the Drawings. Generally, bay widths are not to be greater than 4.5 m for unreinforced slabs, or 6 m for reinforced concrete surface slabs with transverse reinforcement.

Wet-formed longitudinal joints shall consist of wet-formed joint grooves, a bottom crack inducer and tie bars except where transverse reinforcement is permitted in lieu.

Longitudinal joints shall be constructed within the following tolerances:

- Deviations of the bottom crack inducer from the intended line of the joint, parallel to the axis of the road shall not be greater than 13 mm;
- The joint groove shall be located vertically above the bottom crack inducers within a horizontal tolerance of 25 mm;
- The best fit line along the constructed joint groove shall be not more than 25 mm from the intended line of the joint;
- Deviations of the joint groove from the best-fit line of the joint shall not be greater than 10 mm.

- Sawn longitudinal joints shall consist of joint grooves.

Tie bars may be replaced by continuous transverse reinforcement across the joints in continuously reinforced concrete slabs which are constructed in more than one lane width in one operation, provided that the transverse reinforcement is a minimum of 12 mm diameter bars at 600 mm centres. The transverse reinforcement in these circumstances shall be protected by suitable bituminous paint or equivalent coating for a distance of at least 75 mm either side of the joint.

(b) Longitudinal Construction Joints

Longitudinal construction joints between separate slabs shall have tie bars with a joint groove. Alternatively, if split-forms are used, the transverse reinforcement, if 12 mm diameter or more, may be continued across the joint for a minimum of 500 mm or 30 times the diameter of the transverse reinforcement bars, whichever is the greater. The transverse reinforcement in these circumstances shall be protected by suitable bituminous paint or equivalent coating for a distance of at least 75 mm either side of the joint. Where the edge of the concrete slab is damaged, it shall be made good before the adjacent slab is constructed.

4914 JOINT GROOVES

(a) General

Transverse contraction or warping joint grooves shall be sawn in the hardened concrete.

Transverse joint grooves, which are initially constructed less than the full width of the slab, shall be completed by sawing through to the edge of the slab and across longitudinal joints as soon as any forms have been removed and before an induced crack develops at the joint.

(b) Sawn Transverse and Longitudinal Joint Grooves

Sawing shall be undertaken as soon as possible after the concrete has hardened sufficiently to enable a sharp-edged groove to be produced without disrupting the concrete and before random cracks develop in the slab.

The grooves shall be at least $\frac{1}{3}$ of the specified depth of the slab and of width not less than 3 mm or as directed in the Drawings.

The sealing groove may be sawn to the required width later. Expansion joint sealing grooves shall be sealed as soon as practical after sawing.

(c) Wet-Formed Longitudinal Joint Grooves

When slabs are constructed in more than one lane width in one operation, a joint groove shall be formed by inserting a groove-former ahead of the finishing beams from a dispenser. The concrete so displaced shall be re-compacted by a vibrating compactor or similar device, at least 300 mm wide operating symmetrically along the line of the joint.

After finishing the concrete, the groove-forming strip shall be in the correct position and alignment, within 10° of the vertical, and to sufficient depth below the surface to allow for the passage of the finishing beam within the range of 0-3 mm below the finished level of the slab. Groove-forming strips in wet-formed longitudinal joint grooves shall be left in place.

(d) Construction Joint Grooves in Surface Slabs

The grooves shall be formed by fixing a groove-former; or strip or cork seal; along the top edge of the slab already constructed, before concreting the adjacent slab.

Where the edge of the concrete is damaged, it shall be ground or made good before fixing the groove-forming

strip.

Alternatively, the subsequent slab may be placed adjacent to the first and a sealing groove sawn later in the hardened concrete to the minimum depth specified or to the manufacturer's instructions if greater, and to sufficient width to eliminate minor spalling of the joint arris, up to a maximum of 25 mm for longitudinal joints and 40 mm for transverse joints. The joint shall be sealed in compliance with CLAUSE 4916.

(e) Groove Formers and Bottom Crack Inducers

Except where joint grooves are sawn, a bottom crack inducer shall be provided at each longitudinal joint position. The bottom crack inducer shall be triangular or inverted Y-shaped fillet, with a base width not less than the height, made of timber or rigid synthetic material. It shall be firmly fixed to the sub-base so as to remain in position during the whole process of constructing the slab.

The combined depth of groove-formers and bottom-crack inducers shall be between $\frac{1}{4}$ and $\frac{1}{3}$ of the depth of the slab and the difference between the depth of the groove-former and the height of the bottom-crack inducer shall not be greater than 20 mm.

Groove-forming sealing strips for wet-formed longitudinal joints shall be inserted continuously along the joint.

4915 TIE BARS AND DOWELS

(a) General

Dowels and tie bars shall be placed across joints where indicated, correctly aligned, and securely held parallel to the surface of the finished pavement, such that after placement they remain in their specified location. The spacing and vertical location of dowels and tie bars shall be as detailed except where the planned spacing cannot be maintained because of form length or interference with form braces. In such cases, closer spacing with additional dowels or tie bars shall be used.

All reinforcement, dowels and tie bars shall be clean and free of oil, grease, loose rust and other foreign material when the concrete is placed. Paint the free portions of the dowels, including ends, with two coats of bituminous emulsion. The unpainted portions of dowels shall be installed in the initially placed concrete slab.

Dowels installed in contraction joints during paving operations shall be held securely in position by means of rigid metal frame cradles to prevent them from rising, sliding out or becoming distorted under paving operations.

Dowels and tie bars in fixed-form paving shall be placed by the bonded-in-place method. Installation by removing and replacing dowels and tie bars in preformed holes, including their withdrawal to assist in form stripping, will not be permitted.

(b) Tie Bars

Tie bars in warping joints and wet-formed longitudinal joints as per dimensions and spacing as shown in the drawings. These shall be made up into rigid assemblies with adequate supports and fixings to remain firmly in position during the construction of the slab.

Alternatively, tie bars at longitudinal joints may be mechanically inserted by vibration from above using a method that ensures re-compaction of the concrete around the tie bars.

At longitudinal construction joints, tie bars may be adequately fixed to side-forms or inserted into the side of the slab by a method which ensures re-compaction of the concrete around the tie bars; and adequate bond.

Tie bars in warping joints shall be positioned from the top

surface of the slab within +20 to -10 mm of the mid depth of the slab.

Tie bars in other joints shall be positioned to remain in the middle from the top or within the upper middle third of the slab depth, approximately parallel to the surface and approximately perpendicular to the line of the joint, with the centre of each bar on the intended line of the joints within a tolerance of 50 mm; and with a minimum cover of 30 mm below any top crack-inducer of joint groove for slabs 200 mm thick or more; or 20 mm for slabs up to 200 mm thick. Spacing of tie bars on curves of radius less than 360 m shall not be less than 350mm

At transverse construction joints in continuously reinforced concrete, tie bars shall be fixed at twice the normal spacing midway between the longitudinal reinforcement bars so that 750 mm extends each side of the joint at the same level as the longitudinal reinforcement and be tied to the transverse reinforcement. Where paving from a construction joint is not resumed within 5 days, an extra longitudinal reinforcement bar 8 m long shall be lapped and tied to each tie bar. These extra bars may be combined with the tie bars. Where the spacing between longitudinal reinforcement and the extra 8 m long bars is less than 90 mm, the nominal size of aggregate shall be 20 mm for a sufficient number of concrete batches to complete that section of pavement.

Where tie bars are used in longitudinal joints in continuously reinforced concrete they shall be placed at the same level as the transverse reinforcement and tied to the longitudinal reinforcement.

Where adjacent lanes of pavement are constructed separately using side forms, the tie bars may be bent at right angles against the vertical face/ side of the first lane constructed and straightened before placing concrete in the adjacent lane. Broken or damaged tie bars shall be repaired or replaced as required. The groove for sealant shall be cut in the pavement lane placed later.

(c) Dowels

Dowel bars shall be rigidly supported both in vertical and horizontal alignment, on cradles in prefabricated joint assemblies positioned prior to construction of the slab. For contraction joints, as an alternative to prefabricated assemblies, dowel bars may be mechanically inserted with vibration into the concrete by a method, that ensures full re-compaction of the concrete around the dowel bars, and the surface finished by a diagonal finishing beam, or a longitudinal oscillating float travelling across the slab.

Dowel bars shall be positioned at mid-depth from the surface level of the slab ± 20 mm. They shall be aligned parallel to the finished surface of the slab, to the centreline of the carriageway and to each other within the following tolerances after construction of the slab:

- All bars in a joint shall be within ± 6 mm per 300 mm length of bar;
- Two-thirds of the bars shall be within ± 4 mm per 300 mm length of bar;
- No bar shall differ in alignment from an adjoining bar by more than 6 mm per 300 mm length of bar in either the horizontal or the vertical plane;
- Bars shall be equally positioned about the intended line of the joint within a tolerance of 25 mm; and
- Cradles supporting dowel bars shall not extend across the line of the joint.

4916 SEALING OF JOINT GROOVES

(a) General

All transverse joints in surface slabs, except for construction joints in continuously reinforced concrete slabs shall be sealed using one of the joint seals

described in SUB-CLAUSE 4902 (e). Additionally, longitudinal joints, which are sawn or widened, shall be sealed.

(b) Preparation of Joint Grooves for Sealing

That part of the groove-former used to form the sealing groove or any temporary seal shall be removed cleanly without damaging the joint arises to a minimum depth of 25 mm where compression seals are used; or otherwise to such depth as will provide an applied seal to the dimensions shown in the Drawings after allowing for any necessary caulking material.

If joint grooves are not initially constructed to provide the minimum dimensions for the joint seals as given in the Drawings, they shall be widened by sawing. Joint grooves formed by tapered formers need not be widened. The sealing grooves shall be cleaned out immediately after sawing using high- pressure water jets to remove all slurry from the joint before the slurry hardens.

If rough arises develop when grooves are made, they shall be ground to provide a chamfer 5 mm wide. If the groove is at an angle up to 10° from the perpendicular to the surface, the overhanging edge of the sealing groove shall be sawn, or ground perpendicular. If spalling occurs or the angle of the former is greater than 10° the joint sealing groove shall be sawn wider and perpendicular to the surface to encompass the defects up to a maximum width, including any chamfer, of 40 mm for transverse joints and 25 mm for longitudinal joints.

For applied sealants, the sides of the joint sealing groove shall be scoured by dry abrasive blasting. This shall not be carried out before the characteristic compressive strength of the concrete is expected to reach 15 MPa. When compression seals are used, the sides of the groove may be ground or wire brushed.

For hot and cold applied sealants, compressible caulking material, de-bonding strip or tape or cord compatible with the sealant, of a suitable size to fill the width of the sealing groove, shall be firmly packed or stuck in the bottom of the sealing groove to such a depth so as to provide the correct depth of seal as shown in the Drawings with the top of the seal at the correct depth below the surface of the concrete.

All grooves shall be cleaned of any dirt or loose material by air blasting with filtered, oil-free compressed air. The groove shall be clean and dry at the time of priming and sealing.

For applied sealants, the joint grooves shall be primed with the relevant primer for the hot or cold applied sealant in accordance with the manufacturer's recommendations. When necessary, the joint grooves may be primed and sealed earlier than 14-days after construction, as soon as the grooves have been grit-blasted and cleaned.

(c) Sealing with Applied Sealants

Sealing shall be carried out continuously along the full length of joint in any one rip, except for remedial areas. When hot or cold applied sealants are used, the sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. Priming and sealing with applied sealants shall not be carried out when the naturally occurring temperature in the joint groove to be sealed is below 10°C , except that between 8°C and 10°C , it may be carried out when the temperature is rising.

Hot-applied sealants shall be heated in and applied from a thermostatically controlled, indirectly heated dispenser with a recirculating pump. The sealant shall not be heated to a temperature higher than the safe heating temperature nor for a period longer than the safe heating period, both as specified by the manufacturer. The

dispenser shall be cleaned out at the end of each day and reheated material shall not be used.

The components of cold-applied sealants shall be thoroughly mixed in the correct proportions in an automatic metering and mixing dispenser or, for hand application, using a power-operated paddle mixer for sufficient time to produce a homogenous mix and without entrapped air. As soon as possible after mixing and within the work life of the sealant, the material shall be dispensed into the joint, or applied using a caulking gun, to the concrete below the concrete surface. The tack-free time shall be achieved within 3 hours for machine dispensed material, or within 12 hours for hand applied material.

(d) Sealing with Compression Seals

When compression seals are used, the widths of the seal shall be selected in relation to the width of the sealing groove, the bay lengths and the manufacturer's recommendations so that the estimated maximum width of the joint opening shall be not more than 70% of the original width of the seal, the estimated maximum width being calculated on the basis of a movement of 4 mm per 10 m run of slab. The maximum calculated width of sealing groove shall be 30 mm. The depth of groove shall be such that the contact face of the seal shall be a minimum of 3 mm below the surface of the concrete.

Compression seals shall be inserted into the grooves without prior extension or rotation and, where recommended by the manufacturer, with a lubricant adhesive which is compatible with the seal and the concrete. The adhesive shall be applied to both sides of the sealing groove or the seal, or to both. The seal shall be positioned with its axis perpendicular to the concrete surface. Excess adhesive on top of the seal shall be removed to prevent adhesion of the top faces of the seal under compression.

Except when compression seals are used in longitudinal joints, the transverse joint seal shall be continuous across the slab and the longitudinal joint groove forming strips shall be cut to the required depth after the concrete has hardened for the transverse seal to be inserted. If compression seals are used in longitudinal joints where the grooves have been sawn after construction of the slab, they shall be continuous across transverse joints, with the transverse seals butted and fixed to the longitudinal seals with adhesive.

4917 TRIAL PAVEMENTS

Laboratory trials shall be carried out by the Contractor and the Engineer on concrete pavement materials which are to be used in the works in their natural state to establish a relationship between their specified end product requirements and properties which can be readily determined in the field for construction control purposes.

For mixed materials the composition that meets the specified requirements and is accepted by the Engineer shall then be used in the site trials to establish that all specified requirements of the completed pavement course can be achieved.

The Laboratory trials on mixed materials shall be submitted to the Engineer, at least one week before the Contractor proposes the site trials.

Upon the laboratory trial is approved by the Engineer, the site trials shall be conducted.

When commencing with paving operations, the Contractor shall construct a trial section of pavement, in a position approved by the Engineer, to demonstrate the capability of the Contractor to construct the pavement in accordance with the Specifications.

The activity plan for the trials shall be forwarded to the

Engineer for approval not less than 7 working days before the planned trials.

The trial on each pavement layer shall be undertaken at least 21 days ahead of the Contractor proposing to commence full scale work on that pavement layer.

The trial section shall be constructed with the same materials, concrete mix, plant and equipment as those intended for use by the Contractor for the pavement; and the Contractor shall also demonstrate the methods proposed for use in applying the required surface texture; constructing the construction of joints; placing of tie-bars and, dowels; and all other operations to be used in the construction of the pavement in accordance with the Specifications.

Before the Contractor commences with the construction of the trial section, he shall demonstrate to the Engineer that all items of his paving equipment are in a satisfactory working order.

Full scale laying and compaction site trial of not less than 50 m in length for mechanical construction, and at least 30 m in length for manual construction, shall be constructed in one continuous operation and be submitted for approval.

Only when such a trial section has been satisfactorily laid and finished and complies with the specified requirements will the Contractor be allowed to commence with construction of the permanent work. Should the trial fail, the Contractor shall perform additional trials at his own cost until a trial and the trial section report has been approved by the Engineer.

If the Contractor should make any alterations in the methods, processes, equipment or materials used, or if they are unable to comply consistently with the Specifications, the Engineer may require that further trial sections be laid before allowing the Contractor to continue with the permanent work. Any work that does not comply with the Specifications shall be removed or made good to comply with the Specifications to the satisfaction of the Engineer.

The trials shall be carried out with the agreement and in the presence of the Engineer. The Contractor shall prepare the surface on which to lay the trial section and shall also, if required by the Engineer, remove the trial section after completion and restore the surfaces on which it was constructed, at their own cost.

The construction equipment and techniques as well as the mix properties applicable to the approved trial section shall not be changed without prior approval by the Engineer.

No payment shall be made for trial sections and the Contractor must allow for all costs in their rates.

The specification for laboratory trial and site trial in this Clause shall be read in conjunction with CLAUSE 7119 of this Specification.

4918 CONSTRUCTION TOLERANCES

The Construction tolerances shall be as specified under SERIES 7000 of these specifications.

4919 PROCESS CONTROL

The Contractor shall conduct a sufficient number of tests necessary for ensuring compliance with the requirements specified in this section during all phases of the work.

Accelerated early compressive-strength shall be conducted regularly with a view to predicting the 28-day compressive strength of the concrete. Test procedures and methods for the prediction of 28-day compressive strength shall be determined in consultation with the Engineer.

Where the accelerated tests indicate that the required 28-day compressive strengths will not be attained, the Contractor shall immediately effect the necessary changes to the materials and/or mix proportions in order to ensure that further work will comply with the requirements.

4920 QUALITY CONTROL AND WORKMANSHIP

(a) General

Routine inspection and testing shall be carried out by the Engineer to determine whether the quality of materials and workmanship complies with the requirements of this Section.

The assessment of test results and measurements, and the acceptance of the work, shall be done in accordance with a procedure developed by the Engineer.

The following sub-clauses shall also apply.

(b) Compressive-Strength Control

The Engineer may, at his discretion, decide to use the Contractor's test results in the acceptance plan, if he is satisfied that the Contractor has complied with all the process control requirements.

(c) Relationship Between the Compressive and Flexural Strengths of Concrete

The relationship between the 28-day compressive and the 28-day flexural strengths of the concrete established by the preliminary tests shall be monitored during paving operations by regular tests at the discretion of the Engineer.

For this purpose, sets of three samples each for both flexural and compressive strength tests shall be manufactured from the same batch of concrete and tested for flexural and compressive strength respectively.

If the test results indicate a relationship which deviates from that established by the preliminary tests, the specified compressive strength, as specified in CLAUSE 4902, shall be adjusted accordingly.

(d) Air Content of Concrete

If any test for air content shows a value falling outside the specified limits, the quantity of air-entraining agent added to the concrete mix shall be adjusted, until the air content of the concrete is within the specified limits.

(e) Unacceptable Work or Materials

Any work or materials which do not comply with the specified requirements shall be removed and replaced with work or materials which comply with the requirements or, if the Engineer so permits shall be repaired as specified in CLAUSE 4921, so that it shall comply with the specified requirements after having been repaired.

4921 REMEDIAL WORK

When any part of the works or any plant or material is found upon examination by the Engineer not to conform to the requirements or is at any stage before final acceptance damaged so that it no longer conforms to the requirements of the specifications, the Engineer may order its complete removal and replacement, at the Contractor's expense, with satisfactory work, plant or material or he may permit the Contractor to apply remedial measures in order to make good any such defects or damage. The actual remedial measures shall at all times be entirely at the Contractor's own initiative, risk and cost, but subject to the Engineer's approval regarding the details thereof. Remedial measures shall ensure full compliance with specifications of the final product, shall not endanger or damage any other part of

the Works and shall be carefully controlled.

The following shall apply specifically to concrete pavements:

(a) Removing Concrete

Where any section of the pavement which does not comply with the specified requirements is to be removed and reconstructed, the entire portion of the slab shall be removed and reconstructed as prescribed by the Engineer in writing.

(b) Removing High Spots

Where the Engineer so permits, high spots may be removed by approved power chisels and planers. After the high spots have been removed, the Contractor shall, if required, grind the surface up to the nearest longitudinal and transverse joint in order that all the ground areas will be neat rectangular areas with a uniform texture.

On all portions of the pavement where the surface texture has been destroyed or reduced in depth by grinding, the surface texture shall be restored by grooves being cut into the concrete surface. The grooves shall be of the same size and spacing as specified in CLAUSE 4910.

(c) Repairing Joints

Joints along which spalls occur that exceed 5 mm in depth at any point measured from the top surface of the pavement, or any other joints, which in the opinion of the Engineer are unacceptable, shall be repaired with an approved epoxy resin mortar. The method of repairing joints requires the prior approval of the Engineer.

(d) Repairing the Cracks

The Contractor shall be responsible for constructing a pavement that will not exhibit any cracks.

Where cracks occur in the pavement which, in the opinion of the Engineer do not warrant the removal and reconstruction of the particular section of pavement, the Contractor shall, if so required by the Engineer, repair such cracks, in accordance with a method approved by the Engineer.

(e) Rehabilitation of Concrete Pavements

Where concrete pavements have to be widened or where long continuous sections of concrete pavement have to be replaced and, in the opinion of the Engineer, the concrete can be placed with pavers, the work shall be regarded as, and shall be measured and paid for as, new work under the applicable items for new work.

(f) Removal of Existing Concrete

Where any section of the concrete pavement has to be removed, the whole panel between longitudinal and transverse joints shall be removed, unless it is specified in the Specifications or ordered by the Engineer that only part of the panel be removed. In such cases, the concrete shall be removed either over the full length or over the full width of the panel between joints. Where the edge of the section to be removed coincides with an existing joint, the edge shall be accurately demarcated in a straight line and sawn with an approved concrete saw to a depth of at least 50 mm before the removal of the concrete may commence.

Existing concrete may be broken up in any approved manner, but strict control shall be exercised to ensure that the adjacent concrete is not damaged in any way. The Contractor shall repair any damage to the adjacent concrete at his own cost in accordance with the instructions of the Engineer. Such remedial work may involve the partial or complete replacement of the damaged panel should it be deemed necessary by the Engineer.

Care shall be taken at existing joints to ensure that tie bars or dowels are not damaged or bent so as to render them useless.

Broken-up concrete shall be moved to approved spoil dumps.

(g) Placing New Concrete

Before concrete is placed, the underlying surface or layer shall be prepared as specified.

Except where concrete is placed in continuous lengths exceeding 50 m, placing, compacting and finishing with hand equipment shall be carried out as specified in CLAUSE 4908. Where new concrete is placed next to existing concrete, the edge of the existing pavement shall be properly cleaned and all bituminous and other jointing material shall be removed.

Where various adjacent panels are constructed, the concrete in every alternate panel shall first be placed. The concrete in the rest of the panels may be placed only after the concrete in the first panels has sufficiently hardened so that no damage will be done to the first panels during construction activities. All formwork shall remain in position for at least 24 hours.

(h) Surface Texture

Unless otherwise specified in the Special Specifications, the Contractor shall produce a surface texture on the new concrete panels that shall be the same as that on the existing panels.

(i) Joints, Tie Bars and Dowels

Joints shall be shaped and tie bars and dowels shall be placed where indicated on the Drawings and as specified in CLAUSES 4912 up to and including 4916.

At joints in new concrete, the tie bars and dowels in the existing concrete shall be cleaned, and the tie bars shall be straightened, should any such bars be indicated on the Drawings.

In regard to bent dowels, the Contractor shall follow the instructions of the Engineer. Before concrete is placed, all the bars shall be accurately aligned as indicated on the Drawings and specified in CLAUSE 4915. Where the sliding end of a dowel occurs in existing concrete, the dowel shall be extracted, cleaned and treated in accordance with CLAUSE 4915 prior to it being reused.

Where tie bars or dowels are shown on the Drawings at joints between existing and new concrete, but no such bars occur in the existing concrete, holes shall be drilled in the existing concrete and fresh bars placed and fixed as prescribed in the Particular Specifications. In such cases, the dowels shall be placed with their sliding ends in the new concrete.

Where no bars are required between the existing and new concrete but such bars do occur in the existing concrete, such bars shall be cut off flush with the concrete edge.

All joints between the existing and new concrete shall be sawn after the new concrete has hardened sufficiently to prevent splintering or other damage from occurring. Sawing the joints may normally be done from two (2) to five (5) days after the placing of the concrete. The width and depth of the sawn grooves shall comply with the requirements set in the Particular Specifications and on the Drawings.

(j) Repairing Joints and Cracks in Existing Concrete Pavement

Repairing the joints and cracks in the existing concrete pavement shall be done in accordance with the requirements set out in the Special Specifications and on the Drawings, and as required by the Engineer.

(k) Retexturing

Where in the opinion of the Engineer the skid resistance of the concrete pavement surfaces is too low, or the texture is too irregular, and where so specified in the Particular Specifications, such surfaces shall be provided with a fresh texture.

The depth of texture and groove spacing shall comply with the requirements of the Particular Specifications. The work shall be done with approved sawing equipment.

4922 OPENING TO TRAFFIC

No vehicle with an axle load exceeding 20 kN shall travel over the completed surface within 14 days after it has been completed, or such longer period as may be directed by the Engineer.

4923 MEASUREMENT AND PAYMENT

ITEM	UNIT
49.01 CONCRETE PAVEMENT	CUBIC METRE (m ³)
Cement Concrete pavement shall be measured as a finished work in cubic metres of concrete placed based on the net plan area and thickness as measured based on approved levels.	

100/150 mm Cores to be drilled by the Contractor at his own initiative as part of his process control or for testing cracks sealed at the Contractor's own cost, will not be measured for payment.

The tendered rate of Concrete pavement shall include the following specific requirements:

- Drilling the test cores;
- Tests at an approved laboratory and other incidentals;
- Restoring the concrete pavement where holes were drilled

The Contract unit rate for the construction of the cement concrete pavement shall be payment in full for carrying out the operations required for the different items of the work as per these Specifications including full compensation for all labour, tools, plant, equipment, materials, storing, mixing, transportation, placing, compacting, finishing, curing, testing to complete the work as per Specifications.

The tendered rate shall include the following specific requirements:

- Trial mixes;
- Materials and attendance for sampling and testing carried out by the Engineer;
- Protection of mixed material in transit and while awaiting tipping;
- Waterproof membrane underlay;
- Longitudinal, expansion, contraction, warping, and construction joint assemblies, including joint filler and crack inducers, tie and dowel bars, dowel bar caps and bond breaking compound;
- Formwork as item coverage in section 6200;
- Mixing, laying spreading, compaction and finishing;
- Air entrainment;
- Reinforcement;
- Drilling and testing cores;
- Texturing and curing the concrete pavement;
- Forming or sawing grooves, cleaning, caulking, temporary and permanent sealing of joints;
- Forming recesses, openings and bays;
- Cleaning existing joints where new concrete has to join up with existing work, for straightening;

- Existing dowels and tie bars, and for cutting off existing bars;
- Shaping to falls;
- Additional width to suit requirements of equipment;
- Drilling the holes in the existing concrete;
- Placing and fixing the bars with epoxy; and
- Treating the sliding ends of the dowels.

Where the average thickness for the lot is deficient by the extent shown in TABLE 4923/1, payment for cement concrete pavement shall be made at a price determined by adjusting the contract unit price.

TABLE 4923/1: PAYMENT ADJUSTMENT FOR DEFICIENCY IN THICKNESS

Deficiency in the Average Thickness of Day's Work	Percent of Contract Unit Price Payable
Up to 5 mm	100%
6-10 mm	87%

No additional payment shall be made for the extra thickness of the slab than that shown on the drawings.

<u>ITEM</u>	<u>UNIT</u>
49.03 STEEL REINFORCEMENT IN CONCRETE PAVEMENT	
(a) JUCP	
(i) DOWEL BARS (SPECIFY TYPE, GRADE, DIAMETER AND LENGTH)	NUMBER (NO.)
(ii) TIE BARS (SPECIFY TYPE, GRADE, DIAMETER AND LENGTH)	NUMBER (NO.)
(b) JRCP AND CRCP	
(i) MILD STEEL BARS (GRADE SPECIFIED)	TONNE (T)
(ii) HIGH TENSILE STEEL BARS (GRADE SPECIFIED)	TONNE (T)
(iii) WELDED STEEL FABRIC	KILOGRAM (KG)

The unit of measurement for JUCP, steel bars shall be in number of dowel and tie bars of reinforcing steel with specific grade, diameter, length and associated spacing in place in accordance with the Drawings or as authorized.

In case of JRCP and CRCP, the unit of measurement for steel bars shall be the tonne of reinforcing steel in place in accordance with the Drawings or as authorized.

The unit of measurement for welded steel fabric shall be the kilogram of welded steel fabric in place in the special panels of concrete paving which require reinforcement, the quantity of which shall be calculated from the area of the mesh used in accordance with the Drawings or as authorised.

SERIES 5000

ANCILLARY ROADWORKS

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<i>SERIES 2000</i>	<i>DRAINAGE</i>
<i>SERIES 3000</i>	<i>SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE</i>
<i>SERIES 4000</i>	<i>BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT</i>
<i>SERIES 5000</i>	<i>ANCILLARY ROADWORKS</i>
<i>SERIES 6000</i>	<i>STRUCTURES</i>
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SERIES 5000: ANCILLARY ROADWORKS

SECTION 5100: MARKER, KILOMETRE AND GUIDEPOSTS

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5101 SCOPE

This Section covers the furnishing and installation of new as well as removal, renovating and re-erection of existing kilometre and marker posts, in position and in accordance with the dimensions as shown on the drawings or as directed by the Engineer. Marker posts include culvert marker posts, road reserve marker posts, guideposts and delineators.

5102 MATERIALS

(a) Concrete

Concrete work shall be carried out in accordance with the provisions of SECTIONS 6200, 6300 AND 6400.

(b) Paint

Paint for marker and kilometre posts shall be non-reflectorized road-marking paint as specified in SECTION 5500. Paint, if specified, for the recess in the marker posts shall be an approved retro-reflective paint. Flexible units shall be white in colour.

(c) Flexible delineators

Flexible units for delineators shall be made of reinforced fibreglass, thermosetting high polymer resin; an extruded polycarbonate resin; or any other material with similar or equivalent properties.

(d) Alternative materials

Alternative materials for posts, foundations or markers may be stated in the Special Specifications.

5103 FLEXIBLE DELINEATORS

The following are the different types of flexible delineators:

(a) Ground Mounted

Ground mounted flexible units shall have a minimum width of 75 mm and a minimum thickness of 3 mm. The length of each unit shall be variable such that the top of the reflective area is positioned 1200 mm above the near roadway edge.

(b) Guide Rail Mounted

Beam guide-rail-mounted flexible units shall have a minimum width of 75 mm and a minimum thickness of 2.5 mm. Each unit shall have a variable height such that the top of the reflective area is 800 ± 50 mm (1000 ± 50 mm for deceleration and acceleration lanes) above the near roadway edge. The base of each unit shall be designed to mount over the I-beam spacer, or to the top of a wood, polymer, or other type of spacer, of the beam guide rail.

(c) Barrier kerb Mounted

Concrete barrier kerb-mounted flexible units shall be the same as for beam guide-rail-mounted units except that the panel shall be 90 mm by 90 mm with a minimum thickness of 2.5 mm. The base shall form a "T" shape with the panel.

5104 PHYSICAL PROPERTIES

The base and panel for beam guide-rail or concrete barrier kerb flexible units shall be designed to withstand repeated

impacts, after which, the panel returns to its functioning position (90° from the plane of the roadway surface). Following are the minimum physical and performance requirements of flexible delineators.

(a) Material Composition

Flexible units shall contain a minimum of 40% consumer-recycled material in their construction. For ground mounted flexible units, the portion of the unit above ground shall be one component; or shall be bonded together if it consists of two or more components. The shape of the ground mounted unit shall be conducive to protection of the applied retro-reflective sheeting from abrasion.

(b) Impact Resistance

Flexible units shall be self-erecting to within 10° of original upright position within 15 minutes of impact on five separate occasions by a vehicle traveling at 90 km/hr. Tests shall be conducted at 0° , 22° , and 45° variance of the long cross-sectional axis of the unit to the perpendicular of vehicle direction. The same unit(s) shall be used for all angle impact tests; total impacts per unit equalling 15. The re-erected unit shall retain the original cross-section, show no evidence of shedding or splintering, and shall retain 80% of its original retro-reflective sheeting.

(c) Heat Resistance

A unit shall be conditioned in an oven for two (2) hours at $60 \pm 2^\circ\text{C}$. After removal from the oven, the unit shall be bent backwards at 90° from the upright, simulating a field hit. The unit shall, without cracking, recover to its original position within ten (10) seconds for each of three (3) bends. Testing shall be complete within two (2) minutes. Colour shall remain unchanged.

(d) Cold Resistance

The same unit(s) tested for heat resistance shall be tested for cold resistance. The unit shall be conditioned for 24 hours at -18°C and then subjected to the same testing as for heat resistance. The unit shall conform to the same recovery and colour retention standards as for heat resistance.

(e) Weather Resistance

A unit shall be exposed to 1,000 hours of weathering in accordance with ASTM G155 with no significant discolouration.

(f) Depth indicator Mark

A depth indicator mark shall be located on the front (reflective) face of the drivable ground mounted flexible units at a height of 450 mm from the bottom end of the unit with a weather resistant marking material so as not to wash off or weather away prior to unit installation.

(g) Mowability

Ground mounted flexible units shall be capable of being mowed over in both directions a total of twenty (20) times (ten (10) in each direction) by a standard flail mower equipped with a front-mounted deflector and adjusted to a minimum mowing height of 75 mm, without damage. Movable, drivable, flexible units must fold parallel and flat to the ground so as not to deflect upward and into the flail mower mechanism passing above and over the unit causing any damage thereto.

(h) Sampling Rate

Five (5) samples per lot size of approximately 1,000 to 2,000 units will be chosen at random by the Engineer for laboratory testing.

5105 FABRICATING

(a) Marker and Kilometre Posts

Marker and kilometre posts shall be fabricated to the dimensions shown on the Drawings. Concrete of class C45 or as specified by the Engineer shall be used. The forms shall be smooth and shall have accurate dimensions. The mixture shall be placed in the forms and vibrated on a vibrating table or by other approved means. The posts shall be reinforced as shown on the Drawings and shall have an F3 surface finish. The posts shall be true to shape, smooth, and without any honeycombing or other blemishes.

The recess near the top of the Concrete marker post (delineator) shall be fitted with either retro-reflective sheeting applied to a plate, or a plastic corner cube retro-reflector, or shall be painted with retro-reflective paint, as specified in the Special Specifications. The remainder of the exposed portion of the post shall be painted with white road-marking paint.

Flexible median marker units shall be placed on medians or island kerb sections, positioned so that the reflector area faces the direction of traffic. They may be fitted with single- or double-sided reflectors, as the case may be, at a spacing specified in the Drawings or as instructed by the Engineer. The surfaces shall be coated with engineering-grade retro-reflective material that complies with the provisions of US 402:1993 or equivalent standards in the colours shown on the Drawings.

(b) Flexible Delineators

The posts may be made of plastic or similar material if specified in the Drawings and/or the Special Specifications.

For flexible posts, Retro-reflective sheeting shall be pre-applied to the front (surface facing traffic) of the unit by the Manufacturer. The retro-reflective sheeting shall cover a minimum area of 75 mm by 300 mm for Ground Mounted Flexible Units, 115 mm by 115 mm for Guide Rail Mounted Flexible Units and 90 mm by 90 mm for Barrier Kerb Mounted Flexible Units beginning a maximum of 50 mm from the top of the post. The colour shall be white when the delineator is located on the right side to the direction of traffic and shall be red when the delineator is located on the left side of the direction of traffic.

5106 SPACING

The Kilometre and marker posts shall be spaced as shown on the Drawings or as directed by the Engineer.

5107 ERECTING

Marker posts shall be erected after the seal has been completed. They shall be located at such spacing as the Engineer directs with their outside edges in line with the shoulder breakpoint. The edge on which the recess is located is the inner edge. The tops of the marker blocks shall be at a constant height above the centreline of the road.

(a) Concrete post

Holes shall be excavated in the shoulder and the marker posts placed vertically and square to the road centre line.

Backfilling shall be compacted in 100 mm layers right from the bottom of the hole. Surplus excavated material shall be disposed of as directed.

The marker posts shall be painted immediately after having been placed.

(b) Flexible post

i) Ground Mounted Flexible Units

Flexible units shall be driven vertically into the ground to a minimum depth of 450 mm. Units shall be installed so that the plane face of the centre of the reflective area is at an angle of 0° with a perpendicular to the direction of traffic.

ii) Guide Rail Mounted Flexible Units

Flexible units shall be mounted on the spacer of the beam guide rail using either a "U" channel base on the I-beam spacer; or a flat base attached to a wood, polymer, or other solid top spacer. The base shall be attached to the spacer using an adhesive recommended by the Manufacturer of the base and panel. The first unit shall be placed on the beam-guide-rail end treatment, positioned so that the reflector area is facing the direction of traffic, then subsequently every 25 m (13 sections of guide rail) for tangent mainline roadway, and every 13.5 m (seven sections of guide rail) for curved mainline roadways with radii less than 580 m. If a parabolic flare in the beam-guide-rail exists, the second unit shall be placed at the end of the flared section with subsequent units spaced as stated herein. If the distance between the ends of the beam-guide-rail is greater than 6 m on curved mainline roadways, or 12 m on tangent mainline roadways, a unit shall be installed on the last post or end treatment.

iii) Barrier Kerb Mounted Flexible Units

The first flexible unit shall be placed at the beginning of the concrete barrier kerb section, positioned so that the reflector area is facing the direction of traffic, then subsequently every 24 m. If the distance between the end of the concrete barrier kerb and the adjacent unit is greater than 12 m, a unit shall be installed on both sides of barrier kerb openings. Concrete barrier kerb mounted flexible units shall be attached to the side of the barrier kerb, 75 mm from the top of the barrier, using a method recommended by the Manufacturer of the unit.

Marker posts shall be maintained and protected during the entire construction period and any that are damaged or broken before the certificate of completion has been issued, shall be repaired or replaced, as may be required, at the Contractor's own cost.

5108 MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
51.01	MARKER POSTS (DELINEATORS) (RIGID)	
(a)	ROAD RESERVE MARKER POST (CONCRETE)	NUMBER (no.)
(b)	CULVERT MARKER POST (CONCRETE)	NUMBER (no.)
(c)	GUIDEPOST (CONCRETE)	NUMBER (no.)
(d)	RENOVATING AND RE- ERECTION OF EXISTING MARKER POSTS:	NUMBER (no.)
(e)	DELINEATOR (CONCRETE)	NUMBER (no.)
51.01	FLEXIBLE MARKER	
(a)	FLEXIBLE DELINEATOR POSTS	NUMBER (no.)
(b)	FLEXIBLE MEDIAN MARKER	NUMBER (no.)

The unit of measurement shall be the number of marker posts supplied and erected in accordance with the Specifications.

The bid rate for concrete (Rigid) post shall include full compensation for supplying all materials and labour, making and transporting the marker posts, setting out, excavating and backfilling all the holes and disposing of surplus excavated material, including all haulage, placing and painting the marker posts with white reflective road paint as specified in clause 5102 (b) and all the equipment, the tools and incidentals necessary for completing and

maintaining the Works described in this Section.

The bid rate for Flexible Post shall include full compensation for supplying, storing, transporting and erecting including, setting out, excavating and backfilling all the holes and disposing of surplus excavated material, including all haulage. Retro-reflective sheeting shall be pre-applied to the front (surface facing traffic) of the unit by the Manufacturer and all the equipment, the tools and incidentals necessary for completing and maintaining the Works described in this Section.

<u>ITEM</u>	<u>UNIT</u>
51.02 KILOMETRE POSTS	
(a) NEW KILOMETRE POSTS	NUMBER (no.)
(b) RENOVATING AND RE- ERECTION OF EXISTING KILOMETRE POSTS	NUMBER (no.)

The unit of measurement shall be the number of kilometre posts supplied and erected in accordance with the Specifications.

The bid rate shall include full compensation for supplying all materials and labour, making and transporting the kilometre posts, setting out, excavating and backfilling all the holes and disposing of surplus excavated material, including all haulage, placing and painting the kilometre posts with white reflective road paint as specified in clause 5102 (b) and all the equipment, the tools and incidentals necessary for completing and maintaining the Works described in this Section.

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SECTION 5200: SAFETY BARRIERS

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5206 MEASUREMENT AND PAYMENT	5000-8

5201 SCOPE

This Section covers the supplying, installing and maintaining of safety barriers at locations and in accordance with the details, dimensions and design shown on the Drawings or as directed by the Engineer. There are three main types of safety barriers:

- Guard rail system
- Concrete barrier
- Wire Rope

This Section also covers the supplying, installing and maintaining of noise and antiglare barriers at locations and in accordance with the details, dimensions and design shown on the Drawings or as directed by the Engineer.

5202 MATERIALS

(a) Guardrail Systems

Guardrails shall comply with the requirements of MASH or BS EN 1317-2:2010: Road restraint systems Part 2: Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets. The guardrail system specifications shall comply with the

requirements of AASHTO M180 – 23.

The Contractor shall provide the manufacturer's specifications and test certificate for all materials. The test certificate shall set forth the name or brand of the materials to be furnished, the results of tests proving the products meet the requirements, and any other data requested by the Engineer. The manufacturer shall provide all applicable crash test reports that confirm the barrier to have passed the crash tests conducted by an internationally accredited crash testing. All guardrails shall be provided with reflectors.

Guardrail Ends or Terminal Ends shall conform to the requirements of EN 1317-4.

The dimensions of guardrails and end units shall be in accordance with the details shown on the Drawings. and shall comply with the requirements of TABLE 5202/1 or as directed by the Engineer. Guardrails shall be supplied together with all the bolts, nuts, washers and fixing materials required, including the bolts for fixing the guardrails to the posts.

Unless specified otherwise in the Special Specifications, all guardrails, bolts, nuts and washers shall be galvanised with a hot-dip (galvanised) zinc coating, which complies with the requirements of AASHTO M 232M/M 232-2023 or equivalent. Galvanised guardrails shall not be nested when stacked for storage.

(b) Posts

Galvanised Steel Guardrail posts shall be posts of UNP steel profiles 120 x 55 x 5 mm or of the type and size shown on the Drawings and/or described in the Special Specifications.

Concrete Post for the Guardrails shall be of Grade C35 or above and of the dimensions as shown in the Drawings or as approved by the Engineer. A non-destructive rebound hammer test shall be used to confirm the quality of the post.

Timber Post for the Guardrails shall be well seasoned and Treated Guardrail post of the dimensions as shown in the Drawings or as approved by the Engineer.

TABLE 5202/1: SPECIFICATIONS FOR GALVANISED GUARD RAIL SYSTEMS

System Component	Parameters	Specifications
Beam	Description	Corrugated sheet steel beam for guardrail
	Shape/Profile	W-Beam/ Thrie (Single/ Double Sided)
	Width (mm)	300 minimum
	Effective Length between post centres (mm)	As Specified in the Drawings
	Height (mm)	81 minimum
	Surface finish type I, II, III, IV, V and VI	Coating on both sides (minimum) Type I- Zinc coated, 550g/m ² Type II- Zinc coated, 1100g/m ² Type III- Paint coated Type IV- Atmospheric corrosion- resistant steel Type V- Zinc-aluminium-magnesium alloy coated, 245g/m ² Type VI- Zinc-aluminium-magnesium alloy coated, 305g/m ²
	Beam Class A	Base metal nominal thickness of 2.67 mm minimum
	Mechanical Properties (S355JR)	Yield Point: 345 MPa minimum Tensile Strength: 483 MPa minimum Elongation, in 50 mm: 16% minimum
Post	Description	Hot dip-galvanized guardrail post
	Shape/Profile	U-Post, Round, C-post, H-Post
	Width (mm)	120 minimum
	Length (mm)	1800 minimum
	Thickness (mm)	5.0 minimum
	Mechanical Properties (S355JR)	Yield Point: 250 MPa minimum Tensile Strength: 400 - 550 MPa Elongation, in 50 mm: 21% minimum
	Surface finish type I, II, III, IV, V and VI	Refer to section on beam
Bolts, Nuts and Washers	Surface Finish	Shall be hot-dip zinc-coated in accordance with AASHTO M 232M/M 232-2023
	Size	Shall conform with or exceed the requirements of ASTM A307

System Component	Parameters	Specifications
Buffer (Spacer)	Description	Hot dip galvanized guardrail (type I) buffer
	Shape/Profile	U-buffer or C-buffer
	Width (mm)	120 minimum
	Length (mm)	300 minimum
	Thickness (mm)	5.0 minimum
	Mechanical Properties (S235JR)	Yield Point: 227 MPa minimum Tensile Strength: 310 MPa minimum Elongation, in 50 mm: 16% minimum
End Terminal	Surface Finish	Hot dip galvanized guardrail (type I) end
	Thickness (mm)	Base metal nominal thickness of 2.67 mm minimum for Class A
	Mechanical properties (S235JR)	Yield Point: 227 MPa minimum Tensile Strength: 310 MPa minimum Elongation, in 50 mm: 16% minimum

(c) Attenuators/Crash Cushions

Attenuators/Crash cushions shall be moulded from HDPE plastic conforming to the general test acceptance criteria requirement of NCHRP 350 Test Level 3 or BS EN 1317-3:2010, Road restraint systems: Part 3: Performance classes, impact test acceptance criteria and test methods for crash cushions. Minimum Performance Level corresponding to 100 should be provided. A crash test report from the manufacturer or supplier must be submitted to the Engineer to conform to the requirement.

(d) Concrete Barrier

Concrete work shall be carried out in accordance with the provisions of SECTIONS 6200, 6300 AND 6400. The minimum grade of concrete shall be 30/20 or as mentioned in the drawings.

(e) Paint

Paint, if specified, for the Concrete Barrier shall be an approved retro-reflective paint as specified in section 5500.

(f) Wire Rope

The wire ropes shall be hot-dipped galvanised steel wire, supported by hot-dipped galvanised steel posts at a spacing indicated in the drawings. The supplier shall provide calculations in support of the structural details to establish the stability of the barrier against an impact of a heavy commercial vehicle of a gross weight of 36 T, or any weight specified in the Contract. The wire rope barriers shall be compliant with the test acceptance criteria of BS EN 1317-2:2010: Road restraint systems Part 2: Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets. The manufacturer shall provide all applicable reports that confirm the barrier to have passed the crash tests.

(g) Reflective Plates

V-shaped reflective plates shall be manufactured from at least 1.5 mm thick mild steel plate to the dimensions shown on the Drawings. When supplied with galvanised guardrails, they shall also be galvanised, and when supplied with painted guardrails, they shall be finished in white baked enamel. The outer surfaces shall be coated with High Intensity retro-reflective material that complies with the requirements of Type IV retroreflective sheeting as per ASTM 4956 or equivalent standards in the colours shown on the Drawings. Holes for fixing shall be drilled before the reflective plates may be galvanised or painted.

Plastic guardrail reflector housing shall be fabricated with a Carbon Black UV Resistant "Acrylonitrile Butadiene Styrene" (ABS) with impact strength for moderate mechanical impacts. It should also have a minimum 7-year lifespan with local outdoor conditions without changing colour, becoming brittle or cracking. The reflectors should be securely fixed to the guardrails at specified distances or as per the drawings. Unless otherwise specified, the outer surfaces shall be coated with class I white retro-reflective prismatic material and class III red retro-reflective material, which complies with the provisions of SANS 1519-1.

Specification certificates must be requested from

the manufacturer.

(h) Noise Barrier

The choice of barrier materials (and potentially colour of the barrier) are likely to be influenced by a range of factors including the physical dimensions of the barrier, the location of the barrier and local environmental conditions, aesthetic quality requirements including local architectural considerations, the perception and acceptance of the structure by the general public and, last but not least, cost. Noise barriers should have:

- Product specifications, like acoustic performance and CE (Conformité Européene) markings, based on the European standard BS EN 14388:2015;
- A minimum absorption value α_a of at least 10 db, based on the European standard BS EN 1793-1:2017;
- A minimum sound insulation DLR value of at least 25 db, based on the European standard BS EN 1793-2:2018;

The following materials can be considered for:

i) Timber Acoustic Elements:

Timber acoustic elements may be fully reflective or sound absorptive and either single-leaf or double leaf constructions. They may be constructed from planks secured to cross members where the joints between the planks on the opposite side of the cross-members are typically covered with additional timber strips. Sound absorptive materials (if used) typically sit in between the cross-members. Alternatively, they may be constructed from interlocking elements using, for example, a tongue and groove construction. Panels may be prefabricated or constructed in-situ from their component parts and are typically supported in between or up against either metal or timber posts.

ii) Metal Acoustic Elements:

Metal acoustic elements are typically cartridge/cassette-type panels constructed from aluminium, steel or both and can be sound reflective of sound absorptive (when sound absorptive the metal surface in front of the absorptive material is perforated). These elements are typically supported in between metal posts.

iii) Concrete Acoustic Elements:

Whilst noise barriers cast in situ may be used or constructed so as to be self-supporting, more commonly concrete is used for manufacturing precast panels. These may be a combination of reinforced concrete with a porous concrete face or manufactured as a wood-fibre/cement composite. Such panels are supported between metal posts.

iv) Transparent Acoustic Elements:

Transparent acoustic elements are used to either provide a fully transparent barrier or are incorporated as components within an opaque barrier constructed from other materials. As such, their primary benefit is to reduce the visual impact that would result from the use of a conventional opaque barrier. The elements may be constructed from glass, acrylics, Plexiglas,

Polymethyl methacrylate, etc.

v) Plastic/Composite Acoustic Elements:

These are typically cartridge type panels manufactured from plastics or recycled plastics, reinforced with glass fibre. They can be sound reflective or sound absorptive. When sound absorptive, the surface in front of the absorptive material is perforated. These elements are typically supported in-between metal posts.

(i) Antiglare Barrier

Antiglare barriers shall be of HDPE (High Density Polyethylene) material with good intensity and shall bear wind load up to 150 km/h. The working temperature shall be between (-) 5°C to (+) 60°C.

(j) Bollards

Bollards shall be circular in cross section. The posts shall be 1000 mm in height above road level and 200 mm in diameter or as indicated in the drawing or as instructed by the Engineer. The visual and physical performance requirements of trans-illuminated and retroreflective bollards shall comply with BS EN 12899-2:2007. Unless otherwise specified the impact resistance of the bollards shall be IR2 (spring back) or IR3 (deformable) TTB (Trans-illuminated Traffic Bollards) in accordance with BS EN 12899-2:2007. The retroreflective parts of the post shall be Class RA 2 retroreflective in accordance with TABLE 4 OF BS EN 12899-1:2007.

The Contractor shall provide, at their own expense, the manufacturer's specifications and certificate for all materials they intend to adopt. The certificate shall set forth the name or brand of the materials to be furnished, the results of tests proving the products meet the requirements, and any other data requested by the Engineer. The certificate shall be sworn to for the manufacturer by a person having legal authority to bind the company.

(k) Alternative materials

These can be used as long as they are detailed in the Special Specifications. They should meet the requirements in this CLAUSE 5202.

5203 CONSTRUCTION

(a) Erection

i) Guardrail Systems

Steel posts shall be erected and fixed as shown on the Drawings. The posts shall be installed by driving them into the ground, preferably by a mechanical post driver, unless otherwise approved by the Engineer.

The posts, spacer blocks (if applicable) and guardrails shall be erected and set true to line and level, so that the guardrails will be at the required height above the level of the completed road shoulder.

All guardrails shall be so erected as to have no projecting ends that might interfere with or endanger traffic. The edges and the centre of the guardrails shall touch either the spacer block or the post where no spacer blocks are used.

If the installation is done by digging or drilling, then all post holes that are dug or drilled shall be of such size as will permit proper setting of the posts and allow sufficient room for backfilling and tapping. Holes shall be backfilled with selected earth or stable materials in layers not exceeding 100 mm thickness and each layer shall be thoroughly tamped and rammed. When backfilling and tamping are completed, the posts or anchors shall be held securely in place. Post holes that are drilled in rock and holes for anchor posts shall be backfilled with concrete.

Guardrails, if specified, shall be provided with end units as shown on the Drawings or as directed by the Engineer. The two major end treatments recommended for steel barriers are:

- Crashworthy terminal;
- Turned-down-guardrail; and
- Anchored in back slope.

All splices of guardrails shall be at posts, and guardrails shall make contact over the entire area of the splice. All bolts shall be tightened and unless otherwise directed by the Engineer, spot-welded to protect against theft.

Reflective plates shall be fixed in accordance with the details shown on the Drawings. The reflective surfaces shall be arranged with the colours as shown on the Drawings.

ii) Attenuators/Crash cushions

The proprietary attenuator Systems essentially comprise a series of w- beam fender panels supported by diaphragms with a trigger mechanism at the nose, which, when hit, releases a 'front assembly' to absorb the energy of impact. When impacted, the system absorbs the kinetic energy so as to bring the errant vehicle to a controlled stop. The contractor of such system shall furnish a certificate that the system to be installed has been tested in accordance with BS EN 1317-3:2010.

iii) Concrete Barrier

The concrete barrier shall be:

- Precast;
- Cast-in-situ with fixed forms method; and
- Combination thereof as approved by the engineer.

Precast concrete barrier of lengths up to 6 m shall be preferred depending upon the feasibility of transport and lifting arrangements or as directed by the engineer. If the barriers are to be provided in length more than that feasible to be transported or shifted, cast-in-situ concrete barrier Grade C30/20 or as shown in the drawings with fixed forms method or a combination thereof as approved by the Engineer shall be preferred.

Longitudinal roadside concrete barrier shall be placed on adequate bedding as shown in the drawing or as directed by the Engineer. An expansion joint with pre-moulded asphalt filler board shall be provided at the junctions of crash barrier on structure and crash barrier on the fill. The crash barrier on the fill shall be constructed in pieces of length not exceeding 20 m, with pre-moulded asphalt filler board joints or as shown in the drawings.

The roadside concrete barrier shall be provided with an end treatment by tapering the height of the terminating end within a length of 8 m to 9 m.

Median concrete crash barrier shall be terminated sufficiently away from the median opening. It shall be provided with an end treatment, which shall be obtained by tapering the height of terminating end of the median barrier within a length of 8 m to 9 m.

iv) Wire Rope

During installation, each cable shall be post-tensioned to exhibit a tension as shown in the drawings or prescribed by the Engineer. The cables shall be located in slots at the top of the posts. The posts shall be of galvanised steel posts anchored into the ground using a Cement concrete of grade C30/20 or into a socket of an approved design. The wire rope shall be anchored into the ground at the ends by using concrete blocks of minimum grade C30/20 and dimensions as specified by the designer.

v) Noise Barrier

Steel posts shall be erected and fixed as shown on the Drawings. Unless otherwise approved by the Engineer, the posts shall be anchored into the ground using a concrete block of minimum grade C30/20 or as specified by the designer. Typically, the height of the noise barriers varies between 2 m to 5 m.

vi) Antiglare Barrier

Antiglare barriers shall comply with the requirements of EN 12676-1 AND EN 12676-2. It is usually used in combination with the central guardrail, central barrier (cement barrier and steel guardrail). These barriers shall be fixed over the cement barrier or steel barrier as shown in the drawing or as instructed by the Engineer.

vii) Bollard

Where a receptacle base is used it shall be manufactured from steel and shall include a 3 mm steel plate fixed to the bottom or as shown in the drawing or instructed by the Engineer. All bollards shall be fixed to the base with corrosion resistant materials which are less prone to vandalism. Concrete foundations for all bollards shall be in accordance with the drawings or as directed by the Engineer. Minimum material and colour durability for all plastics shall be 5 years. Trans-illuminated bollards shall have all electrical connections stored below ground level.

5204 REQUIREMENTS

The completed barrier system (Safety / Noise) shall have a neat appearance, and shall not show any visible deviations from line and grade. The posts shall be straight and vertical. The guardrail beam shall not be warped but shall be in a vertical plane parallel to the road centre line except at flared terminal sections. The painted or galvanised surface on the barrier shall be smooth and continuous and free from abrasions or scratches. Any damage to the surface shall be repaired at the Contractor's expense.

5205 MAINTAINING, REMOVING, RENOVATING AND RE-ERECTING EXISTING SAFETY BARRIERS**(a) Guardrail with Beams and Posts**

Every effort should be made to reuse existing guardrails provided they meet the requirements of TABLE 5202/1. Where existing guardrails have to be disposed of or reused, the following procedure shall be followed:

i) Removing the Guardrails

All guardrails, reflective plates and end units shall be loosened. Posts shall be carefully dug out and the holes shall be filled and compacted in 150 mm layers. Items used for fixing, such as bolts, nuts and washers, together with the reflective plates, shall be placed into bags, after which all the material shall be transported to a store approved by the Engineer and all stored in groups by type.

Where material is intended for re-use, it shall first be unpacked for inspection and testing to enable the Engineer to decide which material will be suitable for reuse. Suitable material shall then be stored separately from material that is unsuitable for re-use.

ii) Renovating the Guardrails

Guardrails, end units and steel posts suitable for reuse shall be taken to the workshop for cleaning and painting. Rust and existing paint shall be completely removed and minor indentations hammered out. The guardrails shall then be re-galvanised or receive surface treatment and be painted as described in CLAUSE 6908.

Bolts, nuts and washers to be re-used shall be cleaned and all rust removed, and shall then be oiled.

iii) Re-Erection

The guardrails shall be erected as described in CLAUSE 5203.

(b) Concrete Barrier

Every effort should be made to renovate existing concrete barriers rather than dismantling them and constructing new units.

(c) Wire Rope

Every effort should be made to reuse existing wire ropes provided they meet the requirements of CLAUSE 5202. Where existing wire ropes have to be disposed of or reused, the following procedure shall be followed:

i) Removal

All wire ropes, reflective plates and end units shall be loosened. Posts shall be carefully dug out and the holes shall be filled and compacted in 150 mm layers. Items used for fixing, such as bolts, nuts and washers, together with the reflective plates, shall be placed into bags, after which all the material shall be transported to a store approved by the Engineer and all stored in groups by type.

Where material is intended for re-use, it shall first be unpacked for inspection by the Engineer to decide which material will be suitable for re-use. Suitable material shall then be stored separately from material that is unsuitable for re-use.

ii) Renovating

Wire ropes, end units and steel posts suitable for reuse shall be taken to the workshop for cleaning and painting. Rust and existing paint shall be completely removed and minor indentations hammered out. The wire ropes shall then be re-galvanised or receive surface treatment and be painted as described in CLAUSE 6910.

Bolts, nuts and washers to be reused shall be cleaned and all rust removed, and shall then be oiled.

iii) Re-erection

The Wire ropes shall be erected in the positions as indicated and all the removed material suitable for reuse and as much supplementary new material as may be necessary shall be used. Re-erection shall be as specified for new wire ropes, including fixing the retro-reflective plates.

5206 MEASUREMENT AND PAYMENT

<u>ITEM</u>		<u>UNIT</u>
52.01	SAFETY BARRIERS (STATE TYPE OF POST AND SPACING)	
(a)	GALVANISED (STATE TYPE)	METRE (m)

The unit of measurement shall be the metre of guardrail/wire rope erected, excluding end units.

The bid rates shall include full compensation for furnishing all materials and labour and erecting and painting and galvanising the guardrail/ wire ropes, complete with posts, spacer blocks, bolts, nuts, washers and reinforcing plates.

<u>ITEM</u>	<u>UNIT</u>
52.02 EXTRA OVER ITEMS 52.01 AND 52.10 FOR HORIZONTALLY CURVED GUARD-RAILS FACTORY BENT TO A RADIUS OF LESS THAN 45 m	METRE (m)

The unit of measurement shall be the metre of curved guardrail erected and measured in place.

The bid rate extra over the rates bid for ITEMS 52.01 AND 52.10 shall include full compensation for incidentals in respect of supplying and erecting curved guardrails.

<u>ITEM</u>	<u>UNIT</u>
52.03 END UNITS:	
(a) END SECTIONS INCLUDING FOUNDATION IN THE GROUND WHERE SINGLE GUARDRAIL SECTIONS ARE USED (STATE LENGTH)	NUMBER (no.)
(b) END SECTIONS INCLUDING FOUNDATION IN THE GROUND WHERE DOUBLE GUARDRAIL SECTIONS ARE USED (STATE LENGTH OF END SECTION)	NUMBER (no.)
(c) CABLE STAYS COMPLETE WITH ANCHOR BLOCK	NUMBER (no.)
(d) ATTENUATORS/CRASH CUSHIONS	NUMBER (no.)

The unit of measurement shall be the number of end units of each type erected.

The bid rates shall include full compensation for all labour, construction equipment and materials required for installing the end units as shown on the Drawings, including posts and fittings and the bending of turned-down sections, excavations, concrete, backfilling, the removal of surplus backfill and bituminous sealing at posts where guardrail is erected through a bituminous surface.

<u>ITEM</u>	<u>UNIT</u>
52.04 ADDITIONAL GUARDRAIL STEEL POSTS:	NUMBER (no.)

The unit of measurement for additional guardrail posts shall be the number erected over and above those erected in accordance with the normal spacing shown on the Drawings.

The bid rates shall include full compensation for supplying additional posts and erecting the posts.

<u>ITEM</u>	<u>UNIT</u>
52.05 REFLECTIVE PLATES (STATE TYPE)	NUMBER (no.)

The unit of measurement shall be the number of reflective plates installed.

The bid rate shall include full compensation for supplying all materials and labour required for manufacturing, painting and fixing the reflective plates as specified and as shown on the Drawings.

<u>ITEM</u>	<u>UNIT</u>
52.06 REMOVING EXISTING GUARDRAILS	METRE (m)

The unit of measurement shall be the metre of guardrail removed, and the quantity shall be measured between the terminal points of the sections removed, including the end units, but excluding the anchor blocks and anchor cables, if any, projecting beyond the end units.

The bid rate shall include full compensation for the work as described in SUB-CLAUSE 5205 (a), including loading,

transporting to any point on the site, and off-loading and stacking the material.

<u>ITEM</u>	<u>UNIT</u>
52.07 RENOVATING GUARDRAIL MATERIAL:	
(a) GUARDRAILS INCLUDING END SECTIONS	METRE (m)
(b) POSTS INCLUDING BOLTS, WASHERS AND NUTS	NUMBER (no.)

The unit of measurement for SUB-ITEM (a) shall be the metre of single guardrail, whether straight or bent renovated as specified, the length of which shall be measured in accordance with the measurements of the guardrail after dismantling. The unit of measurement for SUB-ITEM (b) shall be the number of treated posts.

The bid rates shall include full compensation for the work as specified in SUB-CLAUSE 5205 (b), including the loading, transporting to and from the workshops, off-loading and storing of the material.

<u>ITEM</u>	<u>UNIT</u>
52.08 RE-ERECTION OF GUARDRAILS WITH RECOVERED MATERIAL:	
(a) SINGLE GUARDRAIL	METRE (m)
(b) DOUBLE GUARDRAIL	METRE (m)

The unit of measurement shall be the metre of single or double guardrail re-erected with used material and measured between the points where they are joined to the end units.

The bid rates shall include full compensation for re-erecting the guardrails as specified in SUB-CLAUSE 5205 (c), including the loading, transporting between any two points on the site and off-loading the material, and providing new fixing material. Payment shall be made separately for any new material required, including spacer blocks, but not for other fixing materials. Where sections are made entirely from new material, payment therefore shall be made under the appropriate items for new guardrails.

<u>ITEM</u>	<u>UNIT</u>
52.09 RE-ERECTION OF END UNITS WITH RECOVERED MATERIAL:	
(a) END WINGS	NUMBER (no.)
(b) TERMINAL SECTIONS WITH SINGLE GUARDRAILS	NUMBER (no.)
(c) TERMINAL SECTIONS WITH DOUBLE GUARDRAILS	NUMBER (no.)
(d) TERMINAL SECTIONS COMPLETE WITH ANCHOR BLOCK	NUMBER (no.)

The unit of measurement shall be the number of end units erected with recovered and, in part, new material.

The bid rates shall include full compensation for erecting the end units and for providing all anchors, fixing materials and anchor blocks. Apart from anchors, anchor blocks and fixing materials payment will be made separately for all new materials. End units made completely from new materials shall be paid for in accordance with the appropriate rates for new end units.

<u>ITEM</u>	<u>UNIT</u>
52.10 NEW MATERIAL REQUIRED FOR THE RE-ERECTION OF GUARD-RAILS WITH RECOVERED MATERIALS:	
(a) GUARDRAILS	METRE (m)
(b) STEEL POSTS	NUMBER (no.)
(c) REFLECTIVE PLATES	NUMBER (no.)
(d) SPACER BLOCKS	NUMBER (no.)

The unit of measurement for SUB-ITEM (a) shall be the metre of guardrail provided, measured in accordance with the measurements of the loose guardrail. The unit of measurement for SUB-ITEMS (b), (c) and (d) shall be the number of new steel posts, reflective plates and spacer blocks provided, respectively.

The bid rates shall include full compensation for supplying the material as specified. ITEM 52.02 shall apply to horizontally bent guardrail factory bent to a radius of less than 45 m.

<u>ITEM</u>	<u>UNIT</u>
52.11 DRILLING AND BLASTING HOLES FOR GUARDRAIL POSTS/NOISE BARRIER POSTS, ERECTION AND BACKFILLING	NUMBER (no.)

The unit of measurement shall be the number of holes drilled and blasted with explosives in rock material that cannot be removed by an auger and where the posts cannot be installed by driving.

The bid rate shall include full compensation for all drilling, explosives, materials, labour and equipment and all incidentals to be incurred for making holes in rock materials and for backfilling the holes after erection of the posts, including concrete backfill and removing any surplus material.

<u>ITEM</u>	<u>UNIT</u>
52.12 NOISE BARRIER ON STEEL POSTS:	
(a) NOISE BARRIER (SPECIFY TYPE AND HEIGHT OF BARRIER)	METRE (m)
(b) ADDITIONAL STEEL POST	NUMBER (no.)

The unit of measurement shall be the metre of noise barrier erected.

The bid rates shall include full compensation for furnishing all materials and labour and erecting and painting and galvanising the noise barrier posts, complete with posts, spacer blocks, bolts, nuts, washers and reinforcing plates.

<u>ITEM</u>	<u>UNIT</u>
52.13 CONCRETE CRASH BARRIER	
(a) CONCRETE CRASH BARRIER	METRE (m)
(b) TRANSITION SECTIONS FOR CONCRETE CRASH BARRIER (STATE LENGTH OF TRANSITION)	NUMBER (no.)

The unit of measurement shall be the length of the concrete crash barrier supplied and erected in accordance with the Specifications.

The unit of measurement shall be the number of completed asphalt transition sections constructed to the details shown on the Drawings.

The bid rate shall include full compensation for supplying all materials and labour, making and transporting the crash barrier with reflective road paint as specified in clause 5200 or as specified in the drawings, setting out, including adequate bedding as detailed in the drawing and all the equipment, the tools and incidentals necessary for completing and maintaining the Works described in this Section.

The bid rate shall include full compensation for procuring, providing, mixing and placing all material and for all labour, formwork and incidentals required for constructing complete transition sections as specified.

<u>ITEM</u>	<u>UNIT</u>
52.14 REPAIR OF EXISTING CRASH BARRIER UNITS	

(a) CONCRETE CRASH BARRIER	METRE (m)

The unit of measurement shall be the length of the concrete crash barrier repaired in accordance with the Specifications.

The bid rate shall include full compensation for supplying all new materials and labour, making repair of concrete crash barrier with concrete of specified grade by cutting and trimming the damaged portion to a regular shape, cleaning the area to be repaired thoroughly, applying concrete after erection of proper form work. Crash barrier with reflective road paint shall be as specified in CLAUSE 5200 or as specified in the drawings.

<u>ITEM</u>	<u>UNIT</u>
52.15 ANTIGLARE BARRIER	
(a) SUPPLY AND INSTALLATION OF AN ANTIGLARE BARRIER	NUMBER (no.)

The unit of measurement shall be the number of antiglare barriers supplied and erected in accordance with the Specifications.

The bid rate shall include full compensation for supplying all materials and labour for making/ procuring, transporting the barriers, setting out, excavating, backfilling all the holes disposing of surplus excavated material, including all haulage, and all the equipment, the tools and incidentals necessary for installation of the antiglare barrier.

<u>ITEM</u>	<u>UNIT</u>
52.16 BOLLARDS (STATE TYPE AND DIMENSION)	NUMBER (no.)

The unit of measurement shall be the number of bollards supplied and erected in accordance with the Specifications.

The bid rate shall include full compensation for supplying all materials and labour for making/ procuring, transporting the bollards, setting out, excavating, backfilling all the holes, disposing of surplus excavated material, including all haulage, and all the equipment, tools and incidentals necessary for installation of the bollards.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5300: FENCING

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5301 SCOPE

This Section covers the relocation of existing fences and erecting new fences along the boundaries of the road reserve and elsewhere as indicated on the Drawings or as directed by the Engineer.

It shall also include the erection and later removal of temporary fences and dismantling of existing fences and stacking of the fencing material.

Except when the Engineer allows otherwise, temporary fences shall be erected before construction on a particular section of the road is commenced, or before temporary bypasses are opened to traffic.

This Section also covers the construction of cattle grids.

5302 MATERIALS

(a) Straining Posts, Stays, Standards and Droppers

Straining posts, stays, standards and droppers shall be of the type and size indicated on the Drawings. Steel sections shall comply with the requirements of BS EN 10365 2017 or BS EN 10162:2003 or equivalent and timber posts with the requirements of BS EN 1995-1-1:2004+A2:2014 or equivalent. Timber posts shall be treated with a preservative in accordance with the requirements of BS 8417:2011+A1:2014.

Unless otherwise specified or shown on the Drawings, rolled steel posts shall be 15 or 22 kg/m rails as shown on the Drawings. Standards shall be 2.5 kg/m Y-sections or timber standards according to SANS 457:2018 or equivalent.

Droppers shall be 0.56 kg/m ridgeback-pattern droppers or timber droppers according to BS EN 1995-1-1:2004+A2:2014 or equivalent.

Tubular straining posts and stays shall be galvanised in accordance with BS EN 10240:1998, BS EN ISO 1461:2022 or equivalent for Class B1 articles, or shall be painted as specified in SECTION 6900 as may be required on the Drawings, and shall have a wall thickness of at least 2.95 mm. Unless otherwise shown on the Drawings, all tubular posts shall be provided with at least a 230 mm x 230 mm foot plate and a pressed-steel or cast-iron cap. Tubular stays shall have a nominal bore of at least 60 mm.

Rolled steel sections shall be provided with a protective coating of tar or other approved material.

(b) Pedestrian Fencing

Pedestrian fencing framework shall generally be 2.0 m long and 1.05m in height or as indicated in the drawing and manufactured using the following minimum sizes in the case of rectangular hollow sections for the components or any section as provided in the drawing or as approved by the Engineer:

Component	Minimum sizes
Post	60x40x4.0 mm
Top rail	60x40x4.0 mm
Bottom rail	50x25x2.5 mm
Intermediate rail	50x50x2.5 mm
Infilling bars	20x20x2.0 mm
Strut	30x30x2.6 mm

Infill panels should be placed with a maximum of 100 mm gap to ensure good visibility through the barriers. Panels shall be manufactured to a radius to meet the requirements of the site and hot dip galvanised to BS EN ISO 1461:2022 after manufacture.

(c) Bolts for Stays

Bolts shall be galvanised steel bolts of the required length and a diameter, which shall not be less than 12 mm. All the necessary bolts, nuts and washers, shall be supplied with each post.

(d) Wire

i) Barbed Wire

Barbed wire shall comply with the requirements of US EAS 135:2021, BS EN 10223-1:2012 or equivalent and shall be one or more of the following types:

- High-tensile-grade single-strand 3.15 mm x 2.5 mm oval-shaped wires, with a 2.81-mm equivalent diameter and fully galvanised.
- High-tensile-grade single-strand fully galvanised (first-class coating), 2.8 mm x 1.9 mm in diameter, oval-shaped wire, with a 2.31 mm equivalent diameter. This wire shall not be used within 500 mm above ground level where bushfires are common.
- Mild-steel-grade double-strand uni-directional twist wire, each strand 2.5 mm in diameter, for use at any height above ground. The wire shall be fully galvanised.

Barbs shall be manufactured from 2 mm galvanised wire and shall be spaced at not more than 152 mm.

ii) Smooth Wire

Smooth wire shall comply with the requirements of US EAS 135:2021, BS EN 10223-1:2012 or equivalent and shall be of the types specified below:

- Straining wire shall be 4 mm in diameter and fully galvanised.
- Fencing wire shall be high-tensile-grade not less than 2.24 mm in diameter wire fully galvanised. This wire should be used 500mm above ground where there is a risk of bushfires.
- Tying wire shall be not less than 2.5 mm in diameter mild-steel galvanised wire for tying fencing wire to standards and droppers and 1.6 mm mild-steel galvanised wire for tying netting and mesh wire to the fencing wire.

(e) Diamond mesh

Diamond mesh (chain-link fencing material) shall comply with the requirements of BS 1722-1:2019 or BS 1722-2:2020 or equivalent. The width shall be as shown on the Drawings and the edge finish shall be both sides clinched or barbed.

The nominal diameter of the wire shall be 2.5 mm and the mesh size shall be 64 mm x 64 mm.

The wire shall be fully galvanised.

(f) Wire Netting

Wire netting shall be fully galvanised mild-steel wire with a minimum diameter of 1.8 mm, with 75 mm hexagonal mesh.

The height shall be as shown on the Drawings.

(g) Barbed-Tape Concertina Wire

Barbed-tape concertina wire shall comply with the requirements of US EAS 135:2021 or equivalent. The high-tensile steel wire shall be heavily galvanised (Class A), and the barbed tape and concertina clamps shall also be heavily galvanised (Class Z600). The diameter of the roll shall be 950 mm or 700 mm according to requirements.

(h) Gates

Gates shall be of the material and dimensions as specified on the Drawings or as approved by the Engineer. Gates shall be complete in every respect, including hinges, washers, bolts and locking chains attached to the gate.

(i) Timber Posts for Wire Mats

Timber posts for holding down wire mats where the fence crosses streams shall comply with the requirements of BS EN 1995-1-1:2004+A2:2014 or equivalent and shall be in accordance with the requirements of BS 8417:2011+A1:2014.

(j) Manufacturing Tolerances for Wire

The actual diameter of the wire supplied shall nowhere be less than the specified diameter minus the following tolerances:

Specified diameter	Tolerance
1.00 - 1.80 mm	0.05 mm
2.00 - 2.80 mm	0.08 mm
3.15 - 4.00 mm	0.10 mm

5303 TYPES OF FENCING

The following types of fences shall be erected in accordance with the dimensions shown on the Drawings:

- Stock-proof fences
- Vermin-proof fences
- Pedestrian fences
- Security fences
- Game fences

Where existing fences have to be dismantled and re-erected, they shall be erected either to the same design as the original, but with such modifications as may be required by the Engineer, or they shall be erected up to one of the standards specified above, all as ordered by the Engineer.

5304 PROTECTING LIVESTOCK

From the time of occupancy up to the date of Taking Over Certificate being issued to the Contractor, they shall take all measures necessary for preventing the ingress of vermin, and for protecting and controlling livestock etc., on the sections of the properties affected by their operations. They shall provide gates at the positions in existing fences cut by him/her for gaining access and shall ensure that all gates are kept closed except when they are opened for admitting their traffic. No fences shall be cut without the approval of the Engineer, and consultation with the Owner of the fence.

Where alternative arrangements cannot be made, the Engineer may direct the Contractor to erect temporary fencing where necessary to protect livestock that may be lost or are exposed to vermin through their operations. Such fencing shall be of an adequate standard and shall be erected ahead of construction operations. The fencing shall be maintained in good order during construction operations and, on completion of the work, it shall be removed from the site and all surfaces shall be restored. The Engineer may order that any permanent fencing which is required be erected ahead of construction operations, where practicable, instead of erecting temporary fencing.

Payment for the protection of livestock, excluding the erection of temporary fences, shall be included in the amounts bid for the Contractor's establishment on the site, as specified in SECTION 1300.

5305 CLEARING THE FENCE LINE

The fence line shall be cleared over a width of at least 1.0 m on each side of the centre line of the fence and surface irregularities shall be graded so that the fence will follow the general contour of the ground. Clearing the line shall include the removal of all trees, scrub, stumps, isolated boulders or stones and other obstructions, which will interfere with the construction of the fence. Stumps within the cleared space shall be grubbed as described in SECTION 3100. The bottom of the fence shall be located at a uniform distance above the ground line in accordance with the requirements shown on the Drawings. All material removed shall be burnt or disposed of in disused borrow pits.

Any areas outside the road reserve where clearing is not permitted by the Owner or is impracticable shall not be cleared if so directed by the Engineer.

5306 ERECTING STRAINING POSTS, PEDESTRIAN FENCING AND STANDARDS

Straining posts shall be erected at all terminal points, low points (as required), corners and bends in the fencing and at all junctions with other fences. Straining posts shall not be spaced further apart than shown on the Drawings. The length of posts above ground shall be such that the correct clearance between the lowest wire and the ground can be obtained.

Straining posts and pedestrian fencing units shall be accurately set in holes and shall be provided with concrete bases to the dimensions shown on the Drawings.

Holes shall be dug to the full specified depth. Where, on account of the presence of rock, the holes cannot be excavated by hand or by pneumatic tools and the Contractor has to resort to the use of explosives, they will be paid separately for the drilling and blasting operations required.

All straining posts and pedestrian fencing units shall be braced by means of stays or anchors as shown on the Drawings or as directed by the Engineer. Tubular stays shall be bolted to the posts. Gateposts shall not be used as straining posts but at each gatepost a straining post shall be placed as shown on the Drawings.

Standards shall be firmly planted into the ground at the spacing shown on the Drawings or as directed by the Engineer. The spacing of standards between any two successive straining posts shall be uniform and not greater than that shown on the Drawings. In rock or hard material standards shall be either driven or set in holes drilled into the rock. The size of drilled holes shall provide a tight fit to the standards. Care shall be taken when driving standards to prevent them from buckling or being damaged.

All straining posts and pedestrian fencing units and standards shall be accurately aligned and set plumb. Where veranda-type security fencing is used, the posts shall be planted with the overhang on the roadside and perpendicular to the direction of the fence. After the straining posts and standards have been firmly set in accordance with the foregoing requirements, fence wires shall be attached thereto at the spacing shown on the Drawings.

5307 ERECTING FENCE WIRES

All fencing wire shall be tied to the sides of standards or posts to prevent the wires from being displaced or becoming loose. The wire shall be carefully tensioned without sagging, and true to line, care being exercised not to tension the wire to such an extent that it will break, or that end, corner, straining or gate posts will be pulled out, or that it will be easily damaged during fires.

Each strand of fencing wire shall be securely tied in the correct position hard up to each standard with soft galvanised tying wire. The tying wire for each strand shall pass through a hole or notch in the standard, while the ends of the tying wire shall be wound at least four times

around the fencing wire to prevent it from moving in a vertical direction.

At end, corner, straining, and gate posts, the fencing wire shall be securely wrapped twice around the post and secured against slipping by tying the end tightly around the wire by means of at least six neat tight twists.

Where high-tensile wire is used, two long twists may first be made followed by the six tight, neat twists around the post to prevent the wire from breaking at the first twist. When a smooth wire is used, the loose end shall preferably be bent over and hooked into the notch between the fencing wire and the first twist.

Splices in the fencing wire shall be permitted if made in the following manner with a splicing tool. The end of each wire at the splice shall be taken at least 75 mm past the splicing tool and wrapped around the other wire by not less than six complete turns with the two separate wire ends being turned in opposite directions. After the splicing tool has been removed, the space left by it in the spliced wire shall be closed by pulling the wire ends together. Unused wire ends shall be cut close so as to leave a neat splice.

The gaps between gate posts and the adjacent straining posts shall be fenced off with short lengths of fencing wires.

Droppers shall be tied to each fence wire with soft tying wire in the required position as specified for standards to prevent slippage in a vertical direction. The spacing of droppers between any two straining posts shall be uniform. Anchoring to structures shall be done as shown on the Drawings.

Barbed-tape concertina wire shall be attached to the fence as shown on the Drawings at maximum spaces of 1.0 m between tying points. Barbed-tape concertina wire rolls shall be spliced by overlapping for one full circle and tied at four evenly spaced points along the circumference. Spliced ends shall coincide with the positions of the standards.

5308 ERECTING DIAMOND MESH OR WIRE NETTING

Where vermin-proof, pedestrian or security fences are erected, or where instructed by the Engineer, wire netting or diamond mesh shall be stretched against the fence and properly tied to the fencing wire as shown on the Drawings. The diamond mesh or wire netting shall be secured by soft tying wire at 1.2 m centres along the top and bottom wires and at 3 m centres along each of the other fencing wires, unless otherwise shown on the Drawings.

In the case of vermin-proof fencing, vermin shall be prevented from creeping under the fence by either one of the two methods described below as ordered by the Engineer:

- i. By folding back the bottom 130 mm of the wire netting so that it lies flat on the ground and by tightly packing stones (having a minimum dimension of 200 mm) end to end on this flap to secure it in position.
- ii. By embedding the lower 130 mm of the wire netting in the ground and thoroughly compacting the earth around it on both sides, to secure the netting.

5309 CLOSING OPENINGS UNDER FENCES

At ditches, streams, drainage channels or other depressions where the fence cannot be erected so as to follow the general ground contour, the Contractor shall close the opening under the fence with horizontal barbed wires at 150 mm spacing. Stretched between additional posts or straining posts as shown on the Drawings or as directed by the Engineer. In the case of pedestrian, vermin-proof and security fences the opening shall be covered with strips of wire netting or diamond mesh 1000 mm wide, fixed to the barbed wires.

In the case of larger streams where damming of debris against the fence would constitute a hazard, the opening

below the bottom fencing wire shall be closed with loose-hanging wire nets. For this purpose, additional straining posts shall be planted on both sides of the stream with a cable consisting of at least five strands of smooth fencing wire stretched between them. Onto this cable vertical strips of diamond mesh hanging down to ground level shall be fixed. The edges of the various strips of diamond mesh shall be tied to each other so that the entire mat will be raised by water flowing underneath to leave a free stream area. These mats at streams shall be erected only when instructed by the Engineer. If it should be necessary to keep the bottoms of the mats on the ground, the Engineer may order that timber posts or pipes be fixed horizontally to the bottom ends of the diamond-mesh strips.

5310 EXISTING FENCES

Where a new fence joins an existing fence whether in line or at an angle, the new fence shall be erected with a new straining post positioned at the terminal point of the existing fence.

Existing fences that require to be taken down or moved to a new location shall be dismantled. Material not required for re-erection or unsuitable for re-use shall be neatly stacked at approved locations in accordance with the Engineer's instructions. Fencing wire and wire netting shall be stacked clear of the ground. Payment will be made only for fences removed in accordance with the written instructions of the Engineer.

Where fences require moving, the Contractor shall re-use all the material, declared to be suitable for this purpose by the Engineer, plus such new material as may be required to erect the fence again to the standard specified for new fences. The Engineer shall not be responsible for any delays or costs arising from the breaking of re-used wire during straining.

5311 ERECTING GATES

Gates shall be erected at the positions indicated by the Engineer. The gates shall be hung on gate fittings in accordance with the requirements shown on the Drawings. Gates shall be so erected as to swing in a horizontal plane at right angles to the gateposts, clear of the ground in all positions. In pedestrian and security fences the double swing gates shall leave a gap not exceeding 25 mm between them when closed and other gates shall not be further than 25 mm from the gate post when closed.

Gates shall be stock-proof to the same extent as the adjoining fence. The clearance below the gates shall not exceed 75 mm with the gates closed. Where the gate crosses a public road, it shall be fitted with a disc or other device easily visible at night, as instructed by the Engineer.

5312 TEMPORARY FENCING, GATES AND MOTOR GATES

If required, the Contractor shall erect temporary fencing, gates and motor gates in accordance with the Drawings, Special Specifications or the Engineer's instructions. The material and erection shall be in accordance with the provisions of this Section, but the material need not necessarily be new. Where used materials are offered, they shall be in a good condition and approved in advance by the Engineer.

When no longer required, the temporary fencing, gates and motor gates shall be dismantled and removed.

5313 FINISHING REQUIREMENTS

The completed fence shall be plumb, taut, true to line and ground contour, with all posts, standards and stays firmly set. The height of the lower fencing wire above the ground at posts and standards shall not deviate by more than 25 mm from that shown on the Drawings. Other fencing wires shall not deviate by more than 10 mm from their prescribed vertical positions.

The Contractor shall, on completion of each section of fence, remove all cut-offs and other loose wire or netting so as not to create a hazard to grazing animals or a

nuisance to the owners of the ground.

5314 CATTLE GRIDS

A cattle grid is a structure that is designed to prevent the passage of cattle and other domestic animals while permitting other traffic to pass. Cattle grids are normally constructed across a road in connection with fencing and gates.

Cattle grids shall be constructed in conformity with the details, dimensions and design shown in the Drawings, and at locations shown in the Drawings or as directed by the Engineer.

5315 MEASUREMENT AND PAYMENT

ITEM	UNIT
53.01 CLEARING THE FENCE LINE, 2m WIDE STRIP:	KILOMETRE (km)

The unit of measurement for clearing the fence line shall be the kilometre of fence line measured along each fence line.

The bid rate shall be in full compensation for clearing the fence line as specified, including the removal of trees, stones, and other obstructions and the disposal of all waste material resulting from clearing operations, as may be directed. The removal of trees and stumps with a girth exceeding 1.0 m shall be paid for as specified in SECTION 3100.

ITEM	UNIT
53.02 SUPPLYING AND ERECTING NEW FENCING MATERIAL FOR NEW FENCES AND FOR SUPPLEMENTING MATERIAL IN EXISTING FENCES WHICH ARE BEING REPAIRED OR MOVED:	
(a) BARBED WIRE (GRADE, SIZE AND TYPE OF GALVANISING INDICATED)	KILOMETRE (km)
(b) SMOOTH WIRE (GRADE, SIZE AND TYPE OF GALVANISING INDICATED)	KILOMETRE (km)
(c) DIAMOND MESH	SQUARE METRE (m ²)
(d) WIRE NETTING	SQUARE METRE (m ²)
(e) BARBED-TAPE CONCERTINA WIRE	KILOMETRE (km)
(f) STEEL AND TIMBER STRAINING POSTS, INCLUDING ANCHORS (TYPE, SIZE AND LENGTH AND WHETHER GALVANISED, TREATED OR PAINTED INDICATED)	NUMBER (no.)
(g) STEEL AND TIMBER STANDARDS (LENGTH AND TYPE INDICATED)	NUMBER (no.)
(h) STEEL AND TIMBER DROPPERS (LENGTH AND TYPE INDICATED)	NUMBER (no.)
(i) TIMBER POSTS TO BE FIXED TO THE BOTTOM OF WIRE MESH IN STREAMS (DIAMETER INDICATED)	METRE (m)
(j) PEDESTRIAN FENCING (GRADE, SIZE AND TYPE OF GALVANISING INDICATED)	METRE (m)

The quantity of material used shall be determined by measuring the quantities of individual items of material used in the completed fence. Linear measurement of the completed fence shall not apply. The appropriate units of measurement are as follows:

i) Fencing wire (SUB ITEMS 53.02 (a) and (b))

The unit of measurement shall be the kilometre of each type of fencing wire measured between end

posts. Tying wire and wire used for anchoring the posts shall not be measured for payment.

ii) Diamond mesh and wire netting (Sub items 53.02 (c) and (d))

The unit of measurement shall be the square metre of diamond mesh or wire netting, the quantity of which shall be calculated according to the prescribed width and the length between straining posts or gate posts, or the length of strips used for covering openings under fences, or the length used for covering the gates.

iii) Barbed-tape concertina wire (SUB ITEM 53.02 (e))

The unit of measurement shall be the kilometre of fence provided with barbed-tape concertina wire of which each concertina is opened to the maximum effective open concertina length as specified in the Drawings.

iv) Straining posts (SUB ITEM 53.02 (f))

The unit of measurement shall be the number of posts, as follows:

All straining posts erected in accordance with the maximum specified spacing or such lesser spacing as authorised by the Engineer, all corner posts authorised by the Engineer, and all end posts. Gate posts for new gates shall not be measured for payment.

v) Standards and droppers (SUB-ITEMS 53.02 (g) and (h))

The unit of measurement shall be the number of standards and droppers erected to the maximum specified spacing or such lesser spacing as authorised by the Engineer.

vi) Timber posts to be fixed to the bottom of wire mesh in streams (SUB-ITEM 53.02 (i)).

The unit of measurement shall be the metre of timber post of every diameter erected in accordance with the Drawings and the instructions of the Engineer.

vii) Pedestrian Fence (Sub items 53.02 (j))

The unit of measurement shall be the metre of type of Pedestrian Fence erected and measured in accordance with the Drawings and the instructions of the Engineer.

The bid rate for each straining post, standard, dropper, each kilometre of fencing wire and barbed-tape concertina wire, and each square metre of diamond mesh or wire netting and for each metre of timber post, shall include full compensation for providing all the materials, including all concrete, tying wire, straining wire, bolts, washers and nuts, for excavating or drilling holes for standards, for erecting the posts, standards and droppers and the complete putting up of the fence as specified and as shown on the Drawings. No separate payment will be made in respect of stone packing and/or trenching in the case of wire netting.

The bid rate for posts shall include full compensation for erecting the stays of the types shown on the Drawings.

ITEM	UNIT
53.03 NEW GATES:	
(a) SINGLE LEAF (SIZE AND TYPE INDICATED)	NUMBER (no.)
(b) DOUBLE LEAF (SIZE AND TYPE INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of new gates erected. At pedestrian and security fences, the pair of gates shall be measured as one.

The bid rates shall include full compensation for procuring and furnishing all materials, including gates, gate posts, hinges, bolts, disks, concrete and straining wire, and for erecting the gates as specified and as shown on the Drawings. It shall not include compensation for any fencing

wire or mesh fitted onto the gate.

	<u>ITEM</u>	<u>UNIT</u>
53.04	MOVING EXISTING FENCES AND GATES:	
(a)	FENCES:	
(i)	STOCK-PROOF FENCES	KILOMETRE (km)
(ii)	VERMIN-PROOF FENCES	KILOMETRE (km)
(iii)	PEDESTRIAN FENCES	KILOMETRE (km)
(iv)	SECURITY FENCES	KILOMETRE (km)
(b)	GATES	NUMBER (no.)

The unit of measurement for moving existing fences shall be the kilometre of fence, the quantity of which shall be taken as the length of fence that has been put up permanently with material obtained from fences that have been dismantled elsewhere. Additional new material used during the re-erection of existing fences shall be measured under ITEM 53.02.

The unit of measurement for moving gates shall be the number of gates moved.

The bid rate for each kilometre of existing fence moved shall include full compensation for dismantling the old fence, coiling and stacking the material unsuitable for re-use, moving all material, including posts and wire and again putting up the fence at the new position and the provision of binding, tying and straining wire. New material used for re-erection of old fences shall be paid for under ITEM 53.02.

The bid rate for each gate moved shall include full compensation for taking down the gate and re-erecting it where required, including all new bolts, nuts and other accessories required but excluding new gate posts.

	<u>ITEM</u>	<u>UNIT</u>
53.05	DISMANTLING EXISTING FENCES AND GATES	KILOMETRE (km)

The unit of measurement shall be the kilometre of existing fencing and gates taken down and dismantled on the instructions of the Engineer.

The bid rate shall include full compensation for taking down existing fences and gates, coiling wires, rolling netting into rolls, transporting the material to designated sites and stacking the material.

	<u>ITEM</u>	<u>UNIT</u>
53.06	PROVIDING TEMPORARY FENCES AND GATES:	
(a)	STOCK-PROOF FENCE	KILOMETRE (km)
(b)	VERMIN-PROOF FENCE	KILOMETRE (km)
(c)	PEDESTRIAN FENCE	KILOMETRE (km)
(d)	TEMPORARY GATES (TYPE AND SIZE INDICATED)	NUMBER (no.)
(e)	TEMPORARY MOTOR GATES	NUMBER (no.)

The unit of measurement for SUB-ITEMS 53.06 (a), (b) and (c) shall be the kilometre of each type of temporary fencing erected on the instructions of the Engineer.

The bid rates shall include full compensation for providing all labour, new or suitable second-hand material, putting up the temporary fence and when no longer required, dismantling and removing it from the site to any new locality where it is required.

The unit of measurement for SUB-ITEMS 53.06 (d) and (e) shall be the number of temporary gates provided by the Contractor.

The bid rates for SUB-ITEMS 53.06 (d) and (e) shall include full compensation for erecting the gates in accordance with the Drawings, by using new or second-hand material, and their dismantling and removal and again putting up any fencing removed from the positions where the gates were erected.

Where new or second-hand materials are used that have been provided by the Employer, e.g., material obtained from taking down existing fences, such material obtained from taking down the temporary fences or gates shall remain the property of the Employer. Material provided by the Contractor for temporary fences will become the Contractor's property after the temporary fences have been dismantled.

	<u>ITEM</u>	<u>UNIT</u>
53.07	RINGBOLTS FOR ANCHORING FENCING TO STRUCTURES:	NUMBER (no.)

The unit of measurement shall be the number of ringbolts supplied and fixed to the structure.

The bid rate shall include full compensation for supplying and fixing ringbolts of the type shown on the Drawings to the structure, including, where necessary, drilling holes, anchorage, grouting ringbolts in with epoxy resin, and for all incidentals.

	<u>ITEM</u>	<u>UNIT</u>
53.08	DRILLING AND BLASTING HOLES FOR POSTS AND ANCHORS:	NUMBER (no.)

The unit of measurement shall be the number of holes for posts and anchors made by drilling and/or blasting where excavation by pneumatic tools cannot be done economically.

The bid rate shall include full compensation for drilling and blasting the holes and for all other expenses in connection with providing, storing, transporting and using explosives.

	<u>ITEM</u>	<u>UNIT</u>
53.09	CATTLE GRIDS (INDICATE TYPE)	NUMBER (no.)

The unit of measurement shall be the number of cattle grids supplied; the type as indicated in the Drawings.

The bid rate shall include full compensation for providing the materials and constructing the cattle grids, including excavation, construction, curing finishing and protection of the works as instructed by the Engineer.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5400: ROAD SIGNS

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5401 SCOPE

This Section covers the supply and erection of permanent and temporary road traffic signs alongside and over the carriageway, ramps and crossroads at intersections and interchanges and at the locations indicated on the Drawings or as directed by the Engineer.

5402 DESCRIPTION

This work shall consist of furnishing and placing road signs, in accordance with these Specifications, at the locations and of the dimensions shown on the Drawings or as directed by the Engineer.

5403 MATERIALS

(a) Concrete

Concrete for foundations shall be Class 30 and shall be executed as specified in SECTIONS 6100 AND 6400 of these Specifications.

(b) Signposts

Signposts if consisting of steel pipes conforming to at least the requirements of ASTM A192:2017 Grade B, shall be galvanised in accordance with ASTM A123:2017 and shall conform to SECTION 6700.

Post caps shall be provided for hollow steel sections and can be made from approved cast or sheet metal or suitable weather resistant plastic material

Concrete Post if specified in the Drawings shall conform to SECTION 6300, AND 6400. Alternative material if any like PVC or other shall be as specified in the drawings or as approved by the Engineer.

Overhead signs shall be sections and type as shown in the drawings. Signs shall be mounted on gantries, cantilevers, and butterfly or on overbridges with vertical clearances as applicable for vehicular operations. After steel trusses have been fabricated and all required holes punched or drilled on both the horizontal truss units and the vertical and support units, they shall be galvanized in accordance with ASTM A 123:2017. High strength bolts, nuts- etc. shall conform to BS 3692:2020.

Stiffening channels shall be made from extruded aluminium channel in accordance with EN12899-1:2008 and painted to match the sign plates.

(c) Sign Plates

Sign Plates shall consist of but not be limited to materials as specified below and shall conform to BS EN 12899 and as indicated in drawings or special Specifications.

i) Steel Sheets:

Sign plates shall consist of steel sheets conforming to the requirements of ASTM A 1008:2021.

ii) Aluminium Alloy Sheet:

Aluminium alloy sheets conforming to ASTM B209-14:2021, ASTM B308/B308M-20:2010, 6061-T6 aluminium, degreased and Alodine treated.

iii) Glass Reinforced Plastic (GRP):

Sign plates shall be manufactured from a self-coloured grey Glass Reinforced Plastic (GRP) material not less than 3.2mm thick. The GRP sheet shall meet the impact requirements of BS EN 12899-1:2007.

iv) Aluminium Composite Board:

These boards shall meet the performance requirements detailed in the special specifications or specified by the Engineer.

v) Reflective Sheeting:

Reflective sheeting shall comply with ASTM D4956-19:2019 and the class of sheeting shall be Type IV (High Intensity Prismatic) unless otherwise specified in the Special Specifications.—The acceptable minimum co-efficient of retro-reflection for High Intensity Prismatic Grade Sheeting (Type IV) shall be as indicated in TABLE 5403/1. All signs shall be fully reflective in all colours with the exception of any part coloured black and shall have a photometric performance in accordance with ASTM D4956:2019. The reflective sheeting is to be non-metallised and designed for use on permanent static road traffic signs.

TABLE 5403/1: ACCEPTABLE MINIMUM COEFFICIENT OF RETRO-REFLECTION FOR HIGH INTENSITY MICRO-PRISMATIC GRADE SHEETING (TYPE IV) (CANDELAS PER LUX PER SQUARE METRE)

Observation	Entrance	White	Yellow	Orange	Green	Red	Blue	Brown
0.1°	-4°	500	380	200	70	90	42	25
0.1°	+30°	240	175	94	32	42	20	12
0.2°	-4°	360	270	145	50	65	30	18
0.2°	+30°	170	135	68	25	30	14	8.5
0.5°	-4°	150	110	60	21	27	13	7.5
0.5°	+30°	72	54	28	10	13	6	3.5

Note: Minimum Coefficient of Retro reflection (RA) (cd.lx⁻¹.m⁻²)

The colour of the material shall be located within the area defined by the chromaticity coordinates in TABLE 5403/2 and comply with the luminance factor when measured as per ASTM D-4956. The colours shall be durable and

uniform in acceptable hue when viewed in daylight or under normal headlights at night.

TABLE 5403/2: COLOUR SPECIFIED LIMITS (DAYTIME)

Colour	1		2		3		4		Daytime Luminance Factor (Y%)	
	x	y	x	y	x	y	x	y	Min.	Max.
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329	15	-
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	24	45
Green	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771	2.5	11
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346	2.5	11
Blue	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216	1	10
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404	12	30
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390	1	6
Fluorescent Yellow-Green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540	60	-
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442	45	-
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355	25	-

Words, figures and other symbols shall be applied to the reflective sheeting by applying coloured overlay film onto white reflective sheeting. The overlay films and the base sheeting must come from the same manufacturer.

The Contractor shall provide, at their own expense, the sign manufacturer's specifications and certificate for all materials they intend to adopt. The certificate shall set forth the name or brand of the materials to be furnished, the results of tests proving the products meet the requirements, and any other data requested by the Engineer. The certificate shall be sworn to for the manufacturer by a person having legal authority to bind the company.

The Contractor shall also provide from the sheeting manufacturer a warranty of Minimum seven-year for satisfactory field performance of the finished signs in respect of retroreflective performance, colour, fungus resistance, and adhesion. The retroreflective performance of the sign at the end of the warranty period should be specified in the warranty and the retroreflective values should not be less than 75% of the original values. Any sign that fails within that period shall be replaced at no cost to the Employer.

The Contractor shall not place any purchase order for road signs until the manufacturer's certificate and form of guarantee have been inspected by the Engineer and accepted.

At any time, the Engineer may request any test they think necessary to verify the compliance of the material with the Specifications.

All the tests shall be carried out in a specialised laboratory previously approved by the Engineer; this laboratory shall certify the results of the tests in question.

All the above-mentioned tests shall be at the expense of the Contractor.

5404 CONSTRUCTION

Road sign plates shall be manufactured from galvanised steel sheet of at least 2 mm thickness, or from aluminium alloy sheet of at least 2.5 mm thickness, glass reinforced plastic material not less than 3.2 mm thick or such other material that is approved by the Engineer.

Sign plates shall be stiffened when the maximum dimension of the sign exceeds 400 mm. The vertical channel spacing shall be in accordance with the sheeting manufacturer's recommendations but should not exceed 400 mm.

Stiffening channels shall be secured using a self-pierce rivet system with maximum rivet spacing of 150 mm and a maximum edge clearance of 30 mm.

Material for fixing such as brackets, socket caps, clips, screws, bolts, nuts and washers, shall be corrosion resistant and to the Engineer's approval. Brass or copper will not be allowed for use in contact with aluminium.

The colours on all road signs, with the exception of black, will normally be reflectorized, unless otherwise specified or ordered by the Engineer. Reflective sheeting shall be applied with a squeeze roll applicator with sheeting that has a pressure sensitive adhesive. Retro-reflective background material shall be pre-applied to individual sections of big informative signs before assembly with the material taken around the face edges of each extension for at least 10 mm without damaging the material. Where possible, letters across the joint between two extrusions should be avoided.

Before painting all signs shall be pre-treated by an approved method, and all frames, brackets, metal stakes, clips, screws, nuts, bolts, rivets, and washers shall be corrosion-proofed prior to painting.

The signs shall be supported on a galvanised steel tube or any other tube of approved material of not less than 75 mm outer diameter and securely bolted to it as shown on the drawings.

To avoid theft or vandalism of the signs, the ends of bolts shall be hammered or spot-welded to prevent the nuts from being removed. It is recommended that each tube be filled from ground level upwards with lean concrete or grout or any other alternative infill material or as instructed by the Engineer to prevent vandalism. For steel tubes four holes each 8 mm diameter at a height 300 mm above ground level should be drilled to provide a safety break point in the case of a vehicle collision.

Where details for the construction of sign faces, the framework of the sign faces and the attachment thereof to the supporting framework are not shown on the Drawings, the Contractor shall design these themselves and submit the details to the Engineer for approval before manufacture.

Care shall be taken to prevent the forced rotation of the sign around the post. A steel bar of 16 mm diameter x 450 mm long shall be welded in the middle horizontally to the foot of the post to prevent the rotation of the post in its foundation. The length of the post shall be such that it is at least 0.65 m in the ground when the sign is at its correct height.

Additional road sign plates shall be provided and mounted on the support of the road sign, as directed by the Engineer.

Posts shall be thoroughly cleaned, free from grease, scale and rust and given at least one coat of rust inhibiting priming paint.

Posts and backs of signs, fittings, etc. shall be painted grey. The back of aluminium road signs will not require painting.

The foundations for road signs shall be as shown on the Drawings or as directed by the Engineer. Concrete foundations shall be poured using formwork.

After the concrete has set sufficiently, the spaces around the concrete foundation shall be refilled to the required elevation with suitable material, which shall be thoroughly tamped in layers of not more than 150 mm thickness.

All road signs shall be marked with the manufacturer's name or trademark, and the year of manufacture.

Mounting of the sign plate on the support shall be made by brackets, which shall be in accordance with and approved by the Engineer, before the actual manufacture and erection in place.

The signs shall be erected at a distance from the edge of the shoulder as shown on the Drawings or as directed by the Engineer.

The Contractor shall cut back trees and vegetation as may be necessary to ensure visibility of the signs.

Overhead signs shall provide a vertical clearance of not less than 5.5 m over the entire width of the pavement and shoulders except where a lesser vertical clearance is used for the design of other structures. Where a median is 3.6 m or less in width, consideration should be given to spanning over both roadways without a central support. Where overhead sign supports cannot be placed at a safe distance away from the line of traffic or in an otherwise protected site, they should either be so designed as to minimize the impact forces or protect motorists adequately by a physical barrier or guard rail of suitable design.

For cantilever mounted signs, the centre of the sign is typically located over the carriageway edge line; however, the left edge of the sign shall be positioned no further left than the left edge of the paved shoulder. On exit ramps, guide signs shall be located over the relevant lanes. Where a number of signs are erected on gantry, the outer edges of signs shall not extend beyond the outer edges of paved shoulders.

All the structures must be such as to bear the stress caused by a wind blowing at 130 km/h on the support and the signs.

From safety and aesthetic considerations, overhead signs should be properly designed based on sound engineering principles, to safely sustain the dead load, live load and wind load on the completed sign system. For this purpose, the overhead signs shall be designed to withstand a wind loading of 150 kg/m² normal to the face of the sign and 30 kg/m² transverse to the face of the sign. In addition to the dead load of the structure, the walkway loading of 250 kg concentrated live load shall also be considered for the design of the overhead sign structure.

5405 STORAGE AND HANDLING

All road signs or parts of road signs shall be transported and handled so as to prevent any damage and deformation. All road signs shall be stored in a vertical position in a weatherproof storeroom. There shall be sufficient space between the road signs to permit free air circulation and moisture evaporation. Contact of road signs with treated timber, diesel, dirt or water shall not be permitted. When required, existing or newly erected road signs shall be fully or partially covered with burlap or other approved adequately ventilated material to obscure destinations that are temporarily inapplicable or irrelevant.

5406 ERECTING ROAD SIGNS

(a) Position

Road signs shall be erected in the positions shown on the Drawings or as indicated by the Engineer.

(b) Excavation and Backfilling

Excavations for the erection of road signs shall be made according to the dimensions as shown on the Drawings. Where the excavations are to be backfilled with soil, a 12:1 soil-cement mixture shall be made if required by the Engineer.

The soil or soil-cement mixture shall then be compacted by tamping at optimum moisture content in 100 mm thick layers in the excavation.

Where posts or structures are to be fixed in concrete, or where concrete footings are to be cast, the concrete, formwork and reinforcement shall comply with the requirements of SECTIONS 6200, 6300 AND 6400. The holes shall be completely filled with concrete up to the level shown on the Drawings or indicated by the Engineer. The upper surface of the concrete shall be neatly finished with sufficient fall to ensure proper drainage.

(c) Erection

Road signs shall be erected as shown on the Drawings or as directed by the Engineer. During erection the structural steelwork shall be firmly bolted and protected to prevent buckling or damage during erection, or by the equipment used for erection.

Posts to which road signs are to be fixed shall be vertical and the undersides of road signs shall be horizontal after having been erected.

Where timber posts are used for erecting the signs, all holes that are drilled in the timber shall be impregnated with creosote.

For overhead signs, the supporting structure and signs shall be fabricated and erected as per the details given in the plans and at locations directed by the Engineer. Sign posts, their foundations and sign mountings shall be so constructed as to hold signs in a proper and permanent position to adequately resist swaying in the wind or displacement by vandalism. The structures shall be erected with the specified camber and in such a manner as to prevent excessive stresses, injury and defacement. Brackets shall be provided for mounting signs of the type to be supported by the structure. For better visibility, they shall be adjustable to permit mounting the sign faces at any angle between a truly vertical position and three degrees from vertical. This angle shall be obtained by rotating the front lower edge of the sign forward. All brackets shall be of a length equal to the height of the signs being supported. Before erecting support structures, the bottom of each base plate shall be protected with an approved material that will adequately prevent any harmful reaction between the plate and the concrete. The end supports shall be plumbed by the use of levelling nuts and the space between the foundation and base plate shall be completely filled with an anti-shrink grout. Anchor bolts for sign supports shall be set to proper locations and elevation with templates and carefully checked after construction of the sign foundation and before the concrete has set. All nuts on aluminium trusses, except those used on the flanges shall be tightened only until they are snug. This includes the nuts on the anchor bolts. A thread lubricant shall be used with each aluminium nut. All nuts on galvanized steel trusses, with the exception of high strength bolt connections, shall be tightened only to a snug condition.

(d) Field Welding

All welding done during erection shall comply with the requirements for welding during manufacture. Field welding for overhead signs is generally not recommended, however, where this must be done, it should be to the satisfaction of the Engineer.

(e) On-Site Painting

All painting done after the road signs have been erected shall comply with the requirements for painting during manufacture.

All places where the paintwork has been damaged during erection shall be repaired by the Contractor at their own cost to the satisfaction of the Engineer.

(f) Time of Erection

Road signs shall be erected immediately prior to the road being opened to public traffic, unless otherwise directed by the Engineer.

(g) General

All destinations and route numbers shown on the Drawings shall be subject to amendment, and confirmation of the details shall be obtained from the Engineer before any particular signs are made. Such particulars may be available only at a late stage, for which allowance shall be made by the Contractor in their program.

5407 PROTECTION AND MAINTENANCE

The Contractor shall protect the completed road signs against damage until they have been finally accepted by the Engineer, and they shall maintain the road signs until the Performance Certificate has been issued. Damage or defects caused by negligence or faulty workmanship shall be rectified by the Contractor at their own cost to the satisfaction of the Engineer.

5408 DISMANTLING, STORING AND RE-ERECTING EXISTING ROAD SIGNS

Where ordered by the Engineer, the Contractor shall dismantle existing road signs, store them, and re-erect them at new positions indicated.

Where required by the Engineer, the signs shall be repainted or repaired and new materials shall be used for part or all of the supporting structure.

5409 MEASUREMENT AND PAYMENT

The quantity to be measured for payment shall be:

- The actual number of road signs complete in place, including support assembly and concrete foundation, and accepted.
- The actual number of additional road sign plates complete in place, regardless of the sizes.
- Guidance signs are to be measured as one sign per site with all names, route numbers and directional arrows shown on the one sign.
- Steel overhead sign structure shall be measured for payment by the specific unit (each) complete in place as indicated in the Bill of Quantities and the detailed drawings(s).
- Flat sheet aluminium signs with retro-reflective sheeting thereon used for overhead sign shall be measured for payment by the square metre, complete in place

The quantities, determined as provided above, shall be paid for at the rate per unit of measurement for each of the pay items listed below, that is shown in the Bill of Quantities, which price and payment shall be full compensation for furnishing and placing all materials, for all labour, equipment, tools and incidentals necessary to complete the work prescribed in this section, including all necessary excavation and backfilling.

<u>ITEM</u>	<u>UNIT</u>
54.01 ROAD SIGNS (SPECIFY TYPE OF POST)	
(a) ROAD SIGNS ON SINGLE POST, PLATE AREA 'A' (STATE PLATE TYPE)	
(i) $A \leq 0.5M^2$	NUMBER (no.)
(ii) $A > 0.5M^2$	NUMBER (no.)
(b) ROAD SIGNS ON MULTIPLE POSTS, PLATE AREA 'A' (STATE PLATE TYPE)	
(i) $A \leq 1.5M^2$	NUMBER (no.)
(ii) $1.5M^2 < A \leq 2.5M^2$	NUMBER (no.)
(iii) $A > 2.5M^2$	NUMBER (no.)

The unit of measurement shall be the number of standard size signs of approved materials as stated.

The bid rates shall include full compensation for providing the completed road sign board, frame, fixing brackets, angle-irons, channel profiles, Caps for Hollow Sections etc including painting, galvanising if specified, reflective lettering, symbols, legends and borders, attaching the road sign board to the road sign support, and for all other materials and workmanship, brackets, bolts, nuts, etc, for the completion of the road sign boards as specified.

<u>ITEM</u>	<u>UNIT</u>
54.02 OVERHEAD ROAD SIGNS	
(a) STEEL OVERHEAD SIGN STRUCTURE FULL WIDTH WITHOUT INTERMEDIATE SUPPORT (AS SHOWN IN DRAWING)	NUMBER (no.)
(b) STEEL OVERHEAD SIGN STRUCTURE FULL WIDTH WITH INTERMEDIATE SUPPORT (AS SHOWN IN DRAWING)	NUMBER (no.)
(c) STEEL OVERHEAD CANTILEVER SIGN STRUCTURE (AS SHOWN IN DRAWING)	NUMBER (no.)
(d) ROAD SIGNS PLATE AREA 'A'	SQUARE METRE (m ²)
(e) (STATE PLATE TYPE)	

The unit of measurement for pay ITEM 54.02 (a) shall be the number of Steel Overhead Sign structures of approved materials and as shown in the drawings.

The bid rates shall include full compensation for providing the completed road signposts, frame, fixing brackets, angle-irons, channel profiles, etc including painting, galvanising if specified, and for all other materials and workmanship, brackets, bolts, nuts, etc, for the completion of the road sign boards as specified.

The unit of measurement for pay ITEM 54.02 (b) shall be the square metre of completed road signboard of approved materials.

The bid rates shall include full compensation for providing the completed road sign board including painting, galvanising if specified, reflective lettering, symbols, legends and borders, attaching the road sign board to the road sign support, or to the overhead road sign structure, or to an over-bridge, and for all other materials and workmanship, brackets, bolts, nuts, etc., for the completion of the road sign boards as specified.

<u>ITEM</u>	<u>UNIT</u>
54.03 ADDITIONAL ROAD SIGN PLATE	NUMBER (no.)

The unit of measurement shall be the number of standard size signs of approved materials as stated in the Specifications.

<u>ITEM</u>	<u>UNIT</u>
54.04 GUIDANCE SIGNS	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of completed road signboard of approved materials.

The bid rates shall include full compensation for providing the completed road sign board, frame, fixing brackets, angle-irons, channel profiles, etc. including painting, galvanising if specified, reflective lettering, symbols, legends and borders, attaching the road sign board to the road sign support, or to the overhead road sign structure, or to an over-bridge, and for all other materials and workmanship, brackets, bolts, nuts, etc. for the completion of the road sign boards as specified.

The rate for Guidance Signs and other Informative Signs shall include the provision and erection of sign support in accordance with the Drawings.

<u>ITEM</u>	<u>UNIT</u>
54.05 DISMANTLING, STORING AND RE-ERECTING ROAD SIGNS (INDICATE SURFACE AREA)	NUMBER (no.)

The unit of measurement shall be the number of signs dismantled and stored and re-erected in each size group.

The bid rates shall include full compensation for dismantling and storing the road signs and supporting structures, transporting the material to a new location, re-erecting the road signs, and restoring the location where they were dismantled.

Payment for excavations, and the new material and concrete required for re-erecting the road signs shall be made under the appropriate Item, and any repairs and painting which may be necessary, shall be paid for as "extra work". No separate payment shall be made for new bolts and nuts required for such re-erection, the cost of which shall be included in the rates bid above.

<u>ITEM</u>	<u>UNIT</u>
54.06 REMOVAL OF OBSOLETE ROAD SIGNS	NUMBER (no.)

The unit of measurement shall be the number of signs dismantled and stored or disposed of as directed by the Engineer.

The bid rates shall include full compensation for dismantling and storing or disposing of the road signs and supporting structures as directed, and restoring the location where they were dismantled.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5500: ROAD MARKINGS

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5501 SCOPE

This Section covers the permanent marking of the road surface with white or yellow painted or thermoplastic lines or symbols, the supply and fixing of retro-reflective road studs and the construction of rumble strips and speed humps as indicated on the Drawings or as specified by the Engineer.

All road markings shall be of the standard regulatory, warning and guidance markings as detailed on the Drawings and in accordance with the current Traffic Signs Manual.

This SECTION also covers the construction of rumble strips, speed humps and raised pedestrian crossings as indicated on the Drawings or as specified by the Engineer.

5502 MATERIALS

(a) Paint for Road Marking

The paint to be used for road marking shall be specifically manufactured for such purposes. The paint shall be reflectorized unless otherwise specified.

i) Physical Properties

Paint shall comply with the requirements of BS EN 1871:2020. The paint shall be delivered at the Site in sealed containers bearing the name of the manufacturer, the type of paint and manufacturing and expiry dates. The viscosity of the paint shall be such that it can be applied without thinning. TABLE 5502/1 shows the minimum proportions of constituent materials for road marking paints.

TABLE 5502/1: PROPORTIONS OF CONSTITUENTS OR PAINTS (PERCENTAGE BY WEIGHT)

Component	White	Yellow
Binder	25.0 min.	18.0 min.
Titanium Dioxide	20.0 min.	-
Calcium Carbonate and Inert Fillers	16.0 min.	29.0 min.
Yellow Pigments	-	14.0 min.

Non-Volatile Matter content by weight shall be a minimum of 65 percent as determined in accordance with test method ASTM D1644. The liquid paint shall have a density of 1.3 g/cc minimum as determined in accordance with test method ASTM D1475.

ii) Reflectorization

Retro-reflective road-marking paint shall comply with the requirements of SUB-CLAUSE 5502 (a) (i) above and BS EN 1424:1998. The retro-reflective glass beads shall conform to the requirements of BS EN 1423:2012 or equivalent, subject to a maximum nominal size of 0.8 mm.

Reflectivity parameters shall be measured and monitored as guided by BS EN 1436:2018 and the required parameters for yellow and white paint shall be provided in the special specifications.

iii) Colour

The colours to be used shall be bright white or yellow. The colour of the yellow marking material shall be to BS Colour No. 08E51 of BS 4800:2011 and the colour of white markings shall be to BS colour number 00E55 of BS 4800: 2011 or as specified in the current Traffic Signs Manual.

When required by the Engineer, the Contractor shall submit with each consignment of paint delivered to the site, test certificates from an approved testing authority to show that the respective materials comply in all respects with relevant specifications.

(b) Thermoplastic Road-Marking Material

Hot applied thermoplastic material shall comply with the requirements of BS EN 1871:2020, BS EN 1436:2018, US EAS 928-1:2019, US EAS 928-2:2019. The material shall be applied to the pavement in a molten state by mechanical means. Thermoplastic material shall be heated and checked as per manufacturer's recommendations to achieve proper viscosity. Thermoplastic road marking material shall be preferred for White/Yellow line markings. The performance of the road marking shall be monitored using a portable retro-reflectometer after application and every 6 months until the end of the Defects Liability Period for parameters specified in TABLE 5502/2 and TABLE 5502/3 or the Special Specifications.

TABLE 5502/2: LUMINANCE COEFFICIENT UNDER DIFFUSE ILLUMINATION Q_d (REFLECTION IN DAYLIGHT OR UNDER ROAD LIGHTING)

Road marking Colour	Road surface Type	Class	Minimum luminance coefficient under diffuse illumination Q_d in mcd/m ² /lx1
White	Asphaltic	Q2	National roads/Urban roads $Q_d \geq 100$
		Q4	Expressways $Q_d \geq 160$
	Cement concrete	Q3	$Q_d \geq 130$
Yellow		Q2	$Q_d \geq 100$
Note: These are minimum values for the expected service life of up to 2 years			

TABLE 5502/3: CLASSES OF R_L (RETROREFLECTION UNDER VEHICLE HEADLAMP ILLUMINATION) FOR DRY ROAD MARKINGS

Road marking type and colour		Class	Minimum coefficient of retroreflected Luminance R_L in mcd/m ² /lx ¹	
White		R2	National roads/Urban roads	$R_L = 100$
		R4	Expressway s	$R_L = 200$
Yellow		R2	National roads/Urban roads	$R_L = 100$
		R4	Expressway s	$R_L = 200$
Note: These are minimum values for the expected service life of up to 2 years				

i) Thermoplastic Material For Markings Up To 3 Mm

The hot-melt thermoplastic road-marking material shall be of tropical grade with a softening point of 102.5°C (+/-) 9.5°C.

In compliance with BS 3262-3:1989 standard, thermoplastic road marking material shall be applied at a rate of 6 – 7 Kg / m² and glass beads spread at a rate of 300 -400 g /m².

The thermo-plastic road marking material shall consist of light-coloured aggregate, pigment and extender bound together with resin, elasticised with oil as necessary.

ii) Acoustic Thermoplastic Road Marking Material

Acoustic thermoplastic material shall meet the requirements of CLAUSE 5502 (b) and the base layer will be applied as detailed in CLAUSE 5502 (b)(i). The work shall involve application of audible and vibratory pavement markings in accordance with the drawings or as directed by the Engineer

All road markings including rumble strip markings above 3 mm shall have single monolithic construction using specialised thermoplastic material used along with flow retarders and other additives.

iii) Cold Plastic Road Marking Material:

For enhanced durability, seamless wide area marking and coloured road surfacing solvent free high build roll on acrylic cross linking resin system material shall be used. Screed applied cold plastic road marking material shall be used for symbols, arrows and letters (hand painted markings) when specified by the Engineer. Marking Material shall be compliant with BS EN 1871:2020 specifications and Drop on Glass Beads shall be compliant with BS EN 1423:2012 specifications.

[1] Colour

The colours to be used shall be bright white or yellow. The colour of the yellow marking material shall be to BS Colour No. 08E51 of BS 4800:2011 and the colour of white markings shall be to BS colour number 00E55 of BS 4800:2011 or as specified in the current Traffic Signs Manual.

[2] Skid Resistance

The skid resistance of all types of marking material shall comply with the requirements of BS 7941-1:2006 or BS 7941-2:2000 or EN 1436:2018 or equivalent. The minimum value of skid resistance shall be 45SRT.

The Contractor shall submit for each consignment of thermoplastic material delivered to the Site the manufacturer's certificate to show that the materials comply in all aspects with the relevant product specifications.

(c) Kerb Stone Painting

Kerb stone painting shall be carried out using water-based road marking paint with mechanical airless spray application for a required uniform finish of smooth gloss finish. Cleaning of the surface thoroughly by removing flakes, dust deposits, vegetation growth, pasted paper etc., using coir/ coil brush shall be carried out to enable the application of respective primer etc.

(d) Retroreflective Paint for Kerb/ Concrete Crash Barriers etc.

Kerb stone/ vertical surface shall be painted with water based acrylic retroreflective paint having wear resistance more than 6 hours. The operation shall be carried out preferably using mechanical application, for one coat water based matt finish priming coat and one uniform retro-reflective finish coat in the required colour. Yellow retroreflective coat shall be bright yellow during night with minimum R_L (dry) > 375 mcd/ m²/ lux and R_L (wet) > 200 mcd / m²/ lux and White Retroreflective Coat shall be Bright White during night with minimum R_L (dry) > 450 mcd/ m²/ lux and R_L (wet) > 250 mcd/ m²/ lux. Cleaning of the surface thoroughly by removing flakes, dust deposits, vegetation growth, pasted paper etc., using coir/ coil brush shall be carried out to enable the application of respective primer etc.

(e) Road Marking Primer

In case of concrete surface/ old worn-out Bituminous surface/ new marking over old marking, after thorough cleaning of the road surface, road marking primer as indicated in the drawing or instructed by the Engineer shall be used for better adhesion.

Primer consumption shall be applied mechanically at a minimum rate of 4 m²/ ltr. Manual application of primer shall be allowed only if the contractor demonstrates the effectiveness of his workmanship which is to the satisfaction of the Engineer. The finished surface must be level, uniform and free from streaks and holes complete prior to application of primer.

(f) Road Studs

Road studs shall be prismatic retroreflective type two-way markers conforming to BS EN 1463-1:2021. Road studs shall comply with the requirements of BS EN 1463-1:2021 Class P-3 or equivalent and shall be of the size and type indicated on the Drawings or specified in the Special Specifications. The Contractor shall, prior to delivery, submit to the Engineer for approval, samples of the type of road studs they propose to use.

In special circumstances at higher risk locations, solar powered illuminated road studs, of specified colour, shall be installed if specified in the Bill of Quantities. The Contractor shall, after receiving confirmation of the type and number to be installed from the Engineer, submit to the Engineer samples of the type of solar powered road studs he proposes to supply for approval. The manufacturer's specifications, warranty, installation requirements, and adhesive requirements shall be provided.

Solar powered road studs shall be installed midway between retro reflective road studs or as per the drawings.

Solar powered road studs shall conform to the following requirements:

- The body of the unit shall be of either UV resistant PVC or aluminium with a shank
- Maximum dimensions are 100 x 100 mm or 100 mm diameter, with an installed maximum height of 22 mm
- The solar panel, electronics and optics shall be sealed inside the unit which shall be waterproof (minimum IP67)
- A suitable power storage battery or capacitor must be incorporated
- Battery life to be 3 years

- vi. The unit must be capable of operating for a minimum of 36 hours continuously after a charge time of 8 hours
- vii. Each unit must be provided with super bright LEDs (18 milli candelas per LED) (number and colour per unit to be as specified in the Contract Document and/or the Schedule of Quantities)
- viii. Operating temperature range -20°C to 60°C
- ix. Compression resistance of unit to be between 200-300 kN
- x. The spacing of the road studs will be determined by the road geometry, at least 3-4 road studs should be visible at a time

(g) Rumble Strips

Rumble strips shall be constructed of Concrete (C30)/asphalt concrete, AC 10, having a high resistance to rutting and deformation, in accordance with the requirements of SECTION 6400/ SECTION 4200 of this Specification and as directed by the Engineer. Rumble strips shall conform to the standards of the Uganda Road Design Manual.

Transverse bar marking made of thermoplastic markings complying with the requirements of BS EN 1871:2020 can also be used to alert drivers to reduce speed. Each set generally comprises of 6 bars 300 mm wide 1000 mm apart of 15 mm high or as directed by the Engineer.

