



THE REPUBLIC OF UGANDA

MINISTRY OF WORKS AND TRANSPORT

ROAD DESIGN MANUAL

VOLUME VII:

NON-MOTORIZED TRANSPORT



JANUARY 2025



THE REPUBLIC OF UGANDA

MINISTRY OF WORKS AND TRANSPORT

ROAD DESIGN MANUAL

VOLUME VII:

NON-MOTORIZED TRANSPORT



JANUARY 2025

Foreword

By the powers vested in me under Section 6 of the Road Act (2019), I am honoured to present the Non-Motorized Transport Manual, 2025. This manual will be used as one of the standards for the safe, efficient, effective and sustainable design of public roads in Uganda.

As a Ministry, we remain steadfast in our commitment to integrating pedestrians and cycling facilities into design and construction of road and bridge infrastructure. This manual will serve as a critical component of the legal and technical framework for the planning, design, construction, maintenance, and operation of efficient and effective public roads and bridges infrastructure in our Country.

In recent years, the Government has embarked on significant investment programs aimed at improving the country's road infrastructure. However, road safety in Uganda is a significant public health concern, with over 13 lives lost daily due to road crashes. Furthermore, Non-Motorized Transport (NMT) — primarily walking and cycling — remains the most common means of transport in Uganda. A large proportion of the population, both in urban and rural areas, relies on walking or cycling to reach their destinations.

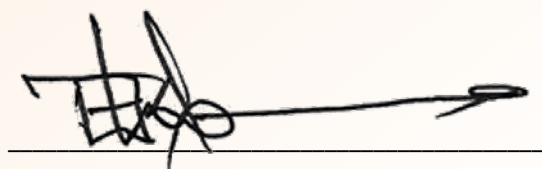
However, NMT still continues to face significant challenges in Government programming and project execution. It often remains the most unsafe mode of transport. Even where NMT facilities have been provided, they frequently suffer from issues such as obstruction by traders, dangerously placed signposts, illegal or improper parking, inconsiderate driving, and inadequately developed and maintained infrastructure.

Recognizing the critical role of NMT, the Ministry has developed this manual through studies from local experiences, consultations with road authorities and stakeholders, and benchmarking from other countries. This manual adheres to Universal Design principles, ensuring appropriate pedestrian access for all, including the elderly, Persons With Disabilities, women and children.

The manual is a living technical document for use on all public roads that will require periodic updates to reflect technological advancements and the emerging needs and best practices. Any contributions towards its improvement will be always welcome and also any substantial deviations from the manual must be approved so as to uphold the integrity and consistency of our road infrastructure nationwide. Proposals for improvement as well as deviations from this

manual, accompanied by rationale and justification, must be submitted to the Engineer-in-Chief, Ministry of Works and Transport, for technical review before approval by the Minister.

I extend my heartfelt gratitude to all those who contributed their knowledge and expertise to the development of this manual. I am confident that stakeholders will find it to be an invaluable resource for efficient and effective planning, design, construction, and maintenance of NMT facilities across Uganda.

A handwritten signature in black ink, consisting of a stylized 'E' followed by a long horizontal stroke and a small flourish at the end.

Hon. Edward Katumba — Wamala
Gen.

MINISTER OF WORKS AND TRANSPORT

Preamble

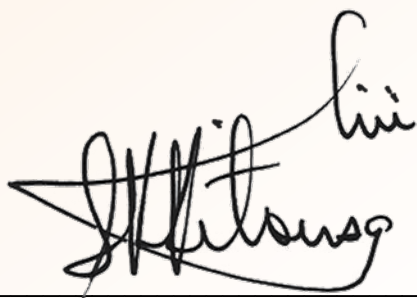
This Road Design Manual VII: Non-Motorised Transport Manual is the seventh volume of the Road Design Manual and one of the series of Engineering Specifications, Standards, Manuals and Guidelines issued by the Minister of Works and Transport in accordance with Section 6 of the Road Act 2019. To date, seven volumes of the Road Design Manual and two volumes of the Traffic Signs Manual have been issued and these include:

- a. Road Design Manual: Vol. I Geometric Design;
- b. Road Design Manual: Vol. II Drainage Design;
- c. Road Design Manual: Vol. III Pavement Design;
- d. Road Design Manual: Vol. IV Bridge Design;
- e. Road Design Manual: Vol. V Low Volume Sealed Roads;
- f. Road Design Manual: Vol. VI Urban Roads;
- g. Road Design Manual: Vol. VII Non-Motorised Transport;
- h. Traffic Signs Manual: Vol. I; and
- i. Traffic Signs Manual: Vol. II Appendices.

The manual has been prepared by the Ministry as a guide for road authorities responsible for the planning, design, construction, maintenance and operation of Non-Motorized Transport (NMT) facilities for public roads. It also complements the Ministry's efforts in the promotion of standardization in the road construction industry, specifically in the provision of infrastructure facilities that meet the needs of the different road users.

The manual provides standards and guidelines for: NMT infrastructure projects life cycle planning and management, design of NMT facilities, street furniture and zoning, provision of pedestrian bridges and underpasses, intersection treatment and pedestrian crossings, signage and road markings, considerations for intermodal transport and building access, safety considerations, traffic calming measures, NMT pavement design, construction and maintenance among others. The basic principle is to deliver more for less, thereby getting greater value for money. The manual shall be the main referral document for design, tendering and execution of NMT related works.

This Manual is a technical document, which, by its very nature, requires periodic updates from time to time arising from the dynamic technological developments and changes. The Ministry, therefore, welcomes proposals from practitioners on areas that need any further improvements and/or revisions stemming from the actual field experiences and best practices. It is hoped that the comments will contribute to future revisions of the Manual and lead to more economical, safe and sustainable designs.

A handwritten signature in black ink, appearing to read 'S. Kitonsa', written over a horizontal line.

Eng. Stephen Kiwanuka Kitonsa
Ag. ENGINEER-IN-CHIEF
MINISTRY OF WORKS AND TRANSPORT

Acknowledgements

The authors of this manual were:

Melissa Groenewald	Lead Author/Project Manager, Aurecon
Gail Jennings	Assistant Author, Aurecon
Avinash Menon	Assistant Author, CIC
Eng. Dr. Seith Mugume	Assistant Author, CIC
Christopher J. Mukuye	Assistant Author, CIC

Acknowledgement is hereby made in recognition of the contributions made by the following key stakeholders:

Eng. Samson Bagonza	Former Director of Engineering and Works/Engineer-in-Chief
Eng. Wilfred Okello	Former Commissioner Construction Standards and Quality Management
Eng. Stephen Kiwanuka Kitonsa	Acting Engineer-In-Chief
Eng. Tonny Mugenyi	Acting Commissioner Construction Industry Development and Regulation

The contract management team comprising of the following members;

Eng. Ben Kyemba	MoWT	Chairman
Mr. Enos Baluku	MoWT	Member
Ms. Juliet Atino	MoWT	Member
Ms. Claire Birungi	ITDP	Member
Mr. Ronald Amanyire	MoWT	Member
Eng. Drake Bagyenda	MoWT	Member
Eng. Edward Byaruhanga	UNRA	Member
Eng. Joel Wasswa	KCCA	Member
Eng. Musa Mwine	MoWT	Member
Mr. Brian Sempebwa	URC	Member

Table of Contents

1	INTRODUCTION	1
1.1	Definition of NMT	2
1.2	NMT in Uganda	2
1.2.1	NMT in Rural Uganda	2
1.2.2	NMT in Urban Uganda	3
1.2.3	The Need for an NMT Implementation Manual	3
1.3	Purpose of this NMT Manual	5
1.4	Method for Developing this NMT Implementation Manual	5
1.4.1	Structure of the Manual	6
1.5	How to Use this NMT Manual	7
1.5.1	Existing NMT Legislative and Regulatory Framework	7
1.6	Universal Access (UA)	11
2	NMT INFRASTRUCTURE PROJECT LIFECYCLE	12
2.1	Understand NMT-Friendly Policies, Legislation and Approval Processes	13
2.2	Master Planning and Network Design	13
2.2.1	How to Develop a Pedestrian Master Plan	13
2.2.2	How to Develop a Bicycle Master Plan	15
2.3	Project Prioritisation and Identification	15
2.4	Preliminary Engineering Study and Concept Designs	17
2.5	Detail Designs	19
2.6	Procurement of Works	19
2.7	Construction Supervision and Management	20
2.8	NMT Facility Operations and Maintenance	20
2.8.1	Asset Register	20
2.8.2	Operations Management	21
2.8.3	NMT Promotion	21
2.9	Project Evaluation	22
2.10	Environmental and Social Issues	22
2.10.1	Employment/Labour-intensive Construction Methods	23
2.10.2	Environment and Social Aspects	23

2.10.3 Funding	26
2.10.4 Stakeholder Engagement.....	26
3 DESIGN OF NMT FACILITIES	28
3.1 Guiding Principles of NMT Design and Decision-making	28
3.2 Safe System Principles.....	29
3.2.1 Road Safety Audits.....	29
3.3 Types of NMT Facilities	30
3.3.1 Class 1 Facilities – Exclusive NMT Use Outside the Road Reserve	32
3.3.2 Class 2 Facilities – Total Separation within the Road Reserve	33
3.3.3 Class 3 Facilities – Partial Separation (kerb or barrier protected) within the Road Reserve.....	34
3.3.4 Class 4 Facility – NMT Vehicles Sharing with vehicular Traffic, Kerb-protected Footway	36
3.3.5 Class 5 Facility – Kerb-protected Footway Only.....	37
3.3.6 Class 6 Facility – Woonerf	37
3.3.7 Shared Facility for Pedestrians and Cyclists.....	38
3.4 Providing NMT Facilities: Choosing a Solution	38
3.4.1 Road Functional Classification	41
3.4.2 NMT Provision and Land-use Integration	43
3.5 Retro-fitting NMT in Built-up Areas	44
3.6 Minimum Width Requirements for Footways and Cycle ways.....	44
3.6.1 Design Vehicle Space Requirements	46
3.7 Demand-based Pedestrian Footway and Cycle way Sizing	46
3.8 Footway Level of Service	47
3.8.1 Case study	50
3.9 LOS for Bicycle Facilities	51
3.9.1 Exclusive/Separated Off-street Bicycle Roads.....	51
3.9.2 Shared Off-street Facilities (Bicycles and Pedestrians)	52
3.9.3 On-street Bicycle Lanes	53
3.9.4 Computation Examples.....	54
4 STREET FURNITURE AND ZONING.....	57
4.1 Zoning Principles	57
4.2 Landscaping	60
4.2.1 Pedestrian Spaces.....	60
4.2.2 Plantings.....	61

5	BRIDGES AND UNDERPASSES	63
5.1	NMT-only Footbridges and Underpasses	63
5.1.1	When to Implement a Footbridge.....	63
5.1.2	Footbridge Design Considerations.....	64
5.2	Footways on Vehicle Bridges	65
5.3	Separate Footbridges Adjacent to Rural Roads or Crossing Drainage/Culverts ...	66
5.4	Handrails	66
5.5	Stairways.....	67
6	INTERSECTION TREATMENT AND PEDESTRIAN CROSSINGS	68
6.1	Principles for Siting and Designing Pedestrian Crossings	68
6.1.1	When Selecting an Appropriate Crossing Facility consider.....	69
6.1.2	Crossing Sight Distance	70
6.1.3	Approach Sight Distance for Drivers.....	70
6.1.4	Variables when Choosing an Intersection Treatment	71
6.2	Pedestrian Crossings.....	72
6.3	Crossings at Intersections.....	73
6.4	Signalised Intersections	76
6.5	Roundabouts and Roundabout Crossings	76
6.6	Roundabout Crosswalks for People with Visual Impairments	79
6.7	Mid-block Crossings	81
6.7.1	Controlled or Signalised Mid-block Crossings	84
6.7.2	Uncontrolled Mid-block Crossings	87
6.8	Uncontrolled Intersections.....	88
6.9	Refuge Islands.....	88
6.10	Tactile Paving Principles at Crossings	89
7	SIGNAGE AND ROAD MARKINGS	93
7.1	Signage.....	93
7.2	Road Markings	98
7.3	Wayfinding	100
8	INTERMODAL TRANSPORT AND BUILDING ACCESS.....	102
8.1	Principles of NMT and Public Transport Integration	102
8.1.1	Separation of Vehicles and NMT Users.....	103
8.2	NMT Design at On-street Multi-modal Transport Facilities.....	105
8.2.1	Shelters and Waiting Areas.....	105
8.2.2	Bus and Taxi Embayment	107
8.2.3	Access Points and Crossings.....	110

8.3	Median Public Transport Stations	110
8.4	Bus and Taxi Parks	112
8.5	Driveway Accesses / Aprons.....	112
8.6	Bicycle Parking at Transport Interchanges.....	113
8.7	NMT Design for Building Access	114
8.8	NMT Design for School Access	115
9	SAFETY CONSIDERATIONS.....	117
9.1	Sound Alerts/ Audible Signals.....	118
9.2	Lighting	119
9.2.1	Design Principles	119
9.2.2	Design Elements	120
9.2.3	Minimum Standards	121
10	TRAFFIC CALMING.....	123
10.1	Horizontal Deflection	124
10.1.1	Kerb Extension or Smaller Kerb Radii	124
10.1.2	Chokers or Chicanes.....	125
10.1.3	Neckdowns	127
10.1.4	Roundabouts or Circles	128
10.2	Vertical Deflection	129
10.2.1	Speed Humps, Speed Cushions or Speed Bumps	130
10.2.2	Raised Pedestrian Crossings or Plateau Speed Humps.....	131
10.2.3	Raised Intersections	132
10.2.4	Rumble Strips	134
10.3	Physical Obstructions	135
10.3.1	Partial or Full Road Closures.....	135
10.3.2	Diverter	136
10.3.3	Raised Medians through Intersections	138
10.4	Separation Elements	139
10.4.1	Concrete Wall	139
10.4.2	Road Shoulders.....	140
10.4.3	W-shaped Guardrail/Steel Beam Strong Post Guard Rail	140
10.4.4	Bollards	141
10.4.5	Barricades and Fences	142
10.4.6	Kerb Treatments	144
11	NMT PAVEMENT DESIGN.....	149
11.1	Guiding Principles of Pavement Design	149

11.2	Estimation of Design Traffic Loading	150
11.3	Determination of Subgrade Strength.....	150
11.4	Pavement Material Type.....	151
11.5	Execution of Pavement Design.....	152
11.5.1	Unsurfaced Pavement	152
11.5.2	Flexible Pavement	153
11.5.3	Rigid Pavement	155
11.6	Pavement Surfacing.....	157
11.7	Drainage	158
11.7.1	Maintenance of Drainage Facilities.....	162
11.8	Grates.....	163
11.9	Case study	164
12	CONSTRUCTION WORKS AND MAINTENANCE	168
12.1	Construction Works	168
12.2	Maintenance.....	168
12.2.1	Guiding Principles.....	169
12.2.2	Maintenance Planning.....	172
12.2.3	Condition Assessment	173
12.2.4	Compliance with Safety Regulations.....	175
13	BIBLIOGRAPHY	176

Figures

Figure 3-1: Typical cross-sections of an exclusive NMT facility (Class 1)	33
Figure 3-2: Typical cross-section of total separation of NMT facilities (Class 2)	34
Figure 3-3: Typical cross-section of kerbed separation of NMT facilities (Class 3)	35
Figure 3-4: Typical cross-section of kerbed separation of pedestrians and cycle way separated byline marking (Class 3)	36
Figure 3-5: Kerb-protected footway (Class 4)	36
Figure 3-6: Kerb protected footway only (Class 5)	37
Figure 3-7: Woonerf zone (Source: The Woonerf Concept, nacto.org)	38
Figure 3-8: Decision Tree, Choosing a Solution	40
Figure 3-9: Effective width of a footway	48
Figure 4-1: A typical layout of a street zone	58
Figure 5-1: Cross-section showing a segregated footway on a bridge	66
Figure 5-2: Examples of typical fencing and barriers used over bridges	67
Figure 6-1: Illustration of how tight radii limit desire lines and sight distances	69
Figure 6-2: Illustration of how large radii increase desire lines and sight distances	69
Figure 6-3: Illustration of conflict points at a four-legged intersection	72
Figure 6-4: Pedestrian facilities for controlled intersections	75
Figure 6-5: Illustration of conflict points at a roundabout	77
Figure 6-6: Illustration of conflict points at a roundabout, roadway, and on shared paths ...	78
Figure 6-7: Illustration of typical layouts of pedestrian crossings at roundabouts	80
Figure 6-8: Dropped kerb treatment	82
Figure 6-9: Mid-block pedestrian crossing	83
Figure 6-10: Pedestrian facilities for controlled intersections	85
Figure 6-11: Illustration of a typical staggered signalised mid-block crossing	86
Figure 6-12: Pedestrian signal sign	86
Figure 6-13: Typical placement of pedestrian signals	87

Figure 6-14: Example of an uncontrolled refuge island crossing facility	89
Figure 6-15: Details of tactile paving patterns.....	90
Figure 6-16: Tactile paving plan for controlled crossings	91
Figure 6-17: Tactile paving plan for a controlled pedestrian crossing.....	92
Figure 6-18: Photographs showing examples (both good and poor) of warning tactile paving	92
Figure 7-1: Examples of signs and directional information to improve wayfinding	101
Figure 8-1: Example of NMT-vehicle separation at a public transport interchange	104
Figure 8-2: Example of pedestrian accommodation on a kerbed footway within a parking environment	105
Figure 8-3: Example of pedestrian accommodation on a kerbed footway within a parking environment in an urban environment.....	105
Figure 8-4: Examples of the principals of shelters and waiting areas	107
Figure 8-5: Typical layout of NMT treatment at a bus bay	108
Figure 8-6: Typical road marking of NMT at a bus bay.....	108
Figure 8-7: A well-planned cycle way separation at a bus stop	109
Figure 8-8: Typical details of a bus-bicycle treatments with and without on-street parking ..	109
Figure 8-9: Typical cross-section showing the pedestrian priority zone at bus stops.....	110
Figure 8-10: Photograph showing NMT access at a median public transport station.....	111
Figure 8-11: Photograph showing integration of pedestrians within a bus/taxi park.....	112
Figure 8-12: Typical U-bar bicycle stand and recommended bicycle parking signage	113
Figure 8-13: Bicycle parking layout.....	114
Figure 8-14: Typical example of building access	115
Figure 9-1: Relationship between vehicle speed and cone of vision.....	117
Figure 9-2: Pedestrian crossing with a sound device installed	118
Figure 10-1: Illustration of kerb extensions and kerb radius reductions	125
Figure 10-2: Illustration of a chicane	126
Figure 10-3: Warning signage proposed at chokers	126
Figure 10-4: Warning signage proposed at chicanes.....	127
Figure 10-5: Example of a roundabout showing NMT facilities with a separated cycle way....	129
Figure 10-6: Illustration of a raised pedestrian crossing	132
Figure 10-7: Illustration of a raised intersection.....	133

Figure 10-8: Illustration of rumble strip application	135
Figure 10-9: Illustration of a full and partial road closure.....	136
Figure 10-10: Illustration of a diagonal diverter	137
Figure 10-11: Illustration of a semi-diverter	138
Figure 10-12: Illustration of a star diverter	138
Figure 10-13: Illustration of a raised median through an intersection.....	139
Figure 10-14: Typical concrete barrier	140
Figure 10-15: Typical detail of a guardrail installation	141
Figure 10-16: Typical detail for bollards.....	142
Figure 10-17: Typical detail of a retractable bollard	142
Figure 10-18: Pedestrian parapets	143
Figure 10-19: Typical fence detail	144
Figure 10-20: Typical barrier kerb details	145
Figure 10-21: Algebraic difference between adjoining surfaces.....	146
Figure 10-22: Dropped kerb with bollard protection.....	147
Figure 10-23: Typical layout of an angled dropped kerb treatment with warning tactile pavers at a signalised intersection (SANDoT, 2014).....	147
Figure 10-24: Illustration showing a dropped kerb treatment with tactile warning and directional paving	148
Figure 11-1: Excerpt of Chart W1 from the Design Catalogue.....	154
Figure 11-2: Typical block paving pavement detail	157
Figure 11-3: Typical drainage treatments.....	162
Figure 11-4: Illustrations of good grate treatment within a footway.....	164
Figure 12-1: Schematic representation of maintenance planning and Implementation	172

Tables

Table 1-1: Existing Ugandan manuals.....	8
Table 2-1: Project prioritisation criteria	16
Table 2-2: Description of the ESIA process	24
Table 2-3: SIA process activities.....	25
Table 3-1: NMT classification in terms of degrees of separation	31
Table 3-2: Functional classification of roads in Uganda.....	42
Table 3-3: Minimum space requirements for pedestrian and bicycle facilities.....	45
Table 3-4: Design vehicle space requirements	46
Table 3-5: Criteria for provision of footways	47
Table 3-6: Pedestrian speed.....	47
Table 3-7: Walkway Levels of Service.....	49
Table 3-8: Levels of Service for queuing and waiting areas.....	50
Table 3-9: Level of Service Criteria for exclusive and Shared Bicycle Facilities	54
Table 4-1: Buffer zone suggestions per functional classification of roads.....	59
Table 4-2: Typical street furniture elements and recommended dimensions.....	59
Table 4-3: Recommended tree placement and tree guard dimensions	62
Table 5-1: Minimum dimensions for NMT bridges and subways	65
Table 6-1: Recommended vehicle approach sight distances	71
Table 6-2: Categories of pedestrian crossings	73
Table 6-3: Pedestrian warrants for the installation of crossings on paved roads	74
Table 6-4: Minimum visibility requirements for roundabouts.....	79
Table 6-5: Minimum safe separation distances between mid-block crossings and other road elements	83
Table 6-6: Recommendations for installing pedestrian crossings at mid-block locations....	84
Table 6-7: Interpretation of pedestrian signals.....	87

Table 7-1: Classification of road signs	94
Table 7-2: Warning traffic signs applicable to NMT infrastructure	95
Table 7-3: Regulatory traffic signs applicable to NMT infrastructure	96
Table 7-4: Information traffic signs applicable to NMT infrastructure.....	97
Table 7-5: NMT appropriate road markings	99
Table 8-1: Examples of access treatments.....	116
Table 9-1: Recommended lighting levels for NMT.....	122
Table 10-1: Advantages and disadvantages of kerb extensions and smaller kerb	125
Table 10-2: Advantages and Disadvantages of chicanes and chokers	127
Table 10-3: Advantages and disadvantages of neckdowns	128
Table 10-4: Advantages and disadvantages of roundabout.....	129
Table 10-5: Advantages and disadvantages of speed humps, cushions and bumps	130
Table 10-6: Cross-section of a circular speed hump and a raised pedestrian crosswalk....	131
Table 10-7: Advantages and disadvantages of raised pedestrian crossings.....	131
Table 10-8: Design dimensions of plateau humps	132
Table 10-9: Advantages and disadvantages of raised intersections	133
Table 10-10: Advantages and disadvantages of rumble strips.....	134
Table 10-11: Advantages and disadvantages of road closures	136
Table 10-12: Advantages and disadvantages of diverters.....	137
Table 10-13: Advantages and disadvantages of raised median through intersections	139
Table 11-1: NMT pavement design process	149
Table 11-2: Traffic class designation.....	150
Table 11-3: Subgrade strength categories	151
Table 11-4: Pavement type choice criteria	152
Table 11-5: Unsurfaced pavement design configurations	153
Table 11-6: Pavement design of concrete block paving.....	157
Table 11-7: Common Road drainage deficiencies.....	163
Table 12-1: Maintenance Categories.....	170

Abbreviations

ADT	Average Daily Traffic
BRT	Bus Rapid Transit
CBD	Central Business District
CBO	Community Based Organisation
CBR	California Bearing Ratio
CBP	Concrete Block Pavers
CCTV	Closed Circuit Television
CRCP	Continuously Reinforced Concrete Pavements
CRPD	Convention on the Rights of Persons with Disabilities
DCP	Dynamic Cone Penetrometer
ESA	Equivalent Standard Axles
ESIA	Environmental and Social Impact Assessment
EPRC	Economic Policy Research Centre
GEF	Global Environment Facility
GKMA	Greater Kampala Metropolitan Area
ICD	Inscribed Circle Diameter
ICE	Institution of Civil Engineers, UK
IFC	International Finance Corporation
ITDP	Institute for Transportation and Development Policy
JUCP	Jointed Unreinforced Concrete Pavements
JRCP	Jointed Reinforced Concrete Pavements
KCCA	Kampala Capital City Authority
km/h	Kilometres per hour
LED	Light Emitting Diode
LOS	Level of Service
MoFPED	Ministry of Finance, Planning and Economic Development
MoWT	Ministry of Works and Transport

m/s	Metres per second
MUZ	Multi Utility Zone
NACTO	United States National Association of City Transportation Officials
NDC	Nationally Determined Contributors
NDP	National Development Plan
NEAP	National Environmental Action Plan
NEMA	National Environment Management Authority
NEMP	National Environment Management Policy
NMT	Non-Motorised Transport
NPA	National Planning Authority
NPDP	National Physical Development Plan
NTLP	National Transport and Logistics Policy
NITMP	National Integrated Transport Master Plan
PMS	Pavement Management System
PPDA	Public Procurement and Disposal of Public Assets
PPP	Public Private Partnership
PWD	People with Disability
RoW	Right of Way
SADC	South African Development Community
SCS	Soil Conservation Service
SIA	Social Impact Analysis
SSATP	Sub-Saharan Africa Transport Policy Program
SARTSM	South African Road Traffic Signals Manual
ToR	Terms of Reference
TRRL	Transport and Road Research Laboratory
TWSI	Tactile Walking Surface Indicators
UA	Universal Access
UD	Universal Design
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Definitions and Terminology

Access

Permission, liberty or ability to enter, approach or pass a given public space or road.

At-grade junction

A junction where all roadways join or cross at the same level.

Average Annual Daily Traffic (AADT)

Total yearly traffic volume in both directions divided by the number of days in the year.

Average Daily Traffic (ADT)

Total number of vehicles (traffic volume) during a given time period in whole days greater than one day and less than one year divided by the number of days in that time period.

Barricade

A portable or fixed barrier used to close all or part of a road to vehicular traffic.

Bollard

A device placed on a street refuge or traffic island to provide a measure of protection for pedestrians and to warn drivers of these obstructions. It also usually indicates by means of a traffic sign the direction to be taken by vehicles. The device is generally illuminated at night.

Boulevard

Wide, multi-lane arterial thoroughfare, often divided with a central median, and perhaps with roadways along each side designed as slow travel and parking lanes and for bicycle and pedestrian usage, often with an above-average quality of landscaping and scenery.

Bridge

A structure erected with a deck for carrying traffic over or under an obstruction and with a clear span of six meters or more. Where the clear span is less than 6 m, reference is to a culvert.

Capacity

The maximum number of pedestrians or cyclists that can pass a point on a walkway or cycle lane in one hour without the density being so great as to cause unreasonable delay or restrict

the user's freedom to manoeuvre under prevailing traffic conditions.

Capping layer

A layer of selected fill material placed on the topmost embankment layer or the bottom of excavation.