(h) Speed Humps

Speed humps shall be constructed of reinforced concrete in accordance with the requirements of SECTIONS 6200, 6300, 6400 AND 6800 of these Specifications unless otherwise specified in the Drawings or instructed by the Engineer.

Speed humps can also be constructed using hot premixed bituminous material to the required depth and shape as indicated in the drawing or instructed by the Engineer. The premixed material shall be well compacted before opening to traffic.

Speed humps shall conform to the standards laid out in the Uganda Road Design Manual and the Contractor should use an approved profile board to ensure that the correct shape of the hump is achieved.

(i) Tactile Paving

Tactile Paving is required to guide differently abled people to safely and independently access facilities like walkways, bus stops and cross a road/ intersection. This provides both directional guidance and warning to partially sighted or blind people. This can be manufactured using precast concrete blocks or clay and calcium silicate pavers. The concrete blocks shall comply with the requirements of BS EN 1338:2003. Similarly, the Clay and Calcium silicate pavers shall comply with the requirements of BS EN 1344:2013.

A standard tactile paving slab is generally 400 mm x 400 mm. The guidance tactile domes on the tiles must be aligned to give the direction of travel to facilitate the visually impaired to cross the road straight. The domes shall be 4 to 5 mm in height having spacing as indicated in the drawing depending upon the intended use.

5503 WEATHER LIMITATIONS

Road marking material shall not be applied to a damp surface or at temperatures lower than 10°C or when, in the opinion of the Engineer, the wind strength is such that it may adversely affect the road marking operations.

5504 MECHANICAL EQUIPMENT FOR APPLICATION OF ROAD MARKING

The equipment shall consist of tools and equipment for cleaning the surfaces, a mechanical road-painting machine or automatic self-propelled thermoplastic laying machine as the case may be and all additional hand-operated equipment necessary for completing the work.

The mechanical road-marking machine shall be capable of marking at least two parallel lines simultaneously and shall

apply the marking material to a uniform thickness at the rates of application specified. The machine shall be so designed that it will be capable of applying the road markings everywhere to a uniform width with sides within the tolerances specified. The machine shall further be capable of marking lines of different widths.

The road-marking machine shall be capable of applying the road marking at a speed of not less than 5.0 km/hr and it shall be provided with clearly visible amber warning flashing lights that shall always be in operation when the machine is working on the road.

5505 SURFACE PREPARATION

Road markings shall be applied to bituminous surfaces only after sufficient time has elapsed to ensure that damage will not be caused to the marking material by volatiles evaporating from the surfacing. In no case shall paint markings be applied until at least 10 days after the completion of bituminous surfacing.

Before the marking material is applied, the surface shall be clean and dry and completely free from any soil, grease, oil, acid or any other material that will be detrimental to the bond between the marking material and the surface. The surface where the marking material is to be applied shall be properly cleaned by means of watering, brooming or compressed air if required. A suitable sealer shall be applied to concrete surfaces before thermoplastic marking material is applied.

Road marking material shall not be applied to damp surfaces or when the relative humidity exceeds 80%, or at temperatures lower than 10°C, or when, in the opinion of the Engineer, wind strength is such that it may adversely affect the road marking operations.

5506 SETTING-OUT OF ROAD MARKINGS, ROAD STUDS AND SPEED REDUCING MEASURES

The lines, symbols, figures or marks shall be pre-marked by means of paint spots of the same colour as that of the final lines and marks. These paint spots shall be at such intervals as to ensure that the road markings can be accurately applied, and in no case shall they be more than 1.5 m apart. Spots of approximately 10 mm in diameter should be sufficient.

The dimensions and positions of road markings shall be as shown on the Drawings or as specified in the appropriate statutory provisions and the current Traffic Signs Manual. After spotting, the positions of the proposed road markings shall be indicated on the road. These painted pre-markings shall be approved by the Engineer prior to any road marking operations being commenced.

The positions and outlines of special markings shall be produced on the finished road in chalk and shall be approved by the Engineer before they are carried out. Approved templates may be used on condition that the positioning of the markings is approved by the Engineer before marking is commenced.

The position of road studs shall be marked out on the road and shall be approved by the Engineer before they are fixed in position.

The position of rumble strips and speed humps shall be as shown in the Drawings and approved by the Engineer.

5507 APPLYING THE MARKING MATERIAL

Where two lines are required parallel to each other, the lines shall be applied simultaneously by the same machine. Paint shall be stirred before application in accordance with the manufacturer's instructions and shall be applied without the addition of thinners.

Before any road-marking machine is used on the permanent Works, the satisfactory operation of the machine shall be demonstrated and the application rate checked on a suitable site that is not part of the permanent

Works. Adjustments to the machine shall be followed by further testing. Only when the machine has been correctly adjusted and the Engineer has approved its use after testing, may the machine be used on the permanent Works. The operator shall be experienced in the use of the machine.

Where road-marking paint is applied by machine, it shall be applied in one layer. Where painting is done by hand, it shall be applied in two layers, and the second layer shall not be applied before the first layer has dried. As most road-marking paint reacts with the bitumen surface of the road, the paint shall be applied with one stroke only of the brush or roller.

Road-marking paint shall be applied at a nominal rate of 0.42 litre/m² or as directed by the Engineer.

Thermoplastic material shall be laid to a thickness of 3 mm $\pm$ 0.5 mm or as directed by the Engineer. The method of thickness measurement shall be in accordance with BS 3262-3:1989 Appendix H.

Edge lines of thermoplastic material shall be broken by a 100 mm gap for every 10 m continuous line.

Where acoustic lines of thermoplastic material are specified, the types and dimensions of the lines and thickness of the marking material shall be 5mm ($\pm$) 0.5 mm or as shown in the Drawings and specified in the Special Specifications. Acoustic edge lines shall normally be not less than 100 mm wide.

Application of cold plastic road marking material shall be carried out using a trowel, screed box or an appropriate roller. Material applied by a paint brush shall not be used.

5508 APPLYING THE RETRO-REFLECTIVE BEADS TO ROAD PAINT

Where retro-reflective paint is required, the retro-reflective beads shall be applied by means of a suitable machine in one continuous operation, immediately after the paint has been applied. Road-painting machines applying the beads by means of gravity only shall not be used. The beads shall be sprayed onto the paint layer by means of a pressure sprayer.

The rate of application of the beads shall be 300 – 400 g/m² of paint or such other rate as the Engineer may direct.

5509 ROAD STUDS

Road studs shall be of the type and size specified in SUB-CLAUSE 5502 (f) and shall be fixed in position as shown on the drawings or as directed by the Engineer.

The road studs shall be fixed by means of an approved epoxy resin or bitumen adhesive in accordance with the manufacturer's instructions, subject to such amendments to the method as may be required by the Engineer. The studs shall be protected against impact until the adhesive has hardened. Before fixing the road studs, the surface shall be thoroughly cleaned as specified in CLAUSE 5505.

Road studs must be protected during the marking of any lines and application of any surface treatments. Any road studs that become loose or are lost during the defects liability period are regarded as defects.

5510 TOLERANCES

The figures, letters, signs, symbols, broken or unbroken lines or other marks shall be marked as shown on the Drawings or as directed by the Engineer.

Road markings shall be applied to accuracy within the tolerances given below:

(a) Width

The width of lines and other markings shall not be less than the specified width, nor shall it exceed the specified width by more than 10 mm.

(b) Position

The position of lines, letters, figures, arrows, retro-reflective road studs and other markings shall not deviate from the true position by more than 100 mm in the longitudinal and 20 mm in the transverse direction.

(c) Alignment of Markings

The alignment of the edges of longitudinal lines shall not deviate from the true alignment by more than 10 mm in 15 m.

(d) Broken Lines

The length of segments of broken longitudinal lines shall not deviate by more than 150 mm from the specified length.

The length of segments and the gap between segments in broken lines shall be as indicated on the Drawings. If these lengths are altered by the Engineer, the ratio of the lengths of the marked section to the length of the gap between marked sections shall remain the same.

Lines on curves, whether broken or unbroken, shall not consist of chords but shall follow the correct radius.

5511 REMOVAL OF TEMPORARY AND REJECTED ROAD MARKINGS

The Contractor shall remove existing obsolete markings from the road surface by means of sand blasting, milling or other approved method. The use of black paint or chemical paint remover to obliterate existing markings will not be permitted, except where it is instructed by the Engineer as a temporary measure.

Rejected road markings and paint and marking material that has been splashed or dripped onto the pavement, kerbs, structures or other such surfaces, shall be removed by the Contractor at their own cost, in an approved manner so that the markings or spilt paint will not show up at all.

5512 PROTECTION

After the marking material has been applied, the road markings shall be protected against damage by traffic or other causes. The Contractor shall be responsible for erecting, placing and removing all warning boards, flags, cones, barricades and other protective measures which may be necessary in terms of any statutory provisions and/or as may be recommended in the Traffic Signs Manual.

5513 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
55.01 ROAD-MARKING USING ROAD-MARKING PAINT:	
(a) WHITE LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(b) YELLOW LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(c) WHITE LETTERING AND SYMBOLS	SQUARE METRE (m ²)
(d) YELLOW LETTERING AND SYMBOLS	SQUARE METRE (m ²)
(e) TRAFFIC-ISLAND MARKINGS (ANY COLOUR)	SQUARE METRE (m ²)
(f) KERB MARKINGS (ANY COLOUR)	SQUARE METRE (m ²)
(g) CONCRETE CRASH BARRIERS (ANY COLOUR)	SQUARE METRE (m ²)

The unit of measurement for painting the lines shall be the metre of each specified width of line and the quantity paid for shall be the actual length of line painted in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines.

The unit of measurement for painting the lettering, symbols or traffic-island paintings shall be the square metre, and the quantity to be paid for shall be the actual surface area of lettering, symbols or traffic-island markings completed.

The bid rate per metre or per square metre as the case may be for painting the road markings shall include full compensation for procuring and furnishing all material and the necessary equipment, and for painting, protecting and maintenance as specified, including the setting-out of lettering, symbols and traffic-island markings, but excluding setting out and pre-marking the lines.

<u>ITEM</u>	<u>UNIT</u>
55.02 ROAD MARKING USING RETRO-REFLECTIVE ROAD-MARKING PAINT:	
(a) WHITE LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(b) YELLOW LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(c) WHITE LETTERING AND SYMBOLS	SQUARE METRE (m ²)
(d) YELLOW LETTERING AND SYMBOLS	SQUARE METRE (m ²)
(e) TRAFFIC-ISLAND MARKINGS (ANY COLOUR)	SQUARE METRE (m ²)
(f) KERB MARKINGS (ANY COLOUR)	SQUARE METRE (m ²)
(g) CONCRETE CRASH BARRIERS (ANY COLOUR)	SQUARE METRE (m ²)

The unit of measurement for painting the lines shall be the metre of each specified width of line and the quantity paid for shall be the actual length of line painted in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines.

The unit of measurement for painting the lettering, symbols or traffic-island markings shall be the square metre, and the quantity to be paid for shall be the actual surface area of lettering, symbols or traffic-island markings completed.

The bid rate per metre or per square metre as the case may be for painting the road markings shall include full compensation for procuring and furnishing all material,

including the retro-reflective beads, and the necessary equipment, and for painting, protecting and maintenance as specified, including the setting-out of lettering, symbols and traffic-island markings, but excluding setting out and pre-marking the lines.

<u>ITEM</u>	<u>UNIT</u>
55.03 ROAD MARKING USING THERMO-PLASTIC ROAD-MARKING MATERIAL:	
(a) WHITE LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(b) YELLOW LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(c) ACOUSTIC LINES (WIDTH OF LINE INDICATED)	METRE (m)
(d) WHITE LETTERING AND SYMBOLS	SQUARE METRE (m ²)
(e) YELLOW LETTERING AND SYMBOLS	SQUARE METRE (m ²)
(f) TRAFFIC-ISLAND MARKINGS (ANY COLOUR)	SQUARE METRE (m ²)
(g) ROAD MARKING USING COLD PLASTIC ROAD MARKING (ANY COLOUR OTHER THAN WHITE/YELLOW)	SQUARE METRE (m ²)

The unit of measurement for marking the lines shall be the metre of each specified width of line and the quantity paid for shall be the actual length of line marked in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines. Acoustic lines, where specified and approved by the Engineer, shall be measured as continuous for payment purposes. All lines wider than 100 mm in Give Way markings, Pedestrian Crossings etc. will be measured under SUB-ITEMS 55.03 (d) or (e).

The unit of measurement for applying the lettering, symbols or traffic-island markings shall be the square metre, and the quantity to be paid for shall be the actual surface area of lettering, symbols or traffic-island markings completed.

The bid rate per metre or per square metre as the case may be for applying the road markings shall include full compensation for procuring and furnishing all material, and the necessary equipment, and for application, protecting and maintenance as specified, including the setting-out of lettering, symbols and traffic-island markings, but excluding setting out and pre-marking the lines.

<u>ITEM</u>	<u>UNIT</u>
55.04 VARIATIONS IN RATE OF APPLICATION:	
(a) WHITE PAINT	LITRE (l)
(b) YELLOW PAINT	LITRE (l)
(c) RETRO-REFLECTIVE BEADS	KILOGRAMS (kg)
(d) THERMO-PLASTIC ROAD-MARKING MATERIAL (SPECIFY)	LITRE (l)

The unit of measurement for variations in the rate of applying of the paint, thermoplastic material and retro-reflective beads shall be the litre and the kilogram respectively.

Payment for variations shall be made as specified in CLAUSE 1212.

<u>ITEM</u>	<u>UNIT</u>
55.05 ROAD STUDS (STATE TYPE)	NUMBER (no.)

The unit of measurement for road studs shall be the actual number of approved road studs placed.

The bid rate shall include full compensation for procuring and furnishing all the necessary material, labour and equipment, and for fixing and maintenance as specified. Distinction shall be made between various types of road studs.

<u>ITEM</u>	<u>UNIT</u>
55.06 SETTING OUT AND PRE-MARKING THE LINES (EXCLUDING TRAFFIC-ISLAND MARKINGS, LETTERING AND SYMBOLS)	METRE (m)

The unit of measurement for setting out lines shall be the metre of lines set out and marked. Where two or three lines are to be marked next to each other, the length of setting-out of such lines shall be measured only once.

The bid rate shall include full compensation for setting out and pre-marking the lines as specified, including all materials.

<u>ITEM</u>	<u>UNIT</u>
55.07 REMOVAL OF EXISTING, TEMPORARY OR PERMANENT ROAD MARKING BY:	
(a) SANDBLASTING	SQUARE METRE (m ²)
(b) OVER PAINTING AS A TEMPORARY MEASURE	SQUARE METRE (m ²)
(c) MILLING	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of road marking removed.

<u>ITEM</u>	<u>UNIT</u>
55.08 REMOVAL OF EXISTING ROAD STUDS	NUMBER (no.)

The unit of measurement shall be the actual number of road studs removed.

<u>ITEM</u>	<u>UNIT</u>
55.09 RUMBLE STRIPS AND SPEED HUMPS	
(a) RUMBLE STRIP (SPECIFY TYPE/SIZE)	METRE (m)
(b) SPEED HUMP (SPECIFY TYPE/SIZE)	METRE (m)

The unit of measurement for rumble strips and speed humps shall be the linear metre of each individual rumble strip of the different types and the linear metre of speed humps constructed to the cross-sectional shape shown on the Drawings and in accordance with the instructions of the Engineer.

The bid rate for rumble strips shall include for preparing the surface, providing, mixing, transporting, laying and compacting the asphalt concrete mix for the rumble strips in accordance with the Drawings and to the satisfaction of the Engineer.

The bid rate for speed humps shall include provision of all materials, excavation, bedding, construction, curing and finishing required for the construction of reinforced concrete speed humps in accordance with the Drawings and to the satisfaction of the Engineer. Road marking for speed humps and other speed reducing measures will be paid for separately.

<u>ITEM</u>	<u>UNIT</u>
55.10 TACTILE PAVING	
(a) TACTILE PAVING (SPECIFY TYPE/SIZE)	METRE (m)

The bid rate for tactile paving shall include provision of all materials, excavation, bedding, construction, curing and finishing required for the construction of paving in accordance with the Drawings and to the satisfaction of the Engineer.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5600: LANDSCAPING AND GRASSING

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5601 SCOPE

This Section covers landscaping of designated areas, establishment of vegetation for functional and aesthetic purposes on cut and fill slopes, landscaped areas and in areas where the natural vegetation has been cleared or covered. The establishment of vegetation should also be at areas where materials were excavated and are likely to be eroded; and eroded areas at culvert outlets that are potentially and actively expanding towards the road pavement and such other areas indicated on the Drawings and where it may be required.

5602 MATERIALS

Any declared noxious weeds, as well as any exotic tree, shrub, herb, grass or water plant which, in the opinion of the Engineer, may pose any problems in specified areas at certain times, is regarded as being undesirable.

(a) Fertiliser/Soil-Improvement Material

The type of fertiliser/soil-improvement material to be used shall be one or more of the following types and any other type of fertiliser/soil-improvement material specified in the Special Specifications or prescribed by the Engineer.

- i. Soil-improvement materials such as dolomitic lime, basic slag, gypsum, superphosphate and agricultural lime.
- ii. Fertilisers such as limestone ammonium nitrate, 2:3:2 (22) and 3:2:1 (25).

(b) Grass Cuttings

Grass cuttings shall be fresh cuttings of an approved type of grass with sufficient root material to ensure good growth.

(c) Grass Seeds

Only fresh certified seed shall be used and the types of seeds in the seed mixture shall be as specified in the Special Specifications.

Mixing the various types of grass seeds for obtaining the prescribed grass-seed mixture shall be done on the Site in the presence of the Engineer. Storing and identifying the grass seeds and the grass-seed mixtures on the Site shall be the responsibility of the Contractor.

The grass seed or seed mixture shall consist of local varieties of *Stenotaphrum secundatum*, *Cynodon dactylon* or *Pennisetum clandestinum* grass or other grass seeds approved by the Engineer.

(d) Grass Sodds

Grass sods shall be either nursery-grown or bush sods as described below. Both types shall be harvested, delivered, planted and watered within 36 hours unless otherwise authorised by the Engineer. The grass sods shall be free from noxious weeds and diseases. Sodds obtained from a nursery shall be in moist soil not less than 30 mm deep, and sods taken from the bush in moist soil not less than 50

mm deep.

i) Nursery-Grown Sodds

These sods shall have been grown specifically for sod purposes, mown regularly and cared for to provide an approved uniformity to the satisfaction of the Engineer.

The grass sods shall consist of local varieties of *Stenotaphrum secundatum*, *Cynodon dactylon* or *Pennisetum clandestinum* grass or other grass varieties approved by the Engineer.

ii) Bush Sodds

These sods may be obtained from approved areas within or near the Site where a suitable type and density of grass and type of soil are found.

(e) Trees, Shrubs and Hedge Plants

Plants shall be of the variety and size shown on the Drawings or in the Special Specifications.

The Contractor shall supply the number of plants as shown on the Drawings or in the Special Specifications and/or Bill of Quantities. The Contractor shall give at least six weeks' advance notice of their requirements to the Engineer. Upon receipt of the plants, the Contractor shall ensure that the plants are in good condition and free from plant diseases and they shall accept full responsibility for maintaining the plants in good condition throughout the Contract and the Defects Liability Period. The plants shall be fully maintained and watered during this period and any losses of plants on account of lack of care or disease during the Contract and Defects Liability Period, shall be replaced at the Contractor's own cost.

Each plant shall be handled and packed in the approved manner for that species or variety, and all the necessary precautions shall be taken to ensure that the plants will arrive at the site of the Works in a suitable condition for successful growth. Trucks used for transporting plants shall be equipped with covers to protect the plants from windburn. Containers shall be in good condition.

Plants supplied by the Contractor shall be healthy, correctly shaped, and well rooted. The plants must be hardened off and be exposed to direct sunlight for at least 6 months prior to planting in the road reserve. Roots shall not show any evidence of having been restricted or deformed at any time. Plants shall grow well and shall be free from insect pests and diseases.

(f) Anti-Erosion Compounds

Anti-erosion compounds shall consist of an organic or inorganic material to bind soil particles together and shall be a proven product able to suppress dust and form an encrustation. The application rate shall conform to the manufacturer's recommendations. The materials used shall be of such a quality that grass seeds may germinate and penetrate the crust.

(g) Topsoil

Topsoil shall consist of fertile loamy soil, obtained from areas with good soil coverage of natural vegetation, preferably grasses. It shall be free from deleterious matter such as large roots, stones, refuse, stiff or heavy clays and the seeds of noxious weeds, which will adversely affect its suitability for grass being planted. Topsoil tripped from areas infested with weeds shall be stockpiled separately.

Topsoil shall be obtained from wherever suitable material occurs either in the road reserve or from areas where cuts and fills are to be constructed. Topsoil stripped from borrow areas may not be removed from that site for topsoiling of other areas, but must be used to rehabilitate the borrow pit itself.

The Engineer shall communicate their requirements to the Contractor regarding the quantity of topsoil which is necessary and the areas from which it shall be selected and removed by the Contractor. Unless otherwise specified, topsoil shall be taken from not deeper than 400

mm below the surface. If the Contractor fails to conserve the topsoil as instructed, they shall obtain suitable substitute material from other sources at their own cost.

Where so specified, the Contractor shall procure and furnish topsoil from their own sources outside the Site, after such sources have been approved by the Engineer.

Topsoil shall be stockpiled in separate loose heaps as tipped from the trucks and shall not be stockpiled in heaps exceeding 2 m in height. Care shall be taken to prevent the compaction of the topsoil in any way, especially by trucks being driven over such material.

(h) Manure

Manure shall, unless another type has been approved by the Engineer, be pure kraal manure free from soil, weed seeds or other undesirable material. It shall not contain any particles that will not pass through a 50 mm screen and shall be approved by the Engineer before being delivered to the Site.

(i) Compost

Compost shall be well decayed, friable and free from weed seeds, dust or any other undesirable materials. It shall not contain any particles that will not pass through a 50 mm screen and shall be approved by the Engineer before being delivered to the Site.

5603 LANDSCAPING AREAS

(a) Shaping

Areas within the road reserve but outside the road prism which require shaping by means of bulk earthworks such as contoured areas at interchanges and intersections and rest areas which require earthworks shall be excavated, filled and compacted when required, and shaped to the correct contours to within a tolerance of plus or minus 150 mm. Such work shall be regarded as being earthworks and measurement and payment therefore shall be made under SECTION 3600, except those quantities may be measured by means of a grid system of levels taken at 10 m intervals before and after shaping or else it may be determined by levelled cross-sections.

(b) Trimming

Trimming shall consist of trimming the existing or previously shaped ground to an even surface with the final levels generally following the original surface. Trimming shall normally be done by a grader, or in more confined or steep areas by a bulldozer. Where machine operations are not practicable, because of confined spaces or steep slopes, or when approved by the Engineer, trimming shall be done with hand tools. When trimming is done on slopes steeper than 1:3, the ridges shall be made parallel to the contour. Such ridges shall be approximately 100 mm wide, and the centres between the ridges approximately 400 mm. Trimming shall be done where instructed by the Engineer to areas inside the road reserve but outside the road prism, i.e., normally outside the tops of cuts or the toes of fills, but trimming of rock outcrops will not be required.

Trimmed surfaces shall be left slightly rough to facilitate a better binding with topsoil or the natural establishment of vegetation.

When subsequent grassing is required or when it is ordered by the Engineer, areas previously shaped shall be trimmed as described above to within a tolerance of plus or minus 100 mm with all undulations following a smooth curve. The above tolerance shall apply only to areas where the final contours are given on the Drawings.

During trimming, all stones in excess of 100 mm in size and all excess material shall be removed. Areas which require grassing shall be trimmed in such a way that, after cultivation and the application of topsoil, the finished surface of the area shall be approximately 25 mm below the top of adjacent kerbing, channelling or pavement.

(c) Equipment Rates

The Engineer shall be entitled to pay for shaping and trimming as described above on the basis of hourly equipment rates. The motor grader and bulldozer to be provided shall each have a flywheel power of not less than 93 kW. All machines shall be in a good condition. Any labour or other equipment required shall be paid for as extra work as specified in the Contract.

5604 PREPARING AREAS FOR GRASSING

The various areas to be grassed shall be prepared as follows:

(a) Soil Ripping

Where soil is too hard to be ploughed with a light tractor, the soil shall be ripped up to a depth of 300 mm before it is loosened by ploughing to a depth of 150 mm.

After an area has been prepared for grassing, the grassing shall be completed before crusting. Where a crust has been formed before grassing is done, the Contractor shall, at their own cost, loosen the crust by ploughing to a depth of 150 mm.

(b) Areas Which do not Require Topsoil

Where the areas to be grassed consist of organically suitable material, the topsoil shall be loosened by ploughing to a minimum depth of 150 mm. All loose stones exceeding 50 mm in size on areas to be mowed by machine and falling within the road reserve and all stones exceeding 150 mm in size in other areas shall be removed.

(c) Areas Which Require Topsoil

Where areas to be grassed consist of organically unsuitable material, the surface shall be roughened to ensure a proper bond between the topsoil and the subsoil. If required, the area shall be scarified as described in paragraphs (a) or (b) above.

Topsoil shall be placed on the prepared surfaces and trimmed to the uniform thickness required. The topsoil shall be scarified by means of hand raking or light rotavators and all stones removed as specified for areas not requiring topsoil in subparagraph (b) above.

Areas inaccessible for topsoil being placed after the construction works have been completed shall be covered with topsoil and protected against erosion during construction works.

(d) Fertilising

For all areas to be planted, the Contractor shall have the top 150 mm of the prepared surface tested to determine the quantity and type of fertiliser that will be required for establishing proper growth conditions for the grass. The Contractor shall record the location of the soil sample taken and the Engineer shall be furnished with the test results. Only after approval by the Engineer of the nature and quantity of the fertiliser, may its application proceed. The fertiliser shall be evenly applied over all surfaces where grass is to be planted, and shall then be thoroughly mixed with the soil to a depth of 100 mm either mechanically or manually. Where hydro seeding is to be performed, the fertiliser may be mixed with the cellulose pulp and water used in hydro seeding.

5605 GRASSING AND SPRIGGING

The method of establishing grass shall depend on the circumstances relating to each case, and the Engineer shall decide which method is to be used. Provision is made for the following methods:

- Planting grass cuttings;
- Sodding;
- Hydro seeding;
- Topsoiling only using, where available, topsoil with the presence of natural grass seeds;
- Grassing with an approved grassing machine;
- Hand seeding; and

- The use of any other method specified in the Special Specifications.

A grass sod shall be placed on the top of the side slopes in one metre width from the shoulder breakpoint in order to protect the pavement material against erosion by water runoff. The remaining disturbed area of the embankment is to be scarified and hydroseeded as specified in SUB-CLAUSE 5605 (c). The Engineer may prescribe an anti-erosion compound to be added in the hydro seeding mixture for these areas.

Grass shall be planted as far as is practicable during periods of the year most likely to produce the best growing results. The Contractor shall make every effort to programme their operations in such a manner that grass shall be planted during this period.

(a) Planting Grass Cuttings

The areas to be grassed shall, unless already wet, be thoroughly watered before the cuttings are planted to ensure that the soil will be uniformly wet to a depth of at least 150 mm when the planting is done.

An approved variety of grass cuttings shall be evenly planted by hand or mechanically at a rate of at least 600 kg of cuttings per hectare. Fresh cuttings only shall be used. Any grass cuttings that have been allowed to dry out shall be discarded. Immediately after having been planted, the grass cuttings shall be given a copious watering, and, when sufficiently dry, shall be rolled with a light agricultural roller.

(b) Sodding

Areas to be grassed by sodding shall be given a layer of topsoil of at least 50 mm in thickness unless, where suitable soil is present, the Engineer orders the topsoil to be omitted. The areas to be sodded shall be thoroughly watered beforehand so that it will be wet to a depth of at least 150 mm during sodding. The surface shall be roughened slightly to ensure a good penetration of roots into the soil. Sods shall be protected against drying out and kept moist from the time of harvesting until they are finally placed.

The first row of sods shall, where possible, be laid in a straight line, and if on a slope, laying the sods shall start at the bottom of the slope. The sods shall be butted tightly against each other, and care shall be taken not to stretch or overlap the sods. Where a good fit cannot be obtained, any intervening spaces shall be filled with topsoil. The next row shall be similarly placed tightly against the bottom row with staggered joints, and so on until the entire area has been covered with sods. On steep slopes, when instructed by the Engineer, the sods shall be held in position by a sufficient number of wooden stakes approximately 300 mm long by 20 mm in thickness and these stakes shall be knocked into the subsoil to a depth of 100 mm.

The Contractor shall water the sods directly after they have been placed to prevent undue drying out. As sodding is completed, each section shall be lightly rolled and thoroughly watered.

(c) Hydroseeding

Where it is specified that hydroseeding should be carried out on topsoil, the thickness of the topsoil shall be as specified in the Special Specifications or as directed by the Engineer.

Areas to be hydroseeded shall be given a layer of topsoil of 100 mm in thickness unless, where suitable soil is present, the Engineer orders the topsoil to be omitted or applied in reduced thickness.

The types and mixtures of seeds to be used shall be as specified in the Special Specifications or, if not so specified therein, shall be agreed on by the Engineer and the Contractor before any seed they may wish to use is ordered by the Contractor. The Contractor shall be solely responsible for establishing an acceptable grass cover, and any approval by the Engineer of seed or seed mixtures

intended for use by the Contractor shall not relieve him/her of this responsibility.

The seed mixture for hydro seeding or hand seeding is to be applied at 45 kg/ha and is to consist of:

• Eragrostis tef (teff)	5%
• Eragrostis curvula (weeping love grass)	20%
• Paspalum notatum (bahia grass)	10%
• Chloris gayana (rhodes grass)	25%
• Digitaria eriantha (finger grass)	20%
• Dactylus glomerata (cocks foot)	10%
• Locally harvested grass seed	10%

All areas to be hydroseeded or handseeded shall be scarified forming horizontal drills running parallel to the contours. The drills are to be spaced at intervals of 150 to 250 mm apart. Seeding to take place immediately after scarifying in order to avoid silting of the drills by rainwater.

Mulch shall be added to the hydro seeding mix at an approved rate.

Hydroseeding shall then be carried out with an approved hydro seeding machine at a rate of application of not less than 38 kg of seed mixture per hectare, unless otherwise specified in the Special Specifications.

When the use of anti-erosion compounds is required and such a compound is to be applied simultaneously with the hydroseeding, it shall be mixed with the hydroseeding mixture before application.

(d) Top Soiling Only

Where, in the opinion of the Engineer, the planting of grass or hydro seeding can be dispensed with on account of favourable climatic and other conditions, they may attempt to establish grass by topsoiling only. Topsoil shall be selected for the presence of natural grass and seeds and shall be removed and placed whenever possible at a time that would favour the establishment of grass. These areas shall be treated with an anti-erosion compound, if so instructed by the Engineer.

After the topsoil has been placed it shall be lightly rolled and well-watered, and afterwards watered and mown whenever instructed by the Engineer.

The Contractor will not be held responsible for establishing an acceptable grass cover as defined in SUB-CLAUSE 5606(d) when this procedure is followed, but will be responsible for the consequences of any omission to water, weed or mow the grass as instructed by the Engineer.

No payment for grassing shall be made other than for placing topsoil, and for mowing and watering the grass, which will be paid for at the bid rates, and for any replanting of grass on bare patches, repairs caused by erosion, and similar work, which will be paid for as extra work as allowed for in the Contract.

(e) Grassing With an Approved Grassing Machine

The areas to be grassed shall be prepared as described in CLAUSE 5604 and the areas shall be thoroughly watered after completion of the operation.

Grassing shall be done with an approved grass planter which plants the seeds in rows spaced not more than 250 mm apart. The planter shall plant the seeds approximately 6 mm deep and shall lightly compact the soil. The prescribed fertiliser may be distributed simultaneously with the grass planting.

(f) Hand Sowing

The areas to be grassed shall be prepared as described in CLAUSE 5604 and the areas shall be thoroughly watered after completion of the operation.

If approved by the Engineer, sowing may be done by hand. The seed shall be spread uniformly over the surfaces and

then lightly raked into the soil.

(g) Other Methods

Whenever specified in the Special Specifications, other methods of grassing may be employed.

(h) The Grassing of Borrow Pits, Temporary Bypasses, Camp Sites, Access Roads and Stockpile Sites

Prior to any grassing that may be required on such areas, the finishing-off of borrow pits as described under SECTION 1700 AND CLAUSE 3406, obliterating the bypasses and access roads as described in CLAUSES 1514 AND 5703 respectively and the clearing of camp sites as described in SECTION 1300 AND 1700, shall have been carried out as specified in the relevant Sections and Clauses.

(i) Sprigging

i) Description

This work shall consist of planting sprigs in close conformity with these Specifications, at the locations shown on the Drawings or required by the Engineer for the protection of slopes against erosion.

ii) Materials

[1] Sprigs

Sprigs shall be healthy, living stems with attached roots of perennial turf-forming grasses harvested without adhering soil and obtained from approved sources in the locality of the work where the sod is dense and well rooted. The presence of weeds or detrimental materials will be cause for rejection.

The grass sprigging shall consist of local varieties of *Stenotaphrum secundatum*, *Cynodon dactylon* or *Pennisetum clandestinum* grass or other grass seeds approved by the Engineer.

[2] Fertiliser

Fertiliser shall consist of an approved compound containing not less than 10% nitrogen, 15% phosphoric acid and 10% pot-ash or similar approved composition.

iii) Construction

[1] Top-Soiling

Where directed by the Engineer the face of slopes or benches shall be covered with a layer of topsoil, as described in CLAUSE 5602 (g).

If topsoil is not available in the project area or soil and moisture conditions are generally not favourable for the growth of grass, planting of grass should be tried on small sections of clay and sand slopes prior to planting of large areas.

All surfaces shall, immediately before planting, be reduced to a fine tilth to a depth of 150 mm and free from stones greater than 25 mm.

[2] Fertilisation

Fertilisation shall be carried out with an even distribution. The rate of application shall not be less than 70 kg to 1000 square metres.

iv) Sprigging

[1] Harvesting Sprigs

The Contractor shall obtain the Engineer's approval of their source of sprigs and shall notify the Engineer at least 5 days before the sprigs are to be harvested.

Sprigs that have dried out or are otherwise damaged during harvesting or delivery shall be rejected.

[2] Planting Sprigs

Planting of sprigs shall preferably be carried out at the beginning of the rainy season. Not more than 24 hours shall elapse between harvesting and planting sprigs.

Sprigging shall not be done during windy weather, or when the ground is dry, excessively wet, or otherwise untillable. If the soil is not moist when the sprigs are being set, water shall be applied until the soil is moist and in a workable condition. One or more of the following methods shall be used, whichever is shown on the Drawings or ordered by the Engineer:

- **ROW SPRIGGING:** Furrows shall be opened along the approximate contour of slopes at the spacing and depth indicated on the Drawings or as instructed by the Engineer. Sprigs shall be placed at intervals not exceeding 150 mm in a continuous row in the open furrow, and shall be covered immediately.
- **SPOT SPRIGGING:** Spot sprigging shall be performed as specified under row sprigging, except that, instead of planting in continuous rows, groups of four sprigs or more shall be spaced 400 mm apart in the rows.
- Alternative methods of planting shall be subject to the approval of the Engineer.

v) Maintenance of Sprigged Areas

The Contractor shall regularly water and maintain sprigged areas in a satisfactory condition for the duration of the Contract and until the end of the Defects Liability Period.

5606 MAINTAINING THE GRASS

(a) Traffic on Grassed Areas

The Contractor shall not plant any grass until all operations that may require road-building equipment to be taken over grassed areas have been completed. No road-building equipment, trucks or water carts shall be allowed onto areas that have been grassed and only equipment required for the preparation of areas, application of fertiliser, spreading of topsoil, watering and mowing will be allowed to operate on areas to be grassed. All damaged areas shall be reinstated by the Contractor at their own expense.

(b) Watering, Weeding, Mowing and Replanting

All sodded and grassed areas shall be adequately watered at regular and frequent intervals to ensure the proper germination of seeds and growth of grass until the grass has established an acceptable cover and thereafter until the beginning of the defects liability period of the grass. The quantity of water and the frequency of watering shall be subject to the Engineer's approval. With hydro-seeding the commencement of watering may be postponed until a favourable time of the year, but watering shall in any case commence and continue as soon as the seeds have germinated and growth has started.

The Contractor shall further mow the grass on all areas where grass has been established whenever so instructed by the Engineer, until the end of the defects liability period. All grass cuttings shall be collected and disposed of if so directed by the Engineer. Weeds shall be controlled by approved means. Any bare patches where the grass has not taken or where it has been damaged or has dried out shall be re-cultivated, planted, sodded or hydro-seeded at the Contractor's own expense.

All grassed areas shall have an acceptable cover as defined below at both the beginning and the end of the Defects Liability Period.

(c) Acceptable Cover

An acceptable grass cover shall mean that not less than 75% of the area grassed or hydro-seeded shall be covered with grass and that no bare patches exceeding 0.25 m² in any area of 1.0 m x 1.0 m shall occur. In the case of sodding, acceptable cover shall mean that the entire area shall be covered with live grass at the end of any period not less than three months after sodding.

(d) Responsibility for Establishing an Acceptable Cover

Notwithstanding the fact that the Engineer will determine the method of grassing and that the type of seed or grass used and the rate of application of the seed may be specified or agreed on by the Engineer, and that the frequency of mowing will be as ordered by him/her, the Contractor shall be solely responsible for establishing an acceptable grass cover and for the cost of replanting grass or re-hydroseeding where no acceptable cover has been established. Where however, in the opinion of the Contractor, it is doubtful from the outset if it will be possible to establish an acceptable cover they may inform the Engineer of their reasons therefore, and the Engineer may, if they agree, either adopt another method of grassing or agree to accept whatever cover can be obtained, provided that all reasonable efforts shall be made to establish a good grass cover by the proposed method. Any such agreement shall be valid only if given in writing by the Engineer beforehand.

In the case of grassing by topsoiling only, the Contractor will not be held directly responsible for establishing an acceptable grass cover, but will be held responsible for the consequences of supplying workmanship which does not conform to the Specifications, or for lack of proper care.

(e) Re-Fertilising

Should it become necessary, the Engineer may instruct the Contractor to undertake a Re-fertilising programme on grassed areas during the twelve-month defects liability period. Payment for re-fertilisation will be made under SUB-ITEM 56.03 (e).

(f) Defects Liability Period

The Defects Liability Period in respect of grass shall commence when an acceptable grass cover as defined in (c) above has been established and shall be one year. This means that the Defects Liability Period in respect of grass can commence earlier or later than the Defects Liability Period for other parts of the Contract.

If the Defects Liability Period in respect of grass expires before the end of the defects liability period for the other roadworks, the Contractor shall further mow the grass on such areas as instructed by the Engineer up to the end of the Defects Liability Period for the other roadworks. For mowing that is executed after the Defects Liability Period in respect of grass has expired, the Contractor shall be paid under ITEM 56.07.

5607 TREES, SHRUBS AND HEDGING PLANTS

Trees and shrubs shall be planted as far as is practicable during periods of the year most likely to produce the best growing results. The Contractor shall make every effort to programme their operations in such a manner that trees and shrubs shall be planted during this period.

(a) Positions of Trees and Shrubs

Unless otherwise directed by the Engineer, the localities where trees and shrubs are to be planted are as follows:

- i. Trees and shrubs shall be planted at locations shown on the Drawings.
- ii. Plants in the median shall be planted in a line 1.5 m from the centre line of the median.
- iii. When the carriageways are at different levels, the plants in the median shall be planted 2 m from the edge of the shoulder on the high side of the median.
- iv. Where the road curves, the plants in the median shall be planted on the inside of the median centre line.
- v. Where the carriageways are at different levels as well as on a curve, the plants in the median shall be planted on the high side, provided they do not impede on sight distance.
- vi. At freeway crossings over roads or rivers, shrubs shall be planted in the positions shown on the Drawings.

vii. At the headwalls of culverts or similar structures, trees and/or shrubs shall be planted to indicate the positions of these structures. The locations for planting shall be as shown on the Drawings or as directed by the Engineer.

viii. Care shall be taken not to obscure traffic signs by plants.

ix. Trees shall not be planted closer than 10 m from the edge line on the outside shoulder.

(b) Preparing Plant Holes

Unless otherwise directed by the Engineer, holes shall be spaced and prepared as follows:

- i. All holes shall be square in plan and shall have loosened sides and bottoms to prevent root balling of plants and trees.
- ii. Holes for hedge plants and shrubs shall be at least 500 mm square by 600 mm deep and 1.5 m from centre to centre. Alternatively, a 500 mm wide trench 600 mm deep may be dug.
- iii. Holes for trees shall be at least 600 mm square by 700 mm deep.
- iv. The holes for plants shall be refilled with selected and approved topsoil thoroughly mixed with manure or compost (one heaped spade-full added to every plant hole) and, depending on soil-test reports, the required quantity and type of fertiliser.
- v. The holes shall be thoroughly watered before plants are planted. Where the soil is poorly drained, 150 mm of crushed stone shall be placed at the bottom of the hole before it is filled with soil.

(c) Planting

Before trees, shrubs and hedging plants are removed from their containers for planting, they shall be well watered.

Directly after having been planted, each plant shall be well watered with a view to settling the soil. After the soil has settled, additional soil shall be added where necessary to bring the replaced soil in the hole to within 150 mm of the ground surface, so as to ensure that sufficient water can be retained in the hole around the plant. All trees shall be tied to a suitable creosote-treated timber stake with a minimum diameter of 35 mm or other suitable stake as approved by the Engineer and firmly planted in the ground. The stake shall be 300 mm longer than the planted tree, and its maximum length shall be 1.5 m above ground level. After planting, the ground surface around the plant shall be covered with straw or grass or any other type of mulch to minimise evaporation.

(c) Maintenance

During the defects liability period, which shall be twelve months after completion of the actual planting of trees, shrubs and hedges, the Contractor shall be responsible for watering the trees, shrubs and hedges and keeping the plants free from weeds and pests.

Every hedge plant, tree or shrub, which is not healthy or shows unsatisfactory growth shall be replaced by the Contractor at their own expense, within one month of having been notified by the Engineer in writing. Any replacement tree or shrub shall be maintained for a period of 1 year from the date of replacement.

5608 EROSION PREVENTION**(a) Requirements and Works Description**

During construction the Contractor shall protect all areas susceptible to erosion by installing all the necessary temporary and permanent drainage works as soon as possible and by taking such other measures as may be necessary to prevent the surface water from being concentrated in streams and from scouring the slopes, banks or other areas.

All side slope areas which consist of a sandy material shall be hydroseeded with the addition of an anti-erosion

compound. The application rate will be as specified by the manufacturer. PAM (Polyacrylamide) or a suitable alternative may be used.

Payment for the supply of the anti-erosion compound will be made under ITEM 56.08.

Vetiveria zizanioides (Vetiver grass) is to be planted as a soil conservation system of "Vegetative Contour Hedges" to minimise the erosion potential of surface water runoff where directed by the Engineer. The Vetiver grass slips are to be separated from the grass clump and planted in rows running parallel to the contour and at spacings of 10-15 centimetres apart. The rows of Vetiver grass are to be spaced at distances varying between 1 and 5 metres on 1:1.5 to 1:4 side slopes. On gentle sloping areas the distances between the rows can increase up to 30 metres apart.

Vetiver Hedge Rows can be considered for protection to cut and fill slopes, bridge approach embankments, gully erosion protecting, storm water and culvert outlets. Vetiver grass is available in Uganda.

Any runnels or erosion channels developing during the construction period or during the defects liability period shall be backfilled and compacted, and the areas restored to a proper condition. The Contractor shall not allow erosion to develop on a large scale before effecting repairs and all erosion damage shall be repaired as soon as possible and in any case not later than three months before the termination of the Defects Liability Period. All topsoil or other material accumulated inside drains shall be removed at the same time. Topsoil washed away shall be replaced.

(b) Proprietary Brand Materials Used for Erosion Prevention

Certain proprietary brands of materials may be necessary for erosion prevention to enable natural grass to become established. In such case the specific brand shall be as described in the Special Specifications. The method of applying the material, the required surface preparation, the type of material to be provided and the method of payment, shall be as set out in the Special Specifications.

5609 MEASUREMENT AND PAYMENT

ITEM	UNIT
56.01 TRIMMING:	
(a) MACHINE TRIMMING	SQUARE METRE (m ²)
(b) HAND TRIMMING	SQUARE METRE (m ²)

The unit of measurement for trimming shall be the square metre of area trimmed on the instruction of the Engineer, including areas trimmed after having been shaped. No trimming within the road prism shall be measured for payment.

All bulk earth-moving operations as described under shaping in SUB-CLAUSE 5603 (a) shall be measured and paid for under SECTION 3600.

The bid rates for trimming shall include full compensation for trimming the areas to the specified finishing requirements, including the moving of a relatively small quantity of material that would be inherent in this process and the removal of surplus material and stones. Payment shall distinguish between machine trimming, which can reasonably be done by bulldozer or motor grader, and hand trimming.

ITEM	UNIT
56.02 USING MACHINES FOR TRIMMING OR SHAPING (ALTERNATIVE TO SUBITEM 56.01(a)):	
(a) BULLDOZER	HOURLY (H)
(b) MOTOR GRADER	HOURLY (H)

The unit of measurement shall be the hour actually worked by each machine in trimming or shaping areas. Standing

time will not be measured.

The bid rates shall include full compensation for furnishing and using the machines, including the cost of fuel, operators, remedy of any defects, transporting the machine to and from the point where it is to be used, and for all other incidentals necessary for carrying out the work.

ITEM	UNIT
56.03 PREPARING THE AREAS FOR GRASSING:	
(a) SOIL RIPPING	HECTARE (ha)
(b) PLOUGHING	HECTARE (ha)
(c) TOPSOILING WITHIN THE ROAD RESERVE, WHERE THE FOLLOWING MATERIALS ARE USED:	
(i) TOPSOIL OBTAINED FROM WITHIN THE ROAD RESERVE OR BORROW AREAS (FREE-HAUL 1.0 km) STOCKPILED UNDER SUB-ITEM 31.01(b) (i)	CUBIC METRE (m ³)
(ii) TOPSOIL OBTAINED FROM OTHER SOURCES BY THE CONTRACTOR (INCLUDING ALL HAUL)	CUBIC METRE (m ³)
(d) PROVIDING AND APPLYING CHEMICAL FERTILISERS AND/OR SOIL-IMPROVEMENT MATERIAL:	
(i) LIME	TONNE (t)
(ii) SUPER-PHOSPHATE	TONNE (t)
(iii) LIMESTONE AMMONIUM NITRATE	TONNE (t)
(iv) 2:3:2(22)	TONNE (t)
(v) 3:2:1(25)	TONNE (t)
(vi) OTHER FERTILISERS AND/OR SOIL-IMPROVEMENT MATERIALS IF REQUIRED (TYPE STATED)	TONNE (t)
(e) STOCKPIILING TOPSOIL	CUBIC METRE (m ³)

(a) Soil Ripping

The unit of measurement for soil ripping shall be the hectare. Only areas ripped on the written instructions of the Engineer shall be measured for payment.

The bid rate shall include full compensation for ripping, complete as specified.

(b) Ploughing

The unit of measurement for loosening the topsoil by ploughing shall be the hectare of soil loosened and prepared in accordance with the Specifications. Only areas loosened by ploughing on the written instructions of the Engineer shall be measured for payment.

The bid rate shall include full compensation for loosening the topsoil by ploughing, removing stones, and levelling and trimming the surface.

(c) Placing the Topsoil

The unit of measurement shall be the cubic metre of topsoil applied at the specified thickness or as directed by the Engineer measured in situ after the topsoil has been placed. The quantity shall be calculated from the net area of the topsoiled surface multiplied by the average thickness of the topsoil but before the grass sods are placed. Any topsoil placed in excess of the average thickness specified or prescribed will not be measured for payment.

Payment shall distinguish between topsoil obtained from designated areas within the road reserve or borrow areas and topsoil obtained by the Contractor from outside sources when sufficient topsoil is not available from the

designated areas mentioned above.

The bid rates shall include full compensation for excavating and loading the topsoil, any royalties or compensation that may be payable, transport (except overhaul), off-loading, placing and spreading it to the required thickness, levelling it off to a smooth surface, for removing any stones as specified and for roughening the surface to be topsoiled.

The free-haul distance of topsoil obtained from the road reserve or borrow areas shall be 1.0 km. The bid rate for topsoil under SUB-ITEM 56.03 (c) (ii) shall also include full compensation for transporting the topsoil to the point of eventual use.

(d) Providing and Applying Fertiliser and/or Soil-Improvement Material

The unit of measurement for fertiliser shall be the tonne of each type of fertiliser and/or soil-improvement material applied in accordance with the Specifications and as instructed by the Engineer.

The bid rates shall include full compensation for furnishing the fertiliser and/or soil-improvement material, transporting it to the point of use, spreading and mixing it into the scarified soil or topsoil, irrespective of the method of application.

(e) Stockpiling the Topsoil

The unit of measurement shall be the cubic metre of topsoil stockpiled on the written instructions of the Engineer where this operation is unavoidable despite proper advance planning. Only material actually loaded, transported to and stockpiled on sites designated for stockpiling will be measured, but not any material merely pushed or bladed into heaps next to the area from which it is taken, unless it was done with the prior approval of the Engineer, and the material was stockpiled in an approved area.

The bid rate shall include full compensation for loading the topsoil, placing it in stockpile and for any payments to private Owners for the use of stockpile areas.

<u>ITEM</u>	<u>UNIT</u>
56.04 GRASSING:	
(a) PLANTING OF GRASS CUTTINGS (TYPE OF GRASS AS INDICATED)	HECTARE (ha)
(b) SODDING BY USING THE FOLLOWING TYPES OF SODS:	
(i) NURSERY SODS (TYPE OF GRASS SPECIFIED)	SQUARE METRE (m ²)
(ii) BUSH SODS	SQUARE METRE (m ²)
(c) HYDRO SEEDING:	
(i) PROVIDING AN APPROVED SEED MIXTURE FOR HYDROSEEDING	KILOGRAM (kg)
(ii) HYDROSEEDING	HECTARE (ha)
(d) PROVIDING AN APPROVED SEED MIXTURE FOR SOWING GRASS WITH A MACHINE OR BY HAND	KILOGRAM (kg)
(e) SOWING GRASS SEED WITH AN APPROVED GRASS-PLANTING MACHINE	HECTARE (ha)
(f) HAND SOWING	SQUARE METRE (m ²)
(g) SPRIGGING	SQUARE METRE (m ²)
(h) OTHER METHODS (SPECIFY)	

Half the payments under ITEM 56.04 will become due when the grassing or hydro seeding has been done, and the remainder will become due when satisfactory cover has been established.

The rate per unit area of grassing, irrespective of the

method of grassing, shall include full compensation for any necessary watering at whatever stage and mowing of grass. ITEMS 56.05, 56.06 AND, 56.07 shall not be measured separately for payment.

(f) Planting Grass Cuttings

The unit of measurement for planting grass cuttings shall be the hectare of established grass with an acceptable grass cover.

The bid rate shall include full compensation for furnishing and planting the cuttings, watering, weeding, and replanting if necessary, and all other incidentals which may be necessary for establishing an acceptable cover and maintaining the grass, except mowing.

(g) Sodding

The unit of measurement for sodding shall be the square metre covered with sods, which has an acceptable cover.

The bid rates shall include full compensation for procuring, excavating, loading, transporting, off-loading, placing and watering the sods, for replanting dead areas, for watering and weeding the grass, for supplying and placing timber stakes and for all other incidentals, except for mowing, which may be necessary for establishing an acceptable cover, and maintaining the grass. Payment shall distinguish between nursery-grown sods and bush sods obtained from within the road reserve or borrow areas. In the case of bush sods the bid price shall include levelling-off and trimming areas from which the sods are taken.

(h) Hydro Seeding

- The unit of measurement for providing seed shall be the kilogram of seed of the specified seed mixture. The mass of any pulp added shall not be measured.

The bid rate shall include full compensation for procuring and furnishing the seeds.

- The unit of measurement for hydro seeding shall be the hectare of grass established by hydro seeding, which has an acceptable cover.

The bid rate shall include full compensation for furnishing cellulose pulp and mixing it with seed and water and with any anti-erosion compound if required, applying the mixture, watering, weeding, re-seeding bare patches, and for any other work, except mowing, which may be necessary for establishing an acceptable cover and maintaining the grass.

(i) Providing Grass Seeds

The unit of measurement for providing seed shall be the kilogram of seed of the specified seed mixture.

The bid rate shall include full compensation for procuring and furnishing the seeds.

(j) Grassing With an Approved Grass Planter

The unit of measurement for sowing any grass seeds by using an approved planter shall be the hectare of grass with an acceptable cover, where the seeds have been planted.

The bid rate shall include full compensation for all labour, material, equipment, weeding, and all incidentals that may be necessary for sowing the grass seeds and establishing an acceptable grass cover, except mowing. The bid rate shall also include full compensation for watering the planted areas until an acceptable grass cover has been established.

Payment for the grass seed will be made separately under SUB-ITEM 56.04 (d).

(k) Hand-Sowing

The unit of measurement for hand-sowing the grass seeds shall be the square metre of grass with an acceptable covering on surfaces instructed by the Engineer to be hand-sown.

The bid rate shall include full compensation for all labour, materials, equipment, weeding, and all incidentals that

may be necessary for planting the grass seeds and establishing an acceptable grass cover, except mowing. The bid rate shall also include full compensation for watering the planted areas until an acceptable grass covering has been established.

Payment for the grass seeds shall be made separately under SUB-ITEM 56.04 (d).

(l) Sprigging

The unit of measurement for sprigging shall be the number of square metres of sprigging which has been planted in accordance with these Specifications and accepted by the Engineer.

The bid rate include full compensation for furnishing and placing of all materials, fertilisers, water, labour, equipment, tools, transport and all costs necessary to complete the work as prescribed in this Section.

(m) Other Methods

Whenever other methods of grassing are specified in the Special Specifications, measurement and payment shall be as specified.

<u>ITEM</u>	<u>UNIT</u>
56.05 WATERING THE GRASS WHEN ESTABLISHED BY TOPSOILING ONLY:	KILOLITRE (kl)

The unit of measurement for watering areas which have been top soiled on the instruction of the Engineer but which have not been hydro seeded or planted with grass, shall be the kilolitre of water applied on the instructions of the Engineer and calculated from the number of tank loads applied, multiplied by the capacity of the tank used in each case.

The bid rate shall include full compensation for procuring, transporting and applying the water as specified.

<u>ITEM</u>	<u>UNIT</u>
56.06 WATERING THE ALREADY PLANTED GRASS, TREES AND SHRUBS IN PERIODS OF DROUGHT DURING THE DEFECTS LIABILITY PERIOD:	KILOLITRE (kl)

The unit of measurement for watering the grass, trees and shrubs shall be the kilolitre of water used as directed by the Engineer in dry periods during the defects liability period in respect of grass, trees and shrubs.

The bid rate shall include full compensation for obtaining, transporting and applying the water.

The Contractor shall keep a careful record of the quantity of water used by him/her for watering the grass, trees and shrubs planted and shall submit such information to the Engineer on a daily basis. When there are times during the normal growing season, as specified in the Special Specifications, when the monthly rainfall is less than 75% of the monthly average, the Contractor will be compensated under this item for the same percentage of the quantity of water used for watering as that for the monthly rainfall that fell short of the average rainfall.

<u>ITEM</u>	<u>UNIT</u>
56.07 MOWING THE GRASS:	HECTARE (ha)

The unit of measurement shall be the hectare measured each time when the grass has been cut on the instructions of the Engineer.

The bid rate shall include full compensation for all plant, equipment and labour, required for every cutting of the grass and disposing of the grass cuttings, i.e., payment will be made every time the grass has been cut on the instructions of the Engineer.

<u>ITEM</u>	<u>UNIT</u>
56.08 ANTI-EROSION COMPOUND (SPECIFY)	KILOGRAMME (kg)

The unit of measurement shall be the kilogram net mass of anti-erosion compound used with the approval of the Engineer.

The bid rate for each kilogram of anti-erosion compound applied with the hydro seeding or separately shall include full compensation for furnishing the material and mixing and applying it.

<u>ITEM</u>	<u>UNIT</u>
56.09 TREES AND SHRUBS:	
(a) PROVIDING THE TREES AND SHRUBS (TYPES AND AGE/SIZE INDICATED)	NUMBER (no.)
(b) PLANTING AND ESTABLISHING:	
(i) TREES	NUMBER (no.)
(ii) SHRUBS	NUMBER (no.)

Unit of measurement for providing the trees and shrubs shall be the number of each species or variety and age/size of the tree and shrub furnished and established.

The bid rate shall include full compensation for furnishing the plants at the point of final use including substitutes for plants that may become diseased or die.

The unit of measurement for planting and establishing trees and shrubs shall be the number of each type planted and established.

The bid rates shall include full compensation for excavating the holes to the specified dimensions, furnishing topsoil, wooden stakes, manure and compost and mixing them together with any fertiliser required for planting and refilling each hole with the topsoil mixture and other soil, for watering the plants until the end of the defects liability period, furnishing and planting substitutes for plants that have died and for maintaining the plants as specified until the end of the defects liability period, including any other incidentals which may be necessary for properly executing the work.

Where the Employer furnishes the plants, the above rates shall also include full compensation for taking delivery of the plants, maintaining them as required, transporting them to point of final use, and for providing substitutes for plants which die or become diseased during storage.

Any chemical fertiliser and/or soil-improvement material required will be measured and paid for under SUB-ITEM 56.03 (e).

<u>ITEM</u>	<u>UNIT</u>
56.10 EXTRA WORK FOR LANDSCAPING	
(a) PROVISIONAL SUM FOR TREE PLANTING ALONG THE EDGE OF THE ROAD RESERVE	PROVISIONAL SUM
(b) PROVISIONAL SUM FOR PROVIDING AND APPLYING CHEMICAL FERTILISERS AND/OR SOIL-IMPROVEMENT MATERIAL, PLANTING OF PASPALUM NOTATUM AND GROUND COVERS, WATERING AND MOWING)	PROVISIONAL SUM
(c) CONTRACTORS' OVERHEADS AND PROFIT AS A PERCENTAGE OF THAT PART OF SUB-ITEM 56.10 (A) AND (B) USED FOR PAYMENT TO THE FORESTRY DEPARTMENT FOR LANDSCAPING WORK	(%) PERCENTAGE

The provisional sum allowed shall be expended at the discretion of the Engineer to cover the cost of work in

addition to the scheduled Items which may be required in respect of landscaping and re-vegetation or any other related Items of work required for which no pay Items have been provided.

Payment shall be made as specified in SUB-CLAUSE 1209 (h).

These Provisional Sums may also be used should the Engineer instruct the Contractor to appoint the Forestry Department (of the Government of the Republic of Uganda) to plant grass, trees, shrubs or hedges. In this instance the Forestry Department shall water and maintain the grass, trees, shrubs or hedges which they plant and will in effect become a nominated sub-contractor to the Contractor.

<u>ITEM</u>	<u>UNIT</u>
56.11 WEEDING THE GRASS WHEN ESTABLISHED BY TOPSOILING ONLY	HECTARE (ha)

The unit of measurement for weeding all grass-seeded areas that have been topsoiled on the instruction of the Engineer (but have not been hydroseeded or planted with grass) shall be the hectare weeded as instructed by the Engineer.

The bid rate shall include full compensation for weeding the prescribed areas in accordance with the Specifications.

<u>ITEM</u>	<u>UNIT</u>
56.12 SOIL ANALYSIS OF TOPSOIL TAKEN FROM THE SITE	NUMBER (no.)

The quantity to be measured for payment shall be the number of soil analysis undertaken on topsoil samples taken from the Site in accordance with the Specifications or as instructed by the Engineer.

The quantity measured as prescribed above shall be paid for at the bid rate, which price shall be full compensation for taking topsoil sample, laboratory testing and preparation of soil analysis report with recommendation on type and quantity of fertiliser / soil-improvement material, including all labour, equipment, tools, transport and all costs necessary to complete the soil analysis.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5700: FINISHING THE ROAD AND ROAD RESERVE AND TREATING OLD ROADS

CONTENTS:

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5704 MEASUREMENT AND PAYMENT	5000-36

5701 SCOPE

This Section covers the final finishing and cleaning up of the road and road reserve after construction, and scarifying and treating old roads and temporary diversions.

5702 FINISHING THE ROAD AND ROAD RESERVE

After completing the seal or surfacing, or gravel surface on gravel roads, the road and road reserve shall be cleared of all excess earth, stones, boulders, debris and other waste material resulting from the construction of the Works and disposed in an approved waste site.

Culvert inlets and outlets, culvert barrels, and open drains shall be cleared of all debris, soil, silt and other material. The surfacing shall be cleared of all dirt, mud and foreign objects. Dragging, pushing or scraping material across the finished surfacing shall not be permitted.

All junctions, intersections, islands, kerbing and other elements making up the completed Works shall be neatly finished off.

The Contractor shall ensure that all declared noxious weeds have been removed from the road-reserve and borrow-pit areas. All noxious weeds shall be burnt to prevent the spread of the seed and cut stumps or coppice shall be sprayed with a suitable herbicide.

All soil, stones, boulders and indigenous plant material resulting from the finishing operations shall be disposed of at locations not visible from the road, and where they will not pollute water sources or create a hazard for livestock or wildlife (e.g., old borrow pits). All other waste such as drums, excess steel, litter, etc. which cannot be sold or recycled shall be dumped in an approved waste site. The Contractor themselves shall make their own arrangements with the owners of properties on which such materials are to be deposited. Disposal shall be carried out in a neat and uniform manner.

The finishing of the road and road reserve shall be regarded as part of the Works and the Contractor's obligations under the Contract and shall not be paid for separately.

5703 TREATING OLD ROADS

All old roads, temporary diversions, haul roads and construction roads, shall, insofar as is practicable, be levelled with the original ground. Surfaces shall be scarified and broken up to a depth of 150 mm to promote plant growth. The old roads shall be rehabilitated as shown in the Drawings, provided in the decommissioning plans or as directed by the Engineer, and shall be re-vegetated in accordance with SECTION 5600.

Where required by the Engineer, in order to prevent soil erosion, banks, dykes or ditches shall be constructed over the old road to dimensions ordered by the Engineer. All roads and temporary diversions treated as above shall be left in a neat and tidy state.

5704 MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
57.01	TREATMENT OF OLD ROADS AND DIVERSIONS	KILOMETRE (km)

The unit of measurement shall be the kilometre of old road or temporary diversion treated.

Any landscaping and grassing shall be measured and paid for under SECTION 5600.

The construction of banks, dykes or ditches shall be measured and paid for under SECTION 2100.

The bid rate shall include full compensation for levelling and scarifying any surfaces and tidying old roads and diversions as specified.

No payment will be made in regard to treating the Contractor's own haul roads and construction roads, which costs shall be included in the rates for constructing the relevant items of work for which such roads are necessary.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5800: ROAD LIGHTING

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5801 SCOPE

This section is intended as a guide for the typical technical specifications and recommended documentation requirements road lighting system. Road Lighting system can use electrical energy from the existing distribution network or solar power or both. Requirements for the different key parts are listed separately. For solar, the key concerns include ensuring the highest efficiency of each part, and how the parts are connected to each other in the most efficient manner, thereby losing the least amount of energy.

5802 LIGHTING SYSTEM USING ELECTRICAL ENERGY

(a) Connection Arrangements

Street lighting connections will normally be via single connections to each column or where specified by the local authority, a single point of connection will be provided to a control point.

Secondary double pole isolation should be provided above the distribution network operator's clear cut-out and the owner of the street lighting equipment in accordance with the local authority's specification.

Where a competent person is on site and can provide certificates of satisfactory tests then the columns can be energised by that competent person.

(b) Adoption of Lighting

Every lighting unit and underground cable, on completion and before being energised shall be inspected and tested to verify that the requirements of BS 7671:2018+A2:2022 have been met.

The contractor shall be responsible for the maintenance (including replacement of damaged columns and the like) of the new equipment and any existing equipment affected by the works from the date of commencement of works up to and including the date of the final adoption certificate.

Upon completion of the installation 'as built' drawings shall be submitted to the Engineer showing column positions, cable routes, depths, sizes and positions, and service positions and centrally managed systems.

On request from the contractor for formal adoption of the development the lighting installation will be inspected and

any remedial works shall be highlighted. The developer shall be responsible for any remedial repairs together with a bulk lamp change and clean prior to a final adoption certificate being issued. In addition, dependent upon the age of the installation, the developer may be required to retest/ re-paint the installation at his own expense.

(c) Design Standards

All public lighting provided on the adopted highway shall be designed and installed in accordance with BS 5489-1:2020, Code of Practice for the design of road lighting part 1: Lighting of roads and public amenity areas and BS EN 13201-2:2015, BS 5489-2:2016, part 2 Lighting of Tunnels, PD CEN/TR 13201-1:2014 Selection of Lighting Classes, BS EN 13201-3:2015 Calculation of Performance, BS EN 13201-4:2015 Methods of Measuring Lighting Performance and BS 5489 Guide to General Principals.,

The actual level of public lighting to be provided shall be in accordance with BS 5489-1:2020 P6, however, P4 shall be provided in areas considered of high crime.

Deviation from Standards shall only be allowed with prior approval by the person indicated in the Special Specification.

(d) Energy Conservation

Lighting systems shall be capable of dimming to allow the Authority to control such systems to reduce CO2 and energy.

Energy efficient equipment shall be used at every opportunity and investigations and monitoring of technological developments shall be undertaken.

The use of lower wattage white light sources such as CDM-T, PL compact fluorescent, CPO, and LED (Light Emitting Diodes) shall be considered.

(e) Obtrusive Lighting

Obtrusive light is lighting, which falls outside the area to be illuminated, which can cause discomfort, annoyance, distraction, or reduces the ability to see. Obtrusive light is referred to as light pollution which can be divided into three main categories:

- i. Sky Glow
- ii. Glare
- iii. Light trespass

The obtrusive light should be restricted by:

- i. The control of the type of light source
- ii. Restricting the level of light emitted at high angles between 70 and 90 degrees
- iii. The use of full horizontal cut off (flat glass) luminaires where appropriate

Within urban locations in areas of medium district brightness glare should be rectified by the use of lanterns with a CEN luminous intensity class of 2 or 3.

(f) General Specification

- i. All luminaires shall comply in all respects with the latest edition of the British Standard and European Norms, be suitable for residential road lighting as defined in BS 5489-1:2020, BS EN 13201-2:2015 and BS EN 13201-3:2015, BS EN 13032, and subsequent amendments.
- ii. Electrical Equipment shall be installed to the levels of radio interference given in BS EN IEC 55014-1:2021 or equivalent are not exceeded.
- iii. The system power factor shall be greater than 0.85 at full power and when dimmed.
- iv. Drivers shall be pre-set to dim by 25% between 10pm and midnight and by 50% between midnight and 5am.
- v. The Contractor shall apply for the required Multi-level Switch Regime for their equipment in accordance with Balancing and Settlement Code (BSC) procedures.

- vi. The Contractor will be responsible for making all necessary arrangements for the collection and disposal of all luminaires replaced during the contract period in accordance with the WEEE directive; any WEEE charges shall be included in the Luminaire price.
- vii. The Contractor may be required to provide technical support with the design of luminaires to meet the requirements of the British and European Standards and subsequent amendments, following contract award. This must be provided throughout the period of the contract.
- viii. All luminaires shall be supplied fully assembled in all respects with LED, dimmable driver and photoelectric control unit at 70/35 lux.
Any departures from the standards above shall be agreed upon in writing with the Street Lighting Engineer prior to work commencing. Where no such prior agreement has been made, the Employer reserves the right not to adopt the equipment.
- ix. Consideration shall generally be given to non-standard columns/lanterns in conservation areas only based upon individual assessment and future revenue implications.
- x. Where non-standard equipment is approved the developer shall supply, at no cost, spare equipment e.g., lantern, bracket, column etc. The quantity to be supplied shall be 10% (rounded up) of that installed or 1 no if fewer than 10 are installed.
- xi. The luminaire life in hours shall be 80,000 hours/ 20 years minimum.
- xii. All luminaires shall be delivered pre-wired with 8 metres of at least 1.5 mm² PVC Insulated 3 core cable of 300/500 volt grade:
 - a. Standards: BS EN 50525-1:2011+A1:2022 TABLE 44, VDE281
 - b. Conductor: Class 5 flexible plain copper conductors to BS EN 60228:2005 (previously BS6360) 3 x 1.5mm²
 - c. Insulation: Arctic grade PVC (Polyvinyl Chloride)
 - d. Sheath: Arctic grade PVC (Polyvinyl Chloride)
 - e. Sheath Colour: Blue
 - f. Voltage Rating: 300/500V
 - g. Temperature Rating: -40°C to +70°C

(g) Columns and Brackets

Columns shall be manufactured from galvanised tubular/ sheet steel, or aluminium and shall conform to the following:

- i. The column and bracket manufacturer shall be registered with and accredited under the Quality Assurance Scheme ISO 9002 for the manufacture, supply and verification of lighting columns. A copy of the accreditation document shall be supplied to the Engineer on request.
- ii. All columns and brackets shall be manufactured, supplied and installed in accordance with the requirements of BS 5649-5:1982 or a revision of such. Columns shall be manufactured in accordance with the requirements of BS EN 40 and amendments by BD 26/04.
- iii. Unless otherwise agreed columns and brackets shall be designed to be capable of accepting lanterns with the following weights and windage of lanterns:

Table 5802/1: Requirements weights and windage of lanterns

Mounting Height Metres	Lantern Weight Kg	Windage Area Sq. Met
5 post top	12	0.15
6 post top	12	0.15
8 post top	16	0.19
10 post top	20	0.19
12 post top	20	0.27
5 side entry 0.5 m projection	12	0.15
6 side entry 0.75 m projection	12	0.15
8 side entry 1.00 m projection	16	0.19
10 side entry 1.5 m projection	20	0.19
12 side entry 2.0 m projection	20	0.27

- iv. All columns shall have a root for planting to a depth shown by the middle range listed in CLAUSE 5 of PART 2 OF BS 5649 as follows:
 - 5 metre columns 800 mm planting depth
 - 6 metre columns 1000 mm planting depth
 - 8 metre columns 1200 mm planting depth
 - 10 metre columns 1500 mm planting depth
 - 12 metre columns 1700 mm planting depth
- v. All columns shall have a cable entry slot at appropriate locations.
- vi. Columns manufactured in galvanised tubular steel shall have shaft and base sections manufactured from continuous lengths of new steel tube and shall not contain any welded or stepped sections.
- vii. Unless otherwise mentioned in the drawing, the base section of columns shall have a minimum wall thickness of 3.2 mm and have base compartment openings of a minimum 500 x 100 mm for 5 and 6 metre columns 600 x 115 mm for 8, 10 and 12 metre columns
- viii. The shaft sections shall have minimum diameters of 76 mm and 114 mm for 5/6 and 8/10 metre columns respectively.
- ix. The height above ground of the base sections shall be 1250 mm.
- x. Column roots shall be treated with dense bitumen
- xi. Bracket arms shall provide an incline of lantern of 5° or 0° or as specified in the drawing.
- xii. The method of joining the base section and the shaft shall be by a swage joint with an internal centralising washer. All welding procedures shall be in accordance with the requirements of BS EN 288 and all welders approved to the requirements of BS EN 287 with welding carried out in accordance with BS EN 1011-1&2.
- xiii. The same pattern of door lock shall be used throughout all columns. Keys shall be supplied for 10% of all columns supplied. The door fixing bolt shall have a tapered end to facilitate self-centering when closing.
- xiv. An internal full length base board, equivalent to the door size, substantially non-hygroscopic shall be fitted in each compartment for mounting control gear. Base board fixing studs or bolts shall not protrude beyond the front face of the base board. The base board shall be firmly bolted in position. On delivery, the column door shall come assembled on the column.
- xv. There shall be no sharp edges within columns or bracket arms to damage electrical cables during installation or service. An anti-chafe ring shall be fitted where cable routes change direction from horizontal to vertical within the bracket.

(h) Corrosion Protection for Columns and Brackets

All columns and bracket arms shall be galvanised unpainted. Additional protection shall be used for columns and bracket arms within a conservation area or as agreed with the Engineer. Additional protection, as per the treatment below, shall be applied before leaving the factory.

- i. Hot dipped galvanised in accordance with BS EN ISO 1461 2022.
- ii. The galvanised surface shall then be degreased and left with a smooth finish to prepare for painting.

The paint system shall comprise:

1st Coat - On the internal root section, to 250mm above ground level and on the overall external surfaces, one coat of Mordant Solution, T wash.

2nd Coat - On the internal root section, to 250mm above ground level, one coat of modified vinyl micaceous iron oxide with high solids to give a high build coating colour grey to provide a minimum dry film thickness of 60 microns.

3rd Coat - On the external surface overall, one coat of two pack high build epoxy zinc phosphate primer, light grey to provide a minimum dry film thickness of 75 microns.

4th Coat - On the external root section to 250mm above ground level, one coat of modified vinyl micaceous iron oxide with high solids to give a high build coating, coloured grey to provide a minimum dry film thickness of 75 microns.

5th Coat - On the external surface overall, one coat of modified vinyl with high solids to give a sheen finish to the dried film colour grey from BS 4800 shade 18B25 to provide a minimum dry film thickness of 60 microns.

A line on the circumference of the base section shall denote ground level. The minimum dry film thickness shall be:

Root - 60µm (internal) External - 210µm (external to 250mm) 135µm (from 250mm)

(i) Light Sources

The type of light source, its colour and colour appearance can have a significant effect on the night scene. The attributes of the various light sources that shall be considered for public lighting are:

- LED. - Light Emitting Diode;
- Low maintenance implications;
- Low energy usage;
- Extensive Lamp Life; and
- Luminaires still under development.

Unless otherwise specified or dictated by environmental/safety factors, LEDs shall be used in all circumstances.

LEDs must comply with the latest revision of all ruling legislation at the time of supply including EC Declaration of Conformity (CE Mark)

All lamps supplied shall carry markings in conformity with the above legislation and any other mandatory markings ruling at the time of supply.

(j) Clear Cut Outs and Isolators

- i. All cut-outs shall be clear and incorporate a double pole isolation switch complying with BS 5419 having a rating of 32 Amps and of adequate short circuit withstand for the position in the circuit in which it is installed. The isolation switch shall be capable of being positively and visibly locked off by means of a padlock or locking bar and it shall not be possible to remove the outgoing fuse(s) unless the isolation switch is in the off position.
- ii. The cut-outs shall be of the all-insulated type with drip proof enclosure affording a minimum degree of protection to IP22 and have a high mechanical and

dielectric strength. The terminals shall be capable of accepting conductors with crimped lug connectors.

- iii. The incoming phase terminals shall be shrouded when all connections have been made, the shroud shall be capable of removal for inspection or disconnection of cable ends, but shall not be capable of accidental detachment or be of a push fit type. Movement of cables shall be prevented by the use of bushes or inserts. Fuse carriers shall utilise HRC fuse links to BS 88.
- iv. The units shall be provided with separate terminals for phase and neutral conductors manufactured from solid brass and electro-tinned and are entirely suitable for connecting the requisite cables.
- v. Where a connection is made into any cut-out for supplying a sub-circuit the cut-out shall incorporate a second fuse link to protect the sub-circuit.
- vi. Electricity Service Connections cut-outs shall be double pole or similar approved by the Implementation Agency.
- vii. The cut-outs shall be securely fitted to the baseboard with non-corrodible screw fixings.

(k) Fuses

No rewirable fuses shall be used. All fuses shall be of High Rupturing Capacity (HRC) conforming to BS HD 60269-2:2013+A1:2022 operating on a 240 volts 50 Hz supply. Fuse ratings shall be 6 amps for lamps up to and including 100 watts and 10 amps for lamps greater than 100 watts.

(l) Cables

Underground cables shall be laid in duct except where they leave the duct to enter the cable slot of the apparatus, and consist of stranded copper conductors, XLPE insulated, PVC extruded bedding, a concentric layer of steel wire armour, overall PVC sheathing suitable for operation in an earthed system and of rated voltage 600/1000 volts at 50 HZ, all in accordance with BS 6346 for metric cable.

All cores shall be of equal cross-sectional area of 6sq mm minimum and be of such a size that the requirements of the current IEE Wiring Regulation, BS 7671:2018/A3:2024, are met and allow for a disconnection time not exceeding 5 seconds.

The internal wiring between the terminal block in the lantern and the components in the base of the column shall be PVC insulated and sheathed 3 core cable of 300/500 volt grade having a copper conductor size of at least 1.5 mm².

Where approved, cable to a two-part photoelectric cell detector unit shall be PVC insulated 3 core cable of 300/500 volt grade, having a copper conductor size of at least 1.5mm².

All cores shall be correctly colour coded and cables for continuous earth bonding shall be green/yellow PVC insulated single core copper cable of minimum cross section 16 mm² 600-volt grade conforming to BS 6004.

All underground cables shall be identified as to their origin and destination by permanent markers located over the sheath at the cable ends.

(m) Cable Ducts

Cable ducts across roadways shall have internal diameters of 100 mm and average wall thickness of 5.0 mm. Cable ducts in footpaths and verges shall have internal diameters of 50 mm and an average wall thickness of 3.5 mm.

Ducts shall be manufactured from low, medium or high-density polyethylene and coloured orange with white, 9 mm high lettering "STREET LIGHTING" at intervals of not more than 1m along its length.

Ducts for street lighting cables under carriageways shall be laid with 750 mm minimum cover and laid on 100 mm bed of Acceptable Material Class 8 (Specification of Highway Works) and covered with Acceptable Material Class 8 but

containing no material greater than 20 mm within 100 mm of the duct.

(n) Cable Laying

Joints in underground cables are not permitted and continuous lengths of cable shall be laid and looped in and out of the terminations.

Cables shall not be laid in a frozen state or when the ambient temperature is below 0°C.

The internal radius of a cable bend shall be such as not to cause damage to the cable.

For cables not accommodated in 50 mm duct, the trench shall be excavated to 525 mm minimum depth and the cable laid on and surrounded by a 75 mm thickness of sand or equivalent material. The trench to be backfilled with acceptable material to within 150 mm of finished level before laying the cable marker tape and completing the backfill and finished surface.

(o) Erection of Columns and Brackets

The columns shall be erected in the locations shown on the approved drawings. The column shall be correctly aligned in the vertical position with the door opening facing away from oncoming traffic.

The columns shall be placed in a hole allowing a minimum of 150 mm clearance all-round the base of the column for the full excavation depth.

Concrete used in the backfill shall be C40 or as specified in the drawings or instructed by the Engineer.

Bracket arms shall be fixed to the columns at the site of installation. The method of securing the bracket arm must be positive such that the arm cannot rotate. The arm and lantern shall be at right angles to the highway to be illuminated.

(p) Internal Wiring and Distribution Cables

Columns not directly supplied from the Electricity Company shall be supplied on a sub-circuit from the serviced column by means of the public lighting underground cable and looped from column to column. All looped connections shall be made in the bottom terminals of the fused isolator cut-out. The armouring of the underground cables shall be secured onto the gland plate of the cut-out or have a nonferrous sleeve fitted below the armouring and earthing clamps fitted to make a positive grip on the armour wires. The earthing clamps and gland plate shall be bonded to the main column earthing terminal with 10 sq. mm single core PVC cable.

(q) Electricity Supply Services

The Contractor shall liaise with the Regional Electricity Company with regard to the provision of electricity supply services to the lighting installation.

The power Distributor shall be advised that where a significant number of services are required, the developer should contact the appropriate utility office eight weeks prior to the supply being required, and provide the following:

- i. A schedule of lamps requiring a new supply or transfer of supply.
- ii. An indication of when the work will be required.

Under no circumstances shall one be made to live side of the electricity company cut-out.

(r) Earthing

The whole of the installation shall be earthed in accordance with the requirements of the current BS 7671, IEE Wiring Regulations, and with the recommendations contained in BS 7430:2011+A1:2015, Earthing. Earthing shall be carried out in PVC insulated copper cable green/yellow in colour. All metallic parts of the ancillary equipment, column, lantern and gear shall be bonded together to form a continuous earth path to the earth stud of the column.

(s) Painting

After erection, any areas of damage to the paint protection system shall be made good by abrading the edges of the damaged areas and coating the damaged areas with M.I.O. modified vinyl, applied by spray, to give a sheen finish coloured grey 18B25.

No further site painting of new columns shall be required unless a finish in a colour other than grey is required. Any further finish paint shall be applied to the overall column and bracket in one continuous flow free coat. All painting shall be carried out in accordance with the paint manufacturer's instructions and no painting shall be carried out during extremes of temperature or when the surface is damp or wet.

(t) Electrical Testing of Equipment and Commissioning

Prior to being energised, all equipment wiring and cabling of every completed installation shall be tested in accordance with Part 7 of BS 7671.

Columns and underground cables should be tested in the following sequence.

- i. Visual Inspection – to verify that the electrical equipment has been correctly installed in accordance with the design with correctly rated protection devices and bonding and that no visible damage exists.
- ii. Continuity – every protective conductor, including bonding, shall be tested to verify that it is electrically sound.
- iii. Insulation Resistance – the insulation resistance should be measured between all the conductors and the conductors to earth with a test voltage of 500 volts. The insulation resistance should not be less than 0.5 megohm.
- iv. Polarity – a polarity test should be made and a check to verify that protective devices are connected correctly and fuses in the phase conductor only.
- v. Earth Fault Loop Impedance – measurements should be taken at the point of supply and, where underground cables have been installed, at the most distant point of each circuit. The values should accord with those shown in BS 7671 to ensure the circuit protective device will function within five seconds.
- vi. Earth Electrode Resistance – tested in accordance with BS 7430:2011+A1:2015 AND BS 7671.
- vii. Operation of Residual Current Device – verify by a test simulating an appropriate fault condition independent of any test facility incorporated in the device. The device shall be tested at 50% and 100% of its rated trip current.
- viii. Voltage Drop – measured at the most remote point from the supply under full load conditions.

5803 LIGHTING SYSTEM USING SOLAR POWER

The Solar Street light operates from Dusk to Dawn i.e., the lamp automatically switches ON after the sunset and switches OFF after sunrise.

The street lighting system basically consists of:

- PV Module
- Rechargeable Battery
- Light Source
- Charge Controller
- Pole
- Battery box
- Interconnecting cables

The PV module is fixed firmly on top of the pole with a suitable tilt and inclination so as to receive maximum sunlight throughout the day. The PV module thus produces suitable voltage and current, which is used to charge the battery inside the battery box. This energy stored in the

battery is used to light up the LED which is housed inside the luminaire during night-time.

The charge controller protects the battery from overcharge and deep discharge.

The PV module, luminaire and the battery box are fixed onto the Pole and are interconnected through the cables. The solar streetlight operates in the stand-alone mode. The battery is housed inside a battery box, which is fixed onto the pole at a suitable height from the ground for easy maintenance and replacement.

5804 QUALITY OF MATERIALS

Only materials approved by the Engineer. Wherever applicable, the material shall comply with the British Standards Specifications, or IEC standards where no British Standards exist.

Materials wherever possible, must be of African manufacture.

5805 PV MODULE

- i. The PV module should have a minimum of Mono-crystalline silicon solar cells with a certificate of testing conforming to IEC 61215 EDITION II / BIS 14286 from an NABL or IECQ accredited Laboratory or any other type as approved by the Engineer.
- ii. Based on the availability of the electrical power or as per the requirement of the Engineer, PV Module shall have the technology to receive electrical power from an external source to charge the batteries should the available sunlight not be adequate. In that case controller must automatically sense that the charging current derived from the solar panel is not adequate and automatically switch over to the mains supplied power supply. The controller will revert to the default setting when the charging derived from the solar panel is adequate.
- iii. There should be a Name Plate fixed inside the module which will give:
 - o Name of the Manufacturer or Distinctive Logo;
 - o Model Number;
 - o Serial Number; and
 - o Year of manufacture.

5806 BATTERY

- i. Rechargeable Lithium Ferro Phosphate Battery or any other type as approved by the Engineer.
- ii. Battery pack should have a proper 'Battery management System' (BMS) for cell balancing, overcharge and over temperature protection.
- iii. Battery should conform to the latest BIS/ International standards.

5807 LIGHT SOURCE

- i. The light source will be a white LED type.
- ii. The light output from the white LED light source should be constant throughout the duty cycle.
- iii. The lamps should be housed in die cast aluminium housing.
- iv. The temperature of heat sink should not increase more than 20°C above the ambient temperature during the dusk to dawn operation.

5808 CHARGE CONTROLLER

- i. Charge controller must be a Maximum Power Point Tracker (MPPT) Type.
- ii. Electronics should operate at an appropriate voltage suitable for proper charging of the battery.
- iii. No Load current consumption should be less than 20 mA.
- iv. The PV module itself should be used to sense the ambient light level for switching ON and OFF the lamp.
- v. The PCB containing the electronics should be capable of solder free installation and replacement.
- vi. Necessary lengths of wires/cables, switches suitable for DC use and fuses should be provided.

5809 CHARGE CONTROLLER PROTECTIONS

- i. Adequate protection is to be incorporated under "No Load" conditions e.g., when the lamp is removed and the system is switched 'ON'.
- ii. The system should have protection against battery overcharge and deep discharge conditions.
- iii. The System should have protection against short circuit conditions.
- iv. Protection for reverse flow of current through the PV module(s) should be provided.
- v. Adequate protection should be provided against battery reverse polarity.
- vi. Load reconnect should be provided at 80% of the battery capacity status.

5810 MECHANICAL COMPONENTS

- i. A corrosion resistant metallic frame structure should be fixed on the pole to hold the PV module.
- ii. The frame structure should have provision so that the module can be oriented at a suitable tilt angle.
- iii. Pole should be Hot dip galvanized pipe as per Hot dipped galvanized in accordance with BS EN ISO 1461:2022.
- iv. The galvanized surface shall then be degreased and left with a smooth finish to prepare for painting.
- v. Pole Columns manufactured in galvanized tubular steel shall have shaft and base sections manufactured from continuous lengths of new steel tube and shall not contain any welded or stepped sections.
- vi. The base section of columns shall have a minimum wall thickness of 4.2mm and have base compartment openings of a minimum 600 x 115mm or as indicated in the drawing.
- vii. The pole should have the provision to hold the luminaire.
- viii. The battery shall be pole mounted in an enclosure, which should be waterproof (IP 65) corrosion resistant, hot dip galvanized metallic box (IP 65) with anti-theft locking

The solar road lighting system supplied must comply with the minimum technical specifications provided in TABLE 5810/1 or as stated in Special Specifications.

TABLE 5810/1: SPECIFICATIONS FOR SOLAR ROAD LIGHTING

Sr. No.	Components	Specification for Solar Street Light Fitting
1	PV module	- The installed capacity of the module shall be a minimum of 400 Wp per panel - Number of PV modules per single arm light: Two (2) - The module efficiency should not be less than 18 %. - Solar cell efficiency should not be less than 18%
2	Battery	- Minimum 100 AH capacity Lithium Ferro Phosphate battery. - CE marked - Battery Nominal Voltage: 24V - Operating Temperature: -5 deg. (°C) To 55 deg. (°C) - Self-Discharge: Less than 2% per month - Life cycle: Minimum 4000 at 80% Depth of Discharge (DoD) - Compatible with a suitable Maximum Power Point Tracking (MPPT) charge controller
3	Light Source	- White Light Emitting Diode (W-LED) 70-Watt minimum - The luminaire must use high efficacy W-LED with a minimum of 140 lumens per watt (and UV free). [A certificate to be submitted by the System supplier to the Engineer during certification] - Expected life: Minimum 50,000 hrs. - LED Chip should be compliant with IES: LM-80 (Approved Method for Measuring Lumen Maintenance of LED Light Sources and LED lumen depreciation time to L70). - Test report for the same should be submitted
4	Luminaire	- The luminaire shall be tested for Electrical, Photometry and Colour parameters as per IES LM-79:2008 or IS: 16106:2012 for following performance parameters: - Total luminous flux: $\geq 12,000$ lm. - Luminous efficacy (i.e., system efficacy): ≥ 140 lm/W. - Colour Temperature: Between 4000 K to 5000 K - Colour Rendering Index (CRI) ≥ 70 - Luminous intensity distribution should follow the batwing patterns in polar curves. - Require a validation report from a third-party tester using .IES file, which is generated during luminous intensity distribution test and using maintenance factor, pole height, Road width and Pole span as shown in the drawing or as instructed by the Engineer. - The average illuminance level and uniformity should comply with the requirements of the relevant IES standard.
5	Charge Controller	- Charge controller must be MPPT Type - Nominal voltage: 24V automatic recognition - Duty Cycle: Dusk to dawn - The lamp automatically switches ON after sunset and switches OFF after sunrise. - At least two stages of dimming function - The first stage system should function at 100% load for hours indicated in the drawing or instructed by the Engineer and the second stage system should function with 50% load as indicated in the drawing or instructed by the Engineer - Working Temperature: -5 deg.(°C) To 55 deg. (°C) - Overall total Efficiency of the Charge Controller should be Minimum 90% - Protection function: Solar reverse-charging protection, Solar reverse-connection protection, Battery over charge protection, Battery over-discharge protection, Battery reverse-connection protection
6	Autonomy	3 days or a Minimum of 33 operating hours per permissible discharge with fully charged Lithium-Ferro Phosphate Battery.
7	Ingress Protection – IP	Optical and Control gear compartment - IP 65 / IP 66
8	Mounting of light	Pole height and location shall be as shown in the drawing or directed by the Engineer.
9	Pole	Hot deep Galvanized Steel Pole, concrete pipes, Glass Reinforced Plastic or as shown in the drawings
10	Connectors	Only snap on connectors shall be used similar to MC4 No taping nor twisted conductors shall be allowed.

5811 QUALITY AND WARRANTY

- The street lighting system (including the battery) will be warranted for a period of minimum five years from the date of supply.
- The PV module(s) will be warranted for a minimum period of 25 years from the date of supply. The PV modules must be warranted for their output peak watt capacity, which should not be less than 90% at the end of Ten (10) years and 80% at the end of Twenty-five (25) years.
- Batteries shall be warranted for a minimum period of five (5) years.
- The supplier shall provide the Warranty Card that contains the details of the system addressed to the Client.

5812 CENTRALIZED SOLAR STREET LIGHTING SYSTEM

For the roads that do not have enough shadow free areas, a standalone solar street lighting system is not recommended but only centralized solar PV system is strongly recommended. A centralized solar PV system requires a detailed technical survey and design that is site specific. Further, the centralized system power output shall be of AC power and therefore the selected LED lamp must be of AC type. In centralised system, arrays of PV panels will be fixed at a convenient location and the power output from the source is distributed to the lights in a particular group via distribution cables. For this type of lighting system, since the battery will be installed at one place as one battery bank, use of a flooded tubular deep cycle battery in addition to a lithium-ion battery can also be used.

5813 QUALITY CONTROL

The Contractor shall arrange for a sample of material they intend to procure, supply, install and commission at their

own expense. The Contractor shall ensure quality control before shipping and at delivery. The Contractor should arrange to conduct a destructive test of at least one set at their expense in the presence of the Engineer.

Upon completion of the work, a full test will be carried out on the installation for a period of 30 days to determine its satisfactory performance. The Contractor shall ensure that the installation is completed in every aspect and that there are no major defects prior to notifying the Engineer (in writing) for inspection. The Engineer will not accept any defect following the final inspection. Should there be any defects, the Engineer will terminate that inspection and request that the contractor arrange another inspection upon correction of the defects.

The contractor shall notify the Engineer prior to tests being undertaken and arrange for the Engineer to be present to verify the tests. The contractor shall supply all equipment and materials necessary for testing purposes, power and the fuel required for the testing and commissioning of the installations.

A "Certificate of Site Acceptance Test Results" shall be approved by the Engineer on successful completion of all site tests.

The following tests shall be carried out for solar road lighting systems or any other test as directed by the Engineer:

- Photovoltaic module performance and environmental tests;
- Battery capacity, cycle life and safety tests;
- LED photometric and optical performance tests;
- Control system calibration and integration checks;
- Electrical safety and mechanical durability tests;
- Testing of installed cables and submission of completed test certificates;
- Factory Acceptance Tests; and
- Impedance to Earth Test.

The following tests shall be carried out for grid-powered road lighting systems or any other test as directed by the Engineer:

- Electrical safety and integrity tests;
- Photometric tests;
- Thermal management, weather resistance and corrosion tests;

Mechanical and durability tests; and Control and communication tests.

5814 WORKMANSHIP AND STAFF

The Contractor shall furnish the Engineer with a certificate of wiring by a certified wireman as per the legal requirements.

Any civil changes to the electrical or related civil works shall be approved by the Engineer.

Any work that does not meet the specified requirements shall be removed and rectified at the expense of the Contractor. rectified by and at the expense of the Contractor.

5815 OPERATION AND MAINTENANCE MANUAL

An Operation, Instruction and Maintenance Manual, in English, should be provided with the Solar Street Lighting System. The following minimum details must be provided in the Manual:

- Basic principles of Photovoltaics.
- A small write-up (with a block diagram) on Solar Street Lighting System - its components, PV module, battery, electronics and luminaire and expected performance.

- Type, Model number, Voltage and capacity of the battery, used in the system.
- The make, model number, country of origin and technical characteristics (including IESNA LM-80 report) of W-LEDs used in the lighting system.
- About Charging and Significance of Indicators.
- Clear instructions about erection of pole and mounting of PV module(s) and lamp housing assembly on the pole.
- Clear instructions on regular maintenance and troubleshooting of the Solar Street Lighting System.
- DO's and DONT's.
- Name and address of the contact person for repair and maintenance, in case of non-functionality of the solar street lighting system.

5816 MEASUREMENT AND PAYMENT

The unit of measurement shall be the number of road lighting provided.

	<u>ITEM</u>	<u>UNIT</u>
58.01	SUPPLY, INSTALLATION AND COMMISSIONING OF GRID-POWERED LIGHTING	
(a)	SUPPLY, INSTALLATION AND COMMISSIONING OF GRID-POWERED ROAD LIGHTING COMPLETE WITH A PLANTED BASE , HIGH COLUMN (SINGLE BRACKET ARM) AS INDICATED ON THE DRAWINGS.	NUMBER (no.)
(b)	SUPPLY, INSTALLATION AND COMMISSIONING OF GRID-POWERED ROAD LIGHTING COMPLETE WITH A PLANTED BASE , HIGH COLUMN (DOUBLE BRACKET ARM) AS INDICATED ON THE DRAWINGS.	NUMBER (no.)
(c)	SUPPLY, INSTALLATION AND COMMISSIONING OF POWER UNITS INCLUDING ALL INCIDENTALS (AS SPECIFIED IN DRAWINGS).	LUMPSUM

	<u>ITEM</u>	<u>UNIT</u>
58.02	SUPPLY, INSTALLATION AND COMMISSIONING OF SOLAR ROAD LIGHTING COMPLETE WITH LIGHTING COLUMN AND PLANTED BASE (AS PER THE DRAWINGS)	NUMBER (no.)

	<u>ITEM</u>	<u>UNIT</u>
58.03	SUPPLY INSTALLATION AND COMMISSIONING OF SOLAR SUBSTATION POWERED ROAD LIGHTING	
(a)	SUPPLY, INSTALLATION AND COMMISSIONING OF SOLAR SUBSTATION POWERED ROAD LIGHTING WITH SINGLE BRACKET ARM COMPLETE WITH LIGHTING COLUMN AND PLANTED BASE (AS PER THE DRAWINGS)	NUMBER (no.)
(b)	SUPPLY, INSTALLATION AND COMMISSIONING OF SOLAR SUBSTATION POWERED ROAD LIGHTING WITH DOUBLE BRACKET ARM COMPLETE WITH LIGHTING COLUMN AND PLANTED BASE (AS PER THE DRAWINGS)	NUMBER (no.)
(c)	SUPPLY, INSTALLATION AND COMMISSIONING OF SOLAR SUBSTATIONS COMPLETE WITH ALL INCIDENTALS (AS SPECIFIED IN DRAWINGS).	NUMBER (no.)

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5900A: TRAFFIC SIGNAL WORK AND MAINTENANCE

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5901A SCOPE

The work shall cover the supply and installation of Traffic Signals. The traffic signal, its configuration, size and location shall be as shown in the drawings or as directed by the Engineer. Prior to installation of signals, the Contractor shall submit to the Engineer, for approval, detailed proposals showing the signal type, sizes, paint and structural details of the signal posts including control system.

5902A MATERIALS

(a) Foundation

Unless otherwise specified, all foundations shall be constructed of reinforced cement concrete.

The bottom of concrete foundations shall rest on firm ground. Cast-in-place foundations shall be poured monolithically where practicable. The exposed portions shall be formed to present a neat appearance. Concrete shall be of the minimum grade of C25 RCC or as indicated in the drawing.

(b) Backfilling

The trench is to be backfilled with acceptable material to finish the level backfill and the finished surface.

When excavating for a foundation entails the removal of surplus ground materials, the excavation must first be backfilled up to 300 mm of the ground level using C15 concrete, and then it must be backfilled to ground level with compacted native material or as per the Engineer's direction.

All backfill for Junction Boxes shall be gravel unless otherwise specified by the Engineer.

(c) Poles

Poles shall be manufactured from galvanised tubular/sheet steel, or aluminium and shall conform to the following:

- The manufacturer of the column and bracket must be certified and accredited with the Quality Assurance Scheme ISO 9002 or equivalent for the manufacturing, supply, and verification of lighting columns. On request, a copy of the accreditation document must be provided to the Engineer.
- All columns and brackets must be made, supplied, and installed in conformity with BS EN 40 specifications.

Unless otherwise mentioned in the drawing or instructed by the Engineer, Galvanising shall be in accordance with BS EN ISO 1461:2022 and Welding shall be in accordance with BS EN 14610:2004.

Poles shall be erected and secured with bolts onto a precast concrete base, as indicated in the drawing or instructed by the Engineer.

(d) Signal Heads

The technical requirements for Traffic Signal Heads with one or more signal lights in terms of red, yellow, and/or green signal for road traffic shall be as stipulated in BS EN 12368:2024 - Signal heads. All new traffic signal lanterns shall be supplied with Light Emitting Diode (LED) Type.

The nominal size of Signal Heads, to be used on all overhead mast arm displays and high-speed approaches shall be a minimum of 300 mm and must make allowance for a 300 mm "LED" module, unless otherwise indicated in the drawing. Signal heads to be mounted on standard 4 m poles shall be 200 mm.

(e) Backing Board

Unless otherwise shown in the drawing or instructed by the Engineer, the backing board shall be manufactured from glass-reinforced plastic or approved UV-resistant plastic. This shall extend between 300 mm and 320 mm (for 200 mm diameter signal heads) and between 400 mm and 420 mm (for 300 mm diameter signal heads) from the centre of the optical system and be rounded at the top and bottom. The backing board shall consist of one single unit and to allow easy replacement of broken backing boards on existing intersections, must be installed onto the head from the front.

(f) Visors

Each visor shall fit tightly against the door and shall not permit any perceptible filtration of light between the door and the visor.

All Visors shall be made from Aluminium or polycarbonate. Unless specified by the Engineer, all visors shall be one of the following:

- Open Type Visor: For use on primary signals.
- Closed Type Visor: For use on secondary or tertiary signals.
- Pedestrian Visor: Each standard 200mm diameter pedestrian signal shall be fitted with an approved rectangular visor.

(g) Lens

The aspect of all signal lenses shall be circular. There shall be two sizes for lenses such that the net diameter of exposure towards traffic (after taking into account the hoods, etc.) is 200 mm or 300 mm.

(h) Conduits

Unless put in poles, pedestals, or mast arms, all cables and conductors not depicted on the designs as aerial cables must be installed in the conduit. All conduits depicted on the designs shall be 100mm (or 50 mm by agreement with the Engineer) internal diameter, smooth bore, single wall constructed in medium density polythene with a wall thickness of not less than 5mm. All transitions shall be through an aluminium threaded coupling. These couplings shall be the only approved method for connecting the 90-degree sweep.

The contractor, at his sole expense, may use a larger conduit if desired. Where a larger conduit is used, it shall be for the entire length of the run. No reducing couplings will be permitted underground.

(i) Cables

All cables shall be armoured. The cables shall comply with the requirements of BS EN 50556:2018, TR 2031D and TR 2029C. All cables shall be laid in 100mm diameter smooth ducts or as indicated in the drawing. Each cable will be provided with an extra length of slack, 2m shall be coiled in the pit located at the base of each traffic signal pole and 0.5m shall be laid in the pit located at the Traffic Signal Controller.

The traffic signal ducting system shall not be shared with any other utilities or under-ground services. Separate cables shall be supplied for Low Voltage (LV: 50-230V) and Extra-Low Voltage (ELV: less than 50V). LV and ELV

cables shall be terminated on separate terminal blocks both within the Traffic Signal Controller cabinet and at the top of the signal poles.

Pulling of cables will be the responsibility of the Contractor. Cables shall not be bent to a radius of less than 12 times their diameter or less than the minimum bending radius recommended by their manufacturer, whichever is the greater. Cables shall be terminated in the controller at the appropriate terminal block and in the correct terminal position.

(j) Paint

After erection, any areas of damage to the paint protection system shall be made good by abrading the edges of the damaged areas and coating the damaged areas with M.I.O. modified vinyl, applied by spray, to give a sheen finish coloured grey 18B25 as per BS 4800:2011.

No further on-site painting of new columns is necessary unless a colour other than grey is specified. Any additional finish paint must be applied in a single, continuous, flow-free coat to the whole column and bracket. No painting shall be performed during severe temperatures or while the surface is damp or wet, and all paint must adhere to the manufacturer's instructions.

(k) Fibre Optic Splice Enclosure

Splice enclosures shall be re-enterable with a mechanical dome-to-base seal and a flash test valve, that prevents the admission of foreign material (water, dust, etc.). Enclosures shall be compatible with installation in junction boxes and manholes. The Enclosure shall conform to BS EN 50411 or as directed by the Engineer.

Enclosures shall have at least one oval port that can take two cables and at least four round ports (for single cables) to accommodate all cables entering the enclosure. Provide gel-sealing or heat-shrinkable cable shields with the enclosure to ensure a weather-tight seal at each cable's point of entry.

Within enclosures, there should be a minimum necessary number of hinged mountable splice trays to store the required number of splices, as well as the capacity to store six more splices. It is recommended that a fibre containment basket be made available for the storage of loose buffer tubes that will be expressed through the enclosure. When the buffer tubes are coiled, it is important to make sure that the enclosures offer enough room to prevent any micro-bending.

Splicing enclosures and other accompanying equipment should have an operating temperature ranging from 10 to 60 degrees Celsius.

5903A CONSTRUCTION

(a) Placement

i) Far-Side Signal Faces

At least two traffic signal faces shall be provided on the far side of the stop line at locations:

- a. That are NOT on the near side of a junction or slipway;
- b. That are not less than 6 m (but preferably not less than 10 m) from the stop line;
- c. Such that the two traffic signal faces shall not be less than 3 m and not more than 20 m apart; Provided that where it is unavoidable that the traffic signals are more than 20 m apart, additional traffic signals shall be provided in such a manner that no traffic signals are more than 20 m apart (signals should preferably not be more than 16 m apart);
- d. At a signalised junction, but not a pedestrian or pedal cyclist crossing, where a straight-through movement is permitted from an approach to the junction, and where the

roadway continues straight through the junction, a traffic signal face for the control of straight-through movements shall be provided subject to the requirements of Sub-Clauses (a) (i) a. to c., on either side of the roadway on the far side of the junction; Provided that when the roadway is divided at the junction by a constructed median island of adequate width to accommodate a signal, the right-hand traffic signal face shall be situated on the median island.

ii) Near-Side Signal Faces

At a signalised junction or slipway, but not a pedestrian or pedal cyclist crossing, at least one signal face containing a red-light signal shall be provided on the near side of the junction or slipway, on the left- or right-hand side of the roadway at a position not further than 3 m from the prolongation of the stop line". Although not prescribed, the near-side signal face is also recommended at pedestrian and pedal cyclist crossings.

iii) Signal Faces for Turning Phases

When a separate left- or right-turn signal is required, at least two traffic signal faces that incorporate a flashing green arrow light signal, flashing green bus light signal or a flashing green tram light signal, shall be provided, one on the far side of the stop line subject to Sub-Clauses (a) (i) a. and b., and the other on the far or near side.

Additional traffic signal faces may be provided at the junction or crossing at any suitable location, even if the minimum requirements for traffic signal faces have been met. Supplementary signal faces must be provided where the minimum visibility requirements cannot be achieved.

(b) Excavation

Unless otherwise indicated, pits of 900mm by 900 mm by 1050 mm in depth shall be excavated for traffic signals other than overhead signals. The poles shall be set in C 25 concrete to a depth of at least 300 mm below ground level and at least 300 mm above ground level. The circular region that will be embedded with concrete must have a diameter of at least 450 millimetres.

Pits of 1200 mm by 1200 mm by 1800 mm in depth are required for overhead-style poles. The poles are set in C 25 concrete to a depth of at least 500 mm below ground level and a height of at least 500 mm above ground level. The circular region that will be embedded with concrete must have a diameter of at least 500 mm.

(c) Backfilling

Unless otherwise instructed by the Engineer, the excavated pit shall be backfilled or poured with C15 concrete within twenty-four hours of opening. Once the backfilling is complete, the excavations need to be kept in a smooth and well-drained state until the permanent repairs are performed. They also need to be kept well-filled.

(d) Junction Box

A junction box shall be installed at all locations as indicated in the drawings and at such additional locations as ordered by the Engineer. At sites where operational traffic signals are being installed, permanent pre-cast junction boxes shall be installed. Junction boxes shall be installed so that the covers are level with a curb or sidewalk grade or level with the surrounding ground when no grade is established.

Crushed rock shall be used to backfill the whole excavation that needs to be done in order to install 90-degree sweeps into a future junction box. This needs to be done from the full depth of the conduit run down to the bottom of the junction box. It is required that there be a minimum depth of 300mm of gravel between the bottom of the excavation and the bottom of the junction box. Crushed rock is to be used to backfill the inside of the junction box, beginning at the junction box's base and continuing to a depth that is no

greater than 300 mm below the conduit lines. It is possible to use the dirt that was excavated during the digging process to backfill the area of the excavation that surrounds the junction box.

(e) Foundation

Anchor bolts are required to meet the standards stated by the manufacturer, and each bolt must be assembled with two (2) flat washers, as well as two (2) nuts. Shims and other comparable devices, such as those used in plumbing or raking, are not going to be allowed. On each and every foundation, stirrups need to be put. Before putting concrete, it is necessary to properly dampen not only the forms but also the ground that will be in contact with the new material. The forms are not to be removed from the concrete until it has completely hardened. A 6-bolt design is required to be used for all pole foundations unless the Engineer gives written permission to use another pattern.

(f) Conduits

All the cables supplying power to the controller and signal heads shall run through ducts when these are required to cross the carriageway. The ducts shall be of minimum 100 mm internal diameter and laid at a depth of about 750 mm from the level of the carriageway or 500 mm in case of footpath or verge and shall be sufficient enough to withstand the projected vehicular loading unless otherwise instructed by the Engineer.

Ducts under roadways shall be installed by boring methods wherever practicable. Where boring is not considered to be practical, the contractor shall contact the Engineer and seek approval for open trenching.

No more than two 100 mm ducts shall be laid side-by-side in one trench in footpaths. If more than two ducts are to be provided, the additional ducts shall be stacked vertically.

(g) Cable Laying

Underground cables are not allowed to have any joints, and instead, they must be laid out in continuous lengths that are then looped in and out of the terminations. It is required that the internal radius of a cable bend be designed in such a way that it does not cause any damage to the cable.

For cables that cannot be accommodated in a duct of 50 millimetres in diameter, the trench must be dug to a minimum depth of 525 millimetres, and the cable must be put on and surrounded by sand or another material with a thickness of 75 millimetres. Before laying down the cable marking tape and finishing the backfill and the completed surface, the trench needs to have appropriate material backfilled into it to within 150 millimetres of the finished level.

(h) Signal Controller

Controller cabinets shall be either pole-mounted or ground mounted. Unless otherwise indicated in the drawings, pole mounted cabinets shall be banded or bolted to the side of a traffic signal support pole.

The field wires from a pole-mounted cabinet either run through the back of the cabinet to the centre of the hollow support pole to which it is attached or run through the bottom of the cabinet to a steel conduit mounted on the outside of the support pole.

Ground-mounted cabinets shall be bolted to a concrete foundation with the heads of the bolts set in the concrete and the cabinet attached to the concrete using a set of washers and nuts.

The field wires from the cabinet run through a conduit that is encased in the cabinet foundation. Larger cabinets shall be ground mounted because of their considerable size and weight. Unless extenuating circumstances prevent it, the cabinet door should open away from the intersection. This allows the technician to easily monitor signal head indications and traffic behaviour while, at the same time, observing the operation of the controller and detector units located within the cabinet.

Circulating air through the controller cabinet is important to keep temperatures at acceptable levels in hot climates. However, doing so can draw dust into the cabinet, and dust can adversely affect electrical components. Consequently, filters must be used at the cabinet air input vents to catch dust particles.

Controller cabinets come in various sizes. Smaller cabinets shall be used for simple intersections with few phases whereas large cabinets shall be used for complicated multiphase intersections. With more phases comes the need for more load switches, and more detectors.

(i) Battery Backups (UPS)

The UPS shall deliver backup on full load for a minimum of 8 hours to the traffic controller and signals and be housed in a standalone lockable cabinet.

(j) Mounting of Vehicular Traffic Signals

i) General

Traffic signal faces may be mounted on one of the following supports:

- a. Standard post;
- b. Extended (longer) post; or
- c. Overhead cantilever or gantry;

Supporting traffic signal faces by means of catenary wires or cables, is NOT allowed.

A lateral clearance of at least 0.5 m should generally be provided from the edge of a roadway and any post or any part of a signal face, including the backboard. If there is a significant tipping of vehicles to one side due to camber or crossfall on the road, or where vehicles tend to cut corners, it is preferable to increase the clearance to 1.0 m or more.

On medians, where insistence on the 0.5 m lateral clearance would mean that signal faces cannot be provided on the median, the lateral clearance can be reduced to an absolute minimum of 0.1 m, but only if the camber or crossfall of the roadway falls away from the median.

ii) Post-Mounted Traffic Signals

Traffic signal faces should preferably be post-mounted at the side of the road. Supplementary traffic signal faces may be either post-mounted or mounted above the road surface on a gantry or cantilever.

Traffic signal faces on the left-hand side of the road, should generally be located not more than 2 m to the left of the continuation of the left-hand edge of the approach roadway, measured parallel to the road centre line and excluding any approach splay.

Traffic signal faces that are mounted on posts at the side of the road, should be not less than 2.3 m and not more than 3 m above the level of a point on the road surface nearest to the post, measured to the centre of the lowest (green) signal aspect. A minimum clearance of not less than 2.1 m above the sidewalk should also be provided.

Where it is necessary to achieve the minimum visibility requirements (e.g. on a vertical curve), supplementary traffic signal faces may be mounted on posts at the side of the road at a height exceeding 3 m. These supplementary traffic signal faces may be mounted on the same post, provided that the two traffic signal faces shall be not less than 1 m apart, measured from the centres of the two nearest light signals on the two signal faces. There is no maximum limit, but line-of-sight and stability factors should be taken into consideration and a practical limit would be 5 m (between centres of two closest light signals).

5904A TESTING AND COMMISSIONING

The Contractor shall notify the Engineer to witness and verify the tests. The Contractor shall supply all equipment

necessary for testing purposes. Unless otherwise indicated, the following tests shall be carried out:

- i. Testing of installed cables
- ii. Completed test certificates of all cables shall be submitted prior to commissioning
- iii. Factory Acceptance Test (FAT) of the controller to demonstrate compliance with the Traffic signal controller work specification and configuration forms
- iv. A "Certificate of Factory Acceptance Test Results" shall be completed and signed by the Engineer and the contractor upon satisfactory completion of the test.
- v. The contractor shall undertake a full green conflict test for all conflicting phase combinations prior to Site Acceptance Test.
- vi. A "Certificate of Green-Conflict Test Results" shall be completed and signed by the Contractor.
- vii. After installation of the equipment, site testing shall be carried out by the Contractor in presence of the Engineering order to demonstrate full compliance with the specification.

viii. Any non-compliance shall be resolved at the commissioning by the Contractor. All labour, plant and materials required to resolve the non-compliant items shall be provided the Contractor's own expense.

ix. Successful completion of this test shall make the system ready for commissioning.

x. Impedance to Earth Test shall be carried out by the contractor at the controller and each traffic signal pole on the site in compliance with BS 7671:2018 using appropriate test equipment.

xi. A "Certificate of Signal Installation Electrical Test Results" shall be completed prior to site acceptance.

xii. A "Certificate of Site Acceptance Test Results" shall be completed and signed by the Engineer and the Contractor on successful completion of all site tests.

The Contractor shall notify the Engineer and the Employer after completion of the traffic signal installation works for a joint inspection and sign-off of a traffic signal commissioning checklist as provided in table 5904A/1. The following shall constitute the checklist items as a minimum;

TABLE 5904A/1: TRAFFIC SIGNAL COMMISSIONING CHECKLIST

Number	Requirement	Checked
GENERAL		
1.1	As-Built layout plans and timing diagrams, modifications shown and approved.	
1.2	Layout plans and timing diagrams signed by the Engineer.	
GEOMETRIC DESIGN, ROAD SIGNS AND CIVIL ENGINEERING		
2.1	Layout and geometric design of junction or crossing	
2.2	Roadworks as per civil engineering requirements	
2.3	Road signs and markings	
2.4	Space provision for signal maintenance	
2.5	Final clean-up and finishing off, removal of waste material	
TRAFFIC SIGNAL HEADS AND FACES		
3.1	Signal heads masked out during installation and other junction control in place	
3.2	Types of traffic signal faces, signal symbols (disc, arrow, etc.)	
3.3	Background screens (Back boards) provided, white retroreflective border if specified.	
3.4	Signal aspect sizes, lenses, reflectors.	
3.5	Signal visors (and louvres)	
3.6	Luminous intensity (normal or high)	
3.7	Alignment of signal axis	
3.8	Signal faces intended for specific movements are not mistaken by other movements	
3.9	All vehicular light signals on same horizontal level	
3.10	Installation, damage, cleanliness, etc.	
POSITION OF SIGNAL HEADS AND FACES		
4.1	Locations and directions of traffic signal faces	
4.1.1	Far-side signal faces not nearer than 6m from the stop line (10m preferable)	
4.1.2	Far-side signal faces not less than 3m apart, nor further than 20m (16m preferable)	
4.1.3	Near-side signal faces not further than 3m from the stop line	
4.1.4	Minimum clearance distance 0.5 or 0.1 on medians where crossfall falls away	
4.1.5	Maximum lateral distance not further than 2m from left edge of the roadway	
4.1.6	Post minimum/maximum mounting heights – 2.3m/3.0m – 2.1m pedestrian minimum	
4.1.7	Overhead minimum/maximum clearance/mounting heights – 5.2m/6.2m	
4.1.8	Overhead preferably on the left-hand side of the road	
PEDESTRIAN SIGNAL FACES AND PUSH BUTTONS		
5.1	Locations and directions of pedestrian signal heads	
5.2	Red man signal not higher than the vehicular green signal	

Number	Requirement	Checked
5.3	Location and directions of push buttons, 1.1m heights	
5.4	Pedestrian symbols on push buttons	
5.5	Correct operation by testing each button	
5.6	Installation, damage, etc.	
SIGNAL POSTS		
6.1	Foundations, anchor bolts, size and depth, backfill, concrete strength, etc.	
6.2	Conduit entry, capping before pouring of concrete	
6.3	Vertical alignment of posts, cantilevers and gantries	
6.4	Yellow retro-reflectorised strips provided if specified	
6.5	Paintwork, damage, etc	
VEHICLE DETECTORS		
7.1	Location, dimensions and layout	
7.2	Saw cut width and depth (if applicable), debris and moisture removed	
7.3	Correct loop wiring, no splicing, no damage, no sharp corners, correct depth	
7.4	Proper sealing of slot, proper adherence to the pavement	
7.5	Correct operation by using an actual vehicle or a metal sheet that simulates a vehicle	
TRAFFIC SIGNAL CONTROLLER		
8.1	Location of controller, foundation and fixing, alignment	
8.2	Controller type, and cables entering cabinet adequately sealed	
8.3	Sealing and water proofing, operation of cabinet doors, cleanliness, damage, paintwork, etc	
8.4	Operation, signal plans, phases and timing, coordination, fallback plan, manual control panel operation	
8.5	Communication with central control system, synchronisation	
8.6	Conflict monitoring	
8.7	Signal start-up sequence, restart after power failure (retention of signal timings)	
8.8	Fault monitoring, red lamp monitoring	
8.9	Maintenance record in cabinet	
DUCTS, DRAW BOXES AND TRENCHES		
9.1	Location and sizes, materials, damage and cleanliness	
9.2	Provision of a draw wire in all ducts	
9.3	Excavation trench width and depth	
9.4	Compaction of excavations, backfill material and asphalt reinstatement	
9.5	Sidewalks, paving, plants and grass	
9.6	Damaged services	
ELECTRICAL (ALL ELECTRICAL WORK TO BE APPROVED BY QUALIFIED ELECTRICIAN)		
10.1	Power supply (source of power)	
10.2	Earthing, ground rods	
10.3	Conduits – size and type, collapsed sections, bending, joints	
10.4	Cables and wiring, colour coding and tags, damage	
10.5	Provision of drip loops	
10.6	No unauthorised splicing of cables	
10.7	Wiring tested for continuity and electrical leaks	
10.8	Wiring certificate issued	

The Contractor shall include in the costing full documentation including installation, commissioning, operation and maintenance manuals and drawings for the systems.

After completion of the Works, the Contractor shall submit as-built drawings to the Engineer on CD in AutoCAD and two hard copies of the drawings showing the complete installation as well as operation and maintenance manuals.

5905A OPERATION

(a) Visibility and Shielding of Signal Faces

Each signal face shall be so adjusted that its indications will be of maximum effectiveness to the approaching traffic for which they are intended. A visor shall be fitted to each of the optical systems and unless otherwise specified shall be as per BS EN 12368:2024. The visors should be dipped at an angle of 5 degrees $\pm$ 3 degrees to the horizontal to aid in directing the signal indication, specifically to

approaching traffic as well as to reduce Sun phantoms resulting from external light entering the lens.

Visibility requirements:

- i. Under normal atmospheric conditions, traffic signal faces should be clearly visible and recognisable on approaches to a signal. Where the signal faces alone cannot provide the required visibility, additional traffic signal faces must be provided to supplement the principal signal faces.
- ii. The overriding objective in deciding the number and location of supplementary traffic signal faces is that light signals should be clearly visible to the approaching vehicles for which they are intended, taking into account:
 - a. The position of the vehicle on the approach;
 - b. The alignment of the approach;
 - c. Obstructions to visibility (including other vehicles that may be queued on an approach);
 - d. Distracting lights and signs; and
 - e. Required sight distances.
- iii. Streetlights, illuminated signs and distracting advertising signs close to, or behind traffic signals may be confusing and distracting to drivers. Such distracting features should not be permitted

(b) Illumination of Lenses

Each signal lens shall be illuminated independently. When a signal lens except in a pedestrian signal is illuminated and the view of such an indication is not otherwise physically obstructed, it shall be visible (to drivers it controls) from a distance of at least 400 metres under normal atmospheric conditions.

(c) Waterproofing

All equipment below or above ground level shall be constructed and treated to permit continuous operation without fault due to immersion in groundwater or other corrosive agents commonly encountered on or beneath roads.

5906A MAINTENANCE OF TRAFFIC SIGNALS

- i. Operations and Maintenance (O&M) Manuals shall be supplied for each component. A reproducible form of each manual shall also be provided. The manuals supplied for the off-the-shelf items shall be those supplied by the equipment manufacturer. The manuals shall contain as a minimum the following operational and maintenance information:
 - a. Installation and set-up procedures;
 - b. Functional descriptions;
 - c. Step-by-step system operating instructions;
 - d. Theory of system operation;
 - e. Recovery procedures to be followed in case of malfunction;
 - f. Procedures for updating all database elements;
 - g. Electrical wiring diagrams;
 - h. Pictorial of components layout on chassis or circuit boards with parts identification; and
 - i. Complete performance specifications (both electrical and mechanical) on each unit Specific.
- ii. Provide for the alternate operation of the signal during a period of failure either on flash or manually, or by having manual traffic direction by proper authority as may be warranted by traffic volumes or congestion.
- iii. Have properly skilled maintenance staff available without undue delay for all emergency calls, including lamp failures.

iv. Provide properly skilled maintenance for all components.

v. Maintain the appearance of the installation in a manner consistent with the intention of this standard, with particular emphasis on painting and cleaning the optical system.

vi. Provide adequate stand-by equipment to minimise interruption of signal operation, due to equipment failure.

vii. Service equipment and lamps, as frequently as experience proves necessary, to prevent undue failures.

viii. All luminaires shall be fitted with bowls of sound and robust construction capable of being easily dismantled for maintenance or repair purposes. All lanterns shall be fitted with bowls manufactured from vandal-resistant material and stabilised to minimise loss of transparency due to weathering and exposure to ultraviolet light.

ix. All luminaires shall be fitted with integral control gear and have a heat barrier between the lamp enclosure and gear compartment. The control gear shall be fitted to a tool less, quick-release gear tray, equipped with a plug and socket connector for ease of maintenance or replacement purposes.

x. Corrosion Protection for Steel Columns and Brackets:

All columns and bracket arms shall be galvanised unpainted. Additional protection shall be used for columns and bracket arms within a conservation area or as agreed with the Engineer. Additional protection, as per the treatment below, shall be applied before leaving the factory. Hot dipped galvanised in accordance with BS EN ISO 1461:2022. The galvanised surface shall then be degreased and left with a smooth finish to prepare for painting.

xi. The paint system shall comprise:

1st Coat - On the internal root section, to 250 mm above ground level and on the overall external surfaces, one coat of Mordant Solution, T wash.

2nd Coat - On the internal root section, 250 mm above ground level, one coat of modified vinyl micaceous iron oxide with high solids to give a high build coating colour grey to provide a minimum dry film thickness of 60 microns.

3rd Coat - On the external surface overall, one coat of two-pack high-build epoxy zinc phosphate primer, light grey to provide a minimum dry film thickness of 75 microns.

4th Coat - On the external root section to 250mm above ground level, one coat of modified vinyl micaceous iron oxide with high solids to give a high build coating, coloured grey to provide a minimum dry film thickness of 75 microns.

5th Coat - On the external surface overall, one coat of modified vinyl with high solids to give a sheen finish to the dried film colour grey from BS 4800:2011 shade 18B25 to provide a minimum dry film thickness of 60 microns. A line on the circumference of the base section shall denote ground level. The minimum dry film thickness shall be Root – 60 µm (internal) 210 µm (external to 250 mm) External – 135 µm (from 250 mm).

5907A MEASUREMENT AND PAYMENT

The unit of measurement of different components of Traffic Signal shall be in numbers of Traffic Signals provided:

Concrete Foundation: Concrete Foundations including excavation and backfilling shall be measured and paid for in cubic Metres (m³). Pay items under SECTION 6100 of this Specification shall be used for this item.

<u>ITEM</u>	<u>UNIT</u>
59.01A CABLE DUCT (DIAMETER SPECIFIED) INCLUDING ALL FITTINGS & ACCESSORIES	METRE (m)

Conduit shall be measured and paid per linear metre (m). This shall include conduit bodies, fittings, bonding systems, pull ropes, pull tapes, plastic spacers.

<u>ITEM</u>	<u>UNIT</u>
59.02A SUPPLY AND INSTALLATION OF JUNCTION BOX INCLUDING ALL FITTINGS & ACCESSORIES	NUMBER (no.)