Carriageway

Part of the roadway including the various traffic lanes and auxiliary lanes but excluding shoulders.

Channelising island

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

Cycle way

A path or road for bicycles and not motor vehicles.

Footway

A path for pedestrians and not for bicycles or motor vehicles.

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.

Mid-block Crossing

Locations between intersections where marked crosswalks have been provided.

Median

The reserved area that separates opposing lanes of traffic on divided roadways, such as divided highways, dual carriageways, freeways, and motorways. The term also applies to divided roadways other than highways, such as some major streets in urban or suburban areas.

Non-Motorised Transport (NMT)

Active and human powered transportation including walking, bicycling, and other variants such as small-wheeled transport (cycle rickshaws, skates, skateboards, push scooters, hand carts and wheelchair travel).

Overpass

A bridge by which a road or railway line passes over another.

On-street

At the side of a public road.

Project

A series of activities that aim to achieve a clearly defined objective within a pre-defined time period and with a defined budget.

Right of Way (RoW)

The legal right of a pedestrian, vehicle, or ship to proceed with precedence over others in a particular situation or place.

Sidewalk

A paved path for pedestrians at the side of a road; a pavement.

Underpass

A road or pedestrian tunnel passing under a road or railway.

Universal Design / Universal Access

Universal Design refers to pedestrian and transport infrastructure, facilities and services designed for the widest range of potential users, including people with mobility and visual impairments (disabilities), the elderly, those in wheelchairs and people walking with small children or with pushchairs. While aiming to address the needs of people with disabilities, it is a comprehensive concept with provisions that can benefit all users.

UA Specialist

A UA Specialist is someone who has studied and is a specialist expert in Universal Design/ Universal Access; although some UA Specialists could also be Architects, Engineers, or Urban planners, some may have studied UA as a standalone qualification.

Woonerf

Universal term (from the Dutch term) used to describe an area, normally of residential development, within which the adverse effects of traffic have been minimised on a local area basis, either as a result of the original layout of the area or by subsequent additional measures, for example, traffic calming.





Introduction

1 INTRODUCTION

The Uganda Vision 2040 set out clear objectives aimed at transforming the country from low-income to upper middle-income status by 2040. To achieve this, the Government of Uganda determined priorities in key sectors that include energy, transport, information and communication technology, and water for production. The transport sector is one of the critical sectors that is to spur the socio-economic development of Uganda through facilitating the movement of people and goods, and catalysing production, commerce, and public service delivery.

The development and management of the road network is undertaken by various agencies that include the Ministry of Works and Transport, which plans, sets standards, formulates policies; and manages the national road network; district local governments, which manage the district roads; and various urban councils, municipalities, and the Kampala Capital City Authority (KCCA), which manage the urban roads. The community access roads are managed by the sub-counties.

The competitiveness and productivity of Uganda as a nation, however, is severely impacted by an inadequate road network, insufficient water and sewer systems, poor rail access, and unreliable supply of energy. Commuters from suburbs less than 20 km from the city centre can take approximately an hour to travel each way, and incur high transportation costs (WorldBank, 2015). Where public transport and roadway improvements are considered, this is largely based on a need to improve mobility and productivity (SLoCaT, 2019).

One of the major challenges facing Uganda's transport sector is the prevalence of motorised vehicles. Motorcycles (boda bodas) dominate, followed by passenger vehicles (buses, minibuses, and cars). The number of vehicles is increasing, with an average annual rate of over 10% (Larsson, 2010). The Ministry of Works and Transport (MoWT) reports that road fatalities per 10,000 vehicles have remained stagnant, averaging 26 deaths since 2015 against the 2019 government target of 20 deaths (MoWT, 2018). Although Non-Motorised Transport (NMT) is also a dominant mode, particularly in rapidly developing urban and peri-urban areas, it is yet to be given adequate recognition during planning and execution of government projects in Uganda.

This NMT Manual presents the guidelines and standards for planners, Engineers, decision-makers and other stakeholders involved in planning, design, and implementing NMT infrastructure

projects, or projects with an NMT component embedded in them.

1.1 Definition of NMT

Non-Motorised Transport (NMT) refers to active and human powered transportation including walking, bicycling, and other variants such as small-wheeled transport (cycle rickshaws, skates, skateboards, push scooters, hand carts and wheelchair travel). NMT includes all forms of movement that do not rely on an internal-combustion or electric engine for movement.

1.2 NMT in Uganda

NMT modes, such as walking and cycling, are common in most parts of Uganda, but are not always well supported by infrastructure in either urban or rural areas. NMT has not always been given the due recognition during planning and execution of government projects. Furthermore, the current transport infrastructure does not provide the minimum level of service to pedestrians and cyclists, both in urban and in rural areas. As a result, the share of NMT users in road fatalities is the highest in Uganda, and has been increasing every year (NPA, 2019).

NMT is often constrained by various challenges that include limited or non-existent facilities, obstruction by traders/vendors, high vulnerability of NMT users to incidents and crashes (caused by motorised traffic), lack of road signage, illegal parking on existing NMT infrastructure, and inadequate maintenance.

1.2.1 NMT in Rural Uganda

The predominant mode of transport in rural Uganda is walking; this includes carrying water and firewood for domestic purposes as well as goods for agricultural and other economic activities. The next dominant mode is cycling, where bicycles are used both for personal transport and for carrying agriculture products.

Bicycle ambulances are also common in rural Uganda (Jennings, 2016). Bicycles are popular and have become widely available in Ugandan rural areas because they can use small, narrow paths, and are able to carry loads of up to 100 kg or more, and are faster when compared to walking. This movement of people and goods takes place not only on rural roads but also on the extensive network of rural footpaths and village tracks. Therefore, a comprehensive rural transport policy and strategy has to take account of this through, for example, considering the improvement of footpaths, footbridges and village tracks as well as rural roads and other transport infrastructure. Women tend to use bicycles less than men partly due to cultural reasons, for example women are expected to stay at home, or not to transport themselves in what can be perceived as 'inelegant' ways, and partly financial, where in a single-bicycle owned household, the man's perceived need might take precedence.

1.2.2 NMT in Urban Uganda

Even with limited NMT provisions and without proper designated NMT facilities, the World Resources Institute (WRI, 2019) estimates that at least 40% of households in Kampala walk as a main mode, and the number of NMT daily trips in the city is estimated to be over 50%. The use of bicycles in Uganda's urban centres, including Jinja, Tororo, Kabale, and Kampala, is predominantly as a transport mode to replace unreliable public transportation. The prevalence of cycling in the Greater Kampala Metropolitan Area (GKMA) is lower than it could be due to unsafe cycling conditions, hilly terrain, and a lack of bicycle parking facilities (Kajuna). Half of all trips in cities are short and within cycling and walking distances. Wheelbarrows are used for short-distance carriage of small loads although the use of carts and animal haulage is not common in Uganda (Kajuna).

1.2.3 The Need for an NMT Implementation Manual

The following NMT challenges were identified in the Uganda NMT Policy (MoWT, 2012):

- Many residents lack the disposable income necessary to pay for transport services; for them, there is no alternative other than to walk, irrespective of the season, including the rainy seasons when conditions are poor for NMT use.
- There is no integrated transport system in Uganda to offer users practical affordable choices between using road or rail; bus or car; or cycle and bus to complete a trip.
- NMT modes are often inadequately provided for, and the limited infrastructure does not necessarily provide the shortest and most comfortable route to a destination.
- When NMT provisions are made, they are almost exclusively alongside motorised roads; NMT-only (stand-alone) facilities are uncommon.
- The prevalence of cycling in the Greater Kampala Metropolitan Area (GKMA) is low due to unsafe cycling conditions, hilly terrain and lack of bicycle parking facilities.
- Cyclists and pedestrians are the most vulnerable of road users, primarily owing to the speed differentials between NMT users and motorised traffic, and a lack of physical protection between the two. Therefore, residents are not necessarily reluctant to walk, but due to the safety risks associated with NMT, they are left to struggle with the inefficient public transport
- Encroachment of NMT spaces and lack of enforcement are major challenges to NMT movement. Parked vehicles, traders, motor-cycles and taxis often take over footways and become obstacles to NMT movement.
- Existing NMT facilities often have poor lighting, which contributes to users feeling insecure. Theft and lack of proper storage facilities for bicycles discourages cycling.

1.2.3.1 Uganda NMT Policy (2012)

To address these NMT challenges, in 2012, MoWT published a standalone NMT policy, with the assistance of the United Nations Environment Programme (UNEP). Emanating from this,

NMT provision is a requirement for infrastructure design and implementation both in urban and rural settings. However, the operationalisation of the policy requires reference standards and manuals tailored to the Ugandan context.

Although some steps have been taken towards the implementation of Non-Motorised Infrastructure, the systematic implementation of NMT has been lacking clearly outlined guidelines and standards, a gap this manual has been developed to fill.

The National NMT Policy (2012) intends to enforce particular NMT requirements, such as that:

- Appropriate Universal Design (UD) principles are included in all new and refurbished NMT transport infrastructure;
- The needs of pedestrians and cyclists are adequately addressed in the planning, implementation, regulation and enforcement of roads and other rural and urban infrastructure;
- The relevant authorities are required to ensure their roads and related infrastructure standards are appropriate for bicyclists and pedestrians, and that Engineers, Consultants, Contractors and supervisors are aware of the relevant standards, and why they are important;
- All national road designs, and related infrastructure such as bridges, should include a non-Motorised transport statement explaining how the needs of pedestrians and cyclists have been incorporated into the designs.
- All relevant construction and maintenance contracts should require a non-motorised transport statement explaining how the needs of pedestrians and cyclists should be incorporated into the works. Government will require the relevant bodies to verify that there is compliance with these requirements;
- All urban road designs, and related infrastructure such as bridges, should include a non-motorised transport statement explaining how the needs of pedestrians and cyclists have been incorporated into the designs;
- The authorities responsible for urban roads identify priority areas for retro-fitting NMT infrastructure, including covered drains, constructed footways and designated shoulders. The use of one-way routes should be considered, to allow greater allocation of space for NMT users;
- Pedestrian crossings should be clearly marked with standard zebra stripes and stop lines. In general, they should be on platforms to emphasise the pedestrian priority of the crossing and to calm traffic speeds. Zebra stripes must be maintained to ensure the markings remain clearly visible. On national roads, appropriate traffic calming infrastructure and rumble strips should precede the crossings.

1.2.3.2 Benefits of Improved NMT Infrastructure

An improvement in NMT facilities would contribute to:

- A reduction in carbon emissions;
- A safe and comfortable environment for NMT;
- An increase in the modal share of NMT;
- Improved attention to the needs of rural communities;
- An increase in the affordability of transport modes;
- Improved provision for people with special mobility needs;
- Improved integration between land-use and transport; and
- Improved social health and economic opportunities.

1.3 Purpose of this NMT Manual

Improving Uganda's NMT infrastructure and implementing its NMT Policy is not only key for road safety, transport justice and road congestion considerations, but also for reducing transport related carbon emissions and thereby contributing to achievement of sustainability objectives in the transport sector. The widespread use of NMT will contribute towards achievement of set Nationally Determined Contributions (NDCs) with respect to reduction of greenhouse gas emissions under the United Framework Convention on Climate Change (UNFCCC) (SLoCaT, 2019). Key areas for adaptation in the transport sector include promoting fuel and vehicle efficiency and increase in the proportion of NMT compared to motorised modes.

Although parts of Uganda's current road design manual describe NMT design aspects, the descriptions have largely not been applied uniformly in implementation of road infrastructure projects across the country. In addition, city and national guidelines are not necessarily integrated. Street elements (such as footways, cycle ways, bus shelters, street vending, on-street parking, underground utilities, etc.); standard cross-sections for different RoWs; and guidelines on intersection design, are lacking. Standards for bicycle parking, maintenance, crossing places and footbridges, bridges, and access to public transport hubs and ports, are also identified in Uganda's NMT Policy (2012) as gaps in the current guidelines.

The purpose of this NMT Manual is not to serve as advocacy material that makes the case for NMT. The case for greater NMT attention (including its role in environmental conservation, climate mitigation, and gender equity) has already been clearly made in Uganda's NMT Policy (2012), from which this Manual evolves. This Manual's purpose is rather to directly contribute to the operationalisation of the Uganda NMT Policy, by specifying the standards and approaches for design of NMT infrastructure as well as give guidance and recommendations to the Engineers responsible for the design of Non-Motorised Infrastructure in Uganda.

1.4 Method for Developing this NMT Implementation Manual

Numerous gaps and challenges have been synthesised with respect to NMT design and construction standards through conducting a literature, policy and document review; undertaking a gap and needs analysis that included interviewing key stakeholders from relevant government

departments as well as civil society; and undertaking a review of NMT infrastructure guidelines that represent international and regional best practice.

1.4.1 Structure of the Manual

This NMT Manual is divided into 12 chapters:

Chapter 1 introduces the Manual and the way in which the Manual was developed, and provides general guidance on how to use the Manual.

Chapter 2 introduces the general NMT facility lifecycle process as well as the overall design process of NMT Infrastructure. This considers concepts, aspects, and procedures to be taken care of within the feasibility and preliminary design stages. Overall procurement and construction guidance are also included therein.

Chapter 3 details the necessary detailed design considerations in the design of NMT Infrastructure. This takes care of the basic pedestrian and cyclist characteristics, the different NMT facility types, as well as general guidance in NMT retrofitting within already built-up areas.

Chapter 4 deals with the street zoning and street furniture principles.

Chapter 5 introduces the general guidance in provision of NMT footbridges and underpasses, stairways and handrails. The section further discusses treatment of NMT at intersections.

Chapter 6 provides guidance on principles and design of pedestrian crossings.

Chapter 7 discusses NMT signage and road markings. General recommendations for the design and positioning of NMT infra signage is also given in this section.

Chapter 8 looks at the treatment of NMT at inter modal connection points with other public transportation modes. This in general includes general guidelines for NMT access to public areas like buildings and schools.

Chapter 9 details NMT safety considerations for NMT infrastructure, including lighting for NMT infrastructure.

Chapter 10 provides further relevant safety measures in terms of traffic calming procedures, techniques, and their respective applicability.

Chapter 11 covers NMT pavement design and drainage considerations.

Chapter 12 offers guidance in NMT facility construction and maintenance measures.

1.5 How to use this NMT Manual

The shift in policy at national level toward NMT requires that responsible agencies acquire relevant tools, knowledge and resources to effectively address the issues. The NMT design and operation (referred to as this Manual) bridges that knowledge gap by providing guidelines, standards, and approaches to planning, designing, and implementing NMT infrastructure.

This Manual is intended primarily as a design and construction manual, to be used by policy makers, planners, and Engineers among others, and is designed to complement other existing relevant technical documents. These documents are listed under Section 1.5.1 below. Therefore, this Manual does not replace the experience of an Engineer in designing context-specific designs, nor does it replace the experience of a transport planner or other relevant professions in network design, landscaping, stakeholder engagement or other necessities.

This Manual also does not remove the responsibility from design engineers, planners and other team specialists for substantive stakeholder engagement, network design processes, promotion and communication, and for the provision of other NMT-related facilities that create an environment that facilitates NMT comfort, safety, and increased use. Infrastructure design is only one element of the NMT environment.

For this reason, the users of this Manual are encouraged to acquaint themselves of the relevant acts and policies when planning any NMT facility or service project. Users are also required to acquaint themselves with the relevant existing national policies and existing development plans that need to be taken into consideration when planning an NMT infrastructure and services project, and ensure that there is no policy contradiction or any conflict areas among the cross-cutting policies/plans. These acts, policies and plans are provided in Section 1.5.1 below.

Further, this Manual is a technical document, which, by its very nature, requires periodic updating arising from the dynamic technological developments and changes. In some instances, special conditions may demand modifications to the standards set herein. In such cases, special consideration should be given in consultation with the Engineer-In-Chief, Ministry of Works and Transport.

1.5.1 Existing NMT Legislative and Regulatory Framework

1.5.1.1 Manuals and Standards

The Manual should be used in conjunction with the existing design manuals and standard guidelines for road and infrastructure design in Uganda, except where this Manual provides updated, more explicit and more generous NMT standards and recommendations to be adhered to. It is important to note that due to the dynamic technological advancements, the aforementioned manuals and standards are updated from time to time and therefore the most updated version should be considered. Some of the major existing road design manuals this

NMT manual complements are provided in Table 1-1 below.

Table 1-1: Existing Ugandan manuals

Manual	Description
Road Design Manual: Vol. I Geometric Design (2010)	Sets the standards to be adopted for the design of rural roads and provides guidance on the geometric design of rural roads.
Road Design Manual: Vol. II Drainage Design (2010)	Provides guidance and standards for road drainage design.
Road Design Manual: Vol. III Pavement Design (2010)	Provides guidance and design standards for three pavement types i.e. Part I – Flexible Pavement Design, Part II – Rigid Pavement Design and Part III – Gravel Pavement Design.
Road Design Manual: Vol. IV Bridge Design (2010)	Standard reference and ready source of good practice for the design of bridges and ensuring appropriate levels of health and safety.
Road Design Manual: Vol. V Low Volume Roads (2018)	Provides guidance for design and construction of low volume roads.
Traffic Signs Manual: Vol. I & II (2004)	Provides guidance for design and construction of traffic signs and road markings.

Other manuals and standard guidelines to be considered when planning and designing NMT infrastructure include:

- MoWT Road Maintenance Management Manual (2010)
- MoWT Guidelines for Mainstreaming Cross-Cutting Issues (2008)
- MoWT General Specifications for Road and Bridge Works (2005)
- MoWT Highway Code (2004)
- MoWT Road Project Implementation Manual (2010)
- Environment Impact Assessment (EIA) Guidelines for Road Sub-Sector (2004)
- MoWT Road Maintenance Specifications (2010)
- MoWT Road Safety Audit Manual (2004)
- PPDA Regulations

1.5.1.2 Legislation

There is no specific legislation for NMT. The provisions are scattered in different laws. The major Acts applicable to NMT include but are not limited to these below:

i) The Roads Act (2019)

This version replaced the Roads Act of 1964 and access to Roads Act and relates to road classification, the development, management and maintenance of public roads, the appointment

of road authorities and their responsibilities, the declaration, control and protection of road reserves, and makes provision for other related matters. The specific provisions in the law regarding NMT include reforming the law relating to demarcation and safety of public roads, placing and maintenance of road furniture and provision for axle load control on public roads among others. (MoWT, 2019).

ii) The Traffic and Road Safety Act, 1998 (Amendment) Act (2020)

This version repeals and replaces the 1998 traffic and road safety act, cap 361 with various amendments of the principal sections to strengthen road transport regulation and safety management.

Other relevant legislation includes:

- The Constitution of the Republic of Uganda (1995)
The supreme law governing the land with various provisions for all sectors including road development.
- Local Government Act (1997)
This Act consolidates and streamlines existing law on local governments to give effect to the decentralisation and devolution of functions, powers and services to ensure good governance.
- Budget Act (2001)
This Act provides for and regulates the budgetary procedure for a systematic and efficient budgetary process and other related matters.
- Public Private Partnership Act (2015)
This provides for Public Private partnership agreements and related aspects and overall management of the PPP.
- Town and Country Planning Act (1951)
This Act consolidates the provisions for the orderly and progressive development of land, towns and other areas, urban or rural.
- The Land Act (1998)
This Act provides the framework for the various land tenure systems.
- The Land Acquisition Act (1965)
This Act provides for the compulsory acquisition of land by government if it is deemed essential for a public good.

1.5.1.3 Policies and Plans

a) National Road Safety Policy (2014)

The policy relies on and encapsulates five pillars which include road safety management, safer roads and mobility, safer vehicles, safer road users, and post-crash care. Provides for NMT for instance measures to protect cyclists and pedestrians.

b) National Urban Policy (2017)

This policy provides a framework to guide the urbanisation process in the country. It also provides for balanced urban development, effective urban planning and management to curtail excessive urban sprawl, efficient urban infrastructure and service delivery.

c) Road Tolling Policy (2017)

This Policy provides a framework for the regulation, management, and operation of toll roads in Uganda. The main goal of this policy is to raise additional funding from toll road users to develop, rehabilitate, operate and maintain reliable efficient and sustainable road infrastructure of which non-motorised transport is part.

d) National Transport and Logistics Policy (2020 draft)

One of the key aspects of this policy is the acceleration of investment in infrastructure to promote the development of reliable, safe and efficient multi modal transport infrastructure and services, including NMT, thereby promoting NMT. Another strategic objective of the policy is to promote the integration of environmental and social safeguards in the sustainable, equitable and inclusive planning of transport infrastructure services.

e) National Environmental Management Policy (2014)

The National Environment Management Policy (NEMP) was one of the outcomes of the National Environmental Action Plan (NEAP) and its overall goal is sustainable social and economic development which maintains or enhances environmental quality and resource productivity on a long-term basis.

f) National Land Use Policy (2017)

This Policy provides a framework to guide the urbanisation process in the country. It also provides for balanced urban development, effective urban planning and management to curtail excessive urban sprawl, efficient urban infrastructure and service delivery.

Other policies and plans to be reviewed include but are not limited to:

- Vision 2040
- The third National Development Plan (NDP III 2020-2025) (2020)
- National Physical Development Plan (NPDP 2018-2040) (2019)

- National Housing Policy (2016)
- Policy on Conservation and Management of Wetland Resources (1995)
- National Gender Policy (1997)
- National Construction Industry Policy (2010)
- Works and Transport Sector Monitoring and Evaluation Policy (2014)

1.6 Universal Access (UA)

In 2008, Uganda ratified the Convention on the Rights of Persons with Disabilities (CRPD), and in 2019 enacted the Persons with Disabilities (PWD) Act. The Act guarantees non-discrimination in the provision of transport services, and is focused on public transport and driving permits; although the Act is less explicit in extending rights regarding the provision of Universal Design (UD) facilities for people with mobility disabilities who use, or wish to use, pedestrian facilities, the document takes the position that people with mobility disabilities should not be discriminated against in the provision of NMT facilities.

This document is not a detailed Universal Design (UD) nor Universal Access (UA) Standards Manual, but it does introduce UA/D principles to design teams working on NMT infrastructure in Uganda. This Manual does not remove the responsibility from designers to appraise themselves of any applicable statutory requirements or approved design standards or to apply their minds to the urban and rural spaces for which they are responsible for making accessible to all.

NMT Infrastructure Project Lifecycle

2 NMT INFRASTRUCTURE PROJECT LIFECYCLE

A project refers to a series of tasks that need to be completed in order to reach a desired specific outcome. Projects may differ in size, scope and complexity but should all be planned and carried out following a general sequence of activities, referred to as the project cycle. The public investment manual for project preparation and appraisal recommends four project phases that include; phase 1 - project identification, phase 2 - pre-investment phase (formulation, planning, design and appraisal), phase 3 - the Investment (implementation) and phase 4 – operation and ex-post evaluation (MoFPED, 2017). Activities involved in a typical project cycle include master planning and project identification, feasibility and preliminary engineering design, detailed design, procurement of works contracts, construction supervision and management, operations, promotion and maintenance, and post project evaluation. All these are in line with the above 4 phases, but are broken down to reflect NMT-specific projects.

This chapter provides a brief overview of the project lifecycle and planning processes, to situate the infrastructure design process (the focus of this Manual) within the bigger picture. Each element of the project lifecycle will require its own plan, strategy and execution, which is not the focus of this Manual.

Overall, the NMT project lifecycle follows this sequence:

- Understand the relevant NMT-friendly policies, legislation, and approval processes;
- Develop a pedestrian and a bicycle master plan per city, county, district or town;
- Identify individual NMT projects within the master plan;
- Prioritise projects and undertake feasibility studies;
- Design the NMT infrastructure (conceptual and detail design);
- Procure contractors for implementation;
- Promote the project and communicate with stakeholders; and
- Monitor and evaluate the project.

2.1 Understand NMT-Friendly Policies, Legislation and Approval Processes

Non-motorised transport is more likely to be appropriately funded and provided for by decision-makers when NMT is consistently and comprehensively included and aligned within all roads, land-use, building, public transport, and urban planning regulations, plans and frameworks, by-laws and other legislative and approvals processes nationally.

It is also important that the national policies around climate mitigation, air quality, social justice, gender equity and road safety, for example, note the importance of NMT in achieving these respective goals and objectives.

2.2 Master Planning and Network Design

For NMT projects to be effective and to serve the needs of users, comprehensive networks of pedestrian and cycling routes and facilities need to be developed, rather than piecemeal or 'ad hoc' initiatives. These networks need to be identified in consultation with stakeholders and user groups. Master planning also ensures consistent designs, decisions and standards throughout the country. From these master plans or networks, individual projects can be identified and prioritised.

During the master planning and network design phase, transport user hierarchy design principles should be carefully considered, and the needs of the most vulnerable road users should be prioritised. Priority NMT areas should therefore be identified in order to make the planning process more effective. Such areas include urban centres with high-volume commercial activity, public transport stations, markets, informal settlements and their access routes, schools, universities and other public service facilities (hospitals, markets, public offices), and recreational hubs such as parks and green corridors.

2.2.1 How to Develop a Pedestrian Master Plan

2.2.1.1 Understand User Requirements

To understand where to develop pedestrian facilities, the project team should find out:

- How many people walk in the area of study, or how many people would like to walk?
- Where do they walk?
- What routes do they take?
- What is the major purpose of the trips made?
- What facilities exist already?
- What are the barriers on their route?
- What are the gaps or missing connections?
- What are the land uses, trip origins and trip destinations?

- What are the hazards (personal safety and security for example) on these routes?

2.2.1.2 Collect Pedestrian Data

To develop a pedestrian master plan, the following types of data are necessary to have in hand:

- Main land-uses and trip attractors;
- Pedestrian crash data;
- Conflict points;
- Road classes and hierarchies;
- Distances walked;
- Time taken to walk;
- Trip purposes and times of day;
- Traffic volumes and speeds;
- Desire lines and route choices;
- Public transport stops and intermodal transfer locations;
- Slope and surface condition of the terrain;
- Continuity of network;
- Current infrastructure condition or existence;
- Cul-de-sacs and other impermeable situations;
- Number and types of bridges and culverts; and
- Obstructions including parked vehicles, signboards, vegetation and light poles.

Ensure that site visits and data collection take place at different times of the day, different days of the week, and under different weather and other operating conditions.

2.2.1.3 Map a Selection of Routes

On the map indicate hazardous locations, public transport stops, desire lines, and other relevant information gathered above. In addition, other details about shade, gradient/slope, comfort, attractiveness and trip attractors should also be included.

2.2.1.4 Develop a List of Proposed Interventions

Interventions could include vehicle speed reductions and traffic calming, sidewalks, crossings, footways, benches and shade, signalised intersections, depending on the findings of the studies, above. Note that interventions need not necessarily require new facilities only, but could focus on slowing the speeds for vehicles.

Interventions should pay attention to the following principles of network design:

- Consistency, continuousness and coherence – networks should be designed to be continuous, logical, and consistent at all locations;
- Directness – networks should be designed in line with the shortest paths from different locations;
- Safety – network design should consider the overall safety measures for the end-user;
- Comfort – the end-user should be physically relaxed and contented with use of the NMT facility;
- Attractiveness – the NMT facility should be able to attract the end-user into choosing NMT rather than other modes;
- Links with public transport – the network should be able to easily connect with other public transport modes; and
- The list of proposed interventions should be shared with the different stakeholders before the master plan is finalised.

2.2.2 How to Develop a Bicycle Master Plan

To develop a bicycle master plan, similar steps are followed to that of developing a pedestrian master plan. However, it is essential to remember that there are key differences:

- Cyclists are able to travel longer distances;
- Cyclists travel faster than pedestrians; and
- Cyclists need a safe and secure place to park and store bicycles, either at their destination or at a public transport stop.

When collecting bicycle-related data, it is less important to pay attention to current trips and numbers as it is to consider future demand. In many instances, the purpose of developing bicycle facilities is to encourage new and greater numbers of users.

2.3 Project Prioritisation and Identification

Project evaluation and prioritisation is a crucial step towards project selection. Well-planned and prioritised NMT infrastructure investment improves productivity and engenders mode competitiveness.

Project prioritisation is to be conducted from a list of proposed projects that result from a systematic assessment of critical infrastructure gaps and the developed NMT master plans.

Prioritisation should consider the pool of available funds, which is usually limited. Therefore, it is paramount to decide on how to allocate the limited resources for NMT infrastructure

development, which requires putting in place frameworks for translating the long-term priorities and goals into a credible, prioritised, and potentially viable pipeline of programmes and projects.

Project identification must be based on consultation with stakeholders, information gathered, and field observations, and aligned to the overall master plan. Every city or county authority will decide on the project prioritisation criteria to be followed, which is usually based on a matrix of technical, operational, environmental, socio-economic, and financial assessment criteria.

Below is a list of some possible overarching NMT project prioritisation criteria; note that every context is different, and stakeholder engagement is essential.

A detailed breakdown of some of the major components for the different project prioritisation criteria is given in **Table 2-1** below.

Table 2-1: Project prioritisation criteria

Prioritisation criteria	List of considerations
Technical criteria	Space availability Improved safety and security
Operation criteria	Improve accessibility and mobility Connectivity Completion of strategic network movements Closing gaps in networks Linkages to schools, employment areas, courts, health-care facilities, and public transport
Environmental criteria	EIA requirements
Socio-economic criteria	Improve healthy environment Reduce congestion Contribution to gender equity in terms of movement opportunities Contribution to People with Disabilities(PWDs), elderly in terms of movement opportunities Support to economic activities (e.g. informal trading)
Financial criteria (depend on the funding available to implement an NMT infrastructure project)	Fiscal allocation through the national budget process Property rates, fines, service charges, charges on use of public facilities, congestion charges among others Grants from development partners Donor funding Public Private Partnerships (PPPs)

2.4 Preliminary Engineering Study and Concept Designs

This phase involves the preparation and finalisation of the project concept with relevant details such as overall project scope, scale, character, form and function, plus preliminary programme and viability of the project. An important initial step in the conceptual design process is to clearly define the project objectives.

Typically, steps involved include:

- To investigate options, evaluate and design an appropriate alignment, cross-section (including intersection/ crossing treatments) for the construction/upgrading of NMT facilities to ensure that:
 - The facility will cater for projected NMT volumes and continue to meet its functional requirements in its design year;
 - The selected alignment is feasible in terms of financial, environmental and technical constraints and that the appropriate geometric, access and safety standards are adopted;
 - The preferred option takes into account regional and local planning/ land-use objectives and to ensure a high degree of compatibility between transportation and land-use objectives;
 - The local supporting road network is not negatively impacted/compromised in that traffic is re-distributed on the adjacent local street network, creating further safety or concerns or unacceptable levels of service. (A detailed local area traffic management study is generally a component of the study unless specifically requested.); and
 - The preferred option and if applicable, the phased construction thereof, is the most economically beneficial in terms of any constraints imposed on the option.
- To establish and provide co-ordinates for the road reserve and identify land acquisition/ expropriation requirements;
- To allow for stage construction and identify phasing options and timing;
- To ensure adherence to the principles of integrated environmental management and obtain the necessary approvals from authorities required to construct the facilities;
- To ensure where possible, the design philosophy will encompass the broader innovative, empowerment and procurement objectives of the relevant authority; and
- Appoint a road safety auditor to conduct road safety audit and incorporate findings from road safety audit report in the design.

An evaluation of how well the design proposal satisfies these objectives, as well as standard technical, environmental and economic objectives, should be addressed when considering the acceptance of the conceptual design proposals.

NMT field surveys are conducted to supplement the findings from the desktop study analysis. Field surveys assist further assessment of the proposed NMT infrastructure to identify future probable project hindrances. During the field surveys, the following data is collected:

- Traffic characteristics (motorised and non-motorised);
- Topographic characteristics and location of topographic constraints
- Availability of construction materials;
- Geotechnical characteristics (soil types, slope stability, foundation conditions);
- Geology (existing rock types and extents);
- Hydrology and drainage (need for structures e.g. bridges);
- Land use;
- Environmental characteristics (existence of forest reserves, swamps, wildlife conservation areas); and
- Road safety concerns and signs of road crashes.

The findings from the field surveys are examined together with the findings from the desktop study to come up with the most appropriate NMT infrastructure design.

The scope of work should describe the extent of the design project and what work elements constitute the conceptual design phase. Typical requirements and works specifications for the preliminary design for the development of feasible corridor concepts and alternatives shall address the following design elements:

- Horizontal and vertical alignments;
- Cross-section including public transport requirements;
- Intersection and access treatments;
- Road network considerations;
- Associated structures;
- Staging options for the alternative concepts that are under considerations;
- Landscaping and urban design;
- Street furniture including primary guidance signage;
- Street lighting;
- Drainage;
- Pavement design; and
- Boundary treatment / fencing.

The development of these concepts to an appropriate degree of technical analysis and evaluation must be undertaken (i.e. construction assessment, compliance with standards, traffic engineering and overall project objectives).

2.5 Detail Designs

As a result of a successful project identification and preliminary engineering study, detailed engineering design studies are then conducted for the NMT infrastructure.

Data on the identified NMT study area provides a factual basis for proper planning, and the extent of data collection is to be determined by the overall project objectives. This data is collected through both desktop and field studies. Potential desktop study sources include peer-reviewed literature, road-safety reports, travel surveys, topographical maps, geological maps, aerial photographs, GIS maps, satellite imagery, completed design reports and drawings of related infrastructure among others. Analysis of the aforementioned data makes it possible to gain a general understanding of the NMT study area, potential risks, existing human activity and the potential environmental impacts of the selected route.

Detailed design of NMT infrastructure can be categorised into the following:

- Detailed topographic, cadastral and valuation surveys;
- Detailed geometric design of horizontal and vertical alignment incorporating road safety audit recommendations;
- Detailed pavement design;
- Detailed design of NMT drainage and structures;
- Detailed design of marking and signage; and
- Cost estimates.

2.6 Procurement of Works

Procurement planning is a systematic process of setting achievable procurement objectives, and entails setting the strategies and defining the timeframe within which the objectives have to be achieved. The general procurement and implementation of NMT infrastructure projects is to be done in accordance with the public procurement laws and regulations of Uganda.

The drafting of a Terms of Reference (ToR) for the project constitutes the ultimate step before the procurement process starts. These may be drafted in any form acceptable to the client although it is important that the ToR be as detailed and comprehensive as possible, since it will also serve as a basis for the project construction contracts.

Procurement and tendering usually involves the preparation of pre-qualification documents for the procurement of construction works, invitations to pre-qualify, and advertisements. This stage

also involves negotiations with potential financiers, Consultants, Contractors and suppliers if applicable. In cases where project financing is obtained from development financing agencies such as the World Bank or African Development Bank, agreements and consensus should be reached on which procurement guidelines to follow.

2.7 Construction Supervision and Management

This stage is aimed at ensuring on-time and on-budget completion of the project while meeting all the relevant regulations and quality standards, as well as mitigating any potential risks to the project. It usually starts with the client entering into contracts for the construction and supervision of the works, which contracts are usually subject to review by the financier.

Engagement of a supervision Consultant on any project may be subject to the client or financier's preference, otherwise the client develops a construction supervision plan. Consultants are usually recruited to assist the client ensure that procurement guidelines, contract drawings, specifications, schedules and other contract documents are followed during the execution of work. A quality management system must be put in place to ensure that the quality expected for each project phase is achieved and that the end product is fit for its intended purpose. The quality assurance process involves consideration of the client's quality expectations (functional requirements, performance, cost and implementation date) to determine the criteria by which the client will accept/sign off the final outcome and these include the project approach, project quality assurance, project and phase quality plans, quality criteria, and quality logs.

To be effective, quality assurance should directly involve both the Consultant and the Contractor's staff with a detailed quality check list for all the project phases.

2.8 NMT Facility Operations and Maintenance

When construction of an NMT facility has been completed and handed over to the client, the operational stage begins (when the facility is put to use), as well as the defects liability period.

2.8.1 Asset Register

An asset register is created or updated after the construction is complete, and the site has been handed back to the authority. The NMT asset register could range from being a simple excel spreadsheet to a cloud based interlinked register on a government server for prevention of data losses.

The information captured in the NMT asset register includes asset name and description, separation, type, owner, function, date of installation, physical location, asset components and dimensions, records of condition assessments, maintenance records and responsible authority, traffic category, materials, geometry, standards, and guidance to other supplementary information in case of need.

The nature and structure of the NMT register varies as it may be a stand-alone document or an annex to the general road asset inventory. The asset register should have an asset classification system with asset IDs or facility codes. It should allow for easy data processing and reporting needs; for example, in performing asset valuations, creation of work and inspection orders.

NMT asset classes could be included in the 'road reserve' section of the road asset inventory to include kerbs, footways, drains, vegetation, and signage.

2.8.2 Operations Management

The facility operations management takes effect and the facility operations manager is responsible for ensuring the efficient use of the facility by all, monitoring and planning the required periodic maintenance and repairs and ensuring that the facility is clean at all times and serving its intended purpose. Funding for maintenance is provided by the relevant designated maintenance agencies.

2.8.3 NMT Promotion

The road user should be educated on how to use the infrastructure, especially when it comes to road safety. As highlighted earlier, pedestrians are the most vulnerable road users. Through television or radio or social media, the road users should be constantly reminded about the rules of the road and road safety. This can also be done through community engagement programmes or forums. Besides improving road safety, these programmes may also enable the community to take ownership of the project, thereby possibly reducing vandalism. These programmes are typically run by the community sensitisation authorities or in-charges, and the design Engineer should involve these departments as one of the stakeholders.

Aspects of operations that need to be considered to promote and improve NMT use include:

- Reduced traffic speeds and volumes, through provision of traffic calming and improved public transport;
- Intersection modifications and priority traffic signals;
- Extensive systems of cycling facilities, bicycle parking;
- Driver education and training, as well as training in tactile paver use, for example wayfinding
- Reflective clothing to ensure visibility of NMT users and learners; and
- Cycling programmes such as school programmes and rental schemes.

This stage requires proper management in order to maximise the life of the facility and its performance while maintaining the required level of service.

2.9 Project Evaluation

This consists of systematically analysing the successful and unsuccessful elements of the project experienced during implementation, and capturing the lessons learnt with a goal of improving the planning of the different project cycle elements in the future.

It is essential to monitor and evaluate impacts and outcomes as well as project outputs. The basic principles to be followed for effective evaluation of NMT projects are:

- Plan the evaluation;
- Identify the monitoring and evaluation activities and the agencies responsible for the activities;
- Identify the indicators to monitor outputs, outcomes and impacts;
- Execute the evaluation consistently;
- Use the evaluation results to improve the programme, and inform the public and other stakeholders about successes or failures; and
- Provide specific recommendations about improving aspects of the project design which is then used to improve on-going and future planning.

Every project will have its own evaluation criteria and indicators, drafted in consultation with stakeholders.

The list below suggests a number of indicators a project may include:

- Crash data – before and after the intervention;
- Cost comparison between modes of transport;
- The level to which NMT planning is integrated into planning;
- Maintenance of NMT infrastructure; and
- The number of new NMT users (by gender, age or other variables).

2.10 Environmental and Social Issues

There are several cross-cutting issues that need to be taken into consideration during the planning, designing and implementation of NMT infrastructure:

- Employment/labour-intensive construction methods;
- Environmental and social aspects; and
- Stakeholder engagement.

2.10.1 Employment/Labour-intensive Construction Methods

Labour intensive construction methods involve the use of hand tools and light manual equipment rather than heavy, automated machinery. These methods allow some project funds to be distributed to local communities by engaging or employing community members.

During the planning and design of NMT infrastructure, labour-intensive construction methods should be considered, such as clearance of the construction site, transporting of aggregate material over short distances using a wheelbarrow, compacting the base and sub-base layers, installation of concrete paving blocks fencing, erection of traffic signs, road marking, and periodic and preventative maintenance.

Labour-intensive methods could help reduce unemployment within a community, and also provide an opportunity for skills transfer and youth training.

Although labour-intensive construction methods have over time been taken to be cheaper, they generally take longer, and thus the project team should find a balance between the labour-intensive methods and the timely delivery of a project. It should also be ensured that the selection of workers is a fair and transparent process, minimum wages are adhered to, and there is enhanced use of community services (SANDOT, 2019).

2.10.2 Environment and Social Aspects

Road infrastructure investments are generally undertaken to improve the economic and social welfare of communities and road users. At the same time, large-scale road projects, and to a lesser extent NMT infrastructure, may also cause adverse effects to the surrounding environment.

The environmental impacts of NMT infrastructure projects may include damage to sensitive eco-systems like forests, acceleration of climate change impacts, soil erosion, changes to drainage patterns, and interference with animal and plant life. Although having a lighter footprint than vehicle infrastructure, this is less often the case as it is with roads. Road infrastructure in particular may also have impacts such as loss of productive agricultural lands, resettlement of people, disruption of local economic activities, demographic changes, accelerated urbanisation, noise air pollution among others. Thus, during any road infrastructure development, including NMT facilities, careful consideration must be given to environment and social impacts as well as the critical issue of climate change.

According to the Uganda's National Environmental Act (NEMA, 2019) and the Environmental Impact Assessment Regulations, an Environmental and Social Impact Assessment (ESIA) for an NMT project should be conducted with the following objectives:

- To determine the alignment route taking into consideration environmental and socio-economic aspects;

- To establish the environmental baseline in the study area and identify any significant environmental and social issues;
- To assess these impacts and provide for the requisite avoidance, mitigation and compensation measures;
- To integrate the identified environmental issues in the project planning and design;
- To develop appropriate management plans for implementing, monitoring and reporting of the environmental mitigation and enhancement measures suggested; and
- To undertake public and stake holder consultations and incorporate their concerns in the Environmental and Social Impact Statement.

The ESIA process for NMT projects is as described in **Table 2-2** below.

Table 2-2: Description of the ESIA process

Activity	Description/purpose
Environmental screening	The purpose of screening is to determine the extent to which an environmental impact study is required, and the screening process results in an environmental categorisation of the project.
Scoping and Terms of Reference	Scoping identifies the critical biophysical, socio-economic and cultural issues that will need to be addressed by the ESIA. It requires consultation with the relevant authorities and stakeholders such as the affected communities. Scoping assists in the planning of the environmental and social impact study and forms the basis for the Terms of Reference.
Environment/Social Impact Study	During the environmental and social impact study, relevant data is collected and analysed, the major impacts investigated in depth, mitigation measures developed for adverse and beneficial impacts and compensatory measures recommended for immitigable impacts.
Environment Impact Assessment report	This report contains a description of the project site, surroundings, proposed activities, and of the significant environmental impacts and risks. The ESIA report should discuss the project alternatives and recommend mitigation measures.

A Social Impact Assessment (SIA) pays attention to the impacts on vulnerable people. Examples include people living with disabilities, the poor, the elderly, the youth, the unemployed, women, members of marginalised groups, and occupational, cultural, political or value-based groups for whom a given community, region or use of the biophysical environment is particularly important. The detailed activities to be carried out during the SIA and their respective purposes is described in the **Table 2-3** below.

Table 2-3: SIA process activities

Activity	Description/purpose
Public involvement	This requires identifying and working with all potentially affected groups starting at the very beginning of planning for the proposed project. The groups of people that need to be considered during this activity include; those who live nearby; those who will hear or see a development; those who are forced to relocate because of a project; and those who have interest in a new project or policy change but may not live in proximity.
Description of project and identification of alternatives	The project details are highlighted, and the data requirements are identified to frame the SIA. The data requirements include; locations, size, land requirements; program of works, need for ancillary features, need for local labour force, institutional resources among others.
Baseline study/ conditions	The baseline conditions are the existing conditions and past trends associated with the human environment in which the proposed project is to be implemented. The project geographical area is identified along with the distribution of special populations at risk.
Projection of estimated effects	This involves study of documents and secondary sources that provide information on existing conditions, plans, reported attitudes and opinions on similar projects. The field research involves interviews with persons who have different interests at stake, different perspectives, and different kinds of expertise through by mass meetings, pre-announced in the media, press or radio, or by identifying pre-existing Community Based Organisations (CBOs) with wide membership, capable of being used as an organ of information distribution and gathering.
Estimation of indirect and cumulative impacts	Indirect impacts are those caused by the direct impacts; they often occur later than the direct impact, or farther away. Cumulative impacts are those impacts which result from the incremental impacts of an addition added to other past, present, and reasonably foreseeable future projects regardless of which agency or person undertakes them
Mitigation	This involves the development of a mitigation plan. Mitigation includes avoiding the impact by not taking or modifying an action; minimising, rectifying, or reducing the impacts through the design or operation of the project or policy; or compensating for the impact by providing substitute facilities, resources, or opportunities.

Overall, a well-articulated ESIA prescribes the mitigations measures to be taken into action for both the environmental and social impacts of any NMT project and consequently all-inclusive parameters such as walking speeds should be used in the design and construction of NMT facilities to include vulnerable persons such children, pregnant women, elderly, women and men.

2.10.3 Funding

The available sources of funding should be considered from as early as the preliminary investigation or feasibility stage. Each funder may have their preference and restrictions on the type of the project they fund. It is essential to identify possible funders and to start liaising with them to get their buy-in early on in the project. During the design phase, a more realistic cost-estimate for implementing the project will be determined. At this stage, more than one source of funding may be sought. It is important to allow for the funding authority to get the funding approved internally. Depending on the value of the project and the authority, the time to get the funding approved may vary from a few months to a few years. It is imperative that this is provided for in the project plan.

In general, the types of funding available to implement NMT infrastructure projects are:

- Fiscal allocation through the national budget process;
- Self-generated revenue with the authority: property rates, fines, service charges, charges on use of public facilities, congestion charges among others;
- Grants from development partners;
- Donor funding/ loans; and
- Public Private Partnerships (PPPs).

2.10.4 Stakeholder Engagement

Stakeholder engagement needs to take place at every phase of the project cycle, from the beginning to the end. When NMT solutions have been planned with all stakeholders, there is a lesser need to enforce these regulations.

2.10.4.1 Key Elements of Stakeholder Engagement

- Identify key local, regional and national stakeholders – these could be businesses, individuals, organisations, the media, political groups or religious groups, and all relevant government departments. Marginalised or vulnerable groups should also be considered.
- Share a practical, concrete plan to get people on board. Find common ground and together understand how the project will benefit each stakeholder.
- Depending on the type of stakeholders and the objective, the type of stakeholder engagement can vary ranging from public meetings, exhibitions, workshops, street stalls, one-on-ones, focus groups and site visits.
- An informal, yet effective, structure of engagement would include walking around with a map (on paper or on a tablet) of the planning area and letting the stakeholders look and make comments (Jarnhammer, 2019). This type of engagement allows an opportunity for the day-to-day pedestrian and bicyclist to give their input, without the fear of being in a large formal meeting.

2.10.4.2 Stakeholder Mapping

Transport planning is influenced by a variety of stakeholders, both inside and outside of government. Stakeholder mapping helps identify who these stakeholders are and understands what role they play in the project lifecycle.

2.10.4.3 Stakeholder Analysis

Stakeholder analysis is the process of identifying and analysing the stakeholders that are likely to affect or be affected by the project (positively or negatively) in order to manage them appropriately and effectively.

One of the goals of stakeholder analysis is to develop cooperation between the stakeholders and the project team. This will lead to less conflict and more cooperation during the project implementation. It helps to identify the people to be informed during implementation, the key people to be involved and consulted, and the people who may have potential negative impact on the project.

Stakeholder analysis is suitable to use in the initial phase when you are defining and organising the project but should be updated continuously during the project as new stakeholders are identified.

The stakeholder analysis normally covers the following steps:

- Identifying stakeholders: listing relevant groups, organisations, and people;
- Analysing stakeholders: understanding stakeholder perspective and interests. Sort them by the power they have and by their interest in the proposed action;
- Prioritising stakeholders: ranking stakeholder relevance and identifying issues. Being strategic and clear about who is being engaged with, and why; and
- Engaging stakeholders: agree on how to engage different stakeholders in different stages of the project.

In conclusion, these cross-cutting issues play an important role throughout the project and are essential for the successful and timely completion of the project.

Design of NMT Facilities

3 DESIGN OF NMT FACILITIES

3.1 Guiding Principles of NMT Design and Decision-making

High quality NMT facilities, when integrated into the road and public transport network, are able to achieve greater equity and reduce access disadvantage; expand the reach of public services; attract new users; reduce the cost of transport provision; improve the safety of people who walk and cycle; improves health of NMT users; reduces greenhouse gas emissions due to lesser use of motorised vehicles, and contribute to the quality of the built environment by limiting harm to the natural environment.

Planning for people who walk and cycle, and integrating walking and cycling with public transport, gives service providers the opportunity to meet Uganda's desire to redress the inequities of majorly car-based planning, and the land-use patterns that accompany urban sprawl and rural isolation.

NMT facilities aim not only to simply accommodate current pedestrian and cyclist needs and uses; particularly regarding cycling facilities, but also to facilitate behaviour change towards greater use of cycling hence attracting the latent demand for this mode. For this reason, designing according to current demand only is not recommended.

The Uganda Road Geometric Design Manual (MoWT, 2010) equally regards vehicles, pedestrians, and animals traveling along a route as 'traffic'. It further outlines general pedestrian and bicycle planning principles as:

- Vulnerable road users should be separated from motorised traffic;
- At points of conflict between vulnerable road users and motor vehicles, the speeds should be low (preferably 30 km/h or lower);
- Intersections should be designed to reduce collision speeds, especially for side-on collisions (preferably to 30 km/h or lower);
- Shoulders should be paved and available for the use of pedestrians and cyclists;
- Bicycle-safe drainage grates should be provided; and

- A smooth and clean riding surface should be maintained.

Safety is one of the primary considerations when implementing NMT infrastructure. A human being can run to a maximum speed (albeit over a very short distance) of 30 km/h. In case a human being falls, while running, the resulting injuries would be minimal such as scrapes and bruises. A commuter travelling on a bicycle can usually travel at 30 km/h and should a crash occur, the human body can still withstand the injuries which may include scrapes and bruises and may be a fractured collarbone. A traffic related crash of a pedestrian or a cyclist at 45 km/h will result in serious injury that will require hospitalisation.

However, a traffic related crash of a pedestrian or a cyclist at a crash speed difference of 60 km/h will most probably result in fatal injuries. It is for these reasons that pedestrians and cyclists are vulnerable road users and should be either separated from motor vehicles when speeds increase. A human body in a motor vehicle can withstand greater speeds during a collision because the vehicle provides some protection in the form of crumple zones, seatbelts, and airbags.

3.2 Safe System Principles

A Safe System approach to road design is an inclusive approach that caters for all groups using the road system, including drivers, boda boda riders, passengers, pedestrians, cyclists, and commercial and heavy vehicle drivers. Key pillars of a safe system include (Larsson, 2010):

- Safe roads and roadsides;
- Safe speeds;
- Safe vehicles; and
- Safe road users.

The aim is to develop a road transport system that is better able to:

- Take account of human limitations;
- Allowing for the fact that humans are likely to make mistakes; and
- When such mistakes occur, take into consideration the vulnerability of the human body.

Thus, the goal of a Safe System is to prevent crashes between road users through proactive actions, and when such crashes do occur, to ensure that they do not result in serious injury.

3.2.1 Road Safety Audits

Conducting road safety audits will ensure that the Safety System principles have been adhered to during design, construction and maintenance. The Uganda Road Safety Audit Manual (MoWHC,

2004) process is to be followed. A road safety audit ordinarily includes the needs of all road users including NMT for all weather and lighting conditions. During the design process, road safety audits can be conducted during the initial design (planning – stage 1 feasibility studies), draft design (stage 2 audit – preliminary design) and detailed design (stage 3 audit – detailed design). After the project is completed the stage 4 audit of pre-opening can be conducted and also the stage 5 audit for monitoring existing roads. Due to the relatively small size of an NMT project, the design audits can be merged into one. The road safety auditors need to understand the road safety concerns prior to the implementation of the design and also to audit the designs for road safety concerns that will specifically affect NMT users.

As a road safety audit will focus on common safety concerns, that need to be taken into account during the NMT design process and the designs should not just meet the design criteria, but also achieve a safe road environment by providing safety for all road users; creating a design that will assist the driver to adjust his speed to the current circumstances; prevent surprises along the route; guide, warn and inform the driver with signage and road markings; ensure design consistency; provide adequate control for both drivers and NMT users at potential conflict points and lastly provide a forgiving environment where human error can occur.

A road safety audit can be conducted on a road that is already in use at stage 5 and also where a higher number of crashes and fatalities. Road sections where higher number of crashes and fatalities are recorded are deemed to be a hotspots. Emphasis may be given to NMT should the majority of crashes and fatalities be affecting NMT users.

When an NMT network is existing, the entire network can be audited in terms of the road safety risks for NMT.

3.3 Types of NMT Facilities

Separating people who walk and cycle from motorised traffic is one of the most important elements of NMT design. Separation can be achieved through grade-separation, barriers, buffer zones, and road markings including colourisation. Pedestrian bridges are discouraged except under particular circumstances as described in Section 5.1.1 on pedestrian bridges. This section describes the different types of NMT facilities in **Table 3-1** and their respective typical cross-sections.

Table 3-1: NMT classification in terms of degrees of separation

NMT treatment	NMT facility class	Description
NMT only/exclusive	1	The NMT facility is separated and removed from motorised traffic over most of its extent. It is also not part of the road reserve.
Total separation	2	Located within the road reserve, but no conflict will occur between motorised and NMT even in the event of loss of control of the motorised or NMT vehicle. A heavy barrier or a guardrail separating the NMT users from motorised vehicles is erected. These are best suited when either the design speed of the vehicles or the operating speeds of the vehicles are more than 60 km/hr, for example along rural highways.
Partial separation	3	A partial separation may be provided between the NMT facility and the motorised vehicles. This is generally achieved by means of a level difference between the two facilities or with the use of bollards. Motorised and NMT traffic may travel on the same surface but are separated by means of continuous road marking and signage to identify a particular lane as a cycle way. The typical cross-sections further elaborate on this.
Mixed traffic	4	The non-motorised Vehicles (i.e NMT users except pedestrians) will share the roadway with vehicular traffic as mixed traffic. However, the pedestrians will use the raised sidewalk. These are ideally suited for streets with very low traffic volumes of less than 300 ADT and where vehicle operating speeds are lower than 30 km/hr. There are very particular circumstances where this can be implemented.
Sidewalk only	5	This is the basic cross-section where a sidewalk is provided to cater for pedestrians. This cross-section is implemented when the volume of NMT vehicles is very low and can share the facility with pedestrians.
Woonerf	6	These are streets where NMT has priority over motorised vehicles.