Junction Boxes shall be measured and paid for in numbers. This shall include concrete collars, frames and covers, tools to remove the cover, ground rods, ground conductors, grounding lugs, knockouts, cable racks, aggregate, excavating, backfilling compacting, disposing of surplus and unsuitable material, and restoring existing areas. Removal and Replacement of existing concrete, asphalt, or brick sidewalk and/or pavement due to the installation shall be incidental to the Junction Box Item.

<u>ITEM</u>	<u>UNIT</u>
59.03A SUPPLY AND INSTALLATION OF CABLES (TYPE INDICATED)	METRE (m)

All electrical cable(s) shall be measured and paid per linear metre (m), for each respective cable. The payment will be full compensation for all materials, labour, equipment, tools, and incidentals necessary to complete the work.

<u>ITEM</u>	<u>UNIT</u>
59.04A SUPPLY AND INSTALLATION OF FIBRE OPTIC SPLICE ENCLOSURE (INDICATE SMALL/ MEDIUM/ LARGE)	NUMBER (no.)

Fibre optic splice enclosure is measured in numbers with different size caps.

<u>ITEM</u>	<u>UNIT</u>
59.05A SUPPLY AND INSTALLATION OF SIGNAL POLES	
(a) SUPPLY AND INSTALLATION OF SIGNAL POLES WITHOUT MAST ARM WITH ALL FITTINGS AND ACCESSORIES	NUMBER (no.)
(b) SUPPLY AND INSTALLATION OF SIGNAL POLES WITH MAST ARM (INDICATE NUMBER OF LANES TO BE COVERED BY CANTILEVER PORTION) WITH ALL FITTINGS AND ACCESSORIES	NUMBER (no.)

Signal Poles without a mast arm shall be measured and paid in numbers. This shall include flange plates, anchor plates, bolts, transformer bases, painting, welding, labour, and all other associated equipment and hardware required for installation.

Signal poles with Mast Arms shall be measured and paid in numbers. This shall include mounting and all other associated equipment and hardware required for installation.

<u>ITEM</u>	<u>UNIT</u>
59.06A SUPPLY AND INSTALLATION OF 3-ASPECT – RED/AMBER/NORMAL FULL GREEN LED TRAFFIC SIGNAL HEAD	

(a) SUPPLY AND INSTALLATION OF 3-ASPECT – RED/AMBER/NORMAL FULL GREEN LED TRAFFIC SIGNAL HEAD COMPLETE WITH PRIMARY HOODS AND BACKING BOARDS, EACH ASPECT (INDICATE DIAMETER) WITH MULTIPLE LEDS INCLUDING ALL BRACKETS TO ATTACH TO TRAFFIC COLUMN	NUMBER (no.)

(b) SUPPLY AND INSTALLATION OF 3-ASPECT – RED/AMBER/NORMAL FULL GREEN LED TRAFFIC SIGNAL HEAD COMPLETE WITH SECONDARY HOODS AND BACKING BOARDS, EACH ASPECT (INDICATE DIAMETER) WITH MULTIPLE LEDS INCLUDING ALL BRACKETS TO ATTACH TO TRAFFIC COLUMN	NUMBER (no.)

(c) SUPPLY AND INSTALLATION OF 2-ASPECT – RED MAN/ GREEN MAN LED TRAFFIC SIGNAL HEAD COMPLETE WITH PEDESTRIAN HOODS AND BACKING BOARDS, EACH ASPECT (INDICATE DIAMETER) WITH MULTIPLE LEDS INCLUDING ALL BRACKETS TO ATTACH TO TRAFFIC COLUMN	NUMBER (no.)

Vehicle Signal Head shall be measured and paid in numbers. This shall include mountings, moulded terminal blocks, visors, back plates, fittings, realignments, lamps and optical adjustments or LED modules as required.

Pedestrian Signal Head shall be measured and paid in numbers. This shall include mountings, LED indication modules, moulded terminal blocks, visors, fittings, and realignments.

<u>ITEM</u>	<u>UNIT</u>
59.07A SUPPLY AND INSTALLATION OF CONTROLLER CABINET ASSEMBLY INCLUDING ALL FITTINGS & ACCESSORIES	NUMBER (no.)

Controller Cabinet Assemblies shall be measured and paid for at the contract unit price per unit. This shall include timing data, timing implementation, training, controller cabinets, back panels, power panels, detector panels, auxiliary panels, police panels, thermostatically controlled fan units in the cabinet with vents, flashers, local flasher switches, radio frequency interference filters, signal switches, main switches, police hand controls, conflict monitors, flasher relay assemblies, power relays, signal control assemblies, lamp receptacles and ground fault receptacles, circuit programs, flexible cables, grounding systems, transient protection devices, fittings, and all other associated equipment as required.

<u>ITEM</u>	<u>UNIT</u>
59.08A SUPPLY AND INSTALLATION OF PEDESTRIAN PUSH BUTTON DEMAND UNIT INCLUDING ALL FITTINGS & ACCESSORIES	NUMBER (no.)

Pedestrian push button unit shall be measured and paid in numbers. This shall include all material, labour, equipment, tools, and incidentals required for installation.

<u>ITEM</u>	<u>UNIT</u>
59.09A SUPPLY AND INSTALLATION OF UPS COMPLETE WITH INVERTER, CONTROL MECHANISM AND COMPLETE COMPATIBILITY WITH THE SUPPLIED TRAFFIC CONTROLLER	NUMBER (no.)

Battery Back-Up (UPS) systems shall be measured and paid in numbers, which shall include the complete UPS unit, battery package, auxiliary cabinet, switching device, all batteries and harnesses, installation, electrical work, grounding, and all other incidentals. The payment shall be full compensation for all materials, labour, equipment and all other incidentals necessary to complete this work.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5900B: BUS STOP STATIONS

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5901B SCOPE

This section covers the installation of Bus Shelters at designated places as indicated in the drawing or as instructed by the Engineer.

5902B GENERAL

Unless otherwise indicated, a shelter must have the following:

- An all-weather shade for the bus commuters.
- Minimum clear floor area of 0.76 m x 1.22 m entirely within the perimeter of the shelter.
- Minimum shelter dimensions of 2.7 m x 1.4 m and at least 1.3 m between the back of kerb and the front of the shelter.
- A clearance between the back of the shelter and the back edge of the adjacent building of between 0.9–1.5 m.
- Been designed to withstand wind load according to regulations.
- The seating shall be made of Square Hollow Section having a minimum size of 80x80x3mm or as indicated in the drawing for seat and back rest with adequate mid span support brackets and floor support. The benches shall be modular type with each unit size of 3800mm x 600mm with a minimum backrest support of 450mm.
- All the steel parts shall be as per the grade mentioned in the drawings or instructed by the Engineer to withstand the local climatic conditions and aluminium parts shall be anodized or powder coated to give longer life and better quality. The material used shall be unaffected by outdoor exposure.
- The materials used shall be Non-flammable.
- The Foundation slab shall be made with min C30 concrete. The cast iron nuts and bolts shall be rust proof hot deep galvanized powder coated etc.
- The Parts used shall not be fragile and shall be safely secured to their foundation with anchor fasteners which makes the furniture more stable and joint fasteners not visible from the outside. None of the joints shall be visible from outside the furniture and it is completely sealed.
- There shall be no falling parts, no sharp edges involved in the furniture all the parts shall be well fastened. The foundation used shall be designed in order to take loads from wind and persons leaning over the panel.
- Advertisement Area shall be integrated within the design of the Bus Shelter. The face shall be of acrylic to prevent vandalism of the advertising panel.

Electric vehicle (EV) charging stations if required shall be installed at bus stop stations as detailed in the drawings. Payment for this item shall be provided through a provisional sum under the item.

5903B MATERIALS

Hollow Steel Pipes, Square Hollow Sections (SHS) as per BS EN 10210-2:2019 or as indicated in the drawing.

Cement, steel and aggregate are as per SECTION 6000 of this specification.

Roof cover made of 4mm tinted polycarbonate or any other Semi-Plastic Cladding Material as indicated in the drawing or as instructed by the Engineer.

(a) Concrete and Structural Steel

Cement, aggregate, water, shall comply with the requirements of SECTION 6400. Reinforcement shall comply with the requirements of SERIES 6200.

Admixtures shall not be used in the concrete mix without the approval of the Engineer who may require tests to be performed before their use. Admixtures if allowed, shall comply with the requirements of SECTION 6400.

Concrete shall be a minimum of C30 and shall be as specified in SECTION 6400. Steel reinforcement shall be as shown on the Drawings and as specified in SECTION 6300.

Structural steel shall be as shown on the Drawings. Painting of structural steel shall be in accordance with SECTION 6900 or as directed by the Engineer.

(b) Welded Steel Fabric

Welded steel fabric shall comply with the requirements of BS EN 10080:2005 or equivalent on approval of the Engineer. Steel fabric reinforcement shall be Grades B500A, B500B or B500C conforming to BS EN 10080:2005 AND BS 4483:2005. Steel fabric reinforcement shall be cut and bent in accordance with BS 8666:2020. Steel fabric reinforcement shall have a minimum nominal bar size of 6 mm (8 mm for Grade B500A) Steel fabric reinforcement shall be delivered to the site in flat mats or pre-bent.

(c) Brickwork

Bricks shall be engineering bricks conforming to the requirements of BS EN 772-3:1998, BS EN 772-7:1998 or equivalent.

The limit for water absorption in the 24-hour immersion test shall be 8%.

Brickwork shall be built in English bond in a mortar consisting of one part of cement and six parts of sand, or in stretcher bond where its thickness does not exceed 115 mm. It shall be well and regularly bonded without any false headers. All bricks shall be unbroken, except where required as closers. Bricks shall be well wetted before laying and each brick shall be exceeding 10 mm in thickness. All joints shall be filled solid with mortar, and joints for exposed faces shall be pointed as the work proceeds.

Where pipes enter brickwork they shall be thoroughly caulked into the wall and rendered with mortar.

(d) Plaster

Where the plastering of brickwork is required, all joints shall be well raked out and the brick face thoroughly wetted before plaster is applied. Plaster shall not be less than 12 mm or more than 20 mm thick. Plaster finish shall be smooth and even and shall not show any trowel marks. Unless otherwise specified, all plaster shall be finished with a steel trowel. Plaster shall consist of one part of cement to four parts of approved fine sand.

5904B MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
59.01	BUS STOP	
(a)	SUPPLY AND INSTALL BUS STOP STATIONS (STATE TYPE)	NUMBER (no.)
(b)	PROVISIONAL SUM FOR SUPPLY AND INSTALLATION OF EV CHARGING STATION COMPLETE WITH ALL INCIDENTALS	PROVISIONAL SUM

Bus Stop shall be measured in number after being installed completely in position.

The bid rate for bus stop shall include full compensation for procuring, providing, loading, transporting, off-loading and installing the Bus Stops as specified. The bid rate also includes for any Excavation Trenches for foundation and Laying of foundation, Sub- structure and Super structure as per drawing and specifications including all material compensation for procuring and furnishing all the materials, storing the materials, providing all plant, mixing, transporting, placing and compacting the concrete, forming the inserts, construction of joints, curing and protecting the concrete, repairing defective surfaces, and finishing the concrete surfaces as specified. The Bid Rate shall also include reinforcement/ Wire mesh used as specified in the drawings.

The Contractor shall be entitled to payments in respect of the number of Bus Stop Shelters installed.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5900C: AXLE WEIGH-BRIDGES

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5901C SCOPE

This Section covers the construction of axle weigh-bridges in conformity with the details, dimensions, design and at locations shown on the Drawings, or as directed by the Engineer.

The Axle weighbridge may be of a portable or fixed type.

Fencing and gates shall be in accordance with SECTION 5300.

5902C MATERIALS

(a) Concrete and Structural Steel

Cement, aggregate, water, reinforcement and structural steel shall comply with the relevant requirements of SERIES 6000.

Admixtures shall not be used in the concrete mix without the approval of the Engineer who may require tests to be performed before their use. Admixtures if allowed, shall comply with the requirements of SECTION 6400.

Concrete class shall be as specified in the Drawings and shall comply with the specifications. Steel reinforcement shall be as shown on the Drawings and as specified in SECTION 6300.

Structural steel shall be as shown on the Drawings. Painting of structural steel shall be in accordance with SECTION 6900 or as directed by the Engineer.

(b) Materials for Earthworks and Pavement Layers

Materials for earthworks and pavement layers shall conform to the relevant requirements set out in SERIES 3000.

5903C CONSTRUCTION

(a) Excavation of Pits

Excavation shall be made large enough to permit construction of the base slab to the dimensions in the Drawings. Excavation shall be made in accordance with the requirements of SECTION 6100. All excavations for cattle grids and weigh-bridges shall be classified as provided in SERIES 3000.

(b) Formwork and Concrete Finish

Formwork and concrete finish shall conform to the requirements of SECTION 6200. Formed surfaces shall have a Class F2 finish in accordance with CLAUSE 6207 and unformed surfaces shall have a Class U2 finish in accordance with CLAUSE 6209.

5904C AXLE WEIGH-BRIDGES

(a) General

If specified or upon directions of the Engineer, the Contractor shall construct, equip and operate axle weighbridge stations in the number and at locations directed by the Engineer. Construction and equipment shall be in accordance with the Drawings and the provisions of this Section.

Operation of the weigh-bridges, if required, shall be in accordance with the manufacturer's instructions. These specifications are minimum requirements. The contractor shall furnish all technical drawings for the pit foundation (for pit-mounted scales) or ramps and foundation (for surface-mounted weighbridges) and scale installation, equipment data sheets, technical manuals, operation manuals, calibration chart for load cells and attach any other relevant documentation. This documentation shall include a list of authorized service, repair and spare part facilities and outlets, a statement on spare parts availability for the equipment for a minimum of 5 years after delivery, a statement on and description of emergency spare parts supply organization (fastest possible supply from abroad), a detailed description of warranty conditions. All the provided documents shall have an English version.

The Contractor shall carry out the necessary setting and levelling of the weighbridge scales and, after installation, the necessary dead-weight in-situ testing and calibration of the weighbridge scales and fully facilitate the verification and certification of the scales by an authorised National Weights and Measures body.

Where axle weighing is to be carried out during the time of construction, the construction and installation shall be in accordance with the requirements for a portable weighbridge.

(b) Fixed Axle Weigh-Bridge and Accessories

i) Layout of the Weigh-Bridge Site

The layout of the weigh-bridge site shall be in accordance with the Drawings or as directed by the Engineer. The following shall be incorporated in the layout plans:

- o Scales houses;
- o Weighbridge office building;
- o Generator house;
- o public toilet block;
- o Weighbridges and approach roads;
- o Parking area and road lights;
- o Traffic signs; and
- o Access plans.

The weighbridge layout drawings shall in general consider the following additional information:

- o The entry lanes to the weighbridge shall be adjoining the decelerating/ queuing lane;
- o The exit lane from the weighbridge should be extended by an accelerating lane;
- o The operations room should be provided such that, the operator in a sitting position can see the weighing platform and also has a 180-degree vision of trucks entering and leaving the weighing scale;
- o The Parking yard hard stand shall be of concrete finish i.e., Concrete slabs (in panels) or of paving blocks; and
- o The Parking yard should be well secured with a Steel fence.

The site shall be provided with supplies of 220 volts AC power, potable water, adequate lighting arrangements, sockets, switches, an appropriate number of air conditioning units or ceiling fans and sanitary installations as well as sewage disposed through the construction of a septic tank and soak-away pit and have the following furnishings:

- o 4 Office desk + 4 office chairs;
- o 4 guest chairs;
- o 2 tables + 6 chairs for meeting room; and
- o 2 filing cabinets.

The Contractor shall make sure that the weighbridge office is fitted with all necessary required wiring compatible with the technical drawings provided by the supplier. The contractor shall install the electronic Axle load scale and make all necessary connections and install all accessories required for the scale to

become operational.

All the equipment shall be accepted officially only after all installation and relevant performance tests are successfully completed. All tests shall be conducted in the presence of Contractor, Client and the Engineer. The purpose of the acceptance test is to see if the equipment is functioning well.

The manufacturer shall provide a maintenance program for the equipment. The program should also indicate how often the equipment should be inspected and tested and the procedure for carrying out inspection and tests.

ii) Construction of Weighbridge Foundation and Approaches

The weighbridge foundation and its approaches shall be constructed according to the Drawings or as directed by the Engineer. The Contractor's attention is

drawn to the high standards of workmanship required in all parts of the operation in order to fulfil the requirements for a stable foundation built to stringent geometric tolerances. The Contractor shall in his programme of works allow sufficient contingencies for chemical soil stabilization, adjustments of mix design for bituminous mixes and concrete as required during the course of the Works. The Contractor's attention is furthermore drawn to the specified earth conductor system to be installed below the foundations of the pit.

iii) The Decks

The platforms shall be made of steel with a surface having high resistance to wear, salt and moisture and in accordance with its Drawings or as directed by the Engineer. The general dimensions of the deck are given in TABLE 5904C/1; however, the Drawings or directions of the Engineer may deviate from these and shall govern in the case of conflicts.

TABLE 5904C/1: NOMINAL REQUIREMENTS FOR THE DECKS OF FIXED AXLE WEIGH BRIDGES

System component	Nominal requirements
Thickness of platform steel	12 mm or more is the general requirement for plate thickness. - A thinner plate may be used on approval of the Engineer provided the deck is designed with sufficient bracing to give the necessary stiffness of the structure, in accordance with the Drawings or latest guidelines from the Employer.
Anti-slip top surface	The surface of the plate shall be chequered to provide an anti-slip surface
MULTIDECK WEIGHBRIDGE	
Number of independent platforms	4
Length of each platform	Platform 1 = 3 metres Platform 2 = 6 metres Platform 3 = 7 metres Platform 4 = 6 metres
width of platforms	3 - 3.5 metres
Minimum load capacity of each platform deck	40 tonnes
AXLE GROUP WEIGHBRIDGE	
Length of platform	4 metres
width of platforms	3 - 3.5 metres
Minimum load capacity of platform deck	100 tonnes
The scale to be adjusted to	60 tonnes
SINGLE AXLE WEIGHBRIDGE	
Length of platform	0.7 metres
width of platforms	3 - 3.5 metres
Minimum load capacity of platform deck	35-40 tonnes

iv) Load Cells

- Each platform shall have a minimum of four (4) load cells.
- The Load cell shall be of a type that automatically aligns itself and keeps debris shielded from its lower end for accurate weighing.
- Each load cell shall be connected to the deck by means of a mounting bracket. The mounting bracket shall protect the load cell from thermal expansion of the platform or its deflection and any horizontal forces due to the movement of vehicles.
- The load cell shall have a minimum life span of 1,000,000 cycles.
- The body of the load cell shall be manufactured from stainless steel material, grade 304 or better, precision machined, and shall be provided with drift compensated strain gauges matched to the material in use.
- The load cell shall be designed to withstand longitudinal and lateral disturbing forces associated with the acceleration and deceleration of vehicles on the scale, without any change in the measuring result.

- Individual adjustments of each load cell shall be possible to ensure that weighing is within tolerance for mass placements.
- All load cells shall perform accurately under all types of weather conditions, e.g., being dry, wet and/or high humidity.
- Load cells shall be interchangeable.
- Each load cell shall have a capacity within the range of 25,000 kg to 50,000 kg (inclusive) with at least 150% safe overload and at least 300% ultimate overload capability without damage occurring to the load cells or other parts of the scale.
- Each load cell shall have an accuracy of 0.1%.
- The cabling between the load cells and to the controller shall be screened and armoured for added environmental and vermin/rodent protection.
- All load cells that are to be supplied shall be supplied with an A-type approval and test certificate.
- The Load cells shall be of Digital type and shall be interconnected using one cable that runs from the DWI (weighing Indicator) weaving through all Load cells with a simple network connection with no junction boxes.

- Protection of the load cells shall be of a minimum rating of IP68 and IP69k
- Lightning protection shall be able to withstand a minimum of 29 kA current.
- All cables shall be double shielded with a military type connector plug.

v) Accessories for Weigh-Bridge Equipment

Traffic lights, displays, UPS device and electric generator with automatic changeover are to be delivered installed and tested at the same time as the installation of the weighbridge. Getting an approval certificate from the Commissioner of Weights or an appropriate Authority or as directed by the Engineer shall be the responsibility of the Contractor. The Contractor's attention is furthermore drawn to the specified earth conductor system to be installed below the foundations of the pit.

TABLE 5904C/2: NOMINAL REQUIREMENTS FOR THE ACCESSORIES OF FIXED AXLE WEIGH BRIDGES

System component	Requirements
Junction boxes	Stainless steel
Traffic lights	Two sets red and green for two directions with cord-connectors and accessories
Digital remote display	One set with cord connectors and accessories
Un-interruptible Power Supply device	One set for protection of load cells, digital indicator, computer, printer and display

vi) Earth Conductor, Protection from Lightning

In order to avoid a direct hit from lightning, no radio tower or tall power pole shall be attached to the scales house. Scales, houses, the weigh-bridge and all cable equipment shall be connected to the same approved earth conductor system. The system shall consist of a steel matrix of sufficient dimensions to allow the earth-conductors from the load cells, the platform, the cords and the scale house equipment to be connected. The anchors shall be made of approved steel reinforcement grids installed below the foundations of the entire weigh- bridge pit and houses as described on the Drawings or as directed by the Engineer. The Contractor's attention is drawn to the necessity for accurate electric installations by competent personnel according to approved plans for the earth protection system. In addition to these measures, an approved UPS device shall be installed to ensure continued weigh-bridge and computer operation in the case of power failure.

vii) Type of Scale and Performance

The scale shall be of an electronic type that utilises load cells giving digital output signals of a manufacturer approved by the Engineer. The load cell shall be made of stainless steel, have plug connections, and be hermetically sealed against water and dust in accordance with the standards of NEMA 6P/IP68. The minimum number of load-cells for each platform shall be four, one load-cell in each corner. The cells shall be installed with protection against lightning and voltage surges. The design shall be such that replacement of load cells is possible without physical calibration of the scales. The scale shall meet the requirements given in TABLE 5904C/3.

TABLE 5904C/3: REQUIRED PERFORMANCE OF FIXED AXLE WEIGH BRIDGE SCALES

System properties	Requirements
Minimum number of Load Cells for each Platform	4 Nos.
Load capacity for each load cell	25 tonnes
Temperature range for operation:	Between -10°C and +60°C
Accuracy:	Complying with EN 45501 (OILM R 76) of EU
Safe overload:	150%

viii) Type of Data System and Performance

The data system shall be of an approved industrial type capable of displaying data, transferring data for storage purposes and making printouts. The reading of the scales shall be electronic, and the data system shall have a computer for storage and data processing. The system shall be able to read axle loads, or any axle configuration within triple axle combinations or tandem axles, up to a magnitude of 2.5 times the legal limit for each axle as well as for the combination. The system should also be able to calculate gross vehicle mass from the sum of weighed single axles, tandem axles, triple axles or other multi - axle combinations. The data system shall consist of a digital weight indicator, a remote display and a computer with weighing software.

(c) Digital Weight Indicator (DWI)

The DWI shall read data from the electronic load cells and shall have the following specifications:

- Power supply rated 220VAC – 240VAC 50/60 Hz
- The DWI shall have diagnostic capabilities to help in troubleshooting errors that could occur with the load cells. Error codes and descriptions shall be used to identify the defective element and the cause of the defect
- The DWI shall have the capability of displaying the measured values in either kilograms or tonnes according to selection.
- The DWI must be able to display the weight from individual load cells, decks and the total vehicle weight as a sum of weights from the individual decks. Each deck and each load cell shall be clearly identified from the DWI.
- The DWI must have the prerequisite components required for communication to a computer for data capture, data storage, reporting and ticket printing by 3rd party software applications (READ-ACCESS TO THE DATA SHALL NOT BE LIMITED TO THE SCALE SUPPLIER). For this purpose, the DWI shall have various open industrial communication protocols including Ethernet/IP, Modbus TCP, and RS-232/422/485 (300 to 115,200 baud).
- The supplier shall supply all the technical documentation indicating the addresses/ registers of the indicator for communication purposes between the 3rd party Software and the Weighbridge.
- The DWI shall have the Keys for common scale functions of Zero, Tare and Print; navigation keys (Up, Down, Left, Right); Numeric Keys (0 – 9, decimal point) and a Graphical LCD display, data storage (hard disk), protection (IP67 protection), program (ROM storage with easy alteration).
- A lightning protection system must be supplied and installed to protect the DWI.
- The DWI shall have a scale calibration feature for use with test weights. This feature shall NOT be limited to the supplier or his agent.

- The Contractor shall seek type approval of the DWI prior to shipping from the Weights and Measures Authority.
- The DWI MUST have a physical metrological switch and a provision for sealing by the Weights and Measures authority in order to ensure that calibration cannot be done without permission from the Authority.
- The DWI must have the ability to store a minimum of 5,000 transactional records.
- The DWI must have a minimum display resolution of 1,000,000 divisions.
- The DWI must have at least 3 user classes (administrator, manager, and user) that are password protected and accessible by the Roads Authority.
- The DWI must be OIML R-76 certified (Accuracy Class C3 minimum) or NTEP certified (Accuracy Class III L minimum)

(d) Remote Displays and Traffic Lights

Supply and install one Remote display of LED type DCA (0–9) characters for each platform. For multi-deck weighbridges, an additional remote display for the gross weight shall be supplied. Each display shall be protected against sunlight and rainwater damage. Both Remote displays and the traffic Light can be mounted on one mast which should be erected not less than 25 m from the centre-line of the weighbridge platform for clear visibility by the drivers.

The data system shall be equipped to control traffic lights at the weigh-bridge site and remote displays as required.

(e) Weighing Software

The computer software program should talk to DWI by picking axle load weights, calculating axle overload weights as well as GVM overloads, and finally calculating the fees for individual axle, group of axles and total GVM fees in Uganda Shillings. When the vehicle is overloaded, both with respect to axle load and gross vehicle mass limits the software should be able to pick the relevant fees in accordance with the regulations.

The allowed GVM limit is as given in the relevant axle load control regulations.

The software shall have a report module as approved by the Engineer, in which data items can be sorted/ queried column and row-wise, exported to MS Excel or MS Word for further processing.

The software must allow for flexible design of ticket printouts with logos, date and time, and all the captured weight data.

The software must support printouts of reports in a customizable format. The required format will be given to the contractor during project implementation.

The equipment shall be able to handle the following minimum data for printouts:

- Name of weighbridge station;
- Date;
- Time;
- Sequential ticket number;
- Axle configuration (manual entry);
- Legal axle load and gross vehicle mass as given in the relevant axle load regulations;
- Actual axle loads, tandem-loads, triple loads and loads of other multi-axle combinations;
- Adjusted axle load limits (inclusive of any tolerance in accordance with relevant axle load regulations);
- Actual gross vehicle mass;
- Overload weights (for axle, group of axles and for gross vehicle mass);

- Name of scales-operator (manual entry);
- Registration number of vehicle (manual entry);
- Trip origin;
- Destination;
- Type of load; and
- Automatically calculate the overloading fees in compliance with relevant axle load regulations.

The system must support multiple user accounts with configurable secure access rights with management of various user groups (administrator, manager, and user). All access rights must be handed over to the Engineer.

Searching of the recorded information in the database should be made possible using the following fields: Vehicle Axle Configuration, Vehicle number, Date, Ticket number, Destination/origin of the vehicle, Operator's name, Vehicle owner's name and Haulier

The weighbridge axle software must have a backup tool to facilitate daily back-up of transactions from the weighbridge operations.

(f) Portable Axle Weighbridge and Accessories

i) Layout of the Construction Site and Approaches

The layout of the weigh-bridge site shall be in accordance with the Drawings or as directed by the Engineer. It is recommended that concrete pavements should be used due to the sensitivity of portable weigh bridges with regard to surface deformation.

ii) The Platform

The weighing platforms shall be waterproof and made of aluminium alloy or as specified by the Engineer and shall have a very high resistance to bending. They shall be easy to handle and be from a manufacturer approved by the Engineer. One weigh- bridge set shall consist of two electronic wheel-load platforms complying with the requirements given in the following.

[1] Dimensions and Weight

The dimensions of the platform shall conform to the following approximate requirements in accordance with the Drawings or as directed by the Engineer:

- The overall dimensions should be at least (L*W*H) 800 mm*350 mm*10 mm
- Weight of each pad: less than 35 kg

[2] Active Surface

The active surface is the area where the wheel is allowed to activate the wheel load scales and its dimensions shall conform to the following approximate:

- Length: approximately 700 mm
- Width: approximately 300 mm

[3] Capacity and Accuracy

The capacity and accuracy of each platform unit shall be as given in TABLE 5904C/4.

TABLE 5904C/4: CAPACITY AND ACCURACY OF PORTABLE AXLE WEIGH BRIDGE UNITS

System properties	Requirements
Capacity on each wheel pad:	15 tonnes
Axle load:	30 tonnes
Maximum Division:	50 kg
Accuracy:	OILM NR 76 Class 4 or better
Acceptance tolerance:	Dynamic: +/- 3% GVW, 95% confidence at <5km/h with levelling track; +/- 5% GVW, 95% confidence at <15km/h with levelling track. Static: ≤0.5% Full Scale
Operating temperature:	-30°C to +40°C

iii) The Processing Unit

The processing unit shall be remote from the scale platforms, but connected to them and shall meet the requirements given in TABLE 5904C/5.

TABLE 5904C/5: REQUIREMENTS FOR THE PROCESSING UNITS

System properties	Requirements
Power supply, AC:	220 to 240 Volts
Power supply, DC:	10.8 to 16 Volts
Data transfer:	RS232 (cable) and Bluetooth (wireless)
Display:	LCD-dot-matrix or screen display. -30°C to +40°C
Temperature range	
Keyboard:	Membrane touch or keyboard
Permissible humidity:	Up to 80%
Weight:	Up to 20 kg.

iv) Printer and the Protocol for Ticket Print-Out

The system for taking printouts shall be included and capable of making printouts in accordance with the following requirements:

- Paper width: 76 mm
 - Characters per line: 28 characters
- Information to be printed:

- Name of roads authority;
- Site;
- Date and time;
- Sequential ticket number;
- Weight limits;
- Wheel-load;
- Axle-load;
- Gross vehicle mass (GVM);
- Overload;
- Vehicle registration number;
- Vehicle make;
- Driver's license number;
- Driver's name;
- Drivers' signature; and
- Name of scales operator.

v) Operation

All portable weighbridges shall be operated in accordance with the manufacturer's guidelines including those for the use of all necessary accessories and equipment such as mats for approaching the platforms, levelling equipment, etc.

All the equipment will be accepted officially only after all installation and relevant performance tests are successfully completed. All tests will be conducted in the presence of the Contractor, client and the Engineer.

- Two years of warranty from the date of delivery is to be included in the contract, unless specified differently in the contract.
- Contractor shall ensure that the manufacturer provides a maintenance program for the equipment. The program should also indicate how often the equipment should be inspected and tested and the procedure for carrying out inspection and tests.
- The Contractor shall ensure that the manufacturer provides a training program.

vi) Stand-By Generator Set

Due to expected grid-power fluctuations and power cuts, a standby generator shall be provided by the Contractor. The generator should have the minimum specification as given in TABLE 5904C/6 below;

TABLE 5904C/6: STANDBY GENERATOR SET

Minimum capacity	20 kVA
Voltage	Three phase: 380 v – 415 v, 50 HZ; and Single phase: 220 – 240 v AC
Diesel engine type	Weatherproof enclosure for low noise, running at 1,500 RPM
Change-over	Automatic change-over

(g) Solar & Inverter System

For sites where there is no power, the contractor shall install the inverter system with a minimum capacity of 8 KVA complete with solar (panels) for charging the inverter system as specified by the Engineer.

(h) High Speed Weigh-In-Motion (HSWIM)

Facilities in the HSWIM system include weight scale devices (sensors and loop coils), image camera units, an automatic license plate recognition system, warning message display units, traffic control units and their supporting devices.

The HSWIM system shall serve for the initial screening of vehicles for axle load control where the managing entity of the system shall;

- Measure the axle load without enforcing them to stop at the scale position and identify suspected overloaded vehicles which are subjected to weighing statically at the weighing station.
- Safely guide the suspected vehicles to the static weighbridge at the weighing station without interruption of the traffic flow of other vehicles and with minimum human intervention.
- Ensure that the suspected vehicles are intercepted in the case a vehicle transgresses or ignores the guidance of the system.
- Collection of correct traffic census data.

At the HSWIM section, all vehicles required to use the weighbridge (in accordance with the relevant axle load regulations) have to pass through HSWIM installed in the highway or in dedicated screening lanes. Also loop coils on the measurement section should collect census data automatically.

- The loop coils trigger the camera for image capturing and automatic number plate recognition (ANPR) and recording.
- When the sensor of HSWIM identifies the suspected vehicle with overweighted axle load beyond the permissible limit, roadside warning rotating/flushing lights and overhead warning message board are activated notifying to the driver that their vehicle may be overloaded, is subject to reweighing and should prepare for the diversion to the static weighing station.

- Suspected overloaded vehicles are also guided by multiple static signboards installed on roadside after the warning message board.
- The overhead changeable message signboard installed between the warning signboard and diversion point to the static weighing station, notifies the drivers of the suspected vehicle's registration number. This reinforces the vehicles' diversion to the static weighing station.
- The static overhead signboards on the 2-lane section just before the diversion point shall show the type of lanes. Small vehicles and legally loaded large vehicles can use the right designated passing lane. The left lane leads the suspected vehicles to the static weighing station for reweighing.
- Legally loaded vehicles are led through the main lanes through the changeable signboard as it displays green "Proceed arrow and Vehicle Number Plate" message when they are approaching. In order to identify the right vehicle, ANPR device with coils for camera triggering is installed with a certain distance between the camera and the variable message display board.
- If overloaded vehicle tries to use the passing lane to avoid the static weighing, the changeable signboard shows red "Entry Arrow and Vehicle Number Plate" message so that the vehicle is forcibly diverted to the static weighing station.
- For the auxiliary measure, the monitoring device showing the axle load and license number data is installed inside the equipment housing located at the diversion point so that the management entity can refer the data for manual traffic control.
- The suspected vehicles guided to the static weighing station are weighed on the multi-deck scale where the operator shall check the license number given by the ANPR camera system.
- Overloaded vehicles identified by the multi-deck scale are guided to the holding yard for impounding, prosecution, unloading, and load redistribution. They are released after the reweighing at the same multi-deck scale and guided back to the main lanes via access road.
- The design speed of large vehicles for the allocation is 50 km/hr.
- The message signboard shall be basically installed on the gantry so that drivers can read the message clearly facing the front.

- Enough intervals between each device should be maintained so that any vehicle can safely change the lane for diversion or passing without hindering other traffic.
- Equipment housing located at the diversion point should have enough space for monitoring device and as station office for management staff.

Each weighbridge system is comprised of the units in TABLE 5904C/7;

TABLE 5904C/7: HSWIM UNITS

Device Unit	Function
HSWIM Processing Unit	Measuring axle load of the running vehicles and collecting both weight and census data
Multi-deck Scale Processing Unit	Statically measuring axle load, collecting weight data and automatic ticket issuance
ANPR Camera Unit	Capturing the image of number plate and processing it into license number data
Vehicle Imaging Unit	Capturing the whole image of the vehicle
Warning Message Display Unit (WMDU) #1	Rotating/flushing lights installed on the roadside and overhead message board for warning and notifying the driver of a suspected overloaded vehicle
Violation detection unit	Detecting vehicles that bypass the weighbridge or HSWIM screening lane
Monitoring Unit	Display the weighing and license number data
Database Unit	Servers for assembling and storing data
Data Network Unit	Transmitting data to the managing entity / adjacent weighbridges

(i) HSWIM Processing Unit

HSWIM Processing Unit measures weight of each axle load and total axle load of running vehicle which are transmitted to Traffic Control Boom Unit and Database Unit tagged with the vehicle's license plate information from ANPR Camera unit and whole vehicle photo from Vehicle Imaging Unit.

TABLE 5904C/8: HSWIM PROCESSING UNIT

Device	Function	Other Requirements
Piezoelectric Sensor or Quartz crystal sensor	Output an electric signal according to an axle load	• Measurable ranges shall be in the following; ○ Gross Vehicle Weight: 10.0 - 180.0 ton (0.1-ton unit) ○ Single Axle Load: 1.0 - 20.0 ton (0.1-ton unit) ○ Furthest Axle Interval: 3.0 - 20.0m (0.1m unit) ○ Axle Number: 2 - 7 axles ○ Vehicle Speed: 10 - 80km/hr. • Measurement accuracy range shall be within $\pm 20\%$ for single axle load, within $\pm 10\%$ for total axle load and within $\pm 0.2\text{m}$ for axle interval for 95% of dynamically measured vehicles
Loop Coil	Detect the ingress and egress of the vehicle in the sensor section	• It can distinguish the vehicles when they are more than 2.4 m apart. • Its wire disconnection can be detected automatically.
HSWIM Data Processing Device	Calculate single axle loads and total axle load by converting sensor data	• It shall convert the sensor data into single axle load, total axle load, axle interval and speed. • Overloading shall be identified by matching the weight data with legal axle load thresholds of each vehicle type. • It shall tag the license number and license plate image data from ANPR Camera Unit with axle load data. • It shall send a command signal to the Vehicle Imaging Unit to take a photo of the approaching vehicle. • The interface shall be Ethernet.

The number of these devices shall be decided as per the project requirement.

(j) Multi-deck Scale Processing Unit

This unit shall comprise of the devices in TABLE 5904C/9.

TABLE 5904C/9: MINIMUM REQUIREMENTS FOR MULTI-DECK SCALE PROCESSING UNIT

Device	Minimum Requirements
Basic Weighbridge Deck	- The weighbridge deck should be multi deck, extra heavy duty - Should be able to handle 57 T load at any single point - The minimum thickness of the top plate should be 12mm. - The deck plates should be bolted using 16mm CSK fasteners. - The structure should be mostly bolted; welding should be limited. - The finish should be hot dip galvanizing with no tie rods permitted. - The deck truck driving area should be protected by guardrails
Load Cells	- The load cells should have a capacity of 30T per load cell. In addition, - Other details shall be decided as per project requirement:
Indicator	- IP65 Stainless Steel Protection - Variable message display system - The indicator should display the weights of each deck and total weight. - Gross weight, allowable gross weight and excess gross weight - Has a storage capacity of at least 5,000 vehicles. - Has a window-based software capable of downloading and uploading data from Laptop computers including its own software update. - Must be waterproof and dust proof.

(k) ANPR Camera Unit

ANPR Camera Unit shall capture the image of the license plate of the vehicle passing through the sensor section and recognize its license number by image processing. The unit shall comprise of the devices in TABLE 5904C/10.

TABLE 5904C/10: MINIMUM REQUIREMENTS FOR ANPR CAMERA UNIT

Device	Minimum Requirements
Close Circuit Digital (CCD) Camera	- It shall capture monochrome images. - Near infrared LED lighting shall be attached for night photo-taking. - It shall be fitted with an outdoor installation and have enough weather-proof function. - Image is captured from the upper front direction and installation height from ground level between 5.5m and 6.5m. - It shall be installed firmly on a camera platform which is fixed on the ground to prevent vandalism. - The image data shall be in JPEG format and one image for one vehicle. - The speed of the target vehicle shall be less than 80 km/hr. - The vehicle shall keep the lane to maintain the right photo position and a physical lane divider shall be attached for this purpose. - Its power consumption is less than 150 VA. - The camera shall be an IP Camera, and the interface shall be Ethernet
License Number Image Data Processing (LNIDP) Device	- Should process at least 8-digit characters with a combination of Roman numbers and alphabet. - It shall have a function to provide electricity to CCD cameras - It shall finish the license number recognition and data transmission to the upper units in less than 0.5 seconds after image capturing. - It shall be installed inside the equipment housing. - Input and output interface shall be Ethernet - It shall connect up to the two (2) cameras. - Electricity shall be supplied from the device stowing rack. - Its power consumption is less than 60VA

Number of these devices and their respective specifications shall be decided as per the project requirement.

(l) Vehicle Imaging Unit

Vehicle Imaging Unit shall capture the whole image of vehicle passing through the sensor section. The unit shall comprise of the devices in TABLE 5904C/11.

TABLE 5904C/11: MINIMUM REQUIREMENTS FOR VEHICLE IMAGING UNIT

Device	Minimum Requirements
Close Circuit Digital (CCD) Camera	- It can capture coloured images at daytime and mono-chrome images at night-time. - It shall be fitted with the outdoor installation and have enough weather-proof function. - It shall capture the image from the upper front direction and be installed in the appropriate position so that the whole image of vehicle with up to 22 m in length shall be in one frame. - It shall be installed firmly on a camera platform which is fixed on the ground to prevent vandalism. - The image data shall be in JPEG format and one image for one vehicle. - The speed of the target vehicle shall be less than 80km/hr. - The vehicle shall keep the lane to maintain the right photo position and a physical lane divider shall be attached for this purpose. - Its power consumption is less than 150 VA - The electricity shall be supplied from the Vehicle Image Data Processing Device.
Vehicle Image Data Processing Device	- It shall finish the data transmission to the upper units in less than 0.5 seconds after image capturing. - It shall have a function to provide electricity to CCD cameras - It shall be installed inside the equipment housing. - The interface shall be Ethernet - It shall connect up to the two (2) cameras. - Its power consumption is less than 60 VA.

The number of these devices and their respective specifications shall be decided as per the project requirement.

(m) Warning Message Display Unit (WMDU)

WMDU shall activate the warning rotating/ flushing light and changeable signboard with the command signal from HSWIM Data Processing Device. The unit shall comprise of the devices in TABLE 5904C/12.

TABLE 5904C/12: MINIMUM REQUIREMENTS FOR WMDU

Device	Minimum Requirements
Warning Light	- It shall be red rotating and flushing light. - It shall be operated with ON/OFF command only. - The light is situated about 1.5 m above the ground level so that the drivers can notice it clearly. - The light is LED type and shall be fitted with outdoor installation with enough weather-proof function. - Its power consumption is less than 50 VA.
Warning Changeable Signboard	- The message shall be fixed to "Divert to Weighbridge" and operated with ON/OFF command only. - It shall have brightness sensors for brightness adjustment conducted at the Control Console. - It shall be fitted with an outdoor installation with enough weather-proof function. - Display panel shall be mono-colour LED type, and the character colour shall be red. - Message shall be displayed on two lines, "Divert To" on the upper line and "Weighbridge" on the lower line. - Size of each character is 450mm in height and 225 mm in width. - Maximum number of characters for each line is twelve (12). - Its power consumption shall be less than 1800 VA
Control Console	- It shall choose between rotation and flushing operations. - It shall adjust the brightness of Warning Changeable Signboard by choosing automatic, daytime, and night-time settings. - It shall be attached to the side of gantry column. - It shall be fitted with an outdoor installation with enough weather-proof function. - Its control panel has enough space for display and switch functions of Warning Lights and Warning Changeable Signboards. - It can store at least four (4) different message patterns in case of display change from the standard message. - The interface with the upper device shall be Ethernet - Its power consumption shall be less than 200 VA. - It shall have a locking function.

The number of these devices and their respective specifications shall be decided as per the project requirement.

(n) Violation Detection Unit

A violation detection system shall be supplied and installed alongside the HSWIM screening system to detect the vehicles that bypass the HSWIM screening lane and those which bypass the fixed weigh station. For vehicles heading to the fixed weigh station, the violation detection system shall detect vehicles that should have used the screening lane but didn't; for vehicles leaving the weigh station, the violation detection system shall detect vehicles that should have reported to the fixed weigh station but didn't. The unit shall comprise of the devices in TABLE 5904C/13.

TABLE 5904C/13: MINIMUM REQUIREMENTS FOR VIOLATION DETECTION UNIT

Device	Minimum Requirements
ANPR Cameras	- The violation detection system shall have 2 ANPR cameras. One shall be installed to face traffic in one direction and the other one in the other direction. - The ANPR cameras shall be of the same type as those installed in the HSWIM lane.
Loop coil	- The violation detection system shall consist of 4 traffic loops, two in each traffic direction. - The loops shall be installed in such a way as to trigger the ANPR cameras for violating vehicles. - The vehicle registration numbers for detected vehicles shall be sent to the monitoring unit for reconciliation.

The number of these devices and their respective specifications shall be decided as per the project requirement.

(o) Monitoring Unit

Monitoring Unit shall display data on vehicles (axle load and image) passing through HSWIM section chronologically in a real-time basis. Also, it shall check the device status, and modify the legal axle load thresholds.

TABLE 5903C/14: MINIMUM REQUIREMENTS FOR MONITORING UNIT

Device	Minimum Requirements
Monitoring PC	Monitoring PC - It shall be a versatile desktop type - Its monitor size shall be 23-inch liquid crystal type. - The interface with the Data Processing Unit shall be Ethernet - The printer cable type shall be USB. - Its power consumption shall be less than 250 VA. Printer - The interface shall be USB type. - Its power consumption is less than 100 VA.

The number of these devices and their respective specifications shall be decided as per the project requirement.

(p) Database Unit

It shall receive and store the data from HSWIM Data Processing Device.

TABLE 5903C/15: MINIMUM REQUIREMENTS FOR DATABASE UNIT

Device	Minimum Requirements
Database Server	- It can transmit the stored data of a designated period by the command from the Monitoring Unit. - It shall count and store the number of traffic control boom movements. - It shall count and store the traffic number by vehicle type, number of axle and other classifications approved by the Engineer. - The interface shall be Ethernet - Its power consumption is less than 1500 VA. - It shall have a time adjustment function. Adjusted time data shall be transmitted to both HSWIM Processing Unit.

(q) Data Network Unit

It shall be networking devices connecting each unit. The unit shall comprise of the following devices.

TABLE 5903C/16: MINIMUM REQUIREMENTS FOR DATA NETWORK UNIT

Device	Minimum Requirements
L2 Switch	- It shall be compliant with IEEE802. - The communication interface shall be Ethernet - The transmission speed shall be 10/100/1000Mbps. - It shall be installed in the Administrative Office in the Static Weighing Station and field equipment housings.
Optical Media Converter	- The communication interface shall be Ethernet. - It shall be installed in the Administrative Office in the Static Weighing Station and field equipment housings

(r) Monitoring System

A surveillance camera system shall be provided for monitoring the state of area where HSWIM system, Static Weighing Station are established. The footage shall be transmitted to the weigh station operations office and the administrative office, which may be remotely located.

(s) Orders

Before placing any order for purchase of the weigh-bridge equipment and apparatus, the Contractor shall submit for the approval of the Engineer his programme of Works and Drawings showing all construction details, weigh-bridge fittings, running of connecting cables, etc. for the axle weigh-bridge station.

5905C MEASUREMENT AND PAYMENT

ITEM	UNIT
59.01C INSTALLATION OF WEIGH BRIDGE STATION(S)	
(a) FULLY FURNISHED BUILDINGS	Lump Sum
(b) FIXED WEIGH BRIDGE	Lump Sum
(c) PORTABLE WEIGH BRIDGE	Lump Sum
(d) HIGH SPEED WEIGH-IN-MOTION	Lump Sum

This rate shall be full compensation for providing and installing the weigh-bridge including all equipment, apparatus, excavation, concrete and frames for pits,

bearing plates, junction boxes, precision load cells, cables, readout units, electrical system in accordance with the Specifications, control panel and computerised terminal, preparation of detailed construction drawings, setting and levelling of weigh pads and platforms, in-situ testing and calibration and any other work and incidentals necessary to complete the work in accordance with the Specifications and the instructions of the Engineer.

Pavement works, parking and landscaping shall be made as under the relevant SERIES 2000, 3000, 4000, AND 5000.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5900D: TOLL PLAZA

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5901D SCOPE

The section covers the construction of toll plazas including toll plaza buildings, toll lanes/ canopies, vehicle stacking and approach areas. It includes the supply and installation of relevant equipment at location specified in the Contract or as directed by the Engineer. The section also includes:

- The Civil and Structural Works including but not limited to pavement, toll islands, canopies, tunnels, foundations, manholes, plaza buildings, tollbooths with necessary internal utilities, drainage system, pavement markings, traffic signs, water supply, fire-fighting system etc. of Toll Plaza.
- Supply and installation of electrical instruments at Toll Plaza area comprising lighting, uninterrupted power supply (UPS), generators and lightning protection etc.
- Supply and installation of toll collection system.

5902D MATERIALS

(a) Concrete and Structural Steel Works

Cement, aggregate, water, reinforcement and structural steel shall comply with the requirements of SERIES 6000.

Concrete class as indicated in the drawing shall comply with the requirements of SECTION 6400.

Painting of structural steel shall be in accordance with SECTION 6900.

(b) Earthworks and Pavement Layers

Materials for earthworks and pavement layers shall conform to the relevant requirements of SERIES 3000.

(c) Ancillary Works

Materials for ancillary works (pavement marking, traffic signs, guardrails, and lighting etc.) shall conform to the requirements under SERIES 5000 of this General Specifications.

5903D CONSTRUCTION

(a) Road and Civil Structural Works

i) Pavement

Concrete or Asphalt pavement shall be provided in the toll plaza area including the tapering zone as per approved drawings or as directed by the Engineer. The use of pavers is not permitted for the construction of rigid pavement.

ii) Transition

The transition area, merging the toll plaza with the general road cross section in its approaches, shall be as per the approved drawings.

iii) Toll Lane

The Width of the toll lanes shall be a minimum of 3.2 m for manual toll collection and 3.5 m for electronic toll collection or as per approved drawings. One wider lane shall be provided in each direction for oversize vehicles. The width of such wider lane shall be a minimum of 4.5m or as indicated in the drawing.

The equipment for the toll lanes required for the toll

collection system shall comprise the following:

- Automatic Vehicle Counter cum Classifier;
- Automatic Boom Barrier;
- Contactless Smart Card Systems;
- Ticket Printer;
- User Fare Display Unit;
- Closed Circuit Television System (CCTV);
- Lane Controller;
- Traffic Light System;
- Intercom System;
- Overhead Lane Signs; and
- Integrated Toll Management Software.

All equipment shall have built-in or external surge protection systems.

iv) Traffic Islands at the Toll Plaza

Between each toll lane of the toll plaza, traffic islands shall be provided to accommodate toll booth. These traffic islands shall be a minimum of 25 m length and 1.8 m wide or as per the approved drawings. Protective barriers of reinforced concrete and traffic impact attenuators shall be placed at the front of each island to prevent out-of-control approaching vehicles from crashing into the toll booth and shall be painted with reflective chevron markings as per the approved drawings. The toll lanes shall be equipped with an automatic vehicle classification system capable of automatically identifying the vehicles as per the classes prescribed in the ROADS ACT CAP. 350.

v) Toll Booths

Toll booths shall be of prefabricated materials or of masonry as per the approved Drawing or as directed by the Engineer. The Toll booth shall have adequate space for seating of the toll collector, computer, printer, cash box telephone etc. It shall have provisions for light, fan and air conditioning and have large glass windows to provide the toll collector with good visibility of approaching vehicles. There shall be CCTV cameras installed at each booth.

vi) Personnel Walkway and Island Stairs

A walkway from the toll islands to the plaza building shall be provided which shall either be overhead or underground. The walkway shall have a minimum width of 3 m and a minimum height of 2.5 m or as indicated in the approved drawings or as directed by Engineer. The walkway shall also be adequately lit and with provisions for lighting on standby power. The walkway should also have adequate ventilation and air conditioning installed. The walkway shall be connected to the toll islands by stairs which may be steel or concrete.

vii) Canopy

All the toll lanes and toll booths shall be covered with a canopy, built in accordance with the approved drawings or as directed by the Engineer. The canopy shall be wide enough to provide weather protection to toll operators, drivers and facilities. The canopy shall have support columns located at traffic islands, so that there is no restriction on visibility and traffic movement. The vertical clearance shall be as per approved drawings.

viii) Drainage

The toll plaza area shall be provided with surface and sub-surface drainage systems conforming to the requirements of SERIES 2000, built as per approved drawings, such that all the storm water is drained off efficiently and no ponding or stagnation of water takes place at any area of the toll plaza. To prevent pollution, all storm water from the toll lanes should be routed through an oil trap before discharge into surrounding water bodies. The trapped oil should be handled as per the provisions of SERIES 1000.

ix) Road Markings

The road markings shall be provided conforming to the requirements of SECTION 5500 and shall be as per

the approved drawings or as directed by the Engineer.

x) Traffic Signs

As per the approved drawings or as directed by the Engineer, traffic signs shall complement the road markings in and around the toll plaza. Such signs shall be in conformity with the requirements of SECTION 5400, and shall be provided to guide and render assistance to the drivers approaching the toll plaza.

xi) Water Supply

Adequate water supply shall be provided at the Toll Plaza for firefighting and wash operations.

xii) Fire Fighting System

The Toll Plaza shall have fire-fighting equipment, including smoke detectors and an auto visual alarm so that the personnel working in the complex and the office and the road users are protected against fire hazards.

xiii) Prevention of Overloading

Toll plaza location shall also be provided with a system for checking and preventing overloading of vehicles at the toll plaza. WIM should be installed at least 500m ahead of the toll plaza to screen heavy vehicles and divert all those flagged as exceeding the axle limits to a static weighbridge or a temporary holding yard provided at the toll plaza building.

(b) Toll Plaza Building and Office-Complex Building Works

Each toll plaza shall have a toll plaza building for housing the tolling equipment at the closest possible location to the toll plaza. All electrical service and communication cabling from the toll plaza up to and into the equipment building and toll lanes shall be provided as per the approved drawings or as directed by the Engineer. The buildings shall include the following minimum facilities:

- Monitoring/ control centre;
- Cash handling provisions including Points of Sale (POS), associated equipment and vault/ drop-in safe;
- Equipment room;
- Toilets linked to a public sewer system or onsite treatment facility by way of septic tanks or in accordance with the requirements of Series 1000;
- Power supply involving grid connections and/or solar panels and batteries and/or standby generator sufficient for plaza operations and for roof lighting as well as for approach lighting;
- Meeting room;
- Parking area;
- Equipment store; and
- Server rooms

The Toll Plaza shall also have a separate office building to provide comfortable office space for managers, cashiers and other staff. There shall be separate rooms for TV monitors, and for the sale of passes, smart cards, on board units and public interaction etc. in accordance with the approved drawings. The building shall have a strong room for keeping the cash and a garage to accommodate the security van (during the operation of loading the collected revenue). There shall be a parking space, in the same campus, for vehicles of the staff and workers and also for other vehicles engaged in the operation of the toll road. The size of the office complex depends on the minimum requirement of the above facilities, and shall be as per the approved drawings or as specified in the Contract.

The plaza building and surrounding holding areas shall be equipped with CCTV cameras that are linked to the control centre. In addition, the plaza building, POS and lane area should be fully networked (for data, video and voice) to enable them to be managed as a single system.

(c) Lighting around the Toll Plaza Location

The toll plaza shall have lighting system to provide visibility to drivers, especially for the road-users to access the correct service lane and also to the toll collector. These shall be in accordance with the approved drawings and shall comply with the requirements of SECTION 5800. This shall consist of interior and exterior lighting as indicated below. Power supply shall be from public power supply system. However, a standby generator set of the capacity to supply the required power sufficiently shall be provided at the toll plaza.

i) Interior Lighting

These are for interior of the toll booths and facility building office, and shall be so provided that these facilities are illuminated adequately. Lighting should be provided in such a manner that glare is avoided or minimized. The level of illumination shall comply with the requirements.

ii) Exterior Lighting

All exterior lighting shall meet the following provisions. The minimum colour rendering index of the lamps shall be 70 and the colour shall be a maximum of 4000K. The recommended maximum glare shall be UGR 19 and the Mean Time Before Failure for the lamps shall be 5000hours. The exterior lighting system shall consist of the following major components:

[1] High mast Lighting:

A high mast of height 30 m or as specified in the drawings or as directed by the Engineer, suitable to have uniform spread and desired level of illumination in the toll plaza area for safe movement of vehicles a minimum requirement of average illumination on the road surface of 40 lux shall be ensured.

[2] Approach Highway Lighting:

A minimum requirement of average illumination on the road surface of 40 lux shall be ensured through lighting over a minimum 500 m length on both approaches of toll plaza (toll booth). There should be provisions for flashing signals for foggy weather conditions.

[3] Canopy Lighting:

A higher level of illumination up to an average of 100 lux by providing LED technology lamps shall be provided at the toll gate and at toll booth locations. LED technology lamps shall be provided at the selected nodes of space frame of the canopy to ensure uniform illumination of the area at a minimum of 100 lux. The minimum colour rendering index of the lamps shall be 70 and the colour shall be a maximum of 4000K. The recommended maximum glare is UGR 19. The Mean Time Before Failure for the lamps shall be 5000 hours.

5904D TOLL COLLECTION SYSTEM

There are three methods of toll collection available. These are: Manual, Automatic, and Electronic.

(a) Manual Toll Collection

Manual toll collection is the most widely used collection method. It requires a toll collector or attendant. Based on the vehicle classification, toll in the form of cash is received by the collector. The collector, who also dispenses change, may accept and sell tickets, coupons, make an entry of the vehicle in the system and issue a receipt to the patron. Due to manual intervention, the processing time is highest. This toll collection method is suitable where the expected throughput is ≤ 300 vehicles per hour. Where higher throughput is expected, it is recommended that this option is only considered together with the other toll collection options below.

In view of the risks associated with handling of cash transactions, consideration should be made to adopt only

automatic and electronic toll collection highlighted below.

(b) Automatic Toll Collection

Automatic toll collection is based on the use of an Automated Coin Machine (ACM). These accept both coins and tokens issued by the operating agency. Depending on the toll rate, the use of automated coin or token collection instead of manual collection reduces transaction and processing time as well as the operating cost.

(c) Electronic Toll Collection

Electronic Toll Collection (ETC) is a system that automatically identifies a vehicle equipped with a valid encoded data tag or transponder as it moves through a toll lane or checkpoint using technologies such as Radial Frequency Identification (RFID) or Automatic Number Plate Recognition (ANPR). The ETC system then posts a debit or charge to a patron's account, without the patron having to stop to pay the toll. ETC increases the lane throughput because vehicles need not stop to pay the toll.

Type of collection system shall be finalised as per the project requirement and the specification shall be included under Special Specifications as per latest available technology.

5905D MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
59.01D	TOLL PLAZA	
(a)	BUILDING, PARKING AREAS AND FENCING	Lump Sum
(b)	TOLL LANES, TOLL CANOPY, TOLL BOOTH AND ASSOCIATED EQUIPMENT	Lump Sum
(c)	INSTALLATION AND COMMISSIONING OF TOLL COLLECTION SYSTEM INCLUDING AN AUTOMATIC VEHICLE CLASSIFIER	Lump Sum
(d)	INSTALLATION AND COMMISSIONING OF OVERLOAD CONTROL SYSTEM INCLUDING HIGH SPEED WAY IN MOTION, STATIC WEIGHBRIDGE AND MONITORING SYSTEM	Lump Sum
(e)	SUPPLY AND INSTALLATION OF A STANDBY GENERATOR	Lump Sum

The bid lump sum shall include full compensation for the installation and commissioning of the toll collection system on the site.

The bid Rate for Civil Works shall include all requirements necessary to carry out earthworks and pavement layers compliant with the requirements of SERIES 3000, SERIES 4000. Ancillary works (Pavement Marking, Traffic Signs, Guardrails, Street Lighting, Traffic calming devices etc.) shall conform to the requirements under SERIES 5000 of this General Specifications. The rate shall include all Machinery, Manpower and material to perform the activity as defined in the drawings or special Specifications.

The bid Rate for all building works which shall include toll plaza building for housing the tolling equipment Monitoring/ computer control room; Cash handling provisions; Meeting room Equipment room; Toilets; canopy and Tolling Booths. It includes provisions of Internal and External Electrical Supply and fittings and Plumbing Connection and fittings. Power supply involving grid connections and/or solar panels and batteries and/or standby generator sufficient for plaza operations and for roof lighting as well as for approach lighting; Parking area, Equipment store; and Server rooms as per drawings. All electrical service and communication cabling from the toll plaza up to and into the equipment building shall be provided as per the approved drawings or as directed by the Engineer.

The bid Rate shall include full compensation for the Installation and commissioning of toll collection system on each lane as per the drawings and technical Specifications on the site.

Payment for works, parking and landscaping shall be made as under the relevant SERIES 2000, 3000, 4000, AND 5000.

SERIES 6000

STRUCTURES

CONTENTS OF THE GENERAL SPECIFICATIONS:

<i>SERIES 1000</i>	<i>GENERAL</i>
<i>SERIES 2000</i>	<i>DRAINAGE</i>
<i>SERIES 3000</i>	<i>SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE</i>
<i>SERIES 4000</i>	<i>BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT</i>
<i>SERIES 5000</i>	<i>ANCILLARY ROADWORKS</i>
<i>SERIES 6000</i>	<i>STRUCTURES</i>
<i>SERIES 7000</i>	<i>TOLERANCES, TESTING AND QUALITY CONTROL</i>
<i>SERIES 8000</i>	<i>DAYWORKS</i>

APPENDICES

SERIES 6000

STRUCTURES

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SERIES 2000	DRAINAGE
SERIES 3000	SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE
SERIES 4000	BITUMINOUS LAYERS SEALS AND CONCRETE PAVEMENT
SERIES 5000	ANCILLARY ROADWORKS
SERIES 6000 STRUCTURES	
SERIES 7000	TOLERANCES, TESTING AND QUALITY CONTROL
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APPENDICES

SERIES 6000: STRUCTURES

SECTION 6100: FOUNDATIONS
FOR STRUCTURES

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6101 SCOPE

This Section covers all foundation work which, for the purposes of these Specifications, shall comprise those elements of construction below the level of the bottom surface of the footings, the pile-capping slabs or the caisson cover slabs, collectively hereinafter referred to as base or bases, which shall include all the associated temporary works. Foundations for prefabricated culverts are not included but are specified in SECTION 2200.

6102 MATERIALS

(a) General

Material used in the permanent foundation work shall comply with the requirements specified for the particular material in SERIES 6000.

(b) Rock (For Rock Fill)

Stones shall be hard, angular, natural or quarry stones of such quality that they will not disintegrate on exposure to water or weathering. The stones shall be free from soil, clay or organic material.

Neither the breadth nor the thickness of a single stone shall be less than one-third its length. Not more than 10% of the total volume of rock fill shall consist of stones with a mass of less than 0.5 times the specified mass and not more than 10% of the total volume of rock fill shall consist of stones with a mass of more than 5 times the specified mass.

At least 50% of the total volume of rock fill shall consist of stones the mass of which exceeds the specified mass.

(c) Crushed Stone

Crushed stone used for the construction of crushed-stone fill shall originate from sound un-weathered rock approved by the Engineer.

(d) Granular Fill

Granular material used for constructing the compacted granular fill shall be approved granular material of at

least Natural Gravel (G30) quality in accordance with TABLE 3702/5 of SECTION 3700,

(e) Sand Fill

Sand used for filling the caissons shall be clean, hard sand free from lumps of clay or organic or other deleterious matter. Any soil exhibiting non plasticity can be used as a sand fill material.

(f) Backfilling Behind Earth Retaining Structures

Granular backfill required for compacting against earth-retaining structures shall consist of well-graded crushed or uncrushed gravel, stone, rock fill, or natural sand or a combination of any of these. It shall not contain a soluble sulphate content exceeding 2.5 g per litre as determined

The material used for backfilling behind the earth Retaining structure should follow the gradation given in TABLE 6102/1.

TABLE 6102/1: GRADATION REQUIREMENTS FOR BACKFILLING MATERIAL

Sieve size (mm)	% Passing
37.5	100
28	90-100
20	65-95
10	40-70
5	29-52
2	20-40
1.18	15-33
0.425	10 - 24
0.075	4 - 12
Maximum layer thickness (mm)	200
Maximum Los Angeles Abrasion Value (%) (AASHTO T 96 :2022)	40

Note: Before backfilling behind the earth retaining structures, Drainage Strip shall be provided.

(g) Structural Steel

Steel in the steel piles shall comply with the requirements as shown in the TABLE:6102/2 -or equivalent for the grade of steel specified on the Drawings. I and H sections shall comply with the requirements of BS EN 10365:2017 AND BS EN 10034: 2020. For circular hollow steel sections refer BS EN 1993-1-1:2005+AC2:2009.

Fabricated sections shall comply with the details shown on the Drawings and the requirements of SECTION 6700.

TABLE 6102/2: REQUIREMENTS FOR STEEL PILES

BS EN 10025-1 : 2004
BS EN 10025-2 : 2019
BS EN 10025-3 : 2019
BS EN 10025-4 : 2019
BS EN 10025-5 : 2019
BS EN 10025-6 : 2019
BS 7668 : 2021
BS EN 10029 : 2010
BS EN 10210 : 2006

(h) Permanent Pile Casings

Permanent pile casings shall be sufficiently rigid so as not to deform permanently or get damaged during handling and construction. The casings and their joints shall be sufficiently watertight to prevent the fluid components of the concrete from leaking during the placing of the concrete or from the ingress of groundwater prior to concreting. Where steel casings contribute to the strength of the pile, the casings shall have a minimum wall thickness of 6 mm and shall comply with the requirements of ASTM A252-98(2002). Welded joints shall comply with the requirements of SECTION 6700.

(i) Driven Pile Casings

Driven pile casings shall have sufficient strength to permit their being driven and not being distorted by the driving of adjacent piles. They shall be sufficiently watertight to prevent water from leaking through the casing walls, prior to or during the placing of concrete.

(j) Grouting**i) Cement Grout**

Cement grout shall meet the appropriate requirements of SUB-CLAUSE 6503 (g).

ii) Proprietary-Brand Grout

Proprietary-brand grout shall be prepared and used strictly in accordance with the instructions of the manufacturer.

6103 GENERAL**(a) Subsurface Data**

The provisions of CLAUSE 1216 shall apply in regard to any information supplied regarding any subsurface conditions likely to be encountered.

If it is found during the course of excavating, founding-pile or caisson work that the soil or founding conditions differ greatly from those shown on the Drawings, the Contractor shall immediately notify the Engineer.

The Engineer shall, as often as they may deem necessary during the course of excavation, be entitled to call on the Contractor to conduct additional foundation investigations and/or tests at or below the respective foundation levels in view of establishing safe bearing pressures and appropriate foundation depths.

(b) Channel Preservation

The flow of the watercourse and the conservation of marine and freshwater life shall be maintained at all times. Access to cofferdams, artificial islands and piling platforms shall be effected without unnecessarily disrupting the flow of the watercourses at the point of crossing, unless otherwise specified.

Precautions shall be taken by the Contractor to maintain water quality standards. Water contaminated with silt shall be settled in ponds before being pumped into streams. Water contaminated with chemicals shall be purified before being returned to the stream or disposed of in an appropriate manner as directed by the Engineer.

Precautions shall be taken by the Contractor to ensure that the natural pH, electrical conductivity and other indicators as prescribed for the water are not raised or lowered.

On completion of the work, surplus excavated materials including materials excavated from caisson compartments and holes for piles, materials used in cofferdams and other temporary works, as well as in-situ material, shall be removed and disposed of by the Contractor to the level of the original bed or such elevation as agreed to by the Engineer or required for stream channelization.

6104 ACCESS AND DRAINAGE**(a) General**

This Clause covers the provision of access, including the construction of cofferdams, and draining the excavations. Where it is unnecessary to provide access in terms of SUB-CLAUSE 6104 (b), the Contractor shall be paid separately for draining the excavations.

After completion of the permanent works, all temporary works shall be completely removed, the ground levelled and the site left neat. Where this is impracticable, such portions as have not been removed, shall be dealt with in accordance with the Engineer's instructions.

(b) Access

Where temporary banks or artificial islands are constructed in view of affording access to the location where structural members, piles or caissons are to be constructed, the banks or islands shall be adequately compacted in view of supporting any constructional plant and material without any undue settling which may have a harmful effect on the works.

The Contractor may use any material, with the approval of the Engineer, deemed by them to be suitable for constructing the islands, but no separate payment will be made for any obstructions, hard or unsuitable material occurring in the material used for constructing temporary banks or artificial islands.

Designing and constructing any cofferdams shall comply with the requirements of BS 8004:2015+A1:2020. Before starting with construction, the Contractor shall submit drawings to the Engineer, which show details of the cofferdams and the method of construction proposed.

(c) Drainage

The Contractor shall apply suitable, effective drainage methods for preventing the ingress of water into excavations and to keep them dry.

The drainage measures, with the exception of pumping, shall be maintained until the backfilling has been completed. Between the various construction stages pumping may be interrupted in consultation with the Engineer.

Any draining or pumping of water shall be done in a manner that will preclude the concrete or materials or any part thereof from being carried away.

6105 EXCAVATION**(a) General**

This work shall include excavations not provided for elsewhere in these Specifications, which are required for founding the structures as well as for the excavating required in respect of the demolition, extension or modification of existing bridges and culverts.

Excavation required for diverting, channelling or widening streams within 5 m of concrete structures shall be measured and paid for under ITEM 61.02. Excavations beyond the 5 m limit shall be measured and paid for under the appropriate Items of SECTIONS 2100 AND 3600.

The Engineer may require additional excavation beyond that described in the Contract to remove any pockets of soft soil or loose rock. The resulting voids and any natural voids shall be filled with hardcore or class of concrete as specified in the drawings or material approved by the Engineer.

No trimming of the sides of the excavation shall be carried out within 24 hours of the placing of any blinding concrete.

Any additional excavation below the bottom of foundations, including that resulting from removal of material which the Contractor has allowed to deteriorate, shall be replaced with hardcore or a class of concrete as specified in the drawings or material approved by the Engineer.

The sides of the excavation for foundations for structures shall either be vertical or sloped at a safe angle for the material to be excavated. Except in rock, vertical sides shall be adequately supported at all times to the satisfaction of the Engineer.

All practical measures shall be taken to prevent the ingress of surface water into the excavated foundations. Any water collecting in the excavated foundation shall be removed as soon as possible thereafter.

(b) Surface Levels Agreed on for Excavations

Prior to commencing with any excavation, the Contractor shall notify the Engineer in good time to ensure that levels are taken of the undisturbed ground surface for determining the ground surface from where the excavation can be measured, and this datum shall be agreed on by the Engineer and the Contractor.

(c) Excavation

Where in the opinion of the Engineer the casting of concrete against the excavated earth faces is not permissible, or where formwork has to be provided, the extremities of the excavation, for purposes of measurement and payment, shall be deemed to be the vertical planes parallel to and 0.5 m outside the perimeter of the member for which formwork is to be provided.

Where suitable, stable material is encountered during excavation, that part of the trench or foundation pit shall be excavated to the neat dimensions of the base unless otherwise directed by the Engineer. Over-excavation (over break) in hard material shall be backfilled with the same class of concrete as that in the base or with mass concrete fill as specified or as directed by the Engineer.

Where blasting is required, the Contractor shall complete the entire foundation excavation before the construction of any permanent concrete work is commenced, unless otherwise approved by the Engineer.

Boulders, logs or any other unsuitable material excavated shall be removed from the site.

When hard material suitable for founding is encountered at the founding level, it shall be cut and trimmed to a firm surface, either level, stepped or serrated, as may be required.

Where, in the opinion of the Engineer, unsuitable material is encountered at founding level, such material shall be removed and replaced with foundation fill in accordance with CLAUSE 6109 and as directed by the Engineer.

(d) Classification of Excavated Material

For payment purposes distinction shall be made between common excavation in soft material, and rock excavation. All excavation for the foundations of structures shall be classified in accordance with CLAUSE 3603.

(e) Blasting

Where blasting is permitted, it shall be carried out in accordance with the requirements of CLAUSE 1221.

(f) Deterioration of Foundation Excavations

Where soft material or hard material which quickly deteriorates when exposed is found at the foundation level, the foundation shall be excavated to the final slope and level immediately before the blinding is placed.

Where the bottoms or sides of excavations in which bases are to be cast are softened on account of negligence on the part of the Contractor in allowing storm or other water to enter the excavations, the softened material shall be removed and replaced with foundation fill as directed by the Engineer, at the Contractor's expense.

(g) The Safety of Excavations

The Contractor shall take the necessary precautions to safeguard the stability and safety of the excavations and adjacent structures.

No person's safety shall be jeopardised, neither shall any situation be allowed to arise which may result in damage of whatsoever nature.

Precautionary measures taken by the Contractor shall

comply with the appropriate legal provisions.

(h) Inspection

No concrete shall be placed before the excavation has been properly cleaned by the Contractor and inspected and approved by the Engineer.

(i) Excavation by Hand

In cases where mechanical excavators cannot be used, the Engineer shall authorise supplementary payment to the Contractor for excavation by hand at the bid rates, provided that the Engineer is satisfied that the Contractor has done everything possible to ensure that hand excavation was the only possible solution. The supplementary rate for excavation by hand shall not apply to minor finishing or clearing jobs in excavations which are otherwise being done by mass excavation plant.

6106 FOUNDING

As a consequence of possible variations of the anticipated founding conditions, the dimensions and founding levels specified or shown on the Drawings may have to be varied during construction.

The Contractor shall make such variations in the actual founding level for each foundation fill, base or caisson during construction as instructed by the Engineer.

The Contractor shall not be entitled to any additional payment as a consequence of any such variation in the dimensions or founding depths over and above that provided for in CLAUSE 6118, irrespective of the stage of construction at the time the instruction to make the variation is given. However, if as a consequence of such an instruction being given, the Contractor is compelled to substitute otherwise suitable machines or equipment, then the Engineer may reimburse the Contractor at a fair price for the relevant costs incurred.

No bases, caissons or piles shall be founded unless authorised by the Engineer. Each founding level shall be accurately measured, recorded and agreed on.

6107 UTILISATION OF EXCAVATED MATERIAL

Excavated material and material recovered from temporary works shall, if suitable, be utilised for backfill. Material unsuitable for use as backfill or in excess of the required quantity, shall be removed from the site or utilised as directed by the Engineer.

Excavated material not used for backfill or not taken to spoil but used in the construction of embankments or other parts of the work, as directed by the Engineer, will be paid for under foundation excavation as well as under the relevant item for the purpose for which it is used.

The free haul distance on excavated material and imported material for backfill shall be determined according to SUB-CLAUSE 1602 (c).

Excavated and stockpiled material shall be so placed as not to endanger the uncompleted structure either by direct pressure or indirectly by overloading the fills contiguous to the structure, or in any other way.

6108 BACKFILL AND FILL NEAR STRUCTURES**(a) General**

When backfill and fill are placed, the following precautionary measures shall be taken:

- i. The material shall be placed simultaneously, insofar as possible to approximately the same elevation on both sides of an abutment, pier, or wall where appropriate. If conditions require the backfill or fill to be placed appreciably higher on one side than on the other the additional material on the higher side shall not be placed until authorised by the Engineer,

and preferably not until the concrete has been in place for 14 days, or until tests show that the concrete has attained sufficient strength to safely withstand any pressure extended by the backfill or fill or by the method of construction.

- ii. The material behind abutments directly restrained at the top by the superstructure e.g. portal type of structures, shall be placed as shown on the Drawings or as directed by the Engineer.
- iii. The material behind the portal walls of portal structures shall not be placed until the top slab has been placed and cured for the specified length of time, unless otherwise authorised by the Engineer.

(b) Backfill

Excavated areas around structures shall be backfilled with approved material in horizontal layers not exceeding 200mm in thickness after compaction to the level of the original ground surface. Each layer shall be moistened or dried to the optimum moisture content for the material and then compacted to a density of not less than 97% of BS-Heavy density for soils and gravels, and not less than 100% of BS-Heavy density for cohesion less sands, or the density of the surrounding soil whichever is the least, except that, in the road prism, the material shall be compacted to a density of not less than 95% of BS-Heavy density.

(c) Fill

Before the space between the structure and the approach fill, or between the structure and the faces of the surrounding excavation is backfilled, the slope of the approach fill, or the faces of the excavation shall be shaped by benching or serrations to prevent wedge action from occurring between the structure and the approach fill or the excavation faces.

The distance between the exposed face of the structure and the toe of the approach fill or the excavation face shall not under any circumstances be less than the height of the exposed face of the structure.

(d) Fill Within Restricted Area

That part of the fill within a horizontal distance of 3 m from the vertical and inclined concrete faces of the structure and that part between the pillars of the spill-through abutments or that part shown on the Drawings, shall be termed "fill within restricted area".

Fill within the restricted area shall comply with the requirements of SECTION 3600 except that it shall be compacted to a density of not less than 95% of BS-Heavy density. In order to achieve the specified density, the Contractor shall, where necessary, import material of suitable quality.

Unless otherwise directed by the Engineer, only mechanical compaction equipment that is pushed or drawn by hand shall be used to achieve the required density within a horizontal distance of 3 m from any concrete structure. Fill in spaces below concrete soffits that are inaccessible for mechanical compaction equipment shall be constructed by methods specified or as approved by the Engineer.

Where a base is required to be constructed on mass concrete fill, the mass concrete fill shall be constructed accurately to the final levels of the underside of the base.

(e) Soil Cement

Soil cement shall consist of at least C1.5 quality material as specified in SECTION 3800 or as specified in the special specification, with a cement content which shall not be less than 3 % if handled and compacted with a similar technique to granular materials or 5 % if handled and compacted with a similar technique to concrete respectively.

6109 FOUNDATION FILL

If it is found during the course of excavation that the material at the indicated founding depth does not have the required bearing capacity as specified on the Drawings, the excavations shall be extended at the discretion of the Engineer until satisfactory founding material is encountered. The Engineer may order the Contractor to make up the difference in levels with foundation fill.

Where the foundation fill consists of rock or crushed stone, it shall be constructed in accordance with the requirements of the Special Specifications or as directed by the Engineer. Foundation fill consisting of granular material shall be constructed in layers not exceeding 150 mm in thickness after compaction. Each layer shall be moistened or dried to the optimum moisture content for the material and compacted to a density of not less than 95% of BS-Heavy density for soils and gravels, and not less than 100% BS-Heavy density for cohesion-less sands. Mass concrete fill to be used shall be of the minimum class C15 or as directed by the Engineer.

Unless otherwise specified or directed by the Engineer, the foundation fill constructed from rock, crushed stone or compacted granular material shall be defined by a prism with vertical sides. The base of the prism lies in the founding plane and coincides with the base of a prismoid with trapezium-shaped inclined sides which extend downwards and outwards at an angle of 60° with the horizontal from each outer edge of the underside of the footing down to the founding level. The upper plane of the prism lies in the plane of the underside of the footing.

Concrete blinding which complies with the requirements shown on the Drawings shall be placed underneath all bases except where mass concrete fill is used or where authorised by the Engineer that this need not be done.

Where a base is required to be constructed on mass concrete fill, the mass concrete fill shall be constructed accurately to the final levels of the underside of the base.

6110 GROUTING OF ROCK FISSURES

Where specified, fissures in the rock below and around the bases shall be sealed by pressure grouting with a neat cement grout or sand-cement grout or with a proprietary brand grout as specified.

The cement water ratio of the grout shall be approved in advance by the Engineer.

The extent of the fissuring shall be established by means of water testing under pressure.

Holes of at least 40 mm in diameter shall be drilled at places indicated by the Engineer and grout shall then be pumped into these holes under suitable pressures. Grouting shall be done in 3 m stages to the maximum depth ordered. Care shall be taken to avoid further fracturing of the rock strata by excessive grouting pressures.

Grouting of the rock fissures shall be done by specialised operators with adequate experience in this class of work.

6111 FOUNDATION DOWELS

Where required, foundation dowels of specified material, diameter and length shall be installed at the positions and to the dimensions shown on the Drawings or as directed by the Engineer. After exposing, clearing and trimming the rock formation, holes with specified diameters and depths shall be drilled in the rock. After the holes have been cleared and prewetted, they shall be filled with grout. Within 15 minutes of having been filled with grout, the dowels shall be carefully driven into the holes. The cement and water in the grout shall be mixed in the ratio of 50 kg of cement (CEM I and II) to 20 litres of water, and an approved expanding additive

which complies with the requirements of SUB-CLAUSE 6402 (e) shall be added.

The dowels shall comply with the requirements of CLAUSE 6306.

6112 FOUNDATION LINING

Where specified or directed by the Engineer, foundation linings shall be installed as described hereafter. The Engineer shall have the right to order the use of linings against the sides of excavations and the undersides of bases and slabs in lieu of formwork and concrete blinding.

All surfaces to be lined shall be covered with an approved sheeting to provide a clean impervious layer. The material shall be of sufficient strength to provide a durable working surface and to support the concrete and reinforcement without tearing. The joints of the material between strips shall have a 150 mm overlap and the lining shall be held firmly in position by nails, pegs, etc.

Polyethylene sheeting with a thickness of 0.150 mm is generally considered to be adequate for use below bridge approach slabs and bases.

6113 FOUNDATION PILING PRELIMINARY ITEMS

(a) General

This Clause covers the construction of piles of concrete, steel, timber or a combination of these materials.

(b) Piling Layout

The piling layout, the minimum pile size and/or bearing capacity and type together with the steel reinforcement and class of concrete required for concrete piles along with pile configurations, minimum pile spacings, dimensions of the pile cap etc. shall be as detailed and specified on the Drawings unless otherwise specified in the Special Specifications.

(c) Alternative Designs for Piling and Piling Layouts

i) Submission

The priced Bill of Quantities submitted for alternative designs shall be compiled strictly in accordance with the relevant measurement and payment clauses of these Specifications.

Where pay items defined in these Specifications have been omitted, it shall mean either that the items do not apply, or that where the Engineer requires work falling under such items to be done, it shall be done without any cost to the Employer. The inclusion of 'rate-only' items will not be permitted.

Where pay items not defined in these Specifications are used, the measurement and payment requirements for such items shall be specified in detail by the Contractor. In the absence of such definitions, or in the case of any ambiguity, the interpretation of the Engineer shall be final and binding.

Except in piling-only Contracts or where otherwise provided in the Special Specifications, the Contractor shall price the Bill of Quantities for the original design irrespective of whether or not an alternative design is offered.

ii) Design

The critical design-load combinations acting upon the underside and the centre of gravity of the pile-capping slab, the maximum permissible set of the pile-capping slab, and the technical data required for designing alternative piles and or piling layouts will be indicated on the Drawings. Alternative

designs shall comply with the prescriptions set out below.

For alternative designs submitted, the Contractor shall submit with their bid a detailed description of the method of analysis used in the design of the piles and the pile group layouts. The average length of pile and/or of the piles per group on which the quantities in the Bill of Quantities for the alternative designs are based shall be stated in each case. The type of pile offered shall be defined in terms of size, materials, working and breaking load.

The Contractor shall be responsible for and shall bear the cost for redesigning, drafting and submitting the detailed drawings for any structural element affected by the alternative pile design. Any economy or incidental cost caused by constructing such element as compared to the original design shall be for the account of the Contractor.

The Contractor shall, as specified in the contract document for alternative designs, submit to the Engineer at least three months prior to work being commenced, drawings detailing the piling-group layout and piles, incorporating such amendments to their original design as may be required by the Engineer, and drawings detailing the amendments required to the pile-capping slab dimensions and reinforcement as a result of the layout of the piles, all as applicable. The Contractor shall apply principles of value engineering in the development of the alternative designs.

No work of whatsoever nature shall be commenced on the piling until the Drawings have been submitted to, and have been approved by, the Engineer, in writing.

After approval of the Drawings, no departure therefrom shall be made without the authorisation of the Engineer.

Final working drawings shall comply with the provisions of CLAUSE 1220.

Where the alternative piles fail in regard to the load test specified in SUB-CLAUSE 6116 (a), the Contractor shall be responsible for the cost of the work required for improving the piles and pile layout so as to comply with the design requirements.

iii) Basis of Payment

Where the quantities in the Bill of Quantities, differ from the number of piles and the average pile length given in the submission for the alternative pile design, the Engineer shall accept the sum in the Bill of Quantities, correct the quantities, and adjust the rates for the applicable pay items accordingly.

(d) Details to be Furnished by the Contractor

In all cases where the choice of the type of pile to be used is left to the Contractor, full particulars, specifications, calculations and drawings of the piles proposed for use by the Contractor shall be submitted with the bid. The Contractor shall submit the following information to the Engineer, two weeks before any piles are driven or holes are formed:

- i. Detailed geotechnical investigations report;
- ii. Range of pile sizes to suit loading;
- iii. Founding levels to meet pile load capacity and settlement criteria;
- iv. Spacing of piles;
- v. Types of piles whether end bearing or skin friction or both;
- vi. How the piles and casings will be installed or the holes will be made through identified obstructions;
- vii. The weight of the piling hammer;

- viii. The set during the last ten blows;
- ix. The expected size of the bulbous base, under ream, rock socket, etc, if any;
- x. How concrete is to be placed and compacted in the case of cast in situ piles;
- xi. How reinforcing steel is to be placed and held in place during the placing and compaction of the concrete in cast in situ piles;
- xii. Details of permanent casing, if any;
- xiii. Environmental effects of the piling;
- xiv. The mix design for the concrete together with an adequate quantity of cement and aggregate to enable the Engineer to conduct the necessary tests.

(e) Pile-Installation Frames and Equipment

The pile-installation frames and equipment used for driving the piles or forming the holes or for other methods of sinking the piles shall be in a good working condition and to the prior approval of the Engineer and shall comply with the relevant legal provisions.

The Contractor shall supply the necessary equipment, gear and instruments required for the prescribed investigations and inspections.

The installation frames shall be so designed as to ensure that piles can be installed in their proper positions and true to line and slope.

(f) Piling Platforms

Piling platforms shall include the prepared in situ material or artificial islands or any structure (excluding the piling equipment) constructed for gaining access to the position where the pile is to be installed and for carrying out the piling operations.

Structural piling platforms shall be rigid. Floating barges used for piling operations shall afford sufficient stability to enable piles to be properly installed.

On completion of the piling, the Contractor shall remove all the artificial, constructed platforms and reinstate the site to the satisfaction of the Engineer.

(g) Setting Out

The Contractor shall set out the pile positions and shall stake these positions with a durable marker. Where the level from which the piling is undertaken is above the underside of the pile capping slab, due allowance shall be made for the offset of raking piles so that the pile at the underside of the pile-capping slab will be in the correct position.

(h) Ground Surface for Foundation Piling

Before starting any piling work, the Contractor shall notify the Engineer in good time to ensure that levels of the ground surface are taken in order that an average ground surface from which the piling is to be measured can be established and agreed on by the Engineer and the Contractor. Where foundation piling at a site is preceded by excavation or the construction of fill, the surface from which the piling is to be done shall be formed as near as possible to the underside of the pile-capping slab as directed by the Engineer.

6114 TYPES OF PILES

(a) Cast In-Situ Concrete Piles

i) Reinforcement

Reinforcement shall not be placed in the pile holes until immediately before concreting. Before the reinforcement is placed in position, all mud, water, and any loose or soft material shall be removed from the hole.

Steel reinforcing shall be accurately maintained in

position without damage being done to the sides of the hole or the reinforcing itself. Spacers shall be used to keep the reinforcing steel at the required distance from the inside face of the pile casing and wall of the pile hole but shall not cause zones through which aggressive ground water may penetrate to the reinforcement.

Pile reinforcement will not be shown in the bending schedules. Only the number, diameter and type of bars and their arrangement will be shown on the Drawings. The Contractor, with the permission of the Engineer, may replace the bars shown on the Drawings with bars with different diameters and spacing and of different types, on the basis of equivalent strength.

The reinforcement shall be assembled in cages, which shall be sufficiently robust to prevent their permanent deformation during handling. In the case of cast in situ piles, the inner sides of the cages shall be left unrestricted for the placing of the concrete.

The longitudinal bars shall project above the cut-off point by the distance shown on the Drawings, or by 40 times the bar diameter if no dimension has been given.

Splicing the reinforcing may be ordered, and the Contractor shall keep available on the site sufficient steel reinforcing so that an additional length of pile reinforcing can be assembled whenever necessary.

The assembly of this additional reinforcing shall be carried out expeditiously and before any concreting of any specific pile commences. If splices have to be provided, the longitudinal bars shall overlap for a distance of 40 bar diameters, or as required by the Engineer.

ii) The Concreting of Piles

The concreting of the piles shall not be commenced before the Engineer's permission has been given.

Except in self-supporting pile holes, a temporary or permanent casing shall be installed for the full depth of the hole to prevent lumps of material from falling from the sides of the hole into the concrete. Where concrete is to be placed under the drilling mud, the temporary casing may be omitted, except at the top end of the hole.

The concrete shall be so proportioned as to be of sufficient strength, but shall be sufficiently workable to enable it being properly placed, and, where self-compacting concrete is not used, it shall be thoroughly compacted by approved means. Extraction of the temporary casing during placement of the concrete shall be such that no damage is caused to the pile and the advancing concrete level is at all times kept considerably above the temporary casing's trailing edge. Concrete shall generally be placed in the dry, but where this is impracticable; it shall be placed by tremie.

The requirements of SUB-CLAUSE 6407 (c) together with the following requirements shall apply when concrete is placed under water by tremie:

- a. The cement content shall be not less than 400 kg/m³ and the slump shall be such that the concrete of the specified strength and desired density can be obtained.
- b. The hopper and tremie shall be a closed unit which cannot be penetrated by water.
- c. The tremie shall be at least 200 mm in diameter for 20 mm aggregate and of greater diameter for larger aggregates such as:

- ♦ 250 mm (10 inches) for 25 mm (1 inch) aggregates;
- ♦ 300 mm (12 inches) for 32 mm (1¼ inch) aggregates;
- ♦ 350 mm (14 inches) for 40 mm (1½ inch) aggregates;
- ♦ 400 mm (16 inches) for 50 mm (2 inch) aggregates.

This ensures that the concrete can flow freely through the tremie pipe without obstruction or blockage, which is critical for successful underwater concreting operations.

- d. The concrete shall be so placed as to prevent the mixing of water and concrete. The tremie shall at all times penetrate into the concrete with an adequate margin of safety against accidental withdrawal of the pipe. The tremie should always be full of concrete.
- e. Placing the concrete in that part of the pile below the water level in the casing shall be done in one operation, and the same method of placing the concrete shall be maintained throughout.
- f. All tremies shall be scrupulously cleaned before and after use.
- g. Before placing the concrete in the water, the Contractor shall ensure that no silt or other materials have collected at the bottom of the hole. Proper cleaning should be conducted to remove all the muck from the bottom and where drilling mud is used, the Contractor shall ensure that no drilling mud suspension with a relative density exceeding 1.3 has collected at the bottom of the hole. Concrete shall be placed in a manner that prevents segregation.

(b) Precast Concrete Piles

i) General

The piles shall be of reinforced or pre-stressed concrete and shall be manufactured, handled, stored and installed in accordance with BS 8004 2015 +A1:2020 AND US EAS 412-2:2019 for Grade B500CWR, unless otherwise specified.

ii) Manufacture

The piles may be manufactured in a factory or a casting yard on the site of the Works. The Contractor shall ensure that the factory or casting yard will at all reasonable times be accessible for inspection by the Engineer.

The relevant requirements of SECTION 6400 shall apply to the concrete work.

Reinforcement shall comply with the requirements of BS 8004:2015 +A1:2020 AND US EAS 412-2:2019 for Grade B500CWR.

The piles shall be cast on a rigid horizontal platform in approved moulds. Particular care shall be taken to keep the reinforcement, coupler sockets and pile shoes accurately in position. Adequate provision shall be made for lifting the piles.

Each pile shall be clearly marked with the date of casting, a reference number, and from the tip of the pile at 1.0 m intervals, with distance marks.

Piles shall be cured for a period sufficient to develop the strength required to withstand, without damage to the pile the stresses caused by handling, transporting, storing and driving. The piles shall not be driven before the concrete in the pile has attained the specified 28-day strength.

iii) Handling, Transport and Storage

Care shall be taken at all stages of lifting, handling and transporting to ensure that the piles are not damaged or cracked.

Piles shall be stored on firm ground which will not settle unequally under the weight of the stack of piles. The piles shall be placed on timber supports which are truly level and spaced so as to avoid undue bending in the piles. The supports in the stack shall be located vertically above one another.

iv) Lengthening of Precast Piles

Piles shall be lengthened where required by such means and methods as approved by the Engineer. Care shall be taken to ensure that the additional length of pile joined is truly axially in line with the original pile within the tolerance requirements for straightness set out in SUB-CLAUSE 6803 (a). Driving shall not be resumed until the pile extension and any bonding agent used has attained the required strength.

(c) Steel Piles

Steel piles shall be of hollow pipe construction or of H or I section construction.

Hollow steel piles may be filled with cast in situ concrete and, provided that adequate connections are provided between the steel and the concrete with a view to transferring the load, the concrete may be deemed to assist in carrying the load.

Wherever steel piles are used, the outside surface shall be given a protective coating of bitumen, coal-tar pitch or synthetic resins to the satisfaction of the Engineer or as specified. The cross-sectional area of the steel shall be adapted to the aggressiveness of the subsurface conditions to compensate for possible reduction in the pile wall thickness caused by abrasion and corrosion during the service life of the pile.

Steel piles shall be used only where permitted by the Engineer.

(d) Timber Piles

i) General

Timber piles shall be of pressure treated round timber approved by the Engineer and shall be manufactured, handled and installed in accordance with BS EN 1995-1-1:2004+A2:2014 unless otherwise specified.

Tropical hardwoods shall be used for all permanent piles. Softwoods may be used for temporary structures subject to the approval of the Engineer.

ii) Manufacture and Testing

The piles may be manufactured in a factory or treated on the site of the works in accordance with BS 5268-5:1989, unless otherwise specified on the Drawings.

When required, the Engineer will order and the Contractor shall carry out tests on the timber piles in accordance with BS 5268-2:2002 to satisfy that the timber is fit for the purpose for which it is to be used.

The Contractor shall ensure that the factory or treatment yard will at all reasonable times be accessible for inspection by the Engineer.

The piles shall be treated and stored in a horizontal position and protected from the weather.

Each pile shall be clearly marked with the date of manufacture, type of tree, date of treatment, a reference number, and from the tip of the pile at 1.0 m intervals, with distance marks.

Piles shall be seasoned for a period sufficient to

develop the strength required to withstand, without damage to the pile, the stresses caused by handling, transporting, storing and driving. The piles shall not be driven before they have attained the specified strength.

iii) Handling, Transport and Storage

Care shall be taken at all stages of lifting, handling and transporting to ensure that the piles are not damaged or cracked.

Piles shall be stored on firm ground which will not settle unequally under the weight of the stack of piles. The piles shall be placed on timber supports which are truly level and spaced so as to avoid undue bending in the piles. The supports in the stack shall be located vertically above one another.

iv) Lengthening of Timber Piles

Piles shall be lengthened where required by such means and methods in accordance with BS EN 1995-1-1:2004 +A2 2014 or as instructed by the Engineer. Care shall be taken to ensure that the additional length of pile joined is truly axially in line with the original pile within the tolerance requirements for straightness set out in SUB-CLAUSE 6803 (a). Driving shall not be resumed until the pile extension and any bonding agent used has attained the required strength.

The butt joint portion between top & bottom pile should be treated as per given in SUB-CLAUSE 6114 (d) (v).

v) Protection of Timber Piles

Timber piles shall be furnished with tip protection and protected by the use of steel straps. Tip protection shall be suitable for use on timber piling of the size to be driven. Details of tip protection shall be furnished to the Engineer for review and approval before driving piles. Not less than two separate steel straps shall be placed within 600 mm of the butt of each pile after the pile is square cut. Not less than two separate steel straps shall be placed within 300 mm of the tip of each pile. Additional intermediate steel straps shall be placed at intervals of not more than 3 m measured along the length of the pile.

Timber piles which are to be capped shall be separately cut off so that true bearing is obtained on every pile. Piles inaccurately cut off shall be replaced. Splicing of timber piles shall not be permitted except by written permission of the Engineer.

(e) Continuous Flight Auger (CFA) Piles

Continuous flight auger (CFA) piles are constructed by drilling in a continuous operation, a CFA auger into the ground and, on reaching the required depth, pumping concrete or grout via a pressurised system, also in a continuous-motion, down the hollow stem as the ground-laden auger is steadily withdrawn.

6115 INSTALLATION OF PILES

(a) Driving the Piles

i) Pile-Installation Frames

Piles and pile casings shall be driven with a gravity hammer, a rapid-action power hammer or by other approved means. Pre-stressed-concrete piles shall be driven with a hammer with a weight of at least equal to that of the pile. Other piles shall preferably be driven by a hammer with similar weight characteristics. The hammer shall not, during driving operations, damage any permanent component of the pile. Pile driving leaders shall be constructed in such a manner as to afford freedom of movement of the hammer and shall be held in

position to ensure adequate support for the pile or pile casing during installation. Inclined leaders shall be used for installing raking piles.

The heads of precast concrete piles shall be protected with packing of resilient material; care being taken to ensure that it is evenly spread and held in place. A helmet shall be placed over the packing, and a dolly of hardwood or other material not thicker than the diameter of the pile shall be placed on top.

ii) Water Jetting

The Contractor may employ water jetting to install piles in granular material. Jetting shall be discontinued before the leading end of the pile reaches a depth of 80% of the anticipated final depth or a depth as agreed on with the Engineer. After jetting, piles or their casings shall be driven to the required depth, level or set.

iii) Installation Sequence

Unless otherwise specified or ordered, the sequence for installing the piles shall be left to the Contractor. However, the sequence for driving the piles in a group shall be programmed to minimise the creation of consolidated blocks of ground into which piles cannot be driven or which cause fictitious penetration values. Piling shall generally commence at the centre of the group and be progressively extended to the perimeter piles unless otherwise agreed on by the Engineer.

The installation of piles shall be undertaken in such a manner that structural damage, distortion or positioning defects will not be caused to previously installed piles or casings.

iv) Heaving of Piles

In soils in which the installation of piles may cause previously installed piles to heave, accurate level marks shall be placed on each pile immediately after installation and all piles that have heaved shall be re-driven to the required resistance, unless re-driving tests on neighbouring piles have shown this to be unnecessary. Piles shall not be concreted neither shall any pile-capping slab be constructed until the piles within a heave-influence zone have been re-driven as required.

v) Bulbous Bases

Where required, bulbous (enlarged) bases shall be formed after the driven casing has reached the required depth. The base shall be formed by progressively displacing the surrounding subsoil with concrete placed by the repeated action of a gravity hammer. The size of the base will depend on the compressibility of the surrounding subsoil but shall in no case have a diameter of less than 1.5 times the diameter of the pile.

vi) Piling Alignment

Where the inclination of a precast concrete pile deviates from the correct slope during installation, the pile shall not be forced into the correct position. The slope of the guiding frame shall be adjusted so as to coincide with the actual inclination of the pile to preclude the bending of the pile. Where the verticality or the inclination of the installed pile falls outside the specified tolerances, the pile will be classified as being defective.

(b) Augering and Boring

i) Auger and Bore Pile Holes

The augering and boring of pile holes shall be carried out as expeditiously as local conditions permit, taking due account of services or other restrictions on the site.

Holes shall be cleaned after augering and boring to obtain a clean and level surface.

Where indicated by the Engineer, suitable casing shall be installed in those parts of the augered holes where the sides are in danger of caving in before the concreting has been completed.

During extraction of the casing, care shall be taken to avoid lifting the concrete and damaging the pile.

The use of water for augering and boring holes shall not be permitted unless approved by the Engineer. Surface water shall not be allowed to enter the hole.

ii) Underreaming

Where required, the holes shall be enlarged or belled out to form an underream. The earth excavated shall be removed in a manner which will not damage the walls of the hole.

The shape of the underream shall be a truncated cone of which the base diameter depends on the bearing capacity of the founding material, but it shall be not less than twice the shaft diameter. The base angle of the cone between the inclined face and horizontal plane shall be not less than 60°.

Full safety measures shall be enforced to protect workmen working at the bottom of the pile hole.

iii) Bulbous Bases

Bulbous bases shall comply with the requirements of SUB-CLAUSE 6115 (a) (v).

iv) Inspecting Preformed Holes

Equipment for inspecting the pile shafts shall be provided and operated in accordance with BS 8008:1996+A1:2008 or similar document.

Immediately before the reinforcement is to be installed or the concrete placed, the Engineer shall be informed thereof with a view to inspect the pile holes. When piles are to be underreamed, the excavation shall be inspected twice by the Engineer; firstly to ascertain that suitable founding material has been obtained before underreaming may start, and, secondly, after the underreaming has been completed for approval to be given by the Engineer for casting the pile.

(c) Continuous Flight Auger CFA Piles

i) Equipment

Rigs shall have adequate torque capacity to install the piles without fighting or undermining of the soil during drilling.

Auger flights for CFA piles shall be continuous from the top to the cutting-face tip, with no significant gaps or other breaks. Gaps less than 25 mm in flights, may only be present where auger sections are joined.

The length of any auger brought to site shall be such that it is capable of installing a pile to a depth 20 % greater than the depth of the pile shown on the approved working drawings. Auger fighting shall be of uniform diameter, bend and damage-free throughout its length, with an outside diameter greater than 97 % of the design-diameter. Only single helix augers shall be used.

The Contractor shall provide evidence that the proposed equipment is appropriate for the pile type and is in good working order for approval by the Engineer.

ii) Installation

CFA piling shall not commence until a sufficient supply of grout/concrete is present on site to complete a pile.

The auger advance rate and rotation shall be continuous to prevent excess spoil from being transported to the ground surface with automated monitoring equipment used to verify that target rates of penetration are maintained during production piling. Augers shall not be extracted at any time during pile construction that results in an open unsupported borehole or inflow of water. Placement of grout/concrete shall commence immediately after auger achieving the planned depth. Placement of grout/concrete shall be continuous and monitored using automated systems to ensure adequate volumes are always pumped at positive pressures as auger-withdrawal is in progress. Augers shall not be allowed to turn in place without either drilling or pumping taking place. Where stoppages occur, holes shall be re-drilled.

Reinforcing steel shall be lowered into the grout/concrete by gravity or pushed gently to the final position by hand, vibrated, or mechanical means while it is in a fluid state before set. It shall be held in position near the ground surface within the fluid grout/concrete column by supports, appropriate for the reinforcement used, which shall remain in place until it reaches initial set, or 24 hours, whichever is longer. Adjacent piles within six diameters, centre to centre, of each other shall not be installed until it is demonstrated by the pile Contractor that the grout/ concrete in the first pile installed, is fully set. Grout/concrete set shall be such that the integrity of existing piles will not be compromised if drilling new piles causes mining of soil away from existing piles.

(d) Raker Piles

Raker piles are normally provided where vertical piles cannot resist the applied horizontal forces. Generally, the rake will be limited to 1 horizontal to 6 vertical. In the preliminary design the load on a raker pile is generally considered to be axial. The distribution of load between raker and vertical piles in a group may be determined by graphical or analytical methods. Where necessary, due consideration should be made for secondary bending induced as a result of the pile cap movement, particularly when the cap is rigid. Free-standing raker piles are subjected to bending moments due to their own weight, or external forces from other causes. Raker piles, embedded in fill or consolidating deposits, may become laterally loaded owing to the settlement of the surrounding soil. In consolidating clay, special precautions, like provision of permanent casing, should be taken for raker piles.

(e) Rock Sockets

Where required, rock sockets to the required dimensions shall be formed in rock formations of adequate strength, quality and thickness for transmitting the specified load.

Depth of socketing in rock shall be as provided in the drawing. In case no such socket length is specified either in design or drawing, the minimum length of socket shall be maintained:

- i. Hard Rock (Class R4, R5, R6) is 1-2 times the diameter of the pile.
- ii. Other than hard rock (Class R1, R2, R3) is 3-4 times the diameter of the pile.

(f) Obstructions

i) Types of Obstructions

[1] Identified Obstructions

Identified obstructions shall mean any obstruction described on the Drawings or in the Special Specifications and for which provision for payment has been made in the Bill of Quantities in respect of penetrating the obstructions.

[2] Unidentified Obstructions

Where provision has been made in the Bill of Quantities in terms of ITEM 61.17 for penetrating identified obstructions and obstructions not described are encountered, such obstructions shall be classified as unidentified obstructions and the penetration of such obstructions shall be paid for under ITEM 61.18 subject to the condition that the rate of penetration drops to below that achieved for identified obstructions when the same method and effort are used, or subject to additional methods and effort over and above those required for identified obstructions being required for penetrating the obstruction.

or

Where no provision has been made in the Bill of Quantities for penetrating identified obstructions and obstructions are encountered and, after resorting to the methods specified in the submission in terms of SUB-CLAUSE 6113 (d), it is found to be impossible to form the holes in the proper positions and at the proper inclinations and depths, and the Contractor has to resort to additional methods for forming the pile holes successfully, such obstructions shall be classified as unidentified obstructions.

ii) Classification Of Materials

For piling, only the following classification of materials shall apply to the identification and description of obstructions.

[1] Matrix

The matrix shall comprise that part of the material which will pass through a sieve with 50 mm x 50 mm openings.

[2] Coarse Gravel

Coarse gravel shall comprise that part of the material (stones, pebbles, cobbles, etc) which will pass through a 200 mm x 200 mm opening, but will not pass through a 50 mm x 50 mm opening. The gravel shall be obtained from material with at least a Class R2 hardness as defined in TABLE 6115/1.

[3] Boulders

Boulders shall mean any rock mass with a hardness of at least Class R2 which will pass through a square opening with dimensions equal to the maximum size boulder specified in the Bill of Quantities but will not pass through a 200 mm x 200 mm opening.

[4] Rock Formation

A rock formation shall be any rock mass with hardness of at least Class R2 which will not pass through a square opening with dimensions equal to the maximum size boulder specified in the Bill of Quantities.

Where a boulder is cut through and part of it is left embedded in the wall of the hole, such boulder obstruction shall be classified as rock formation.

For the identification of rock in terms of this Clause, the classification in TABLE 6115/1 shall apply.

iii) Driven Displacement And Prefabricated Piles

Where obstructions make it difficult to install driven displacement and prefabricated piles in the positions and at the inclinations shown and to the proper lengths by the methods specified in the submission in terms of SUB-CLAUSE 6113(d), the

Contractor shall resort to additional methods which are suitable for the type of pile. If the successful installation of a pile proves to be impossible after such methods have been tried, the Engineer may order an additional pile or piles to be installed.

All such work and additional piles shall be paid for in accordance with the bid rates where applicable, or where they do not apply, under ITEM 61.20.

iv) Auger and Bore Pile Holes

Where identified or unidentified obstructions are encountered when shaping holes for piles, payment for penetrating the obstructions shall be made against the appropriate pay items.

(g) Determining Pile Lengths

The design of the piles and pile groups, and the quantities in the Bill of Quantities are based on the subsurface data shown on the Drawings.

The Engineer will determine the depth of piles as work proceeds.

Where variations in the subsurface conditions occur as regards the material and height of the water table, the Engineer shall be informed immediately.

If the Contractor is not satisfied that the piles will be capable of carrying the specified loads at the depth determined by the Engineer they may, in consultation with the Engineer, lengthen the piles to reach a suitable founding depth. Where the Engineer and the Contractor cannot agree on the founding depth, the Engineer may require the Contractor to:

- i. Undertake additional foundation investigations and/or core drilling in accordance with SUB-CLAUSES 6103 (a) and 6115 (i) respectively; and/or
- ii. Install one or more test piles and conduct a load test in accordance with SUB-CLAUSE 6116 (a). The engineer will prescribe the positions for each test pile. Test piles shall comply with the specified requirements for piling.

(h) Piling Data

The following data on each pile installed shall be recorded in a form prescribed by the Engineer:

- i. The effort used for driving the pile and the resistance to penetration at the founding level.
- ii. A description of subsurface material, the presence of ground water and the quality of material on which the pile is founded.
- iii. The quality of the materials used in the construction or manufacture of the pile, as well as of the permanent casing if used. The method of placing and compacting the concrete in cast in situ piles.
- iv. The method of founding of the piles e.g. bulbous bases, underreams, rock sockets, etc. and their dimensions.
- v. The maximum working load of the pile.
- vi. The length of the pile and the accuracy of installation in respect of position and inclination.
- vii. Nominal dimensions and type of pile.
- viii. Length and details of any temporary and permanent casings used.
- ix. Date of piling, pile reference number and pile location (sketch) relative to the other piles of the same set.

TABLE 6115/1: ROCK STRENGTH CLASSIFICATION

Description of hardness			
Class	Description	Field indicator tests	Unconfined compression strength (MPa)
R1	Very soft rock	Material crumbles under firm (moderate) blows with the sharp end of geological pick and can be peeled off with a knife, it is too hard to cut a triaxial sample by hand. SPT refusal.	1 to 3
R2	Soft rock	Can just be scraped and peeled with a knife, firm blows of the pick point leave indentations 2 mm to 4 mm in specimens.	3 to 10
R3	Medium hard rock	Cannot be scraped or peeled with a knife; hand-held specimen can be broken with the hammer end of a geological pick with a single firm blow. Point load tests shall be conducted for distinguishing between these categories. These results may be verified by means of uniaxial compressive-strength tests.	10 to 25
R4	Hard rock		25 to 70
R5	Very hard rock		70 to 200
R6	Extremely hard rock		> 200
Source: Classification after Core Logging Committee, South African Section, Association of Engineering Geologists: "A guide to Core Logging for Rock Engineering" Bulletin of the Association of Engineering Geologists. Vol. XV. No. 3.1978.			

(i) Stripping the Pile Heads

Precast and timber piles shall be installed to a level of at least 1.0 m above the cut-off level, and cast in situ piles shall be cast to a level of at least 150 mm above the cut-off level. The excess concrete shall be stripped off so that only sound concrete will project into the pile-capping slab.

Before a pile head is stripped, the cut-off plane shall be marked by cutting a 20 mm deep groove with a grinding-machine around the full circumference of the pile.

Heavy concrete demolition equipment may not be used for the stripping of pile heads. All loose aggregate shall be removed from the cut-off plane.

The concrete shall be so stripped off that the pile below the cut-off level will not be damaged, or, should defective concrete be found in the completed pile, the damaged or defective concrete shall be cut away by the Contractor at their own cost and replaced with new concrete well bonded to the old concrete, or the pile shall be replaced as directed by the Engineer.

The main reinforcement of the piles shall extend at least 40 times the diameters of the main reinforcing bar beyond the cut-off level into the pile-capping slab. This reinforcement shall be left straight unless otherwise directed by the Engineer.

The cut-off level for piles shall be the level shown on the Drawings.

(j) Construction of Pile-Capping Slab

The Contractor shall not construct the pile-capping slab before the Engineer has confirmed, in writing, that all the relevant load tests have been completed and the piles have been accepted.

(k) Core Drilling

The Engineer may instruct core drilling to be done with a view to obtaining cores of the founding formation and/or of the concrete in the completed structural member. In the case of piling, the core drilling may precede the piling or may be done through the completed pile, as specified, or as instructed by the Engineer.

The Contractor shall supply the necessary construction plant on the site for drilling under the above conditions. The plant and techniques used shall be suitable for ensuring 100% core recovery. The diameters, depths and lengths of the cores shall agree with the specifications or the instructions of the Engineer.

The Contractor shall keep accurate records of the drilling, which, together with the cores, shall be handed over to the Engineer. The cores shall be placed in the

correct sequence in a clearly identified wooden core box with a lid.

6116 TESTING OF PILES**(a) Load Test****i) General**

The Engineer may order certain selected piles to be load tested. The procedure for loading tests shall comply with the requirements of SECTION 7100. The load testing of piles shall be carried out as per the guidelines given in BS EN 1997 -1:2004 + A1:2014 AND ISO 22477-1:2018. During the period of testing, driving of other piles which may affect the testing shall cease.

No working pile shall be used as an anchor pile. Where anchor piles or earth anchors are required for providing reaction, they shall be so placed as to have a minimal effect on the test results. The minimum distance of the anchor piles to the test piles shall be approved by the Engineer.

The Contractor shall provide the complete testing assembly, the necessary constructional plant, equipment, instruments and labour for carrying out the test and for determining accurately the settlement of the piles under each increase or decrease of the load. The test assembly, constructional plant, equipment and instruments used shall be subject to the approval of the Engineer.

Within two days of having completed the tests, the Contractor shall supply the Engineer with the test results and neatly plotted load against settlement, load against time, and settlement against time graphs.

ii) Loading

The maximum test load applied shall be equal to twice the specified working load or the ultimate test load, whichever shall be the smaller.

The maximum working load shall be half of the maximum test load or the test load which corresponds with the allowable settlement, whichever shall be the smaller. The allowable settlement shall be as specified on the Drawings.

iii) Ultimate Test Load

The ultimate test load in the compression-load test shall be the load where settlement suddenly increases disproportionately to the load applied. If critical creep load in compression of pile has to be determined according to BS EN 1997 -1:2004 + A1:2014, the following shall be used.

The critical creep load in compression of pile F_{cr} is defined as the load beyond which the rate of axial pile displacement under constant load takes place with a notably increased increment. Using the load –creep rate plot, it is defined by the intersection of lines through the first pseudo linear segment and passing through the last points of the curve.

For piles in compression, it is often difficult to define an ultimate limit state from a load settlement plot showing a continuous curvature. In these cases, settlement of the pile top equal to 10% of the pile base diameter should be adopted as the "failure" criterion. The safe load shall be half of the load corresponding to settlement of pile top equal to 10% of the pile base diameter.

The ultimate test load in the tension-load test shall be the load where the upward movement suddenly increases disproportionately to the load applied or the load producing a permanent rise of 10 mm at the top of the pile, whichever is the smaller.

(b) Defective Piles

The test pile and the piles represented by the test pile shall be classified as defective if shown in terms of SECTION 6100 to have a maximum working load of less than the specified working load, or to exhibit excessive settlement. Defective piles shall also include piles damaged beyond repair, piles with structural defects, or piles which do not comply with the tolerance requirements of SECTION 6800.

If required, the defective piles shall be corrected by the Contractor at their own cost, by applying one of the following methods approved by the Engineer:

- i. Extracting the pile and replacing it with a new pile.
- ii. Installing a new pile adjacent to the defective pile.
- iii. Lengthening the pile to the correct length if defective in length only.
- iv. Altering the design to fit in with the new conditions caused by the defective pile(s).

(c) Standing Time in Respect of Pile-Installation Frames

Standing time shall only be paid for pile installation frames standing during normal working hours as laid down in the General Conditions on Contract for such periods during which the pile installation work has come to a standstill following an action by the Employer.

As soon as the pile installation frames have come to such a standstill, the Contractor shall inform the Engineer, in writing that they intend to claim standing time, and shall also furnish:

- i. Full particulars of the action which gave rise to the claim; and
- ii. A list of pile-installation frames in respect of which standing time will be claimed, complete with date and time.

The period in respect of which a claim is lodged shall become operative from the moment when the notice has been handed over to the Engineer and shall continue until the restriction has been removed and normal procedure may be resumed.

(d) Pile Integrity Testing (PIT)

Pile integrity testing is a non-destructive test method for checking the integrity of piles. The purpose of these tests is to prove that the technique used in constructing the piles is satisfactory, by checking for necking of concrete in the pile shafts, honeycombs, cross section, grout loss and segregation of aggregates. It also checks the length of pile constructed. The pile integrity tests shall be done by following any of the two methods given below.

i) Low Strain Integrity Testing of Piles: Sonic Echo/ Impulse Response (SE/IR):

The pile integrity of individual vertical or inclined piles is determined by measuring and analysing the velocity (required) and force (optional) response of the pile induced by an (handheld hammer or other similar type) impact device applied axially to the pile normally at the pile head. This test method is applicable to long structural elements that function in a manner similar to foundation piles, regardless of their method of installation provided that they are receptive to low strain impact testing. The test shall be carried out by following the procedure given in ASTM D 5882:2016.

ii) Ultrasonic Cross Hole/ Cross Hole Sonic Logging (CHSL) Testing Of Piles:

This test measures the propagation time and relative energy of an ultrasonic pulse between parallel access ducts installed in the pile. This method is most applicable when performed between tubes that are installed during pile construction. Two ultrasonic probes, one a transmitter and the other a receiver, are lowered and lifted usually in unison in their respective water-filled access ducts to test the full shaft length from top to bottom. The transmitter probe generates ultrasonic pulses at frequent and regular intervals during the probes-controlled travel rate. The probe depth and receiver probe's output (timed relative to the transmitter probe's ultrasonic pulse generation) are recorded for each pulse. The receiver's output signals are sampled and saved as amplitude versus time. The test shall be carried by following the procedure given in ASTM D 5882:2016.

6117 CAISSONS

(a) General

Caissons shall, for the purposes of these Specifications, be hollow concrete vessels which are wholly or partly constructed at a higher level and lowered by internal excavation or kentledge to the desired founding level to form structural bearing members. Caissons may be of circular, rectangular or any other shape and may contain one or more excavation compartments, all as detailed on the Drawings.

Unless otherwise specified hereafter, the provisions of BS 8004:2015+A1:2020 shall apply in regard to the construction of caissons.

(b) Construction and Sinking

A firm horizontal base shall be prepared on which the cutting edge of the caisson shall be laid truly horizontally. The level of the base shall be determined and shall be agreed on by the Engineer and the Contractor, and shall serve as the ground surface from which the excavation inside the caisson will be measured.

Successive stages of the caisson shall be of convenient height, or as directed by the Engineer, and shall be lined up accurately with the preceding stages.

All precast elements shall have properly constructed joints in accordance with the Drawings to ensure that they fit snugly together.

For in situ phase construction, all construction joints in the walls shall be reinforced and the joints shall be made as specified in CLAUSE 6408.

The lowest element of every caisson, which contains the cutting edges, shall be cured for at least four days or shall have attained at least 50% of the specified 28-day strength before sinking is commenced. Subsequent elements shall be cast in sufficient time to ensure adequate strength for safely resisting the applied forces.

During construction and sinking, the caissons shall be

maintained truly vertically and kept in their correct positions.

The position and inclination of each caisson shall be determined accurately by measurement after every 2m of sinking, or after sinking through the depth of one element, whichever distance is the smaller.

With a view to eliminating excess friction, the Contractor may use bentonite or a similar lubricant, or a water-jet system.

Excavation inside caisson compartments shall, unless otherwise specified herein, comply with the provisions of CLAUSE 6105.

In multi-compartmented caissons, the excavation in any one compartment shall not be taken deeper than 0.6m below that in any other compartment, except where necessary for correcting deviations.

Cutting edges shall be frequently inspected or probed to locate obstacles, which shall be removed immediately.

The Contractor shall supply all grabs, pumps, diving gear and other constructional plant required for sinking and founding all caissons and shall allow the Engineer to use the diving suit and equipment for inspection purposes.

The Contractor shall employ a competent diver to carry out work under water and shall make provision in the rates bid for the respective items for this cost.

Where the caisson strikes a hard inclined layer and work has to be carried out below the cutting edge, such work shall be measured and paid for under the relevant items of CLAUSE 6118, and, where no applicable items exist, such work shall be paid for as extra work.

Should the Contractor wish to apply the pneumatic caisson method (with a compressed air chamber) for construction, they shall furnish the Engineer with full details of the constructional plant, equipment and method to be used for approval.

(c) Founding

The material at the founding level, if sloping and/or irregular, shall in so far as is possible be cut to as nearly level a surface as possible until the entire cutting edge is evenly and firmly supported on the material. Subject to the approval of the Engineer, blasting may be used for this purpose. If blasting should be resorted to, only light charges may be used and the caisson shall be protected against damage by suitable cushioning being provided.

Should the sloping surface be of hard rock which cannot be cut or broken by any safe and feasible means, the foundation shall be built up by means of a solid wedge of concrete which fills the entire space between the bedrock surface and the horizontal plane through the cutting edge. This concrete shall be of the same class as that specified on the Drawings or in the Bill of Quantities for the concrete seal.

The rock or hard material on which the structure is to be founded shall be completely uncovered. The founding surface shall be cleared of all loose material before inspection by the Engineer immediately prior to casting the concrete seal.

No concrete shall be placed in the wedge or the seal before the Engineer has inspected and approved the foundation. For this purpose, the Contractor shall adequately dewater the caisson to enable the Engineer to conduct the inspection.

In the event of a caisson not being vertical or in its correct position when it has reached the required depth, or in the event of a caisson being cracked during the sinking process, the Contractor shall at their own cost carry out the necessary remedial work to the satisfaction of the Engineer.

(d) Data

The Contractor shall provide the Engineer with a complete record of the types of material excavated during sinking, together with the level at which each type of the material was found. In addition, a log showing the rate of sinking shall be kept by the Contractor and furnished to the Engineer.

(e) Filling the Caissons

i) Concrete Seal

The seal shall be constructed of mass concrete of the class specified and shall be placed in accordance with the dimensions and levels shown on the Drawings or as prescribed by the Engineer.

If this seal cannot be placed in the dry and has to be placed under water, the method of placing this concrete shall be approved by the Engineer. The Contractor shall cease placing the concrete under water when sufficient concrete has been placed to seal the foundation effectively.

After the concrete has been placed, the concrete seal and the head of water over it shall remain undisturbed for a period of at least seven days after which the caisson shall be dewatered by pumping for inspection. If more water is still leaking into the caisson, the process of sealing as specified herein shall be continued until the water level within the caisson does not rise at a rate exceeding 10 mm per hour.

The relevant requirements of SUB-CLAUSE 6114 (a) shall apply for placing the concrete under water. For concrete placed under water by methods other than by tremie, the cement content shall be 20% more than the quantity required for ordinary concrete of the same mix but shall be not less than 450 kg/m³ of concrete.

ii) Filling

Subsequent to inspection of the caisson compartments above the concrete seal, the compartments shall be filled with sand. The sand shall be sufficiently wetted to obviate bulking.

The first 2 m of filling above the concrete seal shall be lowered gently into position. The sand may then be poured from the top and compacted sufficiently to prevent settlement while the cover slab concrete is being placed.

The top of the sand fill within the caisson shall be finished off to the level specified below the underside of the caisson cover slab.

(f) Stripping

Where the walls of the caisson have been overbuilt, the concrete shall be stripped to the required level without damage being done to the concrete below the cut-off level. The longitudinal reinforcement of the caisson shall project above the cut-off level by a distance of at least 40 times the bar diameter.

(g) Concrete Blinding Below the Caisson Cover Slabs

A concrete blinding of the specified thickness and class of concrete shall be provided to the level shown on the Drawings over the area covered by the cover slab, including the area within the caissons on top of the sand filling, except where the underside of the cover slab is being formed with formwork.

(h) Environmental Considerations

Water quality and marine life shall not be adversely affected in any way during operations.

Where adverse impacts have been indicated in the Environmental Impact Assessment Report, the

Contractor shall carry out such measures as required to mitigate and minimise negative impacts to the water quality and marine life.

The Engineer shall approve all methods that the Contractor proposes according to the Environmental Impact Assessment Report.

6118 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
61.01 ADDITIONAL FOUNDATION INVESTIGATIONS:	PROVISIONAL SUM

A provisional sum shall be provided in the Bill of Quantities to cover the cost of this work.

The work authorised by the Engineer shall be paid for in accordance with the provisions of the Conditions of Contract.

<u>ITEM</u>	<u>UNIT</u>
61.02 EXCAVATION:	
(a) COMMON EXCAVATION IN SOFT MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(i) 0 m UP TO 2 m	CUBIC METRE (m ³)
(ii) 2 m UP TO 4 m	CUBIC METRE (m ³)
(iii) FURTHER INCREMENTS OF 2 m	CUBIC METRE (m ³)
(b) EXTRA-OVER SUB-ITEM 61.02 (A) FOR EXCAVATION IN ROCK IRRESPECTIVE OF DEPTH	CUBIC METRE (m ³)

The limits for the successive depth ranges shall be measured down from the surface levels described in SECTION 6100 to the founding level agreed on.

In the case of excavations that are required for diverting, channelling or widening watercourses, the successive depth ranges for those portions of the excavations that are within 5 m of a concrete structure shall be measured from the surface levels agreed on to the invert level of the channel or watercourse.

The unit of measurement shall be the cubic metre of material, measured in the original position before excavation. The quantity of excavation for each depth range shall be calculated from the neat outlines of the base or floor and the depth of excavation completed within each range.

Irrespective of the total depth of the excavation, the quantity of material within each depth range shall be measured and paid for separately.

At the concrete faces for which formwork has to be provided, additional excavation shall be measured to 0.5 m outside the concrete perimeter to make provision for a working space.