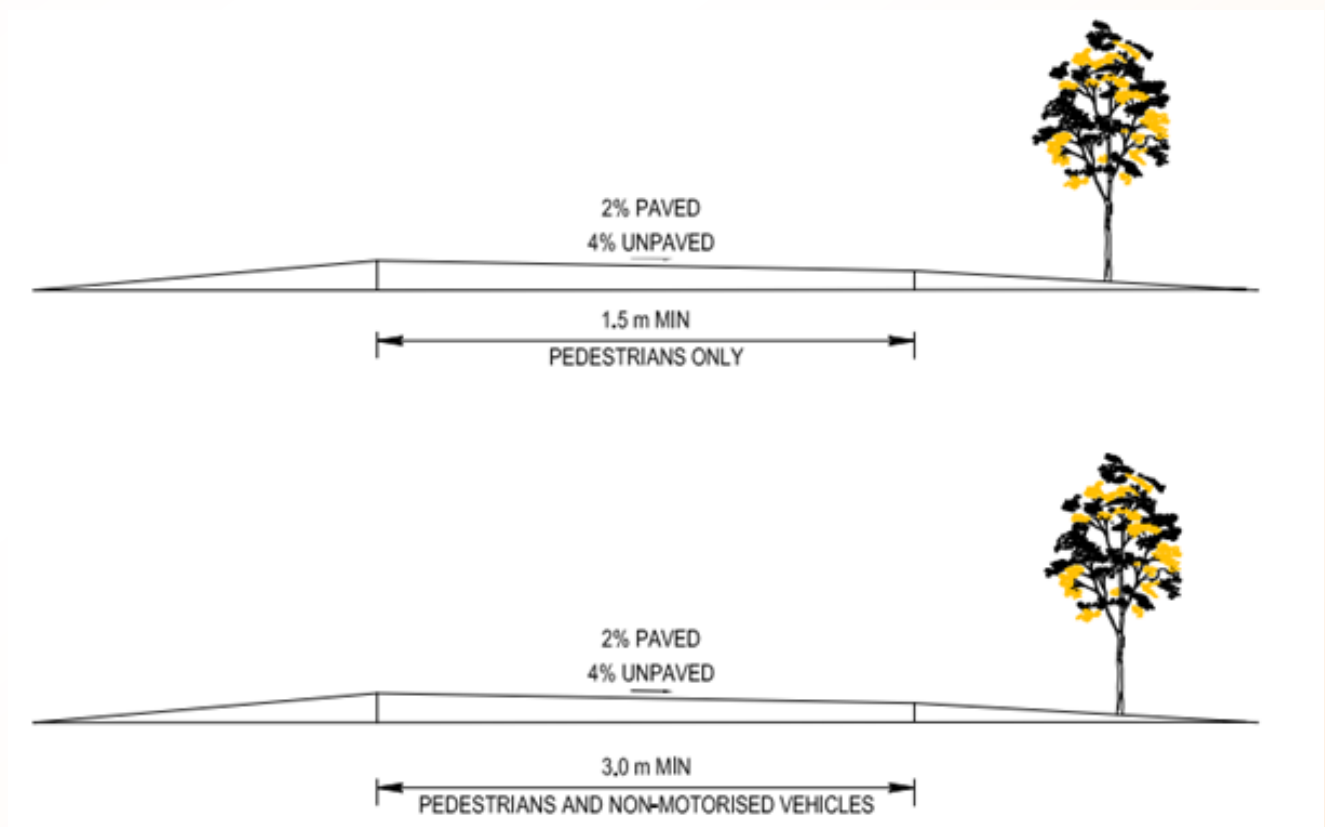
3.3.1 Class 1 Facilities – Exclusive NMT Use Outside the Road Reserve

Facilities reserved entirely for NMT users should take the most direct and shortest distance between their origins and destinations, and not necessarily follow the road. NMT facilities with this level of separation are applicable regardless of the functional class of the road. These could include well-maintained gravel footways, paved footways, or cycle ways.

General guidance

- The facility should follow direct desire lines connecting origins and destinations.
- Width of the facility should be at least 2 m for pedestrians and 2 m for cyclists for one-way. Ideally the bicycles and pedestrians should be separated. However, if the speed and volume of the cyclists is low, then the facility may be shared with signage provided to indicate cycling speeds.
- The general sizing will depend on the results from the pedestrian demand computations.
- Provide lighting for personal safety and security. Personal safety can be a challenge, because such facilities are not necessarily close to areas of high vehicle traffic.
- Provide bridges and culverts with appropriate handrails when crossing water courses.
- Should there be wheelchairs, strollers or push carts, then facilities wider than the minimum recommendations should be provided.

The **Figure 3-1** below shows a typical cross-section of an exclusive NMT route applicable both in rural and urban settings.



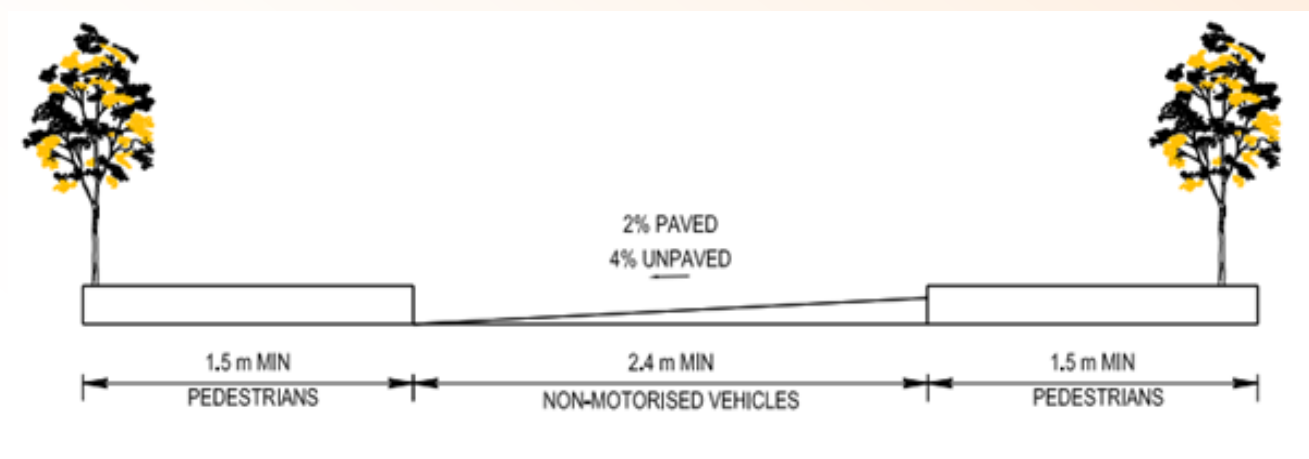


Figure 3-1: Typical cross-sections of an exclusive NMT facility (Class 1)

3.3.2 Class 2 Facilities – Total Separation within the Road Reserve

Class 2 facilities are totally separated facilities and should be provided for pedestrians and cyclists under most circumstances. However, due to space constraints and cost implications, this option may not be always viable. Nevertheless, total separation is possible to achieve and is particularly important on roads with high motorised traffic volume and high speeds. Total separation can be achieved through use of physical barriers such as a guardrails. A pedestrian fence may be installed to prevent pedestrians from climbing over the guardrail. Class 2 facilities are also suitable along rural highways, where the design speeds are more than 80 km/h.

General guidance

- Where possible, in addition to the barrier, you will need to position the footway or shared NMT facility on the outside of the road reserve or at a different level which may be kerbed. Sufficient road shoulder must remain for other vehicle use such as emergency vehicle stops;
- Where the route crosses watercourses, suspend a footway or shared facility below the cantilever portion of a vehicle bridge, the separation distances are as recommended in Table 6-5;
- Where gradient require cuts and fills , bring the NMT facility closer to the road way and consider a double guardrail; and
- Always consider sight lines and personal security concerns between the footway and the road.

A typical cross-section of total separation of NMT facilities is shown in **Figure 3-2** below.

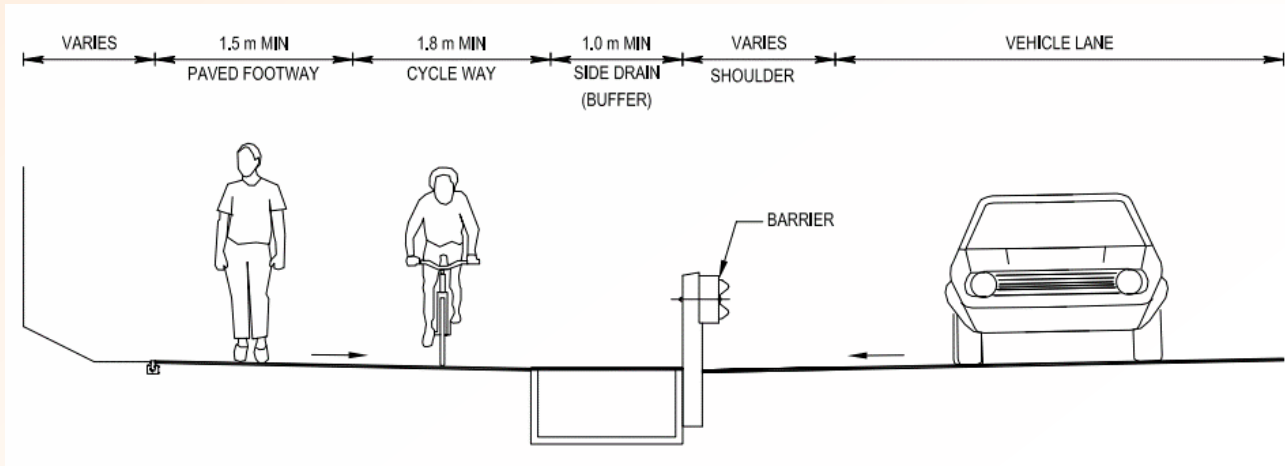


Figure 3-2: Typical cross-section of total separation of NMT facilities (Class 2)

3.3.3 Class 3 Facilities – Partial Separation (kerb or barrier protected) within the Road Reserve

Partial separation is usually created by means of a kerb and sidewalk, a light barrier, and/or buffer zones such as drainage channels, street furniture and vegetation. The type of separation and the decision regarding the extent of separation of bicycle and vehicle traffic, will depend on the road function, the road operating speed, the type of road surface (gravel or paved), and the width of the road reserve.

Kerb separation is mainly used in urban areas where vehicle operating speeds are lower than 60km/hr. Barrier kerbs are primarily used to prevent vehicles from passing over and parking on footways. Cycling on high speed roads can be dangerous, and therefore cycle ways should not be provided on roads with speed limits higher than 60 km/h.

Where operating speeds are below 60 km/hour and conditions permit particularly in urban areas, a footway can be protected by a kerb. A cycle way placed on the road way as separated by road markings and signage.

a) Kerb-protected footway and cycle way

Where operating speeds are between 60 to 80 km/hour and other conditions of space permit, a cycle way can be positioned adjacent to the kerb with a footway on the outer outside as illustrated in **Figure 3-3**.

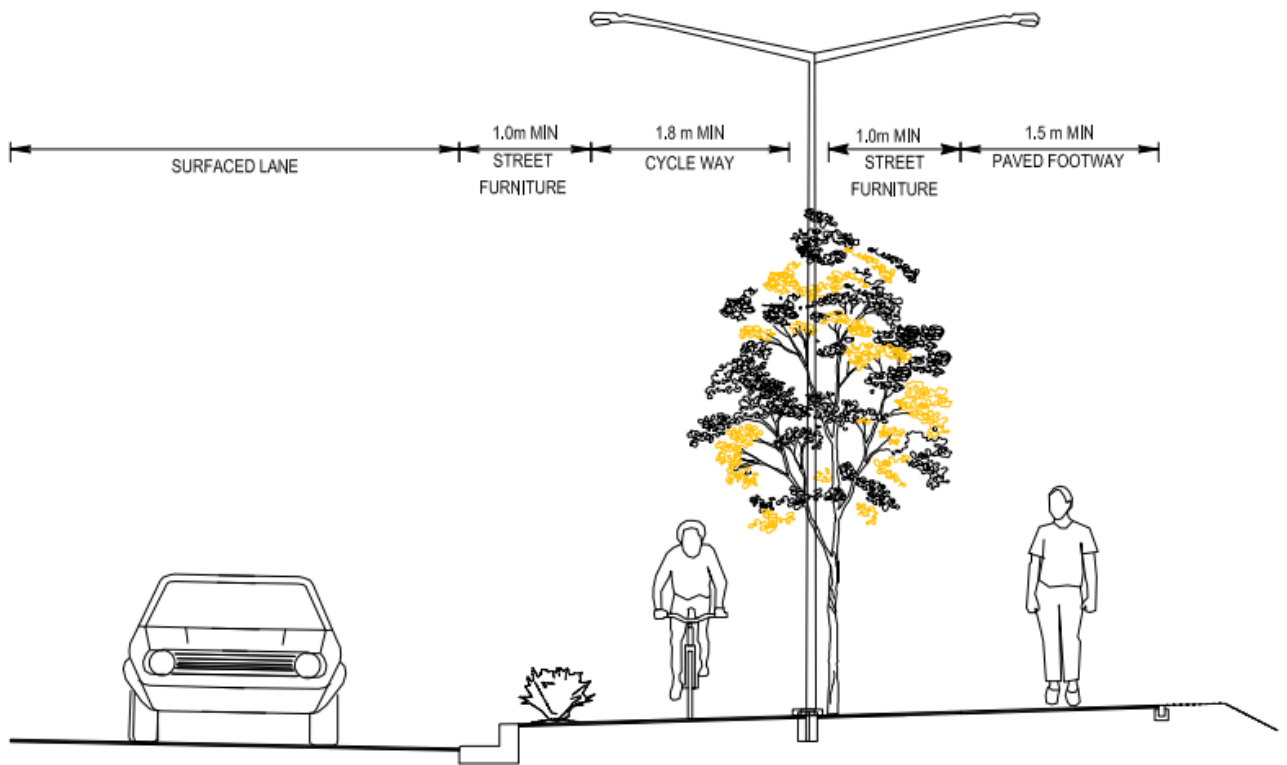


Figure 3-3: Typical cross-section of kerbed separation of NMT facilities (Class 3)

b) Kerb-protected footway only, marked cycle way

Where design speed of the road is less than 60 km/hour and conditions permit particularly in urban areas, a footway can be protected by a kerb, with a cycle way placed on the roadway and demarcated by road markings and signage.

Motorised traffic may be separated from NMT by means of road-marking and signage for cyclists in order to identify and demarcate the cycle way.

Non –slip, green-painted cycle lanes of cementitious epoxy grout or dyed bitumen have become increasing common as additional road markings to alert motorists to the presence of cycle ways.

In urban areas the footways are normally raised and edged with barrier kerbs. Barrier kerbs should normally be 100 to 150 mm high. Higher kerbs of 200 mm are sometimes used in order to deter vehicles from parking on the footways. Kerbs of 200mm are not recommended for use in certain areas, as they can be high for most pedestrians who prefer to walk in the traffic lanes. The kerb should be lowered at all pedestrian crossings, and where private entrances, footways, and cycle ways meet the carriageway.

The dropped kerb should be availed as it is useful for people with disabilities.

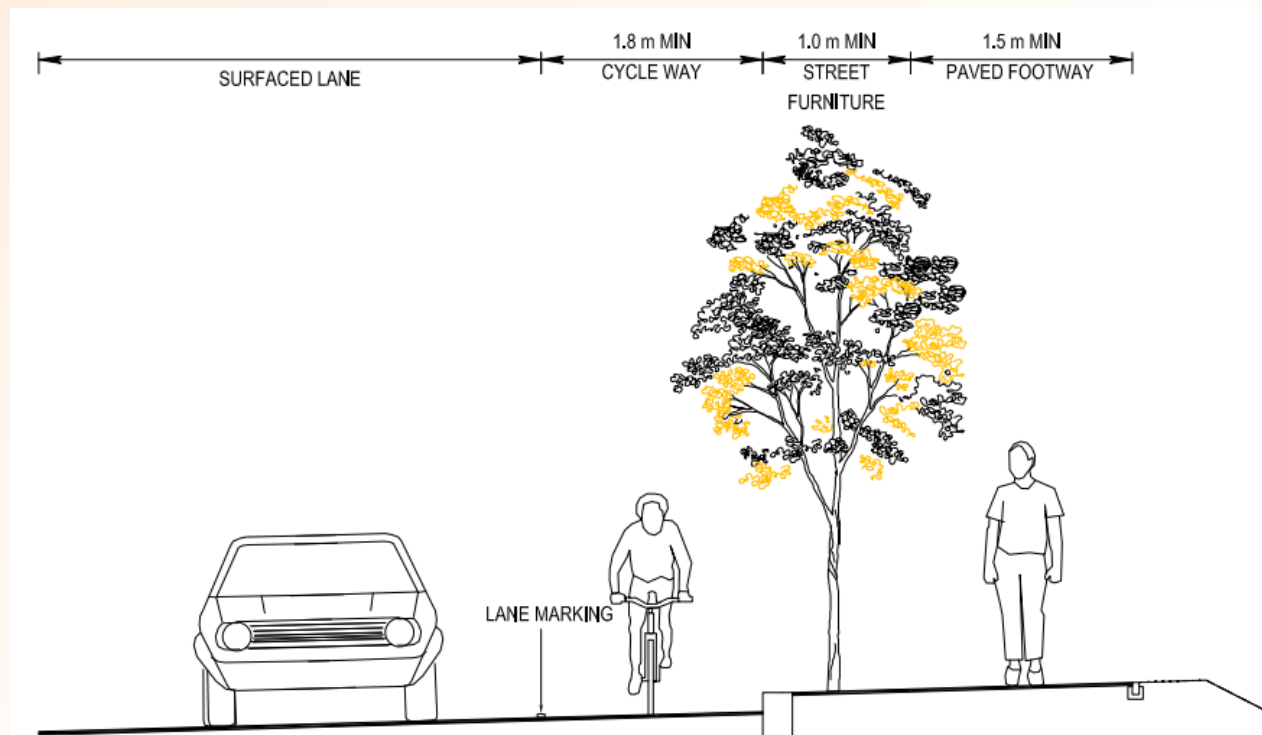


Figure 3-4: Typical cross-section of kerbed separation of pedestrians and cycle way separated by line marking (Class 3)

3.3.4 Class 4 Facility – NMT Vehicles Sharing with vehicular Traffic, Kerb-protected Footway

This type of facility should only be implemented under specific and exceptional circumstances. They are applicable to residential streets where the volume of vehicular traffic is lower than 1,000 vehicles per day and the operating speeds are below 30 km/h. The bicycles may travel on the roadway along with motor vehicles and without dedicated lanes. However, footways must be provided for pedestrians.

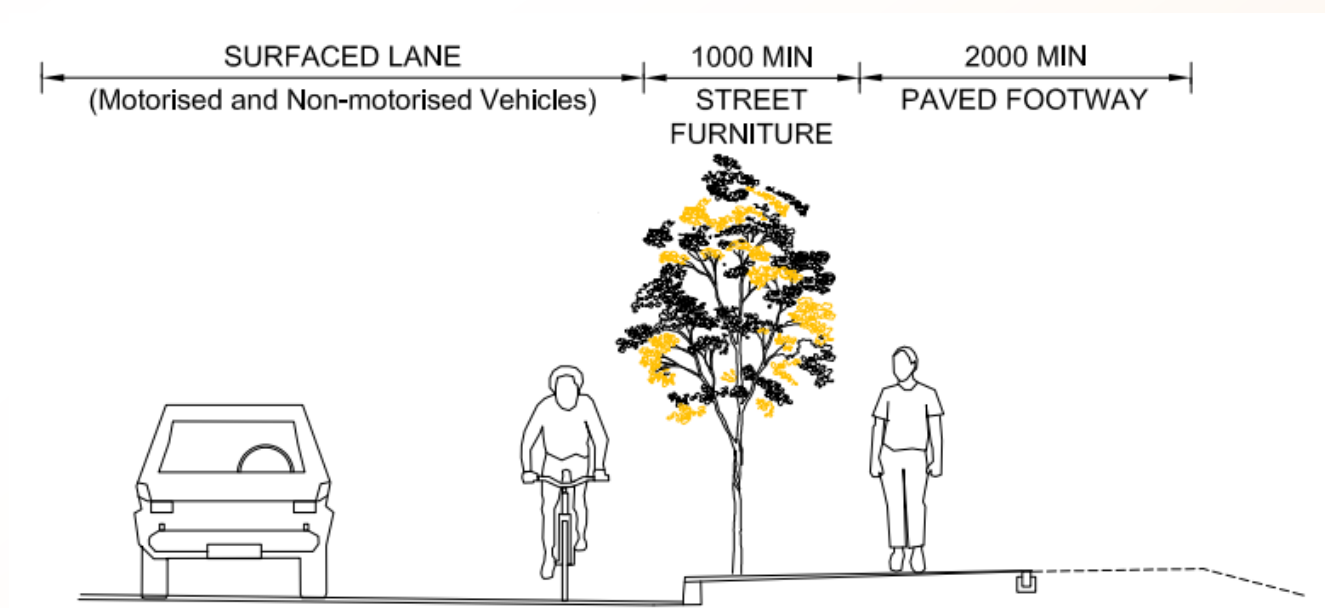


Figure 3-5: Kerb-protected footway (Class 4)

3.3.5 Class 5 Facility – Kerb-protected Footway Only

For minor roads with speed limit of less than 60 km/h, a Class 5 facility can be implemented, where pedestrians are protected by a kerbed footway. If the bicycle volumes are very low, then they may share the footway with pedestrians. However, a sidewalk of at least 3 m wide should be provided.

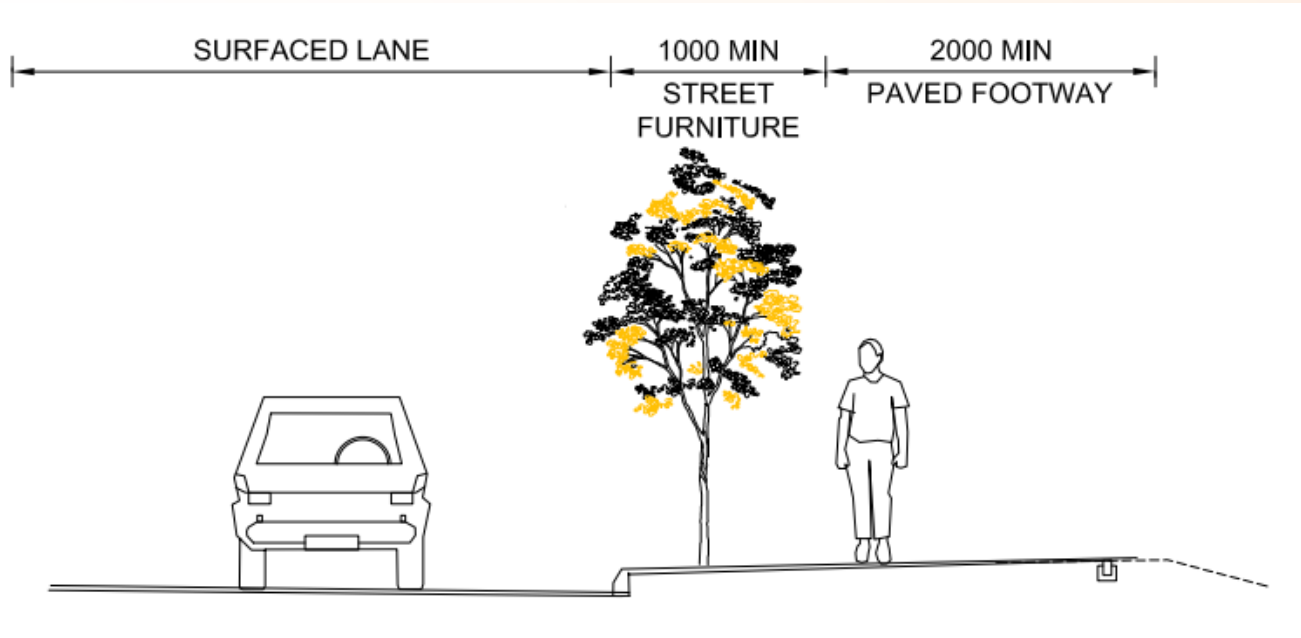


Figure 3-6: Kerb protected footway only (Class 5)

3.3.6 Class 6 Facility – Woonerf

These are roads or road sections where NMT modes have priority over motorised modes. Slow speeds of less than 30km/h for motorised traffic are mandatory on these roads. 'Woonerf', is a Dutch term for a 'living/residential area', and is used to describe an area, normally of residential development, within which the adverse effects of traffic have been minimized on a localised basis, either as a result of the original layout of the area or by subsequent provision of additional speed calming measures. Anticipated vehicles speeds should be restricted to 30 km/h using speed calming measures and/or a road signs.

The Woonerf signs indicate to the driver of a vehicle that, if they go beyond such a sign they shall yield the right-of-way to pedestrians and children who may be in the roadway, and shall observe a maximum speed limit of less than 30 km/h.

Practically, a woonerf is a street or neighborhood where pedestrians, cyclists, carts, horses and any non-motorised means have legal priority over motorists. The needs of car drivers are secondary to the needs of other users of the street or road.

To limit vehicle speed, streets are usually designed or retro-fitted so that a car cannot travel in a straight line for significant distances, for example by placing planters at the edge of the street, alternating parking bays, or by implementing chicanes as shown in the **Figure 3-7** below.

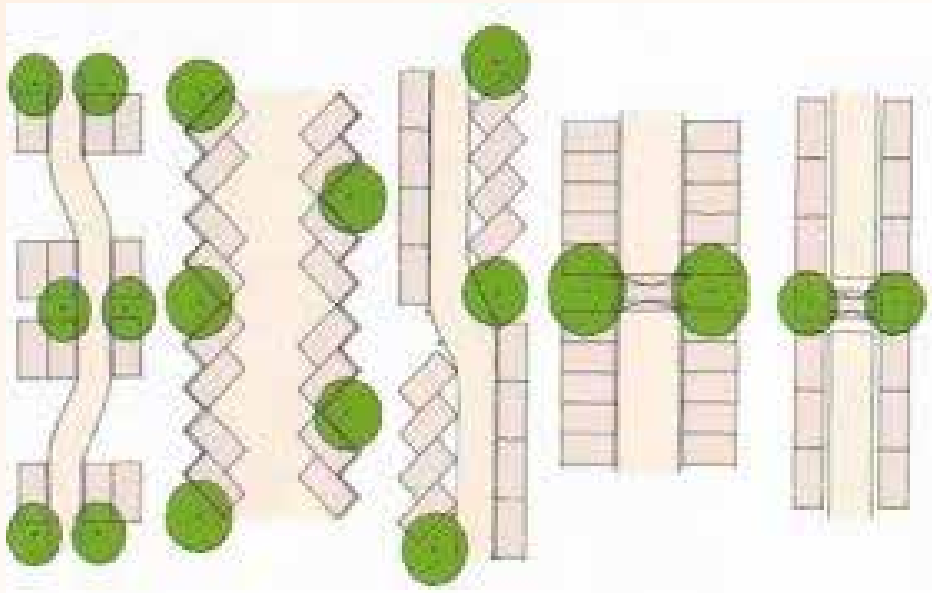


Figure 3-7: Woonerf zone (Source: The Woonerf Concept, nacto.org)

A woonerf:

- Does not change or limit property rights;
- Is not an exclusionary intervention;
- Does not necessarily require any physical intervention other than standard road signage, and traffic calming measures;
- Is not for only gated communities or for security of residential areas; and
- Does not require rates top-up or compulsory contributions.

3.3.7 Shared Facility for Pedestrians and Cyclists

It is not ideal for cyclists and pedestrians to share NMT facilities, as cycling and walking are two entirely different modes, with different movement characteristics, speeds, and particular needs. In cases where space for separate facilities is not available, shared bicycle and pedestrian facilities are deemed to be an acceptable practice. In other circumstances, it is best to separate bicycles and pedestrians with entirely different facilities using road marking, signage, surface treatments (colourisation) and ensure that cross-sections meet the minimum width for the combined modes. Wherever possible, bi-directional bicycle travel should be discouraged, and cycle ways provided on both sides of the roadway.

3.4 Providing NMT Facilities: Choosing a Solution

Sometimes, it can be difficult to determine what type of NMT facility should be implemented. There are various factors that help determine the type of facility and they include:

- Land-use in the area;
- Population density;

- Volume of NMT users both the existing and projected future;
- Volume of vehicles both the existing and projected future ;
- Crash statistics which include type of crashes, severity and vehicles involved to name a few;
- Proximity to public transport;
- Proximity to large employers, and community facilities which may attract NMT traffic;
- Whether urban or rural community; and
- Characteristics of the roadway such design and operating speeds, cross-section, number of lanes and available road reserve.

Based on the aforementioned factors one would have to determine the most suitable type of facility to be implemented. In urban areas, the lack of space is often a challenge. This is further dealt with in detail in the retro-fitting section of this manual.

Some of the principles that need to be considered when choosing the type of NMT facility are:

- While designing a facility one should take into account of existing and future traffic projections on the route;
- The pedestrians should ideally be separated from other NMT users;
- Pedestrians should always be separated from vehicular traffic with a sidewalks provided; and
- A barrier may be provided between pedestrians and vehicles to increase safety. On streets where the design speed is low, vegetation can be used as a barrier, whereas on highways, a guardrail should be erected to protect the pedestrians.

The decision tree in **Figure 3-8** below can be used in determining the type of NMT facility to be design and constructed. This tool is merely a guideline to choose a type of facility. The responsibility remains with the designer to apply their knowledge and experiences and best practices together sound engineering judgement in the selection of the most appropriate type of facility.

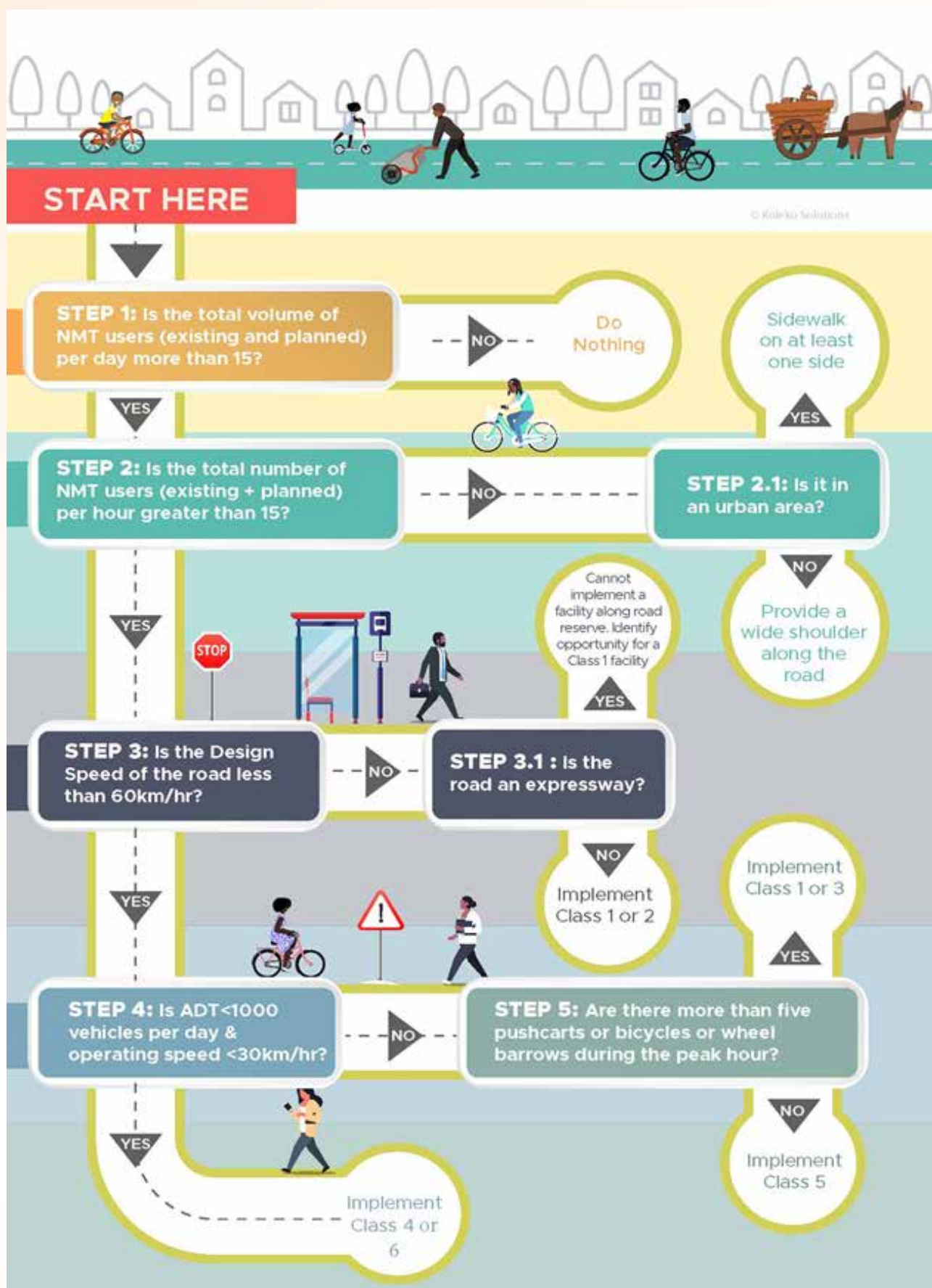


Figure 3-8: Decision Tree, Choosing a Solution

Step 1: Determine the design volume

The existing and forecasted users need to be taken into consideration in determining the design volume. If the design volume of NMT users per day is less than 15 users per day, then an NMT facility may not be warranted and therefore the do nothing alternative is recommended.

If the design volumes are greater or equal to 15 users, then proceed to step 2.

Step 2: Determine the design volume at peak hour

In Step 2, the design volume of NMT users during the peak hour should be determined. It is important to consider the NMT users in both directions and on both sides of the road, as well as existing and projected volume of NMT users. If the design volume during the peak hour is more than 15 users, then proceed to Step 3, otherwise, proceed to Step 2-1.

Step 2-1: Is the road in an urban area?

If the road is in an urban area, then at minimum a sidewalk should be provided on one side of the road – a Class 5 facility. Should the road be in a rural area, then also wide sidewalk should be provided.

Step 3: Is the design speed of the road less than 60 km/hr?

If the design speed of the road is less than or equal to 60 km/hr, then proceed to Step 4, otherwise, proceed to Step 3-1.

Step 3-1 Is the road an expressway?

NMT users are not permitted to use an expressway, hence no facility should be provided along an expressway. However, an exclusive Class 1 NMT facility may be considered connecting the origin and destination. If the road is not an expressway, then a Class 1 or 2 facility may be implemented.

Step 4: Is the ADT is less than 1 000 vehicles and operating speed less than 30 km/hr?

If the Annual Daily Traffic (ADT) is less than 1 000 vehicles per day and the operating speed is less than 30 km/hr, then implement a Class 4; otherwise, proceed to Step 5.

Step 5: Are there more than five non-motorised vehicles during the peak hour?

If there are more than five non-motorised vehicles who are NMT users excluding pedestrians, then implement a Class 1 or Class 3 facility, otherwise, implement a Class 5.

3.4.1 Road Functional Classification

The road functional classification refers to the process of classifying roads into hierarchical networks according to their main purposes. Road infrastructure provides two basic service functions: mobility between origins and destinations; and local access to land and properties. The most important purposes and applications of functional classification include:

- Assignment of a road's ownership and responsibility for its management and financing;
- System planning and access control for all travel modes including NMT; and
- Assignment of minimum standards, including permissible vehicle axle loads, weights and dimensions (Talvitie, 1996).

Table 3-2 presents the existing functional classification of roads in Uganda (MoWT, 2010).

Table 3-2: Functional classification of roads in Uganda

Class	Description	Function	Characteristics	Max design speed range (km/h)	Typical width ranges (m)
A	International trunk roads	Mobility	Longer trip lengths High level of service with high design speed	<u>Paved</u> 50–120	<u>Paved</u> 8.6 –24.60
B	National trunk roads	Mobility	Longer trip lengths High level of service with high design speed	<u>Paved</u> 70–110	<u>Paved</u> 8.6–11.0 <u>Gravel</u> 10
C	Primary roads	Mobility and access	Accommodate shorter trips feeding into higher classes of road Intermediate level of service and design speed	<u>Paved</u> 50 – 90 <u>Gravel</u> 70-90	<u>Paved</u> 8.6–10.0 <u>Gravel</u> 10.0
D	Secondary roads	Mobility and access	Accommodate shorter trips feeding into higher classes of road Intermediate level of service and design speed	<u>Gravel</u> 50–90	<u>Gravel</u> 8.6–10.0
E	Minor roads	Access	Short trip length Low design speeds and level of service	<u>Gravel</u> 40–80	<u>Gravel</u> 6.4–8.6

3.4.2 NMT Provision and Land-use Integration

The Uganda National Land Use Policy (MoLHUD, 2006) provides for three broad categories of land use:

- Agriculture (crops and livestock);
- Built-up areas; and
- Land reserved for conservation.

These categories are not exclusive, and linkages exist between them, for example, as described below:

- Areas exclusively devoted to agriculture;
- Exclusively built up areas;
- Areas exclusively reserved for conservation;
- A combination of built and conservation areas;
- A combination of agriculture and built areas;
- A combination of agriculture and conservation; and
- A combination of agricultural land built and conservation areas.

In addition to the functional class of the facility, the design concepts of the NMT facility also need to consider the land-use context of the road. Improvement in the transport system causes places to be more accessible. The improved accessibility of places results in developers altering the land use of such a place by providing residential, commercial or recreational facilities.

The design of NMT infrastructure should be related to the adjacent land use. Footway requirements in residential areas are different from those in commercial and rural settings. The need for footways should also be related to the pedestrian network functional requirements.

The previous section discussed the functional classification of Ugandan roads and their typical characteristics, as well as different classifications of NMT separation treatments. Generally, cross-sections are selected from the standard types reflected in specific, relevant geometric design Manuals in accordance with road classification and status, with a focus on design vehicle lane widths. Once the understanding of elements that form part of the road's cross-sectional structure and the functional requirement of the road and users' needs are established, one can gain an indication of the spatial requirements for NMT facilities.

3.5 Retro-fitting NMT in Built-up Areas

A major challenge in Uganda is that NMT facilities need to be retrofitted into existing road infrastructure or brownfields in addition to new road infrastructure or greenfields. The design principles remain the same, whether for new or existing infrastructure, although it is more likely that retrofitting will provide the minimum acceptable facilities, while new developments are able to work towards the ideal.

However, it is essential that not only infrastructure is retrofitted, but also the entire network design and planning process, involves all the elements of NMT provision. Unless NMT infrastructure networks are sufficiently continuous, and direct, with links and intersections that are safe and acceptable, the intermittent infrastructure is likely to be under-used.

The most successful infrastructure NMT retrofits are traffic calming and other speed reduction methods, as well as NMT facilities associated with BRT infrastructure. However, it is best to incorporate NMT facilities as part of transport planning.

In cities and urban centres where road space is limited, side drains can be covered to better utilise road spaces for provision of NMT facilities. It is also important that drains are covered with durable covers with small gaps to ensure that cyclists can ride over them without getting their wheels trapped.

3.6 Minimum Width Requirements for Footways and Cycle ways

The **Table 3-3** below provides the minimum space requirements to be provided for both pedestrian footways and cycle ways. The accepted minimum is to strictly be provided in cases where there are space constraints and the recommended minimum or optimal design space requirement cannot be met.

Table 3-3: Minimum space requirements for pedestrian and bicycle facilities

Facility	Parameter	Accepted minimum	Recommended minimum	Optimal
Pedestrian footway – total separation	Min width	1.2 m	2.0 m	3.0 m *
Pedestrian footway – kerb/barrier	Min width	1.2 m	2.0 m	3.0 m *
Cycle way – total separation (two way)	Min width	1.5 m ¹ (with adjacent walkway space)	3.0 m	3.0 m *
Cycle way – kerb separation (two way)	Min width	1.5 m ¹ (check sight distances)	3.0 m	4.0 m *
Cycle way – marked separation (one way)	Min width	1.5 m	2.0 m	2.5 m *
Pedestrian footway	Max gradient	01:15	01:20	01:25
	Min corner splay ²	2.0 m	3.0 m	5.0 m
Cycle way	Min radius	3.0 m	5.0 m	5.0 m
Crossfall / Camber	Max gradient 1	Paved 1:50 Gravel 1:25	Paved 1:50 Gravel 1:25	Paved 1:50 Gravel 1:25
Both pedestrian and cyclist facilities	Total separation: Distance from shoulder break point	120 km/h – 5.0 m	120 km/h – 7.0 m	120 km/h – 9 m
		80 km/h – 2.0 m	80 km/h – 3.0 m	80 km/h – 4 m
		60 km/h – 1.0 m	60 km/h – 1.0 m	60 km/h – 2 m
Vertical clearance (pedestrians)	Vertical clearance	2.5 m	2.5 m	3.0 m
Vertical clearance (cyclists)	Vertical clearance	2.5 m	2.5 m	3.0 m
* Subject to capacity requirements.				
¹ Assume some space on adjacent walkway to be used for passing.				

3.6.1 Design Vehicle Space Requirements

Cross-sections and guidance regarding bicycle and pedestrian infrastructure dimensions are based on the design vehicle space requirements provided in **Table 3-4** below.

Table 3-4: Design vehicle space requirements

Design vehicle	Space requirement
Pedestrian	The practical minimum space requirement for an adult standing pedestrian is 0.3 m² although for design of NMT facilities, a minimum of 0.75 m² is recommended. For the safety of people with sight impairments, no objects should protrude into the footway between the height of 0.7–2.1 m by more than 0.1 m (CROW, 2017).
Bicycle	Clear vertical height required by a cyclist is 2.5 m. Under normal riding conditions, a cyclist requires a basic width of 1.5 m for comfortable maneuvering (CROW, 2017).
Wheelchair	The minimum width required by a person using a wheelchair is 0.9 m. A minimum width of 1.5 m is required for a wheelchair to turn and for two wheelchairs moving in opposite directions to pass each other (CROW, 2017).

3.7 Demand-based Pedestrian Footway and Cycle way Sizing

Pedestrians and cyclists demands are only one of the variables in the decision-making regarding the provision of infrastructure. With reference to the full NMT provision lifecycle in chapter 2, and to the regulatory and policy environment in chapter 1, decisions regarding NMT facility provision are based on multiple factors, including national and international climate mitigation imperatives, transport equity principles together with those of universal access, and national and local transport, urban, public health and other relevant policies. Particularly with regards to bicycle travel, international and regional evidence shows that many more people desire to use a bicycle as a mode of travel, as it is quicker than walking and cheaper than motorised transport; however, they often feel unsafe doing so with no provision of proper NMT facilities.

For this reason, estimating the need for facilities based on current usage does not always take into account this latent demand. Thus, master planning, based on extensive stakeholder engagement and understanding of user needs, is a crucial factor in facility sizing, provision and promotion of facilities at operational level.

For greenfield footway and cycleway sites, the recommended minimum width shall prevail as per **Table 3-3**. An additional 0.5m shall be provided for every pedestrian flow increment of 1,200 pedestrians per hour or 150 cyclists per hour.

The MoWT Geometric Design Manual (2010) provides criteria for the provision of footways based on demand as shown in **Table 3-5** below. However, these should be used with caution since in some circumstances, footways can be justified even at lower pedestrian traffic flows.

Table 3-5: Criteria for provision of footways

Location of footway	Average daily vehicle traffic (vpd)	Pedestrian flow per day	
		Speed limit of 60-80 km/h	Speed limit of 80 – 100 km/h
One side only	400 to 1400	300	200
	1400	200	120
Both sides	700 to 1400	1000	600
	1400	600	400

3.8 Footway Level of Service

Assessing the efficiency of a footway/pedestrian flow requires determining its Level of Service (LOS). The LOS of a walkway including platoons of pedestrians moving together in a group, can be assessed based on the pedestrian spacing and pedestrian flowrates.

The basic data to be collected from the field includes pedestrian volumes and pedestrian speed. Pedestrian volumes shall be collected by conducting pedestrian counts. Pedestrian counts can be counted using video cameras as well as manually with the use of tally sheets or tally counters. The counts shall be conducted in 15-minute intervals and the data shall be processed using computer-based spreadsheet modals. It should however be ensured that counts are not conducted when exceptional events that destabilise the normal conditions like riots, holidays occur.

Pedestrian speeds shall be determined by adopting a relationship between the speed of pedestrians and the proportion of the elderly population in a walking population as shown in the **Table 3-6** below (TRB, 2000).

Table 3-6: Pedestrian speeds

Proportion of elderly pedestrians in a population (%)	Recommended speed (m/s)
0-20%	1.2
>20%	1.0

i) Effective walkway width, (W_E)

Effective walkway width is the proportion of the walkway that can effectively be used by pedestrians considering the several types of obstructions. Computation of effective walkway width is as shown in equation 1 below:

$$W_E = W_T - W_0 \quad (01)$$

Where;

W_E	=	Effective walkway width
W_T	=	Total width of the walkway
W_o	=	Total of widths and shy distances from obstructions along the walkway

The **Figure 3-9** below shows the typical obstructions along walkways and the respective width adjustments accruing from these obstacles (TRB, 2000).

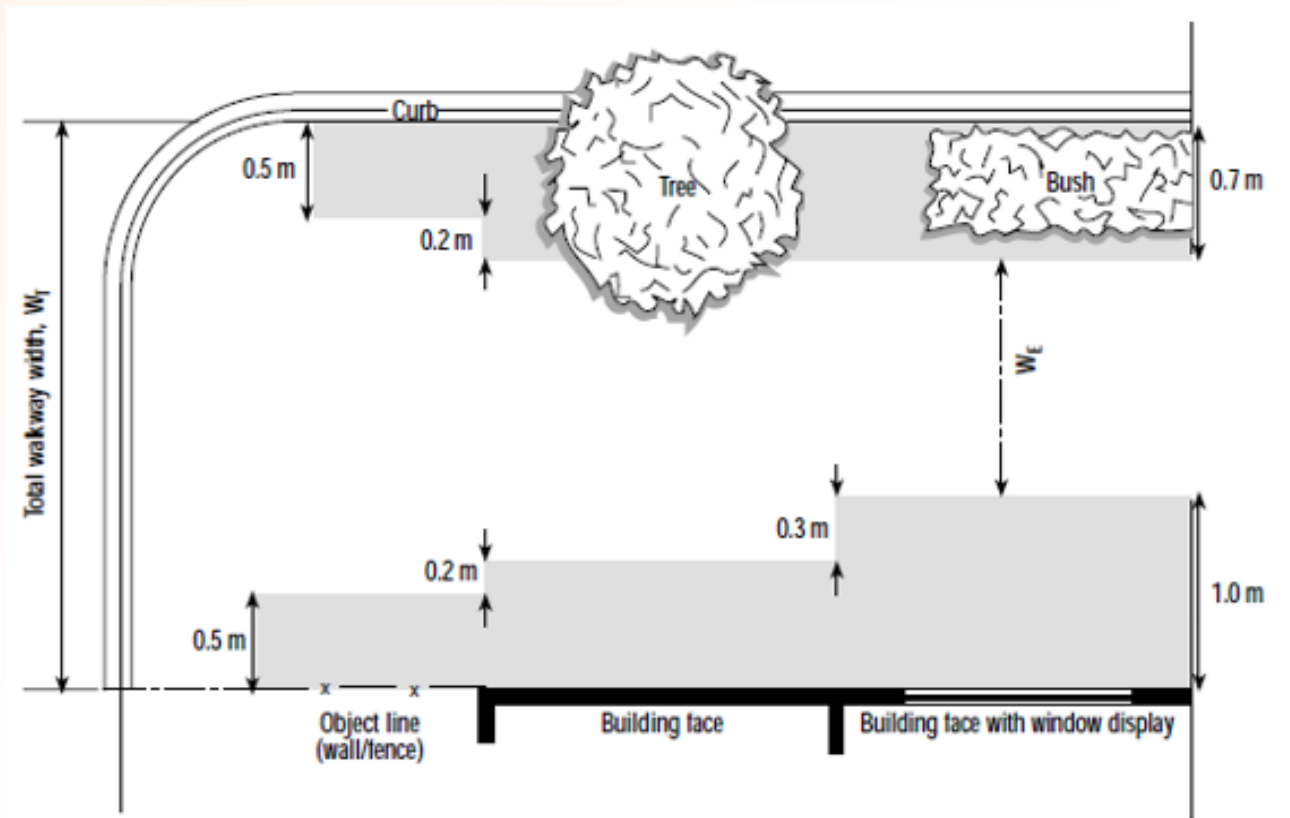


Figure 3-9: Effective width of a footway

ii) Assessing LOS based on pedestrian spacing

The level of service of a footway can be defined in terms of the space available per pedestrian using the footway. The amount of space taken up by a single pedestrian can be measured by dividing the overall area taken up by pedestrians in a given segment by the number of pedestrians in that segment. The assessment of the LOS for a footway should be conducted at selected critical segments along the footway at peak hour periods. The capacity of a walkway can be taken as 0.56 m²/pedestrian (TRB, 2000). The LOS obtained will inform the decision of the designer on the various interventions that can be taken to improve the facility.

iii) Assessing LOS based on pedestrian unit flow rate ()

An alternative approach to determining the LOS of a footway is the pedestrian unit flow rate. Pedestrian unit flow rate refers to the average flow of pedestrians per unit of effective walkway

width. The capacity of a walkway can be assumed and taken as 75p/min/m. Using this approach, the LOS for footways shall be assessed after ascertaining the pedestrian flow rate and average speed at peak hour 15 minutes. (TRB, 2000).

Computation of pedestrian unit flow rate is as per the equation 2 below.

$$V_p = \frac{V_{15}}{15 \times W_E} \quad (02)$$

Where

- V_p = Pedestrian flow rate (p/min/m)
 V_{15} = Peak 15 min flow rate (p/15-min)
 W_E = Effective walkway width (m)

Considering the space available per pedestrian and the pedestrian unit flow rate, **Table 3-7** below shall be used to determine the level of service of a footway.

Table 3-7: Walkway Levels of Service

LOS	Space (m ² /p)		Flow rate (p/min/m)
	Av. pedestrian	Platoons	
A	>5.6	>49.2	<16
B	>3.7-5.6	>8.4 – 49.2	>16-23
C	>2.2-3.7	>3.7 – 8.4	>23-33
D	>1.4-2.2	>2.1 – 3.7	>33-49
E	>0.75-1.4	>1.0 – 2.1	>49-75
F	<= 0.75	<= 1.0	Variable

For queuing areas such as ticketing booths at public transport stations, the available space to pedestrians is an applicable service measure as shown in the **Table 3-8** below (TRB, 2000).

Table 3-8: Levels of Service for queuing and waiting areas

LOS	Space (m ² /p)
A	>1.2
B	>0.9-1.2
C	>0.6-0.9
D	>0.3-0.6
E	>0.2-0.3
F	<0.2

As earlier intimated, knowledge of the desired level of service for a footway can be used to determine the recommendable effective width (W_E) by following the steps below:

Step 1: Select a desired LOS and a corresponding maximum pedestrian flowrate (V_p) as per **Table 3-8** above

Step 2: Estimate the peak pedestrian demand by pedestrian counts, (p/hr)

Step 3: Compute the design pedestrian flow/Peak 15min flow rate (p/15-min), (V_{15})

Step 4: Compute the effective footway width (W_E) using equation 3 below.

$$W_E = \frac{V_{15}}{V_p}$$

3.8.1 Case study

Design Example 1

Determine the required effective footway width (W_E) given a pedestrian peak 15-minute volume rate of 1250p/15min and a pedestrian unit flow rate of 28.7p/min/m.

Solution

$$V_p = \frac{V_{15}}{15 \times W_E}$$

$$28.7 = \frac{1250}{15 \times W_E}$$

$$W_E = 2.9 \text{ m}$$

Design Example 2

What width of the above footway would be required to achieve a Level of service A?

Solution

Considering **Table 3-7** the current level of service for a pedestrian unit flow rate of 28.7p/min/m is C.

To achieve a Level of Service of A, the target pedestrian unit flow rate will be 16p/min/m

Using equation 2;

$$V_p = \frac{V_{15}}{15 \times W_E}$$

$$16 = \frac{1250}{15 \times W_E}$$

$$W_E = 5.2 \text{ m}$$

3.9 LOS for Bicycle Facilities

Bicycle flow principles

For the design of bicycle lanes/roads, the design flow rate is taken as the one for the most heavily trafficked 15 minutes of the peak hour. Bicycle facilities can be designed as:

- i) Exclusive/separated off street bicycle roads;
- ii) Shared off street facilities (bicycles and pedestrians); and
- iii) On-street bicycle lanes along the road or street.