Where foundation fill is constructed in an excavation, the quantity of excavated material measured for payment shall be the material excavated between the average ground level, as described in SUB-CLAUSE 6105 (b), and the founding level, from a prism with vertical sides, as described in CLAUSE 6109 or as prescribed by the Engineer.

In no case shall any of the following excavations be included in the measurement for payment:

- The volume of excavation in excess of the above-mentioned limits.
- The volume included within the excavated road prism, contiguous channels, ditches, etc., for which

payment is provided elsewhere in the Specifications.

The bid rates shall include full compensation for excavation in each class of material, the spoiling or stockpiling of materials, the hauling of excavated material for the free haul distance as defined in SUB-CLAUSE 1602 (c), any additional excavation the Contractor may require for additional working space outside the authorised limits, trimming and cleaning the bottoms and sides of excavations, and strutting, shoring and safeguarding the excavations.

If after a foundation excavation has been completed, cleaned and trimmed ready for concrete blinding, the Engineer orders further excavations to be made on account of changed dimensions and/or founding conditions, an extra over payment (SUB-ITEM 61.02 (c)) on the additional excavation measured for payment shall be payable in full compensation for any incidentals to the Contractor over and above the normal excavation costs.

<u>ITEM</u>	<u>UNIT</u>
61.03 ACCESS AND DRAINAGE:	
(a) ACCESS	LUMP SUM
(b) DRAINAGE, WHERE NO LUMP SUM ACCESS HAS BEEN PROVIDED	LUMP SUM

The bid lump sum for ITEM 61.03 (a) shall include full compensation for providing access which, inter alia, shall include constructing temporary banks, artificial islands and/or cofferdams; their protection, safeguarding and maintenance; draining and keeping dry the working areas; draining the excavations within the access; and any incidentals in respect of work to be done below standing water.

75% of the lump sum will be paid when the access has been constructed. The remaining 25% will be paid after the access has been removed.

Payment for ITEM 61.03 (b) will be made for this work by way of a lump sum for each structure or series of structures appearing separately in the Bill of Quantities. The lump sum shall be paid on a pro rata basis as the work progresses.

The bid lump sum shall include full compensation for draining by pumping or in any other way and for any other work necessary for keeping the excavation dry or for working in the dry.

<u>ITEM</u>	<u>UNIT</u>
61.04 BACKFILL	
(a) THE EXCAVATED PORTION	
(i) MATERIAL FROM THE EXCAVATIONS	CUBIC METRE (m ³)
(ii) IMPORTED MATERIAL	CUBIC METRE (m ³)
(iii) SOIL CEMENT	CUBIC METRE (m ³)
(b) BEHIND THE EARTH RETAINING STRUCTURE	
(i) MATERIAL FROM THE EXCAVATIONS	CUBIC METRE (m ³)
(ii) IMPORTED MATERIAL	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of backfill material measured in the excavation, excluding the volume occupied by the structure. The quantity measured shall be calculated from within the neat outlines defined for the excavation under ITEM 61.02 and the height to which the backfilling is constructed. The volume occupied by the structure shall be subtracted when calculating the volume of backfilling.

The height shall be determined by the upper surface of the road prism or the reference ground surface (SUB-

CLAUSE 6105 (b)), whichever is the lower.

The bid rates shall include full compensation for furnishing and placing all materials within the entire excavation, transporting the material and preparing, processing, shaping, watering, mixing and compaction of the material to the specified densities.

No overhaul shall be paid.

<u>ITEM</u>	<u>UNIT</u>
61.05 FOUNDATION FILL CONSISTING OF:	
(a) ROCK FILL	CUBIC METRE (m ³)
(b) CRUSHED STONE FILL	CUBIC METRE (m ³)
(c) COMPACTED GRANULAR MATERIAL	CUBIC METRE (m ³)
(d) MASS CONCRETE (CLASS INDICATED)	CUBIC METRE (m ³)
(e) CONCRETE BLINDING (THICKNESS AND CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of approved material placed and compacted below the bases as specified or where directed by the Engineer.

The quantity of foundation fill to be measured for payment shall be the material contained within the prism specified in CLAUSE 6109 or shall otherwise be the quantity to the outlines shown on the Drawings or as directed by the Engineer.

The bid rates shall include full compensation for procuring, furnishing, transporting, placing and compaction of the material.

No overhaul shall be paid.

<u>ITEM</u>	<u>UNIT</u>
61.06 ESTABLISHMENT ON THE SITE FOR THE DRILLING OF HOLES (TYPE OF DRILLING INDICATED)	LUMP SUM

The bid lump sum shall include full compensation for establishment on the site, moving to individual bridge positions and the subsequent removal of all special plant for drilling the holes and additional plant for carrying out operations, the cost of which does not vary with the actual amount of work to be done.

This work will be paid for by way of a lump sum, 75% of which will become payable when all the equipment is on the site and the first hole has been drilled. The remaining 25% will become payable after all the holes have been drilled and the equipment has been removed from the site.

<u>ITEM</u>	<u>UNIT</u>
61.07 DRILLING OF HOLES (DIAMETER AND TYPE OF DRILLING INDICATED)	METRE (m)

The unit of measurement shall be the metre of hole drilled.

The bid rate shall include full compensation for drilling and clearing the holes as specified, equipment moving and setting up in position, drilling and clearing the holes as specified. Where no provision has been made for payment in the Bill of Quantities under ITEM 61.09, the bid rate shall also include full compensation for work falling under that item.

<u>ITEM</u>	<u>UNIT</u>
61.08 GROUTING (TYPE OF GROUT AND FOR WHICH PURPOSE IT IS REQUIRED INDICATED)	KILOGRAM (kg)

The unit of measurement for grouting shall be the kilogram of cement or proprietary brand of grout mix as may be applicable used in the grouting operation.

The bid rate shall include full compensation for providing the equipment and all the material, and mixing and pumping the grout into the prepared holes in accordance with the instructions of the Engineer, and also for the water-pressure tests.

<u>ITEM</u>	<u>UNIT</u>
61.09 DOWEL BARS (TYPE, DIAMETER AND LENGTH OF DOWEL BARS TOGETHER WITH TYPE OF GROUT, INDICATED)	KILOGRAM (kg)

The unit of measurement for the dowel bars shall be the kilogram of bars provided and secured in position. The bid rate shall include full compensation for supplying all the material and positioning and grouting the dowel bars as specified.

<u>ITEM</u>	<u>UNIT</u>
61.10 FOUNDATION LINING (TYPE OF MATERIAL AND THICKNESS INDICATED)	SQUARE METRE (m ²)

The unit of measurement for foundation lining shall be the square metre of concrete surface lined.

The bid rate shall include full compensation for procuring, furnishing, lapping and placing all material and for all labour and incidentals required for completing the work as specified.

<u>ITEM</u>	<u>UNIT</u>
61.11 ESTABLISHMENT ON THE SITE FOR PILING	LUMP SUM

The bid lump sum shall include full compensation for generally levelling the piling site, establishing on the site and subsequently removing all structural platforms, rafts, and all special constructional plant and equipment for foundation piling and for carrying out operations, the cost of which does not vary with the actual amount of piling done.

This work will be paid for by way of a lump sum, 50% of which will become payable when all equipment is on the site and the first pile has been installed. The second instalment of 25% of the lump sum will be payable after half the total number of piles have been installed, and the final instalment of 25% after all the piles have been completed and the equipment has been removed from the site.

<u>ITEM</u>	<u>UNIT</u>
61.12 MOVING TO, AND SETTING UP THE EQUIPMENT AT EACH POSITION FOR INSTALLING THE PILES	NUMBER (no.)

The unit of measurement shall be the number of positions to which the installation equipment has to be moved and set up in position. The quantity measured shall be the number of piles installed plus the number of piles red-riven on the instruction of the Engineer, plus any piles provided in addition for load tests, which do not form part of a specific pile group.

<u>ITEM</u>	<u>UNIT</u>
61.13 AUGERED OR BORED HOLES FOR PILES WITH A DIAMETER OF (DIAMETER INDICATED) THROUGH MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(a) AUGERED HOLES:	
(i) 0 M UP TO 10 M	METRE (m)
(ii) EXCEEDING 10 M, UP TO 15 M	METRE (m)
(iii) FURTHER INCREMENTS OF 5 M	METRE (m)
(b) BORED HOLES:	
(i) 0 m UP TO 10 m	METRE (m)
(ii) EXCEEDING 10 m, UP TO 15 m	METRE (m)
(iii) FURTHER INCREMENTS OF 5 m	METRE (m)
(c) CONTINUOUS FLIGHT AUGER HOLES:	
(i) 0 m UP TO 10 m	METRE (m)
(ii) EXCEEDING 10 m, UP TO 15 m	METRE (m)
(iii) FURTHER INCREMENTS OF 5 m	METRE (m)

The limits for the successive depth ranges shall be measured down from the average ground surface (SUB-CLAUSE 6113 (h)) to the agreed founding level (CLAUSE 6106).

The unit of measurement shall be the metre of hole, including the depth of the bulbous base formed, as may be applicable. The depth of the bulbous base shall be deemed to be equal to the diameter of a sphere, the volume of which shall be equal to the quantity of compacted concrete in the bulbous base.

Irrespective of the total depth of the hole, the quantity within each depth range shall be measured and paid for separately.

The bid rates for forming augered holes shall include full compensation for augering and disposing of surplus material resulting from the hole having been formed.

The bid rates for forming bored holes shall include full compensation for boring, supplying, installing and extracting the driven temporary casing as well as for disposing of surplus material resulting from the hole having been formed.

<u>ITEM</u>	<u>UNIT</u>
61.14 DRIVING THE TEMPORARY CASING FOR DRIVEN DISPLACEMENT PILING SYSTEMS FOR FORMING HOLES FOR PILES WITH A DIAMETER OF (DIAMETER INDICATED) THROUGH MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(a) 0 M UP TO 10 M	METRE (m)
(b) EXCEEDING 10M, UP TO 15 M	METRE (m)
(c) FURTHER INCREMENTS OF 5 M	METRE (m)

The limits for the successive depth ranges shall be measured down from the average ground surface to the agreed founding level (CLAUSE 6106).

The unit of measurement shall be the metre of hole plus the depth of bulbous base formed as may be applicable. The depth of the bulbous base shall be deemed to be equal to the diameter of a sphere, the volume of which shall be equal to the quantity of compacted concrete in

the bulbous base. Irrespective of the total depth of the hole, the quantity within each depth range shall be measured and paid for separately. The bid rates shall include full compensation for supplying, driving and subsequently extracting the temporary casing.

<u>ITEM</u>	<u>UNIT</u>
61.15 MANUFACTURING, SUPPLYING AND DELIVERING PREFABRICATED PILES (TYPE AND SIZE INDICATED).	METRE (m)

The unit of measurement shall be the metre of accepted prefabricated pile delivered on the site in accordance with the Engineer's written instructions.

The bid rate shall include full compensation for supplying all the materials, manufacturing, transporting and delivering to the point of use and handling the prefabricated piles.

<u>ITEM</u>	<u>UNIT</u>
61.16 INSTALLATION OF PREFABRICATED PILES (TYPE AND SIZE INDICATED) THROUGH MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(a) 0 M UP TO 10 M	METRE (m)
(b) EXCEEDING 10 M, UP TO 15 M	METRE (m)
(c) FURTHER INCREMENTS OF 5 M	METRE (m)

The limits for the successive depth ranges shall be measured down from the average ground surface to the founding depth agreed on (CLAUSE 6106).

The unit of measurement shall be the metre of prefabricated pile installed. That part of the prefabricated pile projecting above the average ground surface shall not be measured and paid for.

Irrespective of the total length of pile installed, the quantity installed within each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for hoisting and driving the pile.

<u>ITEM</u>	<u>UNIT</u>
61.17 EXTRA OVER ITEM 61.16, IRRESPECTIVE OF THE DEPTH TO FORM AUGERED AND BORED PILE HOLES THROUGH IDENTIFIED OBSTRUCTIONS CONSISTING OF:	
(a) COARSE GRAVEL WITH A MAXIMUM CONTENT OF LESS THAN (MAXIMUM PERCENTAGE INDICATED)	METRE (m)
(b) BOULDERS (DESCRIPTION OF AND MAXIMUM SIZE INDICATED)	METRE (m)
(c) ROCK FORMATION (DESCRIPTION AND CLASS OF ROCK INDICATED)	METRE (m)

The unit of measurement shall be the metre of pile hole formed through the identified obstruction, measured from the depth at which the identified obstruction is encountered to the depth at which normal auger drilling or boring can be resumed or another type of identified obstruction is encountered.

The bid rates shall include full compensation for all additional work and incidentals required for forming the pile hole through the identified obstruction.

Where obstructions other than those provided for in ITEM 61.19 can be identified, they shall be described on the Drawings and/or in the Special Specifications. Provision therefor shall be made in the Bill of Quantities under extensions to ITEM 61.19.

<u>ITEM</u>	<u>UNIT</u>
61.18 FORMING AUGERED AND BORED PILE HOLES THROUGH UNIDENTIFIED OBSTRUCTIONS	PROVISIONAL SUM

A provisional sum shall be allowed in the Bill of Quantities for covering the cost of this work.

Payment for the work authorised by the Engineer shall be in accordance with the provisions of the Conditions of Contract.

<u>ITEM</u>	<u>UNIT</u>
61.19 DRIVING TEMPORARY CASINGS FOR DRIVEN DISPLACEMENT PILING SYSTEMS OR INSTALLING PREFABRICATED PILES THROUGH IDENTIFIED OR UNIDENTIFIED OBSTRUCTIONS	PROVISIONAL SUM

A provisional sum shall be allowed in the Bill of Quantities for covering the cost of this work.

The method of payment for the work authorised by the Engineer shall be in accordance with the provisions of the Conditions of Contract.

<u>ITEM</u>	<u>UNIT</u>
61.20 EXTRA OVER ITEMS 61.16, 61.17 AND 61.19 FOR RAKING PILES:	
(a) HOLES FOR PILES OF (DIAMETER AND RAKE INDICATED)	METRE (m)
(b) TEMPORARY CASING FOR DRIVEN DISPLACEMENT PILE SYSTEMS (DIAMETER AND RAKE INDICATED)	METRE (m)
(c) PREFABRICATED PILES (TYPE, SIZE AND RATE INDICATED)	METRE (m)

The bid rates shall include full compensation for all additional work and incidentals for forming the pile holes or for driving and later extracting the temporary casing, or for installing prefabricated piles to the rake shown.

<u>ITEM</u>	<u>UNIT</u>
61.21 FORMING UNDERREAMS FOR PILES OF (DIAMETER INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of pile holes underreamed. The bid rate shall include full compensation for all work to be done in forming the underreams, but shall exclude the concrete work.

<u>ITEM</u>	<u>UNIT</u>
61.22 FORMING THE BULBOUS BASES FOR PILES OF (DIAMETER INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of bulbous bases formed.

The bid rate shall include full compensation for all work to be done in forming the bulbous bases but shall exclude the concrete work.

<u>ITEM</u>	<u>UNIT</u>
61.23 SOCKETING PILES INTO ROCK FORMATION	
(a) HARD ROCK	METER (m)
(b) OTHER THAN HARD ROCK	METER (m)

The unit of measurement shall be the length of sockets, the length of which shall be not less than the specified length, formed in rock, the hardness of which shall be not less than that of the specified class of rock.

The bid rate shall include full compensation for all work to be done for socketing into the rock formation.

<u>ITEM</u>	<u>UNIT</u>
61.24 INSTALLING AND REMOVING TEMPORARY CASINGS IN AUGERED HOLES FOR PILES OF (DIAMETER INDICATED)	METRE (m)

The unit of measurement shall be the metre of temporary casing installed as directed by the Engineer or shown on the Drawings. Only the installed temporary casing below the average ground surface (SUB-CLAUSE 6113 (h)) shall be measured for payment.

The bid rate shall include full compensation for supplying, installing and removing the temporary casings.

<u>ITEM</u>	<u>UNIT</u>
61.25 INSTALLING PERMANENT PILE CASING FOR PILES OF (DIAMETER INDICATED)	METRE (m)

The unit of measurement shall be the metre of permanent casing installed as instructed by the Engineer or shown on the Drawings. The bid rate shall include full compensation for supplying and installing permanent pile casing.

<u>ITEM</u>	<u>UNIT</u>
61.26 STEEL REINFORCEMENT IN CAST IN SITU PILES:	
(a) MILD-STEEL BARS	TONNE (t)
(b) HIGH-YIELD-STRESS-STEEL BARS (TYPE INDICATED)	TONNE (t)

The unit of measurement for steel bars shall be the tonne of reinforcement in place in accordance with the Drawings or as authorised.

Ties and other steel used for keeping the reinforcing steel in position shall be measured as steel reinforcing under the appropriate SUB-ITEM.

The bid rates shall include full compensation for supplying, delivering, cutting, bending, welding, trial welds, placing and fixing the steel reinforcing, including all tying wires, spacers and waste.

<u>ITEM</u>	<u>UNIT</u>
61.27 CAST IN SITU CONCRETE IN PILES, UNDERREAMS, BULBOUS BASES AND SOCKETS (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m³)

The unit of measurement shall be the cubic metre of concrete placed in the cast in situ piles underreams, bulbous bases and sockets. The quantity shall be calculated from the nominal pile diameter and length of pile from the founding level to the specified cutting-off level, plus the additional quantity of concrete in the underream and bulbous base as may be relevant.

The bid rate shall include full compensation for supplying and storing all material, providing all constructional plant, mixing, transporting, placing and compacting the concrete, curing the concrete and repairing defective concrete. Payment shall distinguish between the different classes of concrete.

<u>ITEM</u>	<u>UNIT</u>
61.28 EXTRA OVER ITEM 61.27 FOR CONCRETE CAST UNDER WATER	CUBIC METRE (m³)

The unit of measurement shall be the cubic metre of concrete cast under water; the quantity being calculated as for ITEM 61.27.

The bid rate shall include full compensation for all additional work, incidentals and extra cement required for placing the concrete under water.

	<u>ITEM</u>	<u>UNIT</u>
61.29	SPLICING/COUPLING PREFABRICATED PILES FOR LENGTHENING(SIZE OF PILE INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of splices/couplings in prefabricated piles for each size of pile. The bid rate shall include full compensation for all work required for splicing/ coupling the piles in accordance with the Specifications.

	<u>ITEM</u>	<u>UNIT</u>
61.30	STRIPPING/CUTTING THE PILE HEADS (TYPE AND DIAMETER/SIZE OF PILE INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of heads of each type and diameter/ size of pile stripped/ cut.

The bid rate shall include full compensation for providing all tools and stripping/cutting the pile heads.

	<u>ITEM</u>	<u>UNIT</u>
61.31	ESTABLISHMENT ON THE SITE FOR THE LOAD TESTING OF PILES	LUMP SUM

The bid lump sum shall include full compensation for the establishment on the site and subsequently removing all the special constructional plant and equipment required for conducting the load tests on piles. This cost does not vary with the number of load tests to be conducted.

Payment for this work shall be made by way of a lump sum, 100% of which will be paid after the testing assembly has been completely assembled and the first load test has been started.

	<u>ITEM</u>	<u>UNIT</u>
61.32	LOAD TESTS ON PILES (COMPRESSION/TENSION TEST, DIAMETER/ SIZE, SPECIFIED WORKING LOAD INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of load tests conducted on the instruction of the Engineer, for each specified working load.

Test piles, but not anchor piles and anchors, shall be measured as specified above for permanent piles. Anchor piles and anchors shall be deemed to form part of the testing equipment under this item.

The bid rate shall include full compensation for installing the anchor piles and anchors where necessary; conducting load tests, and processing and submitting the results.

	<u>ITEM</u>	<u>UNIT</u>
61.33	ESTABLISHMENT ON THE SITE FOR CORE DRILLING	LUMP SUM

The bid lump sum shall include full compensation for the establishment on the site and subsequently removing all the equipment required for conducting the core drilling. This cost does not vary with the quantity of work to be done. This work shall be paid for by way of a lump sum, 100% of which will become payable when the equipment has been set up at the first location and drilling has started.

	<u>ITEM</u>	<u>UNIT</u>
61.34	MOVING THE EQUIPMENT TO AND ASSEMBLING IT AT EACH LOCATION WHERE CORES ARE TO BE DRILLED	NUMBER (no.)

The unit of measurement shall be the number of locations to which the core-drilling equipment is to be moved and at which it has to be assembled.

The bid rate shall include full compensation for the cost of moving and assembling the equipment.

	<u>ITEM</u>	<u>UNIT</u>
61.35	DRILLING THE CORES (DIAMETER INDICATED) IN:	
(a)	CONCRETE	METRE (m)
(b)	FOUNDING FORMATION:	
(i)	IRRESPECTIVE OF HARDNESS	METRE (m)
(ii)	WITH A HARDNESS OF (HARDNESS INDICATED)	METRE (m)

The unit of measurement shall be the metre of hole drilled. The bid rate shall include full compensation for drilling, recovering and packing the cores, keeping the drilling records, providing core boxes, providing and installing the casings, and backfilling the holes with grout.

	<u>ITEM</u>	<u>UNIT</u>
61.36	ESTABLISHMENT ON SITE FOR CONSTRUCTING CAISSONS	LUMP SUM

The bid lump sum shall include full compensation for the establishment on site and later removing all special plant and equipment necessary for constructing the caissons. This cost shall not vary with the number of caissons constructed. This work will be paid for by way of a lump sum, 50 % of which will be paid when all the equipment is on the site and the first caisson is constructed. The second 25 % will be paid after half the caissons are completed, and the final instalment of 25 % after all caissons are complete and equipment is removed from the site.

	<u>ITEM</u>	<u>UNIT</u>
61.37	FORMWORK FOR CAISSONS (CLASS OF FINISH INDICATED)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of formwork, and only the area of formwork in contact with the finished face of the concrete shall be measured. Formwork for construction joints shall be measured for payment under Class F1 surface finish but shall be measured only for construction joints shown on the Drawings or as prescribed by the Engineer.

The bid rate shall include full compensation for supplying all the materials, erecting the falsework and formwork, constructing the forms, forming the grooves, fillets, chamfers, stop ends for construction joints, treating the forms, all accessories, and stripping and removing the formwork after completion of the work. Payment for formwork shall be made only after the formwork has been stripped and the surface finish approved.

	<u>ITEM</u>	<u>UNIT</u>
61.38	STEEL REINFORCEMENT FOR CAISSONS:	
(a)	MILD-STEEL BARS	TONNE (t)
(b)	HIGH-YIELD-STRESS-STEEL BARS (TYPE INDICATED)	TONNE (t)

The unit of measurement for steel bars shall be the tonne of reinforcement in place in accordance with the

Drawings or as may have been authorised.

Ties and other steel used for positioning the reinforcing steel shall be measured as steel reinforcing under the appropriate Sub-Item.

The bid rates shall include full compensation for supplying, delivering, cutting, bending, welding, trial welding joints, placing and fixing the steel, including all tying wire, spacers and waste.

<u>ITEM</u>	<u>UNIT</u>
61.39 CAST IN SITU CONCRETE IN CAISSONS AND CONCRETE SEALS (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)

The unit of measurement for cast in situ concrete shall be the cubic metre of concrete in place. Concrete quantities in the caissons shall be calculated from the dimensions shown on the Drawings or authorised by the Engineer, and the length of the caisson from the founding level to the specified cut-off level. The quantity of concrete in the concrete seal shall be calculated in accordance with the dimensions shown on the Drawings or authorised by the Engineer.

The bid rate shall include full compensation for procuring and furnishing all the materials, storing the material, providing all constructional plant, mixing, transporting, placing and compacting the concrete, all sealing, curing the concrete and repairing defective concrete. Payment shall distinguish between the different classes of concrete.

<u>ITEM</u>	<u>UNIT</u>
61.40 CUTTING EDGE FOR (DIAMETER/ SIZE INDICATED) CAISSONS	NUMBER (no.)

The unit of measurement shall be the number of caissons provided with cutting edges, irrespective of the material they have been constructed of.

The bid rate shall include full compensation for manufacturing, supplying, delivering and installing the complete cutting edge as well as for joining the cutting edge to the caisson unit. Where the cutting edge is of concrete and forms part of the bottom element, the bid rate shall include full compensation for all additional work required for completing the element.

<u>ITEM</u>	<u>UNIT</u>
61.41 SINKING (DIAMETER/ SIZE INDICATED) CAISSONS THROUGH MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(a) 0 M UP TO 5 M	METRE (m)
(b) EXCEEDING 5 M AND UP TO 10 M	METRE (m)
(c) FURTHER INCREMENTS OF 5 M	METRE (m)

The limits of the successive depth ranges shall be measured down from the firm horizontal base (SUB-CLAUSE 6117 (b)) to the agreed founding level (CLAUSE 6106).

The unit of measurement shall be the metre of caisson sunk.

Irrespective of the length of caisson sunk, the quantity for each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for locating and holding in position, dewatering, pumping, ken ledge and lubricating the sides of the caisson, and for all work in connection with the sinking of the caisson which is not paid for elsewhere.

<u>ITEM</u>	<u>UNIT</u>
61.42 EXCAVATION FOR CAISSONS:	
(a) EXCAVATING SOFT MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(i) 0 m UP TO 2 m	CUBIC METRE (m ³)
(ii) EXCEEDING 2 m, UP TO 4 m	CUBIC METRE (m ³)
(iii) FURTHER INCREMENTS OF 2 m DEPTHS	CUBIC METRE (m ³)
(b) EXTRA OVER SUB ITEM 61.44(A) FOR EXCAVATION IN ROCK MATERIAL IRRESPECTIVE OF DEPTH	CUBIC METRE (m ³)

The limits for the successive depth ranges shall be measured down from the firm horizontal base (SUB-CLAUSE 6117 (b)) to the excavated level inside the caisson.

The unit of measurement shall be the cubic metre of material, measured in the original position before excavation. The quantity of excavation for each depth range shall be calculated from the gross area of the caisson in plan and the depth of excavation completed within each depth range.

Irrespective of the total depth of excavation, the quantity of material within each depth range shall be measured and paid for separately. The bid rates shall include full compensation for excavation in the classified material, spoiling or stockpiling the material, hauling the excavated material for the free haul distance according to SUB-CLAUSE 1602 (c), trimming the bottom of the excavation, dewatering, pumping and removing the material leaking into the caisson before sealing.

<u>ITEM</u>	<u>UNIT</u>
61.43 FILLING THE CAISSONS	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of sand placed above the concrete seal in the caisson compartments.

The bid rate shall include full compensation for supplying and placing the sand, transporting the material and compaction of the material as specified.

No overhaul shall be paid.

<u>ITEM</u>	<u>UNIT</u>
61.44 STRIPPING THE (SIZE OF CAISSON INDICATED) CAISSON HEADS	NUMBER (no.)

The unit of measurement shall be the number of caissons of each size stripped.

The bid rate shall include full compensation for cutting away, trimming and disposing of the concrete removed.

<u>ITEM</u>	<u>UNIT</u>
61.45 PILE INTEGRITY TESTING ON BORED PILES:	
(a) LOW STRAIN INTEGRITY TESTING OF PILE	NUMBER (no.)
(b) ULTRASONIC CROSS HOLE/ CROSS HOLE SONIC LOGGING (CHSL)	NUMBER (no.)

The unit of measurement for SUB-ITEM (a) AND (b) shall be the number of piles tested.

The bid rates shall include full compensation for procuring and furnishing all materials, constructional plant and equipment, labour and any incidentals for performing tests, and performing the prescribed integrity tests, complete as specified.

SERIES 6000: STRUCTURES

SECTION 6200: FALSEWORK, FORMWORK AND CONCRETE FINISH

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6201 SCOPE

This Section covers the design, supply, erection and removal of all falsework and formwork used in the construction of permanent work. This Section also describes the classes of surface finishes on formed and unformed concrete surfaces.

6202 MATERIALS

(a) General

The materials used in the construction of falsework and formwork shall be suitable for the purpose for which they are required and be of such quality as to produce the specified standard of work. The type, grade and condition of the material shall be subject to the Engineer's approval.

(b) Falsework

The timber, structural steel and scaffolding used shall be free from defects that may prejudice the stability of the falsework. The jacks, devices, clamps and fittings shall all be in a good working order and of adequate design and strength.

(c) Formwork

i) Plywood for Formwork

The standard that classifies plywood is (BS) EN 636 and the overall harmonized (EU) or designated (UK) standard for wood-based panels is (BS) EN 13986: 2004+A1 2015. The standard gives the requirements for plywood for general purpose use and for structural load bearing applications in dry, humid and exterior conditions. It also gives a classification based on bending properties.

Additionally, Formwork and Falsework shall conform to BS5975:2019, BS EN 13377: 2002, ACI347-04 and any applicable Health and Safety Acts and Publications.

ii) Tongue-and-Groove Boarding

Tongue and-groove boarding shall be of suitably dried timber which will not warp, distort or cause discolouration of the concrete. The widths of the boards shall be as specified on the Drawings or in the Bill of Quantities or as prescribed by the Engineer. Boards shall be supplied in lengths not shorter than 3 m.

iii) Steel Forms to Exposed Surfaces

For classes F2 and F3 surface finish the individual panels shall be assembled sufficiently rigidly and so clamped as not to deform or kick during handling or under the pressure of the wet concrete.

The surfaces of forms which are to be in contact with the concrete shall be clean, free from deposits or adhering matter, ridges or spatter which will impart irregularities and blemishes to the concrete surface, and shall also be free from indentations and warps. For the Specification of structural steel for formwork reference may be made from SECTION 6700.

iv) Void Formers

Void formers used in permanent work shall be subject to the approval of the Engineer.

Where void formers of a special design are required, details thereof will be specified.

Void formers shall be manufactured from material which will not leak, tear or be damaged during the course of construction and shall be of such tight construction as to prevent undue loss of the mortar component of the concrete through leakage. The units shall be sufficiently rigid so as not to deform during handling or under the pressure of the wet concrete.

For mild-steel spiral-lock-formed void formers, the metal thickness shall be as follows, unless otherwise specified:

[1] Unbraced Void Formers

- 0.6 mm for diameters of up to 600 mm.
- 0.8 mm for diameters exceeding 600 mm and up to 800 mm.
- 1.0 mm for diameters exceeding 800 mm and up to 1000 mm.

[2] Braced Void Formers

- 0.6 mm for diameters of up to 800 mm.
- 0.8 mm for diameters exceeding 800 mm and up to 1000 mm.
- 1.0 mm for diameters exceeding 1000 mm and up to 1200 mm.
- 1.2 mm for diameters exceeding 1200 mm.

The thickness specified for braced void formers shall apply to formers internally braced with timber or equivalent braces. The braces shall be spaced at intervals not exceeding 2 m and not more than 1.0 m from the end of each unit. Timber cross braces shall consist of members with cross-sectional dimensions of at least 50 mm x 50 mm.

All hollow void-former units shall be provided with a 12 mm diameter drainage hole at each end.

v) Chamfer and Recess Fillets

Timber fillets used for forming chamfers and recesses on exposed surfaces shall be made from new material unless otherwise authorised.

vi) Jack Rods for Sliding Formwork

The jack rods, base plates and couplers shall be strong enough to carry the design load under all operating conditions without buckling, distorting or causing damage to the concrete. Jack rods which are to remain permanently embedded in the concrete shall comply with the requirements of CLAUSES 6303 AND 6305. Under no circumstances shall bent rods be used in the work.

The jack rods used shall have a diameter of at least 25 mm.

6203 GENERAL

Notwithstanding approval given by the Engineer for the

design and drawings prepared by the Contractor for the falsework and formwork, and the acceptance of the falsework and formwork as constructed, the Contractor shall be solely responsible for the safety and adequacy of the falsework and formwork and shall indemnify and keep indemnified the Employer and Engineer against any losses, claims or damage to persons or property whatsoever which may arise out of or in consequence of the design, construction, use and maintenance of the falsework and formwork and against all claims, demands, proceedings, damages, costs, charges and expenses whatsoever in respect thereof or in relation thereto.

For Works on, over, under or adjacent to any railway line which is controlled by a Rail Authority, the Contractor shall comply, inter alia, with the requirements for the preparation and submission of drawings for falsework and formwork, and the submission of certificates for the proper construction thereof, all in accordance with the relevant Rail Authority Specification.

After having constructed the falsework and formwork, and prior to placing the reinforcing steel and/or the concrete, the Contractor shall inspect the falsework and formwork. Dimensions shall be checked, unevenness of surface shall be corrected, and special attention paid to the adequacy and tightness of all bolts, ties and bracings as well as to the soundness of the foundations.

The Contractor shall give the Engineer at least 24 hours' notice of their intention to place the concrete to enable the Engineer to inspect all aspects of the completed work. However, before notifying the Engineer, the Contractor shall satisfy themselves that the work complies in all respects with the Specifications.

Concrete sections with dimensions smaller than 200 mm shall not be formed with sliding formwork unless authorised by the Engineer.

6204 DESIGN

(a) General

The Contractor's design and drawings of the falsework and formwork shall comply amongst others with all statutory requirements.

The Engineer may require the Contractor to submit to them for consideration and approval the design and drawings of the falsework and formwork for any structure. Contractor has to submit the design of falsework & formwork based on BS EN 12812:2018 or equivalent well before initiating the work. The Contractor shall submit their design criteria and calculations and detailed drawings of the falsework and formwork to the Engineer at least 14 days before the Engineer's approval is required.

- i. The formwork shall be sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and for the appropriate method of placing and compacting. The falsework and formwork shall be so arranged as to be readily dismantled and removed from the cast concrete without shock, disturbance or damage. Where necessary, the falsework and formwork shall be so arranged that the soffit form, properly supported on props only, can be retained in position for such period as may be required by maturing conditions as described in SUB-CLAUSE 6206.
- ii. If the component is to be prestressed whilst still resting on the soffit form, provision shall be made to allow for elastic deformation and any variation in weight distribution. Where it is intended to re-use formwork it shall be thoroughly cleaned and made good. Internal metal ties which require being withdrawn through hardened concrete shall not be used where either face is permanently exposed. Where internal ties are left in, they shall be provided

with a mortar cover of at least 50 mm. The jointing faces of the pocket shall be prepared with an exposed aggregate finish and dampened immediately prior to mortar filling.

- iii. Cleaning and treatment of forms: The faces of the forms in contact with the concrete shall be clean and treated with a suitable release agent, where applicable as described in sub-Clause 6205. Immediately before concreting, all forms shall be thoroughly cleaned out. The source of any compressed air used for the clearing of foreign matter from formwork shall be free from oil and other contaminants.
- iv. Projecting reinforcement and fixing devices: Where holes are needed in forms to accommodate projecting reinforcement or fixing devices, care shall be taken to prevent loss of grout when concreting or damage when striking forms.
- v. Permanent formwork or special formwork shall comply with contract specific requirement. When reinforced concrete plank permanent formwork (floor plates) is used, it shall comply with BS EN 15050+A1:2012 and contract specific document, as described in SUB-CLAUSE 6205. Gaps between permanent formwork units shall be adequately sealed to prevent leakage through the gaps. For composite steel and concrete structures where permanent formwork is used, a suitable compressible construction seal shall be placed between the steel member and the permanent formwork where they overlap, to prevent leakage of grout during subsequent concreting operations. On completion of the curing of the concrete a suitable proprietary adhesive sealant shall be placed along the external interface between the steelwork and the permanent formwork to prevent ingress of moisture. The sealant shall be compatible with the surfaces it will be in contact with and shall have comparable durability to the corrosion protection of the steelwork. In the case of the use of weather resistant steels no sealant shall be provided.

(b) Drawings

When complete details for forms and falsework are not shown on the Drawings, the Contractor shall prepare and submit Drawings according to CLAUSE 1220 of these specifications. The Contractor shall:

- i. Design and show the details for constructing safe and adequate forms and falsework that provide the necessary rigidity, support the loads imposed, and produce in the finished structure the required lines and grades.
- ii. Show the maximum applied structural load on the foundation material.
- iii. Include a drainage plan or description of how foundations will be protected from saturation, erosion, and/or scour.
- iv. Precisely describe all proposed material.
- v. Describe the material that is not describable by standard nomenclature (such as BS, AASHTO or ASTM specifications) based on the manufacturer's tests and recommended working loads.
- vi. Evaluate falsework material and ascertain whether the physical properties and conditions of the material are such that it can support the loads assumed in the design.
- vii. Furnish design calculations and material specifications showing that the proposed system will support the imposed concrete pressures and other loads.
- viii. Provide an outline of the proposed concrete placement operation listing the equipment, labour, and procedures to be used for the duration of each operation.

- ix. Include proposed placement rates and design pressures for each pour.
- x. Include a superstructure placing diagram showing the concrete placing sequence and construction joint locations.
- xi. Provide design calculations for proposed bridge falsework. A registered professional Engineer proficient in structural design shall design, sign, and seal the Drawings. The falsework design calculations shall show the stresses and deflections in load supporting members.
- xii. Show anticipated total settlements of falsework and forms. Include falsework footing settlement and joint take-up. Design for anticipated settlements not to exceed 25 mm.
- xiii. Design and detail falsework supporting deck slabs and overhangs on girder bridges so there is no differential settlement between the girders and the deck forms during placement of deck concrete.
- xiv. Design and construct the falsework to elevations that include anticipated settlement during concrete placement and required camber to compensate for member deflections during construction.
- xv. Show the support systems for form panels supporting concrete deck slabs and overhangs on girder bridges.
- xvi. Show details for strengthening and protecting falsework over or adjacent to roadways and railroads during each phase of erection and removal.
- xvii. Include intended steel erection procedures with calculations in sufficient detail to substantiate that the girder geometry will be correct.
- xviii. Submit details of proposed Anchorage and ties for void forms.
- xix. Submit separate falsework drawings for each structure, except for identical structures with identical falsework design and details, with the layout, safety provisions and calculations included. Construction of any unit of falsework shall not be started until the Drawings for that unit have been submitted, reviewed and accepted by the Engineer.

(c) Falsework

The Contractor shall make their own assessment of the allowable bearing pressure on the foundation material and shall design the footings and falsework to prevent overloading, differential settlement and unacceptable overall settlement. In assessing the allowable bearing pressure, due account shall be taken of the effect of wetting on the foundation material.

In designing the falsework, cognisance shall also be taken of the redistribution of load that may occur on account of the effect of temperature, wind force, the prestressing of curved and skewed structures, stage construction, flooding and debris.

Particular attention shall be given to providing transverse and diagonal bracing as well as rib stiffeners on cross bearers.

(d) Formwork

i) General

Formwork shall be so designed as to be sufficiently rigid to ensure that the specified dimensional tolerances can be achieved under the combined action of self-weight, dead load and imposed loads as well as the additional loads resulting from the rate of concreting, the layer thickness of the concrete cast in one operation and the method of placing and compaction.

Profiled steel sheeting (PSS) permanent formwork systems shall not contain indentations which may

form a shear connection with the in-situ concrete, unless otherwise specified in contract specific document. Protective treatment on edges and adjacent surfaces, including the edges of PSS which have been damaged by cutting, shall be restored to meet the contract specific requirements or an equivalent level of corrosion protection durability, in accordance with SERIES 6700. Only single skin panels, either flat sheet or corrugated, shall be used for glass fibre reinforced concrete (GRC) permanent formwork. Polystyrene formers shall not be used in the corrugations of GRC permanent formwork. When ribbed glass reinforced polymer (GRP) permanent formwork is used, there shall be no filler materials such as expanded polystyrene placed between the GRP ribs, which would prevent full contact between the deck concrete and the surface of the ribbed panels.

Permanent formwork panels which have dimensions that do not comply with manufacturers' dimensional tolerances shall not be used in the works. Damaged panels including those that are cracked, split or have, in the case of the GRP type, exposed steel in the ribs, shall not be used in the works. Formwork panels shall be thoroughly cleaned to remove all traces of oil or grease. Any glass fibre reinforced cement (GRC) panel which cannot be cleaned by following the manufacturers' recommendations shall be replaced.

ii) Sliding Formwork

The Contractor shall be responsible for the design of the sliding formwork. Prior to fabrication or bringing the sliding formwork and any additional equipment to the site, the Contractor shall submit drawings of the complete sliding formwork assembly to the Engineer for approval. The drawings shall show full details of the forms, jacking frames, access ladders, hanging platforms, safety rails and curing skirts as well as details of the jacks and jack layouts.

The Contractor shall be required to submit to the Engineer, before slide casting commences, an instruction manual in which the sliding techniques, jacking procedure, methods of keeping the formwork level, the procedure to be adopted to prevent bonding of the concrete to the forms and a method for releasing the forms in the event of bonding, the instrumentation and monitoring of the slide casting and correcting for verticality, twisting and levelness are described in detail.

The formwork panels shall be inclined to give a small taper, the forms being slightly wider at the bottom than at the top.

The taper shall be so designed as to produce specified concrete thickness at the mid-lift level of the form.

The spacing of the jacks with their jack rods shall be so designed that the dead load of the sliding-formwork assembly, the frictional load, and the weight of materials, personnel and equipment will be evenly distributed and within the design capacity of the jacks used.

iii) Specialized Formwork

Specialized formwork such as slipform, floating caisson, travelling form, etc. and also special formwork for pylons, towers, deck box girders, prestressed concrete, T & I girders require specialized formwork mould to be designed and detailed by a specialized manufacturer/ engineer with required capacity & capability. A set of complete working drawings and installation instructions is to be supplied to the Engineer. In case proprietary equipment is used, the supplier

shall furnish drawings, details, installation instructions etc., in the form of manuals along with the formwork.

6205 CONSTRUCTION

(a) Falsework

Falsework shall be erected in accordance with the approved drawings incorporating such modifications as required by the Engineer.

The Contractor shall take precautions to prevent deterioration of the foundations during the course of construction.

The falsework shall incorporate features that will permit adjustment to the alignment of the formwork to counter the expected settlement and deflection under load.

(b) Formwork

i) General

The formwork for bridge decks shall be erected to levels calculated from the information given on the plans for road works and bridges. The levels shall be adapted to make provision for the specified precamber as well as for the expected deflection and settlement of the fully loaded falsework and formwork. The levels shall be set out and checked at intervals not exceeding 2.5 m.

For constructing the formwork, the Contractor may, subject to the provisions of CLAUSE 6202, use any material suitable for and compatible with the class of surface finish and dimensional tolerances specified for the particular member.

Formwork shall be sufficiently rigid to maintain the forms in their correct position, shape and profile and shall be of such tight construction that the concrete can be placed and compacted without undue loss or leakage of the mortar component of the concrete.

The joints between contiguous formwork elements shall be of a tight fit and, where necessary, the joints shall be caulked, taped or packed with a sealing gasket, all at no extra payment. Paper, cloth or similar material shall not be used for this purpose.

The formwork construction shall permit accurate erection and easy stripping without shock, disturbance or damage to the cast concrete. Where necessary, the formwork assembly shall permit the removal or release of side forms independently of the soffit forms.

Metal supports, ties, hangers and accessories embedded in the concrete shall be removed to a depth of not less than the cover specified for the reinforcement. No wire ties shall be used. The resultant voids shall be filled.

All external corners shall be chamfered by fillet strips being fixed into the corners of the formwork to form 25 mm x 25 mm chamfers. Re-entrant angles need not be chamfered unless specified.

Where polystyrene or similar material, susceptible to damage is used, it shall be lined with a hard surface on the side to be concreted. The hard material shall be sufficiently resilient to ensure that the required quality of work can be achieved.

Where it is specified, all formwork ties shall be provided with recoverable truncated cones between sleeve ends and formwork faces to ensure that sleeve ends are not exposed on concrete surfaces. The cones shall have a minimum depth of 15 mm. The resultant voids shall be filled.

ii) Formwork to Enclosed Surfaces

The formwork and boards shall be so arranged as

to form a uniform and regular pattern in line with and perpendicular to the main axis of the member, unless otherwise approved or directed by the Engineer.

Joints between contiguous members shall, after caulking, taping or sealing, be treated to prevent blemishes, stains and undue marks from being imparted to the concrete surface.

Bolt and tie positions shall be so arranged that they conform to the symmetry of the formwork panels or boards. Bolt and rivet heads which will be in contact with the formed surface shall be of the countersunk type and shall be treated to prevent marks from forming on the concrete surface.

The formwork at construction joints shall be braced to prevent steps from forming in the concrete surfaces at the joints between successive stages of construction. Where moulding or recess strips are specified, they shall be neatly butted or mitred.

iii) Formwork for Open Joints

The requirements for formwork for open joints shall, unless otherwise specified, apply only to cases where the distance between opposite concrete surfaces is equal to or less than 150 mm.

Formwork for open joints shall be constructed to produce a Class F1 surface finish to concealed surfaces or a Class F2 or F3 surface finish corresponding to the in-plane surface finish of the bordering concrete surfaces. The material used and construction of the formwork shall permit its complete removal to form the open joint.

No solvent shall be used to remove formwork unless approved by the Engineer.

iv) Openings and Wall Chases

Openings and wall chases shall be provided only where indicated on the Drawings or as authorised by the Engineer. Frames for openings shall be rigid and firmly secured in position to prevent their moving. Temporary holes shall be so formed that they will not create an irregular pattern in relation to the rest of the exposed, formed concrete surface.

v) Sliding Formwork

[1] Constructional Plant and Equipment

Unless otherwise specified in the Special Specifications, hoisting equipment for sliding formwork, which operates stepwise with upward movements of between 10 mm and 100 mm will be acceptable. However, the use of linked hydraulic or pneumatic jacks is preferable, which are reversible and driven by an electrically operated pump, and which can hoist at a steady rate. The jacks shall have independent controls for regulating verticality and levelness. The jacking system shall ensure that the sliding-formwork assembly can be hoisted evenly.

The use of hoisting systems which operate without jack rods shall be subject to the approval of the Engineer.

All equipment shall be thoroughly tested and inspected before installation and shall be maintained in a good working order throughout the entire sliding operation.

The Contractor shall keep adequate back-up constructional plant, equipment and quantities of materials on the site to ensure that the slide casting can proceed without interruption.

[2] Instrumentation and Monitoring

The Contractor shall supply and install suitable instrumentation on the sliding platform and foundations and against the sides of the

structure for monitoring the height, verticality, levelness and twisting, at regular distances. The equipment used its utilisation and the frequency of recording any readings shall be approved by the Engineer. The Contractor shall be responsible for all monitoring work and shall ensure that records of all readings and measurements taken are filed systematically and are at all times available to the Engineer and the person in control of the sliding operation.

Unless otherwise specified, the verticality of the structure shall be controlled with laser alignment apparatus or optical plummets and the levelness of the sliding forms with a water-level system with reference control points placed at strategic locations.

Height and verticality shall be monitored at intervals not exceeding four hours. The readings shall be plotted immediately on graphs. When the structure is more than 10 mm out of vertical, the Engineer shall be notified immediately.

[3] Supervision

During the entire period of the sliding operation a competent person who is fully acquainted with the sliding technique and the Contractor's methods of construction shall be in attendance on the sliding platform and in control of the sliding operations.

[4] Construction

The jacking frame shall be constructed with adequate clearance between the underside of the cross members and top of the formwork to allow the horizontal reinforcement and embedded items to be correctly installed. A control procedure shall be agreed on by the Contractor and the Engineer to ensure that all the reinforcement is placed. At all times there shall be horizontal reinforcement above the level of the top of the formwork panel.

Guides shall be provided to ensure that the vertical reinforcement can be correctly placed and the specified concrete cover over the reinforcement maintained.

Where the jack rods are to be recovered, adequate precautions shall be taken in respect of their removal without damage being caused to the concrete.

Where jack rods occur at openings or wall chases, adequate lateral support shall be provided to prevent their buckling. Equipment and material shall be so distributed on the working platforms that the load will be evenly distributed over the jacks.

Guard plates shall be provided at the tops of the forms to the outside walls to prevent the concrete from falling down the outside.

The framework, forms and platforms shall be regularly cleared and the accumulation thereon of redundant concrete prevented.

The Contractor shall take all precautions to prevent contamination of the concrete by leaking oil or other causes.

[5] The Sliding Process

The Contractor shall give the Engineer 24 hours' notice of their intention to commence with slide casting. Permission to commence with the sliding shall not be given by the Engineer before the sliding-formwork assembly is fully operative and the complete stock of all materials required for the slide casting as well as back-up constructional plant and equipment are on the site.

The Contractor shall ensure that the rate of sliding is such that the concrete at the bottom of the formwork has obtained sufficient strength to support itself and all loads which may be placed on the concrete at the time, and that the concrete does not adhere to the sides of the forms.

The slide-casting operation shall be continuous, without any interruptions, until the full height of the structure has been reached, and shall be geared and organised so as to maintain an average rate of sliding of 350 mm per hour.

[6] Interruptions

When the sliding operations are delayed for more than 45 minutes, the Contractor shall prevent adhesion of the setting concrete to the formwork panels by easing the forms or moving them slightly every 10 minutes, or alternatively, where reversible jacks are used, by lowering the forms by 10 mm to 25 mm. Wherever interruptions occur, emergency construction joints shall be formed and treated in accordance with CLAUSE 6408. Before concreting is restarted, the form shall be adjusted to fit snugly onto the hardened concrete so as to prevent steps from being formed on the exposed concrete surface. When slide casting is recommenced, care shall be taken to prevent the fresh concrete from being lifted off from the old concrete.

vi) Specialized Formwork

Specialized Formwork such as slipform, floating caisson and travelling form, wherever used, shall follow complete working drawings and installation instructions supplied to the Engineer.

vii) Void Formers

Void formers shall be secured in position at regular intervals to prevent displacement and distortion during concreting. The void formers shall be supported on precast concrete blocks or rigid welded steel cradles; all subject to approval by the Engineer. The ties securing the void formers shall be attached to the formwork and cross bearers of the falsework. The void formers shall not be tied to or supported on the reinforcement.

Fibre-cement plates shall be supported so that the plate spans in the direction parallel to the orientation of the fibres. Asbestos is a banned and dangerous substance; as such asbestos fibres shall NOT be used.

viii) Preparing the Formwork

The surfaces of forms which are to be in contact with fresh (wet) concrete shall be treated to ensure non-adhesion of the concrete to the forms and easy release from the concrete during the stripping of the formwork.

Release agents shall be applied strictly in accordance with the manufacturer's instructions, and every precaution shall be taken to avoid the contamination of the reinforcement prestressing tendons and anchorages. In the selection of release agents, due regard shall be given to the necessity for maintaining a uniform colour and appearance throughout on the exposed concrete surfaces.

Before the concrete is placed, all dirt and foreign matter shall be removed from the forms and the forms shall be thoroughly wetted with water.

ix) Delay in Concreting

Formwork should be erected sufficiently before concreting so that adequate time is available for checking & inspection. If after erection of falsework and formwork concreting cannot be done due to

some unavoidable situation for a long period of time, it is advisable to remove the entire falsework and formwork and keep all the materials in safe storage.

x) Re-Use of Formwork

When the formwork is dismantled, its individual components shall be examined for damage and damaged pieces shall be removed for rectification. Such examination shall always be carried out before their use again. Before reuse all components shall be cleaned of deposits of soil, concrete or other unwanted materials. Threaded parts shall be oiled after cleaning.

All bent steel props shall be straightened before reuse. The maximum permissible deviation from straightness is 1/600 of the length. The maximum permissible axial loads in used props shall be suitably reduced depending upon their conditions. The condition of timber components, plywood and steel shuttering plates shall be examined closely for distortion and defects before reuse.

6206 REMOVAL OF FALSEWORK AND FORMWORK

Falsework and formwork shall not be removed before the concrete has attained sufficient strength to support its own weight and any loads which may be imposed on it. This condition shall be assumed to require the formwork to remain in place after the concrete has been placed, for the appropriate minimum period of time given in TABLES 6206/1 TO 6206/3, unless the Contractor can prove, to the satisfaction of the Engineer, that shorter periods are sufficient to fulfil this condition. In such a case the formwork may be removed after the shorter periods of time agreed on by the Engineer.

Formwork shall be removed only with the permission of the Engineer. The work of striking after the receipt of such permission shall be carried out under the personal supervision of a competent foreman.

Where the Engineer considers the Contractor's proposals for the removal of formwork to be premature either on account of the weather or for any other reasons he may order the Contractor to delay such removal and the Contractor shall have no claim for delay in consequence thereof.

TABLE 6206/1: REMOVING FALSEWORK AND FRAMEWORK - NORMAL COMMON CEMENT

Falsework and formwork for:	Days	
	Normal weather	Cold weather
Beam sides, walls and unloaded columns	1.5	2
Soffits of slabs and beams		
- Spans up to 3 m	7	14
- Spans 3 m to 6 m	10	17
- Spans 6 m to 12 m	14	24
- Spans over 12 m	21	30

TABLE 6206/2: REMOVING FALSEWORK AND FRAMEWORK - RAPID HARDENING COMMON CEMENT

Falsework and formwork for:	Days	
	Normal weather	Cold *) weather
Beam sides, walls and unloaded columns	1	1.5
Soffits of slabs and beams		
- Spans up to 3 m	4	7
- Spans 3 m to 6 m	7	14
- Spans 6 m to 12 m	10	18
- Spans over 12 m	18	28
*) Shorter periods may be used for sections thicker than 300 mm on approval of the Engineer.		

TABLE 6206/3: REMOVING FALSEWORK AND FRAMEWORK - CEMENT WITH MORE THAN 15% BLAST FURNACE SLAG OR FLY ASH*

Falsework and formwork for:	Days	
	Normal weather	Cold weather
Beam sides, walls and unloaded columns	3	5
Soffits of slabs and beams		
- Spans up to 3 m	10	16
- Spans 3 m to 6 m	14	24
- Spans 6 m to 12 m	21	28
- Spans over 12 m	28	36

* Also applicable to 50/50 mixture of Portland cement and milled granulated blast furnace slag.

Falsework and formwork shall be carefully removed without exposing the cast concrete to damage, disturbance or shock and at times to suit the requirements for its curing and to prevent restraint that may arise from elastic shortening, shrinkage or creep.

Weather may be regarded as being 'normal' when atmospheric temperatures adjacent to the concrete, as measured by a maximum-and-minimum thermometer, do not fall below 15°C, and as 'cold' when temperatures, similarly measured, fall below 5°C. When the minimum temperatures fall between these values, the length of the period after which the formwork may be removed, shall be between the periods specified for normal and cold weather.

Any period during which the temperature remains below 2°C shall be disregarded in calculating the minimum time which shall elapse before the forms are removed.

On continuously reinforced concrete structures the falsework and supporting formwork shall not be removed before the concrete of the last pour has reached the appropriate minimum age given in TABLE 6206/1 or the appropriate minimum strength. Where the structure is constructed in stages, the falsework and supporting formwork shall be removed as specified or authorised.

6207 FORMED SURFACES, CLASSES OF FINISH

(a) General

In addition to complying with the tolerances specified in CLAUSE 6803, the surface finish on formed concrete surfaces shall also comply with the following requirements.

(b) Class F1 Surface Finish

After repair work has been done to surface defects in accordance with SUB-CLAUSE 6208 (b), no further treatment of the as-stripped finish will be required. This

finish is required on concealed formed surfaces.

Surfaces that in the final stage will be covered with backfill shall have a finish of Class F1.

(c) Class F2 Surface Finish

This finish shall be equivalent to that obtained from the use of square-edged timber panels and boards wrought to the correct thickness, or shutter boards or steel forms arranged in a regular pattern. This finish is intended to be left as struck but surface defects shall be remedied in accordance with SUB-CLAUSE 6208 (b).

Although minor surface blemishes and slight discolouration will be permitted, large blemishes and severe stains and discolouration shall be repaired where so directed by the Engineer. This surface finish is intended for exposed formed surfaces that cannot readily be seen by the general public as in the case of culverts, remote structures and structures to which access is restricted.

Forms for permanently exposed concrete surfaces shall be lined with plywood, or other such material as approved by the Engineer. The form liner material shall be free from wrinkles, warping, open joints and other surface imperfections at the time of pouring.

(d) Class F3 Surface Finish

This finish shall be that obtained by first producing a Class F2 surface finish with joint marks which form an approved regular pattern to fit in with the appearance of the structure. All projections shall then be removed, irregularities repaired and the surface rubbed or treated to form a smooth finish of uniform texture, appearance and colour. This surface finish is required on all exposed formed surfaces unless a Class F2 finish is specified.

Unless specified to the contrary, steel forms may be used to form surfaces with a Class F3 surface finish.

(e) Board Surface Finish

This finish shall be that obtained by using tongue-and-groove timber boarding arranged in an approved regular pattern. The finish is intended to be left as struck but surface defects shall be remedied in accordance with SUB-CLAUSE 6208 (b) and large fins trimmed where directed by the Engineer.

(f) Protecting the Surfaces

The Contractor shall ensure that all concrete surfaces are protected from rust marks, spillage and stains of all kinds and other damage during construction.

For the erection of formwork, specifically for underground structure, whether sheet pile is to be used for retaining the adjacent soil mass would be decided by the Engineer and it should be done as per specifications and provisions provided under SECTION 3600A. Separate payment for sheet piling works to facilitate formwork erection would be made as specified in SECTION 3600A.

6208 REMEDIAL TREATMENT OF FORMED SURFACES

(a) General

Agreement shall be reached between the Engineer and the Contractor regarding any remedial treatment to be given after the surfaces have been inspected immediately after the formwork has been removed; the treatment shall be carried out without delay by the Contractor at their expense. No surfaces may be treated before inspection by the Engineer. Any concrete which is found to have been treated before inspection by the Engineer, shall be rejected.

(b) Repairs to Surface Defects

Surface defects such as small areas of honeycombing,

cavities produced by form ties, large, isolated blow-holes, broken corner edges, etc, shall be repaired with mortar having a cement and sand ratio equal to that of the concrete being repaired.

For the repair of large or deep areas of honeycombing and defects, special approved methods and techniques, such as pneumatically applied mortar pressure grouting, epoxy bonding agents, etc., may be used.

Where, in the opinion of the Engineer, the extent of the honeycombing or defects is of such a degree that doubt exists about the effectiveness of repair work, the Contractor shall at their own cost perform a load test in accordance with SUB-CLAUSE 6414 (b) to prove that the structural safety of the repaired member has not been prejudiced failing which, the structure shall be rebuilt in part or in full at the Contractor's cost.

Where the concrete has been damaged by adhesion to the formwork panel, the cracked and loose concrete shall be removed; or where the fresh concrete has lifted off at construction joints, the crack shall be scraped out immediately on both sides of the wall to a depth of at least 50 mm. The cavities so formed shall then be repaired as described above.

(c) Rubbing the Surfaces

If the finish of exposed formed surfaces does not comply with the requirements for uniformity of texture, appearance and colour, the Contractor shall, when so instructed by the Engineer, rub down the exposed surfaces of the entire structure or of any part of it as specified below.

The surface shall be saturated with water for at least one hour. Initial rubbing shall be done with a medium-coarse carborundum stone, where a small amount of mortar, having a sand and cement ratio equal to that of the concrete being repaired is used on the surface. Rubbing shall be continued until all form marks, projections and irregularities have been removed and a uniform surface has been obtained. The paste produced by the rubbing shall be left in place. The final rubbing shall be carried out with a fine carborundum stone and water. This rubbing shall continue until the entire surface is of a smooth, even texture and is uniform in colour. The surface shall then be washed with a brush to remove surplus paste and powder.

Where the concrete surfaces formed by sliding formwork require treatment to achieve the surface finish specified for the member, the concrete shall, as soon as the surfaces under the formwork are exposed, be floated with rubber-lined floats to the desired finish.

6209 UNFORMED SURFACES: CLASSES OF FINISH

(a) Class U1 Surface Finish (Rough)

This surface finish is required on those portions of bridge decks or culvert decks which are to receive bituminous or concrete surfacing or which are to be covered by backfilling material.

Where the placing and compacting of the concrete have been completed as specified in Clause 6407, the top surface shall be screeded off with a template to the required cross-section and tamped with a tamping board to compact the surface thoroughly and to bring mortar to the surface, so as to leave the surface slightly rough but generally at the required elevation.

(b) Class U2 Surface Finish (Floated)

This surface finish is required on sidewalks, the tops of wing walls and retaining walls, exposed concrete shoulders and unsurfaced areas on bridge decks, and the inverts of box culverts.

The surface shall first be given a Class U1 surface finish and after the concrete has hardened sufficiently, it shall be wood-floated to a uniform surface free from trowel marks. For non-skid surfaces such as on sidewalks, bridge decks and exposed culverts, the surface shall then be given a broom finish. The corrugations so produced shall be approximately 1.0 mm deep, uniform in appearance and width and shall be perpendicular to the centre line of the pavement.

(c) Class U3 Surface Finish (Smoothly Finished)

This surface finish shall be required at bearing areas and the tops of concrete railings, exposed upper surfaces of floor slabs and upper surfaces in contact with water. The surface shall first be given a Class U1 surface finish, and after the concrete has hardened sufficiently, it shall be floated with a steel float to a smooth surface to within the dimensional tolerances specified in SUB-CLAUSE 6803 (h).

Rubbing with carborundum stone after the concrete has hardened shall be allowed but under no circumstances will plastering of the surface be permitted.

6210 MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
62.01	FORMWORK TO PROVIDE (CLASS OF FINISH INDICATED AS F1, F2, F3 OR BOARD) SURFACE FINISH TO (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m ²)

	<u>ITEM</u>	<u>UNIT</u>
62.02	VERTICAL FORMWORK TO PROVIDE (CLASS OF FINISH INDICATED AS F1, F2, F3 OR BOARD) SURFACE FINISH TO (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m ²)

	<u>ITEM</u>	<u>UNIT</u>
62.03	HORIZONTAL FORMWORK TO PROVIDE (CLASS OF FINISH INDICATED AS F1, F2, F3 OR BOARD) SURFACE FINISH TO (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m ²)

	<u>ITEM</u>	<u>UNIT</u>
62.04	INCLINED FORMWORK TO PROVIDE (CLASS OF FINISH INDICATED AS F1, F2, F3 OR BOARD) SURFACE FINISH TO (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre, and only the actual area of formwork in contact with the finished face of the concrete shall be measured. Formwork for the different classes of finish shall be measured separately. Formwork for construction joints shall be measured for payment under Class F1 surface finish, but only formwork for mandatory construction joints shall be measured for payment.

The bid rates shall include full compensation for procuring and furnishing all materials required, erecting the falsework and formwork, constructing the forms, forming the grooves, fillets, chamfers and stop-ends for construction joints, treating and preparing the forms, all bolts, nuts, ties, struts and stays, stripping and removing the formwork after completion of the work, all labour, equipment and incidentals, and rubbing and surface

treatment. Payment of 80% of the amount due for formwork will be made when the formwork has been removed, and payment of the remaining 20% will be made on approval of the concrete surface finish.

Note: Vertical and horizontal formwork shall be the formwork for which inclination of the finishing surface in relation to the horizontal level shall be larger and smaller than 40° respectively. Inclined formwork shall be the formwork described as such in the Bill of Quantities.

	<u>ITEM</u>	<u>UNIT</u>
62.05	PERMANENT FORMWORK (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of concrete area formed with permanent formwork.

The bid rates shall include full compensation for procuring and furnishing all the materials required, installing the formwork, and labour, equipment and incidentals.

	<u>ITEM</u>	<u>UNIT</u>
62.06	FORMWORK TO FORM OPEN JOINTS (DESCRIPTION OF MEMBER TO WHICH APPLICABLE, AND LOCATION)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of concrete area formed.

Surfaces formed prior to the construction of the final surface for completing the joint, shall be measured under ITEMS 62.01, 62.02, 62.03 OR 62.04, as may be applicable.

The bid rate shall include full compensation for procuring and furnishing all the materials required, constructing the formwork and subsequently removing all the material within the joint space, as well as labour, equipment and incidentals. Payment for formwork to open joints shall be made only after the forms and filler material have been completely removed and approval of the surface finish has been obtained.

	<u>ITEM</u>	<u>UNIT</u>
62.07	ESTABLISHMENT ON THE SITE FOR SLIDING FORMWORK OPERATIONS	LUMP SUM

The bid lump sum shall include full compensation for the establishment on the site and the subsequent removal of the complete sliding-formwork assembly, special constructional plant and equipment, and incidentals for the sliding work, the cost of which does not vary with the actual amount of sliding work done.

This work will be paid for by way of a lump sum, 75% of which will become payable when the sliding-formwork assembly and constructional plant and equipment have been fully installed at the first structural member on the site, and the remaining 25% will become payable after all sliding work has been completed and the said items have been removed from the site.

	<u>ITEM</u>	<u>UNIT</u>
62.08	TRANSPORTING TO AND SETTING UP THE SLIDING FORMWORK ASSEMBLY AT (DESCRIPTION OF EACH STRUCTURE)	NUMBER (no.)

The unit of measurement shall be the number of structures to which the complete sliding-formwork assembly has to be transported and set up in position ready to be commissioned.

The bid rate shall include full compensation for all costs

involved in dismantling, transporting and erecting the complete sliding-formwork assembly.

	<u>ITEM</u>	<u>UNIT</u>
62.09	FORMING THE CONCRETE BY SLIDING FORMWORK FOR (DESCRIPTION OF EACH STRUCTURE AND CLASS OF SURFACE FINISH TO EXPOSED SURFACES INDICATED)	METRE (m)

The unit of measurement shall be the metre height of each structure formed by sliding formwork. The quantity measured shall be the actual height of each structure formed by the sliding technique.

The bid rate shall include full compensation for sliding, instrumentation and monitoring, the maintenance of the complete sliding-formwork assembly and constructional plant and equipment, supplying, installing and recovering the jack rods, floating, repairing and treating the concrete surfaces, forming the emergency construction joints, and all labour, equipment and incidentals.

SERIES 6000: STRUCTURES

SECTION 6300: STEEL REINFORCEMENT FOR STRUCTURES

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6311 MEASUREMENT AND PAYMENT	6000-40

6301 SCOPE

This Section covers the furnishing, inspection, testing, certification and placing of reinforcing steel in concrete structures.

6302 MATERIALS

(a) Steel Bars

Steel reinforcing bars shall be high yield stress deformed bars and shall comply with the requirements of US EAS 412-2:2022, BS 4449:2005+A3:2016 or equivalent on the approval of the Engineer unless otherwise noted on the Drawings. This standard contains provisions for four steel grades, all of 500 MPa characteristic yield strength, but with different ductility characteristics. The four grades are B500A, B500B, B500C and B500D. Plain round steel bars in grade 250 shall comply with the requirements of US EAS 412-1:2019, BS 4449:2005+A3:2016 or equivalent on the approval of the Engineer unless otherwise noted on the Drawings. For each consignment of steel reinforcement delivered on the site, the Contractor shall submit a certificate issued by a recognised testing authority to confirm that the steel complies with the specified requirements.

(b) Welded Steel Fabric

Welded steel fabric shall comply with the requirements of US EAS 412-3:2019, BS EN 10080:2005 or equivalent on approval of the Engineer. Steel fabric reinforcement shall be Grades B500A, B500B or B500C conforming to BS EN 10080: 2005 AND BS 4483:2005. Steel fabric reinforcement shall be cut and bent in accordance with BS 8666. Steel fabric reinforcement shall have a minimum nominal bar size of 6 mm (8 mm for Grade B500A) Steel fabric reinforcement shall be delivered to the site in flat mats or pre-bent. The grade of wire shall be W4 in accordance with AASHTO M32 or equivalent on approval of the Engineer unless otherwise noted on the Drawings. The grid shall be 100 mm x 100 mm unless otherwise noted on the Drawings.

Welded Steel fabric shall be designated with the following information:

- Designation of the product form (welded fabric);
- Number of this European standard;

- Nominal dimensions of the product (dimensions of the wires, dimensions of the sheet, pitch of wires, overhangs); and
- Technical class(es) of the steel(s).

(c) Mechanical Couplers

Bars may be joined with approved patented mechanical devices as indicated on the drawings or as approved by the Engineer e.g. by special grade sleeves swaged onto bars in end-to-end contact or by screwed couplers. In case such devices are permitted by the Engineer, they shall develop at least 125 percent of the characteristic strength of the reinforcement bar.

The tensile properties determined on a test sample with a maximum gauge length of 610 mm, and which consists of reinforcing bars butt-jointed by a mechanical coupler shall comply with the following requirements:

- When tested in accordance with the relevant requirements of CLAUSE 5.3 OF SANS 920 or equivalent such as ISO 15835-1, the tensile properties of the test sample shall show an improvement of at least 25% on the requirements of CLAUSE 3.7 OF SANS 920, EAD160129-00-0301, EN1992-1-1, EN1998-1 or equivalent.
- Where the test sample is subjected to a load equal to 0.58 of the specified minimum yield forces of the bar, the elongation measured on the gauge length shall not exceed the calculated theoretical elongation for a 610 mm length of the bar, based on a stress of 0.58 of the specified minimum yield stresses of the bar and a Young's modulus of 200 GPa.
- The Contractor shall submit to the Engineer test certificates from a recognized testing authority to confirm that the tensile couplers offered comply with the specified requirements. All mechanical couplers used shall be subject to the approval of the

(d) Definitions

For this SECTION 6300, the following definitions shall apply:

i) Bar

A steel product of plain or deformed cross section.

ii) Hot Rolled Deformed Bar

A bar that has been so shaped during hot rolling that it conforms to either the geometrical or the performance test classification given in SUB-CLAUSE 6304.

iii) Cold Worked Deformed Bar

A bar that has been cold worked to conform to the requirements of US EAS 412-1:2019, BS 4449:2005+ A3:2016 and also conforms to either the geometrical or performance test classification given in SUB-CLAUSE 6304.

iv) Nominal Size

The diameter of a circle with an area equal to the effective cross-sectional area of the bar.

v) Batch

Any quantity of bars of one size and grade, whether in coils or bundles, produced by one manufacturer or supplier, presented for examination at any one time.

vi) Characteristic Strength

The value of yield strength having a prescribed probability of not being attained in a hypothetical unlimited test series. The characteristic value is the lower limit of the one-sided statistical tolerance interval at which there is a 90% probability (i.e. $1 - \alpha = 0.90$) that 95% ($p = 0.95$) of the values are at or above this lower limit. This definition refers to the

long-term quality level of production.

6303 STORING THE MATERIALS

Reinforcing steel shall be stacked off the ground in a clean and dry condition, on blocks, racks or platforms and, in aggressive environments, shall be stored under cover. It shall be protected at all times from contamination and corrosion. Reinforcing steel shall be protected from rusting or chloride contamination. Reinforcements shall be free from dust, mortar, loose mill scale, grease, oil or paints. This may be ensured either by using reinforcement fresh from the factory or by thoroughly cleaning it using any suitable method such as sand blasting, mechanical wire brushing etc., as directed by the Engineer.

Different grades of reinforcement shall be stored in separate locations and shall be clearly identified and logged. Steel delivered directly to site shall also be logged accordingly by the Contractor.

Details of each consignment showing source of supply; manufacturer's certificate of test strength; constituents (% carbon etc.); and date of rolling shall be submitted to the Engineer. However, this will not relieve the Contractor of any responsibility for testing the material as instructed by the Engineer.

6304 INSPECTION, TESTING AND CERTIFICATION OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

(a) Manufacturer's Inspection

i) General

All units of continuous production shall be tested according to SUB-CLAUSE 6304 (a) (ii) below.

ii) Selection of Test Specimens

The test unit shall be the cast or part quantity of the cast.

- For chemical composition, one analysis per test unit. The chemical composition (cast analysis) of the steel shall have been determined by the steel producer.
- For re-bend tests, nominal mass per metre and surface geometry, one test piece per test unit and nominal diameter.
- For tensile tests, one test piece per 30 t with at least three test pieces per test unit and nominal diameter. Where bars and coils are produced for the manufacture of welded fabric only, one tensile test piece shall be taken per 30 tons produced.

Test results shall be evaluated in accordance with US EAS 412 and BS 4449:2005+A3:2016 or equivalent.

iii) Condition of Test Specimens

The tensile and re-bend tests shall be carried out on straight bars in the delivery or accelerated aged condition. Bars with a nominal diameter of 40 mm or less shall not be machined. The condition of testing shall conform to US EAS 412 AND BS 4449:2005+A3:2016.

iv) Tensile Test

[1] Steel Grade 250

The tensile strength, yield strength and elongation at fracture A_5 shall be determined by the methods described in BS EN ISO 6892-1:2020. The upper yield strength R_{eH} shall be determined for steel showing a defined yield point. If this is not applicable, and at the discretion of the manufacturer, the 0.2% proof

strength $R_{p0.2}$ shall be determined, using an extensometer calibrated to class 2 of BS EN ISO 9513:2013 using a strain rate corresponding to a rate of loading not exceeding 10 N/mm² per second approaching the yield strength.

At the option of the manufacturer, for routine testing, the percentage total strain may be determined as an alternative to 0.2% proof stress. This is the stress on the specimen, derived from the load, corresponding to an increase in percentage total strain as specified in TABLE 6304/1 below. The strain may be measured by the extensometer in any convenient gauge length.

The 0.2% proof stress shall be used in cases of dispute.

TABLE 6304/1: ALLOWABLE PERCENTAGE TOTAL STRAIN

Percentage total strain	
Steel grade	Total strain (%)
250	0.33

For elongation values, the test results shall be regarded as valid, irrespective of the position of the fracture, provided that the minimum elongation specified in TABLE 6304/2 has been obtained.

TABLE 6304/2: TENSILE PROPERTIES OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

Grade	Yield strength (Re) 1) N/mm ²	Stress ratio (Rm/Re) 2) (min)	Elongation at fracture As (min) %	
250	250	1.15	22	-
1) For routine testing, the yield strength shall be considered a minimum value. For the determination of long-term quality level, the values given shall be for characteristic strength.				
2) Rm is the tensile strength.				

In the following cases, the test results shall be considered invalid:

- if the distance between the fracture and the nearer gauge mark is less than one third of the gauge length;

or

- If the relevant end of the gauge used for measuring the elongation is 2d or less from the face of the machine grips.

[2] For Steel Grade B500A, B500B, B500C and B500D

The specified characteristic values for the tensile properties are given in TABLE 6304/3.

TABLE 6304/3: CHARACTERISTIC TENSILE PROPERTIES OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

Grade of Steel	Yield strength, R_e MPa	Tensile/ yield strength, R_m/R_e	Total elongation at Maximum force, A_{gt} %
B500A	500	1.02	2.0
B500B	500	1.08	5.0
B500C	500	1.15	7.0
B500D	500	1.25	-
* R_m/R_e characteristics are 1.02 for sizes below 8 mm			
** A_{gt} characteristic is 1.0% for sizes below 8 mm			
Values of R_e specified are characteristic with $p=0.95$.			
Values of R_m/R_e and A_{gt} specified are characteristic with $p=0.90$			
Calculate the values of R_m and R_e using the nominal cross-sectional area.			

The absolute maximum permissible value of yield strength is 650 MPa.

For yield strength (R_e), the upper yield strength (R_{eH}) shall apply. Determine the yield strength (R_e) from the 0.2% proof strength ($R_{p0.2}$) if a yield phenomenon is not present.

TABLE 6304/4: ABSOLUTE MINIMUM & MAXIMUM VALUES OF TENSION PROPERTIES

Performance Characteristics	Minimum Value				Maximum Value			
	B500A	B500B	B500C	B500D	B500A	B500B	B500C	B500D
R_e , MPa	500	500	500	500	-	-	-	650
R_m/R_e	1.02	1.08	1.15	1.25	N/A	N/A	N/A	N/A
A_{gt} , %	2.0	5.0	7.0	-	N/A	N/A	N/A	-

By agreement between the manufacturer and purchaser, the type of elongation shall be selected between A_e and A_{gt} . If the type of elongation is not specified by agreement, A_{gt} should be used.

In the case of the bars with a diameter of 32 mm or more in ductility class D, the minimum specified characteristic value for A may be decreased by 2% for each 3 mm increase in diameter. However, the maximum dimension from the minimum specified characteristic value stated is limited to 4%

The cross-sectional area for bars of uniform section to be used for the calculation of stresses is calculated using the formula:

$$A = \frac{M}{0.00785L}$$

Where:

M is the mass of the bar (kg);

L is the length of the bar (m);

A is the cross-sectional area (mm²).

The precision for the measurement of mass and length shall be $\pm 0.5\%$ and the bar length shall not be less than 0.5 m.

v) Evaluation Of Tensile Test Results

All tensile test results shall conform to TABLE 6304/2, TABLE 6304/3 & TABLE 6304/4 above.

vi) Bend Test

[1] Sequence of Operations

- Bend Performance For 250 Grade,

The bend test shall be carried out in accordance with ISO 15630-1. The test bit shall be bent to an angle between 160° and 180° over a mandrel of the diameter specified in the TABLE 6304/5.

TABLE 6304/5: BEND TEST FORMERS FOR TESTING OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

Bend test formers		
Grade	Nominal diameter (d) (mm)	Mandrel diameter, max. ^{a b} (mm)
250	≤ 16 $16 < d \leq 22$	3d 6d

a, By agreement between the manufacturer and purchaser, larger mandrel diameters may be used.

b, For nominal diameters, larger than 22 mm, the mandrel diameters in bend tests shall be agreed between the manufacturer and purchaser.

- Bend Performance For Grade B500A, B500B, B500C & B500D

The bend test shall be carried out in accordance with ISO 15630. Bend Performance shall be demonstrated by means of the following bend test.

Bend the test pieces through an angle of 90°, around a mandrel with a diameter not exceeding those specified in TABLE 6304/6. The test piece shall be bent to an angle between 160° to 180° over a mandrel of diameter in TABLE 6304/6.

After the test, the specimen shall show no sign of fracture or cracks visible to a person of normal or corrected vision.

TABLE 6304/6: MANDREL DIAMETERS FOR BEND TEST

Grade	Nominal Diameter (d) (mm)	Maximum mandrel Diameter
B500A, B500B, B500C and B500D	$d \leq 16$ $16 < d \leq 32$ $32 < d \leq 50$	3d 6d 7d

[2] Failure in Relation to Rib Damage

In the event of a specimen failing the rebend test, if there is any damage to the ribs caused by carrying out the initial bending, the test shall be considered invalid, and shall be repeated on another specimen.

Damage to the ribs may be avoided by inserting an aluminium sheet between the specimen and the former. The aluminium sheet shall have a maximum thickness of 6 mm.

vii) Cross Sectional Area and Mass

The cross-sectional areas for the preferred sizes of bars shall conform to the values in TABLE 6304/7, while the tolerances shall conform to the values in TABLE 6304/8.

TABLE 6304/7: CROSS SECTIONAL AREA AND MASS OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

Nominal size (mm)	Cross sectional area (mm ²)	Mass per metre run (kg)
6*	28.3	0.222
8	50.3	0.395
10	78.5	0.617
12	113	0.888
14	154	1.210
16	201	1.579
20	314	2.466
25	491	3.854
32	804	6.313
40	1257	9.864
50*	1963	15.413

Diameters larger than 50 mm should be agreed upon between the purchaser and the manufacturer.

TABLE 6304/8: TOLERANCE ON MASS FOR GRADE 250

Nominal size	Tolerance on mass per metre run (%)
6 and 8	±6
10 and over	±5

TABLE 6304/9: TOLERANCE ON MASS FOR GRADE B500A, B500B, B500C AND B500D

Nominal size diameter (mm)	Tolerance on mass per metre run (%)
≤ 8	±6
> 8 ≤ 20	±5
> 25	±4

viii) Chemical Composition

The following formula shall be used to calculate the carbon equivalent value, where the chemical symbols represent the percentages of each element:

Carbon equivalent value =

$$C + Mn/6 + [Cr + Mo + V]/5 + [Ni + Cu]/15$$

In cases of dispute, the appropriate methods of test given in BS 6200-3:2002 shall be used.

Mn is the percentage manganese content;

Cr is the percentage chromium content;

V is the percentage vanadium content;

Mo is the percentage molybdenum content;

Cu is the percentage copper content;

Ni is the percentage nickel content;

[1] For Grade 250

The chemical composition of steel based on the cast analysis for grade 250 Steel, shall be in accordance with TABLE 6304/10.

Bars shall have a carbon equivalent value, based on cast analysis, not exceeding the maximum values given in TABLE 6304/11.

TABLE 6304/10: CHEMICAL COMPOSITION OF STEEL 250 GRADE: CAST ANALYSIS

Element	Grade 250 % (max.)
Carbon	0.30
Sulphur	0.040
Phosphorus	0.060
Nitrogen	0.012

Note 1: The maximum value for nitrogen does not apply if the chemical composition shows a minimum aluminium content of 0.020%, or if sufficient other nitrogen binding elements are present.
Note 2: Nitrogen content is not normally given on a release certificate.

TABLE 6304/11: MAXIMUM CARBON EQUIVALENT VALUES: CAST ANALYSIS (FOR 250 GRADE)

Grade	Maximum carbon equivalent value (%)
250	0.42

[2] For Grade 500

The value of individual elements and the carbon equivalent shall not exceed the limits given in TABLE 6304/12. The carbon equivalent value C_{eq} shall be calculated using the following formula;

The chemical composition of steel based on the cast analysis & product analysis for grade B500A, B500B & B500C steel, shall be in accordance with TABLE 6304/12.

TABLE 6304/12: CHEMICAL COMPOSITION (MAXIMUM % BY MASS)

Element	Grade B500A, B500B, B500C & B500D	
	Cast Analysis	Product Analysis
Carbon ¹	0.30	0.25
Sulphur	0.060	0.05
Phosphorus	0.060	0.05
Nitrogen ²	0.012	0.012
Manganese	1.8	1.65
Carbon equivalent	0.50	0.52

Note 1: It is permitted to exceed the maximum values of carbon by 0.03% by mass, provided that the carbon equivalent value is decreased by 0.02% by mass.
Note 2: Higher nitrogen contents are permissible if sufficient quantities of nitrogen binding elements are present.

During product analysis, any bar that falls outside the maximum specified limits in TABLE 6304/10 shall be deemed not to conform to BS 4449:2005 + A3:2016.

In cases of dispute, where a product analysis falls outside the maximum limits specified in TABLE 6304/12, the procedure defined in BS 4449:2005 + A3:2016 shall be applied to

determine whether the materials conform to this standard

ix) Product Analysis and Permitted Deviations for Grade 250 Steel

The maximum deviations on product analysis from the values specified for cast analysis (see TABLE 6304/10 AND 6304/11) shall be as given in TABLE 6304/12.

The maximum deviations on product analysis from the values specified for cast analysis (see TABLE 6304/10 AND 6304/11) shall be as given in TABLE 6304/13.

TABLE 6304/13: MAXIMUM DEVIATIONS IN CHEMICAL COMPOSITION ON PRODUCT ANALYSIS

Element	Deviation above the specified maximum given in Table 6304/5 10 and Table 6304/11 (%)
Carbon	0.02
Sulphur	0.008
Phosphorus	0.001
Total nitrogen	0.001
Carbon equivalent value	0.002
Note: The product analysis may vary from the cast analysis due to chemical heterogeneity arising during the casting and solidification process.	

Samples for product analysis shall be taken in accordance with the appropriate method of BS 6200-3:2002.

During product analysis, any bar that falls outside the maximum deviation limits for the composition range of a specified element, given in TABLE 6304/12, shall be deemed not to conform to US EAS 412 AND BS 4449:2005+ A3:2016.

If during product analysis, a single sample falls outside the maximum deviation limits for the composition range of a specified element, given in TABLE 6304/13, further samples shall be selected for analysis from the remainder of the batch as follows:

- At least two samples from the same cast for delivered masses up to 5 t;
- At least five samples from the same cast for delivered masses up to 20 t;
- At least eight samples from the same cast for delivered masses over 20 t.

If any of the further samples analysed fall outside the maximum deviation limits for any element, the batch shall be deemed not to conform to US EAS 412 AND BS 4449:2005 + A3:2016.

(b) Material Covered by a Third-Party Product Certification Scheme

i) 250 Grade

[1] Consistency of Production

To determine the production consistency of the manufacturer, the long-term quality level shall be regularly assessed. However, no conclusion regarding product conformity to US EAS 412 and BS 4449:2005+ A3:2016 shall be made on the basis of this assessment.

[2] Determination of Long-Term Quality Level

▪ Extent of testing

The results of tests on all test units of continuous production shall be collated and statistically evaluated for R_e , A_{gt} and R_m/R_e , taking either the number of results corresponding to the preceding six months'

operation or the last 200 results whichever is the greater.

▪ Evaluation

The average yield strength m shall satisfy the following:

$$m \geq cv + k\sigma$$

where

cv is the characteristic strength (N/mm²);

k is the acceptability index (see TABLE 6304/14);

σ is the standard deviation of the population.

TABLE 6304/14: ACCEPTABILITY INDEX k AS A FUNCTION OF THE NUMBER OF TEST RESULTS n (FOR A RELIABLE PASS RATE OF 5% (PASS = 0.95) AT A PROBABILITY OF 90% ($1 - \alpha = 0.90$))

n	k
5	3.40
6	3.09
7	2.89
8	2.75
9	2.65
10	2.57
11	2.50
12	2.45
13	2.40
14	2.36
15	2.33
16	2.30
17	2.27
18	2.25
19	2.23
20	2.21
30	2.08
40	2.01
50	1.97
60	1.93
70	1.90
80	1.89
90	1.87
100	1.86
150	1.82
200	1.79
250	1.78
300	1.77
400	1.75
500	1.74
1000	1.71
∞	1.64

[3] Test Certificates

▪ Certificate of Conformity

A certificate of product conformity to British Standard shall be issued when requested by the Engineer.

The certificate shall state:

- That the product materials conform to British Standard and have undergone the tests specified in British Standard, at the specified frequency;
- The address at which the records of the tests are available for inspection.

The certificate shall include the approval number issued by the certifying authority.

- Manufacturer's statement of results

- ♦ In the case of products delivered to a supplier, the manufacturer shall provide the following information:
- ♦ The cast number and cast analysis, including all specified elements and elements used for the calculation of the carbon equivalent value;
- ♦ carbon equivalent value;
- ♦ The results of the tensile and rebend tests, including the effective cross-sectional area;

The information shall include the approval number of the certifying authority.

ii) Grade 500

[1] Extent Of Testing

The results of tests on all test units of continuous production shall be collated and statistically evaluated for R_e , A_{gt} and R_m/R_e taking either the number of results corresponding to the preceding six months' operation or the last the last 200 results, whichever is greater

[2] Evaluation

The evaluation shall be carried out per nominal diameter.

The following requirement shall be satisfied for R_e , A_{gt} and R_m/R_e :

$$x - k\sigma \geq C_v$$

where:

x is the average value;

σ is the estimate of the standard deviation of the population;

k is the coefficient listed in TABLE 6304/15 for R_e and in TABLE 6304/16 for A_{gt} and R_m/R_e ;

C_v is the specified characteristic value.

The foregoing is based on the assumption that the distribution of a large number of results is normal but this is not a requirement of this standard. However, the following alternative methods may be used to establish conformity of the production with the requirements of this British Standard:

- Graphical methods including control charts;
- Non-parametric statistical techniques.

TABLE 6304/15: COEFFICIENT K AS A FUNCTION OF THE NUMBER N OF TEST RESULTS (FOR A RELIABLE FAILURE RATE OF 5 % [$P = 0.95$] AT A PROBABILITY OF 90%)

n	h	n	K
5	3.40	0	2.08
6	3.09	40	2.01
7	2.89	50	1.97
8	2.75	60	1.93
9	2.65	70	1.90
10	2.57	80	1.89
11	2.50	90	1.87
12	2.45	100	1.86
13	2.40	150	1.82
14	2.36	200	1.79
15	2.34	250	1.78
16	2.30	300	1.77
17	2.27	400	1.75
18	2.2	500	1.74
19	2.23	1000	1.71
20	2.21		1.64

TABLE 6304/16: COEFFICIENT K AS A FUNCTION OF THE NUMBER N OF TEST RESULTS (FOR A RELIABLE FAILURE RATE OF 10 % [$P = 0.90$] AT A PROBABILITY OF 90 %)

n	k	n	h
5	2.74	30	1.66
6	2.49	40	1.60
7	2.33	50	1.56
8	2.22	60	1.53
9	2.13	70	1.51
10	2.07	80	1.49
11	2.01	90	1.48
12	1.97	100	1.47
13	1.93	150	1.43
14	1.90	200	1.41
15	1.87	250	1.40
16	1.84	300	1.39
17	1.82	400	1.37
18	1.80	500	1.36
19	1.78	1000	1.34
20	1.77		1.28

[3] Test Certificates

- Certificate of Conformity

A certificate of product conformity US EAS 412 AND BS 4449:2005+A3:2016 shall be issued when requested by the Engineer.

The certificate shall state:

- ♦ That the product materials conform to US EAS 412 AND BS 4449:2005+A3:2016, and have undergone the tests specified in US EAS 412 AND BS 4449:2005+A3:2016, at the specified frequency;
- ♦ The address at which the records of the tests are available for inspection.

The certificate shall include the approval number issued by the certifying authority.

- ♦ Manufacturer's statement of results
- ♦ In the case of products delivered to a supplier, the manufacturer shall provide the following information:
- ♦ The cast number and cast analysis, including all specified elements and elements used for the calculation of the carbon equivalent value;
- ♦ The results of the tensile and bend tests, including the effective cross-sectional area;
- ♦ For deformed bars, the rolled-on mill mark.

The information shall include the approval number of the certifying authority.

(c) Material Not Covered by a Third-Party Product Certification Scheme

i) Grade 250

[1] General

Material not covered by a third-party product certification scheme shall be assessed by acceptance tests on each batch. Sampling and testing shall be carried out by an independent organization at the producer's works or in the Contractor's yard/stockholder's yard.

[2] Extent of Sampling and Testing

For testing purposes, the batch shall be divided into test units each with a maximum mass of 100 t. Each test unit shall comprise products of the same steel grade and nominal diameter of the same cast. The manufacturer shall certify that all products in the test unit originate from the same cast.

Test specimens shall be taken from each test unit as follows:

- a. Fifteen specimens (or if appropriate, 60 specimens from different bars, for testing as specified in SUB-CLAUSE 6304 (c) (iii) (a) and (b).
- b. Two test specimens, from different bars, for testing in accordance with SUB-CLAUSE 6304 (c) (iii) (c).

Preparation of test specimens shall be carried out as described in SUB-CLAUSE 6304 (a).

[3] Properties to be Tested

Specimens selected in accordance with SUB-CLAUSE 6304 (c) (ii) shall be tested for the following:

- a. Inspection by variables:
 - ♦ Tensile strength R_m ;
 - ♦ Yield strength R_e ;
 - ♦ Elongation after fracture A_5 ;
- b. Inspection by attributes:
 - ♦ Behaviour in the bend test;
 - ♦ Deviations from the nominal cross section;
 - ♦ Bond test;
- c. Chemical composition according to the product analysis

All elements listed in SUB-CLAUSE 6304 (a) (viii) and the carbon equivalent shall be determined.

The test procedures shall be as described in SUB-CLAUSE 6304 (a).

- d. Inspection by variables:
 - ♦ Tensile/ yield Ratio R_m / R_e ;
 - ♦ Yield strength R_e ;
 - ♦ Total elongation at maximum force A_{gt}
 - e. Inspection by attributes:
 - ♦ Behaviour in the bend test;
 - ♦ Deviations from the nominal mass per metre;
 - ♦ Bond strength and surface geometry..
 - f. Chemical composition according to the product analysis
- All elements listed in SUB-CLAUSE 6304 (a) (viii) and the carbon equivalent shall be determined. The test procedures shall be as described in SUB-CLAUSE 6304 (a).

- g. Fatigue properties: Grade 500

The fatigue properties of grade 500 steel shall be determined for each size and defined bar shape in the batch. Sampling and testing shall be carried out in accordance with SUB-CLAUSE 6304 (d).

All elements listed in SUB-CLAUSE 6304 (a) (viii) and the carbon equivalent shall be determined.

The test procedures shall be as described in SUB-CLAUSE 6304 (a).

[4] Evaluation of Results

- a. Inspection of variables

Inspection of variables shall be carried out as follows:

- ♦ The following shall be determined for the characteristic strength when testing for properties listed in SUB-CLAUSE 6304 (c) (iii).
 - All individual values for characteristic strength c_v for the 15 test specimens;

- The mean value for the characteristic strength m_{15} (for $n = 15$);
- The standard deviation S_{15} (for $n = 15$).

The test unit shall be deemed to conform to BS 4449:2005 + A3:2016 if all individual values of R_m/R_e and the elongation at fracture A_5 exceed values specified in TABLE 6304/2, and the following condition is fulfilled by the characteristic strength:

$$m_{15} - 2.33 \times S_{15} \geq cv$$

- ♦ If the condition for the characteristic strength stated above is not fulfilled, a secondary calculation (the acceptability index k) shall be determined, where:

$$k = \frac{m_{15} - cv}{S_{15}}$$

If $k \geq 2$, testing shall continue. Forty-five further test specimens shall be taken and tested from different bars in the same test unit, so that a total of 60 test results are available ($n = 60$).

The test unit shall be deemed to conform to BS 4449:1997 if all individual values of R_m/R_e and the elongation at fracture A_5 exceed values specified in TABLE 6403/2, and the following condition is fulfilled by the characteristic strength (1.93 is the value for the acceptability index k for $n = 60$, in accordance with SUB-CLASSES 6403 (c)):

$$m_{60} - 1.93 \times S_{60} \geq cv$$

- b. Inspection by attributes

Inspection by attributes shall be carried out as follows. When testing the properties listed in SUB-CLASSES 6304 (c) (iii) (b), either:

all the results determined on the 15 test specimens shall conform to BS 4449:2005.

- c. Fatigue properties

The batch shall be deemed to conform to BS 4449:2005+A3:2016 if it conforms to SUB-CLASSES 6304 (d).

[5] Test report

A test report shall be produced containing the following data:

- The place of manufacture of the reinforcing steels;
- The nominal diameter of the steel;
- The grade of the steel;
- The making of the steel;
- The cast number;
- The date of testing;
- The mass of the test unit;
- The individual test results for all the properties specified in SUB-CLAUSE 6304 (c) (iii).

ii) Grade 500**[1] General**

Material not covered by a third-party product certification scheme shall be assessed by acceptance tests on each batch. Sampling and testing shall be carried out by an independent organization at the producer's works or in the stockholder's yard.

[2] Extent of Sampling and Testing

For testing purposes, the batch shall be divided into test units with a maximum mass of 100 t. Each test unit shall comprise products of the same steel grade and nominal diameter from the same cast. The manufacturer shall certify that all products in the test unit originate from the same cast.

Test specimens shall be taken from each test unit as follows:

- a. Fifteen specimens from different bars, for testing as specified in SUB-CLAUSE 6304 (c) (iii) (a) and (b).
- b. Two test specimens, from different bars, for testing in accordance with SUB-CLAUSE 6304 (c) (iii) (c).

Preparation of test specimens shall be carried out as described in SUB-CLAUSE 6304 (a).

[3] Properties to be Tested

Specimens selected in accordance with SUB-CLAUSE 6304 (c) (ii) shall be tested for the following:

- a. Inspection by variables
 - ♦ tensile / yield Ratio R_m / R_e ;
 - ♦ yield strength R_e ;
 - ♦ total elongation at maximum force A_{gt}
- b. Inspection by attributes
 - ♦ behaviour in the bend test;
 - ♦ deviations from the nominal mass per metre;
 - ♦ bond strength and surface geometry..
- c. Chemical composition according to the product analysis

All elements listed in Sub-Clause 6304 (a) (viii) and the carbon equivalent shall be determined. The test procedures shall be as described in SUB-CLAUSE 6304 (a).
- d. Fatigue properties: grade -500

The fatigue properties of grade-500 steels shall be determined for each size and defined bar shape in the batch. Sampling and testing shall be carried out in accordance with SUB-CLAUSE 6304 (d).

All elements listed in SUB CLAUSE 6304 (a) (viii) and the carbon equivalent shall be determined.

The test procedures shall be as described in SUB-CLAUSE 6304 (a).

The tests shall be considered invalid if a specimen fails the test due to a defect unique to the specimen, or occurs in an area adjacent to the testing machine grips.

(d) General

Reinforcing bars, coils and decoiled products shall be subjected to fatigue testing. When submitted to axial force-controlled fatigue testing, using a stress ratio ($\sigma_{min}/\sigma_{max}$) of 0.2 and stress range as given in TABLE 6304/17. Test samples shall survive five million stress cycles.

TABLE 6304/17: FATIGUE TEST CONDITIONS

Bar Size (mm)	Stress Range (MPa)
<16	200
>16, <20	185
>20, <25	170
>25, <32	160
>32	150

[1] Bars and Coils

Reinforcing bars from each production site shall be subject to fatigue testing to determine the fatigue characteristics of a particular geometrical shape and process route. The fatigue properties for each steel grade and process route shall be established at an applicable testing laboratory, initially by testing samples selected from the upper, Middle and bottom of the product diameter range. At least once a year, samples shall be tested from different t bars or coils of one diameter from each process route. Test samples shall be selected so that all diameters for each process route shall be tested over a five-year period.

[2] Decoiled Product

Decoiled products, from each production site, shall be subject to fatigue testing. Initially, samples shall be taken from each production site from one decoiling machine type from the largest diameter produced. At a frequency of at least once per year, samples of one diameter shall be selected for test from each production site, from one decoiling machine. Sampling shall be carried out in such a way that the combination of material manufacturing route, type of decoiler and individual machines are covered over a five-year period.

[3] Sampling

Each test unit shall comprise test specimens. For each diameter, from each test unit, five bars shall be selected for the test. The test specimens shall not exhibit isolated defects that are not characteristic of the product from which they are selected

[4] Retests

The products shall be deemed to conform to this standard if all five-test pieces endure five million stress cycles

If one of the five test pieces produces a valid failure, a further five samples from the test unit shall be tested. If one of these further samples fails the test, then the material shall be deemed not to conform to this standard, and an investigation shall be carried out and appropriate actions shall be taken. If all five further test pieces endure five million stress cycles, then the material shall be deemed to comply with this standard

In the case of any failure the test shall be considered invalid if it is initiated from a defect unique to the test piece or in the area within 2d of the testing machine grips (where d is nominal bar diameter); in this case a further single test shall be carried out (see BS EN ISO 15630-1:2002).

(e) Bond Classification of Deformed Bars**[1] General**

Ribbed bars are characterized by their surface geometry, by means of which bond with the concrete is achieved.

Bond property requirements of ribbed reinforcing steels according to this specification shall be based on surface geometry, or by means of the bond test provided in relevant code provisions; bond property requirements

based on surface geometry are preferred. The assessment criteria for the bond tests shall be as given in the appropriate design documents. A suitable means of factory production control based on the control of surface geometry shall be derived from the bond test results.

NOTE: Required levels of bond strength, as measured in the bond test, are given in BS EN 1992-1-1:2004, ANNEX C.

[2] Surface Geometry

a. General

Ribbed bars shall have transverse ribs. There shall be at least two rows of transverse ribs equally distributed around the perimeter of the bar. The transverse ribs within each row shall be distributed uniformly over the entire length of the bar, except in the area of marking.

Longitudinal ribs may or may not be present. Ribs shall conform to the requirements in TABLE 6304/18.

TABLE 6304/18: RANGES FOR THE RIB PARAMETERS

	Nominal diameter d mm	Ribs of uniform height	Crescent-shaped ribs
Rib height, a , min.	All	$0.05d$	$0.065d$
Rib spacing, c Range	$6 \leq d < 10$ $d > 10$	$0.5d \leq c \leq 0.7d$ $0.5d \leq c \leq 0.7d$	$0.5d \leq c \leq 1.0d$ $0.5d \leq c \leq 0.8d$
Transverse-rib inclination, β	All	$35^\circ \leq \beta \leq 90^\circ$	$35^\circ \leq \beta \leq 75^\circ$
Transverse-rib flank, α	All	$\alpha \geq 45^\circ$	$\alpha \geq 45^\circ$
Ribless perimeter, $\Sigma\lambda$, max.	All		$0.25 d\Gamma$

Requirements for ribbed parameters may be specified by agreement between the manufacturer and purchaser. Measurements for rib parameters may be performed in accordance with ISO 15630-1.

b. Transverse ribs

The projection of the transverse ribs shall extend over at least 75% of the circumference of the product, which shall be calculated from the nominal diameter.

The transverse rib flank inclination α shall be greater than or equal to 45° , and the transition from the rib to the core shall be radiused.

c. Longitudinal ribs

Where longitudinal ribs are present, their height shall not exceed $0.10d$, where d is the nominal diameter of the product.

6305 BENDING THE REINFORCING STEEL

Reinforcement shall be cut or cut and bent to the dimensions shown on the bending schedules and in accordance with BS 8666:2020 OR BS EN ISO 3766:2003 or as prescribed by the Engineer.

Contractor shall submit a Bar Bending Schedule at least 30 days prior to the placement of the rebars, for the Engineer's approval. All costs for the preparation of the schedule shall be incidental to the work.

No flame-cutting of high-tensile steel bars shall be

permitted except when authorised.

Except as described below, all bars shall be bent cold and bending shall be done slowly, a steady, even pressure being exerted without jerking or impact.

If approved, the hot bending of bars of at least 32 mm in diameter will be permitted, provided that the bars do not depend on cold working for their strength. When hot bending is approved, the bars shall be heated slowly to a cherry-red heat (not exceeding 840°C) and shall be allowed to cool slowly in air after bending. Quenching with water shall not be permitted.

Already bent reinforcing bars shall not be re-bent at the same spot without authorisation.

6306 SURFACE CONDITION

When the concrete is placed around the reinforcing steel and/or dowels, the reinforcing steel and/or dowels shall be clean, free from mud, oil, grease, paint, loose rust, concrete droppings, loose mill scale or any other substance which could have an adverse chemical effect on the steel or concrete, or which could reduce the strength of bond.

6307 PLACING AND FIXING

Reinforcement shall be positioned as shown on the Drawings and shall be firmly secured in position within the tolerance given in SUB-CLAUSE 6803 (f) by being tied with 1.6 mm or 1.25 mm diameter annealed wire or by suitable clips being used, or, where authorised, by tack welding. Any cover and spacer blocks required to support the reinforcement shall be as small as may be consistent with their use and shall be of an approved material and design.

The concrete cover over the projecting ends of ties or clamps shall comply with the specifications for concrete cover over reinforcement detailed in TABLE 6308/1 at the end of the Section.

Where protruding bars are exposed to the elements for a long period, the bars shall be adequately protected against corrosion and damage and shall be properly cleaned before being permanently encased in concrete.

In members which are formed with sliding formwork, spacer ladders for placing and fixing the wall reinforcement shall be used at spacing's indicated on the Drawings or as prescribed by the Engineer. The spacer ladders shall consist of two bars 3.7 m in length with ties 4 mm in diameter welded to them to resemble a ladder. The ties shall be spaced at multiples of the horizontal bar spacing in the wall, and shall be used to secure the horizontal reinforcement. The laps in the horizontal reinforcement shall be staggered to ensure that no part of two laps in any four consecutive layers lies in the same vertical plane.

6308 COVER AND SUPPORTS

The term "cover" in this context shall mean the minimum thickness from concrete surface to the surface of the nearest reinforcement, including links, stirrups and surface reinforcements.

The minimum cover shall be as shown on the Drawings. Where no cover is indicated, the minimum cover provided shall be at least equal to the appropriate values shown in TABLE 6308/1 at the end of the Section.

The cover shall be increased by the expected depth of any surface treatment, e.g. when concrete is bush hammered or when rebates are provided.

Additional cover as prescribed by the Engineer shall be provided if porous aggregates are used.

The cover blocks or spacers required for ensuring that the specified cover is obtained shall be of a material,

shape and design acceptable to the Engineer.

Concrete spacer blocks shall be made with 5 mm maximum sized aggregate and shall be of the same strength and material source as those of the surrounding concrete. The blocks shall be formed in specially manufactured moulds and the concrete compacted on a vibratory table, and cured under water for a period of at least 14 days, all to the satisfaction of the Engineer.

Ties cast into spacer blocks shall not extend deeper into the spacer block than half the depth of the spacer block.

The Contractor shall provide stools as shown on the Drawings, or where they are not detailed on the Drawings, wherever the Engineer requires them to be installed. The stools shall be suitably robust, and fixed securely so that they cannot swivel or move. The stools shall have sufficient strength to perform the required functions, taking into account amongst others temporary loads such as the weight of workmen and wet concrete, and forces caused by vibrators and other methods of compacting the concrete.

TABLE 6308/1: MINIMUM CONCRETE COVER OVER REINFORCEMENT

Condition of exposure	Description of members/surface to which the cover applies	Min cover (mm)				
		Class of Concrete				
		20	25	30	40	50 & above
1. MODERATE: Concrete surfaces above ground level and protected against alternately wet and dry conditions caused by water and rain	1.1 Surfaces protected by the superstructure, viz. the sides of beams and the undersides of slabs and other surfaces not likely to be moistened by condensation	50	45	40	40	40
	1.2 Surfaces protected by a waterproof cover or permanent formwork not likely to be subjected to weathering or corrosion	50	45	40	40	40
	1.3 Enclosed surfaces	50	45	40	40	40
	1.4 Structures/members permanently submerged	50	45	40	40	40
2. SEVERE: Concrete surfaces exposed to heavy rain and alternating wet and dry conditions	1.5 Railway structures:					
	• Surfaces of precast elements not in contact with soil	NA	NA	NA	40	40
	• Surfaces protected by permanent formwork are not likely to be subjected to weathering or corrosion	NA	40	40	40	40
	• Surfaces in contact with ballast	NA	55	50	50	45
	• All other surfaces	NA	50	40	40	40
	2.1 All exposed surfaces	NA	50	45	45	45
	2.2 Surfaces on which condensation takes place	NA	50	45	45	45
	2.3 Surfaces in contact with soil	NA	50	45	45	45
	2.4 Surfaces permanently under running water	NA	50	45	45	45
	2.5 Railway structures:					
	• Surfaces of precast elements not in contact with soil	NA	NA	NA	45	45
	• Surfaces protected by permanent formwork are not likely to be subjected to weathering or corrosion	NA	45	45	45	45
	• Surfaces in contact with ballast	NA	55	50	50	45
	• All other surfaces	NA	50	45	45	45
	2.6 Cast in situ piles:	50	50	50	50	50
	• Wet cast against casing	75	75	75	75	75
	• Wet cast against soil	75	75	75	75	75
	• Dry cast against soil					
3. VERY SEVERE: Concrete surfaces exposed to aggressive water or a saline atmosphere	3.1 Surfaces in rivers polluted by industries	NA	NA	NA	60	50
	3.2 Cast in situ piles, wet cast against casings	NA	NA	NA	80	80
4. EXTREME: Concrete surfaces exposed to the abrasive action of very aggressive water	4.1 Surfaces in contact with industrially polluted water	NA	NA	NA	80	80
	4.2 Surfaces in contact with marshy conditions	NA	NA	NA	80	80

NOTE: Use TABLE 6308/1 with BS 8500: PART 1&2: 2015

6309 LAPS AND JOINTS

Laps, joints, splices and mechanical couplings shall be applied only by the specified methods and at the positions shown on the Drawings or as authorised.

6310 WELDING

Reinforcement shall be welded only where shown on the Drawings or as authorised.

Flash butt welding shall be done only with the

combination of flashing, heating, upsetting and annealing to the satisfaction of the Engineer, and only those machines which control this cycle of operations automatically shall be used.

Metal-arc welding of reinforcement shall be done in accordance with BS EN 1011-1:2009 AND BS EN 1011-2:2001, and with the recommendations of the reinforcement manufacturers, subject to approval by the Engineer and the satisfactory performance of trial joints. Hot-rolled high-yield-stress steel shall be preheated to between 240°C and 280°C and only low-hydrogen electrodes may be used.

Trial welding joints shall be made on the site in circumstances similar to those which will govern during the making of production welding joints by the person who will be responsible for the production welding joints.

Other methods of welding e.g., resistance welding, may be used subject to approval by the Engineer and to their satisfactory performance in trial joints.

Welded joints shall be full-strength welds and their strength shall be assessed by destruction tests on samples selected by the Engineer.

6311 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
63.01 STEEL REINFORCEMENT FOR:	
(a) (DESCRIPTION OF PORTION OF STRUCTURE TO WHICH APPLICABLE):	
(i) MILD STEEL BARS	TONNE (t)
(ii) HIGH-YIELD-STRESS- STEEL BARS (TYPE INDICATED)	TONNE (t)
(iii) WELDED STEEL FABRIC	TONNE (t)
(b) ETC FOR OTHER STRUCTURES OR PARTS OF STRUCTURES	TONNE (t)

The unit of measurement for steel bars shall be the tonne of reinforcing steel in place in accordance with the Drawings or as authorised.

The unit of measurement for welded steel fabric shall be the tonne of welded steel fabric in place, the quantity of which shall be calculated from the area of the mesh used in accordance with the Drawings or as authorised.

Ties, stools and other steel used for positioning the reinforcing steel shall be measured as steel reinforcement under the appropriate SUB ITEM.

The bid rates shall include full compensation for supplying, delivering, cutting, bending, welding, trial weld joints, placing and fixing the steel reinforcement, including all tying wire, spacers and waste.

SERIES 6000: STRUCTURES

SECTION 6400: CONCRETE FOR STRUCTURES

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6401 SCOPE

This Section covers the supply and storage or stockpile of all materials, manufacture, transport, placing, finishing, curing, protection and testing concrete in bridges, culverts and miscellaneous structures, works where plain, reinforced or prestressed concrete is specified. The completed concrete elements shall conform to the lines, grades, and dimensions shown on the drawings and as specified in the contract documents. The work includes elements of structures constructed by cast-in-place and precast methods using either plain (unreinforced), reinforced, or prestressed concrete or any combination thereof.

6402 MATERIALS

(a) Cement

Cement used for concrete shall be any of the following:

- i. Cement for the concrete and mortar works unless otherwise indicated in the drawings shall comply

with requirements of US EAS 18-1:2017, BS EN 197-1:2011 or equivalent standard on approval of the Engineer.

- ii. Sulphate-resistant cement conforming to the requirements of US EAS 18-1:2017, BS EN 197-1:2011 or as instructed by the Engineer.
- iii. Blast-furnace cement may be used if specified in the Special Specifications, and shall comply with the requirements of US EAS 18-1:2017, AND BS 8500 - 1 (CEM III A, CEM III B, CEM III C) AASHTO M240 BS EN 197-1:2011 or equivalent standard on approval of the Engineer.

In pressurised concrete members or units, the use of Portland blast-furnace cement will not be permitted.

The type of cement to be used for concrete works shall be CEM I, CEM II or as set out in the Special Specifications. Cement for concrete works shall be of classes 42.5 or 52.5 or as instructed by the Engineer.

(b) Aggregates

Both coarse aggregate (stone) and fine aggregate (sand) shall comply with the requirements of BS EN 1367-4:2008, BS 882:1992 AND BS EN 12620:2013 or equivalent, subject to the following:

i) Coarse Aggregate

- o The aggregate impact value shall not exceed 25%.
- o The aggregate crushing value shall not exceed 30%.
- o The Los Angeles Abrasion Value shall not exceed 28%.
- o The 10% Fines Aggregate Crushing Value shall be more than 100 kN.
- o The Sodium/ Magnesium Sulphate Soundness test result value shall not exceed 12%.
- o The water absorption shall not exceed 2%.
- o The Flakiness Index shall not exceed 40%.

ii) Fine Aggregate

- o The silt content for natural sand shall not exceed 4%.
- o And the organic matter content tests results shall be lighter than standard.

The fine and coarse aggregate grading shall comply with TABLE 6402/1, TABLE 6402/2 AND TABLE 6402/3 respectively.

TABLE 6402/1: NOMINAL SIZE AND GRADING OF FINE AGGREGATE

Sieve Size (mm)	Percentage by mass passing sieve (%)			
	Additional limits			Overall limits
	Coarse	Medium	Fine	
10	-	-	-	100
3	-	-	-	89 – 100
2.36	60 – 100	65 – 100	80 – 100	60 – 100
1.18	30 – 90	45 – 100	70 – 100	30 – 100
0.600	15 – 54	25 – 80	55 – 100	15 – 100
0.300	5 – 40	5 – 48	5 – 70	5 – 70
0.150	-	-	-	0 – 15*

* For crushed rock sands the permissible limit is increased to 20%, except when used for heavy duty floors.

- For fine sand, fineness modulus (FM) is 2.2 – 2.6
- Medium sand, FM is 2.6 – 2.9
- Coarse sand, FM is 2.9 – 3.2
- Fineness Modulus is the sum of cumulative percentages retained on the sieves divided by 100.

TABLE 6402/2: GRADING REQUIREMENTS FOR COARSE AGGREGATE

Sieve Size (mm)	Percentage by mass passing BS sieve (%)							
	Nominal size of graded aggregate			Nominal size of single-sized aggregate				
	40 – 5 mm	20 – 5 mm	14 – 5 mm	40 mm	20 mm	14 mm	10 mm	5 mm
50.0	100	-	-	100	-	-	-	-
37.5	90 – 100	100	-	85 – 100	100	-	-	-
20.0	35 – 70	90 – 100	100	0 – 25	85 – 100	100	-	-
14.0	-	40 – 80	90 – 100	-	0 – 70	85 – 100	100	-
10.0	10 – 40	30 – 60	50 – 85	0 – 5	0 – 25	0 – 50	85 – 100	100
5.00	0 – 5	0 – 10	0 – 10	-	0 – 5	0 – 10	0 – 25	50 – 100
2.36	-	-	-	-	-	-	0 – 5	0 – 30

TABLE 6402/3: GRADING REQUIREMENTS FOR ALL-IN AGGREGATE

Sieve Size (mm)	Percentage by mass passing sieve of nominal size (%)			
	40 mm	20 mm	10 mm	5 mm
50	100	-	-	-
37.5	95 – 100	100	-	-
20.0	45 – 100	95 – 100	-	-
14.0	-	-	100	-
10.0	-	-	95 – 100	-
5.0	25 – 50	35 – 55	30 – 65	70 – 100
2.36	-	-	20 – 50	25 – 70
1.18	-	-	15 – 40	15 – 45
0.600	8 – 30	10 – 35	10 – 30	5 – 25
0.300	-	-	5 – 15	3 – 20
0.150	0 – 8*	0 – 8*	0 – 8*	0 – 15

* Increased to 10% for crushed rock fines.

(c) Boulders

Boulders used in concrete shall comply with the following:

- The boulders shall be clean, durable and inert.
- The aggregate crushing value may not exceed 25%.
- The weight of each boulder shall be between 15 kg and 55 kg.
- No dimension of any boulder shall be less than 150 mm or exceed 500 mm.

(d) Water

Water for use in mixing concrete and mortar and for curing and related purposes shall be obtained from a source approved by the Engineer and shall comply with the requirements of BS EN 1008:2002 as shown in TABLE 6402/4.

TABLE 6402/4: WATER CHEMICAL, VISUAL AND IDENTIFICATION TESTS

Parameter	Unit	Specifications for Concrete Works
pH (Potential of Hydrogen)	-	4 Minimum
Chlorides (Cl ⁻)	mg/l	1000 Maximum
Sulphates (SO ₄ ²⁻)	mg/l	2000 Maximum
Visible Suspended Solids	-	-
Alkalinity as CaCO ₃	mg/l	-
Colour	-	Pale Yellow to Colourless
Odour	-	Odourless

Water shall be clean, fresh and free from detrimental concentrations of acids, alkalis, salts, sugar and other

organic or chemical substances that could impair the durability and strength of the concrete or the imbedded steel. The Contractor shall prove the suitability of the water by way of tests conducted by an approved laboratory. For reinforced and prestressed concrete, the chloride content of the mixing water shall not exceed 500 mg/l when tested in accordance with BS 6068-2.37:1990, SANS 5202/ SANS SM 202 or equivalent.

(e) Admixtures

Admixture shall be used in acceptable form as specified by the manufacturer to achieve right required workability and compressive strength and shall be approved by the Engineer who may require that tests to be conducted before the admixtures are used to validate their suitability. The slump loss of concrete with or without the use of admixture shall be established during the trial mixes before use of the admixture in the project.

Admixtures, if their use is allowed, shall comply with the following requirements:

- Admixtures if used in liquid form shall be batched in solution in the mixing water by a mechanical batcher capable of dispensing the admixture in quantities accurate to within 5% of the required quantity. The workability, compressive strength and the slump loss of concrete with or without the use of admixtures shall be established during the trial mixes before use of admixtures.
- All admixtures shall comply with the requirements of BS EN 934-2:2009+A1:2012 and shall be of an approved brand and type.
- Air entraining agents shall comply with the requirements of BS EN 934-2:2009+A1:2012.
- Admixtures shall not contain any chlorides.
- Admixtures should not impair the durability of concrete nor combined with constituents to form harmful compounds, nor increase the risk of corrosion of reinforcements.
- The relative density of liquid admixtures shall be checked for each drum containing admixtures and

compared with the specified value before acceptance.

(f) Curing Agents

Curing agents shall be tested in accordance with ASTM C-156 OR BS 7542:1992 and shall comply with the requirements of ASTM C-309, except that the loss of water within 72 hours shall not exceed 0.40 kg/m². Only approved curing agents shall be used.

Curing agents shall be clear or pigmented as specified or required by the Engineer. A certificate from an approved testing laboratory stating that the curing compound complies with the specified requirements shall be submitted to the Engineer.

Irrespective of the above specifications being met, the curing compound shall be the type that can be applied to a wet surface without loss of stability or impairment of its water retention properties.

(g) Fibres for Concrete

Structural use of fibres is where the addition of fibres is designed to contribute to the load bearing capacity of a concrete element. This section covers fibres intended for use in all types of concrete and mortar, including sprayed concrete, flooring, precast, in-situ and repair concretes. Fibres in concrete shall be used only if it is specified in the contract.

i) Steel Fibres

This section specifies requirements for steel fibres for structural or non-structural use in concrete, mortar and grout. Structural use of fibres is where the addition of fibres is designed to contribute to the load bearing capacity of a concrete element. Steel fibres shall not be used in place of required reinforcing bars.

The objective of using steel fibre reinforced concrete is to improve the mechanical properties and structural properties such as flexural strength, tensile strength, ductility, wear and tear, post cracking strength.

The required testing and inspection of steel fibre reinforced concrete needs to be done as per the provision of BS EN 14889-1: 2006, or any equivalent code, as approved by the Engineer.

ii) Polymer Fibres

Polymer fibres are straight or deformed pieces of extruded, orientated and cut material which are suitable to be homogeneously mixed into concrete or mortar. Fibre reinforced concrete is ideal for improving the durability and toughness performance of concrete and mortar. Fibres in concrete help to reduce shrinkage cracks, increase strength, increase energy absorption and reduce dangerous spalling at high temperatures.

The required testing and inspection of polymer fibre reinforced concrete needs to be done as per the provision of BS EN 14889-2: 2006, or any equivalent code, as approved by the Engineer.

(h) Self-Healing Concrete Additives

The Contractor shall provide concrete with self-healing properties for structures indicated in the drawings or as directed by the Engineer. The concrete shall incorporate crack healing mechanisms capable of sealing cracks up to 0.5mm width within 28 days of crack formation. The healing mechanism may be bacterial based, capsule based or mineral autogenous healing subject to approval of the Engineer. The Contractor shall submit detailed technical information demonstrating the healing mechanisms effectiveness including independent test data showing crack closure performance. The concrete shall achieve the required minimum 28-day compressive

strength and healing mechanism shall remain viable for at least 50 years under normal exposure conditions. Prior to production, the Contractor shall conduct demonstration testing on 150mm cube specimens. Specimens shall be loaded to create visible cracks of 0.3 to 0.5 mm width, then immersed in water for 28 days. At least 90% shall be demonstrated before approval to proceed.

6403 STORING THE MATERIALS

(a) Cement

Cement stored on the site shall be kept under cover which provides adequate protection against moisture and other factors which may promote deterioration of the cement.

If more than one type of cement is to be used in the Works, the storage space shall be suitably subdivided to the satisfaction of the Engineer and great care shall be exercised to ensure that different types of cement do not come into contact with each other. The Engineer shall be furnished with the means of identifying the various consignments of cement delivered.

When the cement is supplied in bags, the bags shall be closely and neatly stacked to a height not exceeding 12 bags and arranged so that they will not be in contact with the ground or the walls and can be used in the order in

Cement shall not be kept in a temporary store except where it is necessary for the efficient organisation of the

mixing station, and only when the prior approval of the Engineer has been obtained.

Where silos are used for the storage of cement, each silo shall be completely separate and fitted with a filter or an approved alternative method of dust control. Each filter or dust control system shall be of sufficient size to allow delivery of cement to be maintained at a specified pressure and shall be maintained to prevent undue emission of dust to prevent interference with weighing accuracy by build-up of pressure. Cement drawn for use from silos shall be measured by weight and not by volume.

Cement shall not be kept in storage for longer than eight weeks without the Engineer's permission, and different brands and/or types of the same brand of cement shall be stored separately.

(b) Aggregates

Aggregates of different nominal sizes shall be stored separately and in such a manner as to avoid segregation occurring. Intermixing of different materials and contamination by foreign matter shall be avoided. Aggregates exposed to a saline environment shall be covered to protect them from salt contamination.

Where concrete is batched on site, the aggregates shall be stored in bins with a 3 m wide concrete apron slab constructed around the outer edge of the aggregate stockpile area, to prevent contamination during the process of tipping and removing the aggregate. The aggregates shall be tipped on the concrete apron slab. The storage bin shall have a concrete floor of 150 mm thickness.

The Contractor may be required to carry out on Site supplementary processing and/or effective washing of aggregates where in the opinion of the Engineer such action is necessary to ensure that all aggregates comply fully with the requirements of this Specification at the time when concrete materials are batched and mixed. Methods used for processing and washing aggregates shall be subject to the approval of the Engineer.

(c) Storage Capacity

The storage capacity provided and the quantity of

material stored (whether cement, aggregates or water) shall be sufficient to ensure that no interruptions to the progress of the work will be occasioned by the lack of any materials.

(d) Deteriorated Material

Deteriorated or contaminated or otherwise damaged material shall not be used in concrete. Such material shall be removed from the site without delay.

6404 CONCRETE QUALITY

(a) General

Concrete shall comply with the requirements for strength concrete as specified in SUB-CLAUSES 6404 (ii).

The total alkaline content (Na_2O equivalent) of the concrete shall be limited considering the degree of reactivity as specified in SUB-CLAUSE 6402 (b).

(b) Normal Concrete Strength

The Contractor shall be responsible for the design of the concrete mix and for the proportions of the constituent materials necessary for producing concrete which complies with the requirements specified below clause for each class of concrete.

Normal Concrete Strength is made on the basis of a design mix proportioned by weight of its ingredients, which in addition to cement, aggregates and water, may contain chemical admixtures to achieve certain target values of various properties in fresh condition, achievement of which is monitored and controlled during production by suitable tests. Generally, concrete of class up to C50 are included in this type.

High Strength Concrete is similar to strength concrete but contains additional one or more mineral admixtures providing binding characteristics and partly acting as inert filler materials which increases its strength, reduces its porosity and modifies its other properties in fresh as well as hardened condition. Concrete of class up to C90 are included in this type.

Minimum cement content, water cement ratio target mean strength against each class of concrete is specified in TABLE 6404/2.

The class of concrete is indicated by the characteristic 28-day cube crushing strength in MPa and the maximum size of coarse aggregate in the mix.

E.g. **CLASS 30/38** concrete means concrete with a characteristic cube crushing strength of 30 MPa after 28 days and a maximum sized coarse aggregate of 38 mm.

The aggregate size shall be selected in accordance with US 101:2002, BS 882:1992 AND BS EN 12620:2002 + A1:2008, SANS 1083 or equivalent.

Characteristic strength shall be defined as that value of the cube strength below which not more than 5% of the results of all possible cube strength measurements of the specified concrete are expected to fall.

Where for reasons of durability or other considerations concrete is designated by the prefix "W".

E.g. **CLASS W30/19**, such designations shall denote concrete having a cementitious content not less than and a water: cement ratio not exceeding the limits given in the Special Specifications.

In such cases, characteristic cube compressive strengths should be:

- i. The specified 28-day characteristic cube compressive strength; or

- ii. A characteristic cube compressive strength corresponding to the designated maximum water: cement ratio; or

- iii. A characteristic cube compressive strength corresponding to the designated cementitious content.