3.9.1 Exclusive/Separated Off-street Bicycle Roads

Provide a width of 3m (AASHTO) however in low volume conditions, a width of 2.4m is also applicable. The bicycle flow rate(v) is a function of the number of opposing (F_m) and passing (F_p) events expressed using the equations 11,12,13 and 14 below, where an event refers to the number of times a cyclist is involved in a meeting or passing manoeuvre.

$$v = \frac{F}{1 - 0.812p} \quad (04)$$

Where:

V refers to the total bicycle flow rate for both directions (bicycles/hr)

P is the proportion of the total flow travelling in the subject direction

F refers to the total number of events on a path (events/hr)

The total number of events on a path can be given by the equation below.

$$F = 0.5F_m + F_p \quad (05)$$

Where;

F_m = number of opposing events (events/hr)

F_p = number of passing events (events/hr)

The Equations below can be used to find F_p and F_m

$$F_p = 0.188V_s \quad (06)$$

$$F_m = 2V_o \quad (07)$$

Where;

V_s = flow rate of bicycles in the subject direction (bicycles/hr)

V_o = flow rate of bicycles in the opposing direction (bicycles/hr)

The LOS for exclusive facilities can be found using **Table 3-9** below

3.9.2 Shared Off-street Facilities (Bicycles and Pedestrians)

In these facilities, pedestrians have a detrimental effect to bicycle capacity and level of service because of their substantially lower speeds. The equations below are used to calculate the total events for a shared facility. The assumption underlying the equations 15, 16 and 17 below is that bicycle speeds are normally distributed with a mean of 18km/hr and pedestrian speeds are normally distributed with a mean of 4.5km/hr

$$F_p = 3V_{ps} + 0.188V_{bs} \quad (08)$$

$$F_m = 5V_{po} + 2V_{bo} \quad (09)$$

$$F = 0.5F_m + F_p \quad (10)$$

Where

F = the total number of events on a path (events/hr)

F_p = number of passing events (events/hr)

F_m = number of opposing events (events/hr)

V_{ps} = flow rate of pedestrians in the subject direction(p/hr)

V_{bs} = flow rate of bicycles in the subject direction (bicycles/hr)

V_{po} = flow rate of pedestrians in opposing direction (p/hr)

V_{bo} = flow rate of bicycles in opposing direction (bicycles/hr)

3.9.3 On-street Bicycle Lanes

A multitude of factors affect the LOS on street facilities and they include the adjacent moving vehicle traffic that is moving much faster than the bicycles. The LOS for an on-street bicycle facility is determined by quantifying the impact of prevailing geometric and traffic conditions on the average and standard deviation of bicycle speeds of the facility. The number of events for on- street bicycle lanes can be calculated using the equation below.

$$F = \frac{2 \times V_b \times SD}{V_{av} \times \sqrt{\pi}} \quad (11)$$

Where

V_b = Bicycle flow rate

SD = Standard deviation of bicycle speeds

V_{av} = Mean bicycle speed

In situations where standard deviation data is unavailable, the following standard deviation values can be adopted (Transportation Research Board, 2000).

- 1.5km/hr for facilities mainly used by commuters
- 3.0km/hr for facilities used by various user types
- 4.5km/hr for facilities used primarily for recreational purposes

The Level of Service criteria for all the above bicycle facilities can be obtained from the **Table 3-9** below (Transportation Research Board, 2000).

Table 3-9: Level of Service Criteria for exclusive and Shared Bicycle Facilities

LOS	Frequency of events (<i>F</i>)	
	2.4m wide shared facilities	3.0m wide shared facilities.
A	<40	<90
B	>40-60	>90-140
C	>60-100	>140-210
D	>100-150	>210-300
E	>150-195	>300-375
F	>195	>375

3.9.4 Computation Examples

Example 1

A 2.4 m wide bicycle road with two effective lanes is observed to have peak hour factor of 0.6, peak hour volume of 90 bicycles/h and directional split of 70/30 (Northbound/Southbound). Determine the level of service of the facility at peak hour.

Solution

Directional flows

$$V_b = \frac{\text{Peak hr volume}}{\text{Peak hour factor}} \times \text{Directional split}\%$$

$$V_b = \frac{90}{0.6} \times 0.3 = 45 \text{ bicycles/hr (SB)}$$

$$V_b = \frac{90}{0.6} \times 0.7 = 105 \text{ bicycles/hr (NB)}$$

Determine the passing and opposing events in both the Northbound and Southbound direction

$$Fp = 0.188Vs$$

$$Fp = 0.188 \times 105 = 20 \text{ events/hr (NB)}$$

$$Fp = 0.188 \times 45 = 9 \text{ events/hr (SB)}$$

Determine the total number of events for both the Northbound and Southbound direction.

$$\text{from } F_m = 2V_o \text{ and } F = 0.5F_m + Fp$$

$$F = (0.5 \times 2 \times 45) + 20 = 65 \text{ events/hr (NB)}$$

$$F = (0.5 \times 2 \times 105) + 9 = 114 \text{ events/hr (SB)}$$

Using Table 3-9 to determine level of service;

LOS C for the Northbound direction

LOS D for the Southbound direction

Example 2

An east-west pedestrian-bicycle shared facility is 3m wide. The peak flow rate of bicycles is 150 bicycles/h and the peak flow rate of pedestrians is 80p/h. Directional split of bicycles is 60/40(EB/WB) and the Directional split of pedestrians is 50/50 (EB/WB). Determine the Level of Service of the Facility at the peak hour.

Solution

Determine the directional flows

Direction	Pedestrian flow rate	Bicycle flow rate
Eastbound	$0.5 \times 80 = 40p/hr$	$0.6 \times 150 = 90 \text{ bicycles/hr}$
West bound	$0.5 \times 80 = 40p/hr$	$0.4 \times 150 = 60 \text{ bicycles/hr}$

Determine number of passing events (Fp)

$$Fp = 3Vps + 0.188Vbs$$

Direction	Number of passing events (Fp)
Eastbound	$Fp = 3(40) + 0.188(90) = 137 \text{ Events/hr}$
Westbound	$Fp = 3(40) + 0.188(60) = 131 \text{ Events/hr}$

Determine number of opposing events (F_m)

$$F_m = 5V_{po} + 2V_{bo}$$

Direction	Number of opposing events (F_m)
Eastbound	$F_m = 5(40) + 2(60) = 320$ events/hr
Westbound	$F_m = 5(40) + 2(90) = 380$ events/hr

Determine the total number of events

$$F = 0.5F_m + F_p$$

Direction	Total number of events (F)
Eastbound	$F = 0.5(320) + 137 = 297$ events/hr
Westbound	$F = 0.5(380) + 131 = 321$ events/hr

Determine the level of service using **Table 3-9**

Direction	Level of Service
Eastbound	LOS D
Westbound	LOS E

Street Furniture & Zoning

4 STREET FURNITURE AND ZONING

Street furniture are the fixtures on streets such as seating and benches, streetlight posts, street signs, waste-bins and other fittings. Street furniture can also include bicycle parking racks, shade trees and planters, and other items that create public spaces on the streets.

Street furniture should create aesthetically interesting environment for pedestrians and encourages greater use of the street as a public space. At the same time, however, pedestrian sidewalks and shared bicycle and pedestrian spaces all depend on what is referred to as effective widths. In other words, a 2.0 m wide sidewalk that is crowded with sign-poles, waste bins and drainage grates might at times have an effective width as small as 0.5 m.

A useful way to design and plan for effective widths is through a zoning system with furniture-buffer zones, frontage zones, and pedestrian and cycling zones.

4.1 Zoning Principles

In a residential or commercial street, ensure that the pedestrian zone provides continuous space for walking. This zone is to be clear of any obstructions, differences in level, or other obstacles to movement, and have an effective or clear width of at least 2.0 m. Street furniture should never obstruct pedestrians and cyclists but be placed in a 'buffer' or furniture zone.

A furniture zone, placed between pedestrians and vehicles, provides space for landscaping, road furniture, lighting, bus stops and shelters, signs and other utility poles, hydrants, and access ramps or driveways. These furniture zones are supposed to have a minimum width of 0.6 m, although 1.2 – 1.5 m is preferred, where there is a sufficient road reserve, and 1.5 m when there are tree-plantings.

Landscaping and street furniture must never obstruct visibility for pedestrians and drivers at crossings and intersections. Attention must be paid to sight-lines, as children are smaller than adults and have different viewpoints.

Bicycle parking and bus shelters should be placed in the furniture zone.

Open drainage channels can serve as buffer zones, as long as there are ways to cross the channels where and when required.

Buffer zones may be designated for vendors and markets, as long as traders do not encroach upon the footways, and that requisite safety standards are met.

The frontage zone can vary from a minimum width of 0.5 m along a compound wall to 1.0 m or more in commercial zones.

The pedestrian zone provides continuous clear space for walking. The clear width must be at least 2.0 m in order to accommodate two wheelchair users at the same time and must be entirely free of any obstructions. The **Figure 4-1** below shows a typical layout of a street zone (ITDP, 2018).



Figure 4-1: A typical layout of a street zone.

A buffer zone is usually the name given to the furniture zone on non-residential roads. A buffer zone can include landscaping, signage and signaling poles, and other necessary road furniture. Buffer or furniture zones can protect pedestrians from vehicles, as well as from water splashes and vehicle noise. The **Table 4-1** below provides buffer zone dimensions per road functional class (NZTA, 2009).

Table 4-1: Buffer zone suggestions per functional classification of roads

Road functional class	Description	Buffer width (where total separation is not provided)
A	International trunk roads	N/A
B	National trunk roads	1.2 – 1.8 m
C	Primary roads	1.2 – 1.8 m
D	Secondary roads	0.6 – 1.2 m
E	Minor	0.6 – 1.2 m

The **Table 4-2** below shows typical street furniture elements and their recommended locations and frequency (NZTA, 2009).

Table 4-2: Typical street furniture elements and recommended dimensions

Furniture	Dimensions		Location and frequency
	Footprint	Height	
Bench	2.4 m by 0.75 m	0.4 m to 1.0 m	At least 0.5 m from the edge of a footway Every 50 m in commonly used pedestrian areas At bus stops and shelters
Bollard	0.3 m diameter	0.6 m to 1.2 m	As required but not more than 1.4 m apart 0.3 m from the kerb
Bus stop shelter	2.6 m by 1.4 m	2.5 m	As required by bus services
Bicycle locker	2.0 m by 1.9 m	2.1 m	At transport interchanges and stops
Bicycle rack	0.75 m by 50 mm	0.75 m	At transport interchanges and stops
Drinking fountain	0.3 m diameter	0.6 m	As required
Rubbish bin	0.8 m diameter	1.3 m	Areas where litter may be generated e.g. at bus stops and restaurants
Parking meter/pay point	0.3 m by 0.15 m	1.5 m	As required by street parking
Planter	Varies	Varies	As required
Lighting pole	0.6 m by 0.6 m	Varies	As required to provide the suitable illuminance
Public transport sign	65 mm diameter pole	2.1 m	As required by public transport providers
Parking sign	65 mm diameter pole	1.5 m	As required by street parking

Furniture	Dimensions		Location and frequency
	Footprint	Height	
Street name sign	65 mm diameter pole	2.1 m	As required
Street tree		5.0 m tall	Varies, but foliage should be above the pedestrian eyeline
Utility vault	Varies	Flush	As required by utility companies

4.2 Landscaping

Creating aesthetically pleasant cycling and walking experience is key to the planning, designing, and promoting NMT and infrastructure. Open and public spaces in urban areas may include smaller plazas that provide social gathering spaces, landscaped open spaces in high-density residential and commercial areas, beautification areas such as landscaped street islands, medians, public art and fountains, and CBD spaces that are usually used for events.

4.2.1 Pedestrian Spaces

Landscaping can be planned along NMT infrastructure and surrounding terrain in order to maintain user visual guidance and visibility, but at the same time care needs to be taken not to encroach on the effective width of the sidewalk or cycle way.

Generally, NMT infrastructure landscape elements should:

- Complement the existing landscape and built neighborhood;
- Not be jarring;
- Give the road users pleasant views with breaks in between the clumps to provide road users with views of the surrounding landscapes;
- Not be so repetitive so as to become monotonous;
- Be harmonious with the existing landscape, and at the same time provide adequate variety and contrast;
- Ensure that in case of fencing, the fenced sections should not be monotonous for longer stretches;
- Selectively cut trees in order to create views; and
- Be in context with the surroundings/cultural environment.

When placing seats in the furniture zone or public space, pay attention to orientation of the sun and prevailing wind directions. Create shades with canopies or trees. Ensure that the seats are with backrests and arm rests, and have different heights to cater for a number of different ages, abilities, and other diversities.

Integrate footways and cycle ways with landforms by following contours and slopes which are the least damaging to the landscape. Minimise the volume of earthworks required to construct the both footways and cycle ways and avoid large cuttings and embankments where possible.

Accommodate landscaping along roads within the medians.

4.2.2 Plantings

Tree planting along NMT facilities not only provides shade and but also improves the aesthetics, cools the air and contributes to a natural and more sustainable storm water management.

Stormwater runoff is detained by trees, shrubs or flowers planted in flow-planters, pervious pavements and bioswales. This helps to reduce storm water flows and pollutants in the water, consequently reducing the burden on the drainage and wastewater systems. Detaining the flows mitigates the peak flow rates from rainfall events hence reducing soil erosion, loss of nutrients, and scouring.

When selecting tree species, consideration should be made of the following:

- Choose form, maturity sizes, colour and texture that reflect the urban or rural design goals of a street;
- Pay attention to the requirements for irrigation, and local / endemic species;
- Consider the mature tree canopy may affect luminance of street lighting, clear view of signage by pedestrians, pedestrians' safety and comfort. Generally, trees with columnar form are appropriate for narrower planting spaces such as small streets and narrow medians, whereas trees with overarching canopies and medium density foliage are appropriate on wider streets and open public spaces. Medium sized trees with light to medium density foliage are appropriate on access roads or residential streets;
- The potential for root systems to affect sidewalks, curbs and utilities;
- Avoid trees that tend to easily succumb to winds or drop heavy leaves like certain types of palm trees or branches; and
- In cases where meaningful plant material exists on a site prior to its development, such landscape material may be used if approved by the planning authority or the local authority.

Table 4-3: Recommended tree placement and tree guard dimensions

Type of tree	Location on street	Size of tree guard (m)
Columnar, Conical	Shoulder	0.6*0.6
Columnar, Conical, Vase Shaped	Multiple use zone (MUZ)	0.6*0.6
Columnar, Conical, Vase Shaped, Broad Upright	Parking / shoulder / MUZ	0.6*0.6
Broad Upright, Broad Oval	Parking / shoulder / MUZ	0.75*0.75
Broad Upright, Broad Oval, Broad Spreading	Parking / shoulder / MUZ	(0.75*0.75) – (2*2)

Tree planting in rural areas could be done along the alignment of the foot/cycle way to provide shade and a wind buffer.

Plantations or tree species adopted for landscaping should do well with the climate and have an attractive inflorescence. The maximum height of plantings should be limited to 0.5 – 1.0 m to allow for visibility and at the same time provide social security (Iganga Foundation, 2014).

These may include palm trees to offer an exotic look to NMT facilities, demarcate boulevards and act as extra decoration for the open green lawns; seasonal shrubs for perimeter barriers and traffic medians; and large shade trees. Perforated pavers can also be used in off-street parking areas to minimise the build-up of heat in extensive parking areas and surface run-off.

Bridges and Underpasses

5 BRIDGES AND UNDERPASSES

5.1 NMT-only Footbridges and Underpasses

A good road network design will either eliminate the need for footbridges and underpasses, or design and site them effectively so that they become part of the desired mobility and access routes of pedestrians and cyclists. Whereas footbridges and underpasses, which are quite costly interventions might intuitively seem like an effective way of separating NMT users from vehicles, they are seldom popular with people walking and cycling. They are usually inconvenient, require detours (taking up extra time and distance), and exertion (stairs or ramps), and are sometimes a risk to personal safety.

Pedestrian and cyclist crossings are safest at ground level, and in situations where motorised vehicles are the ones to change grade instead.

5.1.1 When to Implement a Footbridge

Footbridges might be the right option under the following exceptional circumstances:

- On high order roads (International and national trunk roads);
- Where a high number of pedestrian and cyclist crashes have occurred;
- Where they can be placed right in front of their origin and destination point – the access should be at the most 200 –300 m from pedestrian concentration (such as at public transport interchanges);
- Where there are clear sightlines at every point on the bridge or underpass – users must be able to see the exit from the entrance;
- Where there is a need to allow pedestrian movement with limited interruption to vehicular traffic;
- Where there is a need for children to cross high volume roads; and
- Situations where the at-grade pedestrian facilities are inadequate when assessed against existing demand.

The level of usage of existing pedestrian bridges and underpasses is hampered by social, gender and security challenges that the guidelines presented aim to solve. It should be ensured that pedestrian bridges and underpasses are designed and sited effectively so that they become part of the desired mobility and access routes of pedestrians and cyclists.

5.1.2 Footbridge Design Considerations

Once the decision has been made to provide a footbridge, pay attention to the following:

- Aesthetics do matter. Lighter colours for construction materials and treatments are more appealing than dark colours.
- Provide barriers or fences on both sides of the crossing point.
- The design should limit the amount of deflection under a live load, to reduce feelings of movement (Vibrations) on the bridge.
- Include adequate ramps for pedestrians, wheelchairs, tricycles, cyclists and handcarts. A minimum width of 3.5 m will help avoid conflicts between different types of users.
- Ramps should not have a grade larger than 8%, ideally 5% with landings for every 6 m. Stairs of any sort are not advisable since they are not universally accessible.
- Consider providing seating, and resting places, on ramps.
- Always ensure adequate lighting in and around footbridges and underpasses.
- Safety barriers of either metal, reinforced/prestressed concrete (cast in situ or precast depending on design loading limitations), or polycrystalline-type material are required along the structure to contain pedestrian and cycle or vehicle traffic. Steel railings, however, shall only be used in situations where vandalism or theft of the railings is envisaged to be highly unlikely. Safety barriers shall also be designed in line with the guidelines specified in Section 12.3 and 12.5 of the MoWT Geometric Design Manual (2010), unless this Manual recommends guidelines that improve on these.
- Well-designed underpasses can be more economical and safer than footbridges. A footbridge, for example, could be elevated between 6.0 m and 7.0 m above the road, which would suggest a considerable gain in height, at 1:20 gradient if Universal Access is provided for. An underpass on the other hand would require around 3 m below the road surface, with gentler approach slopes, providing considerable cost savings.
- Underpasses should be as short as possible and with as much daylight as possible. Ensure that there are good sightlines into and through the structures.
- Ensure there is adequate path width, horizontal clearances to objects, and vertical clearance (2.5 m minimum).

Table 5-1 below provides the minimum dimensions for NMT bridges and subways (SANDoT, 2003)

Table 5-1: Minimum dimensions for NMT bridges and subways

Facility	Width (m)	Height (m)
Pedestrian bridges	2.0	5.2
Pedestrian subways		
Length: 14 m or less	2.1	2.5
Length: 14 m to 24 m	2.4	2.5
Length: more than 24 m	3.0	3.0
Shared pedestrian/bicycle subways		
Pedestrian footway	2.0	2.5
Cycle way	3.0	2.5
Total	5.0	

5.2 Footways on Vehicle Bridges

Consider the following in the design:

- Extend footways across any street or road bridge.
- The minimum width of a footway on a bridge should be 2.0 m, but where possible, extend the width of the existing sidewalk across the bridge. Vertically separate footways on bridge decks by means of a kerb barrier of between 150 – 200 mm high or other separation elements.
- Provide barriers to direct pedestrians onto the bridge access point.
- Protect the edges of the sidewalk at the bridge access/exit point with a guardrail.
- Design ramp approaches to encourage pedestrian usage by following established routes and provide a gradient no more than 1:20. Where appropriate, these approaches may be provided with steps along the steeper slopes near the ends of the bridge to encourage usage of the bridge.
- Use signage at the entry/exit points to indicate that cyclists are required to dismount and walk their bicycles along the footway. Entrances must be designed to ensure that motorcycles or other motorised traffic cannot gain access.
- If NMT users are to cross a river using a highway bridge a footway can be suspended below the cantilever portion of the bridge should designers determine that there is sufficient free-board under flooding conditions (SANDoT, 2014).
- Sections 12.3 and 12.5 of the Uganda Geometric Design Manual (2010) specifies additional specifications for footways and bridges. The **Figure 5-1** below shows a cross-section of a segregated footway on a bridge as taken from the MoWT Geometric Design Manual (2010).

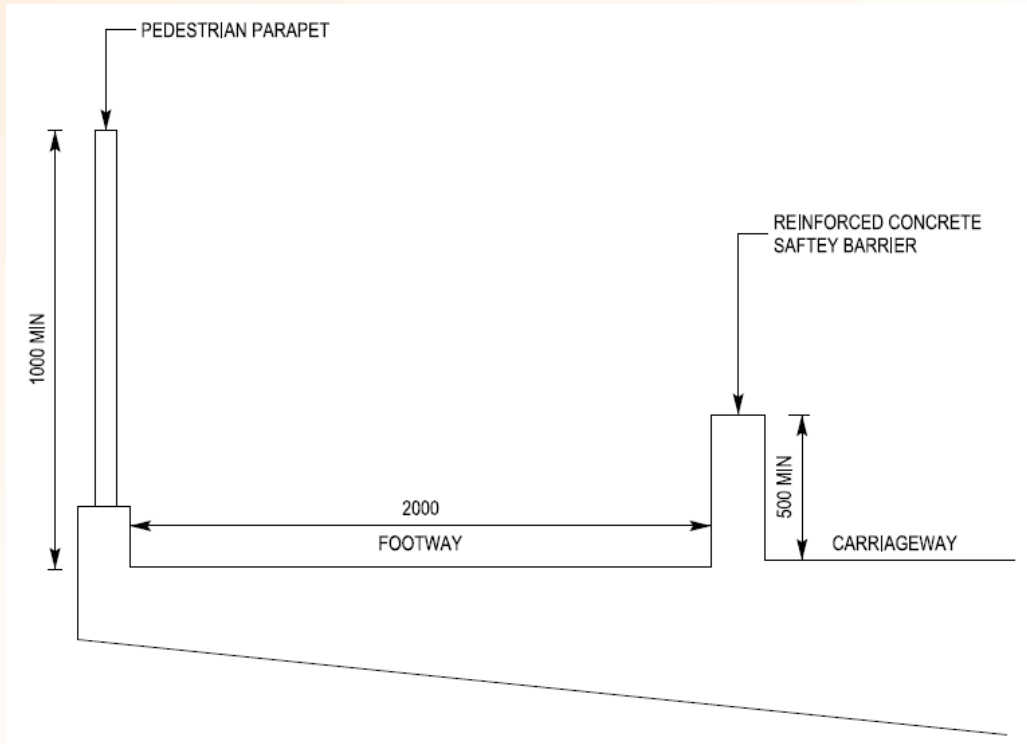


Figure 5-1: Cross-section showing a segregated footway on a bridge

5.3 Separate Footbridges Adjacent to Rural Roads or Crossing Drainage/Culverts

Such structures should follow the same design guidelines stated above, but with a minimum width of 2 m and a minimum handrail height of 1.0 m. If the bridge is used by cyclists, then the handrail should be at least 1.4 m.

Consider the following in the design:

- Ensure that approaches to the bridge are the same width as the bridge, and level with the sidewalk.
- Display danger signage on the roadway for vehicular traffic on both approaches to the bridge.

5.4 Handrails

Handrails of at least 1.0 m in height must be provided on steps or ramps of footbridges and underpasses. Cyclists require a handrail of at least 1.4 m height. The balustrades on the bridges should be higher to deter children and adults from climbing over them.

Handrails shall be designed to be vandal-proof and durable and in compliance with the relevant design loading standards of Uganda. Vandalism includes acts of deliberately dropping objects onto vehicles passing under footbridges. Where such acts are likely to occur or have been known to occur, enclose the footbridge with a cage over its full length. Examples of cages and fencing are provided in **Figure 5-2**.



Figure 5-2: Examples of typical fencing and barriers used over bridges

5.5 Stairways

Stairs include two elements; treads and risers. Their dimensions are measured in relation to a human step.

Consider the following in the design:

- A comfortable stair will follow the following rule: $(\text{riser} \times 2) + (\text{tread}) = \text{between } 610\text{--}640 \text{ mm}$, though for unprotected outdoor stairways, the riser should generally be between 150–160 mm.
- Steps should neither be steep, nor give the appearance of being steep.
- A minimum width of 1,200 mm will allow two people to cross in opposite directions, while 1,800 mm is the minimum for three people.
- A landing of 1,200 mm ought to be present between every 1,200–1,500 mm rise, or nine steps. Stairways require handrails at two heights to facilitate the climb for children and for people with lower mobility.
- Handrails should be continuous with an uninterrupted gripping surface, maintaining an open space of 40 mm between the handrail and the wall or the nearest surface.
- Incorporate a storm water drainage system into the design of pedestrian stairways to facilitate drainage during the rainy season. When they are built of a durable material, these can help stabilise the soil. Prefabricated modules that incorporate drainage and sewage are feasible and effective.

Intersection Treatment and Pedestrian Crossings

6 INTERSECTION TREATMENT AND PEDESTRIAN CROSSINGS

6.1 Principles for Siting and Designing Pedestrian Crossings

- When considering pedestrian crossings, a key factor is to determine the degree to which route continuity from footway to footway across each of the intersecting road legs can be maintained or achieved.
- Varying verge widths and the location of footways within the verge space will impact pedestrian route continuity and the role of kerb radii in accommodating pedestrian route continuity.
- The siting of pedestrian crossings needs to exhibit a balance between following pedestrian desire lines and positioning near midblock or other road intersections. In other words, it may be that pedestrian desire lines are too close to other road intersections, and drivers do not have enough time to react to the presence of pedestrians (in some instances this challenge may require discussion with land-owners to move access points to safer positions further from intersections).

As an integral part of the pedestrian network, crossings should meet the same minimum standards, especially in terms of:

- Maximum permissible crossfall;
- Adequate overhead clearances and protrusions;
- The surface standard that is stable, firm, and slip-resistant; and
- Minimum crossing distance.

Pedestrian crossings should be at right angles to the direction of travel of the road and, where possible, the crossing should be located along the pedestrian desire line. Any road furniture that may obscure visibility should be located away from the crossing, and vegetation near a crossing should be trimmed to a level that doesn't affect pedestrian visibility.

Roadside parking at or near a crossing should be prohibited to at least 15 m on either side of the crossing unless features such as buildouts are incorporated.

Some pedestrian crossings are raised to the same level as that of the footpath, while others require pedestrians to change grade. In both cases, it is important to ensure that all types of pedestrians can make the transition between the footpath and the crossing safely and easily.

Where possible pedestrian crossings should be sited where traffic volumes and speeds are lowest. **Figure 6-1** and **Figure 6-2** show illustrations of the effect of radii limits on pedestrian desire lines and sight distances (SANDoT, 2014). It is recommended to increase the radii at intersections to improve the sightlines for pedestrians.