Before starting with any concrete work on the site, the Contractor shall submit, for approval, samples of the constituent materials of the concrete and a statement of the mix proportions which they propose to use for each class of concrete indicated in the Bill of Quantities.

Where any change occurs in the material sources, the aggregate sizes, or any other components of the concrete, the above procedure shall be repeated.

The samples submitted shall be accompanied by evidence that they comply with the requirements for the various materials specified. The statement regarding the mix proportions shall be accompanied by evidence establishing that concrete made from the materials in the proposed proportions will have the specified properties.

Evidence shall be in the form of:

- i. A statement regarding the test results, which shall be furnished by an approved laboratory; or
- ii. An authoritative report on previous use of and experience in regard to the material.

The actual mix proportions used as well as any changes thereto shall be subject to the Engineer's approval, but such approval shall not in any way relieve the Contractor of their responsibility for producing concrete with the specified properties, without any additional cost to the Employer.

The Contractor is cautioned that the quality of cement may vary considerably from consignment to consignment so as to necessitate adjustments in the cement content of mixes. In order to ensure a uniform quality of concrete, the Contractor shall obtain from the manufacturer the data regarding the relevant cement quality for each consignment with a view to ascertaining the required adjustment in the cement content, without any additional cost to the Employer. This information shall be submitted to the Engineer.

(c) Bleeding

The concrete shall be so proportioned with suitable materials that bleeding is not excessive.

(d) Consistency and workability

The concrete shall be of suitable workability for the nature of the work to be executed without the excessive use of water so that it can be readily compacted into the corners of the formwork and around the reinforcement, tendons and ducts without the material segregating. The maximum free water : cement ratio should not exceed the values as specified in TABLE 6404/1.

Slump measurements obtained in accordance with the test method described in BS EN 12350-2:2019 on concrete used in the Works shall fall within the ranges specified in TABLE 6404/1.

TABLE 6404/1 SLUMP VALUES

Type of construction	Slump (mm) *)	
	Max	Min
Prestressed concrete	75	25
Concrete nosings and pre-fabricated units	75	50
Mass concrete	100	25
Reinforced concrete footings, cast in situ piles (except dry-cast piles), slabs, beams and columns	125	50
*) Where high-frequency vibrators are used, the maximum slump values shall be reduced by one-third.		
Slump test for Pumped Concrete		
Add the following properties ranges for pumped/transport concrete under 6404(VI) subsect i(tabulate as TABLE 6404/1) Slump Values for Pumped Concrete:		
150-180 mm (6-7 inches) for most general concrete applications		
180-200 mm (7-8 inches) for high-rise pumping or long-distance pumping		
120-150 mm (5-6 inches) for specialized applications, such as tunnel lining or shotcrete		

(e) Sulphate Content

The total water-soluble sulphate content of the concrete mix, expressed as SO_3 , shall not exceed 4% (m/m) of the cementitious binder content of the mix. The sulphate content shall be calculated as the total from the various constituents of the mix using the following test methods:

Cementitious binder : BS 1881-124:1998 or equivalent

TABLE 6404/2: CLASSES OF CONCRETE

Class of concrete	Type of construction	Minimum cement content / m ³		Max. Water Cement Ratio	Minimum strength	
		Sulphate resisting (kg)	Common Cements (kg)		Characteristic Strength (MPa)	Target Mean Strength (MPa)
60/20	Prestressed Girder, Deck Slab, Pylon and any other concrete structures as specified in drawings	-	430	0.34	60	74
55/20	Prestressed Girder, Deck Slab, Pylon and any other concrete structures as specified in drawings	-	425	0.35	50	69
50/20	Prestressed Girder, Deck Slab and any other concrete structures as specified in drawings	-	420	0.35	50	63
45/20	Prestressed Girder, Deck Slab and any other concrete structures as specified in drawings	-	400	0.35	45	58
40/20	Prestressed Girder, Deck Slab, Column, Abutment and any other concrete structures as specified in drawings	-	380	0.40	40	52
35/20	Deck Slab, Column, Abutment, Piles, Footing and any other concrete structures as specified in drawings	-	370	0.40	35	47
30/14	All precast work	390	360	0.45	30	45
30/20	Concrete for box culverts and any other concrete structures as specified in drawings	390	360	0.45	30	45

Aggregates : BS 882:1992 OR BS EN 12620:2002+A1:2008 or equivalent
 Water : BS 6068-2.39:1991 OR ISO 9280:1990 or equivalent

(f) Pumped Concrete

Where pumping of the concrete is approved by the Engineer, the concrete mix to be pumped shall be so designed that:

- Settlement/ Slump; should be suitably increased as per the manufacturer's recommendations. However, it should not exceed 125 mm. except for pile concreting in tremie method where the minimum slump should be 150 mm. to be included piling.
- Graded aggregate and suitable admixtures be used, wherever necessary, with a view to improving the pumpability of the mix; and
- Its shrinkage capacity shall not be excessively higher than that of ordinary concrete mixes.

(g) Concrete Classification

Concrete for use in the Works shall comply with the requirements of BS EN 206-1:2013. It shall be classified as shown in TABLE 6404/2 herein. The class of concrete is denoted by the 28-day characteristic strength and the nominal maximum aggregate size. Characteristic strength shall be defined as that value of the cube strength below which not more than 5% of the results of all possible cube strength measurements of the specified concrete are expected to fall.

The class of concrete to be used in each part of the Works shall be as stated in the Bill of Quantities or on the Drawings.

Class of concrete	Type of construction	Minimum cement content / m ³		Max. Water Cement Ratio	Minimum strength	
		Sulphate resisting (kg)	Common Cements (kg)		Characteristic Strength (MPa)	Target Mean Strength (MPa)
25/20	Normal RC structures	360	340	0.45	25	40
20/40	Pipeline protection; benching in manholes and chambers; blinding concrete; mass concrete structures	270	310	0.45	20	35
15/40	Blinding and other unreinforced concrete works	270	290	0.45	15	25

Notes :

- i. The target mean strength of concrete is the desired average compressive strength of the concrete, which is typically specified by the designer or engineer. It is usually higher than the minimum required strength specified in the building codes or standards, to account for variations in materials, mixing, and placement. The target mean strength is calculated using the following formula: Target Mean Strength = Required Strength + (1.65 x Standard Deviation).
- ii. The cement content of the mix specified in TABLE 6404/2 for any class of concrete shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that water cement ratio as specified in the Table is not exceeded.
- iii. Maximum free water cement ratio as specified in the Table against each class of concrete should be maintained. In case the workability needs improvement or adjustment the same should not be done with addition of water. Instead of using additional water for improving the workability suitable admixtures should be used in concrete mix design following guidelines specified in CLAUSE 6402 (e).

(h) High Performance Concrete

i) General

High Performance Concrete shall be used where special performance requirements of high strength, high early strength, high workability, low permeability and high durability for severe service environments, are required. Production and use of such concrete in the field shall be carried out with high degree of uniformity between batches and very stringent quality control.

ii) Materials

Cement, mineral admixtures, chemical admixtures, aggregates and water shall conform to the relevant portion the Specification. Flyash when used, shall neither be less than 20% nor shall be greater than 35% of the total by mass of ordinary Portland cement.

iii) Structural Concrete

Ground granulated blast furnace (GGBS) slag when used, shall neither be less than 50% nor greater than 70% of the total mass of ordinary Portland cement.

The cement content of concrete inclusive of any mineral admixtures shall not be less than 380 kg/m³. The cement content excluding any mineral admixtures (Portland cement content alone) shall not exceed 450 kg/m³. The water/cement (cement plus all cementitious materials) ratio should generally not exceed 0.33 but in no case shall be

more than 0.40.

iv) Compatibility of Admixtures

Compatibility of the superplasticiser and admixtures with the cement and any other Pozzolanic or hydraulic dilutes shall be ensured by trials.

v) Mixing of Concrete

The concreting plant and means of transportation employed to make trial mixes and to transport them to representative distances shall be similar to the corresponding plant and transport to be used in the works. The optimum sequence of mixing of ingredients shall be established by trials. Mixing time may be longer than in normal grade concrete mixes.

The temperature of concrete at the time of placement shall not exceed 25°C. The temperature of concrete at the mixing stage should be lower, to allow for rise in temperature during transport. When a considerable distance of transport is involved, particular attention should be paid to ensure retention of slump as targeted for placement.

vi) Prototype Testing

Mock-up trials or prototype testing may be carried out to ensure that the concrete can be satisfactorily placed and compacted, considering the location of placement and provision of reinforcement, and required adjustments made in concrete mix design and/or detailing of reinforcement.

vii) Curing of Concrete

High performance concrete containing silica fume is more cohesive than normal mixes hence, there is a little or no bleeding and no bleed water to rise to the surface to offset water loss due to evaporation. Plastic shrinkage cracking is possible, if curing is not proper. Initial curing should commence soon after the initial setting of concrete. Concrete should be covered with moist covers, opaque colour plastic sheets or suitable curing compound. Final moist curing should commence after final setting of concrete and continue for at least 14 days.

6405 MEASURING THE MATERIALS

(a) Cement

Where cement is supplied in standard bags, the bags shall be -ascertained to contain 50 kg. All cement taken from bulk-storage containers and from partly used bags shall be batched by weight, accurate to within ± 3% of the required weight.

(b) Water

The mixing water for each batch shall be measured, either by weight or by volume, accurate to within ± 3% of the required quantity. The quantity of water added to the mix shall be adjusted to make allowance for moisture in the aggregates.

(c) Aggregates

All aggregates for strength concrete shall be measured separately by weight, except as otherwise provided in this Clause, accurate to within $\pm 3\%$ of the required quantity.

Fine aggregate shall be tested for bulking at the beginning of and halfway through each concreting shift, and adjustments shall be made.

6406 MIXING**(a) General**

Mixing the material for concrete shall be conducted by an experienced operator. Unless otherwise authorised, mixing shall be carried out in a mechanical batch-mixer of an approved type which will be capable of producing a uniform distribution of ingredients throughout the batch.

(b) Charging the Mixer

The sequence of charging the ingredients shall be subject to approval by the Engineer, and, unless otherwise instructed, the same sequence of charging the ingredients shall be maintained.

The volume of the mixed material by batch shall not exceed the volume recommended by the manufacturer of the mixer.

(c) Mixing and Discharging

The period of mixing shall be measured from the time when all the materials are in the drum until the commencement of discharge. The concrete shall be mixed in a Batch mix plant or in a truck mixer.

i) Batch Mix Plant

Concrete shall be mixed in a batch type mixer manufactured in accordance with BS 1305:1974 and to the approval of the Engineer. Mixing for each batch shall continue until there is uniform distribution of the materials and uniformity of colour and consistency of the concrete. Admixtures for which approval in writing has been given by the Engineer shall be introduced into concrete by means of automatic dosing equipment. Such equipment shall feed a fixed quantity of admixture into the mixing water before the latter is discharged into the mixer and shall be subject to the approval of the Engineer.

The mixing period for the materials shall be 90 seconds and may be reduced only if the Engineer is satisfied that the reduced mixing time will produce concrete with the same strength and uniformity as concrete mixed for 90 seconds. The reduced mixing time, however, shall be not less than 50 seconds or the manufacturer's recommended mixing time whichever is the longer. A suitable timing device shall be attached to the mixer to ensure that the minimum mixing time for the materials has been complied with.

The first batch to be run when starting with a clean mixer shall contain only $\frac{2}{3}$ of the required quantity of coarse aggregate to make provision for "coating" the mixer drum. Discharge shall be so carried out that no segregation of the materials will occur in the mix. The mixer shall be emptied completely before it is recharged with fresh materials.

The Contractor shall take particular care to ensure that the mixer drum is washed and cleaned out immediately following the completion of each concreting operation or when changing a mix using a different type of cement.

ii) Truck Mixer

Concrete shall be mixed in a truck mixer capable of combining the ingredients of the concrete within the

specified number of mixing revolutions into a thoroughly mixed and uniform mass. It shall also be capable of discharging the concrete uniformly.

The volume of mixed concrete permitted in the drum of truck mixers shall not exceed the Manufacturer's rating on the capacity plate. Agitators shall similarly be capable of producing concrete with a satisfactory degree of uniformity.

Mixers with any section of the blades worn by 25 mm or more below the original manufactured height shall not be used.

Mixers and agitators with accumulated hard concrete or mortar in the mixing drum shall not be used.

Admixtures shall be added to the mix water before or during mixing.

The batch shall be charged into the drum so that a portion of the mixing water enters in advance of the cement.

Each batch of concrete shall be mixed not less than 70 and not more than 100 revolutions of the drum or blades at the mixing speed. The count of mixing revolutions shall begin as soon as all materials, including water, are placed in the mixer drum.

Under certain conditions the Engineer may sanction hand mixing, in which case the concrete shall be made on a flat watertight platform or suitable area. The cement and aggregate shall be spread in thin layers and mixed dry until a uniform colour is obtained. Water shall be added and the mixture turned over at least three times or until the concrete is of uniform colour and consistency throughout.

(d) Maintaining and Cleaning the Mixer

If the mixer has stopped running for a period in excess of 30 minutes, it shall be thoroughly cleaned-out particular attention being given to the removal of any build-up of materials in the drum, in the loader, and around the blades or paddles. Worn or bent blades and paddles shall be replaced.

Before any concrete is mixed, the inner surfaces of the mixer shall be cleaned and all hardened concrete removed.

(e) Standby Mixer

When sections are cast where it is important for the casting to continue without interruption, a standby mixer shall be held in readiness to run on 15 minutes notice should the stock mixers break down.

(f) Ready-Mixed Concrete

Where ready-mixed concrete is delivered at the site, the requirements of BS 5328 OR BS EN 206:2013+A2:2021 or equivalent shall have priority over the requirements specified in this Section should inconsistencies occur.

6407 TRANSPORTING, PLACING AND COMPACTING**(a) General**

Concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by means that will prevent segregation or loss of any ingredient. Wherever practicable, concrete shall be emptied from a mixer directly into the skip which shall then be transported to the place of final deposit and the concrete shall be discharged as close as possible to its final position to avoid rehandling or flowing.

Concrete shall be produced and delivered to permit a continuous placement with no concrete achieving initial set before the remaining concrete being placed adjacent

to it.

When a truck mixer or truck agitator is used to transport concrete that is completely mixed in a stationary central construction mixer, mixing during transportation shall be done as per the Manufacturer's recommended agitating speed.

Should the Contractor propose to use concrete pumps for the transporting and placing of concrete he shall submit full details of the equipment and operating techniques he proposes to use for the approval of the Engineer.

Where concrete is conveyed by chuting or pumping, the plant used shall be designed to ensure continuous and unimpeded flow in the chute or pipe. The delivery end of the chute or pipe shall be thoroughly flushed with water before and after each working period and shall be kept clean. Water used for this purpose shall be discharged away from any permanent works.

Concreting operations shall be carried out only during daylight hours unless proper lighting arrangements have been made and the lights are in working order before mixing of the concrete commences. Workmen shall not be allowed to work double shifts and the Contractor shall provide a fresh team for night shifts.

Sufficient material to afford full production to a concrete pour shall be available at the place of work prior to the commencement of concreting.

Placing and compacting the concrete shall at all times be under the direct supervision of an experienced concrete supervisor.

Once the casting of concrete has begun, it shall be carried out in a continuous process between construction joints. Concrete shall be placed within 60 minutes from the start of mixing. These times may be extended by the Engineer where a retarding admixture has been used. All excavations and other contact surfaces of an absorbent nature such as timber formwork shall be damp but no standing water shall be permitted to remain on these surfaces. The formwork shall be clean on the inside.

Water quality, freshwater life or any other sensitive environment shall not be adversely affected in any way.

(b) Placing

Whenever possible, concrete shall be deposited vertically into its final position. Unless otherwise agreed by the Engineer on the basis of satisfactory site trials, concrete shall not be dropped into place from a height exceeding 1 metre. Where chutes are used, their length and slope shall be such as not to cause segregation, and suitable spouts and baffles shall be provided at the lower end to minimise segregation. The displacement of concrete by vibration instead of by direct placement is not permitted.

Care shall be taken when casting bridge decks of a substantial thickness to avoid layering of the concrete, and the entire thickness shall be placed in one pass. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a construction joint has been formed or unless a retarding additive has been used in the concrete.

The pumping of concrete shall be subject to approval by the Engineer. Aluminium pipes shall not be used for this purpose.

In plain concrete with a thickness of not less than 300 mm, boulders may, if approved, be included to displace concrete for up to 20% of the total volume, provided that:

- i. The boulders are spread evenly throughout the concrete;

- ii. No boulder laid shall have a dimension exceeding one third of the smallest dimension of the concrete in any plane, and

- iii. Each boulder is surrounded by at least 75 mm of concrete.

(c) Placing Under Water

Placing under water shall be allowed only in exceptional circumstances where it is not feasible to dewater the location before the concrete is placed. No concrete shall be placed in running water.

Underwater concrete shall be placed by means of tremies. Full details of the method proposed by the Contractor shall be submitted in advance for approval. Placing by skip or pipeline will also be considered under certain circumstances as approved by the Engineer.

During concreting by tremie, the pipe shall be kept filled with concrete at all times to prevent air and water from entering the tremie. When the tremie is charged, an approved sliding plug shall be used. Once concreting has begun by tremie, the discharge end of the tremie shall be kept well below the surface of the concrete. Should this seal be broken, the tremie shall be lifted and plugged before concreting is recommenced. Distribution of concrete by lateral movement of the tremie will not be permitted.

The concrete mix to be placed underwater shall be specially designed and approved for this purpose to ensure good flow ability, plasticity and cohesion. Increased sand and cement contents over those of normal mixes will usually be required.

Underwater placement of concrete is permitted only for seal concrete and drilled shafts. If other than seal concrete is used, the minimum cement content shall be increased by 10%.

(d) Compaction

The Contractor shall regard compacting of concrete as work of fundamental importance, the object of which is to produce a watertight concrete of maximum density and strength.

Concrete shall be fully compacted by approved means during and immediately after placing. It shall be thoroughly worked against the formwork, around reinforcement bars, tendons, ducts and embedded fittings and into corners to form a solid mass free from voids.

The concrete shall be free from honeycombing and planes of weakness and successive layers of the same lift shall be thoroughly bonded together.

Unless otherwise permitted by the Engineer, concrete shall be compacted by means of vibrators of an approved design. Internal vibrators shall be capable of producing not less than 10,000 cycles per minute and external vibrators not less than 3,000 cycles per minute. A sufficient number of vibrators shall be used to handle the maximum rate of concrete production with an allowance for breakdowns and spares.

Vibration shall be applied by experienced labourers, and over-vibration resulting in segregation, surface water and leakage shall be avoided. Contact with reinforcement and formwork shall, insofar as is practicable, be avoided when internal vibrators are used. Concrete shall not be subjected to disturbance by vibration within 4 to 24 hours of it having been compacted.

Concrete that has partially set before placing shall not be used and shall be removed from the site.

Whenever vibration is applied externally, the design of the formwork and positioning of vibrators shall be such as to ensure efficient compaction and avoidance of surface blemishes.

Special attention shall be given to the compaction of concrete in the anchorage zones and behind the anchor plates and in all places where high concentrations of reinforcing steel or cables occur.

Where the placing and compaction of concrete is difficult, a mix containing smaller sized aggregate may be used but only with the approval of the Engineer and after a mix containing such aggregate has been designed and tested.

When placing concrete against horizontal or inclined elements of waterstops, the latter shall be lifted and the concrete placed and compacted to a level slightly higher than the underside of the waterstop before releasing the waterstop to ensure complete compaction of the concrete around the waterstop.

(e) Requirements in Respect of Sliding Formwork

Where sliding formwork is used, the following additional requirements shall apply:

- i. The Contractor shall take all the necessary measures to ensure the continuity of operations. All the necessary lighting and standby equipment for mixing, hoisting, placing and compacting shall be provided and all the materials required for completing each structure shall be ready on the site before casting commences.
- ii. Concrete shall be cast in uniform layers in the formwork so that the level of the top surface of the concrete differs by no more than 250 mm between any two points in the formwork. In addition, the top level of the concrete shall never be so low down in the formwork as will cause structural instability in the formwork. The working platform shall be kept clean and no concrete which has dried out in part may be swept into the formwork.
- iii. The concrete shall be compacted during and immediately after placing. Care shall be taken not to damage or disturb previously placed concrete. To ensure the proper bonding of successive layers not more than one hour shall elapse between the placing of successive layers except where an approved admixture has been applied, in which case the delay may be amended in consideration of such circumstances.
- iv. The slump of concrete may be up to 150 mm should the approved method of sliding so require.

6408 CONSTRUCTION JOINTS

(a) General

The Contractor shall submit for approval by the Engineer his proposals for the position of construction joints having due regard to any that may be shown in the drawings.

Concreting shall be carried out continuously up to the construction joints shown on the working drawings or as approved, except that if, because of an emergency (such as breakdown of the mixing plant or the occurrence of unsuitable weather), concreting has to be interrupted, a construction joint shall be formed at the place of stoppage and in the manner which will least impair the durability, appearance, and proper functioning of the concrete.

Unless otherwise shown on the Drawings, the exact position of horizontal construction joints shall be marked on the framework by means of grout checks in order to obtain truly horizontal joints.

Joint lines shall be clean, true and regular and, wherever possible, arranged to coincide with features of the finished work.

Stub columns, stub walls and stays on footings shall be cast integrally with the footings and not afterwards, even where another class of concrete is being used.

In all cases vertical stop boards of a form to be approved by the Engineer shall be provided at the end of each section of work which is to be concreted in one operation, and the concrete shall be thoroughly consolidated against these stop boards.

(b) Preparing the Surfaces

When the concrete has set and while it is still green, the surface film and all loose material shall be removed without disturbing the aggregate, by means of a water jet assisted by light brushing to expose the aggregate and leave a sound, irregular surface. Where this is not possible, the surface film shall be removed after the concrete has hardened, by mechanical means appropriate to the degree of hardness of the concrete so as to expose the aggregate and leave a sound, irregular surface. The roughened surface shall be washed with clean water to remove all laitance, dirt and loose particles.

Surface retarding agents may be used only with the approval of the Engineer.

(c) Placing Fresh Concrete at Construction Joints

Where fresh concrete is placed the same day as that on which the construction joint was formed, the fresh concrete shall be cast directly against the face of the construction joint.

When concreting recommences a day or more after the construction joint has been formed, the following procedure shall be followed:

- i. The construction joint shall be kept constantly wet for a period of at least six hours. The surface shall be in a saturated, surface dry condition when concreting has to recommence.
- ii. Any dirt, excess water and loose particles shall be cleaned of surface laitance, curing compound and other foreign materials before fresh concrete is placed against the surface of the joint.
- iii. For horizontal construction joints a 25 mm thick concrete layer of the same grade of concrete made richer by reducing the coarse aggregate content by 25% shall be placed on the joint plane immediately before concreting.
- iv. Unless otherwise shown on the plans, horizontal joints may be made without keys; and vertical joints shall be constructed with shear keys. Surfaces of fresh concrete at horizontal joints and construction joints shall be rough floated sufficient to thoroughly consolidate the surface and intentionally left in a roughened condition.
- v. Shear keys shall consist of a formed depression in the surface covering approximately one-third of the contact surface. The forms for the key shall be bevelled so that removal will not damage the concrete.
- vi. For vertical construction joints the fresh concrete shall be placed against a surface prepared in accordance with SUB-CLAUSE 6408 (b) which is in a saturated, surface-dry condition.

Epoxy resins specially designed for bonding old concrete to new shall be used at construction joints where so specified. The preparation of the construction joint surface and the application of the epoxy resin shall be strictly in accordance with the manufacturer's recommendations and the Engineer's instructions. The actual brand and type of resin used shall be subject to the Engineer's approval.

(d) Bonding and Doweling to Existing Structures

When new concrete is shown on the plans to be bonded to existing concrete structures, the existing concrete shall be cleaned and flushed. When the plans show reinforcing dowels grouted into holes drilled in the

existing concrete at such construction joints, the holes shall be drilled by methods that will not shatter or damage the concrete adjacent to the holes. The diameters of the drilled holes shall be 6 mm larger than the nominal diameter of the dowels unless shown otherwise on the Drawings. The grout shall be neat cement paste of Portland cement and water. The water content shall not be more than 15 litres per 50 kg of cement. Sufficient grout shall be placed in the holes so that no voids remain after the dowels are inserted. Grout shall be cured for a period of at least three (3) days or until dowels are encased in concrete.

When specified or approved by the Engineer, epoxy may be used in lieu of Portland cement grout for bonding of dowels in existing concrete. When used, epoxy shall be mixed and placed in accordance with the Manufacturer's recommendations.

(e) Formation of Continuity Joints in Bridge Decks

- i. General: When concrete bridge decks are being widened, built in stages or reconstructed in stages with continuity joints, either by construction of a new part of the deck attached directly to the trafficked deck or by construction of a separate parallel deck followed by an in-fill strip as a second stage, the deck in the finished state shall be monolithic without any permanent joints or gaps.
- ii. Monitoring requirements: The differential deflection between the existing and the new part of the deck at the interface shall be monitored by the Contractor in accordance with contract specific requirements, until the concrete achieves the specified characteristic strength or at least 7 days after placement, whichever is later, in the following situations:
 - a. When decks are widened by attaching a new part of the deck directly to the existing trafficked deck; and
 - b. When decks are widened using the in-fill strip method and traffic is running less than 1m to the interface.
- iii. The limits on differential deflection between the new and existing parts of deck at the interface shall be as follows:
 - a. 6 mm due to the weight of fresh concrete when the concrete for the new part of the deck is poured; and
 - b. 1 mm due to traffic actions

The vibration of the existing trafficked deck during the construction of the new part of the deck shall be monitored by the Contractor in accordance with the requirements in contract specific until the concrete achieves the specified characteristic strength, or at least 7 days after placement, whichever is later. The measured peak particle velocity shall not exceed 5mm/s. If the differential deflection or peak particle velocity measured on site are greater than the specified limits and no specific analysis is available to evaluate their effects on the structure, mitigation measures shall be implemented to reduce the differential deflection and peak particle velocity below their limits.

i) Existing Concrete Deck Preparation

Existing concrete shall be removed in accordance with relevant section of the Specification and as shown on the drawings or as directed by the Engineer. Sufficient reinforcement shall be exposed in the removal to provide the full lap length in accordance with BS EN 1992-2. The removal of existing concrete shall not damage the existing reinforcement. Requirements for and restrictions on phased removal of concrete shall be as specified in contract specific document. The existing concrete substrate shall be prepared to concrete surface

profile grade CSP6 or higher in accordance with the Guideline for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion, 310.1R-2008 published by the International Concrete Repair Institute. The surface of the exposed concrete substrate at the joint shall then be cleaned of all dust and grit using methods that themselves do not add contaminants to the exposed substrate. The prepared substrate shall be continuously wetted with potable water for a minimum period of four hours. Any surface water remaining on the concrete breakout surface or reinforcement shall be removed prior to placement of the new concrete. Placement of the new concrete shall commence before the substrate dries out, and not more than one hour after completion of wetting.

ii) Requirements for Concrete

The concrete used for the construction of the new parts of the deck shall comply with the requirements given in contract specific document, with the slump limited to a maximum of 100 mm.

iii) Requirements for Reinforcement

Reinforcement shall be continuous across the continuity joint. When the in-fill strip method is used, the reinforcement of the existing deck shall not extend beyond the in-fill strip to lap with new reinforcement. The exposed existing steel reinforcement within the continuity joint shall be cleaned to achieve surface preparation standard SA2 ½ to BS EN ISO 8501-1. The exposed surface of the steel reinforcement shall be clean immediately prior to concreting and only light flash rusting on the reinforcement shall be permitted. The reinforcement within continuity joints shall be securely tied at all bar intersections in accordance with CLAUSE 6300.

iv) Requirements for Formwork

When the in-fill strip method is used, formwork for the new part of the deck shall be kept independent from the existing deck to ensure that traffic vibration is not transmitted at the first stage of parallel strip construction.

6409 CURING AND PROTECTING

Formwork shall be retained in position for the appropriate times given in CLAUSE 6206, and as soon as may be practicable, all exposed concrete surfaces shall be protected from loss of moisture by one or more of the following methods:

(a) Method 1

Retaining formwork in place for the full curing period.

(b) Method 2

Ponding the exposed surfaces with water, except where atmospheric temperatures are low, i.e. less than 5°C.

(c) Method 3

Covering it with sand or mats made from a moisture-retaining material, and keeping the covering constantly wet.

(d) Method 4

Constantly spraying the entire area of the exposed surfaces with water (only on surfaces where sand cover or ponding is impossible).

(e) Method 5

Covering with a waterproof or plastic sheeting firmly anchored at the edges.

(f) Method 6

Using an approved curing compound applied in

accordance with the manufacturer's instructions, except that, where the surface has to be subsequently waterproofed, coated or gunited, this method may not be used.

(g) Method 7

Steam curing the concrete (precast units).

(h) General

The method of curing adopted shall be subject to the Engineer's approval and shall not cause staining, contamination, or marring of the surface of the concrete.

The curing period shall be continuous for at least seven days for concrete made with common cements, and at least 10 days if Portland blast-furnace cement or a 50/50 mixture of Portland cement and ground granulated blast-furnace slag is used. Irrespective of cement type for concrete Class 50 and above the minimum curing period shall be 14 days. When the temperature of concrete falls below 5°C, these minimum curing periods shall be extended by the period during which the temperature of the concrete was below 5°C.

When sliding formwork is used, the concrete shall be protected against the weather and rapid drying out by means of a 4 m wide skirt attached to the lower perimeter of the formwork and hanging over the working platform. The skirt shall consist of hessian in the dry seasons and of canvas or other suitable material in the wet seasons. The skirt shall be weighted at the bottom to prevent it from flapping in windy conditions.

The concrete shall be cured by means of a fog spray to keep it wet constantly for the periods stated above or until a curing compound is applied. Wetting the concrete by spraying shall be by means of a fixed spray bar along the full length of the sliding formwork. The spray bar shall be connected to a suitable high-pressure water supply. Wetting shall be discontinued when the ambient air temperature drops below 5°C, and care shall be taken by the Contractor to ensure that the water will not erode the surface of the fresh concrete.

6410 ADVERSE WEATHER CONDITIONS

(a) Cold Weather

Concrete shall not be placed during falling temperatures when the ambient air temperature falls below 7°C or during rising temperatures when the ambient air temperature is below 3°C. When concrete is placed at air temperatures below 5°C the concrete temperature shall not be below 10°C, for which purpose heating of the water and/or the aggregate shall be permitted. The Contractor shall make all the necessary arrangements for heating the material. Heated water and aggregate shall first be mixed and the cement shall then be added only while the temperature is below 30°C.

The temperature of placed concrete shall not be allowed to fall below 5°C until the concrete has attained a strength of at least 5 MPa, and the Contractor shall be responsible for all protective measures necessary to this end. All concrete damaged by casting at temperatures less than 5°C shall be removed and replaced by the Contractor at their own expense.

The Contractor shall provide a thermometer suitable for measuring the temperature of aggregates, and a maximum and minimum thermometer, which shall be hung in a position, indicated by the Engineer.

(b) Hot Weather

When the ambient air temperature exceeds 30°C during concreting, the Contractor shall take measures to control the temperature of the concrete ingredients so that the temperature of the placed concrete will not exceed 30°C unless otherwise determined by the Engineer. Such

measures include spraying aggregate stockpiles with water to promote cooling down by evaporation and, where feasible, shading the stockpiles and the area where concreting is carried out. Curing shall commence immediately after concrete has been placed to prevent an excessive loss of moisture.

Formwork shall be shaded from direct exposure to the sun both prior to the placement of concrete and during its setting. The Contractor shall take appropriate measures to ensure that reinforcement in and projecting from the section to be concreted is maintained at the lowest temperatures practicable.

(c) Precautionary Measures for Using Sliding Formwork

During sliding operations in cold weather, the water only, or the water and the aggregate, shall be heated to ensure that the concrete temperature will not drop below 10°C until it has attained a strength of 5 MPa.

During cold weather the rate of sliding shall be suitably decreased to ensure sufficient strength in the concrete which leaves the bottom of the formwork.

6411 PIPES AND CONDUITS

No pipes and conduits other than those shown on the Drawings shall be embedded in the concrete without the Engineer's approval. The clear space between such pipes or between such pipes and any reinforcing steel shall be at least 40 mm or the maximum size of the aggregate plus 5 mm, whichever is the greater. The thickness of the concrete cover over pipes and fittings shall be at least 25 mm.

The ends of all ferrules used for bracing formwork shall be neatly finished off to the details shown on the Drawings. Where no details are given on the Drawings, ferrules shall be cut back to a depth of at least the specified cover, and the holes shall be filled in with mortar and finished off flush with the concrete surface.

6412 APPLIED LOADING

No load shall be applied to any part of a structure until the specified curing period has expired, after which applied loading shall be allowed only when approved by the Engineer. The Engineer's decision will be based on the type of load to be applied, the age of the concrete, the magnitude of stress induced and the propping of the structure. No structure shall be opened to traffic until test cubes made from the concrete in all parts of the structure have attained the specified minimum 28-day compressive strength.

The Contractor shall not permit backfilling around any structure incorporating a ground or floor slab before that slab has been cast and properly cured and the concrete has attained its specified 28-day strength.

6413 PRECAST CONCRETE

This Clause applies to all reinforced and prestressed concrete members other than precast concrete piles, culverts and pipes in so far as they are dealt with separately elsewhere in these Specifications.

All precast members shall be manufactured in accordance with the requirements specified for cast in situ members in so far as these requirements are relevant. In addition, the following shall apply:

- i. The Contractor shall take all necessary safety and precautionary measures during the handling and erection of precast members and for ensuring the stability of members as positioned and prior to their being cast in.

At all stages of construction, precast concrete elements and other concrete associated therewith shall be properly protected to prevent damage to

permanently exposed concrete surfaces.

Elements shall be lifted or supported at points described in contract specific document and shall be handled and placed without impact. Additional constraints on the support, restraint and dynamic loading during handling or transport as described in the Contract. Erection specification shall be prepared by the Contractor and it shall be submitted for acceptance by the Engineer.

- ii. Where precast concrete members have not been manufactured on the site, the manufacturer shall keep and make available to the Engineer complete records of all the concrete mixes and strength tests pertaining to the members cast. The Contractor shall notify the Engineer in advance of the dates on which members are to be cast so that arrangements for inspecting and testing the precast members can be made.

Precast elements that are manufactured in a factory shall conform to BS EN 13369 'Common rules for precast concrete products', unless otherwise described in the Contract.

If precast elements are not manufactured in a factory in accordance with BS EN 13369 then Contractor shall give reasonable notice to the Engineer in advance of the date of commencement of manufacture and casting of each type of element. A copy of all 28-day cube test results relating to the work, as scheduled in contract specific document shall be made available by the Contractor to the Engineer.

Precast concrete units shall not be moved or transported from the place of casting until they are properly cured and the concrete has achieved its specified 28-day strength.

- iii. For the purposes of identification, all members shall be marked with paint in neat lettering with the member number shown on the Drawings or as agreed on and an identification number relating to the manufacturing records. Letters etc. shall be so positioned as not to be visible when the structural member is placed in its final position in the completed structure.

All precast elements shall be indelibly marked to show the element mark as shown on the drawings, the weight of the element, the production line on which they were manufactured, the date on which the concrete was cast and, if they are of symmetrical section, the face that will be uppermost when the element is in its correct position in the works. The markings shall be so located that they are not exposed to view when the element is in its permanent position.

- iv. All precast members which have been chipped, cracked, warped or otherwise damaged to the extent that such damage will, in the opinion of the Engineer, prejudice the appearance, function or structural integrity of the members shall be rejected or, where so allowed, repaired to the satisfaction of the Engineer.

Prior to placing permanent formwork, the rebates in precast concrete beams intended to receive the formwork shall be inspected to confirm they have been well formed and that any dressing-off is carried out before placing the formwork to ensure an even seating. The in-situ concrete in composite slab bridges shall be placed in such a sequence that the advancing edge of the freshly deposited concrete over the full width of the deck, between longitudinal construction joints, is approximately parallel to the deck supports. Precast beams shall be prevented from moving laterally during the placing of the in-situ concrete.

- v. When elements are stored, they shall be firmly supported only at the points described in contract specific document. Where elements are stacked several units high, packings shall be vertically above each other to prevent additional bending stresses in the elements, and the maximum height of the stack and any provision required to maintain stability shall be as described in contract specific document. The accumulation of trapped water and deleterious matter in the units shall be prevented. Care shall be taken to avoid rust staining and efflorescence. Where disfigurement would be detrimental, packing pieces shall not discolour or otherwise permanently damage the elements.

- vi. The composition and water/cement ratio of the in-situ concrete or mortar used in any connection and in the packing of joints shall be in accordance with the erection specification. Levelling devices shall only be released or removed, in accordance with the erection specification when the structural connection is complete and has achieved sufficient strength. Care shall be taken to ensure that the in-situ material is thoroughly compacted. When using proprietary jointing materials, the manufacturer's recommendations and any particular requirement in contract specific document for the application and methods shall be strictly followed to ensure full compatibility between the joint type and size and the sealing method.

6414 QUALITY OF WORKMANSHIP AND MATERIALS

(a) Criteria for Compliance With the Requirements

Routine inspection and quality control will be done by the Engineer as specified in SECTION 7200. The criteria for compliance with the requirements specified for 28-day characteristic compressive strength shall be as specified in CLAUSE 7205 for full acceptance, and as specified in CLAUSE 7207 for conditional acceptance. The re-submission of concrete lots on the basis of cores for full or conditional acceptance shall not be allowed. The Contractor's attention is drawn to CLAUSE 7208. If the Engineer is satisfied that the requirements of the Contractor's process control have been met, the Engineer may decide at their discretion to use the Contractor's test results in the evaluation of the concrete.

(b) Procedure in the Event of Non-Compliance With the Requirements

Any lot represented by test cubes failing to comply with the criteria specified for the characteristic strength shall be rejected, or the Engineer may at their discretion allow the following tests to be conducted in order to decide whether the concrete may be left in position at further reduced payment:

- i. The Engineer may allow the elements or units concerned to be cured for an additional period not exceeding 56 days. Thereafter the Contractor shall drill cores in accordance with BS EN 206-1:2013 OR BS 5328 or equivalent, and the Engineer will evaluate these cores in accordance with BS 8110-1:1997 or equivalent.
- ii. Where the Engineer so directs, full-scale load tests shall be conducted in accordance with BS 8110-1:1997 or equivalent to determine whether any particular structure or member can be left in position. The cost of such tests shall be for the Contractor's account regardless of the outcome of the tests.

In all cases where concrete has been supplied which fails to comply with the strength requirements, the Contractor shall immediately take the required remedial action by changing the mix proportions to obtain the required strength.

(c) Tests Ordered by the Engineer

Where the routine testing of concrete cubes is not conducted on the site by the Engineer, they may order the Contractor to have the concrete cubes, which have been made by the Engineer, tested at an approved testing laboratory, in which case no separate payment will be made for such tests.

6415 DEMOLITION AND REMOVAL OF EXISTING CONCRETE

Where partial demolition is required for extension work to existing structures the first three paragraphs of CLAUSE 2214 shall apply. In addition the following shall apply:

- i. The Contractor shall take great care to ensure that the reinforcement required to tie in the extension work is not cut off or damaged in the demolition process. Where reinforcement has been cut off, or where in the opinion of the Engineer, the reinforcement has been damaged to such an extent that it will not adequately perform its function, the Contractor shall, at their own expense, install dowel bars of the same diameter as the bar cut off or damaged, all to the satisfaction of the Engineer.
- ii. Only hand operated breaking equipment shall be used for the demolition of concrete where extension work is required.

6416 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
64.01 CAST IN SITU CONCRETE:	
(a) (CLASS OF CONCRETE AND PART OF STRUCTURE OR USE INDICATED)	CUBIC METRE (m ³)
(b) DITTO FOR OTHER CLASSES OF CONCRETE AND OTHER USES OR PARTS OF THE STRUCTURE	CUBIC METRE (m ³)

The unit of measurement for cast in situ concrete shall be the cubic metre of concrete in place. Quantities shall be calculated from the dimensions shown on the Drawings or as authorised. No deduction in volume measured for payment shall be made for the volume of any reinforcing steel, inserts and pipes or conduits under 150 mm in diameter embedded in the concrete.

The bid rate shall include full compensation for procuring and furnishing all the materials, storing the materials, providing all plant, mixing, transporting, placing and compacting the concrete, forming the inserts, construction joints (except mandatory construction joints) and contraction joints, curing and protecting the concrete, repairing defective surfaces, and finishing the concrete surfaces as specified. Payment shall distinguish between the different classes of concrete.

<u>ITEM</u>	<u>UNIT</u>
64.02 MANUFACTURING PRECAST CONCRETE MEMBERS (DESCRIPTION OF MEMBER WITH REFERENCE TO DRAWING)	NUMBER (no.)

The unit of measurement shall be the number of complete members or elements of each type and size in position in the Works.

The bid rate for each precast member shall include full compensation for concrete work, formwork, reinforcing steel and prestressing as required for manufacturing the member complete, excluding only prestressing in connection with in-situ concrete cast subsequent to the placing of the precast members for which prestressing payment is separately provided elsewhere in the Bill of Quantities.

64.03	TRANSPORTING AND ERECTING PRECAST CONCRETE MEMBERS (DESCRIPTION OF MEMBER AND APPROXIMATE MASS TO BE GIVEN)	NUMBER (no.)

The unit of measurement shall be the number of precast concrete members of each type and size placed into position.

The bid rate for each precast member shall include full compensation for all work, costs and equipment required for transporting, erecting and placing into position the precast concrete members.

<u>ITEM</u>	<u>UNIT</u>
64.04 EPOXY BONDING OF NEW CONCRETE SURFACES TO OLD	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of new concrete surface bonded to old by means of an approved epoxy bonding agent as set out in the Specifications. The bid rate shall include full compensation for preparing the surfaces, furnishing and applying the bonding agent and for chamfering the concrete on visible joints, complete as shown on the Drawings.

<u>ITEM</u>	<u>UNIT</u>
64.05 EXTRA OVER ITEM 64.01 OR 64.02 FOR THE USE OF SULPHATE-RESISTANT CEMENT IN CONCRETE	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of concrete manufactured with sulphate-resistant cement and placed in accordance with the details on the Drawings, or as instructed by the Engineer.

The bid rate shall be extra over each of the relevant rates for which sulphate resistant cement is used.

<u>ITEM</u>	<u>UNIT</u>
64.06 DEMOLISHING EXISTING CONCRETE:	
(a) PLAIN CONCRETE (MEMBER INDICATED)	CUBIC METRE (m ³)
(b) REINFORCED CONCRETE (MEMBER INDICATED)	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of plain or reinforced concrete demolished for each member or portion thereof scheduled separately in the Bill of Quantities.

The bid rate shall include full compensation for all labour and construction plant and equipment required to demolish the existing concrete and disposal of the product of the demolition to an approved disposal site. The bid rate shall also include full compensation for any necessary measures to ensure no debris falls into watercourses and for any debris that has fallen into watercourses to be recovered.

<u>ITEM</u>	<u>UNIT</u>

SERIES 6000: STRUCTURES

SECTION 6400A: MAINTENANCE OF STRUCTURES

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6401A DESCRIPTION

Repair of structures shall be carried out in accordance with the repair plans and these Specifications or as directed by the Engineer. Where repair work is not covered by these Specifications, special specification may be framed.

Implementation of repair schemes shall also conform to provisions of the BS standard or equivalent.

6402A GENERAL

(a) Environmental Aspect

Care shall be taken to ensure suitable mitigation measures against noise and dust, pollution and damage to the environment, whether temporary or permanent.

(b) Phasing

The sequence of work shall be in accordance with the drawings or as directed by the Engineer.

(c) Traffic Management

Traffic management, signage, signalling, barricading, and lighting arrangement should be specifically mentioned in drawings and methodology of works and the same should be followed.

(d) Safety Precautions

Adequate precautions shall be taken for the safety of personnel, road users and existing services.

(e) Dismantling and Removal of Material

Dismantling of any bridge component and removal of materials shall conform to relevant Section of Specifications and as shown on the drawings or as directed by the Engineer.

6403A SEALING OF CRACKS BY INJECTION OF EPOXY RESIN

(a) General

The work of structural bonding of concrete using epoxy adhesive shall conform to these Specifications.

The Contractor shall furnish a method statement giving details of the methodology of construction, sources of supply of materials, product catalogue and Specification, tools, equipment, and appliances to be used on work, personnel and supervision.

(b) Personnel

The Contractor's personnel shall be qualified and experienced in epoxy injection process.

(c) Material

The material for injection shall be a suitable two-component low viscosity epoxy resin, having the required characteristics of bonding with concrete and resistance to moisture penetration. Epoxy mortar or polysulphide resin may be used for sealing the surface.

The material for epoxy injection shall conform to the following:

- The resin and hardener shall be mixed by weight and the mixing ratio shall generally be between 1 pbw (parts by weight) to 50 pbw subject to manufacturer's recommendation.
- Neither the mixed epoxy adhesives nor their individual component shall contain solvents and thickeners.
- The components shall be free of lumps or foreign material. The viscosity of the individual components shall not change more than ± 15 percent, while kept in closed containers at 25°C after two weeks.
- Consistency of mixed adhesive shall satisfy the requirements given in TABLE 6400A/1.

TABLE 6400A/1: CONSISTENCY OF ADHESIVE

		Standard Version (cps)	Low Viscosity Version (cps)
i	Viscosity of Mixed Adhesive at 25°C	(200-300)	(100-190)
ii	Pot Life of mixed adhesive at 25°C	1 hour $\pm$ 15 minutes *	
iii	Set the time of mixed adhesive at 25°C	3 - 6 hours	

* In the case of two component injection system where resin and hardener get mixed at point of injection pot life at 25°C shall not be greater than 15 minutes $\pm$ 10 minutes.

(d) Equipment for Injection

The equipment shall be portable positive displacement type pumps with an interlock to provide positive ratio control of exact proportions of the two components at nozzle. The pumps shall be generally electrically powered and shall provide in-time metering and mixing. The tolerance on mix ratio shall be 5 percent by volume. The injection equipment shall have automatic pressure control capable of discharging mixed adhesive at any pre-set pressure within the prescribed limits and shall be additionally equipped with a manual pressure control.

The injection equipment shall be equipped with sensors on both the components A and B reservoirs that will automatically stop the machine when only one component is being pumped to the mixing head.

If considered appropriate, a suitable compressed air

operated epoxy injection gun can be used with prior approval of the Engineer for manual injection of mix when resin and hardener had been mixed in a separate unit.

(e) Preparation

Surfaces adjacent to cracks or other areas of application shall be cleaned of dirt, dust, grease, oil efflorescence or other foreign matter by brushing/water jetting/sand blasting. Acids and corrosives shall not be permitted for cleaning.

Entry ports shall be provided along the crack at intervals of not more than the thickness of concrete at the location.

Surface seal shall be applied to the face of the crack between the entry ports. For through cracks, surface seal shall be applied to both faces.

Before proceeding with the injection, it shall be ensured that the surface seal has gained adequate strength corresponding to concrete strength of the member and to withstand the injection pressure.

(f) Epoxy Injection

Injection of epoxy adhesive shall begin at the lowest entry port and continue until the epoxy adhesive appears at the next adjacent entry port. The injection shall then be discontinued at the first entry port which shall be sealed. Thereafter, epoxy injection shall be carried out from the next adjacent port and continued successively from each port until the crack is completely filled.

If travel of epoxy adhesive from one port to the next does not occur, the work shall be stopped immediately. In case the volume of the injected material exceeds 2 litres for a particular entry port, the work shall be stopped and the specifications may be reviewed.

(g) Precautions for Application

- i. Temperature of components A and B, i.e., resin and hardener shall be between 10°C and 35°C at the time of mixing unless otherwise specified.
- ii. Temperature of structural member during epoxy injection shall be between 10°C and 35°C unless otherwise specified.
- iii. Immediately prior to use, each component shall be thoroughly mixed with a clean paddle. The paddle shall be of a type that does not propel air into the material. Separate clean paddle must be used for each component.
- iv. Any heating of the adhesive components shall be done by application of indirect heat; in case the work is to be done in cold climate.
- v. Just before use, the two components shall be thoroughly mixed in the ratios specified by the manufacturer. The mixing time shall be strictly in accordance with manufacturer's recommendations. When adhesives with different coloured components are mixed, the mixture shall have a uniform colour without streaks.
- vi. The use of solvents and thinners shall not be permitted except for cleaning of equipment.

(h) Testing

i) Material Testing

Prior to approval of material, the following tests shall be carried out by the Contractor at site or in an authorised laboratory for each batch of resin and hardener and each combination.

- a. Viscosity test for resin and hardener and the mix: three specimens each.
- b. Pot life test: three specimens each.
- c. Bond test: three specimens each.

- d. Shear test: six specimens each, 3 after 24 hours and the other three after 72 hours of curing.

Subsequent tests shall be carried out as directed by the Engineer. Procedure for tests shall be as below:

ii) Pot Life Test

- a. 500 gm of resin formulation shall be prepared by thoroughly mixing the resin and hardener / accelerator / catalyst component in proposed proportion in a 1 kg capacity hemispheric porcelain bowl by means of a spatula or any other agitating device and time and the ambient temperature shall be noted.
- b. The resin formulation shall be applied with a clean dry 25 mm size painter's brush, on a clean dry surface such as cement concrete over 150 mm - 200 mm length, starting immediately after mixing the formulation and repeating the operation every five minutes. When it becomes just difficult to spread the resin properly with the brush, the time is noted. The time elapsed since completion of mixing of resin formulation, is taken as its pot life.
- c. One pot life test shall be performed on commencement of work and the same shall be repeated every four hours.
- d. In case the material fails to satisfy the pot life test, it shall not be used for injection.

Where the resin and hardener get mixed at the point of injection, the pot life is not important and no tests may be required.

iii) Bond Test

A standard 150 mm diameter and 300 mm long concrete cylinder shall be cast in 2 pieces by providing a separating medium at an axis of 45 degrees to the longer axis of the cylinder as shown in Figure. 6403A/1.

Three such split cylinders shall be prepared. Two pieces of each cylinder shall be joined with epoxy mortar at four points to give a clear gap of about 0.2 mm, which will be injected with epoxy resin at site. After epoxy has been cured, a load test shall be carried out on the cylinder. The failure shall not take place at the joint injected with epoxy resin. Also the strength of cylinder at failure shall not be less than 80 percent of the 28 days cube strength of the concrete mix.

iv) Shear Tests

Two steel plates, minimum 3 mm thick, shall be bonded with epoxy at site using the same resin mix as used/proposed to be used for injection. The assembly shall be kept in a mechanical clamp till epoxy is cured. A total of six specimens shall be prepared for each batch of materials. Three test specimens shall then be subjected to a shear force along the axis after 24 hours and the minimum shear strength before failure shall not be less than 1 MPa (Refer to Fig. 6403A/2).

The remaining test specimens shall be similarly tested after 72 hours of curing. The shear strength before failure shall not be less than 2.5 MPa.

v) Core Test

If directed by the Engineer, cores shall be tested for the acceptance of the work. The selection of the location of cores shall be as directed by the Engineer in such a way that damage in critical/stressed areas of the structure is avoided.

The Contractor shall obtain 50 mm diameter initial core samples in the first 50 linear metres.

Thereafter, the frequency of core sampling shall be as specified or as agreed by the Engineer. The depth of the core shall normally be less than 200 mm.

Tests and Acceptance Criteria shall be as follows:

- a. Penetration- Visual examination of the core should show epoxy adhesive filling a minimum of 90% of the crack.
- b. Bond Strength- When tested for bond, concrete failure should occur before adhesive failure. Also, a minimum bond strength of 40 MPa should be developed with no failure of adhesive.

If the cores taken in first 50 m length pass tests as specified above, epoxy adhesive injection work at area represented by the cores will be accepted.

If cores fail either by lack of penetration or bond strength, work shall not proceed further until the areas represented by the cores are re-injected and re-tested for acceptance.

(i) Filling of Core Holes

Two-component bonding agent shall be applied to surfaces of cored holes followed by filling of non-shrink cement grout mix placed by hand trowel, thoroughly rodded and tamped in place. The surface shall be finished to match the finish and texture of existing concrete to the satisfaction of the Engineer. Materials to be used and procedures for filling core holes shall be got approved by the Engineer before proceeding with work.

(j) Test for Injection Equipment

At all times during the course of the work, the Contractor shall keep complete and accurate records and make available to the Engineer, the results of the pressure and ratio tests specified below so that the efficacy and accuracy of the injection equipment is verified.

The Engineer at any time may direct the Contractor to conduct additional tests in his presence.

i) Pressure Test

The mixing head of the injection equipment shall be disconnected and the two adhesive component delivery lines shall be attached to the pressure check device, which shall consist of two independent valved nozzles capable of sensing the pressure. The check device shall be closed and equipment operated until the gauge pressure in each line reads 5 MPa. The pumps shall be stopped and the gauge pressure shall not drop below 4 MPa within 2 minutes.

The pressure test shall be run for each injection unit at the beginning and after break of every shift.

ii) Ratio Test

The mixing head of the injection equipment shall be disconnected and the two adhesive components shall be pumped simultaneously through the ratio check device, which shall consist of two independent valved nozzles. There shall be a pressure gauge capable of controlling back pressure by opening or closing valved nozzles capable of sensing the back pressure behind each valve. The discharge pressure shall be adjusted to read 5 bar for both adhesive components, which shall be simultaneously discharged into separate calibrated containers during the same time period. The amounts thus discharged shall be compared to determine whether the volume/discharge conforms to the manufacturer's recommended ratio for applicable material.

6404A REPLACEMENT OF SPALLED CONCRETE BY EPOXY MORTAR/ POLYMER MORTAR

(a) Epoxy Mortar

i) Material

The epoxy resins for use in the mortar shall be obtained from a reputed manufacturer and shall conform to the following:

Pot Life	60 minutes at 30°C
Bond Strength	12 MPa
Tensile Strength	16 MPa

The Contractor/user shall carry out tests on the samples to demonstrate that the above requirements are met.

The sand to be used in the mortar shall be graded quartz sand.

ii) Proportioning and Mixing

The resin and hardener shall be first mixed. Thereafter, dry filler shall be added and again mixed thoroughly. The resultant mix shall be free of lumps of dry filler and shall be of uniform colour. For a total weight of 1 kg or less, the components shall be mixed for 3 minutes in a slow speed (400-600 rpm) mixer. The stirrer shall be moved up and down and along the sides until a uniform colour without streaks, is obtained. While stirring, it shall be ensured that an excessive amount of air is not entrapped. If no power is available, a flat putty knife may be used to reach into the corners of the can and hand mixing done for at least 5 minutes.

iii) Surface Preparation

Two general methods of surface preparation shall be followed:

- c. Mechanical that includes grinding, grit blasting, water blasting and scarification.
- d. Chemical that includes acid etching with 15 percent by weight of hydrochloric solution, followed by repeated flushing with high pressure stream of water.

Contaminants, such as oil, grease, tar, asphalt, paint, wax, curing compounds, surface; impregnates like linseed oil or silicon and laitance, loose material and unsound concrete, shall be removed from the surface on which epoxy mortar is to be placed.

iv) Application

The epoxy primer coat which acts as a bonding agent, shall consist of resin and hardener mixed in the proportions as given by the manufacturer. Epoxy bonding agent shall be applied only on a dry surface and shall not be applied when it rains or in standing water. The overlay, whether epoxy or cement based, shall be done within the pot life of the epoxy primer coat. Epoxy primer coat shall be applied with the help of stiff nylon bristle brushes or hard rubber rollers or spray gun, depending upon the nature of surface and extent of work area. As far as possible, the coating shall be uniformly thick.

Before the primer coat is fully cured, epoxy mortar shall be applied by means of trowels and floats. The interval between the application of primer coat and epoxy mortar shall be approximately 15/30 minutes depending on the ambient temperature.

Seal coat shall be applied 24 hours after curing and mild roughening of the surface of the mortar.

v) Coverage

The coverage of resin mix would depend on the

system of resin used. However, as a general guideline the coverage area shall be as under:

- a. Primer Coat. An area of 3-6 m² will be covered by 1 kg of resin hardener mix, depending on the finish of the concrete.
- b. Epoxy Mortar. 1 m² of surface requires approximately 20-24 kg of epoxy mortar, when laid to a thickness of 10 mm.
- c. Seal Coat. An area of 4-6 m² will be covered by 1 kg depending on the temperature of application.

vi) Cleaning and Maintenance of Equipment

Tools and equipment are best cleaned immediately after use since the removal of cured resin is difficult and time consuming. The bulk of resin shall be removed using a scraper and remainder washed away completely using solvents such as toluene, xylene or acetone. Equipment shall always be cleaned before the epoxy hardens. Solvents used for this purpose may be Acetone (flammable), Methyl Ethyl Ketone (flammable), Methyl Chloride (non-flammable). Cured epoxies may be removed using Methylene Chloride.

vii) Testing

Epoxy used for making mortar shall conform to all requirements and testing procedures as laid down in CLAUSE 6403A.

viii) Personnel and Environmental Safety

Any skin contact with epoxy materials, solvents and epoxy strippers should be avoided. Epoxy resins and particularly epoxy hardeners (B component) may cause a rash on the skin. The official toxicity classification on the container labels may be looked at before starting work.

Rubber gloves, with a cloth liner, and protective clothing shall be worn. Barrier creams are recommended but are not substitutes for protective clothing. Eyes shall be protected where splashing could occur while spraying or mixing. Good ventilation shall be ensured and inhalation of vapours avoided. If materials are sprayed, a respirator shall be used.

If contact occurs with the skin, it shall be immediately washed with a cleaner, followed by soap and water. Should eye contact occur, it shall be flushed immediately with plenty of water for 15 minutes and a doctor shall be called.

If contact occurs with the clothing, it shall be immediately changed to prevent further skin contact, and if the contact occurs with components A or B, the clothing shall be thrown away. Hardened epoxy is not harmful but it will break the clothing.

All emptied, used buckets, rags and containers shall be removed from site. These shall be stored in waste disposal bags and suitably disposed of.

(b) Polymer Mortar

i) Material

The latex acrylic polymer for use in the polymer modified cementitious mortar (PMC) shall be obtained from a reputed manufacturer and shall conform to the following:

Pot Life	60 minutes at 30°C
Compressive strength at 28 days	18.20 N/mm ²
Flexural strength at 28 days	3.0 N/mm ² to 5.0 N/mm ²
Addition to concrete (slant shear)	3.0 N/mm ² to 5.0 N/mm ²

The sand to be used in the mortar shall be graded quartz sand and the sand content shall be in accordance with the desired consistency.

ii) Proportioning and Mixing

A dry mortar of quartz sand and cement (OPC) shall be prepared as per the proportions recommended by the manufacturer. The quantity of polymer shall be measured by measuring jars and shall be added to the dry mortar. It shall be mixed with a trowel or by hand so that no lumps remain in the mixed mortar.

iii) Surface Preparation

Same as Epoxy Mortar.

iv) Application

The polymer bond coat shall consist of a mix of polymer and cement as per the recommendations of manufacturer and shall be applied in the same manner as indicated for epoxy primer coat.

The cement and sand shall be dry mixed and then mixed with liquid polymer, adding the required amount of water in prescribed proportions as per manufacturer's recommendation. The mortar shall be mixed till it attains a smooth consistency. The mix shall be applied over the polymer bond coat by hand and finished with a trowel.

v) Coverage

- a. An area of 3 to 4 m² will be covered by 1 litre of polymer bond coat, depending on substrata conditions.
- b. An area of 1 square metre of surface will be covered by approximately 21-22 kg of polymer mortar when laid to a thickness of 10 mm.

vi) Testing

The polymer used in making polymer mortar, shall be tested for all requirements as indicated by the manufacturer and to satisfy requirements given in CLAUSE 6404A, B Polymer Mortar (a).

6405A EPOXY BONDING OF NEW CONCRETE TO OLD CONCRETE

- i. Epoxy resin used for bonding shall be obtained from a reputed manufacturer. The pot life of such bonding epoxy shall not be less than 60 minutes at normal temperature.
- ii. The entire surface of the existing concrete member should be thoroughly cleaned by wire brush and then with compressed air to remove dust and loose particles from the surface. Any crack or spalling of concrete shall be sealed by epoxy injection/epoxy mortar/grouting as decided by the Engineer. A coating of suitable epoxy resin at the rate of 0.8 kg/m² (minimum) should then be applied on the surface of the existing concrete members. Fresh concrete shall then be placed within the pot life of the resin system.

iii. Testing

- a. Epoxy used for bonding work shall satisfy the criteria mentioned in CLAUSE 6403A.
- b. Two concrete cubes of 150 mm size cast as per approved design mix shall be placed at a distance of 150 mm from each other, as shown in FIGURE 6403A/3. Epoxy resin system suggested for bonding new to old concrete shall be applied on the opposite faces of the cubes.

Fresh cement concrete cube of grade as per approved design mix shall be cast with water

cement ratio of 0.4 or less in the manner shown in FIGURE 6403A/3. The assembly shall be cured in water for 28 days and steel spacer shall be removed thereafter.

The cube assembly shall be subjected to compression load after 28 days of curing, thereby subjecting the bond to shearing load. Failure must not occur at this joint.

6406A CEMENT GROUTING

(a) Material

Grouting shall normally be performed with a mixture of neat Portland cement and water. Other additives and admixtures may be added to improve the impermeability and strength, with the approval of the Engineer. The size of the particles and the consistency of the grout must be suited to the passageways it must follow. Neat grout will not flow freely into holes smaller than about three times the largest cement particle. Except in large cavities where thick mortar can be placed, the sand should all pass the 28-mesh sieve and have a large portion passing the 50-mesh and 100-mesh sieves. The proportions of Ordinary Portland cement to sand will depend upon the size of the spaces to be filled and will vary from a neat grout to about 1:1 mix. The amount of water to be added depends upon the consistency required. Grouts with as little as 16 litres of water per bag of cement could be used and it should seldom be necessary to use more than 35 to 40 litres of water per bag of cement.

Where necessary and approved by the Engineer, additives and admixtures may be added to Portland cement grout mixtures for improving impermeability and strength, delaying the setting time, increasing flowability and minimizing segregation and shrinkage.

(b) Preparation

The surface shall be cleaned with a wire brush and compressed air. Thereafter holes of 15 mm diameter and 150 mm to 200 mm deep may be drilled along the length of the cracks at a spacing of 500 mm by wet drilling using rotary percussion drills and nipples shall be inserted in these holes.

(c) Proportioning, Mixing and Equipment for Grouting

The cement grout shall be mechanically mixed using a system of power-driven paddles of a high-speed centrifugal pump. The grout pump to be used shall permit close control of pressures to allow a flexible rate of injection with minimum clogging of valves and ports. The most satisfactory equipment for injecting grout is a pump of the double-acting flexible reciprocating type giving a steady flow. The grout pump shall be so placed as to reduce the waste in cleaning lines. It is preferable to put 50 percent or more of the mixing water into the mixer before adding the dry ingredients and then the remaining water. A continuous supply of grout is preferable to an intermittent one. Consistency of the grout may be determined by trials starting with thin grout i.e. about 40 litres of water per bag of cement and progressively decreasing the water content to about 15 litres per bag of cement.

Where the mixer and pump are combined in one unit, the dry material shall be screened before mixing. If the mixer and pump are in separate units, the grout shall pass through a screen before it enters the pump.

(d) Application

Highest practical pressure within the limits of 100 kPa - 400 kPa should be used in order to force the surplus water from the grout. As the pressure may be distributed hydraulically over considerable areas, vigilance must be exercised to prevent damage or needless waste of grout. Adequate precautions shall be taken to ensure that

leakage of grout does not occur.

Pressure shall be steady to ensure a continuous flow of grout. Grouting shall not be continued till the hole consumes mix at the rate of not less than 30 litres in 20 minutes or until refusal at the grouting pressure of 400 kPa at any hole. Should the grout escape from an adjacent nipple, it should be plugged or capped. Any seam, crack or joint through which grout escapes shall be caulked with epoxy mortar as soon as thick grout appears.

(e) Cleaning of Equipment

After completion of each grouting operation or temporary shutdown, it is advisable to force clear water through the pump until the discharge line shows no colour, after which the pump covers shall be removed and the valve chambers thoroughly cleaned.

(f) Testing

Percolation test done at the end of the grouting operation shall give a value of less than 2 lug ions. For specialised treatment like polymer modified cementitious grout injection, manufacturer's literature and specifications shall be followed.

6407A GUNITING/ SHOTCRETING

- i. The gunite shall comprise 100 parts by weight of cement, 300 parts by weight quartz sand, 35-50 parts by weight water and 2 parts by weight approved quick setting compound. In general, dry mix shotcrete shall be used.
- ii. Ordinary Portland cement conforming to relevant BS Standard or equivalent shall be used in guniting.
- iii. Sand for guniting shall comply with the requirements stipulated in relevant BS Standard or equivalent. In general, sand should neither be too coarse to increase the rebound nor too fine to increase the slump. Sand should preferably have a moisture content between 3 to 6 percent.

The grading of sand shall lie within the limits given below:

Standard Sieve Designation, Or Equivalent	Percent Passing the Sieve
4.75 mm	95-100
2.36 mm	65-90
1.18 mm	45-75
600 microns	30-50
300 microns	10-22
150 microns	2-8

- iv. For thick sections it may be advantageous to incorporate coarse aggregate in the mix provided adequate guniting equipment is available. Coarse aggregate, when used, shall conform to the grading given in relevant BS Standard or equivalent. The percentage of coarse aggregate may normally be kept as 20 to 40 percent of the total aggregate and the mix shall be suitably designed.
- v. Water/ cement ratio for guniting shall fall within the range of 0.35 to 0.50 by mass; wet enough to reduce the rebound. Drying shrinkage may be between 0.06 percent and 0.10 percent. The quick setting compound shall be added at the nozzle with water just before guniting.
- vi. Workmanship

The cement and sand shall be batched and mixed and conveyed through a hose pipe with the help of compressed air. A separate line shall bring the water under pressure. The cement, sand and water mix shall be passed through and intimately mixed in a special manifold and then projected at high velocity to the surface being repaired. The density

of gunite shall not be less than 2000 kg/m³. The strength of gunite shall not be less than 25 MPa. For effective guniting, the nozzle shall be kept 600 mm to 1500 mm away from the surface, preferably normal to that surface. While enclosing reinforcement bars during repairs the nozzle shall be held closer at a slight angle and the mix shall be wetter than the normal.

- vii. Test panels simulating actual field conditions shall be fabricated for conducting preconstruction testing. The procedure for testing the cubes or cylinders taken from the panels stipulated in relevant BS Standard or equivalent shall be followed.
- viii. It should be ensured from tests that a strength of about 25 MPa at 28 days is available for the mortar/concrete mix.
- ix. The defective concrete shall be cut out to the full depth till a sound concrete surface is reached. Under no circumstances should the thickness of concrete to be removed be less than clear cover to the main reinforcement. No square shoulders shall be left at the perimeter of the cut-off portion and all edges shall be tapered. Thereafter, all loose and foreign materials should be removed and the surface sand blasted to make it rough to receive shotcrete after applying a coat of epoxy bonding as per recommendation of the manufacturer at the rate of 1.0 kg per 1.5 m² of surface area.
- x. The exposed reinforcement shall be thoroughly cleaned free of rust, scales etc. by wire brushing. Wherever the reinforcements have been corroded, the same shall be removed and replaced by additional reinforcement. Before the application of gunite, a coat of neat cement slurry should be applied on the surface of the reinforcement.
- xi. Sufficient clearance shall be provided around the reinforcement to permit encasement with sound gunite. Care shall be taken to avoid sand pockets behind the reinforcement.
- xii. A thickness of 25 mm to 40 mm of gunite can normally be deposited in one operation. If, for some reason, the total thickness is to be built up in successive operations, the previous layer should be allowed to set but not become hard before the application of the subsequent layer. Guniting shall always be done on a damp concrete surface.
- xiii. Where required, welded wire fabrics 50 mm x 50 mm x No. 10 gauge shall be provided in the first layer of guniting. The fabric shall be tied properly. In case the damage to the concrete member is very deep, the specifications for guniting as well as requirement of placement of wire mesh, has to be decided as per field conditions.
- xiv. It would be desirable that green gunite is moistened for at least 7 days. Guniting work shall not be done during windy or rainy conditions.

6408A PROTECTIVE SURFACE COATING OF CONCRETE BY ACRYLIC ELASTOMERIC COATING

- i. The acrylic elastomeric coating shall be water based (solvent free), modified with selected mineral fillers applied over the prepared surface. The coating should have anti-carbonation and water vapor diffusion properties and should be resistant to the action of ultraviolet (UV) radiation. It should be waterproof and capable of bridging cravings and cracks. The shelf life for such coatings shall not be more than 6 months.
- ii. It is necessary that the system should be capable of protecting the surfaces of pre-stressed and reinforced concrete members from all deleterious elements such as chlorides and sulphates. The protective treatment should allow excess water

vapour in the concrete to evaporate out (breathing) without rupturing itself due to vapour pressure. The protective system itself should not deteriorate from exposure to UV rays and weathering.

The acrylic elastomeric coating system shall satisfy the requirements given in TABLE 6408A/1.

TABLE 6400A/1: PROPERTIES OF ACRYLIC ELASTOMERIC COATING

Sl. No.	Parameter	Requirement	Reference
1)	Specific Gravity	1.4±0.05	ASTM D-6083
2)	Solid contents	70±3%	ASTM D-6083
3)	UV resistance	No colour change	ASTM-G-53/DIN-EN-150-105
4)	IR-Spectrum	As per Acrylic Polymer	ASTM-D-4541-021 DIN500014
5)	Adhesion with concrete	1.5 N/m ²	
6)	Dry film thickness	200-225 Microns (for minimum 2 coats)	
7)	Coverage	400-450 gm 1m ² (2 Coats)	
8)	Physical properties Diffusion resistance against carbon dioxide	Equivalent air layer thickness S _p CO ₂ shall be >50 m	DIN 53122 Part-I
9)	Diffusion resistance against water vapour	Equivalent air thickness S _p H ₂ O <4 m	DIN 52615
10)	Water proofing characteristics	Percentage reduction in flux should be >50%	
11)	Re-coatability	Min. 2h to 72 h or as per manufactures specification with the approval of the Engineer in charge.	

The primer shall satisfy the following requirements:

System	Single component universal polymer primer
Base	Acrylic Resin dispersion
Curing	Air Curing
Colour	Milk white, transparent application
Shelf life	6 months from date of manufacturing in tightly sealed container.
Coverage	75 gm/m ² to 100 gm/m ² (depending upon smoothness and absorption of concrete surface)

iii. Quality Assurance

The Acrylic elastomeric material should be tested in Gal accredited laboratories where such laboratories are available, otherwise in other standard laboratories where similar facilities exist for properties specified above. Random samples during execution shall be taken from consignments brought to site to verify that the test results match with the earlier certificates produced before

approval of the product. Both the test results (prior to approval and during execution), shall conform to the requirements as per TABLE 2800/1, failing which the consignment shall be rejected. It shall be made mandatory that the stock register for the materials are maintained at site and signed by the Engineer periodically.

iv. Surface Preparation

The work shall commence after carrying out any repair to the concrete surface as directed by the Engineer. The concrete surface shall be free from all adhesion inhibiting substances such as oil, grease release agents as well as laitance and dust. The surface shall be cleaned by wire brushing, mechanical scraping and any loose material shall be removed by chiselling with a small hammer and washed with clean water. The substrata shall be structurally sound for an effective bond of the acrylic polymer with the concrete surface. All pin holes shall be filled with non-shrink polymer modified fine repair mortar.

v. Application

After preparing the surface and filling the pin holes, primer coat (75-100 gm/m²) shall be applied with brush/lambskin roller/spray gun and shall be cured for 60 minutes or as specified by the manufacturer.

Subsequently, 1st and 2nd coats of polymer coating shall be applied with brush/spray gun/ roller keeping the time between coats not less than 2 h and not more than 72 h. Consumption per coat shall be 200-225 gm/m². The total dry film thickness of the protective coating for all coats shall be in the range of 200-225 microns. The wet film thickness shall be measured at a number of selected locations at the time of application with painting gauges. For measuring the dry film thickness, a suitably located painting gauge shall be used. At least one gauge shall be located on each face of superstructure in each span but not less than one gauge/100 m². For the given solid content in the application, the dry film thickness to wet film thickness ratio should be established by prior testing in the laboratory using appropriate panels like glass plates, flat concrete, and steel plates (300 x 300 mm) with similar coatings. Alternatively, the dry film thickness may be calculated from the measured wet film thickness by multiplying with the solid contents per unit volume.

vi. Performance Guarantee

This type of protective coating shall be executed only through authorized technical applicators of standard manufacturers who have requisite work experience for having carried out similar type coating works. The Engineer shall take a performance guarantee from the agency responsible for the execution of the work for a minimum period of 5 years.

6409A PROTECTIVE SURFACE COATING OF CONCRETE BY PATENTED SYSTEMS OF COATING

Patented system of protective coating like epoxy polyurethane painting system, epoxy phenolic protective system and other systems shall be used only with the approval of Engineer after the assessment of the performance of the product, backed by certificates from users, acceptance tests as per published standards, pertinently to cover the material, processes, carbonation resistance, water vapour diffusion property, crack bridging properties, and UV resistance. The Engineer shall take performance guarantee from the agency responsible for the execution of the work for a minimum period of 5 years.

6410A STRENGTHENING BY FIBER REINFORCED POLYMER

(a) General

Fiber Reinforced Polymer, commonly known as FRP system, comprises of an externally bonded composite reinforcement layer that is designed to an appropriate thickness & size to provide a quick, simple and effective means for increasing the capacity of the structural elements against failure. The primary fibres of the FRP system are oriented in a desired direction with reference to the axis of the structural element concerned in accordance with the type of strength enhancement required.

(b) Types of Fiber Reinforced Polymer

There are several types of composites, but these are three of the most common:

- i. Glass Fiber Reinforced Polymer (GFRP): This is heavier than the composites made with carbon or aramid, but it's especially impact-resistant and, in some cases, can be compared to steel.
- ii. Carbon Fiber Reinforced Polymer (CFRP): Using carbon fibre results in a composite that is water and chemical resistant and holds up against fatigue.
- iii. Aramid Fiber Reinforced Polymer (AFRP): Though sensitive to temperature and moisture, it has high fracture energy, making it ideal for ballistic armour.

(c) Selection of Suitable FRP

Selection of a suitable FRP system for structural application will be governed by several factors including its capacity to withstand stipulated loading conditions; long-term durability to effectively withstand the exposure environment over the service life of the structure; acceptance as per the standard qualification & testing program; level of strengthening that it can render; limitations posed by the existing concrete member or prevailing site conditions; as well as ease of application. It is essential to maintain a good bond between the composite and the concrete surface under all circumstances for FRP to be effective.

FRP system should be qualified for use on a project on the basis of three essential prerequisites that include:

- i. Independent laboratory test data on mechanical & physical properties of the system
- ii. Structural/performance test data for the type of application being considered
- iii. Durability test data to certify its long-term performance in the anticipated environmental exposure conditions

(d) Site Preparation and Access

The necessary access and temporary support structures shall be in place prior to the commencement of surface preparation. If deemed necessary to ensure acceptable environmental conditions and public safety, screening of the work shall be established.

(e) Preparation of Concrete Surfaces

The Surface preparation requirements should be based on the intended application of the FRP system. The marked concrete areas shall be grit blasted to remove all concrete laitance, surface coatings and impregnates, organic growth, bituminous residues, oil, dirt and any other surface contamination. The surface shall be sound and shall exhibit a coarse sand and aggregate texture to present a rough key to the adhesive.

Any cracks wider than 0.3 mm shall be pressure injected using a low viscosity epoxy resin system in accordance with the practice mentioned in ACI 440.2R or equivalent.

The prepared surface profile shall be checked using a 1.0 m long profile edge and any areas deviating by more

than 4.0 mm from the profile edge shall be marked.

Any high areas shall be removed with light scrubbing or grinding equipment and low areas can be filled with the adhesive to be used for bonding. Normal grit blasting preparation shall not remove more than 1.0 mm of the concrete surface.

The Engineer shall inspect the prepared surface to identify areas that are defective or substandard which may require additional preparation or remedial work. Repairs shall not weaken the load transfer to the concrete.

(f) Application of Adhesive to Bond Surfaces

Immediately before the application of the adhesive to the prepared concrete surface, the receiving surface shall be vacuum-cleaned to remove all dust, debris etc.

The mixed adhesive shall be trowelled onto the receiving concrete surface using plastering techniques. The adhesive shall be well worked into the grit-blasted surface to a layer thickness of approximately 2.0 mm. Skilled and experienced operators are essential due to the speed and care demanded by this phase of the work.

Surface preparation requirements including the application of adhesive should be obtained from the FRP system manufacturer, and shall be reviewed by the Engineer before application.

(g) Application of Saturant

The fully mixed saturant shall be applied to the fibre fabric material using a roller brush. Place the resin saturated fibre fabric material, saturant-side against the concrete, onto the concrete surface on which the primer has been applied.

The fibre reinforcement system shall be strongly squeezed in the direction of the fibres two or three times using a de-foaming roller and rubber spatula in order to impregnate the resin into the fibres and to de-foam the resin coat.

For joining strips of fibre sheets, a 150 mm overlap is required in the direction of the fibres and a 20 mm overlap in the direction transverse to the fibres. Additional resin shall be applied at the overlap location on top of the outer layer of fibre sheet to be overlapped. Any lifting or dislocation that occurs within the first 30 minutes shall be corrected using the roller and spatula.

The second coat of mixed saturant shall then be applied onto the surface of the fibre sheet. The coated surface shall be strongly squeezed in the fibre direction two or three times with the roller and spatula in order to impregnate the fibre sheets in the same manner as above.

The impregnated fibre reinforcement shall be left until fully cured before applying a protective topcoat.

(h) Application of Adhesive and Placing of Reinforcement Bars to be Bonded

The concrete slot and reinforcing steel surfaces receiving the adhesive shall be primed with a compatible primer approved by the Engineer. While the primer is still tacky the slot shall be filled with adhesive to a thickness sufficient to fill, with a slight excess, the gap between the concrete substrate and the reinforcement bar.

The reinforcement bar shall be placed and fixed into position within the slot using an approved method. The minimum thickness of adhesive shall be 1.0 mm.

The remainder of the slot depth shall then be filled with adhesive to a slightly convex surface with respect to the surrounding concrete surface.

The elements being bonded shall not be disturbed during the curing period of the adhesive.

(i) Laying of Fibre Fabric Materials

The reinforcing fibres should be gently pressed into the uncured saturating resin in a manner recommended by the FRP system manufacturer. Entrapped air between layers should be released or rolled out before the resin sets. Sufficient saturating resin should be applied to achieve full saturation of the fibres.

Successive layers of saturating resin and fibre materials should be placed before the complete cure of the previous layer of resin, as per the approved drawings. If previous layers are cured, interlayer surface preparation, such as light sanding or solvent application as recommended by the system manufacturer, may be required.

(j) Environmental Protection and Cleaning-Up

Care shall be taken during any work with adhesive components to avoid contamination of the subsoil and the environment. Any spillage, wastage and clean-up residues shall be collected, removed and disposed of in suitable containers at an approved waste disposal site. All work shall be carried out strictly in accordance with the Environmental Management Plan.

The concrete surface adjacent to the prepared surfaces receiving adhesive shall be protected against spillage where necessary. Any adhesive applied or spilled on unwanted areas shall immediately be removed and cleaned with an approved clean-up agent and procedure recommended by the manufacturer for the required purpose, as advised by the Engineer.

(k) Tolerances

The positional and level tolerances of the fibre elements shall comply with those specified on the detailed drawings, or if none is specified, as follows:

Position & Alignment: ± 5.0 mm with maximum 1° angular deviation

Level: ± 2.0 mm

Flatness: ± 5.0 mm deviation over a 2.0 m long straight-edge

(l) Inspection And Testing

FRP systems should be qualified for use on a project on the basis of independent laboratory test data of the FRP constituent materials and the laminates made with them, structural test data for the type of application being considered, and durability data representative of the anticipated environment. Test data provided by the FRP system manufacturer demonstrating the proposed FRP system should meet all mechanical and physical design requirements including tensile strength, durability, resistance to creep, bond to substrate etc. to comply with the provisions of ACI 440.2R or equivalent.

FRP composite systems that have not been fully tested should not be considered for use. Mechanical properties of FRP systems should be determined from tests on laminates manufactured in a process representative of their field installation. Mechanical properties should be tested in general conformance with the procedures listed in ACI 440.2R or equivalent. The specified material qualification programs should require sufficient laboratory testing to measure the repeatability and reliability of critical properties. Testing of multiple batches of FRP materials is recommended. Independent structural testing can be used to evaluate a system's performance for the specific application.

It is also mandatory to prequalify the FRP system supplier from the perspective of his competency in the application and quality control of the proposed FRP system. A composite system considered for use should have sufficient test data demonstrating adequate performance of the system in a similar application including its method of installation. Untested

combinations of fibres and resins could yield an unexpected range of properties as well as potential material incompatibilities.

(m) Workmanship

The Contractor shall submit the following to the Engineer for approval:

- i. The adhesive manufacturer's certification verifying conformance to the specification of the material for each batch of product delivered on site. The certification shall include the relevant laboratory test results.
- ii. A detailed method statement for the execution of the work covered in this section, including details of temporary works, work procedures and equipment to be used for mixing and placement of adhesive and bonding elements, as well as quality assurance procedures and tests that have to be followed to ensure that the correct quality of workmanship is achieved as part of his quality control testing procedure.

The Engineer may instruct that the on-site monitoring, sampling and testing be carried out by an independent test laboratory to ensure that the required standard of surface preparation, adhesive mixing, application and performance is achieved.

Detailed records of all operations and inspections carried out and materials received, issued and tested shall be kept by the Contractor and submitted to the Engineer.

6411A FRP REINFORCEMENT

Only GFRP bars manufactured using vinyl ester resin systems and glass fibres classified as E-CR or R that meet the requirements of ASTM D578 shall be used in road projects. The bars shall be manufactured using pultrusion, variation of pultrusion, or other suitable processes, subject to the approval of the Engineer.

GFRP reinforcing bars may be used in the following concrete components in road projects subject to the approval of the Engineer:

- i. Box Culvert, Slab Culvert
- ii. Approach Slab
- iii. Bridge Decks
- iv. Retaining Walls, Noise Barriers
- v. Crash Barriers, Bridge Parapets, Pedestrian Parapets, Railings
- vi. Mechanically stabilized earth wall panels & coping

The design of concrete components with GFRP reinforcing bars shall be based on relevant AASHTO and ACI specifications. Product qualification certification of GFRP reinforcing bars shall be based on tests given in ASTM D7957. For the determination of mean and guaranteed properties, at least 24 samples shall be obtained in groups of eight or more from three or more different production lots.

Product quality control certification shall be based on random tests of properties. For the determination of each of the property limits, five random samples shall be obtained from each production lot. Each individual sample shall satisfy the property limits given in ASTM D7957.

6412A REPLACEMENT OF BEARINGS

Necessary repair/replacement of bearings shall be carried out as indicated in the repair plan or as directed by the Engineer. Care shall be taken to plan the execution of repair in the shortest possible time.

Lifting of superstructure spans may be carried out by jacking up from below or by lifting the span from top. Where jacks are employed, their location/number and

size shall be selected in such a manner so that no undue stresses are created in the structure. Jacks may be placed on piers/pier caps or specially erected trestles in accordance with the approved methodology for lifting of superstructure. All jacks shall be operated from one control panel by a single control lever. The system shall have a provision for manual override to control the loads of any particular jack. The jacks should be so synchronized that the differential lift between individual jacks does not exceed 1 mm.

Precautions during Lifting of Girders for Rectification of Bearings.

A Walkie-talkie system or similar audio arrangements should be available for communicating instructions during lifting of girders for rectification/replacement of bearings. In the event of replacement it shall be ensured that the new bearing fits into the available space.

6413A REPAIR AND REPLACEMENT OF WEARING COAT

(a) Repair of Wearing Coat

Repair of bituminous wearing coat shall be as per SECTION 4700 of these Specifications.

(b) Replacement of Wearing Coat

- i. The existing wearing coat shall be dismantled before laying a fresh wearing coat.
- ii. Overlay shall not be provided on existing wearing coat on bridge decks unless its structural adequacy to carry extra load of overlay is assured and certified by the Engineer.
- iii. Before commencing dismantling, the nature and condition of the wearing coat shall be ascertained.
- iv. Dismantling of wearing coat shall be carried out using jack hammers or suitable manual/mechanical methods as approved by the Engineer. Care should be taken to avoid any damage to the existing structure including concrete, reinforcement or pre-stressing anchorages for cables, if any, located in the deck slab.
- v. The existing expansion joint assemblies shall be removed carefully along the entire width of the carriageway if included under the scope of work or as directed by the Engineer. In such cases, the deck slab for a width of 400 mm on either side should be removed for the placement of reinforcement, anchor rods, anchor bolts and other fixing assemblies for the new expansion joints and pouring of fresh concrete. The gap between the girders over the piers should be cleared of all debris. A temporary platform under the gap at the end of girders shall be erected to collect the materials falling down during concreting and fixing of expansion joints.
- vi. After dismantling the existing wearing coat fresh wearing coat shall be provided as per standard procedure mentioned in the Specifications. The expansion joint assembly, wherever dismantled shall also be fixed in position true to lines and levels.

(c) Precautions during Dismantling Work

For general guidelines, reference may be made to the relevant clause of the Specifications.

Dismantling work shall not be carried out at night, or during storm or heavy rain. A warning device shall be installed in the area to warn workers in case of a mishap/emergency.

Safety helmets conforming to BS Standards or equivalent shall be used by the workmen engaged in dismantling work. The sheds and toolboxes should be located away from the work site. To protect eyes and face from injuries from flying pieces, dirt, dust etc., celluloid goggles and gas masks shall be worn at the

time of dismantling, especially where tools like jack hammers are deployed. Leather or rubber gloves shall be worn by the workers during the demolition of RCC work. Screens made of GI sheets shall be placed wherever necessary to prevent flying pieces from injuring the workers.

Water should be sprayed to reduce the dust while removing concrete wearing course with jack hammer. No work shall be taken up under the span when dismantling work is in progress.

6414A TESTS AND STANDARDS OF ACCEPTANCE

The material shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

6415A MEASUREMENTS FOR PAYMENT

For epoxy grouting measurement for sealing of cracks and injection shall be made by weight of epoxy consumed in kg for epoxy grouting. For provision of nipples required for grouting, the payment shall be for number of nipples inserted.

For cement grouting measurement for sealing of cracks and injection shall be made by weight of cement consumed in kg.

Measurement for application of epoxy mortar/ protective surface coating of concrete for specified thickness shall be in square metre of surface area of application.

Bonding of old and new concrete by epoxy mortar shall be measured in square metre of surface area of the interface.

Guniting/ shotcreting shall be measured in square metre of surface area of application.

Replacement/ rectification of bearings shall be measured in number of bearing assemblies replaced /rectified.

Dismantling of wearing coat shall be measured in square metre of area of wearing course dismantled.

6416A RATE

The contract unit rate for sealing of cracks and injection of cement grout shall include cost of all materials, labour, tools and plant, placing in position, testing, curing and other incidental expenses for the satisfactory completion of the work as per the Specification.

The contract unit rate for application of epoxy mortar/protective surface coating for specified thickness shall include cost of all materials, labour, tools and plant, placing in position, testing and other incidental expenses including surface preparation for the satisfactory completion of the work as per the Specification and as shown on the drawings.

The contract unit rate for guniting/shotcreting shall include cost of all materials, labour, tools and plant, placing in position, testing, curing, surface preparation and other incidental expenses including the provision of nipples for the satisfactory completion of the work as per the Specification.

The contract unit rate for replacement/rectification of bearings shall include cost of all materials, labour, tools and plant, placing in position, site welding/riveting/bolt connections, operation of jacks and other incidental expenses for the satisfactory completion of the work as per the Specification and as shown on the drawings.

The contract unit rate for dismantling of wearing coat shall include cost of all materials, labour, tools and plant, traffic management, signage, safety precautions and

other incidental expenses including removal of existing expansion joints, if included as a part of the work by the Engineer for the satisfactory completion of the work as per the Specification.

6417A MEASUREMENT AND PAYMENT OF WORKS RELATED TO FRP

<u>ITEM</u>	<u>UNIT</u>
64.01A PREPARATION OF CONCRETE SURFACES	
(a) CONCRETE SURFACES PREPARATION (POSITION, SIZE AND MATERIAL INDICATED)	SQUARE METRE (m ²)
(b) SLOTS IN CONCRETE FOR FIBRE BONDING (POSITION, SIZE AND MATERIAL INDICATED)	METRE (m)

The unit of measurement shall be the square metre of concrete surface area repaired, and the metre of slots of the size specified.

The tendered rate shall include full compensation for all labour, materials, plant and equipment required for the cover and position survey of existing reinforcement, the measurement, recording and working on the concrete member, preparation of steel fabrication drawings, the surface preparation of the concrete surface and cutting of slots as required.

It shall also include the supply and application of an adhesive compatible primer to the prepared concrete surface if required for the type of adhesive being used

<u>ITEM</u>	<u>UNIT</u>
64.02A ADHESIVE AND SATURANT	
(a) ADHESIVE (DESCRIPTION OR TYPE TO LOCATION)	LITRE (l)
(b) SATURANT (DESCRIPTION OR TYPE TO LOCATION)	KILOGRAM (kg)

The unit of measurement shall be the litre of adhesive or kilogram of saturant used as approved by the Engineer. The volume shall be determined from the dimensions indicated on the detail drawings or as authorized by the Engineer following the detailed inspection of the prepared surfaces. Any overcut or excessive preparation resulting in additional adhesive quantities shall not be measured.

The tendered rate shall include full compensation for all labour, material, equipment, etc., required for the supply, mixing and application of the adhesive to the prepared concrete and steel or fibre surfaces, slots and holes. It shall also include the certification testing and quality assurance monitoring and testing by the Contractor, as well as any wastage of mixed or spilled materials and the disposal thereof.

The rate shall also include all costs arising from any clean-up and finishing actions required due to spillage or poor workmanship.

<u>ITEM</u>	<u>UNIT</u>
64.03A BONDED FIBRE FABRIC MATERIALS	
(a) FIBRE FABRIC MATERIAL (MATERIAL AND TYPE INDICATED)	SQUARE METRE (m ²)
(b) BARS (MATERIAL, TYPE AND SIZE INDICATED)	KILOGRAM (kg)

The unit of measurement shall be the mass of steel bars or square metre of fibre fabric bonded to the concrete member.

The tendered rate shall include full compensation for all labour, materials, plant, equipment etc., required for the

fabrication and supply of the steel items on site, the placing and fixing of the steel items into position including all ties, fasteners, waste, etc. complete as per details on the drawings. Fixing studs and bolts are measured separately.

It shall also include all costs arising from the surface preparation, corrosion protection and primer application to the steel or fibre bonding surface, as well as temporary support required during installation.

<u>ITEM</u>		<u>UNIT</u>
64.04A	PROTECTIVE PAINT COATINGS (TYPE AND FILM INDICATED)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of surface area covered by the paint coating measured in place.

The tendered rate shall include full compensation for all labour, materials, plant and equipment required to prepare the surfaces and to supply and apply the protective coating and primer to the required film thickness.

SERIES 6000: STRUCTURES

SECTION 6400B: SELF-COMPACTING CONCRETE (SCC)

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6401B SCOPE

This Section covers specific requirements for the Self Compacting Concrete (SCC) material, its composition and its application. The Section also includes a wealth of useful advice to designers, concrete manufacturers, contractors, specifying authorities and testing organisations.

6402B MATERIAL

(a) General

The constituent materials, used for the production of Self-Compacting Concrete (SCC) shall generally comply with the requirements of EN 206. The materials shall be suitable for the intended use in concrete and not contain harmful ingredients in such quantities that may be detrimental to the quality or the durability of the concrete, or cause corrosion of the reinforcement.

(b) Cement

Ordinary Portland cement either 43 or 53 grade cement can be used conforming to BS EN 197-1.

(c) Aggregates

Aggregates shall conform to BS EN 12620. The maximum size of the aggregates depends on the particular application and is usually limited to 20 mm. Well graded aggregates either round or cubical shape are the best choice. The fine aggregates used in SCC can be either natural aggregates or manufactured aggregates (M-Sand) with a uniform grade. The fine aggregates with a particle size less than 0.125 mm are generally employed. The moisture content should be closely monitored and must be taken into account in order to produce SCC of constant quality.

(d) Mixing Water

Quality of water used is the same as that allowed for reinforced concrete and pre-stressed concrete construction conforming to BS EN 1008.

(e) Admixtures

Admixtures used shall comply with BS EN 934-2: 2009 + A1:2012 (including Annex A), where appropriate. Superplasticizers are an essential component of SCC to provide the necessary workability. Other types may be incorporated as necessary, such as Viscosity Modifying Agents (VMA) for stability, air entraining admixtures (AEA) to improve freeze-thaw resistance, retarders for control of setting, etc.

VMA admixtures are not specifically covered in BS EN 934, but should conform to the general requirements in TABLE 1 of that standard. In addition evidence of performance should be provided by the supplier.

(f) Additions (including mineral fillers and pigments)

General suitability as Type I (semi-inert) addition is established for:

- Filler aggregate conforming to BS EN 12620
- Pigments conforming to BS EN 12878 General suitability as Type II (pozzolanic or latent hydraulic) addition is established for:
- Fly ash conforming to BS EN 450
- Silica fume conforming to DS/EN 13263-1 + A1 (2009)
- Ground granulated blast furnace slag conforming to BS 6699

Due to the special rheological requirements of SCC, both inert and reactive additions are commonly used to improve and maintain the workability, as well as to regulate the cement content and so reduce the heat of hydration. Type II additions can significantly improve the long-term performance of the concrete.

Typical additions are:

Stone powder: Finely crushed limestone, dolomite or granite may be used to increase the amount of Powder: the fraction less than 0.125 mm will be of most benefit.

Note: Dolomite may present a durability risk due to alkali-carbonate reaction.

Fly Ash: Fly ash is a fine inorganic material with pozzolanic properties, which can be added to SCC to improve its properties. However the dimensional stability may be affected and should be checked.

Silica Fume: Silica fume gives very good improvement of the rheological as well as the mechanical and chemical properties. It also improves the durability of the concrete.

Ground (Granulated) Blast Furnace Slag: GGBS is a fine granular mostly latent hydraulic binding material, which can also be added to SCC to improve the rheological properties.

Ground Glass Filler: This filler is usually obtained by finely grinding recycled glass. The particle size should be less than 0.1 mm and the specific surface area should be 2500 cm²/g. Larger particle sizes may cause Alkali-Silica reaction.

Pigments: The suitability of pigments used in SCC is established in BS EN 12878.

(g) Fibres

Fibres used in SCC shall comply with EN (European standard – in preparation). Commonly used types of fibres are steel or polymer.

Fibres may be used to enhance the properties of SCC in the same way as for normal concrete. Steel fibres are normally used to enhance the mechanical characteristics of the concrete such as flexural strength and toughness. Polymer fibres may be used to reduce segregation and plastic shrinkage, or to increase the fire resistance. Ease of mixing and the placing processes proposed, shall be demonstrated by site trials to the approval of the engineer.

ORDINARY CONCRETE		SCC
GRAVEL	Aggregate	GRAVEL
SAND		SAND
CEMENT	Binding material	CEMENT + CHEMICAL ADMIXTURES
WATER (+ PLASTICIZER)		WATER SUPER-PLASTICIZER THICKENER
	Fluid	

MATERIAL COMPOSITION OF ORDINARY CONCRETE AND SCC

6403B GENERAL

Self-compacting concrete (SCC) is fresh concrete that flows under its own weight and does not require external vibration to undergo compaction. It is used in the construction where it is hard to use vibrators for consolidation of concrete. Filling and passing ability, segregation resistance are the properties of self-compacting concrete.

Self-compacting concrete (SCC) has many benefits in terms of production and placement compared to traditional concrete such as, elimination of external or internal vibration for compaction, better flow-ability, workability and pump-ability, as well as increased bonding with congested reinforcement.

The Contractor shall furnish a method statement giving details of methodology of construction, sources of supply of materials, tools, equipment, and appliances to be used on work, personnel and supervision.

6404B DESIGN

Design Requirements for SCC are provided in the following sections.

(a) Personnel

The Contractor's personnel shall be qualified and experienced in Self-compacting concrete (SCC) process.

(b) Referenced Standards

BS EN 197-1 Cement; Composition, specifications and conformity criteria

BS EN 206-1 Concrete – Specification, performance, production, and conformity

BS EN 450 Fly ash for concrete – Definitions, requirements and quality control

BS EN 934-2: 2009 + A1:2012 Admixtures for concrete – Definitions and requirements

BS EN 1008 Mixing water for concrete

BS EN 12350-1 Testing fresh concrete: Part 1: Sampling

BS EN 12350-2 Testing fresh concrete: Part 2: Slump test

BS EN 12620 Aggregates for concrete

BS EN 12878 Pigments for colouring of building materials based on cement ...

BS EN 13263 Silica fume for concrete – Definitions, requirements and conformity control

BS EN ISO 9001 Quality management systems – Requirements

Note: Some of these EN standards may still be in preparation; the latest version should be referred to.

(c) Definitions

For the purposes of this specification, the following

definitions apply:

i) Addition

Finely-divided inorganic material used in concrete in order to improve certain properties or to achieve special properties. This specification refers to two types of inorganic additions: - nearly inert additions (Type I); - pozzolanic or latent hydraulic additions (Type II)

ii) Admixture

Material added during the mixing process of concrete in small quantities related to the mass of cement to modify the properties of fresh or hardened concrete.

iii) Binder

The combined cement and hydraulic addition in a self-compacting concrete

iv) Confined Flow-Ability

See CLAUSE 6404B (c) (ix) Passing ability Specification & Guidelines for Self-Compacting Concrete

v) Filling Ability (Unconfined Flow-Ability)

The ability of SCC to flow into and fill completely all spaces within the formwork, under its own weight

vi) Fines

See CLAUSE 6404B (c) (x) Powder.

vii) Mortar

The fraction of the concrete comprising Paste plus those aggregates less than 4 mm.

viii) Paste

The fraction of the concrete comprising Powder plus water and air constitutes paste.

ix) Passing ability (confined flow-ability)

The ability of SCC to flow through tight openings such as spaces between steel reinforcing bars without segregation or blocking.

x) Powder (Fines)

Material of particle size smaller than 0.125 mm, It will also include this size fraction of the sand.

xi) Self-Compacting Concrete (SCC)

Concrete that is able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration, whilst maintaining homogeneity.

xii) Segregation Resistance (Stability)

The ability of SCC to remain homogeneous in composition during transport and placing is termed as segregation resistance.

xiii) Stability

See CLAUSE 6404B (c) (xii) Segregation resistance.

xiv) Unconfined Flow-Ability

See CLAUSE 6404B (c) (v) filling ability

xv) Unconfined Flow-Ability

A measure of the ease by which fresh concrete can be placed and compacted: it is a complex combination of aspects of fluidity, cohesiveness, transportability, compactability and stickiness.

6405B REQUIREMENTS FOR SELF-COMPACTING CONCRETE**(a) Application Area**

SCC may be used in precast applications or for concrete placed on site. It can be manufactured in a site batching

plant or in a ready-mix concrete plant and delivered to site by truck. It can then be placed either by pumping or pouring into horizontal or vertical structures. In designing the mix, the size and the form of the structure, the dimension and density of reinforcement and cover should be taken into consideration. These aspects will all influence the specific requirements for the SCC.

Due to the flowing characteristics of SCC it may be difficult to cast to a fall unless contained in a form.

(b) Requirements

SCC can be designed to fulfil the requirements of BS EN 206 regarding density, strength development, final strength and durability.

Due to the high content of powder, SCC may show more plastic shrinkage or creep than ordinary concrete mixes. These aspects should therefore be considered during designing and specifying SCC.

Current knowledge of these aspects is limited and this is an area requiring further research. Special care should also be taken to begin curing the concrete as early as possible.

The workability of SCC is higher than the highest class of consistency described within BS EN 206 and can be characterised by the following properties:

- Filling ability
- Passing ability
- Segregation resistance

A concrete mix can only be classified as Self-compacting Concrete if the requirements for all three characteristics are fulfilled.

(c) Test Methods

Many different test methods have been developed in attempts to characterise the properties of SCC. So far no single method or combination of methods has achieved universal approval and most of them have their adherents. Similarly no single method has been found which characterises all the relevant workability aspects so each mix design should be tested by more than one test method for the different workability parameters.

TABLE 6405B/1: LIST OF TEST METHODS FOR WORKABILITY PROPERTIES OF SCC

Sl. No.	Method	Property
1	Slump-flow by Abrams cone	Filling ability
2	T50cm slump flow	Filling ability
3	J-ring	Passing ability
4	V-funnel	Filling ability
5	V-funnel at T5minutes	Segregation resistance
6	L-box	Passing ability
7	U-box	Passing ability
8	Fill-box	Passing ability
9	GTM screen stability test	Segregation resistance
10	Orimet	Filling ability

For the initial mix design of SCC all three workability parameters need to be assessed to ensure that all aspects are fulfilled. A full-scale test should be used to verify the self-compacting characteristics of the chosen design for a particular application.

For site quality control, two test methods are generally sufficient to monitor production quality. Typical Combinations are Slump-flow and V-funnel or Slump-flow and J-ring.

TABLE 6405B/2: WORKABILITY PROPERTIES OF SCC AND ALTERNATIVE TEST METHODS

Property	Test methods	
	Lab (mix design)	Field (QC)
Filling ability	Slump flow T50cm slump flow V-funnel Orimet	Slump flow T50cm slump flow V-funnel Orimet
Passing ability	L-box U-box Fill-box	J-ring
Segregation resistance	GTM test V-funnel at T5minutes	GTM test V-funnel at T5minutes

(d) Workability Criteria for the Fresh SCC

These requirements are to be fulfilled at the time of placing. Likely changes in workability during transport should be taken into account in production.

Typical acceptance criteria for Self-compacting Concrete with a maximum aggregate size up to 20 mm are shown in TABLE 6405B/3.

TABLE 6405B/3: ACCEPTANCE CRITERIA FOR SELF-COMPACTING CONCRETE

Sl. No.	Method	Unit	Typical range of values	
			Minimum	Maximum
1	Slump flow by Abrams cone	mm	650	800
2	T50cm slump flow	sec	2	5
3	J-ring	mm	0	10
4	V-funnel	sec	6	12
5	Time increase, V-funnel at T5minutes	sec	0	+3
6	L-box	(h2/h1)	0,8	1,0
7	U-box	(h2-h1) mm	0	30
8	Fill-box	%	90	100
9	GTM Screen stability test	%	0	15
10	Orimet	sec	0	5

Values outside these ranges may be acceptable if the producer can demonstrate satisfactory performance in the specific conditions, e.g., large spaces between reinforcement, layer thickness less than 500 mm, short distance of flow from point of discharge, very few obstructions to pass in the formwork, very simple design of formwork, etc.

Special care should always be taken to ensure no segregation of the mix is likely.

6406B CONSTRUCTION

(a) General

The mix composition shall satisfy all performance criteria for the concrete in both the fresh and hardened states. For the fresh concrete, the requirements are set out in the above Clauses. In the hardened state, the requirements of EN 206 shall be fulfilled.

(b) Initial Mix Composition:

In designing the mix it is most useful to consider the relative proportions of the key components by volume rather than by mass.

Indicative typical ranges of proportions and quantities in

order to obtain self-compactability are given below. Further modifications will be necessary to meet strength and other performance requirements.

- Water/powder ratio by volume of 0.80 to 1.10
- Total powder content - 160 to 240 litres (400-600 kg) per cubic meter.
- Coarse aggregate content normally 28 to 35 per cent by volume of the mix.
- Water: Cement ratio is selected based on requirements in BS EN 206. Typically water content does not exceed 200 litre/m³.
- The sand content balances the volume of the other constituents

Generally, it is advisable to design conservatively to ensure that the concrete is capable of maintaining its specified fresh properties despite anticipated variations in raw material quality. Some variation in aggregate moisture content should also be expected and allowed for at mix design stage. Normally, viscosity- modifying admixtures are a useful tool for compensating for the

Fluctuations due to any variations in the sand grading and the moisture content of the aggregates.

(c) Adjustment of the Mix

Laboratory trials should be used to verify the properties of the initial mix composition. If necessary, adjustments to the mix composition should then be made. Once all requirements are fulfilled, the mix should be tested at full scale at the concrete plant or at site.

In the event that satisfactory performance cannot be obtained, then consideration should be given to fundamental redesign of the mix. Depending on the apparent problem, the following courses of action might be appropriate:

- Using additional or different types of filler, (if available);
- Modifying the proportions of the sand or the coarse aggregate;
- Using a viscosity modifying agent, if not already included in the mix;
- Adjusting the dosage of the superplasticizer and/or the viscosity modifying agent;
- Using alternative types of superplasticizer (and/or VMA), more compatible with local materials;
- Adjusting the dosage of admixture to modify the water content, and hence the water/powder ratio.

6407B PRODUCTION AND PLACING

(a) General

The production of self-compacting concrete needs to be carried out in plants, where the equipment, operation and materials are suitably controlled. Production should therefore be carried out at ISO 9000 accredited plants or plants with a quality system that conforms to ISO 9000 or similar. It is recommended that production staff involved in the production of self-compacting concrete have been trained and also have experience in self-compacting concrete.

(b) Production

i) Storage of Constituent Materials

If possible, aggregates should be covered to minimise the fluctuation of surface moisture content. It is also necessary to have good storage capacity for aggregates and additions (if used).

Storage of concrete admixtures can be done in the same way as for normal concrete. The supplier's recommendations should be followed.

ii) Mixing

There is no requirement for any specific mixer type. Forced action mixers, including paddle mixers, free fall mixers, including truck mixers, and other types can all be used. The mixing time necessary should

be determined by practical trials. Generally, mixing times need to be longer than for conventional mixes.

Time of addition of admixture is important, and procedures should be agreed with the supplier after plant trials. If the consistency has to be adjusted after initial mixing, then it should generally be done with the admixtures. If the requirements of EN 206 for the water/cement ratio can be maintained, then the water content can be varied to make the necessary modification.

(c) Production Control

i) Aggregates

During production of SCC, tests of aggregate grading and moisture content should be carried out more frequently than usual, since SCC is more sensitive than normal concrete to variations.

ii) Mixing process

At the start of a contract and in the absence of previous experience with the particular mix design, additional resources may be needed for supervision of all aspects of initial production of SCC.

Since the quality of freshly mixed concrete may fluctuate at the beginning of production, it is recommended that workability tests be conducted by the producer on every load, until consistent and compliant results are obtained. Subsequently, every delivered batch should be visually checked before transportation to site, and routine testing carried out to the frequency specified in EN 206.

More frequent adjustment of mix proportions, particularly water content, may need to be made, depending on the results from monitoring aggregate moisture content.

(d) Delivery and Transportation

Depending on the size of the concrete structure to be produced in SCC, production capacity, journey time and placing capability need to be balanced. Unexpected production stops can result in consistent variations that adversely affect the end result.

SCC should be designed so that workability is maintained to meet the requirements of the contract. Placing is faster, especially if a pump is used, but it is still essential to make sure that delivery and placing can be completed within the workability-retention (self-compact ability) time of the concrete.

(e) Placing

i) General

Before placing SCC, It should be confirmed that reinforcement and formwork are arranged as planned. The formwork must be in good condition but no special measures are necessary to prevent grout loss. Contractors may wish to consider possible advantages of pumping from the bottom of formwork. If concrete is placed by a skip, attention should be paid to the closure of the gate.

For forms in excess of 3 m in depth, the full hydrostatic head should be taken into consideration. This may require modification of the formwork design and/or the SCC.

ii) Placing Distance

Though it is easier to place SCC than ordinary concrete, the following rules are advised to minimise the risk of segregation:

- Limit the vertical free fall distance to 5 m; and
- Limit the permissible distance of horizontal flow from point of discharge to 10 m.

iii) Cold Joints

Although SCC bonds well with previously placed concrete, the likelihood of damage resulting from a cold joint cannot be mitigated by vibration, as with normal concrete.

iv) Surface Finishing

Surfaces of SCC should be roughly levelled to the specified dimensions, and the finishing should then be applied at an appropriate time before the concrete stiffens. Difficulty may be encountered with the conventional process of final surface hardening of horizontal areas of concrete by repeated steel trowelling. Alternative procedures or different tools may be required.

(f) Curing

SCC tends to dry faster than conventional concrete because there is little or no bleed water at the surface. Initial curing should therefore be commenced as soon as practicable after placing in order to minimise the risk of shrinkage cracking.

6408B QUALITY CONTROL**(a) Production Control**

All SCC shall be subject to production control under the responsibility of the producer, and this shall be in accordance with the requirements of EN 206-1, clause 9.

(b) Site Acceptance

In the case of SCC it is particularly important that receiving control be standardised. Producer and purchaser should therefore agree on a procedure for acceptance/compliance at the start of a contract. This should include a procedure for action to be taken in the event of non-compliance.

Besides the normal check of delivery ticket, a visual check of the concrete should be made. Site quality control should follow the recommendations of this specification.

The purchaser should ensure that all site acceptance testing is carried out by competent, trained personnel, in a suitable environment – this includes an area protected against the weather, suitably maintained and calibrated equipment, and level, stable ground for performing the test.

6409B MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
64.01B Self-Compacting Concrete:	Cubic Meter (m ³)

For SCC of specified cross-section, the measurement shall be as per cum volume of the finished structure complete in place in compliance with contract drawings.

The unit rate for SCC shall include the cost of concrete and all other items as per the requirements of these Specifications. The contract unit rate shall also include costs of all labour, materials, equipment and all other incidentals involved in conducting quality control tests, including casting, shuttering and curing.

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SECTION 6400C: NO-FINES CONCRETE

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6401C SCOPE

This Section covers the manufacture and placing of no-fines concrete used in the Works.

6402C MATERIALS

Cement, aggregate and water shall comply with the requirements of CLAUSE 6402.

(a) Cement

Cement shall comply with the requirements of US EAS 18-1:2017 (CEM I or II), AASHTO M85-2020 or equivalent standard on approval of the Engineer. The use of rapid-hardening cement shall not be permitted.

(b) Sulphate-Resistant Cement

Cement conforming to the requirements of BS 4027:2007, but only where shown on the Drawings or instructed by the Engineer.

(c) Blast-Furnace Cement

Blast-furnace cement may be used if specified in the Special Specifications, and shall comply with the requirements of US EAS 18-1:2017 (CEM III), AASHTO M240M/M240: 2021 or equivalent standard on approval of the Engineer.

The type of cement to be used for different concrete members shall be set out in the Special Specifications

(d) Aggregates

Both coarse aggregate (stone) and fine aggregate (sand) shall comply with the requirements of BS EN 1367-4:2008 AND BS EN 12620:2013 or equivalent, subject to the following:

Aggregates shall not contain any deleterious amounts of organic materials such as grass, timber or similar materials and shall be free from clay, shale, pyrites and all other impurities as shown in TABLE 6402/1.

Each size of aggregate shall be a single size aggregate graded in accordance with or BS EN 12620:2013, BS 882:1992 or equivalent.

(e) Water

Water for use in mixing concrete and mortar and for curing and related purposes shall be obtained from a source approved by the Engineer and shall comply with the requirements of BS EN 1008:2002.

Water shall be clean, fresh and free from detrimental concentrations of acids, alkalis, salts, sugar and other organic or chemical substances that could impair the durability and strength of the concrete or the imbedded steel. The Contractor shall prove the suitability of the water by way of tests conducted by an approved

laboratory. For reinforced and prestressed concrete, the chloride content of the mixing water shall not exceed 500 mg/l when tested in accordance with BS 6068-2.37:1990, SANS 5202/ SABS SM 202 or equivalent.

6403C CLASSES OF NO-FINES CONCRETE

No-fines concrete shall be classified by the prefix NF and the size of aggregate to be used. E.g. CLASS NF 19 means a no fines concrete with a 19.0 mm nominal size aggregate.

The volume of aggregate per 50 kg of cement for each class of concrete shall be as detailed in TABLE 6403/1.

TABLE 6403C/1: VOLUMES OF AGGREGATE

Class of cement	Aggregate per 50 kg
NF38	0.33 m ³
NF19	0.30 m ³
NF13	0.27 m ³

6404C BATCHING AND MIXING

Cement shall be measured by weight or in full packets of 50 kg each and aggregate shall be measured by volume in approved measuring boxes or barrows.

The aggregate shall be moist or wetted before the cement is added. Where drum mixers are used, about 20% of the water shall be poured into the drum before the aggregate and cement are loaded. The mixing time in the drum shall be about 45 to 50 seconds.

The quantity of water added shall be just sufficient to form a smooth grout which will adhere to and completely coat each and every particle of aggregate, and which is just wet enough to ensure that, at points of contact of aggregate, the grout will run together to form a small fillet to bond the aggregate together. The mix shall contain no more than 20 litres of water for every 50 kg of cement.

Mixing shall be done in an approved batch-type mechanical mixer, but small quantities may be hand mixed.

6405C PLACING

No-fines concrete shall be placed in accordance with the procedure approved by the Engineer. It shall be placed in its final position within 15 minutes of having been mixed.

The concrete shall be worked sufficiently to ensure that it will completely fill the space to be concreted and that adjacent aggregate particles are in contact with one another. Excessive tamping shall be avoided and the concrete shall not in any circumstances be vibrated.

6406C PROTECTION

All no-fines concrete shall be protected from the elements and loss of moisture. Protection against loss of moisture shall be accomplished by one or more of the following methods:

- Retaining formwork in place.
- Covering enclosed surfaces with sacking or other approved material kept continuously wet.
- Covering enclosed surfaces with plastic sheeting.

No-fines concrete placed during cold weather shall be adequately protected against frost for at least three days.

6407C MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
C64.01 CAST IN SITU NO-FINES CONCRETE	CUBIC METRE (m ³)

The provisions of CLAUSE 6416 ITEM 64.01 shall apply with changes as required.

<u>ITEM</u>	<u>UNIT</u>
C64.02 PRECAST NO-FINES CONCRETE UNITS (CLASS OF CONCRETE AND DESCRIPTION OF UNIT)	NUMBER (no.)

The unit of measurement shall be the number of complete units of each size and type in position in the Works.

The bid rate for each precast concrete unit shall include full compensation for providing all the materials, labour, plant and formwork required for manufacturing the unit complete as shown on the Drawings and for transporting and placing the unit in position.

SERIES 6000: STRUCTURES

SECTION 6400D: CABLE - CONCRETE

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6401D SCOPE

This specifies about cable concrete, which is basically a construction product that consists of concrete cubes anchored together with cables and surfaced with a geotextile filter mat.

6402D MATERIAL

(a) General

The materials for production of cable concrete are: concrete cubes, stainless steel cables and geotextile. Materials to be used in the manufacturing of cable concrete are illustrated in the following portions of Specification.

(b) Concrete

Concrete shall be made of a mixture of cement, sand and aggregates using a specified water cement ratio. The concrete shall be manufactured on the grades of the cable concrete such as CC20, CC35, CC45 and CC70. The grade of concrete shall be selected depending on the nature of the job.

The concrete shall meet the requirements of respective sections of specifications for materials, testing, and methods of construction. The concrete mix shall be designed to meet the minimum required concrete strength of 25 MPA @ 28 days with a minimum of 5-8 % air entrainment throughout.

(c) Cable

The cables shall be made of a suitable type of stainless-steel aircraft cable. 1x19 constructions or polypropylene cables shall be used. Cables shall be integral (poured into) to the concrete block and shall traverse through each block in both longitudinal and lateral directions, providing a flexible interlocked system.

TABLE 6402D/1: CABLE SPECIFICATIONS

STAINLESS STEEL CABLE				
System	Lengthwise		Widthwise	
	mm	inches	mm	inches
CC35	4	5/32"	4	5/32"
CC45	4	5/32"	4	5/32"
CC70	4.8	3/16"	4.8	3/16"

(d) Geotextiles

The standard geotextile material used is a needle punched non-woven fabric which is attached to the underside of the mats. An overlap shall be incorporated on three sides with a suitable dimension.

(e) Clamps

Sufficient malleable or stainless-steel cable clamps shall

be used to connect adjoining Cable Concrete mats. The standard placement of clamps shall be placed on 1.22 m (4') centres connecting adjoining mats together. Clamps shall be recommended in applications exceeding 3.05 m (10') with an alternative application.

When placing clamps under existing water, the manufacturer will specify a clamp for the condition.

(f) Anchoring

Cable Concrete mats shall be designed to take certain velocities in certain slope and bedding situations.

Anchoring Cable Concrete mats will offer additional safety to the erosion protection system. If a situation arises where velocities may exceed maximum limits of a system, or if slopes of 1.5:1 or greater are encountered, then anchoring will become an item to be specified by the governing project engineer.

Anchoring system should be ideal for anchoring cable concrete, erosion mats, concrete gabion etc.

The standard anchor has a standard overall length, but it can be customized with extra length supplied as required.

6403D DESIGN

(a) General

Design of cable concrete is to be done in consistent with the nature of the application it is intended to use. The experimental data may be used to obtain the forces for a block on a sloping bed. These forces are transferred to the side slope by trigonometry and are to be calculated by the standard guidelines. The block stability is evaluated in terms of Factors of Safety for sliding and overturning, shear stress distribution on the boundary of a trapezoidal channel.

The Cable Concrete Blocks are connected by cables; however, the analysis ignores the stabilizing effect of these cables for ensuring safety without taking help of cables.

(b) Failure Modes

The modes of failure on the bed should be derived, which includes Sliding & Overturning. Sliding may occur when the shear force in the direction of flow exceeds the maximum available friction force. Overturning may occur due to the design Bending Moment.

The modes of failure on the side should be derived from the following considerations:

- Sliding in which the shear force in the direction of flow exceeds the maximum available friction force
- Sliding down the slope when gravitational force on the block exceeds the maximum available friction
- Sliding in the direction of the resultant force due to the resultant force exceeding the maximum friction force on the side slope
- Overturning in each orthogonal direction and combined direction

(c) Hydraulic Design Criteria

Hydraulic design of Cable Concrete Mats is to be carried out to find:

- Safe jetting velocity for various mat placements
- Correction factors for channel and side slopes are to be applied to the velocity
- Manning's n for subcritical and supercritical flow for various placements of the mats
- Uniform flow design

6404D DRAINAGE

Good drainage of the sub-grade is important in the prevention of slope failure due to slumping or sloughing and of 'piping' failure under the geotextile in steep

channels.

Cable concrete mats are designed as a free draining system; if grout or some other coating is applied to protect the geotextile, it is essential that sufficient venting be provided so that no significant uplift can develop on the mats.

A typical arrangement of sub-surface drains is designed with the associated collectors and risers for drainage of a side slope to improve slope stability and to collect and safely remove overland and ground water flows that might cause erosion under the mats.

The design of sub-surface drainage for long steep channels with super critical flow requires input from an expert. The drainage on these slopes is necessary to prevent erosion or sloughing of the subgrade. This erosion may occur as a 'piping' failure or a sloughing type failure due to fluidization of the subgrade material. The flow that leads to the potential failure may come from seepage through the geo-textile under the mats or from ground water flow.

Sub-surface drain is to collect seepage that passes through the mat installation; this system would normally be combined with a side slope drainage system which would mainly control ground water flow. The purpose of the geotextile is to provide for the free outflow of water from the subgrade materials without loss of the fine material through the filter.

6405D INSTALLATION

Installation equipment shall have a lifting capacity, capable of completely lifting the concrete mat and the lifting bar during unloading, stockpiling and installation etc.

Prepared areas shall be graded to a smooth plane finish. Any roots, debris and stones must be removed and regarded. Specified geotextile will be placed according to manufacturing recommendations. The mats shall be laid on the geotextile in such a manner as to produce a smooth plane surface.

Intimate contact with the subsurface is critical to the system's performance in the field.

The gap between each mat shall not be greater than 2", preferably 1" or it must be closed using a cement mixture.

It is recommended that after the installation of the mat system, it be covered with desired backfill. If vegetation is required, the mat system shall be backfilled and seeded. This will allow moisture to traverse back and forth from subgrade to vegetation. Vegetation will lend support and an even grade for maintenance vehicles (mowers) to traverse over it. Any surface application should not be placed prior to the inspection of the system.

6406D APPLICATION

The mats can be placed in a wide variety of channel cross-sections. Some typical applications for cable concrete mats are as under:

Erosion protection at transitions and bends where the local velocities and/or turbulence exceed the resistance of the soil; or

Temporary erosion protection during construction; or

Erosion protection for banks subjected to a combination of currents and small waves for example due to pleasure boats; or

Headwalls protection.

6407D QUALITY CONTROL

The Following tests for sand are to be performed at the Casting Yard:

(a) Organic Impurities Test

This test will be conducted at the field, for every 20 cum or part thereof.

(b) Silt Content Test

This is also a field test and to be conducted for every 20 cum. The maximum quantity of silt in sand shall not exceed 8%. Fine aggregate containing more than the allowable percentage of silt shall be washed so as to bring the silt content within allowable limits.

(c) Particle Size Distribution

This test will be conducted at site or in laboratory for every 40 cum of sand. On the basis of particle size, fine aggregate will be graded into four zones. Where the grading falls outside the limits of any particular grading zone of sieves, other than 600-micron sieve by a total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone.

(d) Bulking of Sand

This test will be conducted at site for every 20 cum of sand. Based on bulking of sand, a suitable water cement ratio will be calculated for concrete at site. Fine aggregates, when dry or saturated, have almost the same volume but dampness causes an increase in volume. In case fine aggregates are damp at the time of proportioning the ingredients for concrete, its quantity shall be increased suitably to allow for bulkage.

(e) Coarse Aggregates

Coarse aggregates should consist of one or a combination of gravels or crushed stone with particles predominantly larger than 5 mm (0.2 in.) and generally between 9.5mm and 37.5 mm ($\frac{3}{8}$ in. and $1\frac{1}{2}$ in.). Naturally occurring concrete aggregates should be a mixture of rocks and minerals.

6408D MEASUREMENT AND PAYMENT

The measurement of Cable Concrete shall be as per sqm of the finished structure complete in place in compliance with contract drawings.

Payment shall be by the square meter and shall include Cable Concrete mats, labour, equipment including lifting bar rental and delivery to site. Upgrades or additional items shall be considered additional.

<u>ITEM</u>	<u>UNIT</u>
64.01D CABLE CONCRETE	SQUARE METRE (m ²)

SERIES 6000: STRUCTURES

SECTION 6500: PRESTRESSING

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6501 SCOPE

This Section covers the materials, equipment and work required for pre-stressing structural concrete members.

6502 DEFINITIONS

The following definitions shall apply to these Specifications:

(a) Anchorage

Anchorage is the device comprising all the components and materials required for retaining the force in a tensioned tendon and to transmit this force to the concrete of the structure.

(b) Anchorage Reinforcement

Anchorage reinforcement is the spiral and other reinforcement which forms part of the anchorage and is required for strengthening the anchorage and/or assisting in transmitting the tendon force to the concrete. It consists of spalling reinforcement and bursting reinforcement.

i) Spalling Reinforcement

Consideration should also be given to the spalling tensile stresses that occur in anchorage zones. Where the anchorage or bearing plates are highly eccentric, these stresses reach a maximum at the loaded face. The end face of anchorage zone shall be continuously reinforced to prevent edge spalling. Reinforcement shall be placed as close to the end face as possible.

ii) Bursting reinforcement

Bursting reinforcement is the reinforcing steel required in and adjacent to the anchorage zones to resist the lateral tensile stresses induced in the concrete by the pre-stressing forces through anchorage(s). In addition Equilibrium Reinforcement is also required, as specified below:

(c) Equilibrium Reinforcement

Equilibrium reinforcement is required where there are several anchorages in which pre-stressing loads are applied sequentially.

(d) Cable

Cable is the tendon, together with the anchorage, sheathing and all fittings.

(e) Characteristic Strength

Characteristic strength of pre-stressing steel is the manufacturer's guaranteed tensile strength below which no more than 5% of the test results in a statistical population shall fall.

(f) Duct

Duct is the void formed to house the tendon(s) and may be formed by coring, or by using sheaths or by way of extractable cores.

(g) Pre-Stress

Pre-stress is the stress induced in concrete by tensioned tendons.

(h) Pre-Stressed Concrete

Pre-stressed concrete is structural concrete in which effective internal stresses are induced by means of tensioned tendons. In prestressed concrete members, only the use of CEM I and CEM II cements with a strength class of 42.5 or greater, and a rate of strength gain N or R, shall be permitted. A site blend of cement and ground granulated blast furnace slag or ground granulated corex slag conforming to SANS 55167-1 up to a maximum cumulative replacement value of 40 %, fly ash conforming to SANS 50450-1 up to a maximum replacement value of 20%, or silica fume, conforming to SANS 53263-1 up to a maximum replacement value of 7 %, by mass of total cementitious binder may be used only if given in the Contract Documentation or by the Engineer in writing. Reference is further made to Eurocode 2: Design of concrete structures (EN 1992-1-1) and other acceptable reference (references) in managing prestressed concrete elements.

(i) Pre-Tensioned Concrete

Pre-tensioned concrete is pre-stressed concrete where the tendon is tensioned before the concrete has been cast.

(j) Post-Tensioned Concrete

Post-tensioned concrete is pre-stressed concrete where the tendon is tensioned after the concrete has hardened.

(k) Pull-in

Pull-in is the elastic shortening of the tendon caused by relative movement between the anchorage or coupler components on account of seating and gripping action during or immediately after transfer.

(l) Release

Release is the specified elastic shortening of the tendon at the anchorage achieved before or during transfer.

(m) Sheath

Sheath is the tube or casing enclosing the tendon and which temporarily or permanently allows a relative movement between the tendon and the surrounding concrete.

(n) Tendon

Tendon is the pre-stressing steel consisting of the bar, wire or strand individually placed, or of bars, wires or strands placed in a duct, all of which are tensioned to impart pre-stress to a concrete member.

(o) Tensioning

Tensioning is the action of inducing and regulating the force in a tendon by means of tensioning and measuring equipment.

(p) Transfer

Transfer in the case of post-tensioned concrete is the action of transferring the tensioning force from the tensioning equipment (jack) to the anchorage.

Transfer in the case of pre-tensioned concrete is the action of transferring the force in the tensioned tendon(s) to the concrete.

(q) Bond Breaker

Bond breaker is the coating or sheath placed on a tendon to prevent it from bonding to the surrounding concrete.

(r) Coupler

Coupler is a device comprising of all components required to join two tendons.

(s) Deflector

Deflector is the device used to deflect a tendon alignment within a structural element.

(t) Transmission Length

Transmission length is the tendon length required to transmit via bond stresses the full force in the tendon to the concrete.

(u) Precamber

Precamber is the allowance made into formwork to accommodate the slightly convex shape of a horizontal pre-stressed member.

6503 MATERIALS

(a) General

All materials and pre-stressing systems used in the pre-stressing of structural concrete members shall be subject to approval by the Engineer.

(b) Pre-Stressing Steel

i) General

The Contractor shall keep proper records of all material analyses and test certificates for the batches of pre-stressing steel used in the Works. Where required by the Engineer, the Contractor shall produce certificates from recognised testing authorities certifying compliance of the pre-stressing steel with the specified requirements.

Where pre-stressing steel is available in weld-free lengths (production lengths) and lengths containing welds (standard lengths), the batches delivered at the site shall be clearly labelled for identification purposes.

Under no circumstances shall pre-stressing steel after manufacture be subjected to heat treatment other than provided for in the Specifications.

ii) Bars

Cold-worked high-tensile alloy steel bars for pre-stressed concrete shall comply at least with the requirements of BS 5896:2012.

The type of pre-stressing steel shall be indicated in accordance with the requirements of CLAUSE 4.2 OF BS 5896:2012 e.g. BS 4486-RR-32-1230 for 32 mm diameter double-ridged bar with a characteristic strength of 1,230 MPa.

iii) Wires and Seven-Wire Steel Strand

Steel wire and seven-wire steel strand for pre-stressed concrete shall comply at least with the requirements of BS 5896:2012.

The type of pre-stressing steel shall be indicated in accordance with the requirements of CLAUSES 14 AND 20 OF BS 5896:2012 for wire and strands respectively, e.g.:

- a. BS 5896/2 wire 1770-7-PE-relax 1 for a 7 mm diameter plain wire of Class 1

relaxation with a characteristic strength of 1770 MPa; and

- b. BS 5896/3 superstrand 1860-12.9-relax 2 for a 12.9 mm diameter superstrand of Class 2 relaxation with a characteristic strength of 1860 MPa.

iv) Straightness

Pre-stressing bars delivered at the site shall be straight. Only small adjustments for straightness may be made, which shall be done by hand on the site at a temperature above 5°C and under the supervision of the Engineer. Where heating of the bars is required, this shall be by means of steam or hot water. Bars bent in the threaded portion shall not be used.

Pre-stressing wire and strand shall be supplied in coils with a sufficiently large diameter to ensure that the wire and strand will reel off straight.

v) Surface Condition

Pre-stressing steel shall be clean, free from faults or defects, and without any harmful films and matter which may impair adhesion to the grout or concrete. A film of rust is not necessarily harmful and may improve the bond. It may, however, increase the friction between the tendon and duct. The depth of imperfections or pits on the surface of pre-stressing steel shall not exceed 0.1 mm for wire with a diameter up to and including 8 mm, or 0.2 mm for bars or wire with a diameter exceeding 8 mm.

Tendons may be cleaned by wire brushing or by passing through a pressure box containing carborundum powder. Solvent solutions shall not be used for cleaning without the approval of the Engineer.

Pre-stressing steel shall be delivered at the site suitably protected against damage and corrosion. Such protection or the use of a corrosion inhibitor, where allowed by the Engineer, shall not have any deleterious effect on the steel or concrete or impair the bond between the two.

vi) Galvanising

Galvanised pre-stressing steel shall not be used unless specified. Under no circumstances shall pre-stressing steel be subjected to galvanising after manufacture.

vii) Welds

Pre-stressing steel used in structural pre-stressed concrete shall be weld-free. Where the steel is supplied in standard lengths, the welds shall be cut out and delivered to the Engineer.

(c) Anchorages and couplers

Anchorages and couplers to be used in pre-stressed concrete shall comply with the requirements of BS 4447:1973 and shall be of a proved and approved type, constructed from durable material completely free from imperfections and shall not damage, distort or kink the pre-stressing steel in a manner that will result in ultimate tensile strength reduction. They shall resist, without failure and/or excessive deformation or relaxation of the force in the tendons, the full ultimate tensile strength of the tendons. The characteristic value for anchorages and couplers, determined in accordance with BS 4447:1973, shall not be less than 90%.

The anchorages shall effectively distribute the force in the tendon to the structural member, and the resulting local stresses and strains in the member shall be so limited as to prevent damage. Unless otherwise approved by the Engineer, all anchorages and couplers shall be provided with anchorage reinforcement.

Wedges and the insides of barrels or cones shall be

clean to allow the free movement and seating of the wedges inside the taper.

The threads of bars, nuts, anchorages and couplers shall be suitably protected against damage and corrosion. The protection shall be removed at the last moment and the threads properly lubricated before use.

(d) Sheaths

Sheaths shall be grout-tight and of such material and configuration that bond forces can be transferred from the grout to the surrounding concrete. The properties of the sheath material shall be such that no corrosion attack of the prestressing steel will be induced. The sheath shall be sufficiently flexible to accept the required curvature without kinking, and strong enough to retain its cross-section and alignment and to resist damage on account of handling, transporting, tying and contact with vibrators during concreting. Unless otherwise approved by the Engineer the thickness of the metal of steel sheaths shall not be less than 0.4 mm.

Metal sheathing shall be delivered at the site suitably protected against damage and corrosion. At the time of incorporation into the structural member, the sheathing shall be free from loose mill scale, loose rust, lubricants and harmful matter.

Galvanised sheathing shall not be used unless specified.

Unless otherwise specified, the internal diameter of the sheath shall be at least 10 mm greater than the diameter of the tendon. For vertical tendons and where tendons are to be drawn into cast-in sheaths, the cross-sectional duct area shall be at least three times the cross-sectional area of the tendon.

The system of ducts, duct connectors, grouting connections, vents, vent connections, drains, transitions to anchorages and caps for anchors shall form a complete encapsulation for the tendons which is resistant to the ingress of air and water. Ducts shall be of plastic and shall not degrade during the expected life of the structure. The system shall be fully compatible with the pre-stressing anchorages, couplers and other details. Where ducts are non-conductive, metal parts of anchorages shall be electrically bonded to the adjacent reinforcement at each end of the tendon and electrical continuity of the structure over the length of the tendon shall be confirmed by testing. All ducts shall be kept free from standing water at all times and be thoroughly clean before grouting.

Unless otherwise specified in the Contract, each complete duct system including vents, anchorages, anchorage caps, and where appropriate couplers and their connections, shall be air-pressure tested before concreting. Testing to a pressure of 0.01 N/mm², shall demonstrate that the system is undamaged and has been correctly assembled. The testing shall demonstrate that a loss of pressure no greater than 10% occurs after 5 minutes. The minimum manufactured wall thickness of ducting for internal tendons shall be 2 mm. The duct rigidity and type and spacing of fixings and supports shall be such as to maintain line, position and cross section shape during concreting. Local deformation of the duct at supports shall be avoided. For external tendons the minimum wall thickness shall be 4 mm for durability, or such thicker wall as required to withstand grouting pressures of the particular duct configuration. Forms of ducts include but are not limited to the following;

- Plastic ducts (HDPE)
- Metal ducts (steel, aluminium)
- Fiber-reinforced polymer (FRP) ducts
- Composite ducts (combining materials)

(e) Cable Supports

Supports of reinforcing steel or structural steel suitably

braced to prevent buckling under load shall be used to support the cables. The cable saddles shall be rigid and secured in position by welding or by equivalent mechanical means to resist both gravitational and buoyancy forces.

Normal web reinforcement shall not be utilised to support cables.

Saddles for external cables shall be of special design and material to ensure low friction and to prevent the tendon or parts thereof from grooving the surface. The saddle plates shall be curved to the requisite radius to prevent the tendon or part thereof from bearing on the end of the plate and shall incorporate features to ensure that individual bars, wires and strands are seated separately.

(f) Tendon Spacers

Tendon spacers used inside the ducts to separate individual bars, wires or strands of the tendon shall be of a proven and approved type and manufactured from material which will not induce corrosion of the pre-stressing steel.

(g) Grout

Grouts shall comply with BS EN 447 AND BS EN 446. The properties of the grout, made with the materials, and using the plant and personnel proposed for use on site, shall be assessed for suitability for the intended purpose by the Contractor in accordance with 6.1 of BS EN 446.

i) Materials

In addition to the requirements of Sub-clause 6402(d), water shall not contain more than 500 mg of chloride ions per litre of water.

Only ordinary Portland cement which comply with the requirements of US 310-1:2002/EAS 18-1, BS EN 197-1:2011 or equivalent shall be used. The temperature of the cement shall be less than 40°C, and the cement shall be stored in accordance with the requirements of SUB-CLAUSE 6403 (a).

Fine aggregate shall consist of siliceous granules, finely ground limestone, trass or very fine sand. The aggregate used shall pass through a 0.600 mm sieve. The use of fine aggregate shall be subject to the approval of the Engineer and shall be restricted to grout for ducts with a diameter exceeding 150 mm. The aggregate content in the grout shall not exceed 30% of the weight of the cement.

The use of admixtures shall be subject to tests having shown that their use improves the properties of the grout, e.g. by increasing workability, reducing bleeding, entraining air, or expanding the grout. Admixtures shall be free from any product liable to damage the steel or the grout itself, such as halides, nitrates, sulphides, sulphates, etc. The quantity of admixture to be used shall be in accordance with the manufacturer's instructions.

ii) Properties of the Grout

The properties and performance requirements for grout shall be in accordance with SECTION 6 OF BS EN 447. The requirements for suitability testing shall be in accordance with SECTION 6 OF BS EN 446. Test methods are described in BS EN 445. Test requirements for grout during grouting shall be in accordance with SECTION 9 OF BS EN 446.

The mixed grout shall have the following properties:

- a. The chloride ion content shall not exceed 750 mg/litre.
- b. The viscosity of the grout measured in accordance with SUB-CLAUSE 7111 (b) for horizontal cables shall be 500 to 2,500 cP and for vertical cables 400 to 1,500 cP. The

viscosity of the grout, 20 minutes after mixing, shall not exceed 2,500 cP and 1,500 cP for horizontal and vertical cables respectively.

- c. Bleeding at 20°C measured in accordance with SUB-CLAUSE 7112 shall not exceed 2% by volume three hours after the grout has been mixed, and the maximum bleeding shall not exceed 4%. In addition, the separated (bleed) water must be reabsorbed after 24 hours.
- d. The compressive strength of 100 mm cubes made of the grout and cured in a moist atmosphere for the first 24 hours and then in water at 20°C shall exceed 20 MPa at seven days.

iii) Grouting Procedures

Unless otherwise specified in the Contract, grouting procedures shall comply with the requirements of Section 8 of BS EN 446.

Grouting of the ducts shall be carried out within 14 days of installation of the tendon or as soon as is practicable thereafter, in which case additional measures shall be taken to avoid corrosion of the pre-stressing steel. The Engineer's written agreement to commence grouting operations shall be obtained.

During grouting operations, once the fluidity of the grout flowing from the vents is the same as the grout being injected (to within the limits specified in BS EN 447, as per 8.4 of BS EN 446), 5 litres of grout at each vent, or such other requirement of the Contract, shall be vented into a clean receptacle and then discarded. The volume of all grout that is expelled shall be measured. The opening shall be firmly closed. All vents shall be closed in a similar manner one after another in the direction of the flow except that at intermediate crests the vents immediately downstream shall be closed before their associated crest vent. The injection tubes shall then be sealed off under pressure with a pressure of 0.5 N/mm² being maintained for at least one minute. Grout vents at high points shall be reopened immediately after 1 minute, while the grout is still fluid. Any escape of air, water or grout shall be recorded and reported immediately to the Engineer. A further pumping of grout shall then be carried out to expel bleed water – and/or entrapped air. This shall be carried out with the vents open one at a time sequentially in the direction of grouting with a further 5 litres being released at each vent. In the event of disagreement over the quality of the vented grout, testing shall be undertaken immediately by the Contractor. Finally, when all outlets are closed the grout pressure shall be maintained for at least one minute to confirm there is no unintended loss due to leakage.

The filled ducts shall not be subjected to shock or vibration for at least 24 hours from the time of grouting.

When the grout has set, the grout vents shall be temporarily reopened. If voids are apparent on inspecting vents at end caps, the Engineer may require all or some of the end caps to be removed to demonstrate that they are satisfactorily filled with grout. End caps which have been removed shall then be replaced and permanently sealed against ingress of contaminants, such sealing to be proved to the Engineer.

If the method of demonstrating filling of the anchorage caps involves their removal, a photographic record shall be made by the Contractor. The record shall clearly identify the

individual anchorages, and shall be included in the report to the Engineer.

If, in the opinion of the Engineer, there is doubt that the ducts or any part of the system are not satisfactorily filled with grout, the Engineer may require investigations to be carried out.

The Contractor shall keep full records of grouting for each duct in accordance with the acceptance scheme requirements for the installation of post-tensioning systems. Copies of these records shall be supplied to the Engineer within 24 hours of completing grouting to each duct.

On completion of grouting, grout vents shall be positively sealed and waterproofed by a means additional to but separate from the concrete waterproofing.

iv) Grouting During Cold or Hot Weather

Unless otherwise specified in the specification, requirements for grouting in cold or hot weather shall be as given in 8.3 of BS EN 446.

When the ambient temperature is expected to fall below 5°C, accurate records shall be kept by the Contractor of the maximum and minimum air temperatures, and the temperatures of the structural elements adjacent to the ducts to be grouted.

When heating is considered appropriate, methods of heating shall be to the acceptance of the Engineer. Ducts shall not be warmed with steam.

v) Void Grouting

Void grouting is the injection of grout into voids left in tendon ducts after the original grout has hardened and shall not be confused with regrouting, which means the reinjection of grout into ducts while the original grout is still fluid. Where the use of void grouting is proposed, it shall be subject to the approval of the Engineer.

(h) Protecting Agents For Unbonded Tendons

The material used for permanent protection of unbonded tendons shall have the following properties:

- i. It shall remain free from cracks and shall not become brittle or fluid within the temperature range of -20°C to 70°C.
- ii. It shall be chemically stable and the Engineer shall approve its properties.
- iii. It shall be non-reactive with the surrounding materials, i.e. concrete, tendons, wrapping or sheathing.
- iv. It shall be non-corrosive or corrosion-inhibiting.
- v. It shall be impervious to moisture.
- vi. It shall be sufficiently tough to withstand the abrasion caused when a tendon, precoated with the material, is drawn into the sheath.
- vii. It shall have no appreciable shrinkage or excessive volume increase.
- viii. It shall have a suitable viscosity at ambient temperature or require only moderate preheating to permit injection.

(i) Testing

Pre-stressing steel, anchorages and couplers, and grout shall be tested in accordance with the requirements of SUB-CLAUSE 7111 (b). Testing shall be carried out at the frequencies as directed by the Engineer.

6504 EQUIPMENT

(a) General

All equipment used shall be in a good working order and properly maintained.

(b) Tensioning and Measuring Equipment

Tensioning and measuring equipment shall be such that the tendon force can be established to an accuracy of $\pm 2\%$ during any stage of the tensioning operation.

Unless otherwise authorised by the Engineer, the tensioning equipment shall be power driven and capable of gradually applying a controlled total force without inducing dangerous secondary stresses in the tendon, anchorage or concrete.

The force in the tendon during tensioning shall be measured by a direct-reading dynamometer or obtained direct from pressure gauges fitted in the hydraulic system to determine the pressure in the jacks.

Pressure gauges shall have concentric scale dials which comply with the requirements of BS EN 837-1:1998. The dials shall not be less than 150 mm in diameter and the gauges shall be used within the range of 50 to 90% of their full capacity at maximum service pressure.

When pressure gauges not using glycerine are used, a snubber or similar device shall be fitted to protect the gauge against any sudden release of pressure. Provision shall also be made for T-connections for the attachment, when required, for supplementary control gauges.

Only self-sealing connections shall be used in the hydraulic circuit. Where the pressure input pipe is connected to the jack, a pipe rupture valve shall be installed in the circuit.

Tensioning equipment shall be calibrated before the tensioning operation and thereafter at frequent intervals, as directed by the Engineer, with a master gauge or proving ring, and the Engineer shall be furnished with a calibration chart. The load-measuring devices shall be calibrated to an accuracy of $\pm 2\%$.

The extension of tendons shall be measured to an accuracy of $\pm 2\%$ or ± 2 mm, whichever is the more accurate, and pull-in and release to an accuracy of ± 2 mm.

(c) Grouting Equipment

Unless otherwise specified in the specification, grouting equipment shall comply with the requirements of SECTION 7 OF BS EN 446.

The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a valve that can be locked off without loss of pressure in the duct.

During the grouting operation the Contractor shall provide adequate flushing-out plant to facilitate complete removal of the grout in the event of a breakdown of the grouting equipment or other disruption before the grouting operation has been completed. Stand-by and emergency equipment shall be provided.

All equipment shall be kept free from build-up of adhering materials.

i) Mixer

Mechanically operated mixers used shall be of a type capable of producing high local turbulence while imparting only a slow motion to the body of the grout.

The mixer shall be equipped with a screen with openings not exceeding 1.0 mm and shall be capable of consistently producing grout with a colloidal consistency.

ii) Agitator

Where the capacity of the mixer is insufficient to fill the duct completely with grout, an agitator shall be used.

Mechanical agitators used shall be capable of maintaining the colloidal condition of the grout fill during the storage and injection processes. The grout shall be delivered at the structure from the agitator, and the system shall make provision for re-circulating the grout from the pump back to the agitator.

iii) Injection Equipment

The pump shall be of the positive displacement type (piston, screw or similar type), capable of exerting a constant pressure of at least 10 bars on completely grouted cables and shall incorporate a safety device for preventing the build-up of pressure above 20 bars. The pump shall be fitted with a pressure gauge and a valve which can be locked-off without loss of pressure in the cable.

The pump shall be capable of delivering grout at a speed that will produce a speed of the grout in the cable of between 6 and 12 m/minute.

All connections in the pipes and between the pipe and the cable shall be airtight. Only bayonet, threaded, or similar types of connectors shall be used.

6505 TECHNICAL DATA

The following technical data for pre-tensioned and post-tensioned structural members required for the Contract will be furnished on the Drawings:

(a) Tendon Alignment

A diagram showing the alignment of each tendon or group of tendons in both the horizontal and vertical planes, together with the horizontal and vertical co-ordinates, and curve equations of the centroid of the tendon(s), as may be relevant.

(b) Tendon System

The design shall be based on the system shown on the Drawings, but the Contractor may use any suitable system which will meet all the specified requirements, subject to approval by the Engineer.

(c) Tensioning the Tendons

Full particulars regarding the partial tensioning of the tendons, the stage during which the tendons shall be tensioned, and the sequence of tensioning to be followed.

(d) Tensioning Force

The maximum tensioning force and the effective force at the live anchorages, after transfer, as well as the corresponding stress level in the pre-stressing steel, for each tendon or group of tendons. The forces will be given in MN units, and the stress levels will be expressed as a percentage of the characteristic strength.

(e) Extension

The extension per tendon or group of tendons under the maximum tensioning force, together with the modulus of elasticity (E) on which it has been based. The release to be attained at each live anchorage as well as the pull-in for which provision has been made.

The Contractor shall show on their drawings the expected extension based on the actual modulus of elasticity of the strand as well as the expected wedge pull-in and any provision for shimming.

(f) Pre-Stressing Losses in Tendons

The losses allowed for in the design from the causes listed below will be given as follows:

i) Friction loss

The formula used for determining the tendon/duct friction loss together with the values adopted for the friction coefficient (μ) caused by curvature, and the wobble factor (k) caused by unintentional variation from the specified alignment.

ii) Elastic Deformation of Concrete

The elastic factor, which, when multiplied by the compressive stress in the concrete adjacent to the tendon, will give the loss caused by the deformation of the concrete.

iii) Creep Of The Concrete

The creep factor, which, when multiplied by the compressive stress in the concrete adjacent to the tendon, will give the loss caused by the creep of the concrete.

iv) Shrinkage of the concrete

The stress loss in MPa caused by the shrinkage of the concrete.

v) Relaxation of pre-stressing steel

The stress loss in MPa at a stress level of 70% of the characteristic strength of the pre-stressing steel caused by the relaxation of the pre-stressing steel.

(g) Anchorages

The positions where loop or fan-type dead-end anchorage may be used.

(h) Bursting Reinforcement

The bursting reinforcement for the prestressing system on which the design is based.

(i) Precamber

The precamber at intervals not exceeding 0.25 times the span length.

(j) Compressive Strength Of The Concrete During Transfer

The compressive strength to be attained by the concrete in the relevant member before transfer may be effected.

6506 PRESTRESSING SYSTEM

The use of all pre-stressing systems will be subject to approval by the Engineer. Bidders are advised to obtain approval for the pre-stressing system they intend using, prior to submitting their bids.

Within one month of the bid having been awarded, or within a period agreed on with the Engineer, the Contractor shall submit full details regarding the pre-stressing system(s), materials and equipment they intend to use, as well as regarding the methods they propose to adopt in the pre-stressing and related operations.

The Engineer, at their own discretion, may call for further information in the form of detailed drawings, proof of successful previous use, performance certificates from an approved independent testing authority, and calculations substantiating the adequacy of the system. The Contractor shall furnish such information within two weeks of being called upon to do so or within a period agreed on with the Engineer. If, after investigating all the information, the Engineer is not satisfied that the pre-stressing of the structural member can be carried out satisfactorily with the pre-stressing system offered by the Contractor, the Engineer reserves the right to order the Contractor to use any system which is suited to the work and which is readily available to the Contractor.

Only minor alterations to the concrete dimensions shown on the Drawings will be considered in order to accommodate the pre-stressing system finally selected, subjected to the approval of the Engineer.

6507 DRAWINGS PREPARED BY THE CONTRACTOR

All drawings prepared by the Contractor and submitted to the Engineer for consideration shall comply with the requirements of CLAUSE 1220.

The Contractor shall submit to the Engineer at least two months before they intend to commence with the pre-stressing work, drawings detailing the layout and alignment for the individual tendons, the cable supports, modifications to the bursting and other reinforcement, anchorage recesses, tensioning sequence, tensioning loads and extensions, as well as requirements for controlling the tensioning operations. For the pre-stressing system finally selected, the technical data which are at variance with the information given on the Drawings shall be shown on the Drawings. Each tendon shall be separately numbered for identification.

Where required, the Contractor shall submit calculations in respect of the variation of the tendon force along the length of the tendon, the expected extension and the bursting forces.

After approval by the Engineer of the Drawings and calculations prepared by the Contractor, no departure shall be permitted from the forces, stresses and extensions shown thereon, without authorisation by the Engineer.

The prestressing work shall not be commenced before the relevant drawings have been accepted by the Engineer. The Contractor shall make full allowance in their bid rates for all costs in connection with the furnishing of information, making calculations, and preparing and submitting the Drawings. However, no allowance need be made for the cost of checking, undertaken by the Engineer, of drawings and calculations for work which does not qualify as an alternative design.

Alternative designs shall comply with the requirements of contract documents, as specified.

6508 PRECASTING**(a) Casting Yard on the Site**

Subject to approval by the Engineer, precast work may be done at any location selected by the Contractor.

Before the casting yard is established, the Contractor shall submit plans to the Engineer which demarcate the site and detail the layout of the Works, together with a flow diagram of the construction stages and storage.

(b) Manufacture off the Site

The Contractor shall notify the Engineer in advance of the dates when tensioning of tendons, casting of members and transfer, will be undertaken.

Within seven days of transfer, the Contractor shall submit to the Engineer a certificate giving the tendon force(s) and extension(s) attained as well as records of the cube crushing strength and age of concrete at transfer.

Test results relating to all aspects of the work shall be sent to the Engineer immediately upon their becoming available.

Where the Engineer requires tests to be conducted on completed members, no member to which the tests relate shall be dispatched to the site until the tests have been satisfactorily completed and the members accepted by the Engineer.

(c) Manufacture

Before work commences, details of the manufacture and phasing of the work shall be submitted to the Engineer for approval. After approval, no changes shall be made to the methods or systems, without approval by the Engineer.

The Contractor shall ensure that the specified pre-camber is incorporated in the formwork. The magnitude of the pre-camber shown on the Drawings shall be subject to variation depending on the Contractor's construction programme; and the Contractor shall, before manufacture, ascertain in writing from the Engineer, the increase or decrease in pre-camber. This procedure shall also apply to the cases where no pre-camber has been specified.

Lifting and supporting the precast members shall be made only at the points marked and provided on the members.

Precast members which have not been fully tensioned or fully stage extensioned or which have ungrouped tensioned tendons shall not be handled without authorisation by the Engineer.

Where members with ungrouted tensioned tendons are handled, control shall be exercised to guard against possible slip of the tendon at the anchorage.

Pre-stressed precast concrete members shall also comply with the requirements of CLAUSE 6413.

(d) Tolerances

- i. The dimensional tolerances for precast girders shall be as under:

Length	± 10mm
Flange width and thickness	± 5mm
Depth	± 5mm
Web thickness	± 5mm
Minimum surface unevenness	1.5 mm on 3 m template

- ii. Permissible tolerances for positional deviation of pre-stressing strands shall be as under:

Variation from the specified horizontal profile	5 mm
Variation from the specified vertical Profile	5 mm
Variation from the specified position in member	3 mm

6509 PRE-TENSIONING

During the period between tensioning and transfer, the force in the tendon shall be fully maintained by some positive means. At transfer, detensioning shall take place slowly to minimise any shock which could adversely affect the transmission length of the tendon.

In the long-line method of pre-tensioning, sufficient locator plates shall be distributed throughout the length of the bed to ensure that the straight tendons are maintained in their proper position during concreting. Where a number of units are manufactured in line, they shall be free to slide in the direction of their length so as to permit transfer of the tendon force to the concrete along the entire line.

In the individual-mould system, the moulds shall be sufficiently rigid to provide a reaction to the tendon force without distortion.

Where possible, the mechanism for holding down or holding up deflected tendons shall ensure that the part in contact with the tendon will be free to move in the line of the tendon so that friction losses are eliminated. If,

however, a system is used which develops a frictional force, this force shall be determined by test and due allowance made thereof.

For single tendons, the deflector in contact with the tendon shall have a radius of not less than 5 times the tendon diameter for wire, or 10 times the tendon diameter for a strand, and the total angle of deflection shall not exceed 15°.

Transfer of the tendon force to the concrete shall be effected in conjunction with the release of hold-down and hold-up forces in accordance with an approved method.

Transfer shall not be affected until compressive-strength tests on the concrete show that the concrete of the particular member has attained a compressive strength of at least the compressive strength shown on the Drawings. The transmission length is affected by the concrete strength, and the necessary modification for the concrete strength at transfer shall be made in conjunction with the Engineer.

The tendons shall be cut off flush with the end of the member and the exposed ends covered with a heavy coat of approved bituminous material or epoxy resin. The cutting of the pre-stressing steel shall be performed with a high-speed abrasive cutting wheel. Flame cutting will not be permitted.

6510 POST-TENSIONING**(a) Storage, Handling and Protection**

During storage, transit and construction and after installation, the sheaths, prestressing steel, anchorages and couplers shall be protected against corrosion, damage or permanent deformation. The manner and extent of protection required will depend on the environmental factors and the length of time before permanent corrosion protection is applied, and shall be to the satisfaction of the Engineer. Under severe corrosive conditions in damp and wet areas and under aggressive conditions, the materials shall be stored in weatherproof sheds. All materials shall be stored clear of the ground and while in storage shall not be enclosed to the weather.

When pre-stressing steel has been stored for a prolonged period and there is evidence of its deterioration, the Contractor may be called on to prove by tests that the quality of the steel has not been significantly impaired and that the pre-stressing steel still complies with the provisions of these Specifications.

Suitable protection shall be provided to the threaded ends of bars.

After fabrication, the cable ends shall be covered with protective wrapping to prevent the ingress of moisture into the duct.

When the tendon is to be left untensioned for a prolonged period after installation, precautions shall be taken to protect the tendon against corrosion. Corrosion inhibitors, oils or similar materials used as lubrication or to provide temporary protection shall be such that they can be completely removed before permanent protection is effected.

(b) Fabrication

All cutting of pre-stressing steel shall be performed with a high-speed abrasive cutting wheel or by a method approved by the Engineer. Flame cutting will not be permitted.

Care shall be taken to prevent the pre-stressing steel or anchorages from coming into contact with splashes from flame-cutting or welding processes in the vicinity.

Where possible, all bars, wires or strands tensioned in one operation shall be taken from the same parcel of pre-

stressing steel. The tendon or cable shall be labelled to show the tendon or cable number, as well as identify from which parcel the steel has been taken.

Where bars, wires or strands in a tendon are not tensioned simultaneously, tendon spacers shall be used in accordance with the recommendations for the pre-stressing system or, in the absence thereof, as directed by the Engineer.

Cables shall be fitted at both ends with pipes with a diameter of at least 10 mm for the injection of grout or protection agents. The ends of the injection pipes shall be fitted with a clamp, valve or device capable of withstanding a pressure of at least 15 bars without loss of grout or protection agent.

Vent pipes with a diameter of at least 25 mm shall be provided in the duct at every high point, change of sheath cross-section and at such intermediate positions as may be shown on the Drawings or required by the Engineer. The vent pipes shall extend to at least 500 mm above the concrete and shall comply with the requirements for injection pipes.

Connections to, and joints in sheaths shall be made grout-tight by using special sheathing couplings and taping. With bonded cables, the length of taping shall not exceed six sheath diameters. Where over sleeves are used, equal overlaps shall be provided over each length of sheathing. Joints in adjacent sheaths shall be spaced at least 300 mm apart.

(c) Installation

The installation of tendons shall not commence until the requirements of CLAUSE 6507 have been complied with.

The cable, sheath or extractable core shall be accurately installed to the specified alignment and securely held in position both vertically and horizontally at intervals appropriate to its rigidity so as not to be displaced during concreting, either by the weight of the concrete or by buoyancy. The spacing of the cable supports shall furthermore ensure that the tendon can be installed to a smooth alignment without kinks and within the tolerance specified in SUB-CLAUSE 6803 (g). Cable sheaths shall be supported and held in position by means of separate reinforcing steel supports with a diameter of not less than 16 mm. The transverse bars must be welded to the vertical bars or must rest on lugs welded to the vertical bars. The spacing of the vertical supports shall not exceed 1.0 m.

Extractable cores shall not be coated with release agent unless approved by the Engineer.

Unless otherwise shown on the Drawings, the alignment of the tendon within a distance of 1.0 m from the live anchorage and/or coupler shall be straight. The tendon axis shall be set perpendicular to the bearing surface of its anchorage and firmly secured in position so as not to move during concreting. External anchorages shall be seated on a thin mortar bedding to bear evenly on the concrete bearing surface, and the tendon axis shall be perpendicular to the bearing surface of the anchorage.

Unless otherwise shown on the Drawings, the minimum concrete cover over the outside surface of the sheath or cable support shall comply with the requirements of CLAUSE 6307, except that, for sheaths, the cover shall not be less than 50 mm.

The spacing of cables will depend on the size of the cable and shall be such that the concrete can be properly placed and compacted.

Immediately before concreting, the Contractor shall inspect the sheaths for grout-tightness and shall seal all damaged and suspect sections.

External tendons shall be installed to the same standards and accuracy specified herein for internal tendons. The

tendons shall be temporarily supported at regular intervals along the straight length between saddles. The supports shall consist of rigidly constructed frames secured to the concrete face.

(d) Concrete Strength

Full tensioning of all or some of the tendons shall not commence until the compressive-strength of the concrete is 35 MPa or the strength shown on the Drawings, whichever is the greater.

The compressive strength of the concrete shall be determined from cubes manufactured and tested in accordance with SUB-CLAUSE 7106 (a) which have been cured under the same conditions as the structural member which is to be pre-stressed. The number of concrete cubes required for this purpose shall be as agreed on with the Engineer.

Where initially all or some of the tendons are to be partially tensioned, tensioning shall not commence before the concrete has attained the compressive strength indicated on the Drawings.

(e) Tensioning

i) Preparation

Within two hours of the concrete having been placed, the Contractor shall demonstrate that sheaths are free from obstructions, that extractable cores can be removed and, where the design permits, that all tendons are free to move in the ducts. All water in the ducts shall then be expelled with compressed air and the cables/ducts sealed until tensioning takes place.

Before tensioning is commenced, the side forms and other restraining elements shall be released or removed to give the structural member the freedom to deform under the induced force.

ii) Tensioning Sequence

The sequence of tensioning to be followed shall be as shown on the Drawings and/or on drawings prepared by the Contractor in terms of CLAUSE 6507. The Contractor shall make allowance in their bid rates for all incidentals which they may have to incur as a result of having to tension fully only some of the tendons at any one stage or instant. Where partial tensioning of tendons is required, the work shall be executed in accordance with the details on the Drawings or as specified. The Contractor shall, in their bid rates, make provision for all incidentals they may have to incur as a result of having to tension partially only some of or all the tendons at any one stage or instant.

iii) Assembling the Equipment, and Safety Precautions

The tensioning and measuring equipment shall be assembled for tensioning in exactly the same way as they are assembled for calibration.

The Contractor shall take all the necessary safety precautions to prevent accidents caused by the malfunctioning or failure of any part of the equipment or material and shall accept full responsibility for injury sustained by persons or damage to property resulting therefrom.

iv) Friction

The Engineer may require the Contractor to perform friction tests on designated tendons and to revise the relevant theoretical extensions to compensate for the discrepancy between the values adopted in the design and the test results. Payment for these tests shall be made under ITEM 71.01.

Where applicable, allowance shall be made in the tensioning force to compensate for friction loss in

the jack and in the anchorage.

v) Tensioning

Tensioning shall be carried out under the supervision of a technician skilled in the use of the pre-stressing system and equipment and the methods of tensioning to be adopted.

Tensioning shall not be commenced before the Engineer has been advised of each tensioning operation and has given their approval for the work to be started.

The technician and operators shall be supplied with a schedule listing the sequence of tensioning the various tendons and a tensioning record sheet showing the theoretical gauge readings, jacking forces, extensions, release and pull-in for each tensioning operation. The record sheet shall furthermore provide room for entering the corresponding information recorded and observations made during tensioning. A graph of the tensioning force and/or gauge reading versus theoretical extensions shall, where required, be appended to the record sheet and the actual extensions measured for each load increment shall be plotted on the graph. Copies of the completed record sheets and graphs shall be submitted to the Engineer within 24 hours of each tensioning operation having been completed.

The Contractor shall note that the extensions shall be regarded as an indirect measurement of the tensioning force and shall serve as a control on the tensioning force applied.

The protruding ends of all bars, wires and strands shall be clearly marked for the accurate measurement of extension, release and pull-in.

Before tensioning is commenced on external tendons, a small load shall be applied to each tendon, commencing with the uppermost tendon. The force shall be sufficient to take up all slack and prevent entanglement of the tendons.

The jacking force shall be increased to approximately 5% to 10% of the final jacking force to take up the tendon slack and to determine the zero position for measuring the extension and to check the gripping devices and the position and alignment of the jacks. The load shall then be increased gradually to the full specified tensioning force while intermediate gauge readings and extensions are recorded at regular intervals.

The final stage of tensioning shall be deemed to have been satisfactorily accomplished when all the following requirements have been complied with:

- a. The tendons have been tensioned to the required force.
- b. The measured extension on individual tendons is within $\pm 6\%$ of the theoretical extensions.
- c. The average variation between the measured and theoretical extensions of all the tendons in a structural member is less than $\pm 3\%$.
- d. The release and/or pull-in is within ± 2 mm of the theoretical values.

Where the above conditions are not met individually and collectively, the Contractor shall immediately advise the Engineer and obtain a ruling as to the procedure to be followed.

In the event of the tendon friction being too high, the Contractor may, subject to approval by the Engineer, inject an approved lubricant into the sheath after first having detensioned the tendon.

The cost of the remedial and corrective measures and of the release and retensioning of tendons, which have been occasioned by failure of the operations to meet the above requirements shall be for the Contractor's account.

After the tensioning has been accepted by the Engineer, the Contractor may cut off the tendons behind the anchorage as described in SUB-CLAUSE 6510 (b).

(f) Permanent Protection and Bonding of Tendons

i) General

After tensioning, all tendons shall receive permanent protection against mechanical damage and corrosion.

Internal tendons shall be protected and bonded to the structural member by cement grout or, when permitted by the Engineer, by sand-cement grout. Where bond is not important, protection may be effected by the use of bitumen, petroleum-based compounds, epoxy resins, plastics and similar products, all complying with the requirements of SUB-CLAUSE 6503 (h) and subject to approval by the Engineer.

Tendons located outside the structural section (i.e. external tendons) shall be encased with a dense concrete, dense mortar or material sufficiently stable and hard, all subject to approval by the Engineer. The encasement shall be of the thickness shown on the Drawings. Where bonding of the tendon to the structural concrete is required, this shall be achieved by bonding the concrete encasement to the structure with reinforcing steel as detailed on the Drawings.

Protection and bonding of the tendons shall be effected within seven days of the final tensioning of the tendons, or as specified on the Drawings, but shall not take place without the prior approval of the Engineer having been obtained.

After the permanent protection or bonding has been completed the anchorages shall be encased in concrete or grout which shall be bonded to the old concrete with epoxy resin designed for this purpose, or shall be completely coated with a corrosion-resistant material. The protection provided shall in all cases prevent the ingress of water or aggressive agents.

ii) Preparation of Ducts

Before permanent protection and/or bonding of tendons is effected, the following precautions shall be taken:

- a. The cables shall be checked for blockages by water or compressed air being injected.
- b. Unlined ducts which are to be filled with grout shall be flushed with water to wet the concrete.
- c. Temporary protection or lubricants which are incompatible with the permanent protection or bonding, shall be removed by flushing the duct with water or an inert solution, or by any suitable approved method.
- d. On completion of the above, any excess fluid shall be expelled from the ducts by means of compressed air or shall be displaced by the protecting agent or grout, as may be relevant.
- e. Any blockages, leakages or factors which in any way may affect the permanent protection or bonding shall immediately be reported to the Engineer.

iii) Mixing**[1] Protecting Agents**

The mixing of protecting agents shall be strictly in accordance with the manufacturer's instructions.

[2] Grout

The aggregate, if used, and the cement shall be measured by weight, and the water by weight or by volume.

The water: cement ratio by weight shall be as low as possible within the range between 0.36 to 0.45, and shall be consistent with the fluidity requirements of SUB-CLAUSE 6503 (g).

Where an admixture is used, it shall be dissolved in a part of the mixing water before it is added to the grout.

Mixing shall commence by two-thirds of the cement being added to the greater part of the mixing water, and, if used, an additive pre-dissolved in part of the mixing water, and finally the remainder of the cement. Mixing shall continue for not longer than four minutes after which the grout shall be continually agitated at slow speed throughout the injection operation.

Where aggregate is used in the grout mix, the word "cement" in the preceding paragraph shall be replaced by the term "cement/aggregate component".

iv) Injection**[1] General**

The injection of permanent protecting agents or grout shall not commence before approval has been granted that the work may start.

Before injection commences all air shall be expelled from the injection equipment and hoses and all connections checked for air tightness.

Injection shall take place from the anchorage or coupler; whichever is situated at the lower end of the cable. Grout injection shall proceed without any interruption until the cable has been completely filled and closed off.

[2] Protecting Agents

The injection of protecting agents shall be strictly in accordance with the instructions, and with the equipment specified by the manufacturer.

[3] Grout

Immediately after mixing, and also during injection, the fluidity of the grout shall be tested at regular intervals in accordance with SUB-CLAUSE 6503 (g) (i).

Injection shall be continuous at a rate of 6 to 12 m per minute. As soon as grout with the original consistency flows from the intermediate vent pipes they shall be successively closed. Injection shall continue until the grout flowing from the vent at the free end is of the same consistency as that of the injected grout. At this stage the vent shall be closed and the final pressure or a pressure of 5 bars, whichever is the greater, shall have been maintained on the grout column for five minutes before the valve at the injection end is closed.

All vents shall be kept closed and supported vertically until the grout has finally settled. On vertical cables, a riser pipe with a funnel shall be fitted to the top anchor to ensure that the separated water migrates upwards and will not remain in the cable.

If an expanding agent is used in the grout mix, the air vents shall be re-opened after grouting to

release any separated water, and shall then again be closed.

Unless a retarder is used in the grout mix, the grout not used within 60 minutes of mixing shall be discarded.

During the course of grouting, 100 mm cubes shall be made for testing in accordance with SUB-CLAUSE 6503 (g) (i). Whilst the grout is being poured into the cube mould, the sides of the mould shall be slightly tapped to permit any entrapped air to escape.

Precautions shall be taken not to discharge the escaping grout onto railway lines, public roads, water courses or private property.

If a blockage occurs during the course of grouting, the grouting shall be stopped before the maximum grouting pressure is reached. The duct shall then be flushed out immediately and the blockage cleared.

Grouting shall not be carried out during very cold weather when the ambient air temperature drops below 5°C. Care shall be taken that the ducts are completely free from frost or ice before grouting commences after frosty weather.

(g) Concrete – Grouting and Duct Systems

Site operations, including duct installation, stressing and grouting, shall be carried out by a certified Expert approved by the Engineer; The Expert shall issue a certificate for each certified stage of prestressing.

Unless otherwise specified in the Contract, post-tensioning systems shall be in accordance with CLAUSE 7.2 OF BS EN 13670. The system shall have the intended use category and shall meet any performance requirement stated in Contract.

Precast segmental construction using an internal grouted tendon system is not permitted.

Grouts for protection of pre-stressing tendons shall be as required in the Contract.

Unless otherwise agreed with the Engineer, the Contractor shall undertake full-scale trials of the grouting operations as required in the Contract for duct installation, testing, concreting, grouting and any other associated requirements in accordance with the details described in the Contract. The trials are required to demonstrate that the grouting methods and procedures proposed by the Contractor shall ensure that grout fills the ducts and surrounds the pre-stressing steel.

The Contractor shall submit for acceptance of the Engineer, a detailed method statement, at least 4 weeks prior to use in any trials or in the works, covering proposed materials, ducts, anchorage and vent arrangements, personnel, equipment, grouting procedures and quality control. The method statement shall also describe arrangements for storage and protection of materials (tendons etc.) on site, in the time between delivery and grouting.

Where full scale trials are required, these shall be carried out at least 56 days before the planned commencement of fixing ducts for pre-stressing for the permanent works unless specified otherwise in the Contract. The trials shall incorporate all relevant details of ducts, vents, duct supports, pre-stressing anchorages and couplers, pre-stressing strands, grout inlets and outlets. The tendons shall be sufficiently tensioned such that the strands within the duct take up a representative alignment. All systems, methods and materials are to be those proposed for the permanent works and shall have been submitted to the Engineer as part of the detailed method statement required. After three days the Contractor shall carefully cut or core the trial section to expose cross

sections and longitudinal sections of the duct, anchorages and any other locations where required, or as further directed by the Engineer, to demonstrate that the duct is satisfactorily grouted. A report shall be prepared by the Contractor giving full details of the trial, testing results and photographs of the exposed sections and submitted to the Engineer.

Grouting of the ducts shall be shown to leave no void which has either a dimension greater than 5% of the duct diameter measured in the radial direction of the duct or which poses a risk to the protective system. The location of any voids with respect to grout vents and their adequate grouting and subsequent sealing, and the disposition of the steel tendons within the body of the grout shall be reported in writing by the Contractor to the Engineer within 24 days. Pre-stressing for the permanent works shall not be permitted without the prior written acceptance of the grouting procedures by the Engineer and formal acceptance of the results of the grouting trial.

Irrespective of whether the Contract requires full-scale grouting trials, the Contractor shall carry out a materials suitability assessment. Inspection and conformity of grouting works, including requirements prior, during and after grouting shall be in accordance with SECTION 9 OF BS EN 446 unless otherwise specified in the contract.

6511 LOSS OF PRESTRESS

Any structural member which has lost all or part of its prestress through the failure or malfunctioning of any part of the pre-stressing component may be rejected by the Engineer and shall be removed from the Works unless approved remedial measures have been successfully carried out on the member. No payment will be made in respect of such remedial work or loss suffered by the Contractor in this regard.

6512 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
65.01 PRESTRESSING TENDONS:	
(a) LONGITUDINAL TENDONS	MEGANEWTON - METRE (MN-m)
(b) TRANSVERSE TENDONS	MEGANEWTON - METRE (MN-m)
(c) VERTICAL TENDONS	MEGANEWTON - METRE (MN-m)

The unit of measurement shall be the Meganewton-metre which is calculated as the product of the characteristic strength in megapascals of the prestressing steel, the cross-sectional area of the tendon in square metres and the length of the tendon in metres between the faces of the anchorages. In the case of fan and loop anchorages the "length of the tendon" shall include the length of tendon forming the loop or fan.

The bid rates shall include full compensation for preparing and submitting the Drawings, supplying, storing, handling and protecting all materials (excluding anchorages and couplers), fabricating, supporting and installing the cables; lubricating, permanently protecting and bonding the tendons, for the using of all the equipment, as well as for all work and incidentals required for completing the work as specified.

<u>ITEM</u>	<u>UNIT</u>
65.02 ANCHORAGES AND COUPLERS:	
(a) END ANCHORAGE AT JACKING	MEGANEWTON (MN)
(b) ANCHORAGE AT DEAD END	MEGANEWTON (MN)
(c) COUPLER AT JACKING END	MEGANEWTON (MN)
(d) COUPLER AT DEAD END	MEGANEWTON (MN)

The unit of measurement shall be the Meganewton which is calculated as the product of the characteristic strength

in megapascals of the prestressing steel and the cross-sectional area of the tendon in square metres, effectively anchored or coupled.

The bid rates shall include full compensation for supplying, storing, handling, fabricating and protecting the complete anchorage or coupler assembly, anchorage reinforcing, constructing the recesses for the anchorage or coupler, tensioning, anchoring and/or coupling, trimming the tendon ends, using all the equipment, as well as for all work and incidentals required for completing the work as specified.

The coupler shall include the complete assembly consisting of the anchorage built into the first-stage construction and the part coupled to it.

The bid rate for loop or fan anchorages shall exclude the cost of the length of tendon forming the loop or fan.

<u>ITEM</u>	<u>UNIT</u>
65.03 EXTRA OVER ITEM 65.02 FOR PARTIALLY TENSIONING THE TENDONS	MEGANEWTON (MN)

The unit of measurement shall be the Meganewton, which is calculated as for ITEM 65.02.

The bid rate shall include full compensation for the use of all equipment, as well as for all work and incidentals required for tensioning and anchoring the tendons to the specified partial force.

SERIES 6000: STRUCTURES

SECTION 6600: JOINTS; BEARINGS; PARAPETS AND DRAINAGE FOR STRUCTURES

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6601 SCOPE

This Section covers:

- The supply and installation of all permanent joints which will permit relative movement between contiguous structural members;
- The construction, supply and installation of bearings for structures;
- The construction of parapets, railings and sidewalks on structures; and
- The construction and/or installation of drainage works such as weep holes, drainage pipes and gulleys, no-fines concrete blocks, filter lining and concrete channelling;

6602 JOINTS IN STRUCTURES**(a) Materials****i) General**

All materials used in forming, constructing and sealing permanent joints as well as all proprietary or custom-built expansion-joint assemblies shall be subject to the approval of the Engineer.

When required by the Engineer, the Contractor shall submit test certificates issued by an approved, independent testing authority to confirm that the respective materials comply with the specified requirements, or a certificate by the patent holder or designer certifying that the manufactured item complies in all respects with relevant product specifications.

ii) Joint Filler

Joint filler shall consist of sheets or strips of the following materials complying with the requirements of the relevant specifications listed:

- Bitumen-impregnated fibreboard and bitumen impregnated corkboard - US FEDERAL SPECIFICATION HH-F-341 F OR AASHTO SPECIFICATION M-213.
- Resin-impregnated corkboard - US FEDERAL SPECIFICATION HH-F-341F.
- Flexible foams of expanded polyethylene, polyurethane, PVC or polypropylene – AASHTO SPECIFICATION M-153.
- Rigid foams of expanded polyethylene, polyurethane or polystyrene - BS 4840:1994 OR BS 3837:2004 PARTS 1 AND 2.

Other joint filler materials may be used if approved by the Engineer after they have been furnished with full specifications and information by the Contractor.

iii) Sealants

Thermoplastic hot-poured sealants shall comply with the requirements of BS EN 14188-1:2004. The sealants shall be of the rubberised bituminous type containing a minimum of 20% natural or synthetic rubber.

Thermoplastic cold-applied sealants shall comply with the requirements of BS 5212-1:1990. The sealant shall be of the rubberised bituminous type containing a minimum of 20% natural or synthetic rubber.

Thermosetting chemically curing sealants shall comply with the requirements of ASTM C-920, BS EN ISO 11600:2003+A1:2011.

The final IRHD (International Rubber Hardness Degree) hardness of the sealant shall be 20±5.

Silicone sealants shall comply with the requirements of the Special Specifications.

Other sealants may be used if approved by the Engineer after they have been furnished with full information and specifications by the Contractor.

iv) Waterstops

Waterstops shall be of natural rubber or flexible PVC and of the type specified or shown on the Drawings.

Natural-rubber waterstops shall comply with the requirements of BS 6213:2000+A1:2010. Flexible PVC rubber waterstops shall comply with the requirements of BS 2571:1990.

v) Accessory Material**[1] Primers**

Where a primer is to be used in conjunction with the sealant, it shall be of the prescribed proprietary material.

[2] Bond Breakers

Polyethylene tape coated paper, metal foil or similar material may be used where bond breakers are required.

[3] Backup Material

Backup material shall consist of a compressible material of correct width and shape to ensure that, after installation, it will be in approximately 50% compression and the sealant can be formed to the specified depth.

Backup materials shall be compatible with the sealant used. Material containing bitumen or solvents shall not be used with thermosetting chemically curing sealants.

vi) Cover Plates**a. Steel cover plates shall be of**

- Grade 43A steel which complies with the requirements of BS EN 10025-4:2019+A1:2022, BS EN 10155:1993, or
- Grade 300W steel which complies with the requirements of BS EN 10025-4:2019+A1:2022 BS EN 10025-5:2019 - TC or equivalent.

b. Galvanising shall comply with the requirements of BS EN ISO 1461:1999 2009 AND BS EN 10240:1998 or equivalent.

c. Anchor bolts shall be of stainless-steel Grade 302 S.21, which complies with the requirements of BS EN 10083 (various dates)/ BS EN 10088:2014 or equivalent.

(b) Filled and Unfilled Joints**i) General**

Wherever polystyrene or similar material susceptible to damage is used for forming joints, it

shall be lined with a hard surface on the side to be concreted. The hard surface shall be sufficiently resilient to ensure that the joint and surfaces can be formed free from defects.

ii) Filled Joints

Filled joints shall be accurately formed to the dimensions shown and with the filler material specified on the Drawings. The filler shall be secured in position such that it will not be displaced during concreting or thereafter if the filler is to remain permanently in the joint.

Where the removal of the filter is required, it shall be done prior to the installation of the proprietary joint.

iii) Unfilled Joints

Unfilled joints shall be accurately formed to the dimensions given on the Drawings and all external corners chamfered or rounded for at least 5 mm. The concrete face against which the fresh concrete is placed shall be treated in good time with an approved bond breaker.

(c) Concrete Nosings

Concrete nosings forming the edges of expansion joints shall be constructed as follows:

- i. After the concrete in the structural member has hardened sufficiently, the protruding ends of the reinforcing steel shall be bent flat onto the concrete surface of the formed recess.
- ii. Before the asphalt surfacing is laid, the recess shall be filled with well-compacted crusher run, sand or weak mortar. The Contractor shall ensure that the concrete surfaces of the recess and the reinforcing steel are not contaminated with bituminous agents. The asphalt surfacing shall then be laid continuously over the joint.
- iii. The asphalt surfacing shall be cut with a diamond saw blade to correspond to the width of the nosing and all material shall be removed from the nosing recess. The concrete surfaces of the recess shall then be roughened to expose the aggregate and leave sound, irregular surfaces. The reinforcing steel shall then be bent, fixed and placed as shown on the Drawings.
- iv. The prepared concrete surfaces of the recesses shall be treated with an approved epoxy-resin adhesive, immediately before the concrete nosings are cast. Opposite concrete nosings, separated by a joint filler strip, shall be cast simultaneously in accordance with SUB-CLAUSE 6408 (c), and compacted with a vibrator. The nosing shall be screeded flush with the premix surfacing and be given a Class U2 surface finish.
- v. Curing shall be in accordance with CLAUSE 6409 (f), Method 6.
- vi. After three days, the gap between the nosings shall be enlarged to the requisite dimensions by cutting both sides with parallel diamond saw blades. The depth of the saw cut shall be such that a ledge is formed along the lower edge of the cut on which the sealer unit can be supported.
- vii. The exposed corners of the nosings shall be ground to a 10 mm chamfer.
- viii. After the joint has been sealed, the wearing surface of the nosings shall be treated with a bituminous primer to the satisfaction of the Engineer.

Unless otherwise specified, traffic shall not be permitted to pass over the joint before the concrete in the nosing has achieved its specified 28-day strength.

Unless otherwise indicated on the Drawings, the concrete used in the construction of the nosings

shall be Class 40/13 and shall have a slump of not less than 50 mm and not exceeding 75 mm.

Concrete nosings shall be constructed under the direct supervision of experienced and skilled personnel.

(d) Plug type expansion joints

Plug type expansion joint systems, shall be constructed in accordance with the details on the Drawings and the specifications and instructions of the licencess.

(e) Sealing the Joints

i) General

Sealed joints shall be made watertight over the full length of the joint, including the full height of the kerbing, unless otherwise prescribed in the Special Specifications. Unless a waterstop is equipped with an effective watertight interlocking system for joining sections, all joints in waterstops shall be bonded or fused to have a tensile strength of at least 50% of that of the unjointed material. At intersections and abrupt changes of direction, waterstops shall be jointed with prefabricated junction pieces.

Restrictions on joint width and on the temperature at the time of installing the sealant or seal will be shown on the Drawings. In the absence of such restrictions on the Drawings, and unless otherwise specified, installation shall be carried out only within the temperature range between 5°C and 30°C.

ii) Preparing the Joints

Where required, joints shall be sawn at a suitable time so as to avoid edge spalling or ravelling.

After the temporary filler material has been removed or the excess concrete has been broken out, the inside faces of the joint shall be wire brushed or sand-blasted to remove all laitance and contaminants. The joint shall then be cleaned and blown out with compressed air to remove all traces of dust. Solvents shall not be used for removing contaminants from the concrete and porous surfaces.

The Contractor shall ensure that primers are applied only to surfaces which are absolutely dry. The primer shall be applied strictly in accordance with the manufacturer's instructions. Unless otherwise specified, the primer shall be applied within the temperature range of 10°C and 40°C, and the sealant shall be applied after the curing period of the primer and within the period when the primer remains active.

iii) Sealants

Sealants shall be applied strictly in accordance with the manufacturer's instructions by a person skilled in the use of the particular type of sealant. Trapping of air and the forming of voids in the sealant shall be avoided. The sealant shall be finished to a neat appearance to the specified depth.

Thermoplastic hot-poured sealants shall not be poured into the joints when the temperature of the joint is below 10°C. The safe heating temperature shall not exceed the specified pouring temperature by more than 10°C.

Two-part thermosetting chemically curing sealants shall not be applied after expiry of the specified pot-life period which commences once the base and activator of the sealant have been combined.

iv) Waterstops

Waterstops shall be securely and accurately located in position so that they will not be displaced or

deformed during construction.

(f) Proprietary Expansion Joints

i) General

The use of any type of expansion joint shall be subject to approval. Bidders shall obtain approval for the type of expansion joint they intend to use prior to submitting their bids.

ii) Dimensions

The Contractor shall note the overall dimensions of the expansion joints and the limiting dimensions of that portion of the concrete structure which is to accommodate the joints. No alterations to the concrete which will be visible in the final structure or major re-arrangement of the pre-stressing anchorages will be permitted in order to accommodate joints of excessive size.

All joints to be installed skew shall be accurately dimensioned to ensure compliance with the requirements of SUB-CLAUSE 6603 (g).

Unless otherwise specified, proprietary expansion joints shall include the complete expansion-joint assembly, traversing the entire roadway, kerbs, sidewalks and median, and shall include the coping and parapet cover plates as well as the drainage system to drain the expansion joint.

iii) Design and Manufacture

The expansion joint shall be designed to withstand the movements, displacements and rotations specified on the Drawings in conjunction with the loads described in the code of practice adopted for the design of the structure without exceeding in any member the requirement for serviceability limit state. Any strengthening of the supporting member required to resist forces imparted by the joint to the structure shall be for the Contractor's account.

The specified movements, displacements and rotations shall be withstood without the efficacy or riding quality of the joint being impaired.

The joint shall be vibration free, resistant to mechanical wear and other forms of abrasion, and shall resist corrosion. It shall have good riding characteristics, shall be highly skid resistant, silent, and of watertight construction or have provision for the disposal of water, debris or grit collecting in the joint. It shall be of a construction that will facilitate easy inspection, maintenance and repair.

Apart from stainless steel, all steel surfaces shall be prepared in accordance with the requirements of SUB-CLAUSE 6907 (b) and sprayed with a galvanising coat which complies with the requirements of BS EN ISO 14713:1999 or equivalent for Zn 150 coverage. All enclosed surfaces sprayed with zinc shall, within four hours, be covered with a sealant suitable for use with the zinc and the subsequent layer. Two coats of chlorinated rubber paint with a combined dry-coat thickness of not less than 150 µm shall then be applied. They shall be of two different colours.

Prior to manufacture of the joints, the Contractor shall submit for approval detailed drawings in accordance with the requirements of CLAUSE 1221 of each expansion joint. The expansion joints delivered at the site shall be suitably marked to show clearly the sequence and position of installation.

(g) Installing the Expansion Joints

Proprietary expansion joints shall be installed by approved specialist subcontractors only. Installed proprietary expansion joints shall have a 15-year written

guarantee. No expansion joint or part thereof shall be installed prior to the construction of the final surfacing.

The expansion joint shall form an even surface with the road surface on either side or the deviation across and along the expansion joint shall comply with the requirements of SUB-CLAUSE 3405 (e) AND SUB-CLAUSE 3405 (f) for surface regularity measured by a 3 m straight-edge.

On completion of the installation of the proprietary expansion joints, the Contractor shall submit to the Engineer a certificate from the manufacturer or supplier of the joints, certifying acceptance of the installation, only if the manufacturer installed the joints. Notwithstanding the issuing of such a certificate, it shall not relieve the Contractor of their responsibility under the Contract. No separate payment will be made for the inspection of the joints and the issuing of the certificate by the manufacturer or supplier. It will be regarded as an obligation of the Contractor to be covered by the contract prices paid for joints.

6603 BEARINGS FOR STRUCTURES

(a) Materials

i) General

When requested by the Engineer, the Contractor shall submit test certificates from an approved, independent testing authority to show that the respective materials comply with the specified requirements, or a certificate from the patent holder or designer certifying that the manufactured item complies in all respects with relevant product specifications.

Unless otherwise specified, all the materials used for manufacturing the bearings shall comply with the requirements of BS EN 1337-5:2006, BS EN 1337-7:2006, BS EN 1337-8:2006.

ii) Roofing Felt

Roofing felt shall be 3-ply and comply with the requirements of BS 8217:2005 or equivalent for Type 1 roofing felt.

iii) Elastomer

The elastomer used in the manufacture of bearings shall be natural rubber or synthetic rubber.

Natural rubber shall comply with the requirements of BS 1154:2003 for specified IRHD hardness.

Synthetic rubber shall comply with the requirements of BS 2752:2003 for specified IRHD hardness.

iv) Stainless Steel Plate

The texture of the sliding surface of stainless-steel plate used in conjunction with PTFE to form low-friction sliding surfaces shall be equal to or better than 0.2 µm Ra in accordance with the requirements of BS 1134:2010.

v) Stainless Steel Dowels and Bolts

Stainless steel used for the manufacture of dowels and anchor bolts shall comply with the requirements of BS EN 10088 for Steel 316S16.

vi) Mortar

Mortar beddings for seating the bearings shall be composed of an approved sand and either cement or epoxy resin, or may consist of an approved proprietary mortar. The mortar shall comply with the following strength requirements:

[1] Sand-Cement Mortar

The 7-day compressive strength of 150 mm cubes made from the mortar and cured in a moist atmosphere for the first 24 hours and afterwards in water at 20°C shall be not less

than 1.5 times the average contact stress under the bearing or 15 MPa, whichever is the greater.

[2] Sand-Epoxy Resin Mortar.

The cured compressive cube strength of the mortar shall be not less than two times the average contact stress under the bearing, or 20 MPa, whichever is the greater.

[3] Proprietary Mortar

The strength requirements for proprietary mortars shall be in accordance with either SUB-CLAUSE 6604 (a) (i) or (ii) as may be relevant.

(b) Concrete Hinges

Concrete hinges shall be constructed in accordance with the details shown on the Drawings.

Construction joints shall not be formed in the throat area. Where a joint is necessary, it shall be formed as a recess below the throat, level with the top reinforcement mat. The width of the recess shall be slightly greater than that of the throat.

Care shall be taken to eliminate the formation of shrinkage cracks within the throat.

During construction, adequate bracing and support shall be provided to the satisfaction of the Engineer to prevent rotation in the throat from the time of casting to completion of the structure incorporating the hinge. During the course of construction the hinge shall not be subjected to conditions which will induce tensile stresses in the throat area. Upon completion of the structural members incorporating the hinge, the space around the throat shall be filled and sealed with an approved compressible material.

(c) Roofing Felt

Roofing felt used as bearing strips shall consist of at least three layers.

Where lubricated linings are specified, the roofing felt shall be saturated with motor oil and then liberally dusted with graphite powder before it is laid on the bearing surface.

(d) Elastomeric Bearings

i) Technical Data

The following technical data for the elastomeric bearings will be supplied on the Drawings, and shall also be supplied on drawings prepared by the Contractor for submission to the Engineer:

[1] Design Loads and Deformations

The critical design-load combinations and co-existing rotations and horizontal displacements for each bearing or each group of identical bearings.

[2] Size and Construction of Bearing

The size and construction of the bearing shall be designated by:

$$L \times B \times n(t)$$

where:

- L = length of bearing in the transverse direction, in mm
- B = width of bearing in the span direction, in mm
- n = number of elastomer layers.
- t = thickness of individual elastomer layers, in mm

The steel plates shall be encased in a 3 mm thick elastomer layer.

[3] Hardness and Type of Elastomer

The IRHD hardness and type of elastomer, i.e. natural or synthetic rubber, from which the specified bearings are to be manufactured.

[4] Identification

Each bearing shall be identified by a number.

ii) Alternative Bearings

Where alternative bearings are offered by the Contractor, they shall be designed in accordance with the requirements of relevant loadings and deformations shown on the Drawings.

Where a bearing consisting of a type of rubber is offered which differs from that which is specified, the bearing shall be redesigned to make provision for the variation in hardness and/or type of rubber.

iii) Inspection and Testing

On completion of the manufacture of the bearings, the Contractor shall submit bearings selected by the Engineer, or specially manufactured bearings to serve as samples as authorised by the Engineer, to an independent testing authority for testing.

The testing facilities of the manufacturer or supplier may be used if so approved and on condition that the tests are conducted in the presence of the Engineer.

The Engineer shall determine which tests are to be conducted, and the tests shall comply with the appropriate requirements of SUB-CLAUSE 7111 (a). Payment will be made under ITEM 71.01 for these tests, for bearings damaged, and for sample bearings.

Copies of test results and certificates for the above-mentioned tests shall be submitted by the Contractor to the Engineer in good time to enable the Engineer to assess the information before the bearings are installed.

The dimensional tolerances for the bearings shall comply with the requirements of SUB-CLAUSE 6803 (h).

Before the bearings are dispatched to the site of the Works, each bearing, with the exception of large bearings as provided for in the Special Specifications shall be subjected simultaneously to a vertical load equal to 150% of the maximum design load, and to a shear distortion equal to 150% of the maximum design value. The bearings shall be visually inspected for defects by the Engineer or their nominee and shall not at any stage under this test show any cracks visible to the naked eye or any other defects. The cost of this testing shall be included in the rate bid for ITEM 71.01.

The Engineer may instruct that one bearing of each consignment shall be cut open, at the Contractor's expense, with a view to a visual assessment of the bonding and the thickness of layers.

(e) Proprietary Bearings

i) General

This Clause covers custom-built bearings and bearings manufactured under licence, except elastomeric bearings. Combined bearings, consisting of an assembly of an elastomeric bearing in conjunction with a low-friction sliding or mechanical component shall fall under this CLAUSE.

The bidder may base their bid on any bearing which complies with the specified requirements, provided that the efficacy of the bearing has been verified by tests and successful previous use. Evidence hereof as well as information on the durability and suitability of the bearings for the specified use shall

be submitted to the Engineer for consideration.

Details of the product guarantee shall be submitted with the bid.

ii) Drawings and Approval

Prior to manufacturing the bearings, the Contractor or their nominee shall submit the following information to the Engineer for consideration:

- a. The manufacturer's specification containing detailed information on the design standards, materials, manufacture and technical data.
- b. Drawings complying with the provision in CLAUSE 1221 showing the bearing construction and installation details.
- c. Friction properties based on actual tests conducted on the relevant materials.

iii) Technical Requirements

The following technical requirements will be supplied on the Drawings, and shall also be supplied on the Drawings prepared by the Contractor for submission to the Engineer:

[1] Design Loads and Movement

The maximum and minimum vertical loads and co-existing horizontal loads as well as the maximum horizontal load and co-existing vertical load. The maximum values in each direction of the reversible and irreversible movements and the rotation about each axis.

[2] Identification

Identification of each bearing by a number, data on the degree of freedom of movement (fixed, multi-directional or unidirectional bearings) and the type of bearing (spherical, elastomer-pot, etc.) shall appear on each bearing.

iv) Design

The bearings shall be designed in accordance with the requirements and recommendations of BS EN 1337-5:2006, BS EN 1337-7:2006, BS EN 1337-8:2006. The following shall also be complied with:

- a. The average pressure on the area of the elastomer shall not exceed 25 MPa under the serviceability Limit State, unless otherwise prescribed by the Engineer.
- b. The maximum average contact stress and maximum edge stress on the concrete or mortar bedding shall not exceed 0.5 and 0.6 times the 28-day cube characteristic compressive strength under the serviceability Limit State respectively, unless otherwise prescribed by the Engineer.
- c. The bearing pad shall be of dimensions as will fit into the space allowed for its installation. Major alterations to the contiguous members will not be permitted.

v) Construction

Unless otherwise specified, the following shall be complied with:

- a. The thickness of the elastomer disc shall be not less than 0.066 times its diameter.
- b. Approved lubricants only shall be used on the PTFE sliding surfaces.
- c. The bearing shall be provided with tight-fitting seals to prevent the ingress of dust or deleterious matter onto the moving parts. The seals shall be of an approved type and sufficiently durable to last in excess of 50 years.

d. The assembled bearing shall be supplied with welded or bolted lugs or straps, temporarily securing the moving parts firmly in position to ensure that no undesirable relative movement occurs before or during construction.

e. The bearing shall be recessed into adaptor plates or be of such construction as to facilitate removal of the bearing from the installed position without damage to any part of the bearing or the surrounding material after the relevant structural member has been raised by 15 mm or the distance specified.

f. Anchors and holding-down bolts shall be of the specified material.

g. Corrosion protection of all exposed steel surfaces, with the exception of the stainless-steel sliding plate, shall involve the following treatment:

- ♦ Preparing the surfaces by abrasive blasting to a finish equal to the Sa3 finish of BS EN ISO 8501-1:2007, BS 7079-A1:1989 Swedish Standard SIS 05 59 00 or equivalent.
- ♦ Spraying the surfaces with zinc to comply with the requirements of BS 4482:2005 or equivalent on approval of the Engineer for Type Zn 150 surfacing.
- ♦ Coating the zinc-sprayed surfaces within four hours with a sealer compatible with the zinc and the subsequent coats of paint.
- ♦ Applying a coat of chlorinated rubber paint with a minimum of 75 µm of dry-film thickness and of a colour which differs from that of the final coat of paint.
- ♦ Applying a final coat of chlorinated rubber paint with a minimum of 75 µm of dry-film thickness and of dark grey colour.
- ♦ Surfaces in contact with concrete shall be sprayed with zinc so that it complies with the requirements of BS 4482:2005 or equivalent on approval of the Engineer for Type Zn 150 surfacing.

vi) Inspection and Testing

The Engineer may require tests to be conducted to verify compliance of the bearing with the specifications and/or its satisfactory performance under the design loads. Payment for this testing will be made under ITEM 71.01.

Test certificates of all the tests conducted shall be submitted to the Engineer.

The Contractor shall give the Engineer at least seven days' notice prior to final assembly of the bearings to enable the Engineer to inspect the bearings at the factory.

Under no circumstances shall bearings be taken apart and reassembled on the site, except where it is an unavoidable feature of the installation procedure, in which case the dismantling, installation and reassembly shall be under the supervision of qualified personnel.

Rehabilitation, modification and repair work to bearings shall be carried out only in the factory or in an approved engineering Works.

(f) Dowels and Guides

Where dowels and guides are used in conjunction with bearings they shall not complicate or prevent the removal

of the bearings.

(g) Storage and Handling

The bearings shall at all times be stored under cover and clear of the ground, away from sunlight, heat, oils and chemicals deleterious to the bearings. The bearings shall not be stacked in a manner or on a surface which will cause distortion of the bearings.

The bearings shall be handled with care to ensure that they are not subjected to impact loads or any other conditions which may be harmful.

(h) Installation

The concrete surfaces of elements required to receive bearings shall comply with the requirements of SUB-CLAUSE 6209 (c). Plastering of the surface will not under any circumstances be permitted.

Before the mortar bedding is constructed, the concrete surface shall be chipped back to expose the aggregate and leave a sound irregular surface. Bonding of the mortar bedding to the concrete surface shall be in accordance with the manufacturer's recommendations and the Engineer's instructions.

Unless otherwise shown on the Drawings, the bearings shall be installed on a horizontal plane and shall be in full contact with the concrete and bedding surfaces.

To accommodate soffit irregularities and camber in the case of precast members, the member shall be lowered onto a mortar skim on top of the bearing. The member shall then be propped until the mortar skim has hardened into a wedge.

The bearings shall be accurately installed to the specified level, alignment and orientation, all within the construction tolerances set out in SUB-CLAUSE 6803 (h) and the details shown on the Drawings.

Where the bearing has long sliding plates, the latter shall be rigidly supported to prevent their being distorted under the weight of the wet concrete and the construction loads. Before the bearing is incorporated into the structure, it shall be cleaned to remove all deleterious substances and adhering matter, after which it shall be wrapped in polyethylene sheeting and so sealed as to prevent the ingress of mortar and/or slush onto the bearing during the course of construction.

After installation, the polyethylene wrapping shall be removed, the bearing and the space around the bearing thoroughly cleaned and the lugs removed as prescribed by the Engineer.

On completion of installation of proprietary bearings, the Contractor shall submit to the Engineer a certificate from the manufacturer or supplier of the bearings certifying acceptance of the installation, only if the manufacturer installed the bearings. The issuing of such a certificate shall not relieve the Contractor of their responsibility under this Contract. No separate payment will be made for the inspection of the bearings by the manufacturer or supplier and the issuing of the certificate.

6604 PARAPETS, RAILINGS AND SIDEWALKS

(a) Materials

i) Concrete

All concrete work shall be carried out in accordance with the requirements of SECTIONS 6200, 6300, 6400 AND CLAUSE 6603.

ii) Structural Steel

Structural steel work shall comply with the provisions of SUB-CLAUSE 6702(a).

iii) Mortar

Mortar shall comply with the requirements of SUB-

CLAUSE 6604 (a) (i).

(b) Concrete Parapets

Concrete parapets shall be either cast in situ or precast or a combination of the two as shown on the Drawings. Where possible, precast elements shall be placed with the unformed surface downwards or outwards.

Concrete parapets shall be constructed after the removal of the falsework and the completion of the pre-stressing but not before the bridge deck has been accurately measured so as to determine the final lines and levels.

Service ducts in parapets and blocks shall be fixed and cast into position in accordance with the requirements of CLAUSE 6411 and the details shown on the Drawings.

The pipes and fittings to be used for the construction of the ducting shall be rigid PVC pipes and fittings with flexible rubber joints which comply with the requirements of BS EN ISO 1452-1:2009 or equivalent. Duct ends shall be provided with suitable conical wooden stoppers to prevent dirt, concrete, etc., from entering the ducts. Two strands of 2.5 mm diameter galvanised steel wire shall be threaded through each duct. The strands shall extend 2 m beyond each end and be wedged firmly into position with the wooden stoppers. Inspection eyes for the ducts shall be constructed in accordance with the details shown on the Drawings.

No separate payment will be made for service ducts in parapets and end blocks and the rates bid for the parapets and end blocks shall include full compensation for the provision and installation of service ducts complete with stoppers, draw wire and inspection eyes.

(c) Steel Railings

All steelwork shall be manufactured in accordance with the requirements of SECTION 6700.

A mortar bed, not less than 10 mm in thickness, shall be provided below all steel base plates over the full dimensions of the plate. The sides of the beds shall be neatly chamfered at 45°. All open spaces between the bolt and the sides of the holes in the base plate shall be filled with an approved sealant.

Steelwork which is to be cast or grouted into concrete shall be completely painted to a distance of 75 mm in the concrete or grout, and shall be cleaned of all loose rust, mill scale, oil or other material which may impair the bond between the concrete and steel.

All steelwork shall be painted in the shop and on site in accordance with the provisions of SECTION 6900. Surfaces which will be inaccessible after erection of the units shall be painted before the erection commences. If called for on the Drawings or in the Bill of Quantities, steelwork shall be galvanised and painted. Galvanising shall be done after fabrication, in accordance with BS EN ISO 1461:2022 - TC or equivalent for Type A1 articles.

(d) Numbers for Structures

i) Number Plates

Number plates shall be fixed in the positions and according to the method of fixing shown on the Drawings.

ii) Painted Numbers

The surface onto which the numbers are to be painted shall be prepared in accordance with the requirements of SUB-CLAUSE 6909 (a). The background shall be of at least two coats of the prescribed paint. The letters and figures shall be in accordance with the details given on the Drawings and shall be written at the prescribed positions with a template.

iii) Numbers Shaped in Concrete

Bridge numbers shall be placed and shaped in accordance with the requirements shown on the Drawings. The minimum concrete cover over the steel reinforcement behind the numbers shall not be less than the prescribed cover for the structural member in question.

(e) Concrete Sidewalks

After completion of the pre-stressing (if any) and the removal of the formwork, the sidewalks and kerbing shall be constructed, but not before the bridge deck has been accurately surveyed to establish final lines and levels.

The previously cast bridge deck area shall be prepared as specified in CLAUSE 6408 to receive the sidewalk concrete.

Forms shall be accurately set to the final lines and levels and shall be firmly held in position during the placing of the concrete. Stops at the ends of sections shall be accurately placed to ensure that joints between adjacent sections will be truly perpendicular to the surface of the concrete and at right angles to the edge of the road or to the skew angle of the deck at the expansion joint.

After removal of the forms, the enclosed surfaces of the kerbs and copings shall be rubbed and finished in accordance with the requirements of SUB-CLAUSES 6208 (a), 6208 (c) AND 6209 (b). All edges shall be rounded to a radius of 20 mm unless otherwise shown on the Drawings.

(f) Concrete Surface Finish Requirements

All formed concrete surfaces shall have a Class F3 surface finish as specified in SUB-CLAUSE 6207 (d) and all unformed concrete surfaces shall have a Class U2 surface finish in accordance with SUB-CLAUSE 6209 (b).

(g) Transition Blocks

Transition blocks shall be constructed in accordance with the details shown on the Drawings.

(h) Nose Endings

Nose endings of balustrades shall be constructed in accordance with the details on the Drawings.

6605 DRAINAGE FOR STRUCTURES**(a) Weep Holes, Drainage Pipes and Channelling**

Weep holes shall not be placed within 40 mm of any reinforcement and shall be carefully cleaned and kept clean. Drainage pipes shall be of the material prescribed on the Drawings, and the interior surface shall, on completion, be smooth and clean.

Cast in situ concrete channelling shall be provided next to the kerbing if shown on the Drawings and according to the details provided. Concrete work shall be carried out in accordance with the provisions of SECTION 6400 and channelling shall be given a Class U3 surface finish as specified in SUB-CLAUSE 6209 (c). The channelling shall be bonded to the bridge deck concrete in accordance with the provisions of CLAUSE 6408.

(b) No-Fines Concrete Blocks

Blocks shall be of the class of prescribed no-fines concrete and to the required dimensions and shall be placed in advance of backfilling.

No-fines concrete shall comply with the requirements of SECTION 6400C.

(c) Synthetic-Fibre Filter Fabric

Synthetic-fibre filter fabric shall be of the type and grade shown on the Drawings or specified in the Special Specifications. Filter fabric shall be placed as shown on the Drawings and shall be protected against sunlight and

mechanical damage during storage and installation.

The fabric shall comply with the requirements of SUB-CLAUSE 2104 (a).

(d) Crushed Stone in Drainage Strips Behind Walls

The crushed stone used in drainage strips shall comply with the requirements for 20 mm nominal size stone. The crushed stone shall be wrapped in synthetic-fibre geotextile and placed in accordance with the details shown on the Drawings or as instructed by the Engineer.

The fabric shall comply with the requirements of SUB-CLAUSE 2104 (a).

6606 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
66.01 PROPRIETARY EXPANSION JOINTS:	
(a) PRIME COST SUM ALLOWED FOR PURCHASING AND TAKING DELIVERY OF EXPANSION JOINTS	PRIME COST SUM
(b) PERCENTAGE ON PRIME COST SUM FOR CHARGES AND PROFIT	PERCENT (%)

A Prime Cost Sum shall be allowed for payment for the actual costs of purchasing and taking delivery of proprietary expansion joints. A percentage on the prime cost sum shall cover the Contractor's charges and profit for purchase and delivery of the joints.

<u>ITEM</u>	<u>UNIT</u>
66.02 INSTALLATION OF PROPRIETARY EXPANSION JOINTS:	
(a) (DESCRIPTION OF JOINT MEASURED PER METRE)	METRE (m)
(b) (DESCRIPTION OF JOINT MEASURED BY NUMBER)	NUMBER (no.)

The unit of measurement shall be either the metre of complete joint of each type installed or the number of complete joints of each type installed. The bid rates shall include full compensation for supplying all materials not covered under ITEM 66.03, transporting, handling and storing, and all labour, equipment, shaping the recesses, and incidentals required for installing the expansion joint complete in accordance with instructions. Separate payment shall not be made for supplying and/or installing the seal in proprietary expansion joints or the seal between concrete or synthetic nosings.

The cost of forming the open joint(s) shall not be included in the rates bid for ITEM 66.04 as payment for this work shall be made under ITEM 62.06.

The bid rate shall be final and binding, irrespective of the type or make of joint finally installed.

<u>ITEM</u>	<u>UNIT</u>
66.03 EXPANSION JOINTS:	
(a) (DESCRIPTION OF JOINT MEASURED PER METRE)	METRE (m)
(b) (DESCRIPTION OF JOINT MEASURED BY NUMBER)	NUMBER (no.)

The unit of measurement shall be the metre of complete expansion joint of each type installed or the number of completed joints of each type installed.

The bid rates shall include full compensation for supplying all the materials, manufacturing the expansion joint, transporting, handling and storing, and all labour equipment, shaping the recesses, and incidentals required for installing the expansion joint complete in accordance with instructions. Separate payment shall not be made for supplying and/or installing the seal in proprietary expansion joints or the seal between concrete or synthetic nosings.

The cost of forming the open joint(s) shall not be included in the rates bid for ITEM 66.05 as payment for this work shall be made under ITEM 62.06.

<u>Item</u>	<u>Unit</u>
66.04 FILLED JOINTS:	
(a) (DESCRIPTION OF AND THICKNESS OF JOINT FILLER FOR JOINTS MEASURED PER SQUARE METRE)	SQUARE METRE (m ²)
(b) (DESCRIPTION OF AND THICKNESS OF JOINT FILLER FOR JOINTS MEASURED PER METRE)	METRE (m)

The unit of measurement shall be the square metre of filled joint calculated from the surface area of the joint. Where the filled joint is 150 mm or less in depth, the unit of measurement shall be the metre of filled joints measured along the joint centre line. Concrete surfaces formed prior to the construction of the final surface for completing the filled joint shall be measured under ITEMS 62.01, 62.02, 62.03 OR 62.04, as may be applicable.

The bid rates shall include full compensation for supplying and installing the joint filler and all materials not covered under ITEM 66.08, and for all labour and incidentals required for completing the filled joint as prescribed.

<u>ITEM</u>	<u>UNIT</u>
66.05 UNFILLED JOINTS:	
(a) (DESCRIPTION OF JOINT FOR JOINTS MEASURED PER SQUARE METRE)	SQUARE METRE (m ²)
(b) (DESCRIPTION OF JOINT FOR JOINTS MEASURED PER LINEAR METRE)	METRE (m)

The unit of measurement shall be the square metre of unfilled joint, calculated in accordance with the joint area. Where, however, the depth of the joint is 150 mm or less, the unit of measurement shall be the metre of unfilled joint measured along the joint centre line. Concrete areas formed before the final surface is constructed to complete the unfilled joint, shall be measured under ITEMS 62.01, 62.02, 62.03 OR 62.04, as may be applicable.

The bid rates shall include full compensation for providing and applying the bond breaker and all materials not paid for under ITEM 66.08, also for the labour and incidentals required for completing the unfilled joint as prescribed.

<u>ITEM</u>	<u>UNIT</u>
66.06 SEALING JOINTS WITH:	
(a) SEALANT (DESCRIPTION OF JOINT, SEALANT AND SIZE)	METRE (m)
(b) SEAL (DESCRIPTION OF JOINT, SEALANT AND SIZE)	METRE (m)
(c) WATERSTOP (DESCRIPTION OF JOINT, WATERSTOP AND SIZE)	METRE (m)

The unit of measurement shall be the metre of sealant, seal or waterstop of each type installed.

The bid rates shall include full compensation for supplying all materials, forming or cutting the concrete to the required shape and size, all labour, equipment and incidentals required for sealing the joint completely in accordance with the prescriptions, and for all waste materials.

<u>ITEM</u>	<u>UNIT</u>
66.07 PROPRIETARY BEARINGS:	
(a) PRIME COST SUM ALLOWED FOR PURCHASING AND TAKING DELIVERY OF BEARINGS	PRIME COST SUM
(b) PERCENTAGE ON PRIME COST SUM FOR CHARGES AND PROFIT	PERCENTAGE (%)

A Prime Cost Sum shall be allowed for payment for actual costs of purchasing and taking delivery of proprietary bearings, complete with anchor bolts and/or dowels. A percentage on the prime cost sum shall cover the Contractor's charges and profit for purchase and delivery of the bearings.

<u>ITEM</u>	<u>UNIT</u>
66.08 INSTALLING THE PROPRIETARY BEARINGS (DESCRIPTION OF EACH TYPE, AND STATE CLASS)	NUMBER (no.)

The unit of measurement shall be the number of complete bearings of each type and class installed.

The bid rate shall include full compensation for supplying all the materials not covered under ITEM 66.09, constructing the bedding, transporting, handling and storing, and all labour, equipment and incidentals required for installing the bearings complete as detailed.

The bid rate shall be final and binding, irrespective of the type or make of bearing finally installed.

<u>ITEM</u>	<u>UNIT</u>
66.09 BEARINGS (DESCRIPTION OF EACH TYPE AND CLASS)	NUMBER (no.)

The unit of measurement shall be the number of complete bearings of each type and class installed.

The bid rate shall include full compensation for supplying all the materials, including anchor bolts and/or dowels, constructing the bedding, manufacturing the bearings, transporting, handling and storing, and all labour, equipment and incidentals required for installing the bearings complete as detailed.

<u>ITEM</u>	<u>UNIT</u>
66.10 CONCRETE HINGES:	
(a) (DESCRIPTION OF HINGE MEASURED PER METRE)	METRE (m)
(b) (DESCRIPTION OF HINGE MEASURED BY NUMBER)	NUMBER (no.)

The unit of measurement shall be either the metre of complete hinge of each type manufactured and installed or the number of complete hinges of each type manufactured and installed.

The bid rates shall include full compensation for supplying all materials, including formwork, manufacturing the hinges, transporting, handling and storing, sealing the hinges, and all labour, equipment and incidentals required for installing the hinges complete as detailed.

<u>ITEM</u>	<u>UNIT</u>
66.11 BEARING STRIPS (DESCRIPTION OF THE MATERIAL AND NUMBER OF LAYERS)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of bearing area lined with the specified material irrespective of the number of layers placed.

The bid rate shall include full compensation for supplying all the materials, transporting, handling and storing, and all labour and incidentals required for installing the

bearing strips complete as detailed.

<u>ITEM</u>	<u>UNIT</u>
66.12 DOWELS/GUIDES (DESCRIPTION OF EACH TYPE)	NUMBER (no.)

The unit of measurement shall be the number of dowels/guides of each type installed.

The bid rate shall include full compensation for supplying all materials, including anchor bolts, manufacturing the dowels/guides, transporting, handling and storing, and all labour, equipment and incidentals required for installing the dowels/guides complete as detailed.

<u>ITEM</u>	<u>UNIT</u>
66.13 CONCRETE PARAPETS	METRE (m)

The unit of measurement for concrete parapets shall be the metre of concrete parapet complete in accordance with the Drawings. Concrete parapets shall include all work above the top level of the sidewalks or, where not placed on a sidewalk, above the top of the bridge deck concrete, wing walls or retaining walls and shall also include any kerbing and coping forming an integral part of the concrete parapet.

The bid rate for concrete parapets shall include full compensation for all concrete, formwork, service ducts, drawing wires and accessories. The rates will exclude only the cost of reinforcing steel as this will be measured and paid for under ITEM 63.01.

<u>ITEM</u>	<u>UNIT</u>
66.14 STEEL RAILINGS (TYPE DESCRIBED)	METRE (m)

The unit of measurement for steel railings shall be the metre of railing complete in accordance with the Drawings.

The bid rate for steel railings shall include full compensation for all steelwork and corrosion protection, including fastenings, anchor bolts, mortar bedding, etc, as may be required for erecting the railings.

<u>ITEM</u>	<u>UNIT</u>
66.15 END BLOCKS	NUMBER (no.)

The unit of measurement of bridge end blocks shall be the number of end blocks constructed complete in accordance with the Drawings.

The bid rate shall include full compensation for all materials, labour, plant, and other incidentals required for constructing the end blocks complete as specified, excluding only reinforcing steel.

<u>ITEM</u>	<u>UNIT</u>
66.16 NUMBERS FOR STRUCTURES:	
(a) NUMBER PLATES	NUMBER (no.)
(b) PAINTED NUMBERS	NUMBER (no.)
(c) NUMBERS FORMED IN CONCRETE	NUMBER (no.)

The unit of measurement shall be either the number of bridge number plates provided and installed, or the number of complete numbers painted on the structures, or the number of complete numbers formed in concrete. A bridge number may consist of a combination of letters and digits; e.g. B1533.

The bid rates shall include full compensation for providing and installing either the number plates, or preparing the surface and painting the numbers, or forming the numbers in concrete, and for all material, labour and equipment required in this connection.

<u>ITEM</u>	<u>UNIT</u>
66.17 DRAINAGE PIPES AND WEEP HOLES:	
(a) DRAINAGE PIPES: -	
(i) (TYPE AND SIZE INDICATED)	METRE (m)
(ii) (TYPE AND SIZE INDICATED)	NUMBER (no.)
(b) WEEP HOLES:	
(i) (TYPE AND SIZE INDICATED)	METRE (m)
(ii) (TYPE AND SIZE INDICATED)	NUMBER (no.)

The unit of measurement shall be either the metre of pipe/weep hole or the number of pipes/weep holes of each type and size of pipe/weep hole completed.

The bid rates shall include full compensation for supplying all the materials, manufacturing and installing the pipes and making weep holes.

<u>ITEM</u>	<u>UNIT</u>
66.18 DRAINAGE GULLEYS DESCRIPTION OF EACH TYPE GIVEN	NUMBER (no.)

The unit of measurement shall be the number of drainage gulleys of each type installed.

The bid rate shall include full compensation for providing all the material and manufacturing and installing the drainage inlets.

<u>ITEM</u>	<u>UNIT</u>
66.19 SYNTHETIC-FIBRE FILTER FABRIC (TYPE INDICATED AND DESCRIPTION)	SQUARE METRE (m ²)

The unit of measurement shall be the square metre of filter fabric installed as specified, including the specified overlap.

The bid rate shall include full compensation for supplying, cutting, lapping and installing the filter fabric, and for waste material.

<u>ITEM</u>	<u>UNIT</u>
66.20 CONCRETE CHANNELLING (SIZE INDICATED)	METRE (m)

The unit of measurement shall be the metre of completed concrete channelling of each size constructed.

The bid rate shall include full compensation for providing all the materials, all labour, equipment and expenses required for completing the work.

<u>ITEM</u>	<u>UNIT</u>
66.21 CRUSHED STONE IN DRAINAGE STRIPS	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of crushed stone placed in position as specified, in accordance with the details shown on the Drawings or instructed by the Engineer.

The bid rate shall include full compensation for procuring, furnishing and placing the crushed stone, and for wrapping it in synthetic-fibre geotextile as specified. The geotextile will be measured for payment under ITEM 66.21.

<u>ITEM</u>	<u>UNIT</u>
66.22 NOSE ENDINGS OF BALUSTRADES	NUMBER (no.)

The unit of measurement shall be the number of nose endings constructed complete in accordance with the

details shown on the Drawings.

The bid rate shall include full compensation for all labour, constructional plant and materials required, for filling the recesses with concrete or nosing material, 20 mm x 20 mm plastijoint seal between the end block and the transition block, steel cover plate complete with anchor bolts, and all incidentals required for constructing the nose endings complete.

<u>ITEM</u>	<u>UNIT</u>
66.23 CONCRETE TRANSITION BLOCKS (LENGTH INDICATED)	NUMBER (no.)

The unit of measurement shall be the number of each size of concrete transition block constructed completely in accordance with the details shown on the Drawings.

The bid rate shall include full compensation for all labour, construction plant, materials and all incidentals required for constructing the transition blocks.

SERIES 6000: STRUCTURES

SECTION 6600A: EARTH RETAINING STRUCTURE MECHANICALLY STABILIZED EARTH (MSE)

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6601A SCOPE

This Section covers the furnishing materials required for the construction of Mechanically Stabilised Earth (MSE) walls that are reinforced, with reinforcements and different possible facings and reinforced earth slopes.

6602A MATERIALS**(a) General**

All materials used in constructing MSE walls, shall comply with BS EN 14475:2016 OR SANS 54475 or as specified in the Special specifications and be subject to approval by the Engineer. When requested by the Engineer, the Contractor shall submit test certificates from an approved independent testing authority to show that materials comply with specified requirements, or where applicable certificates from patent holders or licensees certifying that manufactured items comply in all respects with relevant product specifications. All facings, soil reinforcement and fastener materials shall be designed and sourced from a single supplier to ensure compatibility.

The Contractor shall provide detailed specifications, test data, performance data and compliance certificates from independent reputable agencies for all proprietary systems, processes and materials proposed for use. These shall demonstrate conformance with the performance requirements as specified in the Drawings, Special Specifications or as instructed by the Engineer.

Unless otherwise specified, all proprietary materials shall be used and placed in strict accordance with the relevant manufacturer's current published instructions.

(b) Concrete Facings

Concrete facings shall be manufactured from materials which comply with relevant requirements of Sections 6200, 6300 and 6400 and should have a minimum 28-day cube strength of 35 MPa unless otherwise specified in the Special Specifications or in Drawings.

(c) Concrete Block Facings

Concrete block facings used in MSE walls shall be manufactured and tested in accordance to BS EN 1992-1-1:2004 + A1:2014. These shall have a positive connection to reinforcement.

Pigments used for colouration of concrete blocks shall conform to BS EN 12878:2014.

(d) Concrete Bases and Foundations for Earth Retaining Systems

All materials for concrete bases and foundations for earth retaining systems shall comply with requirements of

SECTIONS 6300 AND 6400.

(e) Metallic Soil Reinforcements

Metallic soil reinforcement shall be manufactured from corrosion-resistant materials designed to ensure adequate performance when buried for the design life of the structure. This metallic reinforcement may take the form of sheets, grids, meshes, strips, bars, rods, ladders etc. and shall comply with section 3.2.1 of BS 8006-1+A1:2021.

Galvanizing shall comply with the requirements of ISO 1461: 2022 for bars and SANS 675 for wire up to 5.0 mm in diameter.

(f) All Facing Units and Their Applications Shall Conform to BS EN 14475:2016 Fasteners Between Facing and Reinforcing Elements

Fasteners or joints (either metallic or polymeric) between facing and reinforcing elements shall comply with Section 3.4 of SANS 8006-1. Facings shall have a positive connection to reinforcing elements. Galvanising shall comply with ISO 1461:2022.

(g) Joint Filler Materials on Facings

Fillers shall be durable, flexible, and resistant to the effects of air pollution, and water that might be contaminated with de-icing salt.

(h) Bedding Material

Selection of bedding material depends upon structural behaviour of the facing assumed in design of the wall. Cement mortar or a durable gasket material such as resin bonded cork, bitumen bonded cork, rubber or ethylene propylene diene monomer (EPDM) may be used upon the approval of the Engineer.

(i) Sealing Material

Filling of joints other than bedding joints may be done either with closed cell polyethylene foam, closed cell polyurethane foam strips in the joint, or geotextile strips over the rear face of joint as approved by the Engineer.

Any accessory proprietary products, elements or fittings necessary for the construction of MSE structures shall comply with appropriate, accepted standards or specifications.

(j) Polymeric Materials

All polymeric materials delivered to a site shall be identified in accordance with BS EN ISO 10320 AND ISO/TR 20432:2007.

(k) Fill Materials

Selected fill behind MSE wall facings over the length of reinforcement shall comply with requirements of material class G45 material as given in Table 3702/4 with a maximum size of 50 mm and be free draining.

(l) Permeable Filter Material

Permeable filter materials behind the MSE wall shall consist of crushed stone of suitable grading. Crushed stone shall be of hard, clean rock. If permeable filter material conforming to the criteria given below is not obtainable in the opinion of the Engineer, then geotextile shall be used as directed by the Engineer.

Permeable filter material shall be free of organic material, silt or clay lumps and shall conform to the following requirements:

- d_{85} for the permeable filter material shall be minimum 1.25 times the width of the slots in the drainage pipe
- d_{15} for the permeable filter material shall be maximum 5 times d_{85} for the adjacent soils

- iii. d_{50} for the permeable filter material shall be maximum 25 times d_{50} for the adjacent soils
- iv. d_{15} for the permeable filter material shall be minimum 5 times d_{15} for the adjacent soils
- v. the permeable filter material shall have maximum 50 % passing the 2 mm sieve
- vi. the permeable filter material shall have maximum 3 % passing the 0.075 mm sieve

Where:

d_{15} , d_{50} and d_{85} are the corresponding grain sizes which passes 15%, 50% and 85% respectively in the sieve analysis.

(m) Polymeric Reinforcement Joints

i) General

Joints are subdivided into prefabricated joints and joints made during execution of the works. A number of different jointing systems are in use.

Joints in geotextiles shall normally be sewn where load transference is required utilising either single or double chain stitching. Types of stitching and seams (prayer, butterfly, J, flat or Z) for geotextiles and bodkin details for polymeric meshes or grids should be as given in the Drawings, Special Specifications or as instructed by the Engineer.

Care shall be taken to ensure that:

- Bodkins are of sufficient cross-sectional area and strength to avoid excessive deformation,
- Bodkins are not so large as to distort the parent material causing stress concentrations, or
- Joints are pre-tensioned prior to loading, to reduce joint displacement as components lock together.

Joints shall be formed to have high mechanical and durability efficiency, compared to the performance characteristics of the parent materials. Test methods used to assess joints shall correspond closely to those procedures employed when determining properties of the parent materials. All joints used in permanent structures designed to carry loads shall be tested in accordance with BS EN ISO 10321:2009 and results presented to the Engineer for approval.

ii) Overlaps

In situations where relatively small tensions develop, overlapping may be employed utilising coarse sand-filled 20 mm thick joints (Permeable Filter Material complying with CLAUSE 2104 of the standard Specification).

Such joints are sometimes used in secondary tensile directions but shall not be employed in primary tensile directions in reinforced soil structures. Overlapping may also be used for jointing underwater where amount of overlap depends on design considerations and construction conditions.

iii) Stapling

This method may be used with geotextiles to make temporary joints. Stapling shall never be used for structural jointing.

iv) Other Jointing Methods

Other jointing methods may be adopted. However, general recommendations as set out above still apply.

(n) Fasteners and Connections Between Facing

and Reinforcing Elements

i) General

Fasteners are used to make a connection between the reinforcement and the facing and take the form of dowels, rods, hexagon headed screws and nuts and bolts, and shall consist of either steel or polymers.

The choice of material used to form the fastener shall be compatible with design life of structure. Materials for fasteners and connections shall conform to criteria described in BS EN 14475:2016

ii) Steel Coatings

These may be divided into two groups:

- Metallic coatings, including galvanizing in accordance with BS EN ISO 1461:2022 and aluminium-zinc coatings in accordance with BS 2569; and,
- Organic coatings, including bitumen in accordance with BS 3416:2018 AND BS EN 10300:2020, polyvinyl chloride (PVC), liquid and powder epoxies and liquid polyurethanes.

The application rates of coating to the base metal of the fastener should be as given in the Drawings, Special Specifications or as instructed by the Engineer.

6603A MSE WALLS WITH CONCRETE FACINGS

(a) Construction Equipment

Normal earthmoving and compaction equipment may be used in the construction of MSE walls and slopes except for the proviso that no compaction equipment of mass greater than 1,500 kg may be used within 2.0 m of facings. This area shall be compacted with pedestrian rollers and mechanical thumpers.

(b) Execution of the Works

All MSE walls constructed with concrete block facings shall be installed as per the Concrete Block Retaining Wall (CBRW) Installation Manual 5th edition 2009, SANS 54475 OR BS EN 14475:2016.

All MSE walls constructed with concrete facings shall be constructed in accordance with SANS 54475 OR BS EN 14475:2016.

i) Concrete Facings

Concrete facings shall be manufactured in accordance with the dimensions and details shown on the MSE wall supplier's drawings and where necessary, these details shall be adapted to suit joining onto existing structures, inclined foundations, varying heights or similar conditions. Special facings shall be produced for copings, and terminal sections. The 28-day compressive strength of the concrete shall be 35 MPa unless otherwise specified in the Drawings, Special Specifications or as instructed by the Engineer.

These facings shall be manufactured in accordance with the provisions of SECTIONS 6200, 6300 AND 6400 with due regard to cover, durability considerations and alkali silica reaction. They shall have an off-shutter class F2 surface finish. Concrete facings are typically between 140 and 180 mm thick. Selected facings shall have a protruding patterned or exposed aggregate finish as indicated in the Drawings or as specified in Special Specifications.

Date of manufacture and classification of every facing panel shall be clearly marked on the back of such panel at the top end.

Concrete facing panels shall not be removed from their moulds until the concrete has attained sufficient strength to avoid for any sag, crack or

edge break. They shall not be stacked more than five high during storage. Bottom concrete facing panels shall be supported off-ground via timber blocking and adjacent concrete facing panels shall be separated by timber blocks packed between the tie strips to prevent any forces from being transmitted onto the tie strips.

ii) Metallic Reinforcement

[1] Handling

Metallic reinforcement shall be loaded, unloaded and handled in such a way as to prevent bending which causes permanent set or damage to any protective coating.

Reinforcement shall not be dragged across abrasive surfaces such as reinforced concrete or coarse angular soils or through deleterious materials.

To avoid punctures or fractures in any covering that might allow ingress of corrosive media, only fibre rope, webbing slings or protected chains shall be used.

Connecting lugs attached to the facing elements shall be handled with similar care to prevent damage to the protective covering.

[2] Storage

Metallic reinforcement shall be stored in neat stacks clear of ground at all times and supported on non-absorbent materials to avoid contamination. Ideally storage shall be located close to construction activities. Items of different lengths and cross-sectional dimensions shall be stacked separately and clearly marked.

Storage arrangements shall preferably maintain separation between batches delivered. Ideally one batch shall be fully utilised before the next one is used to facilitate quality control.

iii) Polymeric Reinforcement

[1] General

Polymeric reinforcements are woven, knitted, coated or extruded geotextiles, geo-grids or geo-composite geotextiles. Polymeric reinforcements shall be assessed according to ISO/TR 20432:2007. Details of packaging and hence handling and storage thus vary from product to product. The manufacturer's prescriptions to this effect shall be strictly adhered to.

Where recommendations given below do not relate to a particular product further advice shall be sought from an approving authority, supplier or manufacturer.

[2] Handling

Polymeric reinforcement materials are generally supplied in rolls, which shall bear a conformity identification mark, e.g. according to BS EN ISO 10320:2019. Site handling shall ensure that surface abrasion, slitting, notching or tearing is prevented.

Where a central tube or mandrel to facilitate lifting is supplied, the manufacturer's recommendations shall be followed. In any case, geotextiles supplied in rolls shall be supported at a minimum of two points to prevent excessive bending unless a central steel tube is used for support.

[3] Storage

Storage conditions of geo-synthetic reinforcing materials shall take into account their characteristics and placement needs.

Generally, short term storage on site may be carried out without particular precautions as long as products are kept within their packaging. Prolonged exposure to light shall be

prevented either by storage under cover or by opaque-packaging cover.

Geotextiles shall be stored in dry conditions particularly for materials that absorb water and where low temperatures might cause freezing and make placement difficult.

Where bars or other fixings are required for geo-synthetic reinforcement, these shall be stored in clean dry conditions.

iv) Accessories

Any accessory proprietary products, elements or fittings shall be manufactured in accordance with the dimensions and details shown on the drawings. Accessories shall be handled in accordance with the supplier's recommendations.

(c) Construction

i) Excavations

All excavation for bases of earth retaining systems shall be in accordance with the provisions of SECTION 6100. Construction of the bases shall not commence before the excavations are properly cleaned and inspected and approved by the Engineer.

ii) Foundation

Foundation planes for MSE structures shall be graded for a width equal to the length of soil reinforcement and to heights shown on the MSE drawings and compacted to greater than 95 % of the Maximum Dry Density as per SECTION 6100 AND 7000 or in accordance with the requirements of SECTION 3600 higher density as may be specified. All foundation soils found to be unsuitable shall be removed and replaced with compacted, approved granular material or other such materials as are approved by the MSE supplier's Engineers. Measurement and payment for this work will be paid for under the relevant items of Section 3600. Alternatively, such preparation preceding foundation construction, as may be specified in the Special Specification, shall be carried out in accordance with the provisions of the section.

A concrete footing, conforming to correct lines and levels, shall be constructed in accordance with details shown on the MSE drawings.

iii) MSE

Prior to the placing reinforcing elements a method statement shall be submitted to the Engineer for approval providing details of operation sequence. The method adopted shall ensure the reinforcement does not suffer deterioration during placement and any joints or connections are effectively formed.

Construction of MSE shall conform to SANS 54475 OR BS EN 14475:2016 and any procedures specified by wall system supplier as agreed with the Engineer. Concrete facing panels can only be installed after characteristic cube crushing strength corresponding to 28 days have been achieved as specified in the Drawings or Special Specifications. Testing in this regard shall conform to the requirements of SECTION 6400 AND 7000 for concrete strengths.

The following specifications are considered as minimum construction requirements (In all cases the MSE supplier's engineering specifications shall prevail if they exceed minimum construction requirements):

- The bottom row of facing panels shall be carefully aligned on the foundation footings in accordance with the details provided on the approved construction drawings. These facing panels shall be properly braced to prevent

movement during placing of the first layers of backfill. Each facing panel shall be individually checked by survey after placement to confirm it is correctly placed to line, levels, inclinations and tolerances specified.

- Geo-synthetic/polymer reinforcement shall either be fixed to the panels providing a positive connection in an approved manner or clamped between the panels where specified. Special care shall be taken to ensure the edges on facing panels are not sharp or jagged such that the reinforcement may be damaged.
- The geo-synthetic layer shall be uniformly laid taut over its specified length and held in place by approved means. The Engineer's approval of such tensioning shall be obtained prior to any placement of backfill. There shall be no loss of tension during backfilling operations. Damaged reinforcements shall be removed and replaced at the Contractor's cost.
- Fill material behind the facing panels shall be placed and compacted in accordance with Section 3600 and greater than 95 % of the Maximum Dry Density at a moisture content of 0 to plus 2 % of the optimum moisture content, except that the layer thickness may vary slightly to suit the position of soil reinforcement.
- Deposition, spreading, levelling and compaction of fill shall generally be carried out in a direction parallel to the facings, and shall be executed in stages to alternate with placing and fixing of the reinforcing elements and the facing.
- Fill shall be deposited, spread, levelled and compacted in horizontal layers of appropriate/specified thickness. Spreading and compaction shall be carried out so that all layers of the soil reinforcing elements are fixed at the specified levels on top of the compacted fill.
- Fill shall be placed such that it slopes away from the face at 2 % to ensure water ponding at the soil/facing element interface does not occur.
- Fill shall not be placed right up to the cladding panels before the underlying reinforcing is covered, with compacted fill materials to anchor the reinforcement adequately to maintain the facing panel in position. Fill shall be placed from the end of the reinforcement to the cladding panels.
- Metallic reinforcement shall be placed on compacted fill and in intimate contact with the ground, which shall have a nominal fall of 2 % away from the facing.
- If inspection of elements prior to or during placement reveals bends or kinks with a radius less than twice the reinforcement thickness, these shall be rejected.
- Small areas of galvanized coating damaged during handling shall be repaired in accordance with BS EN ISO 1461:2022.
- Most sheet products exhibit preferential strength direction and therefore placement of reinforcement shall be consistent with the direction of major stresses. Details shall be indicated on the drawings and Special Specifications or as instructed by the Engineer.
- Ideally, strips shall be laid in the major load bearing direction, i.e. transverse to the embankment centreline. However, construction is facilitated and sewing time minimized if geo-synthetics are laid in centreline direction. This is not recommended but may be allowed if joint-integrity is assured and the design takes account of likely transverse-direction-reduced-strength.

- Geo-textiles and geo-grids are generally supplied in rolls of specific width. Rolls shall not be cut along their width to fit a smaller area and overlapping between adjacent rolls shall be adopted, this to avoid ravelling after cutting.
- Geo-textiles may be cut to length using a sharp blade, scissors or shears. Materials which may ravel shall be heat-treated or bonded with approved adhesive tape at the cut position. Cutting to size of polymeric sheet geo-grids shall be performed before placing.
- Care shall be taken to ensure that reinforcing elements are not damaged or displaced beyond specified tolerances during filling and compacting. Filling shall be arranged so that no machines or vehicles run over the reinforcing elements. All vehicles and construction equipment greater than 1,500 kg mass shall be kept more than 2.0 m away from the facing. Suitable compaction equipment of mass less than 1,500 kg may be used within 2.0 m of the facing

6604A WORKMANSHIP

(a) Facing Foundations

Facing foundations shall at all times be level or stepped in facing panel size benches to ensure subsequent panels are always placed level even if on sloping surfaces. Ground improvement or drainage works to be carried out prior to commencement, if specified in drawings or in Special Specifications or as instructed by the engineer and shall comply with SECTION 2100 AND 3800 of the standard specification.

(b) Unsuitable Founding Conditions

Where the bottom of the trench does not provide a suitably firm foundation for the MSE on account of soft, mucky or otherwise unsuitable material being encountered, the unsuitable material shall be excavated to a depth as may be indicated by the Engineer.

The Contractor shall excavate the unsuitable material to the depth indicated and shall replace it with gravel or other approved material properly compacted to provide a firm earth cushion.

The width of the excavation shall be as prescribed by the Engineer, or as indicated in the drawings.

Other special construction methods may be as shown on the Drawings, or as specified in the Special Specifications or as instructed by the engineer in specific cases.

(c) Classification of Excavation

All excavations for MSE walls shall be classified as provided in CLAUSE 3603 for payment purposes.

(d) Disposal of Excavated Material

Where excavated material does not comply with the requirements for backfilling material as per SERIES 6000 or is surplus to backfilling requirements, such excavated material shall be removed from the site and used for rehabilitation of borrow pits or at other places as directed by the Engineer.

Material suitable for use in the Works, however, shall be used as prescribed by the Engineer.

Payment for such material will be made as for excavation under ITEM 66.02, and also under the appropriate item for such part of the Works as may be constructed from such material.

No haulage will be paid for excavated material.

(e) Concrete Facings

Concrete quality shall be tested to ensure compliance with 28-day strength, oxygen permeability, water sorptivity and chloride conductivity as detailed in SECTION 7000 and/or as specified in Special Specifications.

(f) Concrete Blocks**i) Tolerances**

Blocks shall comply with category D2 of BS EN 771-3+A1:2016. The width of a block is the distance from the front face to the soil face and shall be as defined in BS EN 771-3+A1:2016. In some instances, the exposed face is often a textured face or else is a rough face created by splitting a double-width block, which may be outside the specified width. The location of any nibs or voids is critical and the method statement shall provide details of the specific blocks used and the associated operation sequence).

ii) Shear Strength

The shear strength between blocks and connection strength between block and reinforcing element shall be determined. Concrete block facings used in MSE walls shall be manufactured and tested according to BS EN 1992-1-1:2004 + A1:2014.

The test methods in ASTM D6916 AND ASTM D6638 for measuring block-to-block shear strength and block-to-soil reinforcement connection strength for blocks with plane-faced bedding material shall be used as and where required.

6605A MEASUREMENT AND PAYMENT

	<u>ITEM</u>	<u>UNIT</u>
A66.01	ESTABLISHMENT ON SITE FOR MECHANICALLY STABILIZED EARTH WALL	LUMP SUM

The unit of measurement shall be a lump sum. The tendered lump sum for MSE shall include full compensation for establishing all necessary plant and equipment on site to carry out the works and for the removal from site of all such plant and equipment including all temporary works such as access roads, staging, platforms and such like on completion of the works.

Work shall be paid as a lump sum, 50 % of which shall be due when all the equipment is on site, trials (if any) are completed and 25 % of the first production wall is installed to full height as specified. The second instalment of 25 % shall be payable after 50 % of the walls are installed and final 25 % instalment after the specified walls are installed, accepted and in service and all equipment is removed from site.

The tendered lump sum shall include full compensation for all post-construction requirements as specified. No extra payment shall be made for the establishment of additional plant should the established plant not be capable of achieving desired objectives.

	<u>ITEM</u>	<u>UNIT</u>
A66.02	EXCAVATION:	
(a)	EXCAVATING SOFT MATERIAL SITUATED WITHIN THE FOLLOWING DEPTH RANGES BELOW THE SURFACE LEVEL:	
(i)	UP TO 1.5 m	CUBIC METRE (m ³)
(ii)	Exceeding 1.5 m AND UP TO 3.0 m	CUBIC METRE (m ³)
(iii)	Exceeding 3.0 m AND UP TO ... (PER INCREMENT OF 1.5 m)	CUBIC METRE (m ³)
(b)	EXTRA OVER SUB-ITEM 28.02 (A) FOR EXCAVATION IN ROCK AS DEFINED IN CLAUSE 3603, IRRESPECTIVE OF DEPTH	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material excavated within the specified widths over the lengths and depths authorised by the Engineer in each case. Excavation in excess of the widths specified or authorised by the Engineer shall not be measured for payment.

The quantity of material within each depth range shall be measured and paid for separately.

When measuring excavation for the removal of existing culverts, the volume occupied by the culvert shall not be subtracted from the calculated volume of excavation.

In the case of manholes, catch pits and inlet and outlet structures, the dimensions for determining the volume of excavation shall be the neat outside dimensions of the structure, plus an allowance of 0.5 m of working space around the structure.

The bid rates shall include full compensation for all excavation, temporary timbering, shoring and strutting, for preparing the bottom of the excavation for the culvert beds, the disposal of excavated material unsuitable for backfilling, keeping excavations safe, dealing with any surface or subsurface water, and for any other operations necessary for completing the work as specified.

No haulage will be paid.

	<u>ITEM</u>	<u>UNIT</u>
A66.03	BACKFILLING:	
(a)	USING EXCAVATED MATERIAL	CUBIC METRE (m ³)
(b)	USING IMPORTED SELECTED MATERIAL	CUBIC METRE (m ³)
(c)	FILTER MATERIAL BEHIND MSE WALL	CUBIC METRE (m ³)

The unit of measurement shall be the cubic metre of material in place after compaction. The quantity shall be calculated from the leading dimensions of the backfilling as specified or as authorised by the Engineer.

If excavations were carried out in excess of the dimensions authorised by the Engineer, the quantity of backfilling will nevertheless be based on the authorised dimensions. The volume occupied by the culvert shall be subtracted when calculating the volume of backfilling.

The bid rates shall include full compensation for backfilling, for watering, and for compacting the backfill material to the specified density. The bid rate for SUB-ITEM A66.03 (b) shall, in addition, include full compensation for supplying selected material of subbase quality from approved sources, including a free haul determined according to SUB-CLAUSE 1602 (c) in the cases where haulage is paid for in accordance with the

Special Specifications.

The bid rate for SUB-ITEM 66.03 (c) shall be additional to the rates bid for SUB-ITEMS 66.03 (a) and (b) and shall include full compensation for all incidentals required for the complete backfilling with filter material behind the MSE Wall.

<u>ITEM</u>	<u>UNIT</u>
66.04 CAST IN SITU CONCRETE AND FORM WORK:	
(a) CONCRETE FOR WALL FOUNDATION INCLUDING FORMWORK, (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m ³)

The unit of measurement for cast in situ concrete shall be the cubic metre of concrete in place. Quantities shall be calculated from the dimensions shown on the Drawings or as authorised.

The bid rate for cast in situ concrete shall include full compensation for procuring and furnishing all the materials, storing the materials, providing all plant, mixing, transporting, placing and compacting the concrete, forming the inserts, construction of joints, curing and protecting the concrete, repairing defective surfaces, and finishing the concrete surfaces as specified. Payment shall distinguish between the different classes of concrete.

No separate payment shall be made for any formwork required for concreting and the Contractor's rates for concrete shall include full compensation for formwork

<u>ITEM</u>	<u>UNIT</u>
A66.05 STEEL REINFORCEMENT:	
(a) MILD STEEL BARS	TONNE (t)
(b) HIGH-TENSILE STEEL BARS	TONNE (t)

Measurement and payment for steel reinforcement shall be made as specified in SECTION 6300.

<u>ITEM</u>	<u>UNIT</u>
A66.06 PREPARATION OF SURFACE FOR LAYING STRIPS/ MESH	SQUARE METER (m ²)

The unit of measurement shall be the square metre of base surface prepared for the initial (first layer) strips or geo-synthetic only. Subsequent layer preparation costs are deemed to be included in the unit cost for backfill.

<u>ITEM</u>	<u>UNIT</u>
A66.07 SOIL REINFORCEMENT STRIPS/ MESH /SHEET (SPECIFY TYPE AND DIMENSION)	
(a) METALLIC REINFORCEMENT STRIPS (SPECIFY TYPE AND DIMENSION)	METER (m)
(b) METALLIC REINFORCEMENT MESH (SPECIFY TYPE AND DIMENSION)	SQUARE METER (m ²)
(c) POLYMER/ GEO-SYNTHETIC STRIPS REINFORCEMENT	METER (m)
(d) (SPECIFY TYPE AND DIMENSION)	
(e) POLYMER/ GEO-SYNTHETIC SHEET REINFORCEMENT	SQUARE METER
(f) (SPECIFY TYPE AND DIMENSION)	(m ²)

The unit of measurement for PAY-ITEMS A66.07 (a) AND A66.07 (c) shall be the metre of strips of required section installed.

The tendered rate shall include full compensation for the supplying of all the materials, labour, plant and equipment required for the operation.

The unit of measurement for PAY-ITEMS A66.07 (b) AND 66.07 (d) shall be the square metre of reinforcing sheet /mesh of required section installed.

The tendered rate shall include full compensation for the supplying of all the materials, labour, plant and equipment required for the operation.

<u>ITEM</u>	<u>UNIT</u>
A66.08 FACINGS (SPECIFY TYPE AND DIMENSION)	
(a) REINFORCED CONCRETE PANEL FACING (SPECIFY TYPE AND DIMENSION)	SQUARE METER (m ²)
(b) CONCRETE BLOCK WALL FACING (SPECIFY TYPE AND DIMENSION)	SQUARE METER (m ²)
(c) METALLIC FACING	SQUARE METER
(d) (SPECIFY TYPE AND DIMENSION)	(m ²)

The unit of measurement shall be the square metre of panel of the indicated size and thickness.

The tendered rate shall include full compensation for the manufacture, supply, labour, plant and equipment required for the installation as well as for the sealing of the panel to prevent material egress through panel joints.

SERIES 6000: STRUCTURES

SECTION 6700: STRUCTURAL STEELWORK

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6701 SCOPE

This Section covers the manufacture, transport, fabrication, erection and painting of structural steelwork, rivet steel, cast steel, steel forging, cast iron and other incidental metal construction of the kind, size and quantity in conformity with the drawings and these Specifications or as directed by the Engineer.

6702 MATERIALS

(a) Structural Steel

Unless otherwise permitted, all Structural steel shall comply with the following requirements:

- BS EN 10025 – 2: 2019: Non-Alloy Structural Steels
- BS EN 10025 – 3: 2019: Normalized/Normalized rolled weldable fine grain Structural Steels
- BS EN 10025 – 4: 2019: Thermomechanical rolled weldable fine grain Structural Steels
- BS EN 10025 – 5: 2019: Structural Steels with improved atmospheric corrosion resistance
- BS EN 10025 – 6: 2019: Conditions for flat products of high yield strength Structural Steels in the quenched and tempered condition

The use of structural steel not covered by the above standards may be permitted with the specific approval of the Engineer under the BS EN 10025 Family of codes of practices and other acceptable codes.

Following Table shows the Grade of Steel along with the values of Minimum Yield Strength:

TABLE 6702/1: MINIMUM YIELD STRENGTH (MPa)

Standard and Steel Grade	Nominal thickness of Plate (mm)			
	≤16	>16	>40	>63
S 235	235	225	215	215
S275	275	265	255	245
S355	355	345	335	325
S420	420	400	390	380
S460	460	440	430	410
S500	500	480	460	450

The dimensions and properties of ~~rolled~~ steel sections shall comply with the prescriptions given in the structural steel tables issued by the British Standards Institution or equivalent.

(b) Steel Tubes

Steel tubes shall comply with the requirements of BS EN 39:2001 or equivalent.

(c) Bolts, Nuts and Washers

Ordinary bolts and nuts shall be bolts and nuts used for transferring forces by tensile stress, compressive stress and shear stress without any friction-grip action being considered. Ordinary bolts and nuts shall comply with BS 3692:2014 OR BS 325:1947 or equivalent. Washers for ordinary bolts and nuts shall comply with the requirements of BS EN 2138:2000 (R 2017) or equivalent.

High-strength friction-grip bolts, nuts and washers shall comply with the requirements of BS EN 14399-1:2015 or equivalent.

Other approved friction-grip fasteners equal to the above may be used.

(d) Rivets

Mild-steel rivets shall comply with the requirements of BS A 341:1999 or equivalent. High-tensile rivets shall be so manufactured that they can be driven and their heads formed satisfactorily without the physical properties of the steel being impaired.

(e) Welding Consumables

Welding electrodes shall comply with the requirements of SANS 455 or equivalent.

The quality, handling and storage of all consumables shall be so as to achieve the desirable properties of the weld metal.

The welding consumables used shall be appropriate to produce weld metal which will yield all the weld-metal test specimens as specified in BS EN ISO 17639:2022, BS EN ISO 9016:2022, BS EN ISO 9015-1:2011, BS EN ISO 4136:2022, BS EN ISO 9018:2015 (R2020), BS EN ISO 9017:2018, BS EN ISO 9015-2:2016, BS EN ISO 5173+A1:2010, BS EN ISO 5178:2019 having both minimum yield and minimum tensile strengths not less than those of the parent metal.

(f) Test Certificates

The Contractor shall submit test certificates, as required by the Engineer, of the structural steel and anchor bolts that will be used.

6703 CODES OF PRACTICE

The design, where undertaken by the Contractor, of all work shall comply with the requirements of BS EN 1993:2006 PARTS 1 TO 6 or equivalent.

6704 SHOP DETAILS

Contractor shall prepare shop drawings from design drawings in accordance with CLAUSE 1220 to the satisfaction of the Engineer prior to fabrication of any item.

Shop details shall be approved and signed by the Engineer prior to the fabrication of any items.

6705 FABRICATION AND ASSEMBLY

(a) General

All structural steel both before and after fabrication shall be within the tolerances specified in SUB-CLAUSE 6803 (g) unless mentioned in TABLE 6707/1 and shall be flat, straight (unless required to be formed to another shape) and free from twists.

(b) Marking the Steel

At all stages of fabrication, all structural steel shall be clearly marked by grade by means of a suitable marking system.

(c) Cutting

Steel shall be cut by sawing, shearing with shears,

cropping, or flame-cutting.

Edges shall be free from any defects or distortions and all burrs, notches and similar defects shall be removed.

All structural welds shall be full-strength joints.