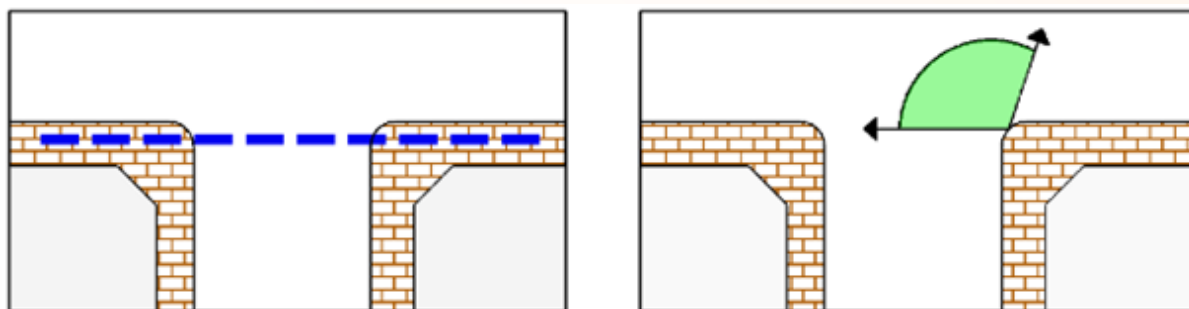


Figure 6-1: Illustration of how tight radii limit desire lines and sight distances

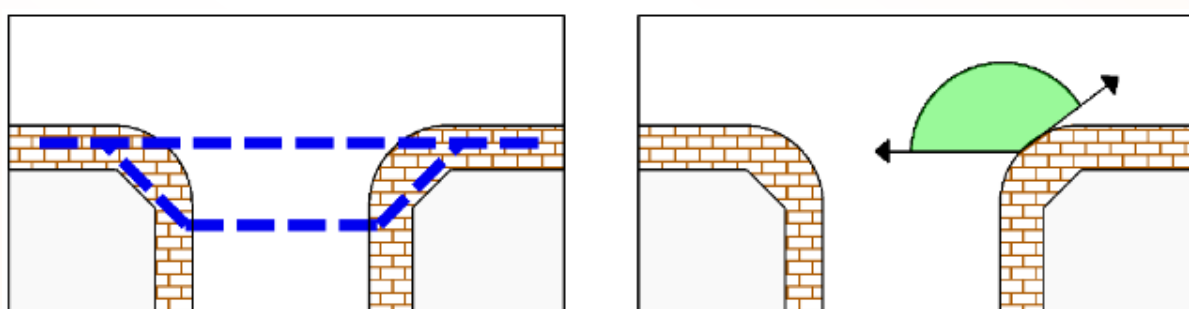


Figure 6-2: Illustration of how large radii increase desire lines and sight distances

6.1.1 When Selecting an Appropriate Crossing Facility consider

- What the road environment and land-use context is.
- What the appropriate physical aids to crossing are.
- Whether the control of the crossing point is appropriate.
- How the facility can be designed to fit the environment.

When deciding on the appropriate facility, consider the hierarchy of solutions below:

- Reduce traffic volumes on the roadway;
- Reduce traffic speed on the roadway;
- Reallocate space in the road corridor to pedestrians;

- Provide at-grade crossings;
- Improve pedestrian routes on existing desire lines; and
- Provide new pedestrian routes and grade separation.

Reducing traffic and speed has the highest priority, as it not only benefits pedestrians but can also improve road safety, air quality, and noise, thus enhancing the environment for others in the area.

6.1.2 Crossing Sight Distance

Pedestrians need to identify and choose gaps in the traffic stream to cross safely, and therefore they must be able to see oncoming traffic in good time. The crossing sight distance is a critical element in ensuring that pedestrians safely cross the road. Crossing site distance is determined using the equation below (NZTA, 2009):

$$\begin{aligned} &\text{Crossing sight distance (m)} \\ &= \frac{\text{Crossing distance (m)}}{\text{Walking speed (m/s)}} \times \frac{85\text{th percentile vehicle speeds (km/hr)}}{3.6} \end{aligned}$$

The above equation should be used to calculate sight distance taking into account the following;

- The pedestrian line of sight may be blocked by permanent or temporary obstructions;
- Walking speed can vary owing to factors such as pedestrian ages, and physical condition, route gradients, pedestrian densities and environmental conditions;
- Some pedestrians may take additional time to start crossing because of mobility or visual impairments, uncertainty or double-checking that it is safe; and
- The signed speed limit in the area should not be used as an indication of actual vehicle speeds. Actual speeds are usually faster than posted limits.

6.1.3 Approach Sight Distance for Drivers

Drivers should be able to see all crossings easily so they can adjust their speed and be aware of the potential for pedestrians to step into the roadway. In that case, an appropriate approach sight distance needs to be provided. **Table 6-1** indicates the recommended approach sight distances for rural and urban roads considering a driver's reaction time of 2 seconds in rural and 1.5 seconds in urban (NZTA, 2009).

Table 6-1: Recommended vehicle approach sight distances

Vehicle approach speed (km/h)	Approach sight distance (m)	
	Rural	Urban
10	6	5
20	14	11
30	23	19
40	35	30
50	45	40
60	65	55
70	85	70
80	105	95

Intersections are significant conflict points, not only between vehicles but between vehicles, pedestrians and cyclists. Thus, in planning and designing road intersections, the needs of all users must be taken into account; motorised vehicles should not have greater priority than people using NMT modes.

6.1.4 Variables when Choosing an Intersection Treatment

Pedestrians and cyclists need to be accommodated across intersections while maintaining a continuous effective footway, and bicycle momentum. This can present challenges that require the following to be considered:

- Road classification;
- Separation treatments;
- Dropped kerb treatment;
- The number of lanes to be crossed (crossing distance);
- Traffic volume;
- Vehicle speed management;
- The volume of pedestrian and potential cyclist traffic;
- Pedestrian age and life-cycle profile (elderly, pregnant women, pedestrians with children)
- Public transport and boda-boda (motorcycle taxi) routing; and
- Vehicle turning radii.

In general, pedestrian/cyclist and vehicle conflict can be reduced at intersections by reducing turning radii, simplifying vehicle turning movements, avoiding slip lanes, and limiting free left or right-hand turns.

If slip lanes cannot be avoided, reduce the turning radius for vehicles, and reduce the distance that pedestrians have to cross.

While elevated crossings flush with the footway, they are also able to improve pedestrian safety significantly and this can also make it easier for vehicles to cut corners, therefore, kerbs, barriers, and other separation treatments may be necessary.

'Right-sizing' pedestrian crossing distances includes intersection corner treatments and refuge islands.

The **Figure 6-3** below Typical four-legged intersection showing potential conflict points for both vehicles and pedestrians. The number of observed conflicts for vehicle and pedestrians respectively is shown below (SANDoT, 2014).

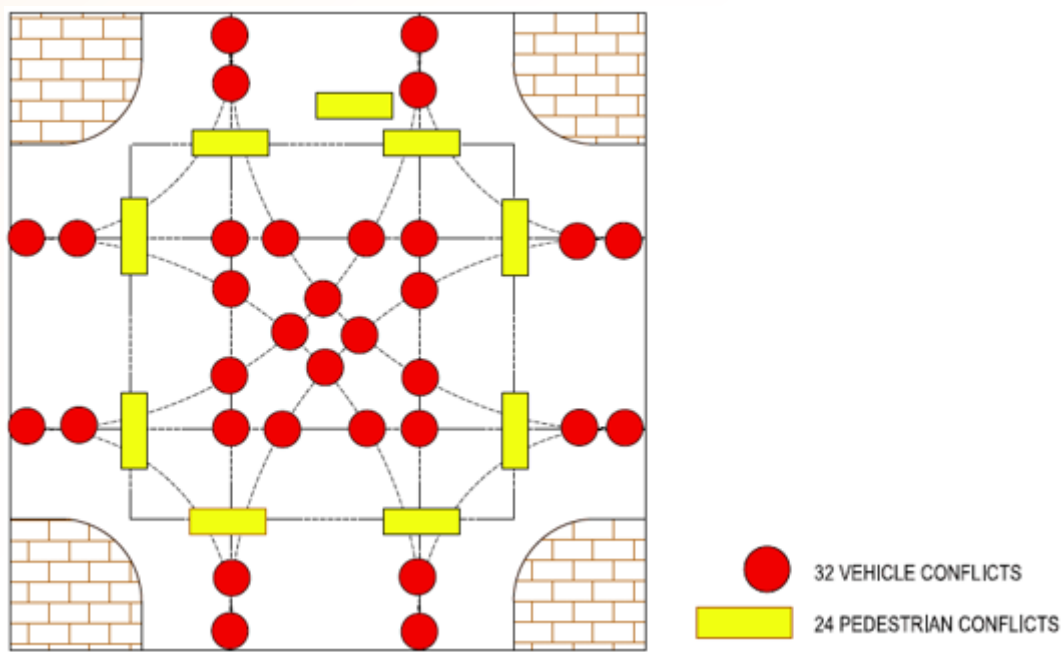


Figure 6-3: Illustration of conflict points at a four-legged intersection

6.2 Pedestrian Crossings

Pedestrian crossings can be provided at two main locations:

- At mid-block locations (between road junctions);
- At road junctions.

Pedestrian crossing facilities fall under three major categories i.e. physical aids, priority/time separated, and partially separated as shown in the **Table 6-2** (NZTA, 2009).

Table 6-2: Categories of pedestrian crossings

Pedestrian crossing category	Objective	Treatment example
Physical aids	To simplify decisions for drivers and pedestrians by shortening the crossing distance or dividing the crossing movement into two for easier crossing	Kerb extensions Pedestrian refuge islands Splitter islands Medians
Priority/time separated	To give pedestrians priority, or to allot pedestrian-only periods for use of an on-road section, alternating with periods for vehicles.	Zebra crossings Mid-block signalised crossings Signalised intersection crossings School patrol
Spatially separated	To eliminate conflict by putting pedestrians and vehicles in physically different areas.	Pedestrian underpasses (seldom recommended) Pedestrian overpasses (seldom recommended)

6.3 Crossings at Intersections

Where intersections have more than two lanes, have a separate NMT signal phase.

Separation distances between pedestrian crossings and other elements of the road network (such as road intersections, midblock crossings, and on-street transport stops and interchanges), should be considered given the number of pedestrians and vehicular traffic during peak periods.

Table 6-3 below provides guidance on treatment options for the implementation of pedestrian crossings on paved roads where pedestrian crossing volumes exceed 50 pedestrian/h adapted from SADC RTSM Vol 1, 1997 (SADC, RTSM, 1997).

Table 6-3: Pedestrian warrants for the installation of crossings on paved roads

Class	Description	Road design class	Road width (m)	Maximum operating speed (km/h)	Vehicle volumes per hour	Pedestrian volumes per hour	Treatment options
A	International trunk roads	Ia	20.8–24.0	120			Very high risk and not suited to road hierarchy. Grade separated crossing preferred
		Ib	11	110			
		II	10	90			
		III	8.6	80			
B	National trunk roads	Ib	11	110			Very high risk. Consider grade separated crossing
		II	10	90			
		III	8.6	80	> 650	> 387	Signalised pedestrian crossing
						> 50	Uncontrolled pedestrian crossing
C	Primary roads	II	10	90			Too high risk. Consider grade separated crossing
		III	8.6	80	> 650	> 387	Signalised pedestrian crossing
						> 50	Uncontrolled pedestrian crossing
		II	10	90			Too high risk. Consider grade separated crossing
D	Secondary roads	III	8.6	80	> 650	> 387	Signalised pedestrian crossing
						> 50	Uncontrolled pedestrian crossing
		II	8.6	80	> 650	> 387	Signalised pedestrian crossing
						> 50	Uncontrolled pedestrian crossing
E	Minor	III	6.4	60	> 700	> 387	Signalised pedestrian crossing
						> 50	Uncontrolled pedestrian crossing
		II	8.6	80	> 650	> 387	Signalised pedestrian crossing
						> 50	Uncontrolled pedestrian crossing

i) Controlled or Signalised Intersections

Consider the following in controlled or signalised intersection design:

- Use a design walking speed of 1.2 m/s for calculating the pedestrian or cyclist clearance time under normal operating conditions.
- A slower speed of 1.0 m/s may be used for elderly, young or disabled pedestrians.
- The pedestrian or cyclist must be able to clear the roadway by the time the parallel vehicular inter-green ends (end of the all red interval).

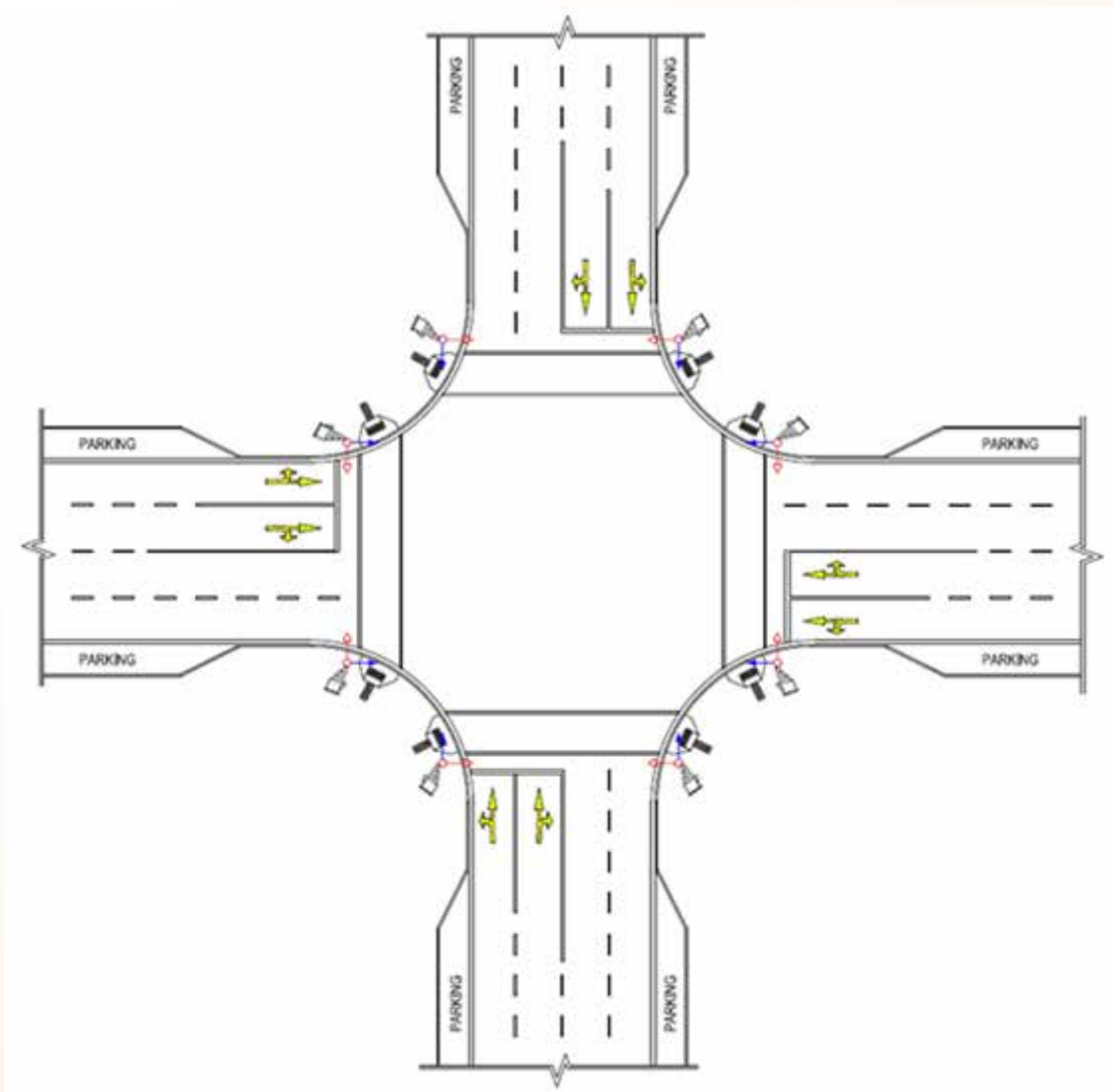


Figure 6-4: Pedestrian facilities for controlled intersections

ii) Uncontrolled Intersection

The same principles apply (in terms of crossing position, kerbs, etc.) at an uncontrolled intersection, except that signage, road markings, lighting, vertical markers and traffic calming placed before the crossing should be used to indicate to drivers that they are approaching a pedestrian crossing at an uncontrolled intersection.

It is essential that at such an intersection, corner radii are kept to a minimum, to reduce the speed of the cars. Dropped kerb and tactile paving are to be installed differently at uncontrolled intersections. The tail of the tactile paving, using linear pavers, must be placed in the corner that coincides with the direction of oncoming motorised transport.

6.4 Signalised Intersections

Signalised intersections with a pedestrian and cyclist phase may give the semblance of improved safety, but phasing does not always give pedestrians adequate time in which to cross.

The requirements of pedestrians are paramount when timing signals. A leading pedestrian signaling phase is also able to reduce pedestrian exposure to risk, whereby a pedestrian-only phase starts a few seconds before the vehicle phase and enables pedestrians to cross halfway (and be clearly visible) before vehicle movement is permitted (SARTSM, 2012).

It is often the case that the pedestrian clearance interval determines the length of the vehicular green period. In this case, there is little that can be done to alleviate the problem by adjusting signal timings, so investigate other measures, for example, the provision of pedestrian phases only on-demand using pushbuttons, construction of central refuges, and/or grade separation (SARTSM, 2012).

Pedestrian signals at junctions have the advantage that safety is improved by restricting the pedestrian movement to a period during a signal cycle and can be considered when exclusive vehicular left- or right-turn phases are provided that conflict with pedestrian movements.

Pedestrian movements across slipways at junctions may be signalised when warranted by pedestrian queues or delays, or when pedestrians require additional protection due to special conditions such as high vehicle speeds, poor sight distance, and pedestrian disabilities.

6.5 Roundabouts and Roundabout Crossings

Roundabouts can reduce conflicts for pedestrians but are particularly challenging for cyclists (in such a situation it is usually better to permit cyclists to share the road with vehicular traffic, unless traffic circles are of high-speed) (SANDoT, 2014).

i) Principles of roundabout design

- Control vehicle speeds;
- Reduce the amount of vehicle space;
- Raise driver awareness; and
- Provide unobstructed passage for cyclists.

For improved pedestrian and cyclist safety, ensure a tight entry radius to reduce speed to between 30 and 40 km/h. Single-lane roundabouts are generally safer for cyclists than intersections, though, particularly when these roundabouts have high central islands and/or separate cycleways.

Splitter islands on all approaches to roundabouts improve pedestrian and cyclist protection, as does setting the pedestrian crossing at least one vehicle length back from the yield line to reduce conflict.

Roundabouts with two or more circulatory lanes can present significant safety and inconvenience challenges for both cyclists and pedestrians. Large Inscribed Circle Diameter (ICD) and wide and multi-lane circulatory carriageway lead to higher circulating vehicle speeds and hazardous weaving movements. **Figure 6-5** below shows a typical roundabout intersection showing potential conflict points for both vehicles and pedestrians (SANDoT, 2014). The number of observed conflicts points for vehicles and pedestrians respectively is also shown. **Figure 6-6** shows the different conflict points at a roundabout, roadway, and on shared paths depicting both NMT and vehicle exposure (Stanek, 2017). The blue line depicts the NMT exposure, while the green lines depict the vehicle exposure.

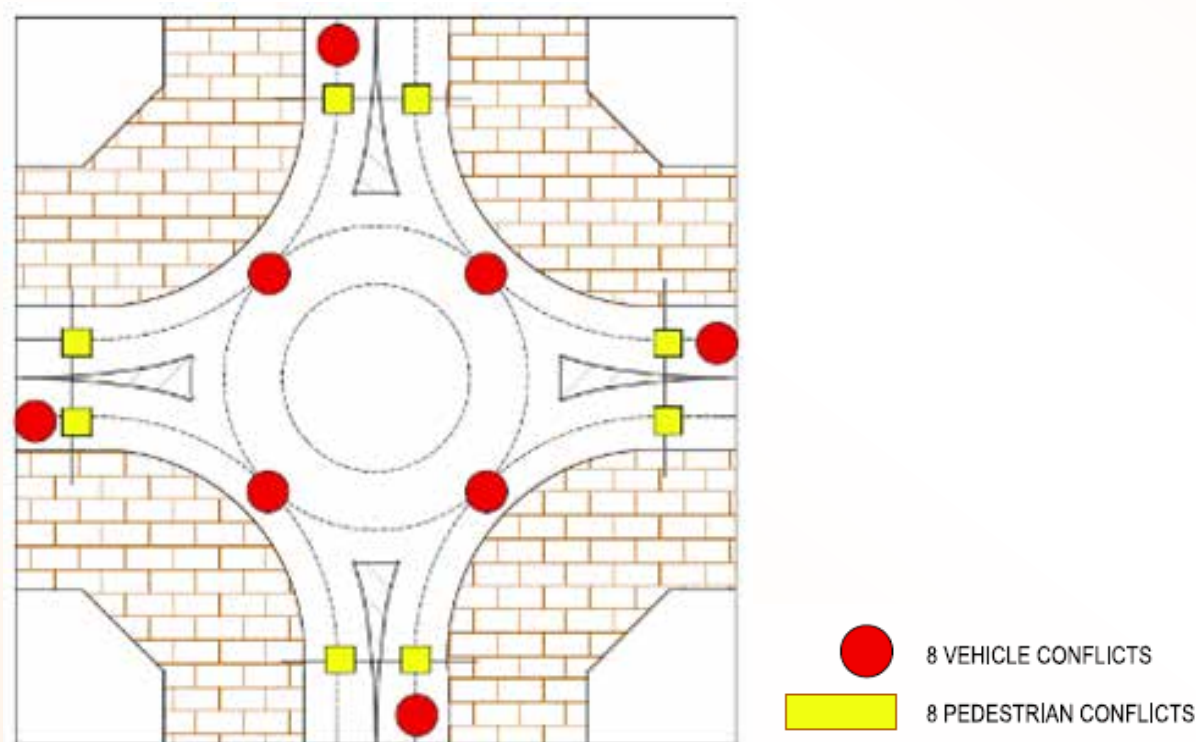


Figure 6-5: Illustration of conflict points at a roundabout

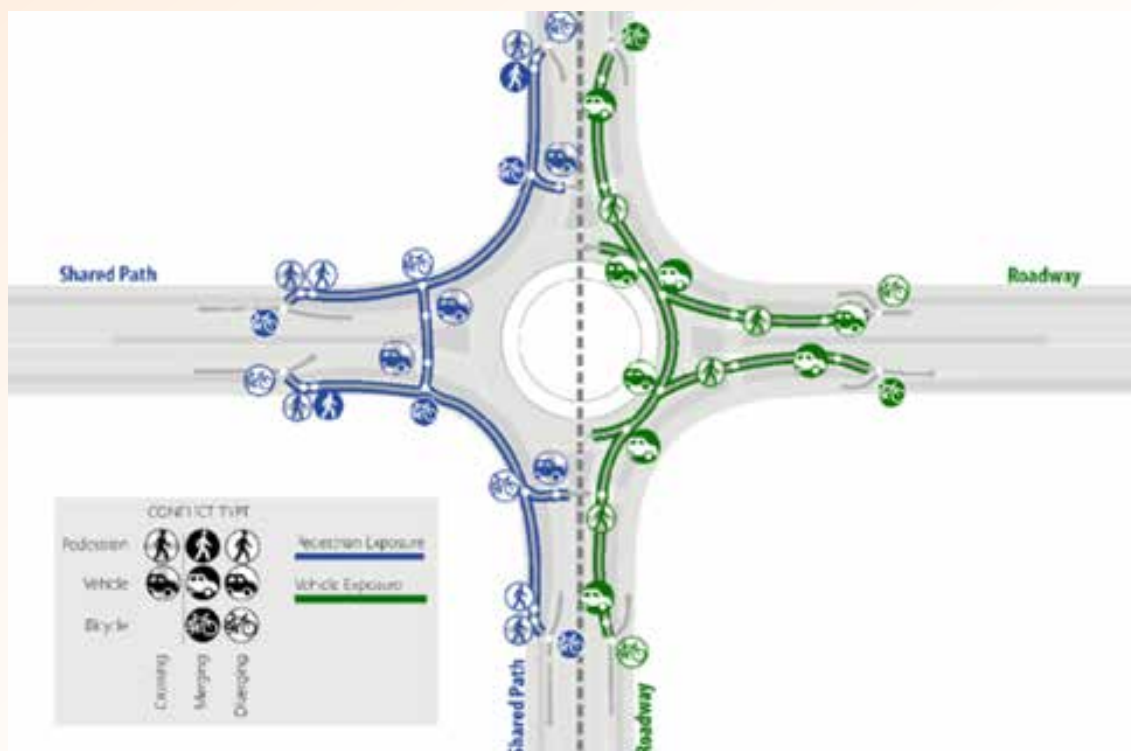


Figure 6-6: Illustration of conflict points at a roundabout, roadway, and on shared paths

ii) Visibility between Pedestrians and Drivers at Roundabouts

Pedestrians must be able to see and be seen by approaching traffic, therefore visibility should not be obscured or restricted by parked vehicles, trees, street furniture, or any other obstruction. If it is not possible to site the crossing elsewhere, consideration must be given to:

- Removing or re-siting the obstacle; and
- Building out the kerb-line where the carriageway is sufficiently wide to provide enhanced sightlines between pedestrians and drivers.

For controlled roundabouts, the controller should not be in a position that obstructs the inter-visibility between pedestrians, wheelchair users, children, and approaching vehicles.

If visibility is restricted by parked/loading vehicles, it may be necessary to make a Traffic Regulation Order or impose the maximum waiting and loading restrictions in the appropriate crossing regulations.

Additional signal heads may be employed at a signal-controlled crossing where this will improve driver awareness

Table 6-4 below shows the minimum visibility requirements at roundabouts based on the 85th percentile approach speed (Scottish DOT).

Table 6-4: Minimum visibility requirements for roundabouts

85 Percentile approach speed (km/h)	40	48	56	64	72	80
Desirable minimum visibility (m)	50	65	80	100	125	150
Absolute minimum visibility (m)	40	50	65	80	95	115

iii) Planning for Cyclists at Roundabouts

In general, there are two ways of dealing satisfactorily with cyclists at roundabouts:

- Use of mini or compact roundabouts, where traffic volumes are relatively low and speeds are slow, and widths are narrow (5-7 m) such that cyclists can safely share with single file traffic, in a primary position. The inscribed circle diameter of a mini roundabout should not exceed 15 m;
- Where traffic volumes are higher (exceed 10,000 vpd) and at larger roundabouts, provide a separate cycle track around the outside of the junction, preferably with cycle priority or signaled crossings of the entries and exits (Sustrans, 2014).

Roundabout crosswalks away from the flared entries of the roundabout are preferable, as the carriageway widths are shorter. They should be set back from the yield line by one or more car lengths but conveniently close to the roundabout to minimise out-of-direction travel for pedestrians. The crosswalk should be located so that approaching drivers have time to see a crossing pedestrian, react and apply brakes, and stop their vehicles before reaching the crosswalk. This distance, which is a function of speed, is referred to as stopping sight distance. Stopping sight distances on level ground for wet pavement conditions are provided in the Table 6.19 of the MoWT Geometric Design Manual (2010).

Positive signage and way finding to the crosswalk is also critical, regardless of location. The curvilinear nature of roundabouts makes it substantially more difficult for a pedestrian with vision disabilities to locate the appropriate crossing location and to maintain the correct heading through the crosswalk.

Positive channelisation also assists pedestrians without vision disabilities by encouraging them to cross at the appropriate crossing location and discouraging them from crossing at inappropriate locations.