(d) Holes for Fasteners

Holes for fasteners shall not be formed by flame cutting. Holes in light members not thicker than 12 mm or the diameter of the hole, whichever is the smaller, may be punched.

Holes for fasteners of up to 25 mm in diameter shall not be more than 2 mm larger than the diameter of the fastener and holes for larger fasteners shall not be more than 3 mm larger than the diameter of the fastener.

Holes for friction-grip fasteners shall be in accordance with BS EN 1993-1-8:2024 or equivalent.

All burrs shall be removed from holes before assembly.

(e) Joints In Compression

The abutting surfaces of joints dependent on contact for the transmission of load shall be accurately prepared so that the full area intended for bearing will be in contact as specified in SUB-CLAUSE 6803 (g).

(f) Hollow Sections

Unless protection against corrosion is provided by other means, the interior of any hollow section shall be sealed to prevent the ingress of moisture. Where a sealed hollow member is holed for a fastener or pin, precautionary measures shall be taken to prevent the ingress of water to the interior of the member. Vent holes for galvanising shall be sealed after galvanising has been completed.

(g) Alignment of Holes

All matching holes for fasteners or pins shall be accurately aligned so that the fasteners can be inserted freely through the assembled members in a direction at right angles to the faces in contact. Drifting for aligning the holes shall not distort the metal or enlarge the holes.

(h) Welding

Welding shall be done in accordance with the requirements of BS EN 1011-1:2009.

The welding techniques shall be such as to avoid undue distortion and to minimise shrinking stresses.

All slag shall be removed.

Where required for certain welding:

- i. The manufacturer shall hold a valid welding-procedures certificate in accordance with BS EN ISO 15607:2019 or equivalent for Grade B welding joints, and the welding shall be done by a welder qualified in accordance with BS EN ISO 9606-1:2017 or equivalent; or
- ii. The welder shall hold a valid certificate of competency in accordance with BS 4872-1:1982 or equivalent for the specified type of welding.

(i) Bolting

The jointed parts shall be firmly drawn together. Where necessary, tapering washers shall be used for each bolt head and nut to transfer the compressive stress over its full surface. Where bolt holes have greater than normal clearance, washers shall be placed under the bolt heads and nuts.

The length of each bolt shall be such that, after tightening, at least one full thread projects through the nut on the outside and at least one full thread (in addition to the thread run-out) remains clear between the nut and the bolt head.

(j) Friction-Grip Fastening

The use of friction-grip bolts shall be in accordance with BS EN 1993-1-8:2024 (CORR: 2010) or equivalent. Where use is made of equivalent types of friction-grip fasteners, they shall comply with the requirements of BS EN 1993-1-8:2024 or equivalent for equivalent fasteners and shall be installed in accordance with the appropriate requirements of BS EN 1993-2:2006 or equivalent.

(k) Riveting

Wherever possible, riveting shall be done with pneumatic equipment.

Riveted units shall have all parts firmly drawn together and aligned before riveting. Every rivet shall, when driven, completely fill the hole and shall have a well-formed head or, if countersunk, fill the countersink completely.

All loose, eccentric-headed, badly formed, burnt or otherwise defective rivets shall be cut out and replaced.

(l) Trimming

All fabricated steel work shall be neatly trimmed so as not to show any sharp edges. Acute angles shall be rounded off to a radius of at least 1.0 mm.

(m) Corrosion Prevention

i) Painting

Before removal from the place of manufacture the steelwork shall be painted as specified in SECTION 6900.

Where the finishing coats are to be applied on the site, the shop painting shall include the application of an undercoat as specified in SECTION 6900.

Galvanised steel shall not be painted unless painting is specifically called for in the specifications.

ii) Sprayed Metal Coatings

Where the sprayed metal coating of steel surfaces is called for, it shall be done in accordance with the requirements of BS EN ISO 14713-1:2017, BS EN ISO 14713-3:2017, BS EN ISO 14713-2:2020 or equivalent. The type of metal used shall be as specified, and, unless otherwise specified, the metal coating shall comply with the requirements of Type Al 150 or Type Zn 150.

iii) Galvanising

Where the galvanising of structural steelwork is required, the members shall be hot-dip galvanised. Structural steel members shall be given an 85 µm coating or such other thickness as may be specified, in accordance with BS EN ISO 1461:2022 or equivalent and sheet steel and strip a Class M coating in accordance with BS EN 10346:2015 or equivalent.

All nuts, bolts, screws and threaded articles shall be hot-dipped galvanised in accordance with the appropriate requirements of BS EN ISO 1461:2022 or equivalent for Type C1 or Type C2 articles.

Cut ends and small damaged areas shall be repaired by the application of a zinc-rich paint or by zinc spraying.

(n) Built-Up Sections

In addition to the requirements of SECTION 6700, built-up sections shall be produced in accordance with Drawings and Special Specifications to the Engineer's approval.

6706 ERECTION

(a) General

These provisions shall apply to the erection of steel bridge superstructures or steel main members of bridge superstructures, which span between supports.

The Contractor shall erect the structural steel, remove the temporary construction and do all work required to complete the construction included in the contract, in accordance with the drawings and the specifications and to the entire satisfaction of the Engineer.

Erection over traffic is not permitted, and a temporary diversion for traffic shall be provided.

Provision for traffic accommodation will be paid for in accordance with the appropriate items under SECTION 1500.

(b) Safety During Erection

The Contractor shall submit erection plans showing the method and procedure of erection, compatible with the details of fabrication.

A detailed scheme shall be prepared showing stage-wise activities, with complete drawings and working instructions. This should be based on detailed stage-wise calculations taking into account specifications and capacity of erection equipment machinery, tools and tackles to be used and temporary working loads as per respective code provisions.

The scheme shall also take into account site conditions such as hydrology, rainfall, flood timings and intensity, soil and subsoil conditions in the riverbed and banks, maximum water depth, temperature and climatic conditions and available working space.

All components of the bridge shall be got checked for their adequacy to take care of temporary forces to which they are subjected during erection so as to ensure safety of the structure at all stages of erection.

The Contractor shall supply and erect all necessary falsework and staging and shall supply all labour, tools, erection plant and other materials necessary to carry out the work complete in all respects. Unless otherwise provided in the contract entire erection should be considered incidental to the structural steel work.

Prior to actual commencement of erection, all equipment, machinery, tools, tackles, ropes, etc. need to be tested to ensure their efficient working. Frequent visual inspection of vulnerable areas is essential to detect displacements, distress, damages, etc. Any unusual deviation or looseness of fittings, is to be noted and reviewed.

For welded structures, welders' qualifications and skills are to be checked as per standard norms. Non-destructive tests of joints are to be carried out as per designer's directives.

Safety requirements shall conform to relevant code provisions as applicable and all aspects of safety commensurate with economy and speed of construction, shall be considered.

Erection work should start with complete resources mobilized as per latest approved drawings and after a thorough survey of foundations and other related structural work. For works of large magnitude, mechanization is to be adopted to the maximum extent possible.

The structure should be divided into erectable modules as per the scheme. The module should be pre-assembled in a suitable yard/platform and its matching with members of the adjacent module checked by trial assembly before erection.

The structure shall be set out to the required lines and levels. The steelwork should be erected, adjusted and completed in the required position to the specified lines and levels with sufficient drifts and bolts. Packing materials shall be available to maintain this condition. Quality surveillance checks need to be carried out frequently.

Before starting work, the Contractor shall obtain necessary approval of the Engineer for the methodology/ procedure of erection, drawings of temporary works, use of erection equipment and the number and character of tools and plant. The approval of the Engineer shall not relieve the Contractor of his responsibility for the safety of his methodology and equipment or from carrying out the work fully in accordance with the drawings and specifications.

During execution, the Contractor shall have a competent engineer or foreman in charge of the work, who has adequate experience in steel erection and is acceptable to the Engineer.

(c) Handling and Storing of Materials

Suitable area for storage of structures and components shall be located near the site of work. The access road should be free from water logging during the working period and the storage area should be on firm levelled ground.

Rusted, bent or damaged steel shall be rejected. Methods of storage and handling steel, whether fabricated or not, shall be subject to the approval of the Engineer.

Fabricated materials are to be stored with erection marks visible. They should not come into contact with earth surface or water and should be accessible to handling equipment.

All materials, consumables, including raw steel or fabricated material shall be kept free from dirt and other foreign matter and shall be protected as far as possible from corrosion and distortion.

The Contractor shall be held responsible for loss or damage to any material paid for by the Employer while in his care or for any damage to such material resulting from his work.

(d) Formwork

The formwork shall be properly designed, substantially built and maintained for all anticipated loads. The Contractor shall submit plans for approval to the Engineer. Approval of the plans, however, shall not relieve the Contractor of his responsibility for adequacy and effective performance of the formwork

(e) Assembling Steel

The parts shall be accurately assembled as shown on the drawings and match marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged.

Hammering which will injure or distort the members shall not be done. Bearing surface or surfaces to be in permanent contact shall be cleaned, before the members are assembled. All joint surface for bolted connections including bolts, nuts, washers shall be free from scale, dirt, burrs, other foreign materials and defects that would prevent solid seating of parts.

(f) Alignment

Each part of a structure shall be aligned as soon as possible after erection. Members shall not be permanently connected until sufficiently large members of the structure have been aligned, plumbed, levelled, and temporarily secured to prevent their displacement during the erection or alignment of the remainder of the

structure.

(g) Corrections

Drift pins, jacking equipment and the like shall not be used for bringing improperly fabricated members into place. A moderate degree of cutting and reaming may be done to correct minor misfits if, in the opinion of the Engineer, this will not be detrimental to the appearance or strength of the structure. The burning of holes will not be permitted without written approval.

(h) Repairs to Painting and Site Painting

Repairs to painting and site painting shall be effected in accordance with the provisions of CLAUSE 6907.

(i) Grouting

The grout shall be poured under and around the base plates of columns after the steelwork has been finally checked for alignment and height, and after the approval of the Engineer has been obtained to proceed with the grouting. The column base plates shall be supported by the top and bottom nuts and by steel wedges. The area under the steel shall be thoroughly cleaned and shall be dust and oil-free, and the concrete shall be thoroughly rinsed with water to leave the surface clean and moist.

The grout shall be an approved non-shrinking, pourable, cementitious grout. The grout shall be prepared and applied strictly in accordance with the manufacturer's recommendations and the Engineer's directives.

Leak-proof formwork shall be used for the pourable grout, and all corners shall be chamfered. The surface finish shall be Class F2 and Class U2 as applicable.

(j) Field Inspection

No protective treatment shall be applied to the work until the appropriate inspection and testing have been carried out. The stage inspection shall be carried out for all operations so as to ensure correctness of fabrication and good quality. Girder dimensions and camber shall not be finally checked until all welding and heating operations are completed and the member has cooled to a uniform temperature.

6707 TESTING

(a) Testing

All structural steel connections shall comply with Eurocode 3 Part 1-8. and, all connections shall be inspected, tested and certified by a qualified expert/organization.

(b) Testing by the Engineer

The Engineer may nominate a testing authority to inspect the Works and to conduct such tests as they may deem to be necessary to test compliance with the specifications. Where required, test samples of welds shall be prepared by the Contractor, free of charge.

Payment for these tests shall be made under ITEM 71.01.

(c) Testing of Material

Structural steel shall be tested for mechanical and chemical properties as per appropriate Standards as may be applicable and shall conform to requirements specified in BS provisions or equivalent.

Rivets, bolts, nuts, washers, welding consumables, steel forging, casting and stainless steel shall be tested for mechanical and chemical properties in accordance with the appropriate British Standards or equivalent.

Rolling and cutting tolerance shall be as per British Standards or equivalent. Check for laminations in plates shall be carried out for areas specified by ultrasonic testing or any other specified method. Flame cut edges without visual signs of laminations need not be tested

unless otherwise specified by Engineer.

Steel work shall be inspected for surface defects and exposed edge laminations during fabrication and blast cleaning. Significant edge laminations found shall be reported to the Engineer for his decision. Chipping, grinding, machining or ultrasonic testing shall be used to determine the depth of imperfection.

(d) Testing of Connections

i) Bolted Connections

Bolts and bolted connection joints with high strength friction grip bolts, shall be inspected and tested according to British Standards or equivalent. Bolted connection joints with black bolts and high strength bolts shall be inspected and tested.

All Bolts and Bolt connection joints shall be inspected and tested in accordance with EUROCODE 3: PART 1-8.

ii) Riveted Connections

Rivets and riveted connections shall be inspected and tested for compliance of code requirements. The firmness of joint shall be checked by 0.2 mm filler gauge, which shall not go inside under the rivet head by more than 3 mm. There shall not be any gap between members to be riveted. Driven rivets shall be checked with a rivet testing hammer. When struck sharply on the head with the hammer, the rivet shall be free from movement and vibration.

Testing of flame cut and sheared edges is to be done, where the hardness criteria given in the code are adopted. Hardness testing shall be carried out on six specimens.

iii) Welded Connections

Welding procedure, welded connections and testing shall be in compliance with code requirements. Welders qualification test shall be carried out as per requirements laid down in British Standards or equivalent. For approved welding procedures, the approval tests shall be as per requirements of British Standards or equivalent. Welding procedure, connections and testing shall follow Eurocode 3: Part 1-8

All facilities necessary for stage inspection during welding and on completion shall be provided to the Engineer or his inspecting authority by the fabricator. Adequate means of identification either by identification mark or other record shall be provided to enable each weld to be traced to the welder(s) by whom its welding was carried out. All metal arc welding shall be in compliance with relevant code provisions.

(e) Test Procedure for Welds

The destructive and non-destructive test of weld shall be carried out according to relevant British Standards or equivalent.

i) Process Control

Welds shall be regularly inspected and tested by the Contractor in terms of their obligations in regard to process control, as described in CLAUSE 1205. This shall include visual inspection of welds to ensure that no undercutting, uneven lengths, porosity, or evidence of cracking occurs and that full fusion of the metals has been achieved. In doubtful areas, cores containing weld metal and adjacent parent material shall, if so required by the Engineer, be cut out, polished and examined and the hole repaired.

At least 30% of the welds shall be examined by ultrasonic or radiographic means. If more than 5% of the examined welds show unsatisfactory results, additional examinations covering all welds shall be

performed. Certificates of the examination confirming that the steel plates and welds comply with the requirements of SANS 044 PART III or equivalent shall be submitted to the Engineer.

The cost of testing shall be deemed to be included in the rate bid for ITEM 67.01 Structural steel.

ii) Non-Destructive Testing of Welds

The following methods shall be applied for inspection or testing of weld:

[1] Visual Inspection:

All welds shall be visually inspected, to cover all defects of weld such as size, porosity, crack in the weld or in the HAZ (Heat Affected Zone) etc. Suitable magnifying glass may be used for visual inspection. A weld shall be acceptable by visual inspection if it is seen that:

- The weld has no cracks;
- Thorough fusion exists between weld and base metal and between adjacent layers of weld metal;
- The weld is of full cross section, except for the ends of intermittent fillet welds outside their effective length; and
- The full penetration groove weld in butt joints transverse to the direction of computed tensile stress, shall have no piping porosity.

[2] Magnetic Particle and Radiographic Inspection:

Welds that are subject to radiographic or magnetic particle testing in addition to visual inspection, shall have no crack. Magnetic particle test shall be carried out according to relevant BS Standards or equivalent for detection of crack and other discontinuity in the weld.

Radiographic test shall be carried out for detection of internal flaws in the weld such as crack, piping porosity inclusion, lack of fusion, incomplete penetration, etc. This test may be carried out as per relevant BS Standards or equivalent.

[3] Ultrasonic Inspection:

Ultrasonic testing, in addition to visual inspection, shall be carried out for detection of internal flaws in the weld such as cracks, piping porosity inclusion, lack of fusion, incomplete penetration, etc. Acceptance criteria shall be as

per relevant BS Standards or equivalent, as agreed by the Engineer.

[4] Liquid Penetration Inspection:

The liquid penetrant test in addition to visual inspection, shall be carried out for detection of surface defects in the weld.

Non-destructive testing of the following welds shall be carried out using any of the methods described at [2], [3] and [4] above, as may be agreed to by the Engineer.

- a. All transverse butt welds in tension flanges
- b. 10 percent of the length of longitudinal and transverse butt welds in tension flanges.
- c. 5 percent of the length of longitudinal and transverse butt welds in compression flanges.
- d. All transverse butt welds in webs adjacent to tension flanges as specified by the Engineer.

The particular length of welds in webs to be tested shall be agreed with the Engineer, in case b or c.

iii) Testing of Stud/Channel Shear Connectors

Both Shear studs and Channel Connectors shall be fabricated in accordance BE EN 1994 or other relevant codes/manuals.

Stud shear connectors shall be subjected to the following tests:

- a. The fixing of studs after being welded in position shall be tested by striking the side of the head of the stud with a 2 kg hammer to the satisfaction of the Engineer.
- b. The selected stud head shall not show displacement of more than 0.25 times the height of the stud, from its original position, if struck once with a 6 kg hammer. The stud weld shall not show any sign of a crack or lack of fusion.
- c. Similar tests such as Ring and Bend tests are also required for channel connectors

The studs whose welds have failed the tests given in a. and b. shall be replaced.

(f) Inspection of Members

i) Inspection Requirement

The fabricated member/component made out of rolled and built-up section shall be checked for compliance of the tolerances given in TABLE 6701/1.

TABLE 6707/1: FABRICATION TOLERANCES - INDIVIDUAL COMPONENTS

1)	Length	
a)	Member with both ends finished for contact bearing	± 1 mm
b)	Individual components of members with end plate connection	+0 mm -2 mm
c)	Other members of length Up to and including 12 M Over 12 M	± 2 mm ± 3.5 mm
2)	Width	
a)	Width of built-up girders	± 3 mm
b)	Deviation in the width of members required to be inserted in other members	+ 0 mm - 3 mm
3)	Depth	
	Deviation in the depths of solid web and open web girders	+ 3 mm - 2 mm
4)	Straightness	
a)	Deviation from straightness of columns In elevation In plan	L/3000 subject to maximum of 15 mm Where L is length of member + 5 mm - 0 mm L/1000 subject to a maximum of 10 mm
5)	Deviation of centre line of web from centre line of flanges in built-up members at contact surface	3 mm
6)	Deviation from flatness of plate of webs of built-up members in a length equal to the depth of the members	0.005 d to a maximum of 2 mm where d is depth of the member
7)	Tilt of flange of plate girders	
a)	At splices and stiffeners, at supports, at the top flanges of plate girders and at bearings	0.005 b to a minimum of 2 mm where b is width of the member
b)	At other places	0.015 b to a maximum of 4 mm where b is width of the member
8)	Deviation from squareness of flange to web of columns and box girders	L/1000, where L is nominal length of the diagonal
9)	Deviation from squareness of fixed base plate (not machined) to axis of columns. This dimension shall be measured parallel to the longitudinal axis of the column at points where the outer surfaces of the column sections make contact with the base plate	D/500, where D is the distance from the column axis to the point under consideration on the base plate
10)	Deviation from squareness of machined ends to axes of columns	D/1000, where D is as defined in 9 above
11)	Deviation from squareness of machined ends to axes of beams	D/1000, where D is as defined in 9 above
12)	Ends of members abutting at joints through cleats or end plates, permissible deviation from squareness of ends	1/600 of depth of member subject to a maximum of 1.5 mm
Note: Fabrication tolerances shall comply with either of the following and with consent from the Engineer, Eurocode 3: Part 1-8, AASHTO or ASTM including other acceptable publications.		

Inspection of members/components for compliance with tolerances, and the check for deviations shall be made over the full length.

During checking, the inspection requirement shall be indicated in such a manner that local surface irregularities do not influence the results.

For the plate, out-of-plane deviation shall be checked at right angle to the surface over the full area of the plate.

The cross girder or cross frame deviation shall be checked over the middle third of its length between each pair of webs and at the end of member for cantilever.

The web of rolled beam or channel section shall be checked for out-of-plane deviation in a longitudinal direction over a length equal to the depth of the section.

During inspection, the component/member shall not have any load or external restraint.

ii) Inspection Stages

The stages of inspection to be carried out for compliance of tolerances shall include, but not be limited to, the following:

- For completed parts, component/members - on completion of fabrication and before any subsequent operation such as surface

preparation, painting, transportation, erection.

- For webs of plate and box girder, longitudinal compression flange stiffeners in box girders and orthotropic decks and all web stiffeners at site joints - on completion of site joint.

- For cross girders and frames, cantilevers in orthotropic decks and other parts in which deviations have apparently increased - on completion of site assembly.

Where, on checking member/component for out-of-plane or out-of-straightness at right angles to the plate surface, and any other instances, the deviation exceeds the tolerance, the maximum deviation shall be measured and recorded. The record shall be submitted to the Engineer who will determine whether the component/member may be accepted without rectification, accepted with rectification or rejected.

6708 MEASUREMENT AND PAYMENT

ITEM	UNIT
67.01 STRUCTURAL STEEL:	
(a) (STRUCTURE/ARTICLE DESCRIBED)	TONNE (t)
(b) (STRUCTURE/ARTICLE DESCRIBED)	METRE (m)

(c) (STRUCTURE/ARTICLE DESCRIBED) NUMBER (no.)

The unit of measurement shall be either the tonne or the metre of erected permanent steel structures or articles, or the number of erected permanent steel structures or articles. Where the unit of measurement is the tonne the weight of the steel waste caused by punching, drilling, sheared edges, milling or planing, or metal cut-outs shall not be deducted, and the weight of rivets, bolts, nuts, washers, welding fillets or temporary bracing shall not be added. In computing the weight of steel, the nominal weight per unit of length or area will be used and tolerances and other permissible deviations will be ignored.

The bid rates shall include full compensation for preparing shop details where not provided on the Drawings, the supply of all the required materials, fabrication, process control, loading, transporting to the site, off-loading, and erecting. It shall also include full compensation for all nuts, bolts, washers, rivets, cutting, waste, and any temporary bracing necessary for transporting and erecting.

The bid rate shall also include full compensation for supplying and pouring the specified grout under and around the base plates of steel columns, for procuring and supplying all the necessary labour, constructional plant, tools and materials, as well as waste, formwork for the grout, and finishing to obtain the required surface finish for the grout under and around base plates of steel columns.

<u>ITEM</u>	<u>UNIT</u>
67.02 ANCHOR BOLTS:	
(a) (DESCRIPTION OF EACH ASSEMBLY, AND GRADE/TYPE OF STEEL, DIAMETER AND LENGTH INDICATED)	KILOGRAM (kg)
(b) (DESCRIPTION OF EACH ASSEMBLY, AND GRADE/TYPE OF STEEL, DIAMETER AND LENGTH INDICATED)	NUMBER (no.)

The unit of measurement shall be either the kilogram of installed anchor-bolt assemblies or the number of installed anchor-bolt assemblies.

The bid rates shall include full compensation for the materials, fabrication, handling, transporting and installing the anchor-bolt assemblies, including corrosion protection.

<u>ITEM</u>	<u>UNIT</u>
67.03 CORROSION PROTECTION:	
(a) SPRAYED-ON METAL:	
(i) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF COATING INDICATED)	TONNE (t)
(ii) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF COATING INDICATED)	METRE (m)
(iii) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF COATING INDICATED)	NUMBER (no.)
(b) HOT-DIP GALVANISING:	
(i) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF ZINC COAT INDICATED)	TONNE (t)
(ii) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF ZINC COAT INDICATED)	METRE (m)
(iii) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF ZINC COAT INDICATED)	NUMBER (no.)

The unit of measurement shall be either a tonne or a metre of steel structures or articles protected against corrosion, or the number of steel structures or articles protected against corrosion. The quantities are calculated as specified in ITEM 67.01.

The bid rates shall be extra over the rates for ITEM 67.01 and shall include full compensation for applying the specified corrosion protection, including surface preparation, materials, labour, tools, equipment and all incidentals required.

Note:

Payment for painting shall be made under Item 69.01.

SERIES 6000: STRUCTURES

SECTION 6800: CONSTRUCTION TOLERANCES FOR STRUCTURES

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6801 SCOPE

This Section covers the requirements in regard to the construction tolerances applicable to the various structures and structural members.

6802 DEFINITIONS

Except where otherwise specified, the following aspects of construction to which tolerances apply shall have the meanings attributed to them below:

(a) Position

The position of a structure or structural member shall be the horizontal position of its centre line(s) and/or centre point(s) in relation to the overall layout of the Works as shown on the Drawings.

(b) Alignment

The alignment of a structure or structural member shall be the alignment of its centre line(s) in relation to the overall layout of the Works as shown on the Drawings. Deviation from true alignment shall be measured in degrees of an arc.

(c) Leading and Cross-Sectional Dimensions

The leading and cross-sectional dimensions of a structure or structural member shall be the dimensions relating to width, length, height, thickness, etc., which collectively determine its shape, and are shown on the Drawings. Dimensional tolerances not relating to leading or cross-sectional dimensions shall be shown on the Drawings.

(d) Levels

The level of any structure or structural member shall be the level of the upper or lower surface, as may be relevant, with reference to an established datum level on the site.

(e) Surface Regularity

Surface regularity is the shape of a surface with reference to a 3 m straight-edge (or template in the case of curved surfaces) placed on the surface.

The tolerance for surface regularity is expressed as a distance by which the surface tested may deviate from a straight-edge (or template in the case of curved surfaces) held against the surface.

6803 TOLERANCES

The tolerances given below shall be the maximum permissible deviations from the specified dimensions, levels, alignment, positions, etc., shown on the Drawings of the structures or structural members.

(a) Foundations, Footings, Pile Capping Slabs,

Columns, Walls, Piers, Abutments, Bridge and Culvert Superstructures

The tolerances are given in TABLES 6803/1, 6803/2, 6803/3, 6803/4 AND 6803/5.

TABLE 6803/1: TOLERANCES OF PILE FOUNDATIONS

Position:	
0.167 times the diameter of the pile, or 100 mm, whichever shall be the greater	
External dimensions:	
Prefabricated piles	+25 mm -5 mm
Cast in situ piles	plus-tolerance not specified, minus-tolerance 0 mm
Pile-head level:	Average level of trimmed cut pile head ± 25 mm
Verticality or rake	1.5°
Straightness:	
For precast piles the permissible maximum deviation from straight is 5 mm for piles up to 3 m in length and 1.0 mm more for each additional metre of pile length.	

TABLE 6803/2: TOLERANCES OF CAISSONS

Position of top of caisson:	
10% of the smallest outer dimension of the caisson, measured in plan.	
Verticality:	
1.5°	
Dimensions:	
Wall thickness	+25 mm -5 mm
Outer dimension of circular, rectangular or square cross-section	± 25 mm
Level: Upper level of trimmed/cut caisson head:	
Maximum deviation of average level	± 25 mm
Maximum deviation of any individual level	± 50 mm
Foundation fill:	
Average level of top of fill	± 25 mm

TABLE 6803/3: TOLERANCES OF FOOTINGS, PILE CAPPINGS, CAISSON COVER SLABS ETC.

Position:	
15 mm	
Alignment:	
Individual members	5°
Members as they collectively determine the alignment of the structure as a whole	1 minute
Dimensions:	
Leading dimensions in plan	± 25 mm
Thickness	+25 mm -15 mm
Levels:	
Average level of slabs, footings, etc.	± 25 mm

TABLE 6803/4: TOLERANCES OF COLUMNS, WALLS, PIERS, ABUTMENTS, ETC.

Position:	
10 mm	
Alignment:	
Walls, piers, abutments and column groups	2 minutes
Dimensions:	
Leading dimensions of walls, piers and abutments	±25 mm
Thickness of walls, piers and abutments and cross-sectional dimensions of columns:	
Plus-tolerance	25 mm
Minus-tolerance	3% of the specified dimensions within the range of 5 mm to 25 mm
Levels:	
Levels: Average level of finished or trimmed/cut columns, piers, walls, abutments, etc.	±10 mm
Verticality:	
Using ordinary formwork	1 in 400. Maximum 25 mm
Using sliding formwork	1 in 200. Maximum 50 mm
Surface regularity:	
Using ordinary formwork	3 mm
Using sliding formwork 1 in 200.	6 mm

TABLE 6803/5: TOLERANCES OF BRIDGE AND CULVERT SUPERSTRUCTURES

Position:	
10 mm	
Alignment:	
Superstructure as a whole	1 minute
Dimensions:	
Leading dimensions in plan	±25 mm
Thickness of slabs, width and depth of beams:	
Plus tolerance	15 mm
Minus tolerance	3% of the specified dimensions within the range of 5 mm to 15 mm
Surface regularity:	
All surfaces other than upper surface of deck	3 mm
Bridge and culvert decks, surface tolerances:	
The tolerances specified in CLAUSE 3405 for the base in respect of level, grade, cross-section and surface regularity shall apply. Surface regularity shall be tested by a straight-edge.	

(b) Precast Beams

The following tolerances shall apply to precast beams in addition to the requirements stated in SUB-CLAUSE 6803 (d) for the superstructure.

The width of the gap between contiguous beams shall not exceed twice the width of the specified nominal gap shown on the Drawings or the width of the nominal gap plus 40 mm, whichever is the less, and the overall width between the outermost beams of the bridge deck shall be within 40 mm of the specified width.

STRAIGHTNESS OR BOW: The deviation from the prescribed line measured on the overall length of the beam shall not exceed the following:

i) In the Horizontal Plane:

0.5 mm per metre length of the beam within the tolerance range of 6 mm to 15 mm.

ii) In the Vertical Plane:

- I-beams: 2 mm per metre length of the beam within the tolerance range of 6 mm to 20 mm.
- Other beams: 1.0 mm per metre length of the beam within the tolerance range of 3 mm to 20 mm.

CAMBER: The soffits of adjacent beams when placed side by side on the bridge deck shall not at any place differ by more than 2 mm per metre length of the beam within the tolerance range of 6 mm to 20 mm.

THE LENGTHS OF PRECAST BEAMS: Before stressing, the length shall be $\pm 0.1\%$ of the total length within the tolerance range of ± 5 mm to 20 mm.

SURFACE REGULARITY: 6 mm

(c) Reinforcing Steel

Except for the requirements given below, no tolerances are given for the placing and fixing of reinforcing steel. The steel, however, shall be neatly and accurately fixed in a manner which is consistent with proper workmanship and the structural integrity of the structural member. Specifically the following requirements shall apply:

i) Tension Steel

The actual position of tension steel shall not deviate from the true position by a distance which would reduce the effective lever arm by more than 2% of the overall depth of the member, or 10 mm, whichever is the greater.

ii) Concrete Cover

The concrete cover on reinforcing steel shall nowhere be less than the specified cover.

iii) Spacing Between Bars

The spacing between closely spaced parallel bars, especially in beams and columns, shall, unless otherwise specified, be not less than the maximum size of the aggregate used in the concrete.

iv) Bending of Reinforcement

The requirements of BS 8666:2020 or equivalent regarding dimensional tolerances for cutting and bending of the reinforcing steel shall apply, with the proviso that the other requirements set out in this Clause shall be complied with even if the tolerances in BS 8666:2020 or equivalent are not exceeded.

(d) Pre-Stressing

Sheaths for pre-stressing tendons shall be placed and maintained in position within the following tolerances:

i) In the Direction of the Width of the Member:

For members of up to 200 mm in depth: ± 20 mm

For members exceeding 200 mm in depth: ± 10 mm

ii) In the Direction of the Depth of the Member:

For members of up to 200 mm in depth: $\pm 0.025 \times \text{depth}$

For members exceeding 200 mm in depth: $\pm 0.01 \times \text{depth}$ within the tolerance range of ± 5 mm to ± 25 mm.

(e) Bearings

Bearings for structures shall be installed to within 5 mm of the position shown on the Drawings and to within 2 mm of the required level.

Dimensional tolerances for elastomeric bearings shall comply with the requirements of BS EN 1337-3:2006.

(f) Miscellaneous**i) Chamfers**

Fillets used for forming chamfers shall be within a tolerance of 1.0 mm in cross-sectional dimensions, and the actual chamfer on the concrete shall not vary by more than 3 mm from the specified dimensions.

ii) Kerbs, Copings, Sidewalks, Bridge Railings, Parapets, etc.

The members shall be constructed within a tolerance of ± 5 mm for all dimensions. The alignment shall not deviate from the true alignment by more than 10 mm in any place, nor shall the alignment deviate by more than 5 mm from the true alignment over any length of 5 m.

(g) Fabrication and Assembly Tolerances for Structural Steel**i) General**

The fabrication and assembly tolerances on all dimensions for structural steel shall be ± 2 mm. Holes for connections shall be drilled/punched and aligned as specified in SUB-CLAUSES 6705 (d) AND (g) respectively.

ii) Cross-Section

The tolerances on cross-sectional dimensions of rolled sections shall be as specified in the Design Tables according to Eurocode 3 or equivalent.

iii) Straightness

A structural member before erection shall not deviate from straightness (or the specified shape) by more than the following:

For compression members and beams, one-thousandth of the length between points which are laterally restrained. For other members, one five hundredth of the overall length, but not exceeding 25 mm.

iv) Length

The length of a member shall not deviate from its prescribed length by more than the following:

For compression members faced at both ends for bearing, ± 1.0 mm

For other members: +0 mm and -4 mm

For such members as trusses and lattice girders, the above tolerances shall apply to the members as a whole. The lengths of component parts shall be such that the structural member can be properly assembled with the required accuracy.

v) Bearing Surfaces

Where two steel surfaces are required to be in contact for transferring compressive forces, the maximum clearance between the bearing surfaces shall not exceed 1.0 mm when the members in contact are aligned.

vi) Accuracy of Erection

Steelwork shall not be out of plumb over any vertical distance by more than 5 mm or one thousandth of the distance, whichever is the greater.

(h) Fabricating and Construction Tolerances for Reinforced-Earth Structures**i) Individual Concrete Panels:**

Surface regularity:

- When tested with a 1.5 m straight-edge, the deviation shall not exceed 5mm.
- Leading dimensions ± 5 mm

ii) Completed Walls:

Surface regularity:

- When tested with a 3 m straight-edge, the deviation shall not exceed 20 mm.
- No point of the structure shall be out of position vertically by more than 10 mm per metre height of the structure, with a maximum of 50 mm.

6804 MEASUREMENT AND PAYMENT

No separate measurement and payment shall be made to the Contractor for complying with the requirements of this Section.

SERIES 6000: STRUCTURES

SECTION 6900: PAINTING

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6901 SCOPE

This Section covers the painting of structural steel, guard rails, overhead road sign supports and other structures according to the requirements of the various Sections of these Specifications where painting is called for. It does not include the treatment of timber posts which are included under SUB-CLAUSE 5202 (b).

6902 MATERIAL

Paints shall comply with the requirements of the following Specifications:

(a) Primers

- [1] **Zinc-Chromate Primers for Steel:**
BS 4652:1995 or equivalent
- [2] **Wash Primer (Metal Etch Primer):**
SANS 723 or equivalent
- [3] **Calcium-Plumbate Primer:**
BS 3698:1964 or equivalent
- [4] **Two-Pack Zinc-Rich Epoxy Primer:**
SANS 926 or equivalent

(b) Undercoat

BS 7664:2000 or equivalent

(c) Finishing Coats

- i. Decorative enamel for interior and exterior:
SANS 630 or equivalent
- ii. High-gloss paint:
684 (Type A) or equivalent
- iii. Micaceous iron-ore-pigmented paint:
SANS 684 or equivalent
- iv. Baking enamels:
SANS 783 or equivalent
- v. Emulsion paint for exterior use (polyacrylic):
SANS 634 or equivalent
- vi. Chloro-rubber paint:
SABS 1413 or equivalent
- vii. Bituminous aluminium paint:
SANS 802 or equivalent

(d) Other

- i. Epoxy-tar paints:
SANS 801 (Type I) or equivalent
- ii. Bonding liquid for concrete surfaces:
CKS 564 or equivalent
- iii. Bituminous-emulsion paint shall consist of a stable bituminous emulsion as specified in SECTION 4200 and about 5% of approved fibre.

6903 GENERAL

All painting works shall comply with all applicable codes such as AISC, EN, BS, AASHTO, ASTM and any other.

All paint shall be obtained only from suppliers approved by the Engineer. Unless otherwise agreed by the Engineer, all paints forming part of any one paint system shall be obtained from the same source. Paints shall be supplied in sealed containers of not more than 5 litres capacity and shall be used in strict rotation. Unless otherwise agreed by the Engineer samples of paint of not less than 2 litres capacity shall be submitted for testing to the Engineer or his nominated testing authority.

Paint shall be stored on site under cover and in conditions as recommended by the manufacturers.

Paint shall be stored in such a manner that each batch can be issued for use in the order of delivery.

A separate store shall be provided for cleaning solvents used for brush or other cleaning purposes. Cleaning solvents shall not be stored where paint or paint thinners are stored or where paint is prepared for application.

Paints with a limited safe shelf life shall not be used after the period stated in the manufacturer's data sheets.

Inflammable material shall be stored in accordance with the appropriate regulations.

Flat and gloss paints shall not be boxed up together and skinned ullages shall be discarded.

No paint shall be applied to surfaces containing physically adhering contaminants such as oil, grease, dirt, marking material, water-soluble salts, wax, paint and temporary protectives, or to surfaces containing chemically bonded contaminants such as rust, mill scale, slag and flux.

All surfaces which are to be painted shall be dry. Unless otherwise stated, subsequent coats of paint shall be applied over dry paint surfaces.

All traces of soluble salts and corrosive airborne contaminants shall be thoroughly washed from the surface prior to painting, and the surface shall be dried and painted immediately afterwards.

Where surfaces are to be welded, unless otherwise specified, no paint shall be applied within 75 mm of the weld position.

After the welding has been completed, the welds and adjacent parent metal shall be completely deslagged, and the surfaces shall then be inspected and approved by the Engineer. All spatter shall be removed prior to the surfaces being painted. The weld area shall be abrasive-blasted and/or ground and all contaminants such as flux shall be removed prior to the surface being painted.

Surfaces which are to rest on concrete or other floors shall receive all the prescribed coats of paint prior to the member being erected.

Damaged paint areas shall be cleaned, rust spots removed and the surface primed again so that the patch painting covers the damaged areas and extends over a strip of 20 mm beyond each damaged area.

Where the shop coat is allowed to age for a few months

before the next layer of paint is applied, light sanding with sandpaper or rubbing with steel wool and scrubbing with clean water with a bristle brush shall be carried out.

Steel to be embedded in concrete shall be entirely painted to a distance of 50 mm within the concrete, measured from the concrete outer surface.

All epoxy coating shall be carried out by a specialist firm or contractor approved by the Engineer. With its quotation the specialist firm shall be required to submit a letter of guarantee that the product it proposes to supply when applied in accordance with this specification and any additional specifications which shall be quoted by the firm will withstand the environmental service conditions to be encountered. The Contractor shall quote the guarantee period in number of years from time of application of the coating.

The paint manufacturer's instructions shall be strictly adhered to.

Painted steel members shall be stacked so as to be off the ground.

Friction-grip surfaces shall not be painted but shall be treated in accordance with the Special Specifications.

Implementation of the manufacturer's recommendations concerning health and safety aspects of paints approved by the Engineer for use on the works shall be mandatory under this contract.

6904 APPLYING THE PAINT

Unless otherwise specified, paint may be applied either by brush, spray or roller method, or by any combination of these three methods.

Where brushes are used, they shall have sufficient body and length of bristle for spreading the paint in a uniform coat. Paint shall be evenly spread and thoroughly brushed out. If brush marks are visible, it will be considered that the paint has been improperly applied, and the paint will not be accepted.

On all surfaces which are inaccessible to painting by regular painting equipment, the paint shall be applied by bottle brushes, sheepskin daubers, or by any other acceptable method so as to render the required coating of paint.

If spray methods are used, the operator shall be thoroughly experienced. Runs, sags, thin areas in the paint coat, skips, or where air bubbles have formed or the paint has delaminated, shall be considered as being unsatisfactory, and the Contractor will be required to repaint the surface by brush.

A water trap and an air-regulating valve acceptable to the Engineer shall be furnished and installed on the equipment used for spray-painting.

Mechanical mixers shall be used for mixing paint properly when no ready-mixed paints are used. Prior to application, the paint shall be remixed for a sufficient length of time to mix the pigment and vehicle thoroughly. Paint shall be constantly kept well stirred to keep the pigments in suspension during its application. All skins in the paint shall be removed by screening. If it cannot be removed effectively, the paint and paintwork already completed may be condemned at the discretion of the Engineer.

No thinners or cleaners shall be employed other than those recommended by the paint manufacturer and to the Engineer's approval.

Paint shall not be applied when the temperature of the surface to be painted is less than 3°C above dew point or when the temperature of the steel is below 5°C or above 35°C, unless otherwise prescribed by the Engineer.

Paint shall not be applied in fog or mist, when it is raining or when rain is expected, or when the relative humidity is above 90%.

6905 PROTECTING THE WORKS DURING PAINTING OPERATIONS

All necessary precautions shall be taken by the Contractor before the commencement of any painting activities to ensure that no damage or disfigurement of any kind is caused thereby to any part of the works. If in the opinion of the Engineer the precautions taken are inadequate the Contractor shall at their own expense make all such improvements as the Engineer directs.

The Contractor shall protect all parts of the structure against disfigurement by splatters, splashes and/or smirches of paint or of paint materials. The Contractor shall be responsible for any damage to or paint on or contamination to vehicles, persons or property, including plants and animals, as a result of their operations, and they will be required to provide protective measures at their own cost to prevent such damage.

Any unsightly paint stains shall be removed by the Contractor at their own cost.

If passing traffic creates sufficient dust to harm or spoil the appearance of painted surfaces, the Contractor shall sprinkle the adjacent roads and shoulders with water at their own cost, for a sufficient distance on each side of the location where the painting is being done, to keep the dust away from freshly painted surfaces. The Contractor shall at their own cost, also furnish and post DRIVE SLOWLY signs and take other necessary precautions to prevent dust and dirt from adhering to freshly painted surfaces.

6906 PREPARING SURFACES FOR PAINTING

The Contractor shall regard the preparation of surfaces to be painted as a work of fundamental importance the object of which is to ensure the production of sound, clean, smooth and dry surfaces. The preparation shall have no detrimental effect on the sub-strata to be painted nor shall it be prejudicial to subsequent painting operations.

In addition to the specific processes described below and/or in the manufacturer's instructions and specifications all surfaces shall be cleaned free from all dirt, grease, oil or other deleterious matter both before the application of primer and between subsequent successive coats of paint.

All surfaces prepared and made ready for painting shall be to a standard approved by the Engineer before painting work is begun.

6907 PAINTING STRUCTURAL STEEL

(a) General

This Section includes the painting of structural steel, steel guardrail posts, steel road sign supports and steel sign face frames, where required.

The surface preparation, priming and application of an undercoat shall be carried out under cover at the fabricator's works. Where possible, all painting shall be done at the fabricator's works but, where this is not feasible, the Engineer may permit the application of the finishing coats on the site, in which case an undercoat shall be applied at the fabricator's works prior to the members being despatched to the Works.

Unless otherwise specified, the protection described in SUB-CLAUSES 6907 (c), (d) AND (e) shall be applied to all steelwork. Corrosion protection of steelwork exposed to aggressive or severe conditions shall comply with the requirements of the Special Specifications. In absence of any details provided in drawings or special specifications

guidelines mentioned in the TABLE 6907/1 can be adopted for protective coatings:

TABLE: 6907/1: GUIDELINES FOR SELECTION OF TYPES OF PROTECTIVE COATINGS

	Type of Coating	Exposure Condition
i.	Wire brush to remove all loose rust and scale; 2 coats drying oil type primer, and 1 undercoat alkyd type paint; 1 finishing coat alkyd type. Total dry thickness = 150 µm	Structure in dry or permanently wet condition; low humidity (Relative humidity<50%; humid (Relative humidity>70%)
ii.	Wire brush to remove all loose rust and scale; 2 coats drying oil type primer; 2 under coats micaceous iron oxide (MXO) pigmented phenolic modified drying oil. Total dry film thickness = 170 µm (life up to 5 years)	Polluted inland environment
iii.	Blast clean the surface; 2 coats of quick drying primer; undercoat alkyd type paint; 1 finishing coat alkyd type. Total dry film thickness : 130 — 150 µm	Structure in dry or permanently wet condition; low humidity (Relative humidity<50%; humid (Relative humidity>70%)
iv.	Blast clean the surface; 2 coats of drying type oil primer; 1 undercoat micaceous iron oxide pigmented drying oil type paint. Total dry film thickness : 165-190 µm	Polluted inland environments
v.	Blast clean the surface; 2 coats of metallic lead pigmented chlorinated rubber primer, 1 undercoat of high build chlorinated rubber primer, 1 undercoat of high build chlorinated rubber; 1 finishing coat of chlorinated rubber. Total dry film thickness : 200 µm	Severe coastal and non-coastal interior situations
vi.	Blast clean the surface; 350 — 450 µm thickness coal tar epoxy.	Wet, rarely dry; moderate humidity (Relative humidity≥50% and≤70%)
vii.	Pickle; hot dip galvanised (Zinc). Total thickness : 85 µm (life up to 15-20 years)	Structure in dry or permanently wet condition; low humidity (Relative humidity<50%; humid (Relative humidity>70%)
viii.	Grit blast, hot dip galvanised. (Zinc). Total thickness = 140 µm (life more than 20 years)	Structure in dry or permanently wet condition; low humidity (Relative humidity<50%; humid (Relative humidity>70%)
ix.	Grit blast; 1 coat of sprayed zinc/aluminium followed by suitable sealer Total thickness = 150 µm (life up to 15-20 years)	Wet, rarely dry; moderate humidity (Relative humidity≥50% and≤70%)

(b) Surface Preparation

[1] New Structures

After all cutting, drilling, welding and punching have been completed, it shall be ascertained that all sharp edges have been uniformly rounded off and smoothed down. All physically adhering contaminants shall be removed and the surface shall then be abrasive-blasted to Sa 2½ finish in accordance with the BS EN ISO 8501-1:2007,—"second quality" or equivalent. The profile limit of the surface finish shall be between 30 µm and 60 µm. The abrasive-blasting profile shall be measured in accordance with BS EN ISO 8503-3:2012 or equivalent and shall comply with BS EN ISO 8503-1:2012, or equivalent.

No abrasive-blasting shall be done during rainy weather or when corrosive air conditions prevail.

Unless the application of a primer follows within four hours of abrasive blasting and before any oxidation of the prepared surface takes place, the abrasive-blasted surface shall immediately after abrasive blasting be given one coat of a wash primer.

[2] Existing Structures

The surface preparation of existing structures shall be carried out on site in accordance with BS EN ISO 8504-1:2019, or equivalent.

(c) Primer

The prepared surface shall be given two coats of a zinc-chromate primer in accordance with BS 4652:1995 or equivalent. The first coat shall be applied within 12 hours in the case of wash-primed surfaces and within four hours, but before any oxidation of the surface takes

place, in the case of abrasive-blasted surfaces that have not been wash-primed. A fast-drying zinc chromate in accordance with BS 4652:1995 or equivalent, may be used as a primer. In all cases the dry-film thickness shall not be less than 30 µm per coat.

When steel has to be welded after the primer has been applied, the steel shall be left unpainted for a distance of 75 mm from the weld joint unless a weldable type of paint has been used. The welds shall be treated in accordance with the instructions of CLAUSES 6903 AND 6907.

(d) Undercoat

Where the finishing coats are to be applied on the site, the primed surfaces shall be given one coat of a universal undercoat with a suitable colour in the fabricator's shop before despatch. The undercoat shall be applied as soon as the prime coat has dried sufficiently. The dry-film thickness shall not be less than 25 µm.

(e) Finishing Coat

Two finishing coats of high-gloss structural paint (BS EN ISO 12944-5:2019 or equivalent) of the specified colour shall be applied to leave a dry-film thickness of not less than 25 µm per coat.

Where the finishing coats are applied on the site, the undercoat shall be lightly sanded and the members washed and cleaned of all contaminants. The first finishing coat shall be applied as soon as the structural members are dry.

Where specified in the Special Specifications, the second finishing coat shall consist of a micaceous iron-ore-pigmented structural paint of the specified colour to a dry-film thickness of not less than 30 µm. Unless otherwise specified, the second finishing coat shall be

applied within 48 hours of the application of the first finishing coat.

The dry-film thickness of the total paint system shall not be less than 110 µm when no undercoat is used and not less than 135 µm when an undercoat is used. Where the second finishing coat is an iron-ore-pigmented paint, these thicknesses shall be increased by 5 µm.

(f) Mating Surfaces

When mating surfaces are brought together, both surfaces shall already have been covered with all the specified coats of paint, but, where this is impossible, each surface shall be given a copious coating of primer and the surfaces drawn up while the paint is still wet.

(g) Back-to-Back Members and Areas not Easily Accessible

Back-to-back members and areas not easily accessible shall be fully coated with all the specified coats of paint up to and including the finishing coats before erection.

(h) Damaged Areas

Damaged areas shall be treated as follows:

Sand down to bright metal and clean. Spot prime with two coats and sand down lightly when hard. Rinse off with water and allow to dry. Apply two finishing coats.

(i) Structural Steel to be Embedded Below Ground

Those parts of structural-steel members to be embedded in soil and all bases to a height of 500 mm shall be given two coats of an epoxy-tar prime instead of the zinc-chromate prime specified for other surfaces.

(j) Epoxy Coating Work Generally

In addition to the general requirements of this specification the following conditions shall apply wherever epoxy coating work is being carried out:

- i. The work shall be illuminated to the satisfaction of the Engineer.
- ii. Forced draught ventilation to the approval of the Engineer shall be used wherever required for the needs of personnel or for drying out surfaces.
- iii. Operatives shall work in pairs.

The Contractor shall demonstrate all his methods, equipment and materials before any work commences. Sample areas of substrate shall be prepared and coated as required by the Engineer and for his approval.

There shall be strict control of surface cleanliness between primer and epoxy coating and between coats of the same. Vacuum removal of dust and sand shall be employed and contamination shall be removed as specified in appropriate preparation clauses herein. Where dirt or dust has become trapped in the painted surface it shall be removed with suitable abrasive paper. The surface being painted shall be free of visible moisture throughout these operations.

The paint shall be applied only to clean dry primed or previously coated surfaces. Any thick runs or collections of paint shall be removed before they harden.

Not less than two coats shall be applied over the primer by airless spray; not less than 3 by brush.

Each coat shall be distinctly different in colour from the primer or previous coat. The colour of the final coat shall be as required by the Engineer.

Each coat shall be seen to have completely covered the preceding coat without "misses" or pinholes or any areas visibly low in thickness. A high voltage pin-hole detector shall also be used to determine the integrity of the coats.

The coat manufacturer shall stipulate primer and epoxy recoat intervals for all curing temperatures likely to be

encountered and these shall be adopted with a maximum tolerance of +4 hours. Where this is exceeded, the surfaces to be recoated shall first be suitably abraded to remove gloss and give a good key.

6908 PAINTING GUARD RAILS

(a) General

This Section covers the painting of guardrails, should it be prescribed. The painting of steel guardrail posts is covered in SUB-CLAUSE 6907 and the treatment of timber guardrail posts is covered in SUB-CLAUSE 5202 (b).

(b) Surface Preparation and Priming

All dirt, loose mill scale and loose corrosion products shall be removed by hand or power tools and all rust and mill scale by pickling, after which the surface shall be rinsed. A neutralising rinse shall also be applied, or the surface shall be phosphated.

(c) Priming

Apply two coats of zinc-chromate primer to a dry-film thickness of not less than 20 µm per coat.

After the prime coats have hardened, the guard rails may be transported to the site.

(d) Storage on the Site

The primed guardrails shall be stored off the ground under cover and protected against rain and weather until erection. Guardrails shall be stacked individually and not nested so as to prevent corrosion during storage. The finishing coats shall be applied as soon as possible and the primed surfaces shall not be allowed to corrode as a result of prolonged exposure to the weather. Any guardrails showing signs of rust before the application of the finishing coats shall be rubbed down with steel wool or fine sandpaper until all rust is removed, and it shall then be recoated with a zinc-chromate primer.

(e) Finishing

Before the first finishing coat is applied, the guard rails shall be thoroughly washed down to remove all traces of salt and/or other air-borne corrosive materials and all dirt or other contaminants.

As soon as the rinsed guard rails are dry, a finishing coat of aluminium paint or a white high-gloss enamel in accordance with BS 7664:2000 or equivalent shall be applied to a dry-film thickness of not less than 25 µm. Within 48 hours this shall be followed by a second coat as described before.

The guard rails shall preferably be given both finishing coats before erection, but, where this is impossible, the Engineer may permit the finishing coats to be applied after the guard rails have been erected, provided that all mating surfaces and spots which are not easily accessible are painted with the finishing coats before the guard rails are erected.

The total dry-film thickness of all coats of the paint shall not be less than 90 µm. All damaged spots shall be treated as specified in SUB-CLAUSE 6907 (h).

6909 PAINTING CONCRETE

(a) Surface Preparation

The surface of the concrete to be painted shall be cleaned of all dust, loose particles, laitance, impurities and other deleterious materials, and then washed and allowed to dry.

Unless the surface is to be covered with a bituminous paint, all cracks, holes and cavities shall be filled with grout or an acrylic filler.

(b) Sealing and Priming

The surface shall be sealed with an approved clear sealer which complies with CKS 564 or equivalent and then primed with a primer consisting of an undercoat diluted to 50%.

(c) Undercoat and Finishing

An undercoat shall be applied after priming, followed by two finishing coats of the prescribed paint.

(d) Bituminous Paint

The surface shall be prepared in accordance with the requirements of SUB-CLAUSE 6909 (a). Before it dries out, a primer shall be applied in accordance with the instructions of the fabricator of the bituminous paint.

After the primer has been applied, two coats of bituminous paint shall be applied at the rate of 0.75 litre/m²/coat. No paint coat shall be applied unless the previous coat has dried out completely, and no paint shall be applied to the paintwork for so long as any moisture occurs on the surface.

6910 PAINTING GALVANISED SURFACES

Galvanised surfaces shall be painted as specified in this Section for steel surfaces, except that the surface preparation and priming shall be as follows:

(a) Surface Preparation

Dirt and other adherent contaminating matter shall be removed from galvanised surfaces by brushing with wire or stiff bristle brushes or by other methods approved by the Engineer. Cleaning shall not damage the galvanising. Oil or grease shall be removed from galvanised surfaces by the application of an emulsion cleaner. Any zinc corrosion products remaining shall be removed by washing with sweet water and scrubbing with hard bristle brushes.

After being cleaned and degreased all galvanised surfaces shall be etched with T-wash as described in BS EN ISO 12944-7:2017. If any surface fails to turn black, the cleaning degreasing and etching processes shall be repeated.

(b) Priming

Two coats of calcium-plumbate primer shall be applied to a dry-film thickness of at least 25 µm.

The undercoat shall follow within one week of the primer.

6911 PAINTING OF ROAD SIGNS

The painting of ungalvanized steel road signs, supports, and sign face frames shall be carried out as specified for structural steel in CLAUSE 6907.

The painting of galvanised steel road signs, supports and sign face frames shall be carried out as specified in CLAUSES 6906 AND 6907.

The back of all road sign faces shall be painted grey.

6912 PAINTING OF TIMBER**(a) Surface Preparation**

All dirt, peeling or cracking paint and other foreign matter shall be removed by wire brushing, scraping, approved wax-free flushable paint remover, or other approved means immediately prior to painting.

The moisture content of the timber shall not be more than 20% at the time of applying the first coat.

All cracks, shakes or scars shall be filled with putty, flush to the surface, before painting.

The surfaces shall then be washed with G1 cleaner or an equivalent and allowed to dry.

(b) Primer

One coat of wood primer shall be applied.

(c) Finishing

Two coats of high gloss enamel shall be applied in the specified colour. They shall be of two different colours.

6913 MEASURING PAINT THICKNESS

The dry-film thickness of paint shall be determined in accordance with BS EN ISO 2808:2019 or equivalent.

At least 90% of all thickness measurements shall comply with the minimum specified requirements. The thickness shall not in any case be less than 70% of the specified thickness.

6914 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
69.01 PAINTING:	
(a) (DESCRIBE STRUCTURE/ ARTICLE STATE TYPE OF PAINT, AND NUMBER OF COATS)	SQUARE METRE (m ²)
(b) (DESCRIBE STRUCTURE/ ARTICLE, STATE TYPE OF PAINT, AND NUMBER OF COATS)	NUMBER (no.)
(c) (DESCRIBE STRUCTURE/ ARTICLE, STATE TYPE OF PAINT, AND NUMBER OF COATS)	METRE (m)
(d) (DESCRIBE STRUCTURE/ ARTICLE STATE TYPE OF PAINT, AND NUMBER OF COATS)	TONNE (t)

The unit of measurement shall be the square metre of surface painted. Only the surface covered by the final finishing coat shall be measured.

The unit of measurement may also be the number of structures or articles painted, or a metre length of the structures or articles painted, or a tonne of the structures or articles painted, the quantities are calculated as specified in ITEM 67.01.

The bid rates shall include full compensation for surface preparation, applying all the coats of paint, repairing any damaged surfaces, and all materials and construction plant necessary for completing the work.

SERIES 7000

TOLERANCES, TESTING AND QUALITY CONTROL

CONTENTS OF THE GENERAL SPECIFICATIONS:

<i>SERIES 1000</i>	<i>GENERAL</i>
<i>SERIES 2000</i>	<i>DRAINAGE</i>
<i>SERIES 3000</i>	<i>SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE</i>
<i>SERIES 4000</i>	<i>BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT</i>
<i>SERIES 5000</i>	<i>ANCILLARY ROADWORKS</i>
<i>SERIES 6000</i>	<i>STRUCTURES</i>
<i>SERIES 7000</i>	<i>TOLERANCES, TESTING AND QUALITY CONTROL</i>
<i>SERIES 8000</i>	<i>DAYWORKS</i>

APPENDICES

SERIES 7000

TOLERANCES, TESTING AND QUALITY CONTROL

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CONTENTS OF THE GENERAL SPECIFICATIONS:

<i>SERIES 1000</i>	<i>GENERAL</i>
<i>SERIES 2000</i>	<i>DRAINAGE</i>
<i>SERIES 3000</i>	<i>SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE</i>
<i>SERIES 4000</i>	<i>BITUMINOUS LAYERS SEALS AND CONCRETE PAVEMENT</i>
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SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

SECTION 7100: TESTING OF MATERIALS AND WORKMANSHIP

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7101 SCOPE

This Section covers the tests and methods of testing which are required for the selection and control of the materials and for control of workmanship, trials and construction control testing.

During the progress of the Work, tests shall be conducted on materials and workmanship to ensure compliance with the requirements of the Specifications.

The Contractor's attention is drawn to the provisions of CLAUSE 1205 in regard to his/her obligations to conduct tests on a regular basis for the check of compliance with specification requirements. The intensity of control and of tests to be conducted by the Contractor is not specified but shall be adequate to ensure that proper control is being exercised. This process control shall be detailed in a quality control management system to be prepared by the Contractor.

7102 MATERIALS GENERALLY

All materials shall conform to the requirements of the Contract, the Drawings and the Specifications.

All materials shall be of approved manufacturer, origin and the best quality of their respective kinds. Unless otherwise specified such materials shall be new (as compared to used or reprocessed).

No materials of any description shall be used without the prior sanction of the Engineer and any materials condemned as unsuitable for use in the Works shall be removed immediately from the Site by and without recompense to the Contractor.

7103 GENERAL SPECIFICATIONS

Where in the Specifications tests on materials, tests on completed Works and construction control tests are called for or implied, they shall be carried out according to the test methods listed in SECTION 7502 (a), unless the test in question is not covered within this Section. When a particular test is not covered by the referred standard, then the method shall be to an equivalent standard called for in the contract documents or as directed by the Engineer.

Materials shall comply with, the requirements of the current edition of Specifications issued by the Uganda National Bureau of Standards (UNBS), American Association of State Highway and Transportation Officials (AASHTO) or American Society for Testing Materials (ASTM) or British Standard (BS), or European Standards (BS EN) or South African National Standards (SANS), or where applicable, an equivalent Specification called for in the contract documents or as directed by the Engineer.

Other equivalent national standard specifications may only be substituted for the above at the sole discretion of the Engineer.

7104 MATERIALS TESTING AND ACCEPTANCE

As soon as possible after the Contract has been awarded, the Contractor shall submit to the Engineer complete statements as to the origin, composition and manufacture of all materials to be used in the Works together with a list of the suppliers from whom he proposes to purchase these materials.

Prior to delivery of materials to the job site, the Contractor shall submit certified test reports as per Section 7500 and samples to the Engineer of all materials proposed for use in the Works, whether from an outside supplier or whether supplied by the Contractor from his own resources. The certification(s) shall show the appropriate test(s) for each material, the test results, and a statement that the material meets the specification requirement. The Engineer's approval shall be received prior to any materials being delivered in bulk to the works.

The Engineer may request further samples for testing, prior to and during construction to verify the quality of the materials and to ensure conformance with the applicable specifications. The Contractor shall provide all samples free of charge.

All equipment to be used in testing shall be calibrated at the start of the project, and at regular intervals throughout the project period as approved by the Engineer.

The Contractor shall test samples as specified from each quarry location and borrow pit proposed for use in the Works. The particular tests to be carried out will be determined by the function for which the Contractor proposes to use the material in the Works, as necessary to show compliance to these Specifications. The results of these tests shall be approved by the Engineer before the quarry or borrow pit is required for use. Should any quarry or borrow pit prove to be unsuitable, the Contractor shall investigate further sites until suitable materials are found and approved.

The Contractor's programme shall allow sufficient time for materials testing and no claim for delays or extra costs arising out of this will be accepted.

All materials supplied for use in the Works shall conform within specified tolerances, to the quality of the approved samples, which will be retained at the Engineer's office until the completion of the Contract.

Where a material has been specified by a manufacturer's

trade name, the product of another manufacturer will be accepted provided that, in the opinion of the Engineer, it is in all respects of an equivalent or higher quality.

7105 LABORATORY FOR THE ENGINEER

The Contractor shall facilitate independent testing by the Engineer as he may deem necessary in accordance with SECTION 1410.

7106 TESTING BY THE CONTRACTOR

The Contractor shall provide, use and maintain on the site throughout the period of execution of the works a suitable laboratory and adequate equipment operated by competent staff for carrying out tests required for the selection and control of the quality of materials and for the control of workmanship in accordance with this specification, in accordance with SECTION 1410. The contractor shall assume that tests will be required on all materials used in the works and on all finished work.

The Contractor shall carry out all necessary tests and shall report to the Engineer the results of such tests before submitting materials and finished work to the Engineer for approval. In appropriate circumstances, tests may be carried out at the place of manufacture.

7107 ACCEPTANCE STANDARDS FOR MATERIALS

All materials used in or upon the works shall comply with this Specification and the Special Specification and shall be acceptable to the Engineer. Where so specified, the material shall comply with the US EAS specification named or with an alternative national specification or specification named in CLAUSE 7502 on the approval of the Engineer.

Similarly, where a material has been specified by manufacturer's trade name, the product of another manufacturer will be acceptable provided it is in all respects equivalent or of higher quality and provided that the Engineer's approval has been obtained.

Samples of all materials proposed to be used shall be submitted to the Engineer and shall, where required, be tested prior to the material being delivered in bulk upon the works.

7108 THE COST OF TESTING

(a) Process Control

The cost of testing undertaken by the Contractor in terms of his obligations under CLAUSE 1205 for purposes of process control, including the taking of samples, reinstating where samples have been taken, and all testing equipment, labour, materials, etc., shall be included in the bid rates for the various items of work supplied and will not be paid for separately.

(b) Producing Certificates

Where the properties of materials or manufactured products are required in these Specifications to comply with specified specifications published by a Standards Authority approved by the Engineer, the Contractor shall produce, when called upon to do so, certificates from the manufacturer confirming that the materials or products supplied comply with the relevant specifications. All costs of providing such certificates shall be borne by the Contractor.

(c) Testing Materials and Products Covered by Certificates

The Engineer shall be entitled to take samples of, and order tests to be made on, products and materials in respect of which certificates of compliance may be required. The Contractor shall only be paid at the appropriate rates if the costs of such tests are itemised in the Bill of Quantities.

7109 GEOTECHNICAL INVESTIGATIONS

The minimum depth and number of exploration points are given in TABLE 7109/1.

TABLE 7109/1: GUIDELINES FOR GEOTECHNICAL INVESTIGATIONS

Item	No of Investigation Points	Depth of Exploration
Shallow Foundations	For substructure (e.g., piers or abutments), a minimum of two investigation points per substructure	(1) Deep enough to fully penetrate unsuitable foundation soils (e.g., organic soil, soft clays, loose sands, loose silts) into competent material of suitable bearing capacity (e.g. very stiff to hard for cohesive soil, dense to very dense for cohesionless soil or bedrock). (2) At least 2.0 times the width of footing below the anticipated foundation depth. (3) If bedrock is encountered before the depth required by item (2) above is achieved, exploration depth should be great enough to penetrate a minimum of 10 ft (3 m) into the bedrock, but rock exploration should be sufficient to characterize compressibility of infill material of near horizontal-to-horizontal discontinuities.
Deep foundations	For substructure (e.g., piers or abutments), a minimum of at least two investigation points per substructure	(1) In soil, the depth of exploration should extend below the anticipated pile or shaft tip elevation a minimum of 5.00 m, or a minimum of one times the minimum pile group dimension, whichever is deeper. (2) For piles bearing on rock, a minimum of 3.00 m of rock core shall be obtained at each exploration point location to verify that the boring has not terminated on a boulder. (3) For shafts supported on or extending into rock, a minimum of 3.00 m of rock core, or a length of rock core equal to at least three times the shaft diameter for isolated shafts, whichever is greater, shall be extended below the anticipated shaft tip elevation to determine the physical characteristics of rock within the zone of foundation influence.
Swamps	(1) One investigation point at every 100m (2) If DPL is conducted along with boreholes, then DPL and the investigation point can be conducted alternatively at every	(1) Deep enough to fully penetrate unsuitable foundation soils (e.g., organic soil, soft clays, loose sands, loose silts) into competent material of suitable bearing capacity (e.g. stiff to hard for cohesive soil, dense to very dense for cohesionless soil or bedrock). (2) Minimum 10.00 m into soil from the riverbed.

Item	No of Investigation Points	Depth of Exploration
	100m. (3) For swamps less than 100m minimum one investigation point should be conducted.	
High Embankment (height > 6.00m)	A minimum of one investigation point every 100m.	(1) Deep enough to fully penetrate unsuitable foundation soils (e.g., organic soil, soft clays, loose sands, loose silts) into competent material of suitable bearing capacity (e.g. stiff to hard for cohesive soil, dense to very dense for cohesionless soil or bedrock). (2) Minimum 10.00m into soil or up to the rock top level.
Cut Slopes	(1) A minimum of one investigation point every 100m. (2) For cut slopes in rock, perform geologic mapping along the length of the cut slope. (3) For cuts less than 100m minimum one borehole should be conducted.	(1) Exploration depth should be, at a minimum 3.0 m below the minimum elevation of the cut unless a hard stratum is encountered below the minimum elevation of the cut. (2) Exploration depth should be great enough to fully penetrate through soft strata into competent material (e.g., stiff to hard for cohesive soil, dense to very dense for cohesionless soil, or bedrock).

7110 TAKING AND SUBMITTING SAMPLES

(a) General

Where the Contractor is required in these Specifications to submit samples of materials or mixtures to the Engineer for approval prior to their being used in the Works, the use of these materials or mixtures without the Engineer's written approval shall constitute default on the part of the Contractor, who shall be liable for the consequences of such default. All samples shall be submitted in sufficient time for proper testing.

The Engineer's approval of any materials or mixtures shall in no way relieve the Contractor of his obligation to provide materials, mixtures and workmanship which comply with the Specifications.

All samples for testing shall be taken from the road after completion of work on the particular layer to be tested except as specified elsewhere in these Specifications. Where specified or required by the Engineer, stratified random sampling methods, as defined in SUB-CLAUSES 7203 (b) AND 7204 (b), shall be followed. For the testing of layer work, stratified random sampling methods shall be used for obtaining all the sample portions and for determining the locations of in-situ test sites.

The method of taking samples shall be as specified in the appropriate sampling and testing methods listed in SECTION 7502 (a) or similar as approved by the Engineer.

The Engineer shall have full access to the Works for the purpose of taking samples. The Contractor shall render any assistance necessary for taking the samples and shall be responsible for the reinstatement of pavement layers or other structures at the positions where the samples have been taken. Full compensation for rendering assistance with sampling and for reinstatement where samples have been taken shall be included in the rates tendered for the various items of work tested, and no additional payment will be made in

this respect.

(b) Sampling Frequency

Samples shall be taken for laboratory testing for each new material encountered, or when there is a significant change in material properties in the opinion of the Engineer.

The minimum sampling frequencies shall be as given in TABLE 7110/1. Samples for tests that are not mentioned in TABLE 7110/1, but for which there are material requirements in these Specifications, shall be taken as required in the opinion of the Engineer.

7111 TESTING METHODS

All tests shall be conducted in accordance with the standard methods specified in the Specifications.

Where in the Specifications tests on materials, tests on completed Works and construction control tests are called for or implied, they shall be carried out according to test methods listed in SECTION 7502 (a), unless the test in question is not covered within this Section. When a particular test is not listed in SECTION 7502 (a), then the method shall be an equivalent standard called for in the contract documents or as directed by the Engineer.

In addition to the above standard methods of testing, equivalent standard specifications or test methods of other bodies may be used in these specifications if approved by the Engineer.

In all cases the latest amendment at the closing date of the tender is implied when reference is made to one of the above standards in the Specification.

The Contractor shall have on the Site all the relevant standards required for the work he is to undertake under the Contract. The Engineer shall be provided a copy of such standards.

TABLE 7110/1: SAMPLING AND TESTING FREQUENCIES

Layer and Nominal Class of Material	Tests to be carried out ¹	Sampling Frequency, Minimum			
Roadbed	CBR,	1	Per	10000	m ²
	MDD, PI, Grading,	1	Per	5000	m ²
Earthworks Fill using Soils: (G7)	CBR, PI, Grading	1	Per	2000	m ³
	MDD	1	Per	1000	m ³
Backfill to Culverts and Structures	CBR, PI, Grading	1	Per	500	m ³
	MDD	1	Per	200	m ³
Improved Subgrade (G7, G15) or Gravel Wearing Course (GW)	CBR, PI, Grading, CBR Swell, SP, GC	1	Per	10000	m ²
	MDD	1	Per	5000	m ²
Subbase: (G30, G45)	CBR, CBR Swell, Grading, MDD, PI, LL, LS	1	Per	5000	m ²
Subbase: (CM, C0.7, C1.0, C1.5)	UCS, PI, MDD, TFV, GM,	1	Per	5000	m ²
Base Course: (G60, G80)					
	CBR, PI, Grading, CBR Swell, LL, LS, TFV	1	Per	5000	m ²
	MDD	1	Per	2500	m ²
Base Course: (C1.0, C1.5 C3.0, C4.5)	Chemical Analysis, Durability Test	1	Per	10000	m ²
	UCS, PI, Grading, TFV, GM, UC, LL	1	Per	5000	m ²
	MDD	1	Per	2500	m ²
Base Course using Crushed Aggregate: (CRS)	Grading, LL, PI, LS, TFV, FI	1	Per	5000	m ²
	MDD	1	Per	2500	m ²
Base Course using Crushed Aggregate: (CRR)	MDD, TFV, CBR	1	Per	10000	m ²
	LL, LS, Grading, Flakiness, PI	1	Per	5000	m ²
Base / Binder Course of a Bituminous Mix or Asphalt Concrete Surfacing or Stone Matrix Asphalt as Surfacing Course, Cold Mixed Bituminous Base Course	Performance Tests	1	Per	Design Mix	
	Extraction, Grading	1	Per	10000	m ²
	Marshall Test with Mix Properties / Gyratory Compaction Test, ITS	1	Per	5000	m ²
Surface Treatments – Surfacing Seals, Surface Dressing, Otta Seals, Sand Seals, Sand Capping, Grit Seals, Surfacing of Bridge Deck, Crack Seal, Tack Coat, Prime Coat, Curing Membrane	TFV	1	Per	20000	m ²
	Grading, Flakiness	1	Per	5000	m ²
	Tray Test ²	1	Per	500	m ²
Concrete Pavement	Core Strength	1	Per	10000	m ²
	Strength (Cube & Beam)	1	Per	5000	m ²
	Workability	1	Per	2500	m ²
Geo-synthetics / Geotextile	Wide width Tensile Strength	1	Per	5000	m ²
	Elongation %	1	Per	5000	m ²
	CBR Puncture Resistance	1	Per	5000	m ²
	Permeability 10 Cm Head	1	Per	5000	m ²
	Pore Size	1	Per	5000	m ²
	Tensile Breaking Load	1	Per	5000	m ²
Binders (Bitumen, Priming Material, Bituminous Curing Membrane, Cement, Joint Sealant, etc.) Water, Curing Agents, Separation Membrane, Admixtures, Chemical / Stabilising Agents, Cellulose Fibres, Aggregate	Water Flow	1	Per	5000	m ²
	Physical & Chemical Properties		Per Lot / Per Batch or Every 3 Months		

¹ The referred tests shall be carried out in accordance with standards test methods indicated in the special specifications or other standards approved by the Engineer.

²Tray test shall be performed for both bitumen spraying rate and chipping spreading rate.

It is emphasised that the Atterberg limits of soil fines shall be measured according to the British Standard (BS) procedures and utilise BS equipment. Other laboratory test procedures and equipment do not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

All CBR testing shall be carried out using the three-point method as described in Section 7502 (a) or other

approved methods at the discretion of the Engineer. All CBR tests relate to material compacted to the dry density obtained using the compaction test as specified in the respective Clauses for material requirements. The CBR testing shall be carried out at moisture content as specified in the respective Clauses for material requirements.

7112 TESTING CEMENTITIOUS BINDERS AND CONCRETE

(a) Testing Aggregates for Concrete

Aggregates shall be regularly tested by the Contractor at a frequency to the satisfaction of the Engineer as part of the Contractor's process control as they are being manufactured or brought onto the site and used or taken to a stockpile.

The appropriate test methods shall be those included under the respective Clauses of the Specifications, or any other relevant tests prescribed by the Engineer.

Accelerated tests shall be carried out to determine the potential alkali reactivity of aggregates where this is considered appropriate by the Engineer.

(b) Test for Cementitious-Binder Content

The test method used for determining the cementitious binder content of soils, gravels or crushed stone mixed with a chemical stabilising agent shall be determined by the Engineer and may be any test method currently recognised by the Engineer as being acceptable.

Where the cementitious binder content is determined, due allowance shall be made for the presence in the unstabilised material of naturally occurring MgO or CaO which affects the result of such tests. If the standard deviation of the natural CaO plus MgO content of the untreated material exceeds 0.35% any determination of the cementitious-binder content shall be ignored.

Sample holes shall be randomly (as defined in SUB-CLAUSES 7203 (b) AND 7204 (b)) spaced transversely as well as longitudinally over the area to be tested, or as directed by the Engineer, and if the material is road – mixed, samples shall be taken from the top and bottom of each hole. The minimum number of samples per test shall be 10.

(c) Canvas Patch Test for the Spreading Rate of Cementitious Binder

The following method shall be used for determining the spreading rate of a chemical stabilising agent where bulk distributors are used.

At least 10 clean canvas patches, each measuring 1.0 m x 1.0 m shall be weighted and placed flat on the road in selected positions in relation to the bulk distributor's track. After the stabilising agent has been spread by the bulk distributor, the canvas patches shall be carefully lifted and weighted. The total mass of stabilising agent is the difference of weight of the canvas patch before and after being spread on each patch is then recorded and the average rate of application determined. Instead of canvas patches, flat metal trays may be used for collecting the stabilising agent.

(d) Test for Mix Uniformity in Chemically Stabilised Layers

Where required by the Engineer, the Contractor shall determine the mix uniformity in chemically stabilised layers by means of unconfined compressive strength tests, using an approved method.

The Contractor shall without delay make the necessary arrangements to take samples in accordance with the requirements of the method used.

(e) Test for Initial Consumption of Lime

The objective of the gravel ICL test is the control of the pH in lime and cement stabilised soil in order to allow the possible formation of cement minerals, calcium silica hydrate in particular, and for proper modification to take place. It is recommended that the stabiliser to be used during construction (or the nearest equivalent) should be used to carry out this test.

(f) Determining the Compressive Strength

The procedure for sampling and manufacturing, storing, curing and testing test cubes shall be in accordance with appropriate tests in SECTION 7502 (a).

Where specified in the Special Specifications, the compaction of concrete specimens in the moulds by means of a vibrating table shall be obligatory. In such a case the method of compaction shall be as follows:

i) Plastic Concrete

Fill the mould halfway and vibrate it and spade it on all four sides with a suitable trowel to remove air bubbles. Stop the vibration as soon as a wet sheen appears on the surface. Fill the mould and repeat the procedure, but stop when again a wet sheet appears on the surface.

ii) Stiff Concrete

The same procedure is followed, except that the mould is filled in three to four steps instead of two steps. The vibration is stopped for each layer when a wet sheen appears.

(g) Consistency

The test method described in BS EN 12350-2:2019 shall apply in regard to the slump test.

(h) Air Content

The air content of the freshly mixed concrete shall be tested by the method given in BS EN 12350-7:2019 or equivalent. Air content tests shall be conducted on the same samples of concrete from which cubes were made for the 28-day compressive strength tests.

(i) Drilling and Testing the Cores

Where sections of concrete which have failed to comply with the Specifications are required to be further investigated by extracting and testing concrete cores, 100 mm or 150 mm cores shall be drilled and tested. The sampling and testing procedure to be followed shall be in accordance with the publication Concrete Core Testing for Strength – Concrete Society Technical Report No.11, published by the Concrete Society of Great Britain.

The instructions of this report shall be followed for determining the "estimated potential strength", which shall be compared with the 28 days cube strength specified for each type of concrete. Corrections to the actual core strength to allow for excess voids, included steel and the length: diameter ratio of cores shall be as stated in this publication, and the correction for curing shall be determined by the Engineer in accordance with this publication and such other information as he may deem to be appropriate.

The Engineer's decision regarding the degree to which the concrete, which is represented by the cores tested as described above, complies with the requirements and also regarding the properties and suitability of the concrete, shall be final and binding.

7113 TESTING SOILS, GRAVEL AND CRUSHED AGGREGATE FOR EARTHWORKS AND PAVEMENT LAYERS

Specimens of soils, gravel and crushed stone materials in earthworks and pavement layers shall be taken in accordance with CLAUSE 7104, and subjected to tests as prescribed for each respective layer in the relevant sections of SERIES 3000.

7114 TESTING BITUMINOUS BINDERS AND MIXES

Specimens of bituminous binders and mixes shall be taken in accordance with SECTION 7104, and subjected to tests as prescribed for each respective layer in the

relevant sections of SERIES 4000.

The Engineer shall be entitled to order the Contractor to have material tested by an approved laboratory for compliance with all of the requirements specified, and the results of such tests shall be submitted directly to the Engineer by the testing laboratory with copies, if requested, to the Contractor.

The cost of such tests shall be borne as specified in CLAUSE 7108.

7115 DEFECTIVE MATERIALS

All materials which the Engineer has determined as not conforming to the requirements of the Specifications and or Contract shall be rejected whether in place or not, they shall be removed immediately from the site as directed. Materials which have been subsequently corrected, shall not be used in the work unless approval is accorded in writing by the Engineer. Upon failure of the Contractor to comply with the removal of rejected material, the Engineer shall deduct the removal cost thereof from any payments due to the Contractor.

7116 IMPORTED MATERIALS

The Contractor shall furnish a list of materials/ finished products manufactured, produced or fabricated which he proposes to use in the work. The Contractor shall be responsible for the timely delivery of all such materials to the project site.

The materials imported shall conform to the relevant Specifications of the Contract. In cases where materials/ finished products are not covered by the Specifications in the Contract, the details of laboratories/ establishments where tests are to be carried out shall be as specified in the Contract.

The Contractor shall furnish to the Engineer a certificate of compliance of the tests carried out. In addition, certified test reports clearly identifying the lot, shall be furnished to the Engineer.

7117 FIELD DENSITY TESTING

(a) General

All earthwork and pavement layers and backfill to drainage works and structures will be subject to construction control testing by the Engineer, and the Contractor must allow for any disturbance or delays to the sequence of his operations occasioned by such control testing.

The contractor shall request, in writing, the Engineer's approval for each layer of each section of earthworks and pavement construction and backfill to drainage works and structures. Such requests shall be made only when the Contractor is fully satisfied that the section of the work concerned is in the condition required by this Specification. Such requests shall be accompanied by the test results required in accordance with this Specification.

The Engineer shall thereupon without undue delay inspect the section for any visible wet spots, laminations, heaving material (visible during compaction or on proof rolling), segregation, and for the uniformity of the mixing and compaction. Provided the visual aspects are satisfactory, the Engineer shall test the section of the works submitted and inform the Contractor in writing of the results of the tests at the same time accepting or rejecting the section or layer concerned.

Work on layers shall in no circumstances commence until the preceding layer has been approved and accepted by the Engineer in writing. The Contractor is wholly responsible for protecting and maintaining the condition of the work which has been submitted for approval.

Should any layer be left unprotected for more than 24 hours subsequent to approval, the Contractor shall request re-approval of the layer and the layer will again be subject to proof rolling, construction control testing, and tolerance checks in accordance with this Specification.

Notwithstanding the Engineer's approval of a layer, the Contractor shall be responsible for making good any subsequent damage due to traffic, ingress of water or any other reason and should any damage occur, the layer will again be subject to proof rolling, construction control testing and tolerance checks in accordance with this Specification.

(b) Testing Frequency

The minimum testing frequencies for field density shall be as given in TABLE 7117/1. The density holes shall be placed following a randomly stratified pattern representing the laid area prepared for the test. The rate of testing may be increased at the discretion of the Engineer in case of doubt or to determine the extent of the defective area in the event of non-compliance.

TABLE 7117/1 TESTING FREQUENCIES FOR FIELD DENSITY TESTING

Layer and Nominal Class of Material	Frequency, Minimum	Absolute, Minimum
Roadbed	1 test per 100 m ²	3 tests per section and 1 test per 50m
Earthworks Fill using Soils: (G7)	1 test per 200 m ²	3 per section per layer
Backfill to Culverts and Structures	2 tests per 10 m ³	2 per section
Fill or Improved Subgrade Layers using Dump Rock: (DR)	Method Specification	
Improved Subgrade Layers using Gravel/Soils: (G7, G15)	1 test per 1000 m ²	4 per section per layer
Gravel Wearing Course used on Gravel Roads: (GW)	1 test per 1000 m ²	4 per section
Subbase: (G30, G45, CM, C 0.7, C 1.0, C1.5)	1 test per 750 m ²	5 per section
Base Course: (G60, G80, CRS, CRR, C3.0, C4.5)	1 test per 500 m ²	6 per section
Base / Binder Course of Bituminous Mix: (BEMIX, FB MIX, DBM40, DBM30, 37.5, 25.0 Nominal Size) and Stone Matrix Asphalt as Binder Course (19.0 Nominal Size)	1 test per 500 m ²	6 per section
Asphalt Concrete Surfacing (AC20, AC14, AC10, 19.0, 12.5, 9.5 Nominal Size) and Stone Matrix Asphalt as Surfacing Course (13.0, 9.5 Nominal Size)	1 test per 400 m ²	6 per section

(c) Testing Methods

If a nuclear method is used for determining density and moisture content, tests will be done at least at the same frequency required when using the sand replacement method but at each nuclear densometer test location, the average of two readings taken at positions rotated by 180° shall be used. A check/comparison test using the sand replacement method shall be carried out as required by the Engineer.

Initial calibration of the nuclear testing equipment shall be done by carrying out at least fifty tests in parallel with the sand replacement method for each different material encountered.

When starting to use a new material source, or whenever there is a change of material type, a calibration shall be carried out in accordance with the manufacturer's guidelines or as required by the Engineer to establish a moisture correction and any correction of density required. Check tests will be used to update the initial calibration of the nuclear density testing equipment.

(d) Field Density Requirements

The required field densities for each material type shall be as shown in TABLE 7117/2. The values shown are nominal values to which an assessment of the results shall be applied in accordance with SECTION 7200.

TABLE 7117/2: MINIMUM FIELD DENSITY, NOMINAL VALUES

Layer and Nominal Class of Material	Field Density, Lower Specification Limit
Roadbed (after removal of topsoil etc.)	Depends on the depth below formation, reference is made to TABLE 3606/1
Backfill to culverts and structures	To be the same as adjacent layers at the same level, not less than 93% BS-Heavy
Fill or improved subgrade layers using dump rock: (DR)	Method specification
Earthworks Fill using Soils: (G7) (more than 300mm below Formation Level)	93% of BS-Heavy
Lower Improved Subgrade Layers using Gravel/Soils: (G7)	93% of BS-Heavy
Upper Improved Subgrade Layers using Gravel/Soils: (G15)	95% of BS-Heavy
Gravel Wearing Course used on Gravel Roads: (GW)	95% of BS-Heavy
Subbase of Natural Gravel: (G30, G45)	95% of BS-Heavy
Subbase of Cemented Material: (CM, C0.7, C1.0, C1.5)	95% of BS-Heavy
Base Course of Natural Gravel: (G60, G80)	98% of BS-Heavy
Base Course of Cemented Material: (C1.0, C1.5, C3.0, C4.5)	98% of BS-Heavy
Base Course of Crushed Aggregate: CRS	98% of BS-Heavy
Base Course of Crushed Aggregate: CRR	102% of BS-Heavy
Base Course of Cold Bituminous Mix: (BEMIX, FB MIX)	98% of Marshall Density or Method Specifications ¹⁾
Base / Binder Course of Hot Bituminous Mix: (DBM40, DBM30)	93.5% of Max. Theoretical Density Gmm ²⁾
Base / Binder Course of Hot Bituminous Mix: (37.5, 25.0 Nominal Size)	93.5 % of Max. Theoretical Density Gmm ²⁾
Asphalt Concrete Surfacing (AC20, AC14, AC10)	93.5% of Max. Theoretical Density Gmm ²⁾
Asphalt Concrete Surfacing (19.0, 12.5, 9.5 Nominal mixes)	93.5% of Max. Theoretical Density Gmm ²⁾
Stone Mastic Asphalt as Surfacing Course (13.0, 9.5 Nominal Size)	93.5% of Max. Theoretical Density Gmm ²⁾
¹⁾ Marshall Density cannot be used on coarse bituminous material types, i.e. with nominal aggregate size 30 mm or larger. Whether or not Marshall compaction can be applied for a specific type of Cold Bituminous Mix shall be decided by the Engineer.	
²⁾ For Low Volume Roads Compaction of Bituminous Layers shall be evaluated with reference to Marshall Density	

7118 TESTS OF SURFACE REGULARITY, LEVELS AND LAYER THICKNESS

(a) General

i) Straight Edge Measurements, Normal Conditions

Measurements of surface regularity shall be carried out with a 3 m straight edge having sharp right-angled corners at the bottom, and shall be placed on the road at any angle to the centreline as directed by the Engineer. Measurements shall be carried out by measuring the largest deviation from true surface along the straightedge.

Using the rolling straight edge for measuring surface irregularities, the apparatus and testing method for this shall be in accordance with testing Method ST3 of TMH6 of South Africa.

ii) Straight Edge Measurements, Severe Conditions

Where surface irregularities are measured on a surface with a coarse surface texture in the opinion of the Engineer, such as grooved concrete pavements, crushed aggregate pavement layers,

natural gravel base course, asphalt with rolled in chippings, seals and other like surfaces, the following procedure shall be followed:

A metal wedge of 100 mm in length and 50 mm in width shall be constructed with a taper of 7.5 horizontal to 1.0 vertical and tapering to a feather edge (50 mm wide). Parallel lines spaced at 7.5 mm intervals shall be engraved on the sloping face and numbered to indicate the positions where the wedge is 1.0 mm, 2.0 mm, etc., thick.

iii) Horizontal Tolerances

At no point shall the distance between the centreline and the edge of the top of a layer be less than that detailed or more than 150 mm in excess of that detailed.

iv) Shoulders

Shoulders shall be constructed to the same thickness, level, crossfall and surface regularity requirements as for the adjacent pavement layers, except otherwise as stated in the other contract document.

(b) Surface Regularity, Straight Edge Measurements

The required surface regularity, measured with a 3 m straight edge at any angle in relation to the centreline, shall be within the limits shown in TABLE 7118/1.

TABLE 7118/1: SURFACE REGULARITY MEASUREMENTS WITH 3 METRE STRAIGHT EDGE

Layer	Maximum Straight Edge Deviation (mm)
Bituminous Wearing Course	5
Concrete Pavement	5
Bituminous Base / Binder Course	6
Base Course (not PM materials) / Surface Dressing	7
Gravel Wearing Course	10
Subbase	25
Stone Pitching	20

(c) Surface Levels

The maximum deviation in levels shall be as shown in TABLE 7118/2.

TABLE 7118/2: SURFACE LEVELS

Layer and Material Class	Maximum Deviation in Levels (mm)			
	High (+)		Low (-)	
	H90 Value 1)	Absolute Max Hmax Value	H90 value 1)	Absolute Max Hmax Value
Bituminous Wearing Course	3	5	3	5
Base / Binder Course, when followed by a Seal only	5	8	5	8
Base / Binder Course, when followed by AC Surfacing	NIL	NIL	5	10
Subbase	NIL	NIL	15	25
Formation	NIL	NIL	20	30
Gravel Wearing Course	10	15	10	15
Concrete Pavement	NIL	NIL	5	10
1) H ₉₀ is the limit within which 90% of the measurements shall fall when assessing 50 or more measurements against the specified level at the respective locations where the measurements were taken.				

(d) Surface Crossfall

The maximum deviation in longitudinal slope or crossfall shall be as shown in TABLE 7118/3. The values shown are nominal values to which an assessment of the results shall be applied in accordance with SECTION 7200.

TABLE 7118/3: SURFACE CROSSFALL

Layer	Maximum Crossfall Deviation ± (%)
Bituminous Wearing Course	0.25
Concrete Pavement	0.25
Gravel Wearing Course	0.50
Base Course (not PM materials)	0.25
Subbase	0.50
Formation	0.50

(e) Layer Thickness

The final compacted layer thickness measured by excavating trial pits or core drilling shall not deviate from the specified thickness than the maximum deviations shown in TABLE 7118/4. The measurements shall be taken at locations as directed by the Engineer at intervals not less frequent than 25 metres and a lot size shall be at least 20 measurements where surface levels are used otherwise the frequency in TABLE 7117/1 should be adopted

TABLE 7118/4: LAYER THICKNESS

Layer	Maximum Deviation in Layer Thickness ± (mm)	
	T ₉₀ value 1)	Absolute max T _{max} value
Bituminous Wearing Course	3	5
Concrete Pavement	5	10
Gravel Wearing Course	10	15
Bituminous Base / Binder Course (not PM materials)	3	5
Base Course, Aggregate or Natural Gravel	10	20
Subbase	15	25
Improved Subgrade Layers	20	30
1) T ₉₀ is the value with which 90% of the measurements shall comply when assessing 20 or more measurements against the specified layer thickness.		

7119 LABORATORY TRIALS AND SITE TRIALS

(a) Laboratory Trials

Laboratory trials shall be carried out by the Contractor and the Engineer on earthwork and pavement materials which are to be used in the works in their natural state to establish a relationship between their specified end product requirements and properties which can be readily determined in the field for construction control purposes.

Laboratory trial mixes and site trials for earthwork & granular mixes shall be carried out in accordance with the requirements of SERIES 3000 of this Specification and for bituminous mixes shall be carried out in accordance with the requirements of SERIES 4000 of this Specification.

For mixed materials the composition which meets the specified requirements and is accepted by the Engineer shall then be used in the site trials to establish that all specified requirements of the completed pavement layer can be achieved.

The Laboratory trials on mixed materials shall be submitted to the Engineer, at least two weeks before the Contractor proposes the site trials.

(b) Site Trials

The Contractor shall prepare a Trial Section Programme for the approval of the Engineer detailing all sequences of the proposed trial section. In addition to the items listed further below, at least the following, where appropriate, shall be included:

- Date And Time, Location, Sketch Of Location And Type Of Layer To Be Placed;
- Preparation Of Surface;
- Rate Of Application Of Coating;
- Temperature Of Mix At Different Stages During Execution;
- Frequency Of Testing (Test Trays, Cores, Density Measurements, Gradation, Etc.);
- Type And Number Of Equipment To Be Used;
- Construction Equipment Weight, Speed, Other Settings, Etc.;
- Rolling Pattern;
- Joint Construction Methods;
- Programme Of Instruction To Every Person Involved In Site Trials;
- For in-place recycling, forwards speed of recycler and rate of rotation of milling drum influence the degree of pulverisation of pavement materials. In order to attain the required gradation of milled material, an appropriate combination of speed of recycler and milling drum shall be specified; and
- For in-place recycling the rolling sequence and compaction effort required to achieve the target density.

The plan for the proposed trial section shall be forwarded to the Engineer for approval not less than 7 working days before the planned trial. Attention shall be given to joint construction methods, limitations of longitudinal and transversal joints and handling of materials.

Full scale laying and compaction site trials shall be carried out by the Contractor on all earthwork and pavement materials proposed for the works using the construction plant and methods proposed by the Contractor. The trials shall be carried out with the agreement and in the presence of the Engineer.

The trials shall be carried out to enable the Contractor to demonstrate the suitability of his/ her mixing and compaction equipment to provide, lay and compact the material to the specified density, grade and level and to confirm that the other specified requirements of the completed earthwork or pavement layer can be achieved.

Each site trial shall be at least 100 metres long unless otherwise specified and to the full construction width and shall be laid to the specified depth for the material. It may form part of the permanent works provided it complies with this Specification. Any areas which do not comply with this Specification shall be removed and a new trial shall be laid.

The Contractor shall allow in his programme for conducting site trials and for carrying out the appropriate tests. The trial on each pavement layer shall be undertaken at least 21 days ahead of the Contractor proposing to commence full scale work on that pavement layer and/or any other works.

Each trial section shall be compacted using a range of compactive effort proposed by the Contractor, and if appropriate, the following data shall be recorded for each level of compactive effort:

- i. The composition and grading of the material before the site trial.
- ii. The composition and grading of the material including the cement, lime or bitumen content particularly during modification or stabilisation.
- iii. The moisture content at the time of compaction and the optimum moisture content for the specified compaction.
- iv. The type, size, tyre pressure, frequency of vibration and the number of passes of the compaction equipment.
- v. The maximum dry density or target density as appropriately measured on a sample before and at intervals through the site trials.
- vi. The density achieved for each specific compaction effort.
- vii. The compacted thickness of the layer.
- viii. The relevant construction control tests (TABLES 7110/1 AND 7117/2) for the specified layer/ material before the site trials.
- ix. Any other relevant information as directed by the Engineer.

At least eight sets of tests as mentioned above shall be made by the Contractor and the Engineer on each 100 metres of trial for each level of compactive effort. Provided all sets of results over the range of compactive effort proposed by the Contractor meet the specified requirements for the material, the site trial shall be deemed successful. The above data recorded in the trial shall become the agreed basis on which the particular material shall be provided and processed to achieve the specified requirements.

The Contractor shall not proceed with the placing of the layer tried in the trial section until the methods, materials and procedures established in the trials have been approved. Such approval shall be based on a detailed trial section report prepared by the Contractor including all observations and test results. Should the trial fail, the Contractor shall perform additional trials at his own cost until a trial and the trial section report has been approved by the Engineer.

If during the execution of the works, the construction control tests indicate that the requirements for a material are not being consistently achieved, then work on that layer shall stop until the cause is investigated by the Contractor. Such an investigation may include the effect of using other compaction methods, further laboratory and site trials on the material to determine a revised set of data as above which, when agreed, shall be the basis on which all subsequent material will be provided and processed to achieve the specified requirements. Any work that does not comply with the Specifications shall be removed or made good to comply with the Specifications to the satisfaction of the Engineer.

The mix properties, construction equipment, techniques

and methodology mentioned in the approved laboratory and site trial shall not be changed without prior approval by the Engineer.

Agreement by the Engineer to a set of data recorded in a site trial shall not relieve the Contractor of any responsibility to comply with the requirements of this Specification and the Special Specification.

No payment shall be made for trial sections, and the Contractor must allow for all costs in his/ her rates.

7120 TESTS ON STRUCTURES

(a) Test on Elastomeric Bearings

Tests on elastomeric bearings shall be conducted in accordance with BS EN 1337-3:2005 or equivalent and the bearings shall comply with the test requirements specified in the said specification.

(b) Prestressed Concrete

i) General

Where so directed by the Engineer the Contractor shall make arrangements for samples of the materials he intends to use in the works to be tested by an Independent testing authority. The cost of testing prestressing steel, anchorage assemblies and couplings shall be included in his rates.

Material represented by samples which do not comply with the specified requirements shall be removed and replaced with suitable material.

ii) Anchorages And Couplers

Anchorages and couplers shall be tested in accordance with the requirements of CLAUSE 6503. The anchorages and couplers shall be assembled in accordance with their practical application on the site where all components necessary for anchoring shall be used but excluding the ducts.

iii) Prestressing Steel

Prestressing steel shall be tested in accordance with the requirements of CLAUSE 6503. Should any test piece fail to comply with the requirements specified for the prestressing steel, the material represented by that sample shall be replaced with materials conforming to the specifications if further testing confirms that they do not comply with the specifications.

iv) Grout

The fluidity of grout shall be measured with a flow cone, immersion apparatus or viscometer. The instrument shall be accurately calibrated in a laboratory so that the specified viscosity of grout can be controlled satisfactorily.

The readings obtained during grouting shall be compared with the times determined in the laboratory for grouts of the specified viscosities.

The bleeding of grout shall be measured in a metal or glass container with an internal diameter of approximately 100 mm and a height of approximately 120 mm. The grout and water levels in the container shall be controlled with a metal bridge into which two adjustable studs A and B are secured.

The procedure for determining the bleeding of grout shall be as follows:

Studs A and B in the metal bridge shall be adjusted and locked so that the distance from the lower tips of studs to the bottom of the container will be approximately 100 mm and 107 mm respectively. The volumes V_a and V_b for the container at the respective levels of the stud settings shall then be

determined to the nearest millilitre.

The container shall be filled with freshly mixed grout to a level where the grout will just touch the tip of stud A which points downwards. The bridge shall then be removed and the container tightly sealed to prevent evaporation. The container shall then be stored at 20°C and kept free from vibrations for the entire duration of the test.

Three hours after the grout has been mixed, the container shall be opened and the free (bleed) water poured off. The bridge shall be placed over the container with tip of stud B pointing downwards and water poured onto the grout with measuring apparatus until the water level touches the tip of stud B. The volume of water added shall be determined to the nearest millilitre.

(c) Load Test on Foundation Piles

The head of the test pile shall be exposed for checking position and slope. Where necessary, the head shall be cut further back so as to expose a full bond length of main reinforcing steel, and a suitable pile head slab for applying an axial load to the pile shall be cast. As an alternative, the head may be cut at right angles and the load applied directly to the pile.

The test load shall be applied to the top of the pile with a hydraulic jack. Where more than one jack is used for applying the load, all the jacks in the circuit shall be activated by the same pumping unit. The jack (s) shall be placed so as to ensure that the load is applied axially.

The applied load shall be calculated in accordance with the hydraulic pressure which is being monitored by two pressure meters in the circuit. The pressure meter shall be calibrated in divisions not exceeding 2% of the maximum pressure applied, and the range of the meters shall not exceed 150% of the maximum pressure. The jack(s) and meters shall be calibrated by an approved testing laboratory not more than four weeks before the test commences.

The deflection of the pile head shall be measured with two scale rulers and two dial extensometers. The scale rulers shall be fixed to the pile and placed on both sides of the pile on a diameter line and the dial extensometers shall be similarly placed but on a diameter line at right angles to that on which the scale rulers have been mounted.

Level measurements shall be taken on the scale rulers and reduced as a level mark to a similar scale ruler placed at a distance from the test pile. All three scale rulers shall be calibrated in millimetres and the level – indicating instrument shall be capable of taking readings to 0.5 mm, and approximate readings of up to 0.1 mm.

The dial extensometers shall have a range of 50 mm and shall be marked in 0.1 mm divisions to enable measurements to 0.05 mm to be taken. The plungers of the extensometer shall rest on a machined metal or glass surface.

The extensometer shall be supported by one or more beams kept in the shade. The supports for the beams shall be so placed as to limit the effect of earth movements around the test pile on the deflection readings.

The test load shall be applied in increments of 20% of the specified working load to a maximum test load equal to twice the specified working load or the ultimate test load whichever is the smaller.

A load increment may not be applied before the subsidence, or the rate has stabilised at a rate of not more than 0.10 mm in 20 minutes under the load applied.

After the loading has been completed, the maximum test load shall be maintained until the movement is less than

0.2 mm within a period of 24 hours. The load shall be removed in decrements of 20% of the specified working load at intervals of not less than 20 minutes.

After the loading has been removed, the readings on both meters registering the movement of the pile shall be recorded accurately to 0.1 mm at intervals of 5, 10 and 20 minutes and then every 30 minutes until the load is changed. The final recovery shall be recorded 24 hours after the maximum test load has been removed.

During the test, the pile shall be loaded with up to 100% of the specified working load and the load shall then be removed. It shall then be loaded to the maximum test load after which the test load shall be removed.

7121 TESTS ON COMPLETION

The Contractor shall no later than 30 days prior to the likely completion of the Project, notify the Engineer of their intent to subject the Project to Tests and no later than 7 days prior to the actual date of Tests, furnish the Engineer with a detailed inventory and particulars of all works and equipment forming part of the Project.

The Contractor shall notify the Engineer of their readiness to subject the Project to Test at any time after 7 days from the date of such notice, and upon receipt of such notice, the Engineer shall determine the date and time for each Test.

(a) Visual Condition Inspection and Physical Tests

Visual condition inspections shall include the measurements of the following parameters: rutting, surface defects, cracks (all cracks and wide cracks greater than 3mm), conditions and drainage conditions.

The extent of inspections and measurements shall be as in TABLE 7121/1:

TABLE 7121/1: TYPES OF ROAD PROJECTS

Type	Interventions	Class of road
A	Upgrading, new construction, rehabilitation, reconstruction of paved roads	Expressways
		Class I, II, III paved standard national, urban roads
B		Other roads

(b) Tests and Test Frequencies

The required frequencies of testing shall be as in TABLE 7121/2:

(c) Acceptance Criteria

The criteria for acceptance of the road project shall be as in TABLE 7121/3.

TABLE 7121/2: TEST FREQUENCY

	Test No	Test (s)	Minimum test frequency (m)	
			Type A	Type B
Detailed condition surveys	(i)	Rutting, measured both sides in outer wheel path only	50	100
	(ii)	Surface defects patches, cracks, bleeding, loss of stones, potholes.	Continuously measured	
Structural surveys	(iii)	*DCP, the side with the highest rutting values	500	1000
	(iv)	Maximum surface deflection, measured on the side with highest rutting values, in outer wheel path only.	100	200
	(v)	**Test pits excavated to design depths or as directed by the Engineer. Sampling and testing of pavement materials	1000	2000
The test frequencies are the minimum acceptable.				
* DCP Tests may be conducted for unbound, modified and stabilised pavement layers where possible				
** Tests pits tend to be destructive and therefore may be done at the instruction of Engineer depending on the results of the other tests				
Test (i), (ii), (iv) shall be carried out as part of the tests on completion.				

TABLE 7121/3: PAVEMENT ACCEPTANCE CRITERIA

Parameter/Defect and unit of measurement		Traffic class	
		Less than 1MESA	Greater than 1MESA
Rutting, 90%-ile over a section (mm)		<10	<5
Surface defects (% of carriageway area)	Potholes	<0.01	<0.01
	All cracks	<10	<5
	Wide cracks (>3mm)	<5	<5
	Loss of stones (ravelling)	<5	<5
	Patches	<0.3	<0.2
Roughness, IRI (m/Km)		<3	<3
Max. Deflection-90%-ile over a section (mm)			
Granular base course		<0.7	<0.5
Lightly cemented base course		<0.55	<0.35

7122 MEASUREMENT AND PAYMENT

Payment for the Engineer's laboratory shall be in accordance with SECTION 1400.

ITEM	UNIT
71.01 SPECIAL TESTS REQUESTED BY THE ENGINEER	
(a) TESTS	PROVISIONAL SUM
(b) CONTRACTOR'S OVERHEAD AND PROFIT	PERCENTAGE (%)

The actual costs of special tests requested by the Engineer shall be reimbursed from the provisional sum entered in the Bill of Quantities for such tests. The Contractor's overhead and profit associated with arranging and paying for the tests shall be covered by a percentage of the actual costs.

SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

SECTION 7200: QUALITY CONTROL

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7201 SCOPE

This Section describes the scheme used for determining, by means of tests and measurements and by applying statistical judgement plans, whether certain specified requirements in regard to the properties of materials and workmanship are being complied with.

It also covers the requirements in regard to the control to be exercised by the Contractor for monitoring the quality of his work and materials and the routine tests and inspections to be carried out by the Engineer.

7202 JUDGEMENT PLANS: GENERAL

Certain requirements and nominal limit values are laid down in the Specifications in regard to the properties of materials and workmanship to be supplied. Tests shall be conducted and measurements taken for controlling the relevant properties of the workmanship and materials supplied, and the results of such tests and measurements shall be assessed on the basis of the prescribed criteria for compliance with the specified requirements.

Wherever possible, acceptance criteria shall be determined by way of statistical principles described in this Section. Wherever statistical acceptance criteria are deemed inappropriate in the opinion of the Engineer, a specified minimum requirement shall be fully complied with.

Despite acceptance of those properties judged by these statistical methods, the materials or work submitted will be rejected when other properties (which are not controlled by statistical methods) fail to comply with the requirements of the Specifications, or where there are other causes for rejection such as obviously defective workmanship or excessively variable properties, visible signs of poor workmanship, and similar considerations which constitute sufficient grounds for rejecting the work without any further testing in the opinion of the Engineer.

The Engineer shall be entitled to assess separately any specified portion of a lot if, in his opinion, it exhibits significant deviations as compared with the remainder of the lot.

7203 DEFINITIONS

The limit values will depend on the sample sizes and may be a lower limit L, an upper limit or double limits. For the purposes of this Section the following words and symbols shall have the following meanings:

(a) Lot

A lot is a sizeable portion of work or quantity of material which is assessed as a unit for the purpose of quality control and selected to represent material or work produced by essentially the same process and from essentially the same materials.

(b) Random Sample

Random samples are test measurements at separate test positions or on separate sample portions obtained from the lot in an unbiased manner.

(c) Nominal Value or Specification Limit

This is the limit value of the property of any material outside which not more than a specified percentage of the population of values representing an acceptable material is allowed to lie. The nominal value may be a single lower limit or a single upper limit or a double limit consisting of a lower limit and an upper limit.

(d) Acceptance Limit for Sample Mean

This is the limit value of a product property within which the sample mean shall lie for a product to be acceptable.

(e) Acceptance Limits for Individual Test Values

These are the limit values of a product property within which the sample values representing a product shall lie for the product to be acceptable.

(f) Conditional Acceptance

This is the acceptance of a lot under conditions that specific rectification measures are taken and carried through to completion to the satisfaction of the Engineer before the lot can be approved in the permanent Works and certified for payment. Conditional acceptance shall be subject to the provisions of CLAUSE 7202.

(g) Outliers

Where, in a sample, one or more test results differ significantly from the other values obtained, this difference could be ascribed to an assignable cause if so deemed by the Engineer, in which case such test result shall be regarded as an outlier and disregarded when assessing the lot.

7204 GENERAL REQUIREMENTS

(a) Determining the Lot Size

i) Road-Construction Layers

The lot size shall be a section compacted in one process where essentially the same materials and construction equipment have been used.

Where production is on a continuous basis, a lot shall normally mean the product of one day's work and shall not exceed the product of two full days' work. However, a lot of any smaller size may be ordered by the Engineer where:

- The properties under investigation exhibit abnormal local variation within the normal lot size;
- An area is obviously of a different quality than the rest;
- The rate of production is very high.

ii) Concrete

The lot size shall be determined by the Engineer, with due regard being given to the size and the type of structure in which the concrete is placed, the specific portion of the structure, and the total quantity of concrete placed in a day. The lot sizes in concrete structures could therefore vary considerably, and, particularly in the case of small structures, it could be necessary to combine

samples of the same grade of concrete from different structures at the discretion of the Engineer, provided that the concrete has been obtained from the same concrete plant and has been cast in the same period.

iii) Other

In certain cases, as for example in material stockpiles, others where the definition of a lot in accordance with this Section does not apply directly in the opinion of the Engineer, the Engineer will determine lot sizes in accordance with circumstances pertaining to each case.

(b) Random Sampling

When any lot is tested whether a normally sized lot or an isolated section that clearly exhibits an abnormal variation of the properties under consideration, all samples shall be taken in a random pattern.

For this purpose, use shall be made of tables of random numbers according to standard instructions approved by the Engineer.

(c) Sample Sizes

For purposes of acceptance control, the Engineer will determine sample size, i.e. the number of values to be assessed in a lot.

(d) Outliers

Test results shall be scanned for possible outliers. Where there is reason to believe that a test result may be erroneous, it shall, if possible, be re-examined by further testing, and, if there is reasonable evidence to suggest that the test result is erroneous, it shall be regarded as an outlier, rejected and replaced with a fresh result.

Where reinvestigation of a test result is not possible, the procedure described below shall be used for identifying outliers:

Calculate the value of T_o from:

$$T_o = \frac{abs(X_o - \bar{X}_n)}{S_n}$$

Where $\bar{X}_n$ and S_n are the arithmetic mean and the sample standard deviation respectively, and X_o is the value of the test differing most from the mean.

Compare the value of T_o with the value of T for the applicable value of n from TABLE 7204/1.

If T_o is greater than T , then X_o is an outlier.

Every outlier shall be disregarded and replaced by another random test value. The sample mean and the sample standard deviation shall then be recalculated. If an outlier cannot be replaced, the sample mean and the standard deviation shall be calculated using the remaining test results. The final number of test results used in the assessment, after the elimination of outliers, shall never be less than three.

(e) Resubmission

Where a lot has been accepted conditionally, or has been rejected, the Engineer may agree to its resubmission for approval if it has been rectified to the satisfaction of the Engineer. In such case a fresh sample shall be taken, and a fresh (second) set of test values determined.

The first and second sets of test values shall then be compared with each other to determine whether their properties differ significantly.

Where in the opinion of the Engineer a significant difference does occur, the submission of the lot shall be regarded as a first submission and assessed as such,

and only the second set of test values shall then be used for this purpose.

TABLE 7204/1: VALUES OF T FOR DIFFERENT SAMPLE SIZES

Number of Observations n	Critical Value T
1	
2	
3	
4	1.46
5	1.67
6	1.82
7	1.94
8	2.03
9	2.11
10	2.18
11	2.23
12	2.29
13	2.33
14	2.37
15	2.41
16	2.44
17	2.47
18	2.5
19	2.53
20	2.56

7205 PROCEDURES

(a) General

The statistical judgement procedures described below shall apply to the corresponding product properties for the purpose of acceptance control. Outliers shall be identified, disregarded, and, if possible, replaced at the discretion of the Engineer.

(b) Straight Edge Measurements

Six straightedge measurements shall be taken in the longitudinal direction and six measurements shall be taken in the transversal direction every 25 m along the road or as otherwise directed by the Engineer. The measurements shall be taken at offsets as agreed with the Engineer. All measurements taken shall fall within the limits given in TABLE 7118/1 including the requirement for surface dressing.

(c) Surface Levels

At least 5 points across the road width shall be taken every 25 m. The levels shall be taken at the centreline, at the edge of the carriageway and at the edge of the shoulders or as directed by the Engineer. The levels may be taken at shorter intervals than 25 m, see CLAUSE 7303.

At least 50, but preferably more, levels shall be determined for each lot of completed work. The lot will be considered to comply with the requirements in respect of surface levels if, before any repair work is undertaken, at least 90% of the level measurements show a deviation from the specified levels which is smaller than the tolerance specified in TABLE 7118/2 and no measurements fall outside the maximum allowed deviation H_{max} .

Isolated spots, where the surface levels deviate by more than the appropriate tolerance of the specified levels

shall be repaired to bring the deviation to within the tolerance.

(d) Crossfall and Longitudinal Slope

All measurements of crossfall and longitudinal slope as directed by the Engineer shall fall within the limits given in TABLE 7118/3.

Isolated spots, where the crossfall and longitudinal slope deviate by more than the appropriate tolerance of the specified crossfall shall be repaired to bring the deviation to within the tolerance.

(e) Layer Thickness

At least 20, but preferably more, layer thickness shall be determined in accordance with a stratified random pattern (as defined in SUB-CLAUSES 7203 (b) AND 7204 (b)) for each lot of completed layer work. Layer thickness may not be determined by means of level measurements, but shall be measured by core drilling or excavation of sample pits at locations approved by the Engineer.

The lot will be considered to comply with the requirements for layer thickness if both the following conditions are fulfilled:

- At least 90% of all the thickness measurements taken before any thickness repairs are made are equal to or greater than the specified nominal thickness, minus the T_{90} tolerance specified in TABLE 7118/4.
- The mean layer thickness of the lot is not less than the specified nominal thickness

(f) Relative Compaction of Earthworks and Pavement Layers

At least the following number of relative density determinations shall be taken in a random pattern (as defined in SUB-CLAUSES 7203 (b) AND 7204 (b)) on each section or as directed by the Engineer and assessed as a lot:

• Roadbed, fill:	3 tests
• Improved subgrade layers, gravel wearing course:	4 tests
• Subbase:	5 tests
• Base course, surfacing:	6 tests

After outliers have been examined and replaced as directed by the Engineer, compliance with the specified density requirements shall be determined by the statistical method specified below unless a fixed minimum average value and/or absolute minimum value has been specified for the compaction elsewhere in these Specifications.

The lot will be considered to comply with the requirements for field density if the following conditions are fulfilled:

(1) For a lower limit specification, LL_s

$$X_n > LL_s + S_n * K$$

Accept the lot if the sample mean satisfies the expression, otherwise reject the lot.

(2) For an upper limit specification, UL_s

$$X_n < UL_s - S_n * K$$

Accept the lot if the sample mean satisfies the expression, otherwise reject the lot.

(3) For a double limit specification, LL_s and UL_s

$$LL_s + S_n * K < X_n < UL_s - S_n * K$$

Accept the lot if the sample mean satisfies the expression, otherwise reject the lot.

Where:

X_n is the arithmetic mean of a set of n test results constituting the sample.

S_n is the sample standard deviation defined by:

$$S_n = \left(\frac{\sum (X - \bar{X}_n)^2}{n - 1} \right)^{0.5}$$

Where:

X is the value of an individual sample portion, i.e. an individual test result or measurement.

n is the number of sample portions, i.e. the number of individual test results or measurements.

K is a statistical constant defined by:

$$K = \frac{t}{\sqrt{n}}$$

Where:

t is the Student's t .

The value of K is dependent on the number of sample portions in the sample and the acceptance criteria. The acceptance criteria normally used where statistical control of materials and workmanship are applied is that the specification limit, L_s is satisfied for more than 90% of the lot and that the risk of accepting a lot that does not satisfy the specified requirement is less than 10%.

The value of K determined according to the above criteria is given in TABLE 7205/1.

(g) Cementitious Binder Content of Cemented Layers

i) Method

- Take 50 samples according to a random pattern (as defined in SUB-CLAUSES 7203 (b) AND 7204 (b)) and determine their cementitious binder content.
- Examine the results for outliers and replace them if any in the opinion of the Engineer.

ii) Analysis

The lot will be considered to comply with the requirements for cementitious binder content if the following conditions are both fulfilled:

- The mean cementitious-binder content shall be not less than 91% of the specified binder content.
- The cementitious binder content in not more than 12 of the 50 samples may be lower than 70% of the specified binder content.

TABLE 7205/1: VALUES OF STUDENT'S T AND K FOR DIFFERENT SAMPLE SIZES

n	Student's t	$K = \frac{t}{\sqrt{n}}$
3	1.89	1.09
4	1.64	0.82
5	1.53	0.68
6	1.48	0.60
7	1.44	0.54
8	1.42	0.50
9	1.40	0.47
10	1.38	0.44
11	1.37	0.41
12	1.36	0.39
13	1.36	0.38
14	1.35	0.36
15	1.34	0.35
16	1.34	0.34
17	1.34	0.32
18	1.33	0.31
19	1.33	0.31

(h) Binder Content of Bituminous Mixes**i) Method**

- Take at least four specimens of bituminous mix in a random pattern (as defined in SUB-CLAUSES 7203 (b) AND 7204 (b)) and determine the binder content.
- Examine the results and replace any outliers as directed by the Engineer. Determine the sample mean and assess the lot by using the following criteria.

ii) Analysis

The binder content of bituminous mixes shall not deviate from the specified binder content by more than the values given in TABLE 7205/2 or according to the Special Specifications.

TABLE 7205/2: ACCEPTANCE LIMITS FOR BITUMINOUS BINDER CONTENT IN MIXES

Number of Tests in Lot	Maximum Deviation from the Specified Binder Content (%)	
	Sample Mean	Single Values
2	0.37	0.54
3	0.33	0.58
4	0.30	0.60
5	0.28	0.62
6	0.27	0.64
7	0.26	0.65
8 or more	0.25	0.66

(i) Concrete Compressive Strength, 28-day**i) Method**

Take at least the minimum number of samples as given in TABLE 7205/3 according to a random pattern (as defined in SUB-CLAUSES 7203 (b) AND 7204 (b) and make test specimen. Test them for compressive strength after 28 days.

TABLE 7205/3: MINIMUM NUMBER OF TESTS OF STRUCTURAL CONCRETE FOR COMPRESSION STRENGTH

Volume of Lot (m³)	Minimum Number of Tests in Lot
0 – 20	4
21 – 40	6
41 – 70	9
71 – 100	12
101 – 150	14
> 150	16

Each test consists of the average value of a set of three specimens.

ii) Analysis

Examine the results for outliers and disregard as required in the opinion of the Engineer. The results are then assessed according to the criteria set out below. A lot will comply with the requirements for the characteristic strength denoted **X**, if it meets the following requirements by using the acceptance factors **A** and **B** given in TABLE 7205/4:

- Mean value: minimum (**X** + **A**)
- Single test value: minimum (**X** - **B**)

TABLE 7205/4: ACCEPTANCE FACTORS FOR THE STRENGTH OF STRUCTURAL CONCRETE

Number of Tests in Lot	Acceptance Factors for Strength of Structural Concrete	
	A (MPa)	B (MPa)
3	2.7	3.9
4	2.7	4.2
5	2.6	4.5
6	2.5	4.7
7	2.4	4.9
8	2.3	5.0
9	2.2	5.2
10	2.1	5.3
11	1.9	5.4
12	1.7	5.5
13	1.4	5.6
14	1.1	5.7
15	0.5	5.8

7206 CONDITIONAL ACCEPTANCE**(a) General**

Where a lot is rejected under a statistical judgement plan described in this Section, but the test results are such that the lot complies with the requirements for conditional acceptance specified in this Clause, the Engineer may accept the lot conditionally. The Engineer may then apply a number of conditions for rectification of the layer at his own discretion for the product to be approved and certified for payment. Conditional acceptance shall be the sole discretion of the Engineer and is not an option which may be exercised by the Contractor or a right he may claim.

The Contractor shall have the option to remove and reinstate completely at his own cost, conditionally accepted work with work which complies with the requirements.

(b) Application

Conditional acceptance may be applied in respect of the properties of structures as shown in TABLE 7206/1 and/or as specified by the Engineer in accordance with the provisions of the contract.

(c) Criteria

When properties to which conditional acceptance may apply are assessed in accordance with this Section, two requirements shall always apply, viz one in relation to the sample mean and one in relation to individual test values. A lot may be conditionally accepted when it complies with one of the two requirements for acceptance, but not with the second requirement provided that it complies with the requirements for conditional acceptance in relation to the second requirement.

TABLE 7206/1: PROPERTIES TO WHICH CONDITIONAL ACCEPTANCE MAY APPLY

Property	Structure
Relative compaction	- Bituminous Base/ Binder Course or Surfacing Course - Cemented Layers - Granular Layers - Gravel / Earthwork Layers - Any Plant Mixed; Paver Laid Layers
Bituminous Binder Content	Layers of Bituminous Mixes & Recycled Bituminous Mixes
Cementitious Binder Content, 3- & 7-days Cube Strength	Cemented Layers
28-day Cube Strength	All Structural Concrete (except Concrete Pavements)
Application/ Spray Rate	Surface Treatments – Surfacing Seals, Surface Dressing, Otta Seals, Sand Seals, Sand Capping, Grit Seals, Surfacing of Bridge Deck, Crack Seal, Tack Coat, Prime Coat, etc.
Levels	Earthworks and Pavement Layers
Layer Thickness	Earthworks and Pavement Layers

(d) Resubmission

Where a lot has been accepted conditionally or has been rejected, the Engineer may agree to its resubmission for approval if it has been reworked and the Engineer is satisfied that a proper attempt was made to improve the properties which were unacceptable. A fresh sample shall be taken, and a fresh (second) set of test values determined. The first and second sets of test values shall then be compared with each other to determine whether their properties differ significantly. Where in the opinion of the Engineer a significant difference does occur, the submission of the lot shall be regarded as a first submission and assessed as such, and only the second set of test values shall then be used for this purpose.

7207 ROUTINE TESTS AND INSPECTION BY THE ENGINEER

The Engineer will at regular intervals inspect and test materials and completed work for compliance with the specified requirements, and, where applicable the various specified judgement plans will be applied. The testing frequencies and sample and lot sizes for routine testing shall be at the Engineer's discretion.

All sections of completed work shall be submitted to the Engineer for routine inspection and testing, and the Contractor shall not cover up or construct any work on top of sections of completed work before being advised by the Engineer of the outcome of his tests and inspection. The Contractor shall arrange the submission of work for testing in a manner that will afford the Engineer reasonable opportunity for inspecting and

testing.

7208 PROCESS CONTROL BY THE CONTRACTOR

The requirements of CLAUSE 1205 shall apply in respect of the Contractor's obligation to institute and implement a control system for monitoring the quality of the work and materials supplied.

For continuous concrete and asphalt-production processes, the Engineer may order the Contractor to augment the above control system by introducing a process-control system for monitoring the various properties to be controlled. The specific system to be applied shall be subject to the Engineer's approval, and the attention of the Contractor is drawn to the systems described in TRH5, which will normally be regarded as suitable.

The Contractor shall take immediate steps to rectify any deviation from the specified requirements indicated by his process-control system, and the Engineer shall have the right to inspect and be given all details of tests and testing procedures in order to satisfy himself that the Contractor is implementing an adequate process-control system.

7209 MEASUREMENT AND PAYMENT

No separate measurement or payments apply to this Section.

SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

SECTION 7300: SETTING OUT AND TOLERANCES

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7302 GENERAL	7000-20
7303 DETAILED SETTING OUT	7000-20
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7301 SCOPE

This Section covers the procedures for setting out and gives the limits for geometric tolerances for earthworks and layer work.

7302 GENERAL

The Engineer will provide sufficient basic survey information to enable the Contractor to set out the works and the Contractor shall be responsible for setting out all necessary reference points and for the maintenance thereof.

The Contractor shall satisfy himself as to the accuracy in line, level and dimension of the basic survey and setting out details provided and should the Contractor discover any error in the information provided by the Engineer, he should at once notify the Engineer. If the information is confirmed to be in error the Engineer will issue amended drawings or instructions regarding the correction of the error.

Prior to commencing construction, the Contractor shall establish the road reserve boundary posts, or if no boundary posts are instructed, then the Contractor shall establish reference points to define the road reserve at 100 m intervals on both sides.

The Contractor shall establish temporary benchmarks along the road at intervals not exceeding 200 m and shall provide the Engineer with a schedule of their levels and locations.

The Contractor shall not remove, damage, alter or destroy in any way plot beacons or survey beacons. Should the Contractor consider that any beacon will be interfered with by the works, he shall notify the Engineer who, if he considers necessary, will make arrangements for the removal and replacement of the beacon.

If the Contractor removes or disturbs a beacon without permission of the Engineer, he shall be liable for the full cost of its replacement and any legal consequences thereof.

7303 DETAILED SETTING OUT

The Contractor shall set out the line and level of the works at intervals of not more than 20 m or such lesser intervals as are required to construct the Works to the tolerances specified in this Specification. Reference pegs and batter rails clearly and indelibly marked with all the relevant information shall be provided clear of the road and at right angles to it from which the centreline, level and batter slope can be directly established at any time. These shall be maintained by the Contractor for as long as they are needed to check the work.

After completion of the setting out and site clearance, the Contractor shall take ground cross-sections at intervals of 20 m along the road centreline and along the

centreline of all culverts and structures. These shall be plotted to a natural scale of 1:100 on a stable transparent material or other approved material and a copy of the plot shall be submitted to the Engineer for agreement. If the Contractor fails to take requisite levels, levels determined by the Engineer shall be taken as correct.

The Contractor shall programme for a period of 30 days between submitting the ground cross sections and being issued with final road, culvert and structure levels. A minimum 5 km section of road shall be submitted, but where the Contractor submits cross-sections for more than 10 km of road within the same 30-day period the initial 30 days shall be extended by 30 days for each additional 10 km or part thereof. Final road, culvert or structure levels will be determined by the Engineer and may be different from the levels shown on the Drawings.

On receipt of the final road levels the Contractor shall mark up the details on the transparencies and the original and one print of the cross-sections shall be provided free of charge by the Contractor for the Engineer.

On completion of the earthworks but before starting formation or pavement layers, the Contractor shall establish steel pins at a constant offset to the edges of the carriageway shoulders. The offset may however vary between sections in cut and those in fill. The steel pins will be clearly and indelibly marked with all the relevant information necessary to directly establish the centreline and level at any point across the carriageway by using either boning rods or a string line.

The interval between pins shall not be more than 10 m and the pins shall be maintained by the Contractor for as long as they are needed by the Engineer to check the work.

7304 TOLERANCES

(a) General

In addition to the requirements set out in this Clause attention is drawn to the requirements of CLAUSE 7118 which shall all be fulfilled.

(b) Horizontal Alignments

Horizontal alignments shall be determined from the centreline of the pavement surface as constructed, and all other parallel alignments shall be corrected within a tolerance of ± 10 mm therefrom.

(c) Thickness of Pavement Layers

The thickness of any pavement layer as specified or ordered by the Engineer, measured at five points in any length of 100 m, shall meet the requirements given in TABLE 7118/4.

(d) Surface Levels of Pavement Layers and Formation

The level measured at any point on the surface of a pavement layer, or the formation level shall not deviate from the corresponding level calculated from the Drawings by more than the tolerances shown in TABLE 7118/2.

For checking compliance with TABLE 7118/2 measurements of surface levels will be taken at points to be selected by the Engineer at 10 m centres longitudinally and at 2 m centres transversely. At junctions, the grid point spacing shall be determined by the Engineer.

(e) Surface Regularity

The surface regularity of pavement layers and the formation shall be tested at points decided by the Engineer with a rigid, 3 m long steel straightedge placed at any angle to the centreline of the road. The maximum

allowable deviation of the surface below the straightedge shall be as given in TABLE 7118/1.

In addition, the longitudinal slope or transverse crossfall shall not deviate from that shown on the Drawings by more than the tolerances given in TABLE 7118/3.

(f) Shoulders

Shoulders shall be constructed to the same thickness, level and surface regularity requirements as for the adjacent pavement layers.

(g) Cutting and Embankment Slopes

In the final trimmed slope of cuttings, a tolerance of +0.25 will be permitted, i.e. if a slope of 1 in 2 is specified, the acceptable slope shall be not steeper than 1 in 2 or slacker than 1 in 2.25

In the final trimmed slopes of embankments, a tolerance of +0.25 will be permitted, i.e. if the specified slope is 1 in 2, the acceptable slope shall be not steeper than 1 in 2 or slacker than 1 in 2.25.

(h) Width of Cuttings and Embankments

The tolerance permitted in the width of the bottom of cuttings shall be 200 mm between the centreline of the road and the toe of the cutting slope.

The width of embankments measured as the horizontal distance from the centreline of the road to the top of the embankment shall not be less than that shown on the Drawing or more than that shown on the Drawings plus 0.25 m.

(i) Depth of Side Drains

The depth of side drains measured as the vertical height difference from the centreline of the finished pavement and the invert of the side drain shall not be less than that shown on the Drawings nor more than that shown on the Drawings plus 0.15 m.

(j) Construction Control Testing

Unless otherwise, directed values given in this Specification are minimum values and the workmanship will only be considered satisfactory if all tests, taken at the frequency specified in SECTION 7100 of this Specification are at least equal to those specified in the relevant section.

7305 MEASUREMENT AND PAYMENT

No separate payment shall be made for work described in this Section.

SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

SECTION 7400: RECTIFICATION OF EARTHWORKS AND PAVEMENT LAYERS OUTSIDE PERMITTED GEOMETRIC TOLERANCES

CONTENTS:

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7402 RECTIFICATION MEASURES	7000-22
7403 MEASUREMENT AND PAYMENT	7000-22

7401 SCOPE

This Section sets out the methods for rectification of earthworks and pavement layers constructed outside permitted geometric tolerances. Where any tolerances in SECTION 7300 are exceeded, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the pavement course, earthworks or formation in the manner described below.

7402 RECTIFICATION MEASURES

(a) Earthworks Excluding Improved Subgrade Layers

Where a cutting slope is steeper, and an embankment slope is slacker, than the specified slope then the slope shall be trimmed to the specified slope. Where a cutting slope is slacker, and an embankment slope is steeper, than the specified slope then the slope shall be benched and fill material placed and compacted and the slope shall be trimmed all in accordance with the requirements of SERIES 3000 and any other relevant part of this Specification.

Where the width of a cutting is less than, and the width of an embankment more than, the specified width then the cutting or embankment shall be trimmed to the specified width. Where the width of a cutting is more than, and the width of an embankment is less than, the specified width then the embankment or cutting shall be benched and fill material placed and compacted and the slopes shall be trimmed all in accordance with the requirements of this Specification.

Where the depth of a side drain is less than that specified, the side drain shall be trimmed to the specified depth. Where the depth of a side drain is more than specified, the side drain shall be backfilled with fill material compacted to a dry density of at least 90% MDD of BS-Heavy up to the specified depth.

Where the results of the construction control tests are less than that specified, the full depth of the layer shall be reworked to specification. The area treated shall be the whole section submitted for approval or, following a retest, a length of at least 50 m both sides of each test and retest failure or such area to be determined by the Engineer as necessary to obtain compliance with this Specification.

(b) Improved Subgrade Layers

Where the levels or widths are out of tolerance, then the full depth of the layer shall be reworked to specification. The area treated shall be at least 12.5 m long and 3 m wide or such area to be determined by the Engineer as

necessary to obtain compliance with this Specification.

Where the results of the construction control tests are less than that specified, the full depth of the layer shall be reworked to specification. The area treated shall be the whole section submitted for approval or following a retest, a length of at least 50 m on both sides of each test and retest failure.

(c) Base Course and Subbase

Where the levels or widths are out of tolerance and the courses consist of unbound (i.e. natural or graded stone) material, the full depth of the material shall be reworked to specification. The area treated shall be at least 30 m long and 3 m wide or such area as determined by the Engineer as necessary to obtain compliance with this Specification.

Where the courses consist of cement or lime treated material or lean concrete, the full depth of the layer shall be removed from the pavement and replaced to specification. The area treated shall be at least 5 m long and the full width of the paving laid in one operation. If areas are corrected within 7 days of laying, no construction traffic or compaction plant shall use the surrounding satisfactory areas during that period.

For bituminous bases, the full depth of the layer shall be removed and replaced with fresh material laid and compacted to specification. Any area so treated shall be at least 5 m long and the full width of the paving laid in one operation.

Where the results of the construction control tests for any of the base or subbase materials are less than that specified, the full depth of the layer shall be reworked to specification in case of unbound material and removed and replaced to specification in case of cemented and bituminous materials. The area treated shall be the whole section submitted for approval or, following a retest, such area to be determined by the Engineer as necessary to obtain compliance with the Specification.

(d) Surface/ Wearing Course

Where the levels or widths are out of tolerance, the full depth of the layer shall be removed and replaced with fresh material laid and compacted to specification. The area rectified shall be the full width of the paving laid in one operation and at least 15 m long.

Where the results of the construction control tests for the wearing course are less than that specified, the full depth of the layer shall be removed and replaced to specification. The area treated shall be the whole section submitted for approval or, following a retest, such area to be determined by the Engineer as necessary to obtain compliance with the Specification.

7403 MEASUREMENT AND PAYMENT

The Contractor shall be deemed to have allowed in his general rates and prices for the cost of complying with the requirements in this Section and no additional payment will be made.

SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

**SECTION 7500:
SPECIFICATIONS AND TEST
METHODS**

CONTENTS:

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7501	REFERENCE AUTHORITIES	7000-23
7502	STANDARDS AND TEST METHODS	7000-23
7503	ADDRESSES	7000-42

- American Society for Testing and Materials (ASTM)
- British Standards Institute (BS)
- European Standards (BS EN)
- Standard Coordination Specification (CKS)
- Deutsche Ingenieur Norme (DIN)
- South African National Standards (SANS),
- Southern African Bitumen and Tar Association (SABITA)
- Swedish Standard (SIS)
- Technical Methods for Highways (TMH)
- Technical Recommendations for Highways (TRH)
- International Standards Organisation (ISO)
- Uganda National Accreditation Services

7502 STANDARDS AND TEST METHODS

(a) Test Methods

7501 REFERENCE AUTHORITIES

- Ministry of Works and Transport, Uganda.
- Uganda National Bureau of Standards (UNBS)
- American Association of State Highway and Transport Officials (AASHTO)

i) Tests on Soils and Gravel:

Name of Test	Standard Test Method	Name of Code
Moisture Content	BS 1377-2: 2022, BS EN ISO 17892-1:2014+A1:2022	Methods of Test for Soils for Civil Engineering Purposes
Liquid Limit (Cone Penetrometer)	BS 1377: Part 2:2022, BS EN ISO 17892-12:2018+A1:2021	Methods of Test for Soils for Civil Engineering Purposes
Plastic Limit & Plasticity Index	BS 1377: Part 2:2022, BS EN ISO 17892-12:2018+A2:2022	Methods of Tests for Soils for Civil Engineering Purposes
Linear Shrinkage	BS 1377-2: 2022, ASTM D4943-18	Methods of Test for Soils for Civil Engineering Purposes
Particle Density Determination – Pycnometer	BS 1377-2:2022, BS EN ISO 17892-3:2015	Methods of Test for Soils for Civil Engineering Purposes
Bulk Density for Undisturbed Samples	BS 1377-2: 2022, BS 1377-1:2016	Methods of Test for Soils for Civil Engineering Purposes
Determination of Dry Bulk Density	BS EN ISO 11272:2017	Soil Quality - Determination of Dry Bulk Density
Particle Size Distribution	BS 1377-2: 2022 BS EN ISO 17892-4:2016	Methods of Test for Soils for Civil Engineering Purposes
Particle Size Distribution - Hydrometer Method	BS 1377-2: 2022 BS EN ISO 17892-4:2016	Methods of Test for Soils for Civil Engineering Purposes
Compaction Test - BS Light and BS Heavy	BS 1377-2: 2022	Methods of Test for Soils for Civil Engineering Purposes
Unsoaked CBR Test - One Point Method	BS 1377-2: 2022	Methods of Test for Soils for Civil Engineering Purposes
Unsoaked CBR Test - Three-Point Method	BS 1377-2: 2022	Methods of Test for Soils for Civil Engineering Purposes
Soaked CBR Test - One Point Method	BS 1377-2: 2022	Methods of Test for Soils for Civil Engineering Purposes
Soaked CBR Test - Three-Point Method	BS 1377-2: 2022	Methods of Test for Soils for Civil Engineering Purposes
Consolidation Test - Oedometer	BS 1377-2: 2022	Methods of Test for Soils for Civil Engineering Purposes
	BS EN ISO 17892-5:2017	Geotechnical investigation and testing. Laboratory testing of soil. Incremental loading oedometer test
Triaxial Test	BS 1377-2: 2022 BS EN ISO 17892-8:2018 and BS EN ISO 17892-9:2018	Methods of Test for Soils for Civil Engineering Purposes. Geotechnical investigation and testing. Laboratory testing of soil. Unconsolidated undrained triaxial test (UU, CD and CU tests)
Shear Box Test	BS 1377-2: 2022 BS EN ISO 17892-10:2018	Methods of Test for Soils for Civil Engineering Purposes
Permeability Test - Constant Head	BS 1377-2: 2022	Methods of Test for Soils for Civil Engineering Purposes
	BS EN ISO 17892-11:2019	Geotechnical Investigation and Testing — Laboratory Testing of Soil - Part 11: Permeability Test

Name of Test	Standard Test Method	Name of Code
Organic Content - Ignition Loss Method	BS 1377-3:2018+A1:2021	Methods of Test for Soils for Civil Engineering Purposes Chemical and Electro-Chemical Testing
Crumb Test	BS 1377-2: 2022	Methods of Test for Soils for Civil Engineering Purposes
Ph Value (Ph Meter)	BS 1377-3:2018+A1:2021	Methods of Test for Soils for Civil Engineering Purposes Chemical and Electro-Chemical Testing
Sulphate Carbonate Content	BS 1377-3:2018+A1:2021	Methods of Test for Soils for Civil Engineering Purposes Chemical and Electro-Chemical Testing
Chloride Content	BS 1377-3:2018+A1:2021	Methods of Test for Soils for Civil Engineering Purposes Chemical and Electro-Chemical Testing
Durability Test	BS 1377-2:2022 BS EN ISO 17892-11:2019 BS EN ISO 17892-5:2017	Methods of test for soils for civil engineering purposes. Compressibility, permeability and durability tests
		Methods of Test for Soils for Civil Engineering Purposes, Geotechnical Investigation and Testing — Laboratory Testing of Soil - Part 11: Permeability Test & Geotechnical investigation and testing. Laboratory testing of soil. Incremental loading oedometer test
Field Density	BS 1377: Part 9: 1990	Methods for test for soils for civil engineering purposes. In-situ tests
In Situ Tests: Sand Replacement, CBR Testing, Vane Shear Strength, Cone Penetrometer and Plate Bearing Test	BS 1377: Part 9: 1990	Methods for test for soils for civil engineering purposes. In-situ tests
	BS EN ISO 22476-1:2023	Geotechnical investigation and testing. Field testing. Electrical cone and piezocone penetration test
	BS EN 1997-2:2007	Eurocode 7. Geotechnical design. Ground investigation and testing
	BS EN ISO 22476-2:2005+A1:2011	Geotechnical investigation and testing. Field testing. Dynamic probing
Sampling, Sample Preparation and Tests on Materials Before Stabilisation	BS 1924: Part 1: 2018	Hydraulically Bound and Stabilized Materials for Civil Engineering Purposes Sampling, Sample Preparation and Testing of Materials Before Treatment
Preparation of Stabilised Samples for UCS	BS1924: Part 2:2018	Hydraulically Bound and Stabilized Materials for Civil Engineering Purposes Sample Preparation and Testing of Materials During and after Treatment
Compaction Test and UCS of Stabilised Materials	BS1924: Part 2:2018	Hydraulically Bound and Stabilized Materials for Civil Engineering Purposes Sample Preparation and Testing of Materials During and After Treatment
Initial Consumption of Lime - ICL	BS 1924: Part 2:2018	Hydraulically Bound and Stabilized Materials for Civil Engineering Purposes Sample Preparation and Testing of Materials During and After Treatment
	ASTM D6276 - 19	Standard Test Method for Using pH to Estimate the Soil-Lime Proportion Requirement for Soil Stabilization
Quicklime, Hydrated Lime and Natural Calcium Carbonate-Methods of Physical Testing	BS 6463-103:1999	Quicklime, hydrated lime and natural calcium carbonate. Methods for physical testing
Methylene Blue Index of Clay	ASTM C837 - 09(2019)	Standard Test Method for Methylene Blue Index of Clay
Sand Equivalent Value of Soils and Fine Aggregate	ASTM D2419 - 22	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
One Dimensional Swell or Settlement Potential of Cohesive Soils	ASTM D4546 - 21	Standard Test Methods for One-Dimensional Swell or Collapse of Soils

ii) Tests on Aggregates

Name of Test	Standard Test Method	Name of Code
Guide to Sampling and Testing Aggregates	BS EN 932-6:1999	Tests For General Properties of Aggregates Definitions of Repeatability and Reproducibility
Methods of Sampling of Aggregates	US EAS 131-1:2008	Concrete Specification
	BS EN 932-1:1997	Tests for general properties of aggregates. Methods for sampling
Determination of Physical Properties of Aggregates	US EAS 131-1:2008	Concrete Specification
Moisture Content of Aggregates	BS EN 1097-5:2008	Tests for mechanical and physical properties of aggregates. Determination of the water content by drying in a ventilated oven
Relative Density	BS EN 1097-3:1998	Tests For Mechanical and Physical Properties of Aggregates Determination of Loose Bulk Density and Voids
	ASTM C128 - 22	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate
Determination of Loose Bulk Density and Air Voids / Bulk Density ("Unit Weight") And Voids in Aggregate	BS EN 1097-3:1998	Tests For Mechanical and Physical Properties of Aggregates Determination of Loose Bulk Density and Voids
	ASTM C29/C29M - 23	Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
	AASHTO T 19M/T 19: 2022	Standard Method of Test for Bulk Density ("Unit Weight") and Voids in Aggregate
Water Absorption	BS EN 1097-3:1998	Tests For Mechanical and Physical Properties of Aggregates Determination of Loose Bulk Density and Voids
	BS EN 1097-6:2022	Tests for mechanical and physical properties of aggregates. Determination of particle density and water absorption
Determination of Voids of Dry Compacted Filler	BS EN 1097-4:2009	Tests For Mechanical and Physical Properties of Aggregates Determination of The Voids of Dry Compacted Filler
Determination of Resistance to Wear by Abrasion from Studded Tyres – Nordic Test	BS EN 1097-9:2014	Tests For Mechanical and Physical Properties of Aggregates Determination of The Resistance to Wear by Abrasion from Studded Tyres. Nordic Test
Sieve Tests on Aggregates	BS 812: Part 103.2:1989	Testing aggregates. Method for the determination of particle size distribution. Sedimentation test
Flakiness Index (FI)	BS EN 933-3:2012	Tests for geometrical properties of aggregates. Determination of particle shape. Flakiness index
Average Least Dimension (ALD)	US 144:2000 or BS EN 933-3:2012	Tests for geometrical properties of aggregates. Determination of particle shape. Flakiness index
Particle Shape Index	US 144:2000 or BS EN 933-4:2008	Tests for geometrical properties of aggregates. Determination of particle shape. Shape index
Aggregate Crushing Value (ACV)	BS 812-110:1990	Testing aggregates. Methods for the determination of aggregate crushing value (ACV)
	BS EN 1097-2:2020	Tests for mechanical and physical properties of aggregates. Methods for the determination of resistance to fragmentation
Ten Percent Fines Value (TFV)	BS 812-111:1990	Testing aggregates. Methods for the determination of ten per cent fines value (TFV)
	BS EN 1097-2:2020	Tests for mechanical and physical properties of aggregates. Methods for the determination of resistance to fragmentation
Aggregate Impact Value (AIV) - Standard	BS 812-112:1990	Testing aggregates. Method for the determination of aggregate impact value (AIV)
	BS EN 1097-2:2020	Tests for mechanical and physical properties of aggregates. Methods for the determination of resistance to fragmentation
Aggregate Impact Value (AIV) - Modified	BS 812-112:1990	Testing aggregates. Method for the determination of aggregate impact value (AIV)
	BS EN 1097-2:2020	Tests for mechanical and physical properties of aggregates. Methods for the determination of resistance to fragmentation
Los Angeles Abrasion Test (LAA)	ASTM C535 – 16	Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
	BS EN 1097-2:2020	Tests for mechanical and physical properties of aggregates. Methods for the determination of resistance to fragmentation
Polished Stone Value (PSV)	BS 812-114:1989	Testing aggregates. Method for the determination of the polished-stone value
	BS EN 1097-	Tests for mechanical and physical properties of aggregates. Determination of the

Name of Test	Standard Test Method	Name of Code
	8:2020	polished stone value
Determination of Percentage of Crushed & Broken Surfaces in Coarse Aggregate Particles	BS EN 933-5:2022	Tests for geometrical properties of aggregates. Determination of the percentage of crushed particles in coarse and all-in natural aggregates
Determination Of Shell Content - Percentage Shells in Coarse Aggregate	BS EN 933-7:1998	Tests for geometrical properties of aggregates. Determination of shell content. Percentage of shells in coarse aggregates
	BS EN 933-10:2009	Tests for geometrical properties of aggregates. Assessment of fines. Grading of filler aggregates (air jet sieving)
Determination of Resistance to Wear (Mico-Deval)	BS EN 1097-1:2023	Tests for mechanical and physical properties of aggregates. Determination of the resistance to wear (micro-Deval)
Determination of Resistance to Fragmentation	BS EN 1097-2:2020	Tests for mechanical and physical properties of aggregates. Methods for the determination of resistance to fragmentation
Sodium Soundness Test (SSS) / Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate	ASTM C88/C88M - 24	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate
	AASHTO T 104 - 22	Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulphate or Magnesium Sulphate
Chemical Properties	BS EN 1744-1:2009+A1:2012	Tests for chemical properties of aggregates – Chemical analysis
Magnesium Sulphate Test	BS EN 1367-2:2009	Tests for thermal and weathering properties of aggregates. Magnesium sulphate test
“Sonnenbrand” Boiling Test	BS EN 1367-3:2001	Tests for thermal and weathering properties of aggregates. Boiling test for Sonnenbrand basalt
Determination of Drying and Shrinkage	BS EN 1367-4:2008	Tests for thermal and weathering properties of aggregates. Determination of drying shrinkage
Aggregate Soundness	BS 812-121:1989	Testing aggregates. Method for the determination of soundness
Alkali-Silica Reactivity	BS 812-123:1999	Testing aggregates. Method for determination of alkali-silica reactivity. Concrete prism method
	ASTM C1567 – 23	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
	AASHTO T 380	Standard Method of Test for Potential Alkali Reactivity of Aggregates and Effectiveness of ASR Mitigation Measures (Miniature Concrete Prism Test, MCPT)
	ASTM C1260 - 23	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
Tests For Filler Aggregates Used in Bituminous Mixes – Delta Ring and Ball	BS EN 13179-1:2013	Tests for filler aggregate used in bituminous mixtures. Delta ring and ball test
Tests For Filler Aggregates Used in Bituminous Mixes – Bitumen Number	BS EN 13179-2:2000	Test for filler aggregate used in bituminous mixtures. Bitumen number
Clay Lumps and Friable Particles in Aggregates	ASTM C142/C142M - 17(2023) or AASHTO T 112	Standard Method of Test for Clay Lumps and Friable Particles in Aggregate
Sand Equivalent Value of Soils and Fine Aggregate	ASTM D2419 - 22	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
Flat Particles, Elongated Particles, Or Flat and Elongated Particles in Coarse Aggregate	ASTM D4791 - 19(2023)	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
Determining The Percentage of Fractured Particles in Coarse	ASTM D5821 - 13(2017)	Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate

Name of Test	Standard Test Method	Name of Code
Aggregate		
Specific Gravity and Absorption of Fine Aggregate	AASHTO T84	Standard Method of Test for Specific Gravity and Absorption of Fine Aggregate
Specific Gravity and Absorption of Coarse Aggregate	AASHTO T85	Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate
Plastic Fines in Graded Aggregates and Soils by Use of The Sand Equivalent Test	AASHTO T176	Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of The Sand Equivalent Test
Uncompacted Void Content of Fine Aggregate	AASHTO T304	Standard Method of Test for Uncompacted Void Content of Fine Aggregate
Resistance To Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in The Los Angeles Machine	AASHTO T96	Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in The Los Angeles Machine
Standard Method of Test for Resistance of Coarse Aggregate to Degradation by Abrasion in The Micro-Deval Apparatus	AASHTO T327	Standard Method of Test for Resistance of Coarse Aggregate to Degradation by Abrasion in The Micro-Deval Apparatus
Petrographic Test	BS EN 932-3:2022	Tests for general properties of aggregates. Procedure and terminology for simplified petrographic description

iii) Tests on Concrete

Name of Test	Standard Test Method	Name of Code
TESTING CEMENT		
Determination Of Strength	US EAS 148-1:2017	Cement Test methods Part 2: Chemical analysis
	BS EN 196-1:2016	Methods of testing cement. Determination of strength
Chemical Analysis of Cement	US EAS 148-2:2017	Cement — Test Methods — Part 2: Chemical Analysis
	BS EN 196-2:2016	Method Of Testing Cement Chemical Analysis of Cement
Determination of Standard Consistency, Setting Time and Soundness	US EAS 148-3:2017	Cement Test methods Part 3: Determination of setting times and soundness
	US EAS 148-4:2017	Cement Test methods Part 4: Quantitative determination of constituents
	BS EN 196-3:2016	Methods Of Testing Cement Determination of Setting Times and Soundness
Determination Of Chloride, Carbon Dioxide and Alkali Content	US EAS 148-8:2017	Cement Test methods Part 8: Heat of hydration Solution method
Pozzolanicity Test for Pozzolanic Cements Soundness	US EAS 148-5:2017	Cement Test methods Part 5: Pozzolanicity test for pozzolanic cements
	BS EN 196-5:2011	Methods of testing cement. Pozzolanicity test for pozzolanic cement
Determination of Fineness	US EAS 148-6:2017	Cement Test methods Part 6: Determination of fineness
	BS EN 196-6:2018	Methods of testing cement. Determination of fineness
Methods of Taking and Preparing Samples of Cement	US EAS 148-7:2017	Cement Test methods Part 7: Methods of taking and preparing samples
	BS EN 196-7:2007	Methods of testing cement. Methods of taking and preparing samples of cement
TESTING FRESH CONCRETE		
Sampling	BS EN 12350-1:2019	Testing Fresh Concrete - Sampling and Common Apparatus
Slump Test	BS EN 12350-2:2019	Testing Fresh Concrete. Slump Test
Vebe Test	BS EN 12350-3:2019	Testing fresh concrete. Vebe test
Degree Of Compactibility	BS EN 12350-4:2019	Testing Fresh Concrete - Degree of Compactibility
Flow Table Test	BS EN 12350-5:2019	Testing Fresh Concrete - Flow Table Test
Determination Of Density	BS EN 12350-6:2019	Testing Fresh Concrete - Density
Air Content		Testing Fresh Concrete - Air Content. Pressure Methods

Name of Test	Standard Test Method	Name of Code
	BS EN 12350-7:2019	
Measuring Fibre Content in Fresh Glass Fibre Reinforced Concrete	BS EN 1170-2:1998	Precast concrete products. Test method for glass-fibre reinforced cement. Measuring the fibre content in fresh GRC, 'Wash out test'
TESTING HARDENED CONCRETE		
Shape, Dimensions and Other Requirements for Specimens and Moulds	BS EN 12390-1:2021	Testing Hardened Concrete - Shape, Dimensions and Other Requirements for Specimens and Moulds
Making And Curing Specimens for Strength Tests	BS EN 12390-2:2019	Testing Hardened Concrete - Making and Curing Specimens for Strength Tests
Compressive Strength of Test Specimens	BS EN 12390-3:2019	Testing Hardened Concrete - Compressive Strength of Test Specimens
Flexural Strength of Test Specimens	BS EN 12390-5:2019	Testing Hardened Concrete - Flexural Strength of Test Specimens
Tensile Splitting Strength of Test Specimens	BS EN 12390-6:2023	Testing hardened concrete. Tensile splitting strength of test specimens
Density of Hardened Concrete	BS EN 12390-7:2019	Testing Hardened Concrete - Density of Hardened Concrete
Depth of Penetration of Water under Pressure	BS EN 12390-8:2019	Testing Hardened Concrete - Depth of Penetration of Water Under Pressure
Cored Specimens – Taking, Examining and Testing in Compression	BS EN 12504-1:2019	Testing concrete in structures. Cored specimens. Taking, examining and testing in compression
Method Of Normal Curing of Test Specimens	BS EN 12390-2:2019	Testing Hardened Concrete - Making and Curing Specimens for Strength Tests
Method For Testing Cement in a Reference Concrete	BS 1881-131:1998	Testing concrete. Methods for testing cement in a reference concrete

iv) Tests on Asphalt and Bituminous Materials/ Cemented Material

Name of Test	Standard Test Method	Name of Code
Sampling Bituminous Mixes	ASTM D979/D979M - 22	Standard Practice for Sampling Asphalt Mixtures
Preconditioning of Bitumen Samples Prior to Mixing or Testing	NPRA 014 Test 14.511	Norwegian Public Road Administration (NPRA)
Density Of Bituminous Binders	ASTM D70/D70M - 21	Standard Test Method for Specific Gravity and Density of Semi-Solid Asphalt Binder (Pycnometer Method)
Flash And Fire Point by Cleveland Open Cup	ASTM D92 - 18	Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
Thin-Film Oven Test (TFOT)	ASTM D1754/D1754M - 20	Standard Test Method for Effects of Heat and Air on Asphaltic Materials (Thin-Film Oven Test)
Rotating Thin-Film Oven Test (RTFOT)	ASTM D2872 - 22	Standard Test Method for Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin-Film Oven Test)
Penetration of Bituminous Materials	ASTM D5- 2020	Bitumen And Bituminous Binders — Determination of Needle Penetration
Softening Point Test	ASTM D5/D5M – 20 BS EN 1427:2015, BS 2000-58:2015	Bitumen And Bituminous Binders — Determination of The Softening Point — Ring and Ball Method Bitumen and bituminous binders. Determination of the softening point. Ring and Ball method
Ductility	ASTM D113/D113M –17 (2023) E1	Standard Test Method for Ductility of Asphalt Materials
Viscosity Determination Using the Brookfield Thermosel Apparatus	ASTM D4402/D4402M – 23 BS EN 12846-2:2022	Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer Bitumen and bituminous binders. Determination of efflux time by the efflux viscometer. Cut-back and fluxed bituminous binders
Kinematic Viscosity of Asphalts	ASTM D2170/D2170M - 24	Standard Test Method for Kinematic Viscosity of Asphalts
Viscosity of Asphalts by Vacuum Capillary Viscometer	ASTM D2171/D2171M - 22	Standard Test Method for Viscosity of Asphalts by Vacuum Capillary Viscometer
Density and Water Absorption of Aggregates Retrieved on A 4.75 Mm Sieve	ASTM C127	Standard Test Method for Relative Density (Specific Gravity) And Absorption of Coarse Aggregate
Density and Water Absorption of Aggregates Passing The 4.75 Mm Sieve	ASTM C128 - 22	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate

Name of Test	Standard Test Method	Name of Code
Calibration of Glass Pycnometers (0.5-1 Litre)	NPRA 014 Test 14.5922	Norwegian Public Road Administration (NPRA)
Mixing of Test Specimens; Hot Bituminous Mixes	NPRA 014 Test 14.5532	Norwegian Public Road Administration (NPRA)
Determination of Maximum Theoretical Density of Asphalt Mixes and Absorption of Binder into Aggregates	ASTM D2041/D2041M - 19	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures
Bulk Density of Saturated Surface Dry Asphalt Mix Samples / Bulk Specific Gravity (Gmb) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens	ASTM D2726/D2726M - 21 or AASHTO T166-22	Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Asphalt Mixtures
Bulk Density of Paraffin-Coated Asphalt Mix Samples / Bulk Specific Gravity (Gmb) Of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens	ASTM D1188/D1188M - 22 or AASHTO T 275-22	Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples
Bulk Density of Asphalt Mix Samples, Calliper Measurements	NPRA 014 test 14.5622	Norwegian Public Road Administration (NPRA)
Calculation of Void Content In Bituminous Mixes	ASTM D3203 - 22	Standard Test Method for Percent Air Voids in Compacted Asphalt Mixtures
Marshall Test	BS EN 12697-34: 2020	Test Method for Resistance of Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
	ASTM D5581-07a(2013)	Bituminous mixtures. Test methods. Marshall test
Refusal Density Mix Design	TRL Overseas Road Note 31, Appendix D: 1990	Test Method for Resistance of Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6 inch-Diameter Specimen)
Temperature Measurement	BS EN 12697-13:2017	A Guide to the Structural Design of Bitumen Surfaced Roads in Tropical and Sub-tropical Countries
Indirect Tensile Strength Test	BS EN 12697-23: 2017	Bituminous Mixtures - Test Methods Temperature Measurement
Determination of Binder Content and Aggregate Grading by Extraction	BS EN 12697-23: 2017	Bituminous mixtures. Test methods. Determination of the indirect tensile strength of bituminous specimens
Bitumen Recovery: Rotary Evaporator Soluble Binder Content	ASTM D2172 / 2172M:2018	Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
	BS EN 12697-1:2020	Test Methods Soluble Binder Content
Bitumen Recovery: Fractionating Column	BS EN 12697-3+A1:2013	Test Methods Bitumen Recovery - Rotary Evaporator
	ASTM D5404 / D5404M -21	Standard Practice for Recovery of Asphalt Binder from Solution Using the Rotary Evaporator
Water Content	BS EN 12697-4:2023	Bituminous mixtures. Test methods. Bitumen recovery. Fractionating column
Sampling	BS EN 12697-14:2020	Test Methods Water Content
Distillation of Cut Back Asphalt (Bituminous) Products	BS EN 12697-27:2017	Test Methods for Hot Mix Asphalt - Sampling
Frass Breaking Point of Bitumen	BS 2000- 525: 2010 or ASTM D402/D402M: 2014 or BS EN 13358: 2019	Bitumen And Bituminous Binders - Determination of The Distillation Characteristics of Cut-Back and Fluxed Bituminous Binders Made with Mineral Fluxes
Resin Compositions-Method for Preparation of Test Specimens	BS 2000-80 BS EN 12593:2015, BS 2000-80:2015	Bitumen and bituminous binders. Determination of the Fraass breaking point
Plastics/Rubber – Polymer Dispersions and Rubber Lattices- Determination of Residual Monomers and their Organic Components by Capillary Chromatography	BS 6319-1:1983	Testing of resin and polymer/cement compositions for use in construction. Method for preparation of test specimens
Plastics and Liquid Epoxy Resins- Determination of Tendency to Crystallise	BS ISO 13741-1:2023	Plastics/rubber. Determination of residual monomers and other organic components by capillary-column gas chromatography. Direct liquid injection method
Effect Of Water on Bituminous Coated Aggregates, Boiling Test	BS EN ISO 4895:2014	Plastics. Liquid epoxy resins. Determination of tendency to crystallize
Loss on Heating of Oil and Asphaltic Compounds	ASTM D3625/D3625M - 20	Standard Practice for Effect of Water on Asphalt-Coated Aggregate Using Boiling Water
Water In Petroleum Products and Bituminous Materials by	ASTM D6/D6M - 95(2018)	Standard Test Method for Loss on Heating of Oil and Asphaltic Compounds
	ASTM D95 - 23	Standard Test Method for Water in Petroleum Products and Bituminous Materials by Distillation

Name of Test	Standard Test Method	Name of Code
Distillation		
Float Test for Bituminous Materials	ASTM D139 - 24	Standard Test Method for Float Test for Asphalt Materials
Emulsified Asphalts	ASTM D244 - 23	Standard Test Methods and Practices for Emulsified Asphalts
Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures	ASTM D2041/D2041M -19 or AASHTO T 209-22	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures
Solubility Of Asphalt Materials in Trichloroethylene or Toluene	ASTM D2042 - 22	Standard Test Method for Solubility of Asphalt Materials in Trichloroethylene or Toluene
Density Of Semi-Solid and Solid Asphalt Materials (Nickel Crucible Method)	ASTM D3289 - 17(2022)	Standard Test Method for Density of Semi-Solid and Solid Asphalt Materials (Nickel Crucible Method)
Asphalt Content of Asphalt Mixtures by The Nuclear Method	ASTM D4125/D4125M - 21	Standard Test Methods for Asphalt Content of Asphalt Mixtures by the Nuclear Method
Effect Of Moisture on Asphalt Concrete Paving Mixtures	ASTM D4867/D4867M - 22	Standard Test Method for Effect of Moisture on Asphalt Mixtures
Resistance To Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6 Inch-Diameter Specimen)	ASTM D5581-07A (2021) E1	Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6 In. Diameter Specimen)
Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures	ASTM D6390 – 23 or AASHTO T305 -22	Standard Test Method for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
Pressurized Aging Vessel (PAV)	ASTM D6521 - 22	Standard Practice for Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)	ASTM D6648 - 08(2016)	Standard Test Method for Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
Preparation and Determination of The Relative Density of Asphalt Mix Specimens by Means of The Superpave Gyratory Compactor	ASTM D6925 - 23 or AASHTO T312-22	Standard Test Method for Preparation and Determination of the Relative Density of Asphalt Mix Specimens by Means of the Superpave Gyratory Compactor
Preparation of Asphalt Mixture Specimens Using the Marshall Apparatus	ASTM D6926 - 20	Standard Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus
Marshall Stability and Flow of Asphalt Mixtures	ASTM D6927 - 22	Standard Test Method for Marshall Stability and Flow of Asphalt Mixtures
Settlement And Storage Stability of Emulsified Asphalts	ASTM D6930 - 19	Standard Test Method for Settlement and Storage Stability of Emulsified Asphalts
Oversized Particles in Emulsified Asphalts (Sieve Test)	ASTM D6933 - 22	Standard Test Method for Oversized Particles in Emulsified Asphalts (Sieve Test)
Determining Cement Mixing of Emulsified Asphalt	ASTM D6935 - 22	Standard Test Method for Determining Cement Mixing of Emulsified Asphalt
Determining Demulsibility of Emulsified Asphalt	ASTM D6936 - 23	Standard Test Method for Determining Demulsibility of Emulsified Asphalt
Distillation Of Emulsified Asphalt	ASTM D6997 - 12(2020)	Standard Test Method for Distillation of Emulsified Asphalt
Evaluating Aggregate Coating Using Emulsified Asphalts	ASTM D6998 - 19	Standard Practice for Evaluating Aggregate Coating Using Emulsified Asphalts
Determining The Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)	ASTM D7175 - 23 or AASHTO T315 -22	Standard Test Method for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer
Determining The Viscosity of Emulsified Asphalts Using a Rotational Paddle Viscometer	ASTM D7226 - 13(2023)	Standard Test Method for Determining the Viscosity of Emulsified Asphalts Using a Rotational Paddle Viscometer
Determining The Resilient Modulus of Asphalt Mixtures by Indirect Tension Test	ASTM D7369 - 20	Standard Test Method for Determining the Resilient Modulus of Asphalt Mixtures by Indirect Tension Test
Identifying Cationic Emulsified Asphalts	ASTM D7402 - 09(2017)	Standard Practice for Identifying Cationic Emulsified Asphalts
Viscosity of Emulsified Asphalt by Saybolt Furol Viscometer	ASTM D7496 - 18	Standard Test Method for Viscosity of Emulsified Asphalt by Saybolt Furol Viscometer

Name of Test	Standard Test Method	Name of Code
Solubility of Asphalt Materials In N-Propyl Bromide	ASTM D7553 - 15(2021)	Standard Test Method for Solubility of Asphalt Materials In N-Propyl Bromide
Recovery of Asphalt from Solution Using Toluene and The Rotary Evaporator	ASTM D7906 - 22	Standard Practice for Recovery of Asphalt from Solution Using Toluene and The Rotary Evaporator
Laboratory Conditioning of Asphalt Mixtures	AASHTO R30 - 22	Standard Practice for Laboratory Conditioning of Asphalt Mixtures
Superpave Volumetric Design for Asphalt Mixtures	AASHTO R35 - 22	Standard Practice for Superpave Volumetric Design for Asphalt Mixtures
Designing Stone Matrix Asphalt (SMA)	AASHTO R46 - 22	Standard Practice for Designing Stone Matrix Asphalt (SMA)
Recovery of Asphalt Binder from Solution by Abson Method	AASHTO R 59 - 22	Standard Practice for Recovery of Asphalt Binder from Solution by Abson Method
Mechanical Analysis of Extracted Aggregate	AASHTO T30 - 21	Standard Method of Test for Mechanical Analysis Of Extracted Aggregate
Quantitative Extraction of Asphalt Binder from Asphalt Mixtures	AASHTO T164 - 22	Standard Method of Test for Quantitative Extraction Of Asphalt Binder From Asphalt Mixtures
Specific Gravity and Density of Semi-Solid Asphalt Materials	AASHTO T228 - 22	Standard Method of Test for Specific Gravity and Density of Semi-Solid Asphalt Materials
Resistance To Plastic Flow of Asphalt Mixtures Using the Marshall Apparatus	AASHTO T245 - 22	Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus
Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage	AASHTO T283 - 22	Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
Determining The Asphalt Binder Content of Asphalt Mixtures by The Ignition Method	AASHTO T308 - 22	Standard Method of Test for Determining the Asphalt Binder Content of Asphalt Mixtures by The Ignition Method
Determining The Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)	AASHTO T313 - 22	Standard Method of Test for Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
Quantitative Extraction and Recovery of Asphalt Binder from Asphalt Mixtures	AASHTO T319 - 22	Standard Method of Test for Quantitative Extraction and Recovery of Asphalt Binder from Asphalt Mixtures
Permanent Shear Strain and Stiffness of Asphalt Mixtures Using the Superpave Shear Tester (SST)	AASHTO T320 - 22	Standard Method of Test for Determining the Permanent Shear Strain and Stiffness of Asphalt Mixtures Using the Superpave Shear Tester (SST)
Fatigue Life of Compacted Asphalt Mixtures Subjected to Repeated Flexural Bending	AASHTO T321 - 22	Standard Method of Test for Determining the Fatigue Life of Compacted Asphalt Mixtures Subjected to Repeated Flexural Bending
Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures	AASHTO T324 - 22	Standard Method of Test for Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures
Bulk Specific Gravity (Gmb) And Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method	AASHTO T331 - 22	Standard Method of Test for Bulk Specific Gravity (Gmb) And Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method
Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle of Gyraton Using Simulated Loading	AASHTO T344 - 22	Standard Method of Test for Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle of Gyraton Using Simulated Loading (ASTM Designation: D 7115-05)
Dynamic Modulus & Flow Number Test Using AMPT	AASHTO T378 - 22	Standard Method of Test for Determining the Dynamic Modulus and Flow Number for Asphalt Mixtures Using the Asphalt Mixture Performance Tester (AMPT)
Creep Compliance & Strength of HMA using Indirect Tensile Test	AASHTO T322 - 22	Determining the Creep Compliance and Strength of Hot Mix Asphalt (HMA) Using the Indirect Tensile Test Device
Standard Specification for Stone Matrix Asphalt	AASHTO M325	Standard Specification for Stone Matrix Asphalt
Bituminous Mixtures – Test Methods – Wheel Tracking	BS EN 12697-22:2020+A1:2023	Bituminous mixtures. Test methods. Wheel tracking
Determination of the Affinity between Aggregate & Bitumen	BS EN 12697-11:2020	Bituminous mixtures. Test methods. Determination of the affinity between aggregate and bitumen
Measure Longitudinal Pavement Profile	AASHTO M328 - 18	Standard Specification for Inertial Profiler
Pavement Ride Quality Using	AASHTO R54-14 (2022)	Standard Practice for Accepting Pavement Ride Quality

Name of Test	Standard Test Method	Name of Code
Inertial Profiling Systems		When Measured Using Inertial Profiling Systems
Polymer Modified Bitumen	BS EN 14023:2010	Bitumen and bituminous binders. Specification framework for polymer modified Bitumen
Wetting and Drying Test of Cemented Mixture	AASHTO T135	Standard Method of Test for Wetting-and-Drying Test of Compacted Soil. Cement Mixtures
Cationic Bituminous Emulsions	BS EN 13808:2013	Bitumen and bituminous binders. Framework for specifying cationic bituminous emulsions
Modified Rolling Thin Film Oven Test	METHOD MB-3: TG-1 (5th Edition) - SABITA	The use of Modified Bituminous Binders in Road Construction
Elastic Recovery of Polymer Modified Binders by Durometer	METHOD MB-4: TG-1 (5th Edition)- SABITA or ASTM D6084/D6084M: 2021	The Use of Modified Bituminous Binders in Road Construction
Storage Stability of Polymer Modified Binders	METHOD MB-6: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Ball Penetration and Resilience of Bitumen-Rubber Blends	METHOD MB-10: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Compression Recovery of Bitumen Rubber Binders	METHOD MB-11: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Flow Test for Bitumen-Rubber Binders	METHOD MB-12: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Dynamic Viscosity of Bitumen-Rubber Binders	METHOD MB-13: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Particle Size Distribution and Loose Fibre Content of Rubber Crumbs	METHOD MB-14: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Bulk Density of Rubber Crumbs	METHOD MB-16: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Softening Point of Modified Bitumen by Ring and Ball Method	METHOD MB-17: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Dynamic (Apparent) Viscosity of Polymer Modified Binders	METHOD MB-18: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Recovery Of Residue of Modified Bitumen Emulsion	METHOD MB-20: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Residue On Sieving of a Modified Bitumen Emulsion	METHOD MB-23: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction
Particle Charge of Modified Bitumen Emulsions	METHOD MB-24: TG-1 (5th Edition)- SABITA	The Use of Modified Bituminous Binders in Road Construction

(b) Uganda National Bureau of Standards (UNBS)

US 100	US EAS 148:2017, Cement — Test Methods	Cement - Methods of Testing
US 101: 2000	US EAS 131: 2008, Concrete — Specification	Aggregates From Natural Sources for Concrete
US 104: 1993	US EAS 73: 2000, Building Limes (Quicklime and Hydrated Lime) — Specification	Pozzolanas For Use with Lime
US EAS 135: 2021	US EAS 135:2021, Steel Wire and Steel Wire Products for Fencing — Specification	Steel Wire and Steel Wire Products for Fencing
US 144: 2000	US EAS 131-1: 2008, Concrete — Specification	Aggregates-Particle Size and Particle Shape Determination
US 145: 2000	US EAS 131-1: 2008, Concrete — Specification	Aggregates-Methods of Sampling
US 146: 2000	US EAS 131-1: 2008, Concrete — Specification	Aggregates-Determination of Physical Properties
US 288: 2001	US 288:2001 Specification for Lime for Soil Stabilization	Lime For Soil Stabilisation
US 290: 2001	US 290:2000 Glossary of Terms Used in Lime Products	Glossary Terms Used in Lime Products
US 310: 2001	US EAS 18-1:2017, Cement — Part 1: Composition, Specification and Conformity Criteria for Common Cements	Compositions, Specifications, Conformity Criteria and Evaluation for Common Cements
US 320: 2001	US 310-3:2000 Definitions and Terminology for Cements	Cement-Definition of Terminologies
US 40: 1993	US 533:2006 Retro Reflective Warning Signs for Road Vehicles – Chevron Signs	Reflective Sheeting Materials for Traffic Control Signs
US EAS 982-1	US EAS 982-1:2020, Bitumen and Bituminous Binders — Specification — Part 1: Penetration Grade Bitumen	Penetration Grade Bitumen
US EAS 982-2	US EAS 982-2:2020, Bitumen and Bituminous Binders — Specification — Part 2: Cutback Bitumen	Cutback Bitumen
US EAS 982-3	US EAS 982-3:2020, Bitumen and Bituminous Binders — Specification — Part 3: Anionic Bitumen Emulsion	Anionic Bitumen Emulsion
US EAS 982-4	US EAS 982-4:2020, Bitumen and Bituminous Binders — Specification — Part 4: Cationic Bitumen Emulsion	Cationic Bitumen Emulsion
US EAS 982-5	US EAS 982-5:2020, Bitumen and Bituminous Binders — Specification — Part 5: Performance Graded Bitumen	Performance Graded Bitumen
US EAS 18-1	US EAS 18-1:2017, Cement — Part 1: Composition, Specification and Conformity Criteria for Common Cements	Cement: Composition, Specification and Conformity Criteria for Common Cements
US EAS 18-2	US EAS 18-2:2017, Cement — Part 2: Conformity Evaluation	Cement: Conformity Evaluation
US EAS 148-1	US EAS 148-1:2017, Cement — Test Methods — Part 1: Determination of Strength	Cement: Determination Of Strength
US EAS 148-3	US EAS 148-3:2017, Cement — Test Methods — Part 3: Determination of Setting Times and Soundness	Cement: Determination Of Setting Times and Soundness

(c) American Association of State Highway and Transport Officials (AASHTO)

M – 85	AASHTO M85 - Standard Specification for Portland Cement	Ordinary Portland Cement
M – 140	AASHTO M140 - Standard Specification for Emulsified Asphalt	Bituminous Prime Coat
M – 153	AASHTO M 153 -Standard Specification for Preformed Sponge Rubber, Cork, and Recycled Rubber Expansion Joint Fillers for Concrete Paving and Structural Construction	Joint Filler
M – 154	AASHTO M 154 - Standard Specification for Air-Entraining Admixtures for Concrete	Air Entraining Agents.
M – 173	AASHTO M 173 - Standard Specification for Joint-Sealer, Hot-Poured Elastic Type	Thermoplastic Hot Poured Sealant
M – 194	AASHTO M 194 – Standard Specification for Chemical Admixtures for Concrete	Concrete Admixtures
M – 213	AASHTO M 213 -Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)	Joint Filler
M – 216	AASHTO M 216 -Standard Specification for Quicklime and Hydrated Lime for Soil Stabilization	Road Lime
M – 240	AASHTO M 240 -Standard Specification for Blended Hydraulic Cement	Portland Blast Furnace Cement
M – 320	AASHTO M 320 -Standard Specification for Performance-Graded Asphalt Binder	Performance-Graded Asphalt Binder
M – 323	AASHTO M 323 -Standard Specification for Superpave Volumetric Mix Design	Superpave Volumetric Mix Design
M – 332	AASHTO M 332 -Standard Specification for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test	Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery
T – 87	AASHTO T 87-Standard Method of Test for Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test	Preparation Of Disturbed Soil & Soil Aggregate Samples for Test
T – 89	AASHTO T 89-Standard Method of Test for Determining the Liquid Limit of Soils	Liquid Limit of Soils
T – 90	AASHTO T 90-Standard Method of Test for Determining the Plastic	Plastic Limit & Plasticity Index of

	Limit and Plasticity Index of Soils	Soils
T – 132	AASHTO T 132-Standard Method of Test for Tensile Strength of Hydraulic Cement Mortars	Tensile Strength of Hydraulic Cement Mortars
T – 180	AASHTO T 180-Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54kg (10-lb) Rammer and a 457mm (18-in) Drop	Maximum Dry Density Test Method

(d) American Society for Testing and Materials (ASTM)

A – 252-68	ASTM A 252-Standard Specification for Welded and Seamless Steel Pipe Piles	Pile Castings
C – 156	ASTM C 156-Standard Test Method for Water Loss [from a Mortar Specimen] Through Liquid Membrane-Forming Curing Compounds for Concrete	Curing Agents
C – 260	ASTM C 260-Standard Specification for Air-Entraining Admixtures for Concrete	Air Entraining Agents
C – 309	ASTM C 309-Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete	Curing Agents
C – 494	ASTM C 494/C 494M-Standard Specification for Chemical Admixtures for Concrete	Concrete Admixtures
C – 719	ASTM C 719-Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)	Sealant Tests
C – 920	ASTM C 920-Standard Specification for Elastomeric Joint Sealants	Thermosetting Chemically Cured Sealant
C – 227-90	ASTM C 1260-21 - Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)	Test Method for Alkali Reactivity of Aggregates
D – 8	ASTM D-8 - Standard Terminology Relating to Materials for Roads and Pavements	Terminology Relating to Materials for Roads and Pavements
D – 36	ASTM D 36- Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)	Bitumen Tests (Softening Point)
D – 977	ASTM D 977-Standard Specification for Emulsified Asphalts	Emulsified Asphalt
D – 1557	ASTM D 1557-Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf/ft ³ (2,700 kN-m/m ³))	Maximum Dry Density Tests
D – 2397	ASTM D 2397-Standard Specification for Cationic Emulsified Asphalt	Cationic Emulsified Asphalt
D – 3910	ASTM D 3910-Standard Practices for Design, Testing and Construction of Slurry Seal	Design, Testing, And Construction of Slurry Seal
D – 4402	ASTM D 4402-Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscosity	Bitumen Tests (Dynamic Viscosity)
D – 6373	ASTM D 6373-Standard Specification for Performance-Graded Asphalt Binder	Performance-Graded Asphalt Binder
D – 559	ASTM D559 / D559M - Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures	Wetting and Drying of Cemented Mixture
D - 8139	ASTM D8139 - 23 Standard Specification for Semi-Rigid, Closed-Cell Polypropylene Foam, Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction	Closed-Cell Polypropylene Foam, Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction

(e) British Standards Institute (BS)

BS – 812	BS 812-124:2009 Testing aggregates. Method for the determination of frost heave	Method for the determination of frost heave
	BS 812-123:1999 Testing aggregates. Method for determination of alkali-silica reactivity. Concrete prism method	Method for determination of alkali-silica reactivity. Concrete prism method
	BS 812-104:1994 Testing aggregates. Method for qualitative and quantitative petrographic examination of aggregates	Method for qualitative and quantitative petrographic examination of aggregates
BS – 1134	BS 1134:2010 Assessment of surface texture. Guidance and general information	Guidance and general information
BS – 1154	BS 1154:2003 Natural rubber compounds. Specification	Specification
BS – 1377	BS 1377-2:2022 Methods of Test for Soils for Civil Engineering Purposes Classification Tests and Determination of Geotechnical Properties	Methods Of Test for Soils for Civil Engineering Purposes - Classification Tests and Determination of Geotechnical Properties
BS – 1707	BS 1707:2018 Road surface dressing, bond coats, seals, preservatives and other sprays. Specification for the method of test for binder sprayers for the accuracy of spread of binder (spray bar bench test)	Specification for the method of test for binder sprayers for the accuracy of spread of binder (spray bar bench test)
BS – 1881	BS 1881-124:2015+A1:2021 Testing Concrete Methods for Analysis	Tests For Concrete

	of Hardened Concrete	
BS – 2571	BS 2571:1990 Specification for General-Purpose Flexible PVC Compounds for Moulding and Extrusion	General-Purpose Flexible PVC Compounds for Moulding and Extrusion
BS – 2752	BS 2752:2003 Chloroprene rubber compounds. Specification	Specification
BS – 3692	BS 3692:2014 ISO metric precision hexagon bolts, screws and nuts. Specification	Hexagon bolts, screws and nuts. Specification
BS – 4449	BS 4449:2005+A3:2016 Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification	Steel for the Reinforcement of Concrete
BS – 4486	BS 4486:1980 Specification for Hot Rolled and Hot Rolled and Processed High Tensile Alloy Steel Bars for The Prestressing of Concrete	High Tensile Alloy Steel Bars
BS – 4987	BS 4987-1:2005 Coated macadam (asphalt concrete) for roads and other paved areas. Specification for constituent materials and for mixtures	Specification for constituent materials and for mixtures
BS - 5306	BS 5306-8:2023 Fire extinguishing installations and equipment on premises. Selection and positioning of portable fire extinguishers. Code of practice	Selection and positioning of portable fire extinguishers. Code of practice
BS – 5328	BS 5328-1:1997 Concrete. Guide to specifying concrete	Specifying Concrete
	BS 5328-2:1997 Concrete. Methods for specifying concrete mixes	Specifying Concrete
	BS 5328-3:1990 Concrete. Specification for the procedures to be used in producing and transporting concrete	Specifying Concrete
	BS 5328-4:1990 Concrete. Specification for the procedures to be used in sampling, testing and assessing compliance of concrete	Specifying Concrete
BS – 5896	BS 5896:2012 High Tensile Steel Wire and Strand for The Pre-stressing of Concrete. Specification	Steel Wire
BS – 5911	BS 5911-1:2021 Concrete pipes and ancillary concrete. Unreinforced and reinforced concrete pipes (including jacking pipes) and fittings with flexible joints (complementary to BS EN 1916:2002). Specification	Precast Concrete Pipes
BS – 5930	BS 5930:2015+A1:2020 Code of Practice for Ground Investigations	Site Investigation
BS – 6031	BS 6031:2009 Code of Practice for Earthworks	Earthworks
BS – 6068	BS 6068 Water Quality. Physical, Chemical and Biochemical Methods	Water Quality
BS – 6213	BS 6213:2000+A1:2010 Selection of Construction Sealants. Guide	Selection of Construction Sealants
BS – 7373	BS 7373-1:2001 Guide to the preparation of specifications. Guide to preparation	Preparation of Specifications
BS – 7533	BS 7533-101:2021 Pavements Constructed with Clay, Concrete or Natural Stone Paving Units - Code of Practice for The Structural Design of Pavements Using Modular Paving Units	Pavement Design-Clay or Concrete Pavers
	BS 7533-3:2005+A1:2009 Pavements constructed with clay, natural stone or concrete pavers. Code of practice for laying precast concrete paving blocks and clay pavers for flexible pavements	Pavement Design-Clay or Concrete Pavers
	BS 7533-4:2006 Pavements constructed with clay, natural stone or concrete pavers. Code of practice for the construction of pavements of precast concrete flags or natural stone slabs	Pavements constructed with clay, natural stone or concrete pavers.
BS – 7542	BS 7542:1992 Method of Test for Curing Compounds for Concrete	Test For Curing Compounds for Concrete
BS – 7668	BS 7668:2016 Weldable Structural Steels. Hot Finished Structural Hollow Sections in Weather Resistant Steels. Specification	Weldable Structural Steels - Hot Finished Structural Hollow Sections in Weather Resistant Steels
BS – 7903	BS 7903:2020 Selection and installation of manhole tops and gully tops within the highway. Guide	Selection And Use of Gully Tops and Manholes
BS – 8000	BS 8000:2014 Workmanship on Construction Sites	Code Of Practice for Concrete Work
BS – 8004	BS 8004:2015+A1:2020 Code of Practice for Foundations	Code Of Practice for Foundations
BS – 8006	BS 8006-1:2010+A1:2016 Code of practice for strengthened/reinforced soils and other fills	Strengthened / Reinforced Soils and Other Fills
BS – 8217	BS 8217:2005 Reinforced Bitumen Membranes for Roofing. Code Of Practice	Reinforced Bitumen Membranes for Roofing
BS - 8442	BS 8442:2022+A1:2023 Miscellaneous Road traffic signs and devices. Requirements and test methods	Requirements and test methods
BS – 8500	BS 8500-1:2023 Concrete. Complementary British Standard to BS EN 206. Method of specifying and guidance for the specifier	Method of specifying and guidance for the specifier
BS – 8666	BS 8666:2020 Scheduling, Dimensioning, Bending and Cutting of Steel Reinforcement for Concrete. Specification	Scheduling, Dimensioning, Bending and Cutting of Steel Reinforcement for Concrete
BS 594987	BS 594987:2015+A1:2017 Asphalt for roads and other paved areas. Specification for transport, laying, compaction and product type testing protocols	Specification for transport, laying, compaction and product type testing protocols

(f) European Standards

BS EN 124	BS EN 124-2:2015 Gully Tops and Manhole Tops for Vehicular and Pedestrian Areas - Gully Tops and Manhole Tops Made of Cast Iron	Concrete-Specification, Performance, Production and Conformity
BS EN 125	BS EN 125:2022 Flame Supervision Devices for Gas Burning Appliances. Thermoelectric Flame Supervision Devices	Gully And Manhole Tops- Loading, Design and Dimensions
BS EN 197	BS EN 197-1:2011 Cement - Composition, Specifications and Conformity Criteria for Common Cements	Cement-Composition, Specifications, Conformity Criteria and Conformity Evaluation
BS EN 206	BS EN 206:2013+A2:2021 Concrete. Specification, Performance, Production and Conformity	Concrete-Guidance to Specifier/Specification for The Constituent Materials and Concrete
BS EN 410	BS 410-2 Test Sieves - Technical Requirements and Testing - Part 2: Test Sieves of Perforated Metal Plate	Test Sieves
BS EN 445	BS EN 445:2007 Grout for Prestressing Tendons. Test Methods	Grout For Prestressing Tendons. Test Methods
BS EN 446	BS EN 446:2007 Grout for Prestressing Tendons. Grouting Procedures	Grout For Prestressing Tendons. Grouting Procedures
BS EN 450	BS EN 450-1:2012 Fly Ash for Concrete - Definition, Specifications and Conformity Criteria	Fly Ash for Concrete Definition
BS EN 480	BS EN 480-1:2023 Admixtures for concrete, mortar and grout. Test methods. Reference concrete and reference mortar for testing	Admixtures for concrete
	BS EN 480-2:2006 Admixtures for concrete, mortar and grout. Test methods. Determination of setting time	Admixtures for concrete
	BS EN 480-4:2005 Admixtures for concrete, mortar and grout. Test methods. Determination of bleeding of concrete	Admixtures for concrete
	BS EN 480-5:2005 Admixtures for concrete, mortar and grout. Test methods. Determination of capillary absorption	Admixtures for concrete
	BS EN 480-6:2005 Admixtures for concrete, mortar and grout. Test methods. Infrared analysis	Admixtures for concrete
	BS EN 480-10:2009 Admixtures for concrete, mortar and grout. Test methods. Determination of water-soluble chloride content	Admixtures for concrete
	BS EN 480-11:2005 Admixtures for concrete, mortar and grout. Test methods. Determination of air void characteristics in hardened concrete	Admixtures for concrete
	BS EN 480-12:2005 Admixtures for concrete, mortar and grout. Test methods. Determination of the alkali content of admixtures	Admixtures for concrete
	BS EN 480-8:2012 Admixtures for concrete, mortar and grout. Test methods. Determination of the conventional dry material content	Admixtures for concrete
BS EN 485	BS EN 485-3:2003 Aluminium and aluminium alloys. Sheet, strip and plate. Tolerances on dimensions and form for hot-rolled products	Tolerances on dimensions and form for hot-rolled products
	BS EN 485-2:2016+A1:2018 Aluminium and aluminium alloys. Sheet, strip and plate. Mechanical properties	Mechanical properties
BS EN 512	BS EN 512:1995 Fibre-Cement Products. Pressure Pipes and Joints	Fibre-Cement Products, Pressure Pipes and Joints
BS EN 515	BS EN 515:2017 Aluminium and aluminium alloys. Wrought products. Temper designations	Temper designations
BS EN 573	BS EN 573-3:2019+A2:2023 Aluminium and aluminium alloys. Chemical composition and form of wrought products. Chemical composition and form of products	Chemical composition and form of products
BS EN 755	BS EN 755-1:2016 Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Technical conditions for inspection and delivery	Technical conditions for inspection and delivery
	BS EN 755-2:2016 Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Mechanical properties	Mechanical properties
	BS EN 755-3:2008 Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Round bars, tolerances on dimensions and form	Round bars, tolerances on dimensions and form
	BS EN 755-4:2008 Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Square bars, tolerances on dimensions and form	Square bars, tolerances on dimensions and form
	BS EN 755-6:2008 Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Hexagonal bars, tolerances on dimensions and form	Hexagonal bars, tolerances on dimensions and form
	BS EN 755-7:2016 Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Seamless tubes, tolerances on dimensions and form	Seamless tubes, tolerances on dimensions and form
	BS EN 755-8:2016 Aluminium and aluminium alloys. Extruded	Porthole tubes, tolerances on

	rod/bar, tube and profiles. Porthole tubes, tolerances on dimensions and form	dimensions and form
	BS EN 755-9:2016 Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Profiles, tolerances on dimensions and form	Profiles, tolerances on dimensions and form
BS EN 771	BS EN 771-1:2011+A1:2015 Specification for masonry units. Clay masonry units	Clay masonry units (Clay Bricks)
	BS EN 772-3:1998 Methods of test for masonry units. Determination of net volume and percentage of voids of clay masonry units by hydrostatic weighing	Determination of net volume and percentage of voids of clay masonry units by hydrostatic weighing
	BS EN 772-7:1998 - Methods of test for masonry units. Determination of water absorption of clay masonry damp proof course units by boiling in water	Determination of water absorption of clay masonry damp proof course units by boiling in water
BS EN 837	BS EN 837-1:1998 Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing	Dimensions, metrology, requirements and testing
BS EN 934	BS EN 934-2:2009+A1:2012 Admixtures for concrete, mortar and grout. Concrete admixtures. Definitions, requirements, conformity, marking and labelling	Admixtures For Concrete, Mortar and Grout
	BS EN 934-6:2019 Admixtures for concrete, mortar and grout. Sampling, assessment and verification of the constancy of performance	
BS EN 1008	BS EN 1008:2002 Mixing Water for Concrete. Specification For Sampling, Testing and Assessing the Suitability of Water, Including Water Recovered from Processes in The Concrete Industry, As Mixing Water for Concrete	Mixing Water for Concrete - For Sampling, Testing and Assessing the Suitability of Water
BS EN 1011	BS EN 1011-1:2009 Welding. Recommendations for welding of metallic materials. General guidance for arc welding	Recommendations for welding of metallic materials.
	BS EN 1011-2:2001 Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels	Recommendations for welding of metallic materials.
BS EN 1097	BS EN 1097-3:1998 Tests for mechanical and physical properties of aggregates. Determination of loose bulk density and voids	Determination of loose bulk density and voids
BS EN 1337	BS EN 1337-2:2004 Structural bearings. Sliding elements	Bridge bearings
	BS EN 1337-3:2005 Structural bearings. Elastomeric bearings	Bridge bearings
	BS EN 1337-4:2004 Structural bearings. Roller bearings	Bridge bearings
	BS EN 1337-5:2005 Structural bearings. Pot bearings	Bridge bearings
	BS EN 1337-6:2004 Structural bearings. Rocker bearings	Bridge bearings
	BS EN 1337-7:2004 Structural bearings. Spherical and cylindrical PTFE bearings	Bridge bearings
	BS EN 1337-8:2007 Structural bearings. Guide bearings and restraint bearings	Bridge bearings
BS EN 1338	BS EN 1338:2003 Concrete paving blocks. Requirements and test methods	Concrete paving blocks
BS EN 1339	BS EN 1339:2003 Concrete paving flags. Requirements and test methods	Concrete paving flags
BS EN 1340	BS EN 1340:2003 Concrete kerb units. Requirements and test methods	Concrete kerb units
BS EN 1344	BS EN 1344:2013 Clay pavers. Requirements and test methods	Clay pavers
BS EN 1423	BS EN 1423:2012 Road marking materials. Drop on materials. Glass beads, antiskid aggregates and mixtures of the two	Road marking materials
BS EN 1436	BS EN 1436:2018 Road marking materials. Road marking performance for road users and test methods	Road marking performance for road users and test methods
BS EN 1871	BS EN 1871:2020 Road marking materials. Paint, thermoplastic and cold plastic materials. Physical properties	Paint, thermoplastic and cold plastic materials. Physical properties
BS EN 1992	BS EN 1992-1-1:2023 Eurocode 2. Design of concrete structures. General rules and rules for buildings, bridges and civil engineering structures	General rules and rules for buildings, bridges and civil engineering structures
BS EN 1995	BS EN 1995-1-1:2004+A2:2014 Eurocode 5: Design of timber structures. General. Common rules and rules for buildings	Design of timber structures
BS EN 10025	BS EN 10025-1:2004 Hot rolled products of structural steels. General technical delivery conditions	General technical delivery conditions
	BS EN 10025-3:2019 Hot rolled products of structural steels. Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels	Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels
	BS EN 10025-4:2019+A1:2022 Hot rolled products of structural steels. Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels	Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels
BS EN 10210	BS EN 10210-1:2006 Hot finished structural hollow sections of non-alloy and fine grain steels. Technical delivery requirements	Technical delivery requirements
BS EN 12020	BS EN 12020-2:2022 Aluminium and aluminium alloys. Extruded precision profiles in alloys EN AW-6060 and EN AW-6063. Tolerances on dimensions and form	Tolerances on dimensions and form
BS EN 12899	BS EN 12899-1:2007 Fixed, vertical road traffic signs. Fixed signs	Fixed signs

BS EN 1367	BS EN 1367:2014 Tests for Thermal and Weathering Properties of Aggregates	Tests For Thermal and Weathering Properties of Aggregates
BS EN 1423	BS EN 1423:2012 Road Marking Materials. Drop On Materials. Glass Beads, Antiskid Aggregates and Mixtures of The Two	Road Marking Materials-Glass Beads, Antiskid Aggregates and Mixtures of The Two
BS EN 1424	BS EN 1424:1998 Road Marking Materials. Premix Glass Beads	Road Marking Performance for Road Users and Premix Glass Beads
BS EN 1452	BS EN 1452 Plastics Piping Systems for Water Supply - Unplasticized Poly (Vinyl Chloride) (PVC-U)	Plastics Piping Systems for Water Supply
BS EN 1456	BS EN 1456-1:2001 Plastic Piping Systems for Buried and Above-Ground Drainage and Sewerage Under Pressure. Unplasticized Poly (Vinyl Chloride) (PVC-U) - Specifications for Piping Components and The System	UPVC Pipes
BS EN 1463	BS EN 1463-1:2021 Road marking materials. Retroreflecting road studs. Initial performance requirements	Road Marking Materials - Retro Reflective Road Studs
	BS EN 1463-2:2021 Road marking materials. Retroreflecting road studs. Road test performance specifications	Retroreflecting road studs. Road test performance specifications
BS EN 1824	BS EN 1824:2020 Road Marking Materials. Road Trials	Road Trials
BS EN 1871	BS EN 1871:2020 Road Marking Materials. Paint, Thermoplastic and Cold Plastic Materials. Physical Properties	Physical Properties for Paint, Thermoplastic and Cold Plastic
BS EN 1916	BS EN 1916:2002 Concrete Pipes and Fittings, Unreinforced, Steel Fibre and Reinforced	Precast Concrete Pipes
BS EN 1992	BS EN 1992-1-1:2004+A1:2014 Eurocode 2: Design of Concrete Structures - General Rules and Rules for Buildings	Design Of Concrete Structures
BS EN 1995	BS EN 1995-1-1:2004+A2:2014 UK National Annex to Eurocode 5: Design of Timber Structures - General. Common Rules and Rules for Buildings	Design Of Timber Structures
BS EN 5268	BS 5268:1998 Structural Use of Timber	Structural Use of Timber
BS EN 10025	BS EN 10025:2004 Hot Rolled Products of Structural Steels	Hot Rolled Products of Structural Steels
BS EN 10029	BS EN 10029:2010 Hot-Rolled Steel Plates 3 Mm Thick or Above. Tolerances On Dimensions and Shape	Hot-Rolled Steel Plates 3 Mm Thick or Above. Tolerances On Dimensions and Shape
BS EN 10034	BS EN 10034:1993 Structural Steel I And H Sections. Tolerances On Shape and Dimensions	Structural Steel I And H Sections - Tolerances on Shape and Dimensions
BS EN 10080	BS EN 10080:2005 Steel for The Reinforcement of Concrete. Weldable Reinforcing Steel. General	Steel For the Reinforcement of Concrete. Weldable Reinforcing Steel
BS EN 10083	BS EN 10083-1:2006 Steels for quenching and tempering. General technical delivery conditions	General technical delivery conditions
BS EN 10088	BS EN 10088-3:2014 Stainless Steels - Technical Delivery Conditions for Semi-Finished Products, Bars, Rods, Wire, Sections and Bright Products of Corrosion Resisting Steels for General Purposes	Stainless Steels - Technical Delivery Conditions for Semi-Finished Products, Bars, Rods, Wire, Sections and Bright Products of Corrosion Resisting Steels
BS EN 10095	BS EN 10095:1999 Heat resisting steels and nickel alloys	Heat resisting steels and nickel alloys
BS EN 10113	BS EN 10113:1993 Hot-Rolled Products in Weldable Fine Grain Structural Steels	Structural Steel
BS EN 10137	BS EN 10137-1:1996 Plates and Wide Flats Made of High Yield Strength Structural Steels in The Quenched and Tempered or Precipitation Hardened Conditions - General Delivery Conditions	Plates And Wide Flats Made of High Yield Strength Structural Steels in The Quenched and Tempered or Precipitation Hardened Conditions
BS EN 10155	BS EN 10155:1993 Structural Steels with Improved Atmospheric Corrosion Resistance. Technical Delivery Conditions	Structural Steel
BS EN 10162	BS EN 10162:2003 Cold rolled steel sections. Technical delivery conditions. Dimensional and cross-sectional tolerances	Technical delivery conditions. Dimensional and cross-sectional tolerances
BS EN 10210	BS EN 10210-2:2019 Hot Finished Steel Structural Hollow Sections - Tolerances, Dimensions and Sectional Properties	Hot Finished Steel Structural Hollow Sections, Tolerances, Dimensions and Sectional Properties
BS EN 10250	BS EN 10250-4:2021 Open die steel forgings for general engineering purposes. Stainless steels	Stainless steels
BS EN 10365	BS EN 10365:2017 Hot Rolled Steel Channels, I And H Sections. Dimensions And Masses	Hot Rolled Steel Channels, I And H Sections, Dimensions and Masses
BS EN 12201	BS EN 12201-1:2024 Plastics piping systems for water supply, and for drains and sewers under pressure. Polyethylene (PE). General	Plastic piping systems for water supply, and for drains and sewers under pressure.
	BS EN 12201-2:2024 Plastics piping systems for water supply, and	Plastic piping systems for water

	for drains and sewers under pressure. Polyethylene (PE). Pipes	supply, and for drains and sewers under pressure.
	BS EN 12201-5:2024 Plastics piping systems for water supply, and for drains and sewers under pressure. Polyethylene (PE). Fitness for purpose of the system	Plastic piping systems for water supply, and for drains and sewers under pressure
BS EN 12271	BS EN 12271:2006 Surface Dressing. Requirements	Surface Dressing
BS EN 12350	BS EN 12350-1:2019 Testing Fresh Concrete Sampling and Common Apparatus	Testing Fresh Concrete. Sampling And Common Apparatus
BS EN 12591	BS EN 12591:2009 Bitumen and bituminous binders. Specifications for paving grade bitumens	Specification For Pavement Grade Bitumen
BS EN 12597	BS EN 12597:2014 Bitumen and Bituminous Binders. Terminology	Bitumen And Bituminous Binders-Terminology
BS EN 12620	BS EN 12620:2002+A1:2008 Aggregates for Concrete	Aggregates For Concrete
BS EN 12889	BS EN 12889:2022 Trenchless Construction and Testing of Drains and Sewers	Trenchless Construction and Testing of Drains and Sewers
BS EN 13043	BS EN 13043:2002 - Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
BS EN 13055-1	BS EN 13055-1:2002 Lightweight Aggregates - Lightweight Aggregates for Concrete, Mortar and Grout	Lightweight Aggregates for Concrete
BS EN 13108	BS EN 13108-4:2016 Bituminous mixtures. Material specifications. Hot Rolled Asphalt	Hot Rolled Asphalt
BS EN 13249	BS EN 13249:2016 Geotextiles and Geotextile-Related Products. Characteristics Required for Use in The Construction of Roads and Other Trafficked Areas (Excluding Railways and Asphalt Inclusion)	Geotextiles-Characteristics Required for Use in Construction of Roads and Other Trafficked Areas
BS EN 13251	BS EN 13251:2016 Geotextiles and Geotextile-Related Products. Characteristics Required for Use in Earthworks, Foundations and Retaining Structures	Geotextiles-Characteristics Required for Use in Earthworks, Foundations and Retaining Structures
BS EN 13252	BS EN 13252:2016 Geotextiles and Geotextile-Related Products. Characteristics Required for Use in Drainage Systems	Geotextiles-Characteristics Required for Use in Drainage Systems
BS EN 13263	BS EN 13263-1:2005+A1:2009 Silica Fume for Concrete - Definitions, Requirements and Conformity Criteria	Silica Fume for Concrete
BS EN 13369	BS EN 13369:2018 Common Rules for Precast Concrete Products	Common Rules for Precast Concrete Products
BS EN 13391	BS EN 13391:2004 Mechanical tests for post-tensioning systems	Mechanical tests for post-tensioning systems
BS EN 13556	BS EN 13556:2003 Round and sawn timber. Nomenclature of timbers used in Europe	Nomenclature of timbers used in Europe
BS EN 13670	BS EN 13670:2009 Execution of Concrete Structures	Execution Of Concrete Structures
BS EN 13791	BS EN 13791:2019 Assessment of in-situ compressive strength in structures and precast concrete components	Assessment of in-situ compressive strength in structures and precast concrete components
BS EN 13924	BS EN 13924-1:2015 Bitumen and bituminous binders. Specification framework for special paving grade bitumen. Hard paving grade bitumens	Specification framework for special paving grade bitumen. Hard paving grade bitumens
BS EN 14188	BS EN 14188:2006 Joint Fillers and Sealants	Joint Fillers and Sealants.
BS EN 14475	BS EN 14475:2006 Execution of special geotechnical works. Reinforced fill	Reinforced fill
BS EN 14490	BS EN 14490:2010 Execution of special geotechnical works. Soil nailing	Soil nailing
BS EN 15167	BS EN 15167-1:2006 Ground granulated blast furnace slag for use in concrete, mortar and grout. Definitions, specifications and conformity criteria	Ground granulated blast furnace slag for use in concrete, mortar and grout
	BS EN 15167-2:2024 Ground granulated blast furnace slag for use in concrete, mortar and grout. Assessment and verification of the constancy of performance	Ground granulated blast furnace slag for use in concrete, mortar and grout
BS ISO 2476	BS ISO 2476:2014 Butadiene rubber (BR). Solution-polymerized types. Evaluation procedures	Evaluation procedures
BS ISO 3310	BS ISO 3310-1:2016 - Test sieves. Technical requirements and testing. Test sieves of metal wire cloth	Test sieves. Technical requirements and testing. Test sieves of metal wire cloth
BS EN ISO 683	S EN ISO 683-3:2022 Heat-treatable steels, alloy steels and free-cutting steels. Case-hardening steels	Case-hardening steels
	BS EN ISO 683-4:2018 Heat-treatable steels, alloy steels and free-cutting steels. Free-cutting steels	Free-cutting steels
	BS EN ISO 683-5:2021 Heat treatable steels, alloy steels and free-cutting steels. Nitriding steels	Nitriding steels

BS EN ISO 11600	BS EN ISO 11600:2003+A1:2011 Building construction. Jointing products. Classification and requirements for sealants	Classification and requirements for sealants
BS EN ISO 1461	BS EN ISO 1461:2022 Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles. Specifications And Test Methods	Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles. Specifications And Test Methods
BS EN ISO 3766	BS EN ISO 3766:2003 Construction Drawings. Simplified Representation of Concrete Reinforcement	Construction Drawings. Simplified Representation of Concrete Reinforcement
BS EN ISO 4136	BS EN ISO 4136:2022 Destructive tests on welds in metallic materials. Transverse tensile test	Transverse tensile test
BS EN ISO 5173	Destructive tests on welds in metallic materials. Bend tests	Bend tests
BS EN ISO 5178	BS EN ISO 5178:2019 Destructive tests on welds in metallic materials. Longitudinal tensile test on weld metal in fusion welded joints	Longitudinal tensile test on weld metal in fusion welded joints
BS EN ISO 6892	BS EN ISO 6892-1:2019 Metallic Materials. Tensile Testing. Method Of Test at Room Temperature	Metallic Materials. Tensile Testing Method of Test at Low Temperature
BS EN ISO 8501	BS EN ISO 8501:2020 Preparation of Steel Substrates Before Application of Paints and Related Products. Visual Assessment of Surface Cleanliness	Preparation Of Steel Substrates Before Application of Paints and Related Products
BS EN ISO 9015	BS EN ISO 9015-1:2011 Destructive tests on welds in metallic materials. Hardness testing. Hardness test on arc welded joints	Hardness test on arc welded joints
	BS EN ISO 9015-2:2016 Destructive tests on welds in metallic materials. Hardness testing. Microhardness testing of welded joints	Microhardness testing of welded joints
BS EN ISO 9016	BS EN ISO 9016:2022 Destructive tests on welds in metallic materials. Impact tests. Test specimen location, notch orientation and examination	Test specimen location, notch orientation and examination
BS EN ISO 9017	BS EN ISO 9017:2018 Destructive tests on welds in metallic materials. Fracture test	Fracture test
BS EN ISO 9018	BS EN ISO 9018:2015 Destructive tests on welds in metallic materials. Tensile test on cruciform and lapped joints	Tensile test on cruciform and lapped joints
BS EN ISO 9513	BS EN ISO 9513:2012 Metallic Materials. Calibration Of Extensometer Systems Used in Uniaxial Testing	Metallic Materials — Calibration of Extensometer Systems Used in Uniaxial Testing
BS EN ISO 10320	BS EN ISO 10320:2019 Geo-synthetics. Identification On Site	Geotextiles-Identification on Site
BS EN ISO 11600	BS EN ISO 11600:2003+A1:2011 Building Construction. Jointing Products. Classification And Requirements for Sealants	Building Construction — Jointing Products — Classification and Requirements for Sealants
BS EN ISO 14713	BS EN ISO 14713:2020 Zinc Coatings. Guidelines And Recommendations for The Protection Against Corrosion of Iron and Steel in Structures	Protection Against Corrosion of Iron and Steel in Structures
BS EN ISO 17639	BS EN ISO 17639:2022 Destructive tests on welds in metallic materials. Macroscopic and microscopic examination of welds	Macroscopic and microscopic examination of welds
BS EN ISO 18286	BS EN ISO 18286:2010 Hot-rolled stainless-steel plates. Tolerances on dimensions and shape	Tolerances on dimensions and shape
PD 970	PD 970:2005 Wrought steels for mechanical and allied engineering purposes. Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels	Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels

(g) Southern African Bitumen Association

TG-1 (5th Edition)	TG-1 (5th Edition):2020 The Use of Modified Bituminous Binders in Road Construction	The Use of Modified Bituminous Binders in Road Construction
TG-2 (3rd Edition)	TG-2 (3rd Edition):2020 Bitumen Stabilised Materials	Bitumen Stabilised Materials
TG-3 (3rd Edition)	TG-3 (3rd Edition):2022 Asphalt Reinforcement for Road Construction	Asphalt Reinforcement for Road Construction
Manual 2	Manual 2 (PG):2012 Bituminous Products for road construction and maintenance,	Bituminous Products for Road Construction and Maintenance
Manual 19	Manual 19:2019 Guidelines for the design, manufacture and construction of bitumen rubber asphalt wearing courses	Guidelines for The Design, Manufacture and Construction of Bitumen-Rubber Asphalt Wearing Courses
Manual 35 / TRH 8	Manual 35/TRH8:2020 Design and use of Asphalt in Road Pavements	Design and Use of Asphalt in Road Pavements
Manual 39	Manual 39:2021 Laboratory Testing Protocols for Binders and Asphalt	Laboratory Testing Protocols for Binders and Asphalt

(h) Technical Methods for Highways (TMH), South Africa

TMH – 1	TMH1: Standard Methods of Testing Road Construction Materials, 1986	Standard methods of testing road construction material
TMH – 5	TMH5: Sampling Methods for Road Construction Materials, 1981	Sampling methods for road construction materials
TMH – 6	Special Methods for Testing Methods 1984	Special methods for testing roads

(i) International Standards Organisation

ISO / R – 161	ISO/R 161:1960 Pipes of Plastics Materials for The Transport of Fluids	Specification for High Density Polyethylene (HDPE) pipes
BS ISO 8349	ISO 8349:2002 Road Vehicles — Measurement of Road Surface Friction	Road vehicles-measurement of road friction by the direct liquid injection method

(j) South African National Standards (SANS)

SANS – 044	Welding procedures
SANS – 064	Abrasive blasting
SANS – 094	Holes for friction grip fasteners
SANS – 0100	Concrete cores
SANS – 0142	Electrical installations
SANS – 0162	Design of work/codes of practice
SANS – 05	Timber treatment
SANS – 82	Steel reinforcing bars
SANS – 92	Roofing felt (bridge bearings)
SANS – 113	pH test (Water)
SANS – 134	Paint
SANS – 135	Bolts and nuts
SANS – 136	Bolts and nuts
SANS – 141	Paint thickness test
SANS – 202	Chloride content (Water)
SANS – 212	Sulphate content (Water)
SANS – 213	Total dissolved solids (Water)
SANS – 227	Bricks
SANS – 307	Penetration grade bitumen
SANS – 308	Prime
SANS – 309	Bitumen emulsion
SANS – 435	Rivets
SANS – 455	Welding electrodes
SANS – 457	Timber Posts
SANS – 471	Ordinary Portland Cement
SANS – 533	Pipes
SANS – 538	Timber treatment
SANS – 539	Timber treatment
SANS – 548	Bitumen emulsion
SANS – 558	Manhole covers
SANS – 626	Portland blast-furnace cement
SANS – 630	Finishing coats (paint)
SANS – 634	Finishing coats (paint)
SANS – 657	Steel tubes
SANS – 673	Timber treatment
SANS – 675	Wire
SANS – 677	Pipes
SANS – 679	Primer (paint)
SANS – 681	Undercoat (paint)
SANS – 684	Finishing coats (paint)
SANS – 723	Primer (paint)
SANS – 731	Road marking paint
SANS – 741	Sulphate content (cementitious binders)
SANS – 748	Prime
SANS – 1519	Paint
SANS – 1555	Delineation signs
SANS – 1580	Wire mesh
SANS – 749	Prime
SANS – 754	Timber posts
SANS – 763	Galvanising
SANS – 772	Abrasive blasting
SANS – 783	Finishing coats (paint)
SANS – 791	Pipes
SANS – 801	Epoxy tar paint
SANS – 802	Finishing coats (paint)
SANS – 821	Road Lime

SANS – 831	Rapid hardening cement (OPC15)
SANS – 836	Aggregate test
SANS – 837	Sugar Content (Water)
SANS – 838	Sand equivalent test
SANS – 841	Alkali carbonates and bicarbonates (water)
SANS – 844	Relative density tests
SANS – 845	Compacted bulk density
SANS – 848	Polished stone value tests
SANS – 850	Sulphate content (aggregates)
SANS – 855	Free water content (aggregates)
SANS – 856	Bulking of fine aggregates
SANS – 862	Slump (concrete)
SANS – 864	Flexure strength test (concrete)
SANS – 865	Compression strength (Concrete cores)
SANS – 878	Ready mix concrete
SANS – 912	Primer (paint)
SANS – 920	Steel reinforcing bars
SANS – 921	Pipes
SANS – 926	Zinc rich epoxy
SANS – 927	Kerbing
SANS – 934	Galvanising
SANS – 967	Rubber joints for pipes
SANS – 986	Culverts
SANS – 1024	Welded steel fabric
SANS – 1058	Paving blocks
SANS – 1077	Joint sealant
SANS – 1083	Aggregate
SANS – 1085	Sand
SANS – 1091	Paint
SANS – 1143	Steel bolts and nuts
SANS – 1149	Washers
SANS – 1223	Pipes
SANS – 1260	Prime
SANS – 1282	Friction grip nuts and bolts
SANS – 1350	Guardrails
SANS – 1373	Diamond mesh
SANS – 1391	Galvanising
SANS – 1413	Finishing coats (paint)
SANS – 1431	Structure steel
SANS – 1442	Road Studs
SANS – 1500	Electrical installations

(k) Standard Coordination Specification (CKS)

CKS – 82	Steel sections
CKS – 176	Corrugated metal culverts
CKS – 191	Retro-reflective materials
CKS – 192	Retro-reflective road marking paint
CKS – 388	Natural rubber water stops
CKS – 389	PVC rubber water stops
CKS – 437	Corrugated metal culverts
CKS – 564	Bonding liquid for concrete surfaces
CKS – 592	Barbed tape concertina wire

7503 ADDRESSES

The Ugandan, AASHTO, ASTM, BS, BS EN, ISO, CKS, DIN, SANS, SIS and US Federal specification and test method documents referred to in this document can be obtained from the following sources:

Central Materials Laboratory, Ministry of Works and Transport
P. O. Box 7174
Kampala
Uganda
Tel.: +256 414 259 139
Email: mowt@works.go.ug
Website: www.works.go.ug

Uganda National Bureau of Standards
P. O. Box 6329
Kampala
Uganda
Tel.: +256 417 333 250
Email: info@unbs.go.ug
Website: www.unbs.go.ug

South African Bureau of Standards
1Dr Lategan Rd, Groenkloof,
Pretoria
0027
Tel.: +27 861 277227
Email: info@sabs.co.za
Website: www.sabs.co.za

The SABITA specification and test method documents:
SABITA
5 Lonsdale Building, Lonsdale Way, Pinelands,
7405 Western Cape, South Africa,
Tel.: +27 21 5312718
Email: info@sabita.co.za
Website: www.sabita.co.za

The TMH and TRH documents:
Department of Transport (Publications Department)
Private Bag x193
Pretoria, 0001
South Africa
Tel.: +27 12 309 3000
Email: info@dot.gov.za
Website: www.transport.gov.za

Comité Européen de Normalisation
Rue de la Science 23
B-1040 Brussels, Belgium
Tel.: +32 2550 08 11
Fax: +32 2550 08 11
Email: info@cencenelec.eu
Website: www.cencenelec.eu

International Organisation for Standardisation (ISO)
Chemin de Blandonnet 8
CP 401
1214 Vernier (Geneva)
Switzerland
Tel.: +41 22 749 0111
Fax: +41 22 733 34 30
Email: central@iso.org
Website: www.iso.org

SERIES 8000

DAYWORKS

CONTENTS OF THE GENERAL SPECIFICATIONS:

<i>SERIES 1000</i>	<i>GENERAL</i>
<i>SERIES 2000</i>	<i>DRAINAGE</i>
<i>SERIES 3000</i>	<i>SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE</i>
<i>SERIES 4000</i>	<i>BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT</i>
<i>SERIES 5000</i>	<i>ANCILLARY ROADWORKS</i>
<i>SERIES 6000</i>	<i>STRUCTURES</i>
<i>SERIES 7000</i>	<i>TOLERANCES, TESTING AND QUALITY CONTROL</i>

SERIES 8000 DAYWORKS

APPENDICES

SERIES 8000

DAYWORKS

SECTION	PAGE
8100 LABOUR	8000-2
8200 MATERIAL	8000-3
8300 EQUIPMENT	8000-4

CONTENTS OF THE GENERAL SPECIFICATIONS:

SERIES 1000	GENERAL
SERIES 2000	DRAINAGE
SERIES 3000	SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE
SERIES 4000	BITUMINOUS LAYERS SEALS AND CONCRETE PAVEMENT
SERIES 5000	ANCILLARY ROADWORKS
SERIES 6000	STRUCTURES
SERIES 7000	TOLERANCES, TESTING AND QUALITY CONTROL

SERIES 8000 DAYWORKS

APPENDICES

SERIES 8000 DAYWORKS**SECTION 8100 LABOUR**

- iv. All other costs which the Contractor may incur in the employment of labour including overheads, profit and any other costs or allowances.

CONTENTS:

CLAUSE	PAGE
8101 SCOPE	8000-2
8102 MEASUREMENT AND PAYMENT	8000-2

8101 SCOPE

This Section covers the method of payment where the contractor is paid based on the actual time spent by workers in executing works that cannot be measured in advance or are outside the original works contract.

8102 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
81.01 LABOUR	
(a) UNSKILLED LABOUR	Hour (hr)
(b) SKILLED LABOUR	Hour (hr)
(c) HEADMAN	Hour (hr)
(d) FOREMAN	Hour (hr)
(e) ENGINEER	Hour (hr)
(f) SITE MANAGER	Hour (hr)
(g) DRIVER HEAVY	Hour (hr)
(h) DRIVER LIGHT	Hour (hr)
(i) PLANT OPERATOR H/D	Hour (hr)
(j) PLANT OPERATOR L/D	Hour (hr)
(k) LAND SURVEYOR	Hour (hr)
(l) DRAFTSMAN	Hour (hr)
(m) MASON	Hour (hr)
(n) CARPENTER	Hour (hr)
(o) PLUMBER	Hour (hr)
(p) WATCHMAN/SECURITY	Hour (hr)

The Contractor shall be entitled to payments in respect of the total time that labour is employed on Dayworks calculated from the rates entered by him in the "Schedule of Dayworks, Section 8100: Labour". Hourly labour rates shall include all transport to and from the place of work. Only time engaged in working on the particular work task ordered by the Engineer will be paid.

Payment shall only be made for the time each class of labour is working on Dayworks instructed by the Engineer.

The rates for labour shall include compensation for the cost of the following:

- i. Supervision and transport of staff;
- ii. Any special allowance to such labour in respect of subsistence, overtime, bonuses, feeding, housing, holiday, transport to and from the place of Daywork, overhead charges in respect of recruitment, camp administration and welfare and insurances;
- iii. Supply, transport about the Site, used, maintenance and renewal of small tools used on Dayworks, such as picks shovels, barrows, trowels, hand saws, buckets, trestles, hammers, chisels and all items of a like nature and not specifically referred to in the items for construction plant and protective clothing; and

SERIES 8000 DAYWORKS

iv. Supervision, overheads, profit and any other costs or allowances.

SECTION 8200 MATERIALS**CONTENTS**

CLAUSE	PAGE
8201 SCOPE	8000-3
8202 MEASUREMENT AND PAYMENT	8000-3

8201 SCOPE

This Section covers the method of payment where the contractor is paid based on the actual cost of materials used in executing works that cannot be measured in advance or are outside the original works contract.

8202 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
82.01 MATERIALS	
(a) DIESEL (GAS OIL)	LITRE (l)
(b) PETROL	LITRE (l)
(c) COARSE CRUSHED AGGREGATE	TONNE (t)
(d) FINE AGGREGATE (SAND)	TONNE (t)
(e) GRANULAR MATERIAL FOR SUBBASE	CUBIC METRE (m ³)
(f) ORDINARY PORTLAND CEMENT	TONNE (t)
(g) LIME	TONNE (t)
(h) MILD STEEL REINFORCEMENT	TONNE (t)
(i) HIGH YIELD STRESS STEEL BARS	TONNE (t)
(j) TIMBER	SQUARE METRE (m ²)
(k) FORMWORK	SQUARE METRE (m ²)
(l) THERMOPLASTIC ROAD PAINT	LITRE (l)
(m) BITUMEN (50/70 OR 80/100 OR, ETC AS APPLICABLE)	TONNE (t)
(n) CUTBACK BITUMEN MC-30	LITRE (l)
(o) 30% BITUMEN EMULSION	LITRE (l)
(p) LUBRICANT	KILOGRAMME (kg)
(q) GEOTEXTILE	SQUARE METRE (m ²)
(r) GEOGRID	SQUARE METRE (m ²)
(s) GEOCELL	SQUARE METRE (m ²)

The Contractor shall be entitled to payments in respect of materials used for Dayworks at the rates entered by him in the "Schedule of Dayworks, Section 8200: Materials". Materials unit rates shall include all transport of materials to the location where they are to be incorporated into the Works.

Payment shall only be made for materials instructed by the Engineer for use on Dayworks. The net weights, volumes and areas as appropriate, verified by the Engineer in accordance with his instructions, shall be measured.

The rates for materials shall include compensation for the cost of the following:

- i. Purchase or provision of the material;
- ii. Transport to the site and place of dayworks;
- iii. Storage, insurance, handling, placing; and

SERIES 8000 DAYWORKS**SECTION 8300EQUIPMENT****CONTENTS**

CLAUSE	PAGE
8301 SCOPE	8000-4
8302 MEASUREMENT AND PAYMENT	8000-4

8301 SCOPE

This Section covers the method of payment where the contractor is paid based on the actual time equipment is deployed and executing works that cannot be measured in advance or are outside the original works contract.

8302 MEASUREMENT AND PAYMENT

<u>ITEM</u>	<u>UNIT</u>
83.01 EQUIPMENT	
(a) D4 DOZER OR EQUIVALENT WITH BLADE AND RIPPER	Hour (hr)
(b) D8 DOZER OR EQUIVALENT WITH BLADE AND RIPPER	Hour (hr)
(c) WHEELED EXCAVATOR, BUCKET CAPACITY UNDER 1M ³	Hour (hr)
(d) WHEELED EXCAVATOR, BUCKET CAPACITY 1-2M ³	Hour (hr)
(e) TRUCK LOADER, 3-4M ³ BUCKET CAPACITY	Hour (hr)
(f) BACKHOE LOADER	Hour (hr)
(g) 5T TIPPER LORRY	Hour (hr)
(h) 9T TIPPER LORRY	Hour (hr)
(i) DUMP TRUCK	Hour (hr)
(j) MOTORGRADER, COMPLETE WITH SCARIFIER	Hour (hr)
(k) PULVIMIXER	Hour (hr)
(l) 5-6T DRAWN VIBRATING ROLLER AND TRACTOR	Hour (hr)
(m) 10-12T SMOOTH WHEELED ROLLER	Hour (hr)
(n) 16-18T SMOOTH WHEELED ROLLER	Hour (hr)
(o) PNEUMATIC ROLLER, 500KG PER TYRE WHEN FULLY BALLASTED	Hour (hr)
(p) VIBRATING PLATE COMPACTOR	Hour (hr)
(q) SELF-PROPELLED WATER TANKER MIN. 14,000LTR WITH PICK-UP PUMP	Hour (hr)
(r) COMPRESSOR 120L/M COMPLETE WITH ALL TOOLS	Hour (hr)
(s) GENERATOR 15KW	Hour (hr)
(t) GENERATOR 150KW	Hour (hr)
(u) ROCK DRILL	Hour (hr)
(v) CONCRETE MIXER UP TO 400 LITRES	Hour (hr)
(w) CONCRETE MIXING PLANT, COMPLETE 1M ³ OR ABOVE	Hour (hr)
(x) ASPHALT PLANT 120T/H	Hour (hr)
(y) CONCRETE VIBRATOR	Hour (hr)
(z) PICK-UP TRUCK	Hour (hr)

The Contractor shall be entitled to payments in respect

of equipment already on site and employed on Dayworks calculated from the rates entered by him in the "Schedule of Dayworks, Section 8300: Equipment". Hourly equipment rates shall include all transport of the equipment to and from the place of work. Only time engaged in working on the task ordered by the Engineer will be paid.

Payment shall only be made for the time each item of plant is working on Dayworks instructed by the Engineer. Idle time, where due solely to the nature of the dayworks activity or authorized method of procedure, shall be paid for at 50% of the bid rate. Idle time due to breakdowns, inefficiency or incompleteness of the plant shall not be paid.

The rates for the plant shall include for:

- i. Supervision and transport of supervisory staff;
- ii. Transporting or travelling of each time of plant to and from the place of Dayworks activity;
- iii. Operators, drivers and turnboys, including overtime;
- iv. Power, water, fuel, oil, grease and other consumables and equipment;
- v. Power cables, delivery or suction pipes and fittings, steam or air hoses and tackle and all other appurtenances of whatever nature required for the safe and efficient operation of the plant;
- vi. Maintenance, spare parts, drill bits and chisel points and all costs of repairs; and
- vii. Depreciation, insurance, overheads, profit and any other costs or allowances.

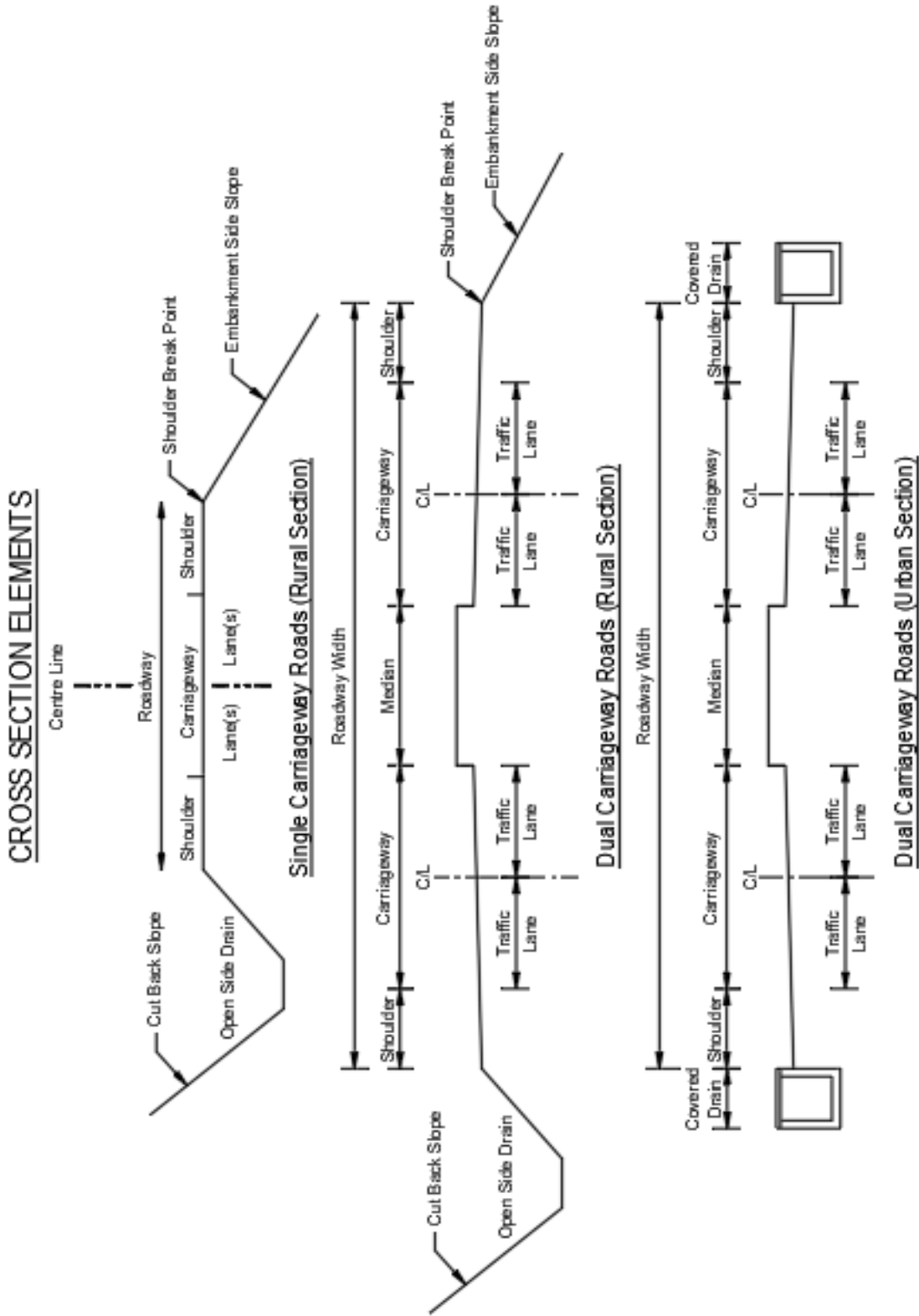
APPENDICES

CONTENTS OF THE GENERAL SPECIFICATIONS:

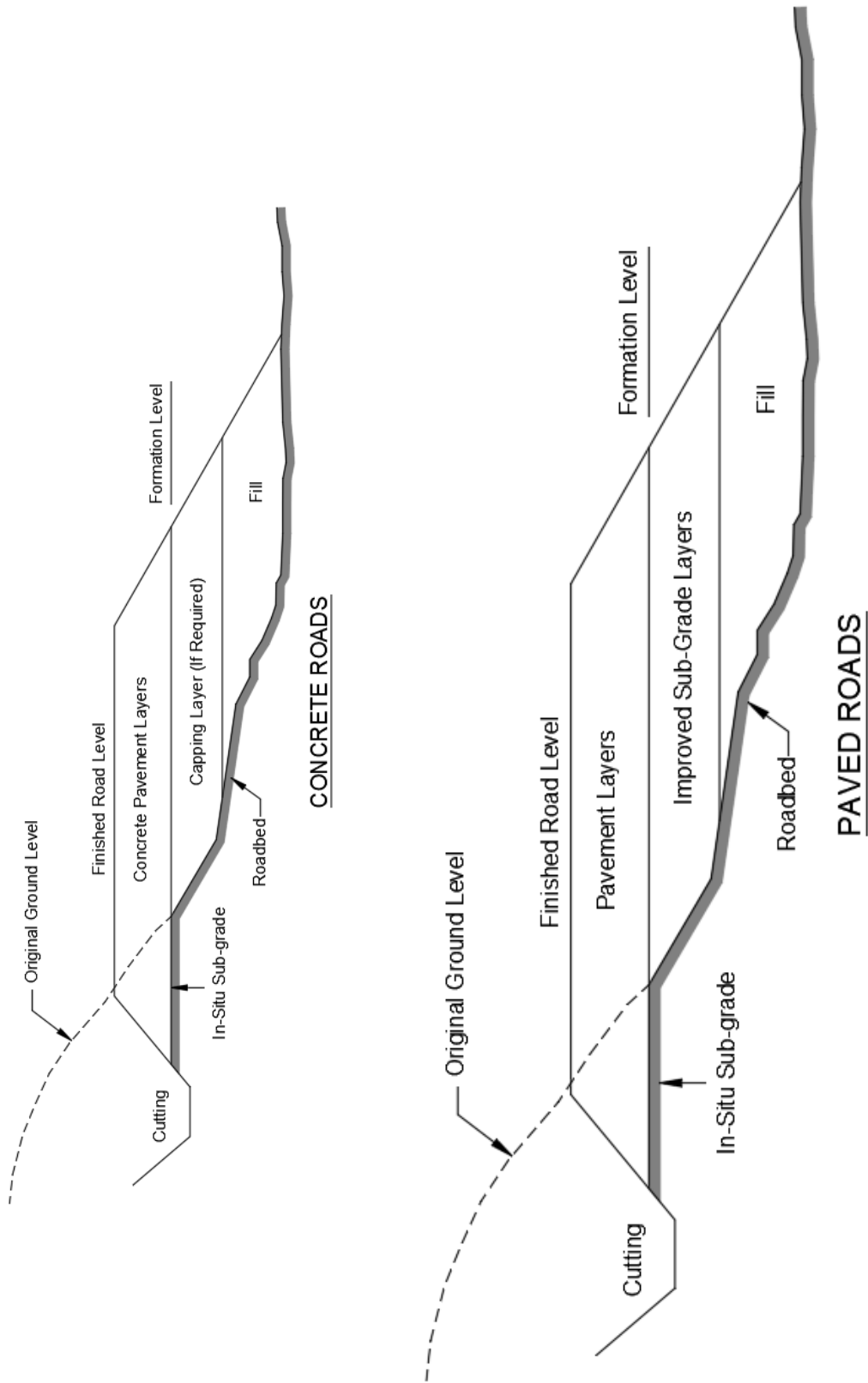
<i>SERIES 1000</i>	<i>GENERAL</i>
<i>SERIES 2000</i>	<i>DRAINAGE</i>
<i>SERIES 3000</i>	<i>SITE CLEARANCE, EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE</i>
<i>SERIES 4000</i>	<i>BITUMINOUS LAYERS, SEALS AND CONCRETE PAVEMENT</i>
<i>SERIES 5000</i>	<i>ANCILLARY ROADWORKS</i>
<i>SERIES 6000</i>	<i>STRUCTURES</i>
<i>SERIES 7000</i>	<i>TOLERANCES, TESTING AND QUALITY CONTROL</i>
<i>SERIES 8000</i>	<i>DAYWORKS</i>

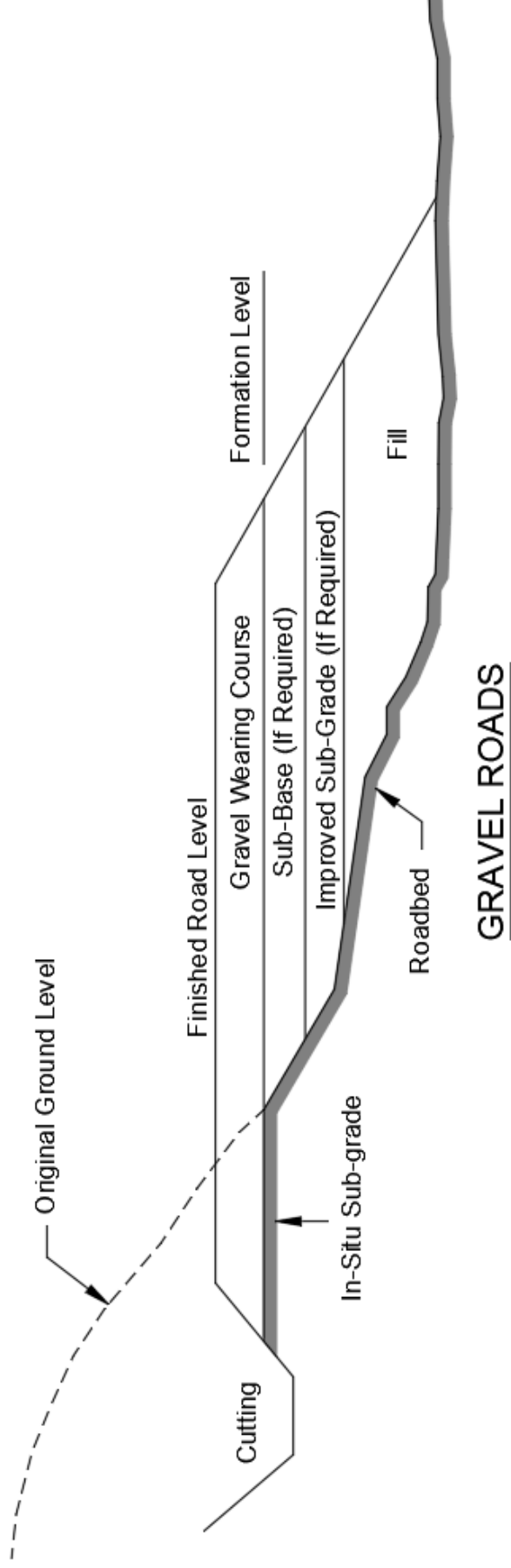
APPENDICES

APPENDIX A: DRAWINGS



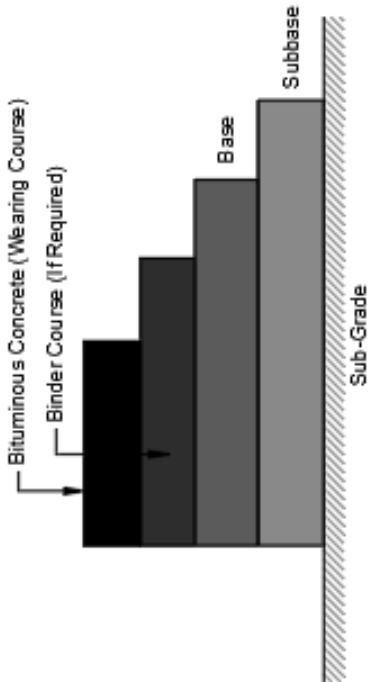
CROSS SECTION TERMS



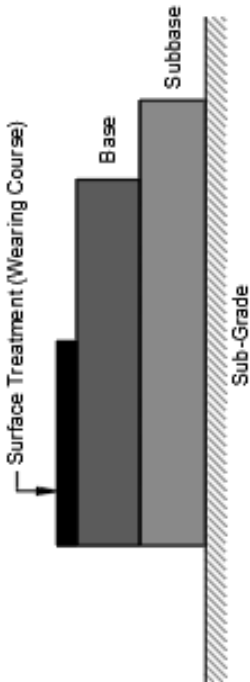


PAVEMENT DETAILS

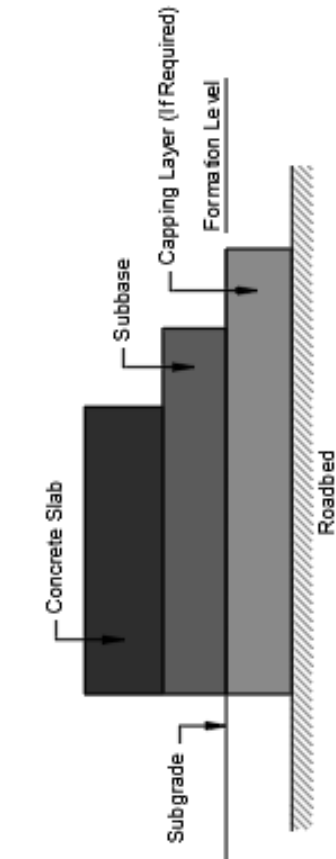
PAVED ROADS



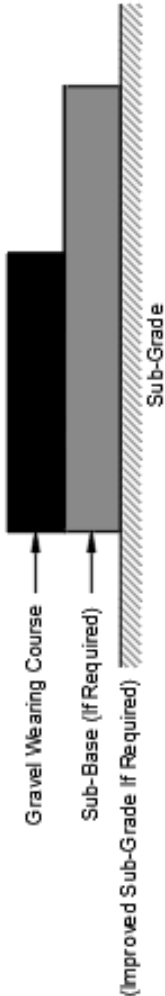
SURFACE TREATED ROADS

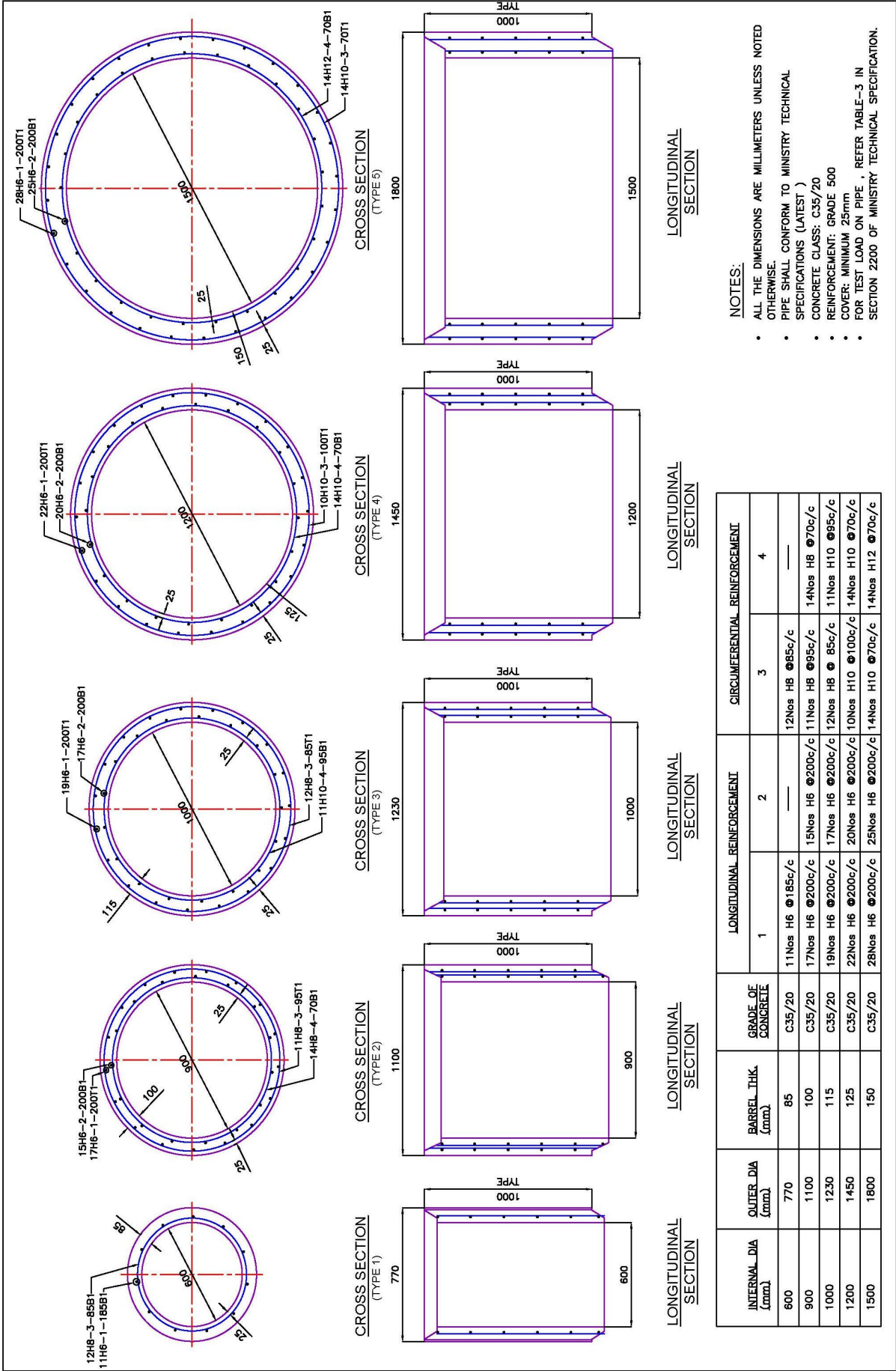


CONCRETE ROADS



GRAVEL ROADS





INTERNAL DIA (mm)	OUTER DIA (mm)	BARREL THK. (mm)	GRADE OF CONCRETE	LONGITUDINAL REINFORCEMENT			CIRCUMFERENTIAL REINFORCEMENT		
				1	2	3	4		
800	770	85	C35/20	11Nos H6 @185c/c	—	12Nos HB @85c/c	—		
900	1100	100	C35/20	17Nos H6 @200c/c	15Nos H6 @200c/c	11Nos HB @95c/c	14Nos HB @70c/c		
1000	1230	115	C35/20	19Nos H6 @200c/c	17Nos H6 @200c/c	12Nos HB @85c/c	11Nos H10 @95c/c		
1200	1450	125	C35/20	22Nos H6 @200c/c	20Nos H6 @200c/c	10Nos H10 @100c/c	14Nos H10 @70c/c		
1500	1800	150	C35/20	28Nos H6 @200c/c	25Nos H6 @200c/c	14Nos H10 @70c/c	14Nos H12 @70c/c		

NOTES:

- ALL THE DIMENSIONS ARE MILLIMETERS UNLESS NOTED OTHERWISE.
- PIPE SHALL CONFORM TO MINISTRY TECHNICAL SPECIFICATIONS (LATEST)
- CONCRETE CLASS: C35/20
- REINFORCEMENT: GRADE 500
- COVER: MINIMUM 25mm
- FOR TEST LOAD ON PIPE , REFER TABLE-3 IN SECTION 2200 OF MINISTRY TECHNICAL SPECIFICATION.

APPENDIX B: ABBREVIATIONS

Wherever the following abbreviations of titles, terms and units of measurement are used in the Standard and Special Specifications or on the Drawings, the meaning shall be as described hereunder.

Abbreviation	Titles and Terms

A.C.	Alternate current
AADT	Annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
AC10, AC12.5, AC14, AC19, AC20	Asphalt concrete (max. particle size 10 / 12.5 / 14 / 19 / 20mm)
ACV	Aggregate Crushing Value
AIDS	Acquired Immune Deficiency Syndrome
AIV	Aggregate Impact Value
ALD	Average Least Dimension
ART	Antiretroviral Therapy
ASTM	American Society for Testing and Materials
av.	Average
BEMIX	Bitumen emulsion mix
bit.	Bitumen/bituminous
BoQ	Bill of Quantities
BS	British Standard
BS EN	European Standard
C 0.7, C1.0, C1.5, C2.0, C3.0, C4.0	Cemented material layer (UCS minimum 0.7/1.0/1.5/2.0/3.0/4.0 MPa)
CBR	California Bearing Ratio
C-ESMP	Contractor's Environment and Social Management Plan
CML	Central Materials Laboratory
CMS	Cationic Medium Setting
conc.	Concrete
CRR	Crushed aggregate base with enhanced requirements
CRS	Crushed Aggregate Base
CSS	Cationic Slow Setting
D.C.	Direct Current
DBM30, DBM40	Dense Bituminous Macadam mix (max. particle size 30 / 40mm)
DBSD	Double Bituminous surface dressing
DR	Dump rock
DSR	Dynamic Shear Rheometer
equiv.	Equivalent
ESA	Equivalent Standard Axles
EVA	Plastomer polymer
FBMIX	Foamed bitumen mix
FI	Flakiness Index

G25, G 30, G45, G60, G80	Natural gravel with CBR % value min. 25 / 30 / 45 / 60 / 80
G3, G7, G15	Natural gravel with CBR % value min. 3 / 7 / 15
GM	Grading Modulus
Gmb	Specific Gravity of bituminous mix
Gmm	Specific Gravity Maximum of mix
GVM	Gross vehicle mass
GW	Gravel wearing course
HCT	HIV/AIDS Counselling and Testing
HIV	Human Immunodeficiency Virus
HSE	Health Safety and Environment
i.a.	Inter alia
ICL	Initial Consumption of Lime
IEC	Information Education and Communication
IPC	Interim Payment Certificate
ISO	International Organisation for Standardization
LAA	Los Angeles Abrasion
LAMBS	Large aggregate mixes for base (hot-mixed bituminous base)
LCD	Liquid crystal display
LL	Liquid Limit
LS	Linear Shrinkage
max.	Maximum
MC	Moisture content
MC-30, MC-70	Medium curing cut-back Bitumen
MDD	Maximum Dry Density
min.	Minimum
MOH	Ministry of Health
MS	Anionic Medium Setting
MSDS	Material Safety Data Sheet
N/A	Not applicable
NSP	Nominated Service Provider
OHS	Occupational Health and Safety
OMC	Optimum Moisture Content
OPC	Ordinary Portland Cement
PAV	Pressure Ageing Vessel
PBFC	Portland blast-furnace Cement
PI	Plasticity Index
PL	Plastic Limit
PLC	Project Liaison Committee
PLWDs	People Living With Disabilities
PM	Plasticity Modulus
PM30/PM60/PM80	Penetration Macadam
PPE	Personal Protective Equipment
Pro rata	Proportional / proportionally
PSV	Polished Stone Value
pts.	Points
PVC	Polyvinyl chloride
R&B	Ring and ball softening point test

RAP	Resettlement Action Plan
RC	Reinforced concrete
ROW	Right-of-way
RS	Anionic Rapid Setting
RTFOT	Rotating Thin Film Oven Test
SABITA	Southern African Bitumen and Tar Association
SABS	South African Bureau of Standards
SATCC	Southern African Transport Coordinating Commission
SBR	Styrene-butadiene rubber
SBS	Styrene-butadiene-styrene
SE	Sand Equivalent
SG	Specific Gravity
SP	Shrinkage Product
SS	Anionic Slow Setting
SSD	Single surface dressing
SSS	Sodium Sulphate Soundness
STD	Sexually Transmitted Disease
STI	Sexually transmitted infection
Stn.	Station (location along the designed road centreline)
TFOT	Thin Film Oven Test
TFV	Ten Percent Fines Value
TLA	Trinidad Lake Asphalt
TRL	Transport Research Laboratory (previously TRRL)
TSR	Tensile Strength Ratio
UCS	Unconfined Compressive Strength
UGX	Uganda shilling
UPS	uninterrupted power supply
VFA	Voids Filled with Asphalt
VMA	Voids in Mineral Aggregates

<u>Abbreviation</u>	<u>Titles and Terms</u>
A	Ampere (s)
°C	Degree Celsius (Centigrade)
cm	Centimetre(s)
cst	Centistoke(s)
cu.m or m ³	Cubic metre(s)
dB	Decibel(s)
g	Gram(s)
hr/hrs	Hour(s)
ha	Hectare(s)
hp	Horsepower
Hz	Hertz (Frequency)
kg	Kilogram
km	Kilometre(s)
km/hr	Kilometres per hour
kN	kilo Newton
kPa	Kilo Pascal
kW or kVA	Kilowatt
lin.m	Linear metre(s)
L.	Litre(s)
L.S.	Lump Sum
m	Metre(s)
max	Maximum
min	Minute(s)
ml	Millilitre(s)
mm	Millimetre(s)
MPa	Mega pascal
N	Newton
no.	Number
Pa	Pascal
%	Percent
P.S.	Provisional Sum
ppm	Parts per million
rpm	Revolutions per minute
sec	Seconds
sq.cm or cm ²	Square centimetre(s)
sq.m or m ²	Square metre(s)
sq.mm or mm ²	Square millimetre(s)
t, tonne, MT	Metric ton (1,000 kg)
V	Volt (s)
W	Watt

MINISTRY OF WORKS AND TRANSPORT

📍 Off Jinja Road/ Old Port Bell Rd,
P. O. Box 7174, Kampala, Uganda

☎ +256 414 320135 / 0 414 321364

✉ mowt@works.go.ug