6.6 Roundabout Crosswalks for People with Visual Impairments

The general principles for inclusive design solutions at roundabout crossings include;

- Use landscaping, fences, or other features that restrict the ability of pedestrians to cross at locations other than crosswalks, or at least make it very clear where crossing is not intended. Provide direction to the crosswalk location.

- Orient curb ramps so that the running slope is in the same direction as the crosswalk and the edges of landscaping are aligned in the direction of travel on the crosswalk.
- Align the far side of the crosswalk and any channelisation and splitter islands with the nearside ramp. Design to compensate for the expected error in the crossing angle.
- In urban areas, where large numbers of pedestrians are present, it may be necessary to provide guard rails or other means of deterring pedestrians from indiscriminate crossing of the carriageway.
- Crosswalks at roundabouts can be aligned in two different ways: i.e. entry and exit crosswalks equidistant from circulatory roadway (straight alignment or angled alignment) and with the exit crosswalk further from the roundabout (staggered crosswalk alignment)

The illustrations in **Figure 6-7** show typical layouts of pedestrian crossings at roundabouts (NCHRP, 2010).

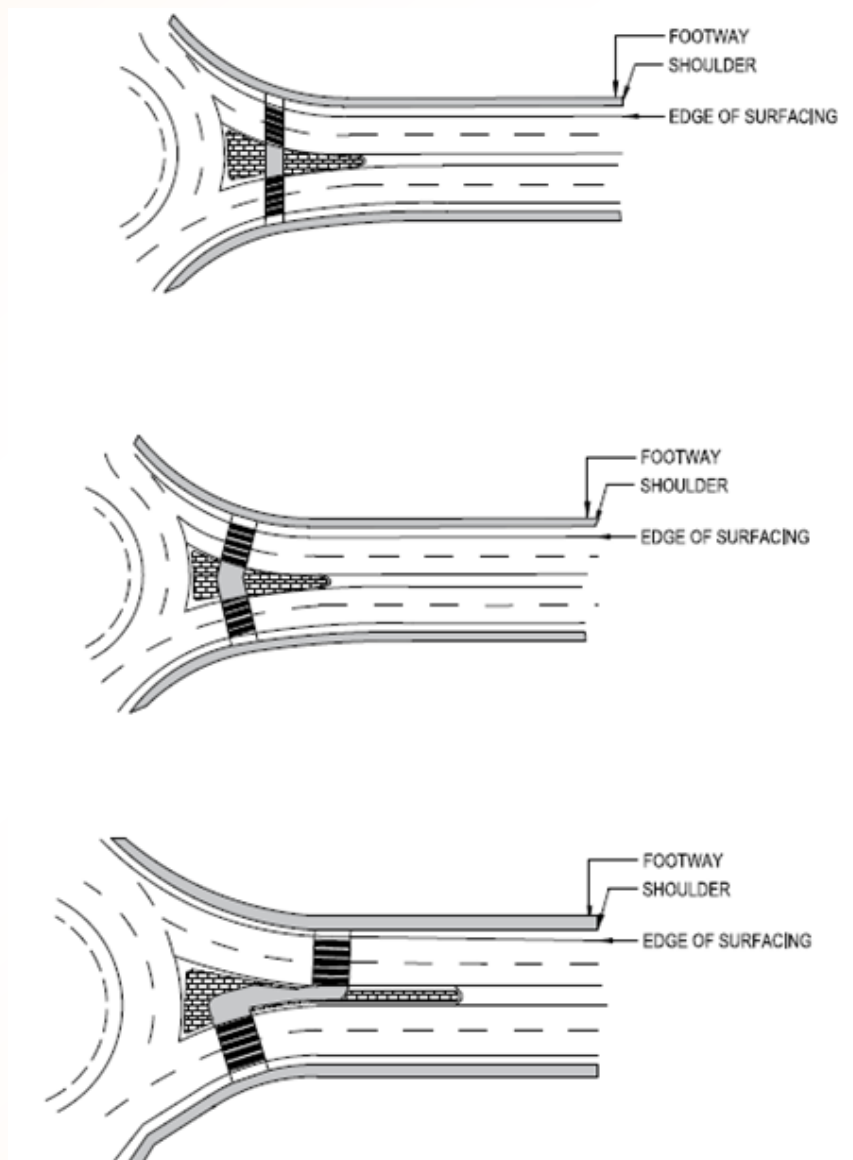


Figure 6-7: Illustration of typical layouts of pedestrian crossings at roundabouts

6.7 Mid-block Crossings

Mid-block crossings are implemented on roads with high volumes or high speeds of motorised traffic. Where necessary, a midblock island and dropped kerbs will be required; it is also possible to reduce crossing distance using kerb extensions or neckdowns but be sure that these do not encroach upon any at-grade (marked) cycleways.

Formal mid-block pedestrian crossings should be provided at regular intervals (i.e., at least every 200 m) to ensure that pedestrians have a safe place to cross. To ensure safety, formal crossings should either be signalised or constructed as tabletop crossings with ramps for vehicles (ITDP, 2013). Mid-block crossings may be across one or many traffic lanes, and controlled, uncontrolled, or staggered.

The need for a mid-block crossing is further informed by a number of additional circumstances, all of which should be subject to the appropriate level of traffic engineering analysis. These include:

- Pedestrian desire lines and volumes;
- Where road junctions are relatively far apart;
- Where a road divides a large integrated community;
- Adjacent to community centers, homes for the aged, infirm or visually impaired;
- Adjacent to major public transport interchanges;
- In, and, adjacent to shopping centers;
- Outside school entrances; and
- In industrial areas.

There are typically two options for achieving the necessary transition from the footway to the road level:

- A typical dropped kerb ramp, at 90 degrees to the direction of travel on the footway, assuming sufficient verge width is available to accommodate the dropped kerb and landing area; and
- Dropping of the entire section/ width of the footway.

The minimum width (between the two rows of studs) for a Zebra, Pelican or Puffin pedestrian crossing is 2.4 m. If the crossing is of the Toucan type, or is used by a substantial number of cyclists on foot, the minimum width should ideally be 4.0 m. However, 3.0 m, is also acceptable, depending on the situation.

Always remember that:

- The highest level of exposure to crashes occurs at crossings; and
- Crossings must be able to be used by people with disabilities.

Typical layout of the dropped kerb treatment is shown in the **Figure 6-8** below.

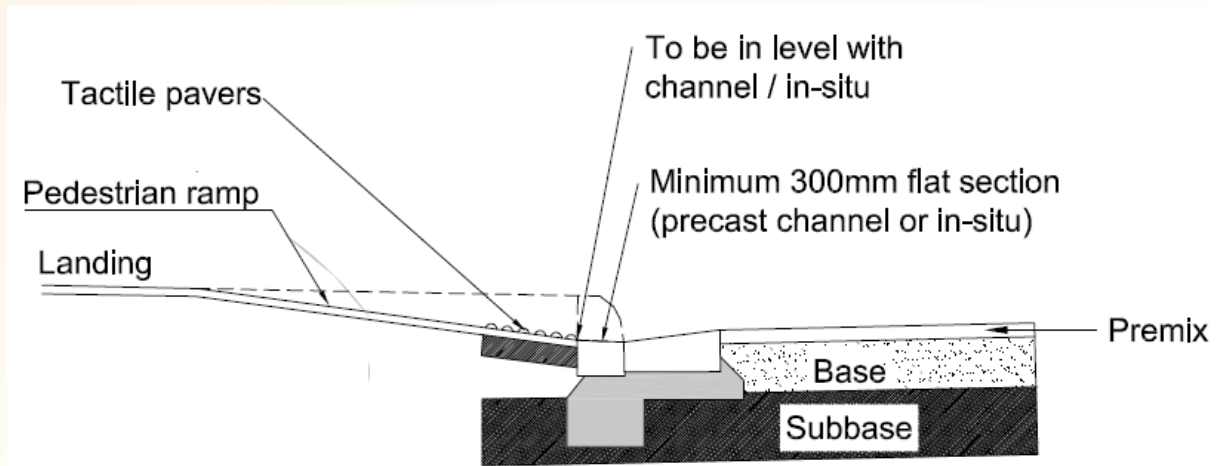


Figure 6-8: Dropped kerb treatment

Linear paving is positioned in such a way that people with visual impairments can locate the push button location. Audible signals can assist people even further, providing specific sounds for the various traffic controller colours. The buffer strip must not protrude from the road surface (SANDoT, 2014).

In the case of a kerb-drop arrangement, the verge requirement is determined by a 1:15 ramp slope to negotiate the kerb height (usually 150 mm) and the provision of a landing area at the top of the ramp that is a minimum of 1 500 mm wide.

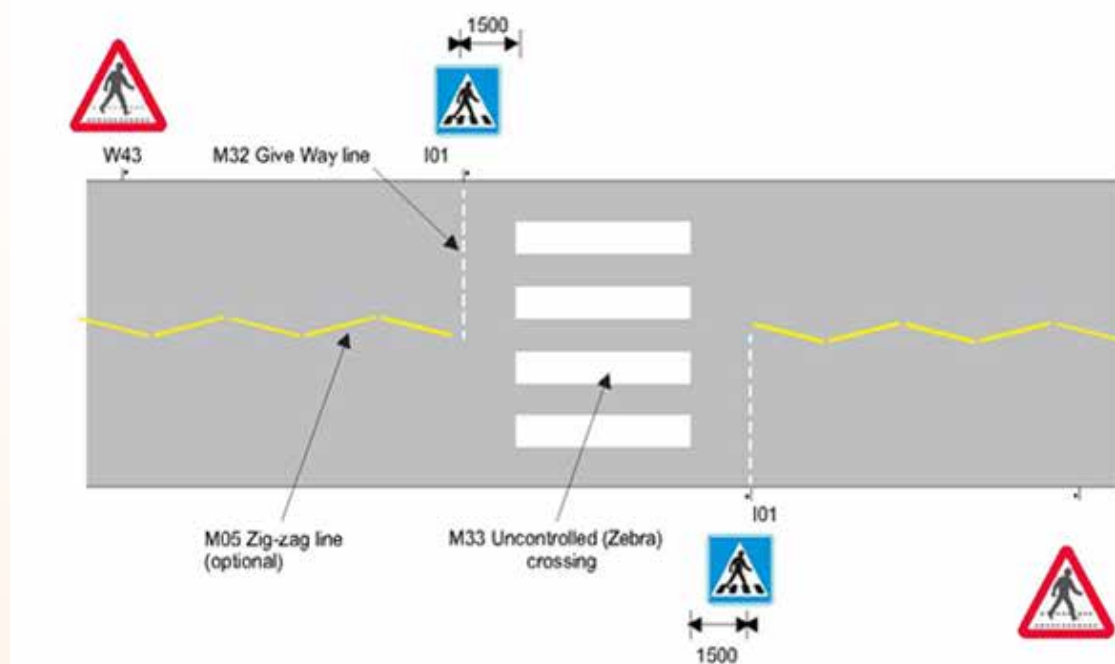
In both cases, the preferred ramp gradient is 1:15 (6.6%), although a maximum gradient of 1:12 (8.3%) can be used if there are uncontrollable space constraints. A cross-fall of 1:50 or 2%, is required to be provided to facilitate drainage.

Pedestrian crossings should be located at positions where they would attract the maximum number of pedestrians who would otherwise cross the road at various positions. Crossings should be located on the desire-lines that would serve the majority of pedestrians. Midblock crossings should, however, not be located so near other road elements like junctions so that drivers have sufficient time to react to the presence of pedestrians. The **Table 6-5** gives the minimum safe separation distances between mid-block crossings and other road elements (SANDoT, 2003).

Table 6-5: Minimum safe separation distances between mid-block crossings and other road elements

Operating speed (km/h)	Separation distance
20	15
30	20
40	30
50	35
60	45
70	50
80	55

In addition to the separation distance, sufficient sight distance should be provided to allow a vehicle to safely come to a stop in case of a hazard. At yield-controlled crossings the sight distance should be such a safe gap acceptance is accorded to the pedestrians. For signal-controlled crossings, the sufficient decision sight distance for the drivers is guided by the Geometric Design Manual (2010). A schematic of a mid-block pedestrian crossing is given in **Figure 6-9** below.

**Figure 6-9: Mid-block pedestrian crossing**

The **Table 6-6** makes recommendations for installing pedestrian crossings at mid-block locations based on vehicle speed, vehicle volume, and street type. On a two-lane street with low volumes and speeds, a marked crosswalk will suffice. As speeds, volumes and/or road widths increase, additional measures and/or signals are needed.

Table 6-6: Recommendations for installing pedestrian crossings at mid-block locations

Street family	Vehicles ADT < 9000			Vehicles ADT >9 000 to 12 000			Vehicles ADT > 12 000 to 15 000			Vehicles ADT >15 000		
	Speed limit (km/h)											
	≤30	40	60	≤30	40	60	≤ 30	40	60		≤ 30	60
Street	√	√	N/A	√	√	N/A	√	√	N/A	√		N/A
Avenue	√	√	+	√	+	⏏	+	+	⏏	⏏	⏏	⏏
Boulevard	⏏	⏏	⏏	⏏	⏏	⏏	⏏	⏏	⏏	⏏	⏏	⏏
√ Acceptable to use marked uncontrolled												
+ Crossing												
⏏ Consider traffic calming, signal or other. Do not use marked crosswalk without signal and consider additional traffic calming measures												

Where mid-block crossings are un-signalised, signage, road markings (e.g. yield signs), lighting, vertical markers and traffic calming need to be placed before the crossing should be used to indicate to drivers that they are approaching an uncontrolled pedestrian crossing.

The critical criteria to determine which option is to be used is that of verge width.

In the case of a kerb-drop arrangement, the verge requirement is determined by a 1:15 ramp slope to negotiate the kerb height (usually 150 mm) and the provision of a landing area at the top of the ramp that is a minimum of 1 500 mm wide.

In both cases, the preferred ramp gradient is 1:15 (6.6%), although a maximum gradient of 1:12 (8.3%) can be used if there are uncontrollable space constraints. A cross-fall of 1:50 or 2%, is required to be provided to facilitate drainage.

6.7.1 Controlled or Signalised Mid-block Crossings

Principles of controlled mid-block crossings

Consider the following for NMT design at controlled or signalised intersections:

- Use a design walking speed of 1.2 m/s for calculating the pedestrian or cyclist clearance time under normal operating conditions;
- A slower speed of 1.0 m/s may be used for elderly, young, or disabled pedestrians;
- The signals must be positioned in a way that they can be clearly seen by pedestrians; vertical clearances from the carriageway shall not be less than 2.1 m and more than 2.6 m;
- The pedestrian or cyclist must be able to clear the roadway by the time the parallel vehicular

inter-green ends (end of the all-red interval);

- Drivers must have a clear view of at least one signal head-on approaching, and when stationary at, the stop line. Where the view of the vehicular signals is reduced by the vertical or horizontal alignment of the road or other situations such as masking of signals in heavy traffic conditions or by overhanging trees, the conspicuity should be enhanced. This can be done, for example, by the provision of additional secondary heads, tall posts, building out kerb-lines if the carriageway width is sufficient or installing signals over the carriageway;
- To assist blind and partially sighted pedestrians, as they approach the crossing, the primary push button/indicator panel should normally be located on the right-hand side. The alignment should encourage them to face oncoming vehicles. The centre of the push button should be between 1.0 and 1.1 m above the footway level; and
- The push-button unit should be close enough to the tactile surface to allow all pedestrians, who could reasonably be expected to use the crossing, to reach it easily. A typical push button assembly is given in the **Figure 6-10** below.

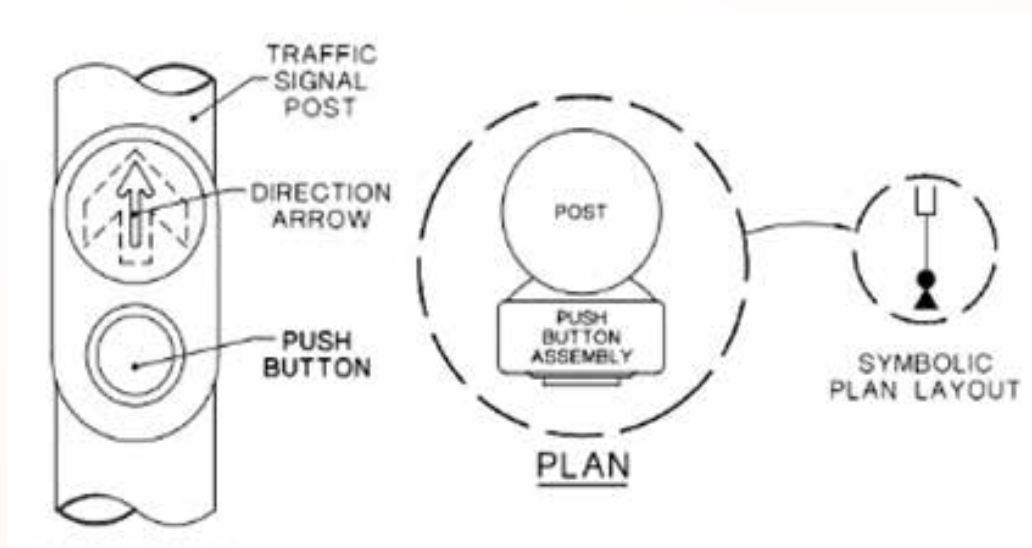


Figure 6-10: Pedestrian facilities for controlled intersections

A staggered crossing layout is relatively inconvenient and does not follow pedestrian desire lines and should only be implemented where there is a substantial safety risk to NMT users.

Figure 6-11 shows a typical layout of a staggered midblock crossing (SANDoT, 2014).

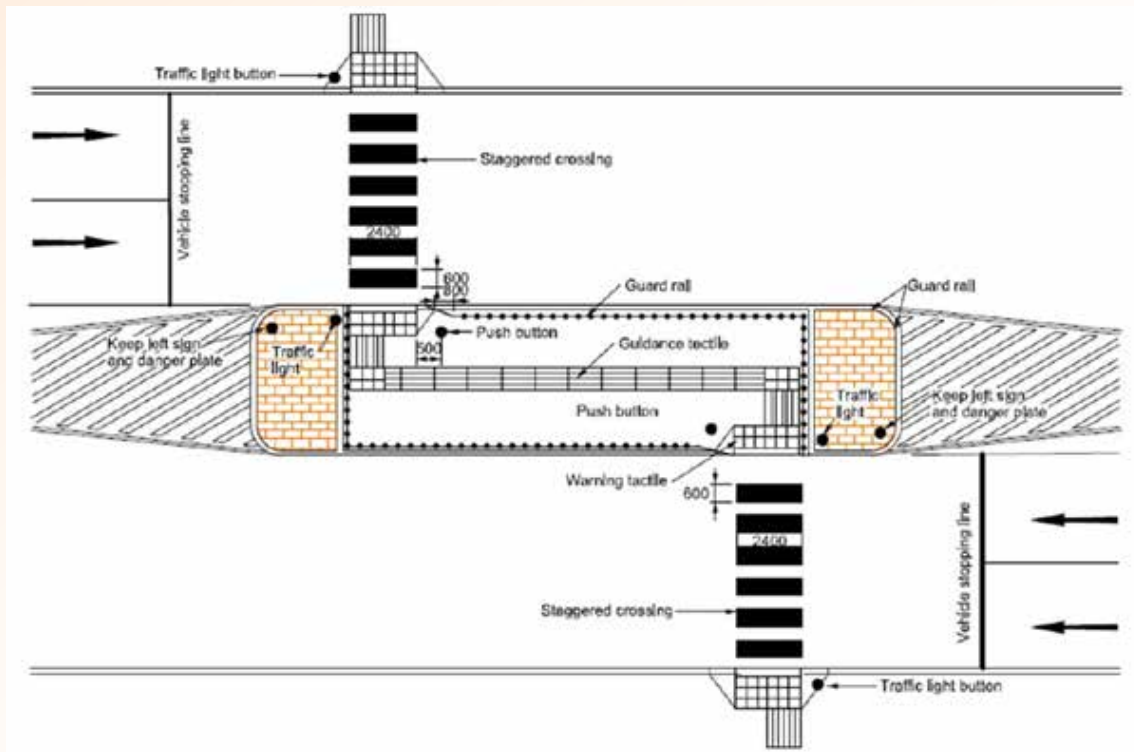


Figure 6-11: Illustration of a typical staggered signalised mid-block crossing

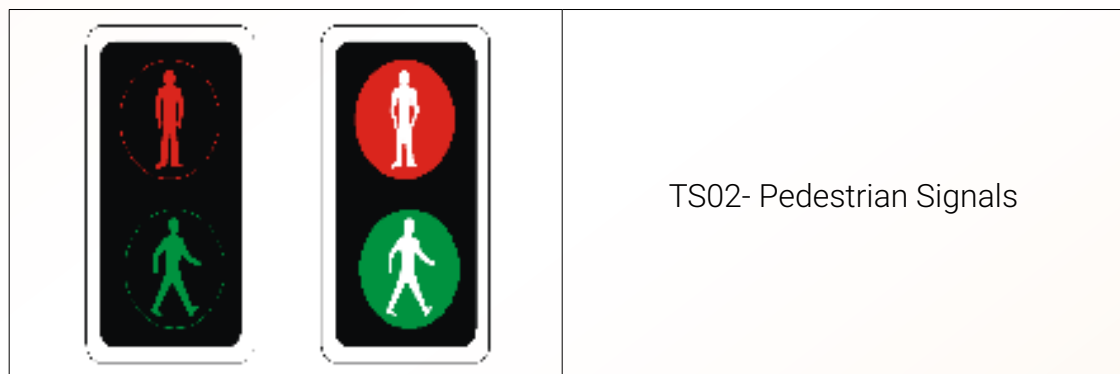


Figure 6-12: Pedestrian signal sign

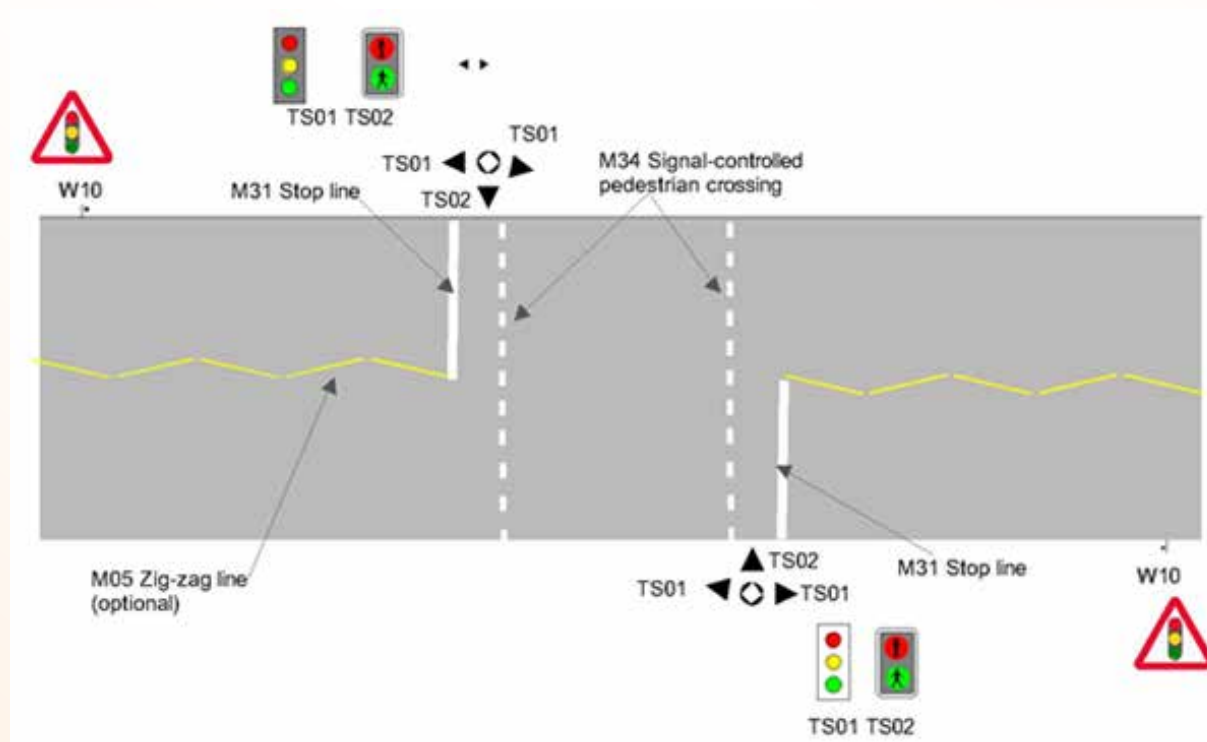
The signal lens should have a diameter of 200 mm. At complicated intersections and at intersections with many pedestrians, the diameter can be increased to 300 mm.

The interpretation of the above signals shall be as detailed in **Table 6-7**:

Table 6-7: Interpretation of pedestrian signals

Symbol			
Meaning	Steady red pedestrian figure Do Not Cross the road Wait by the kerb	Green walking pedestrian figure After checking it is safe, cross the road	Flashing green pedestrian figure Signal about to turn, do not start to cross the road
Minimum timing	Longest average waiting time should be 30 seconds to avoid pedestrians choosing their own gap	5-6 seconds	A pedestrian already in the roadway should be able to the opposite kerb

A schematic showing the placement of pedestrian signals is given in **Figure 6-13** below.

**Figure 6-13: Typical placement of pedestrian signals**

6.7.2 Uncontrolled Mid-block Crossings

Where mid-block crossings are unsignalised, signage, road markings (e.g. yield signs), lighting, vertical markers, and traffic calming need to be placed before the crossing should be used to indicate to drivers that they are approaching an uncontrolled pedestrian crossing.

6.8 Uncontrolled Intersections

The same principles apply (in terms of crossing position, kerbs, etc.) at an uncontrolled intersection, except that signage, road markings, lighting, vertical markers and traffic calming placed before the crossing should be used to indicate to drivers that they are approaching a pedestrian crossing at an uncontrolled intersection.

It is essential that at such an intersection, corner radii are kept to a minimum, to reduce the speed of the cars. Dropped kerb and tactile paving are to be installed differently at uncontrolled intersections. The tail of the tactile paving, using linear pavers, must be placed in the corner that coincides with the direction of oncoming motorised transport.

6.9 Refuge Islands

Pedestrian refuge islands can be one of the most basic and effective devices to assist pedestrians cross the road, which are usually located centrally in the road and enable pedestrians to cross one direction of traffic at a time.

The simplest form of pedestrian refuge is an isolated concrete island. This can be particularly useful where there is a concentration of pedestrians and it is difficult to cross the full width of the road in one stage. Kerb extensions can be used in conjunction with the refuge island to further reduce the road width.

Refuge islands normally take the form of kerbed islands which may be used with a painted median where pedestrians cross over a significant length of the road.

Consider the following in the design:

- The desirable cut-through width should be 3–5 m (MoWT, 2010) other than signalised intersections, where pedestrians are not required to wait within the island /cut-through.
- Ensure that parking restrictions and lighting meet visibility requirements.
- Grab rails can be installed in refuges ≥ 2 m.

An example of an uncontrolled refuge island crossing facility is shown in **Figure 6-14**.

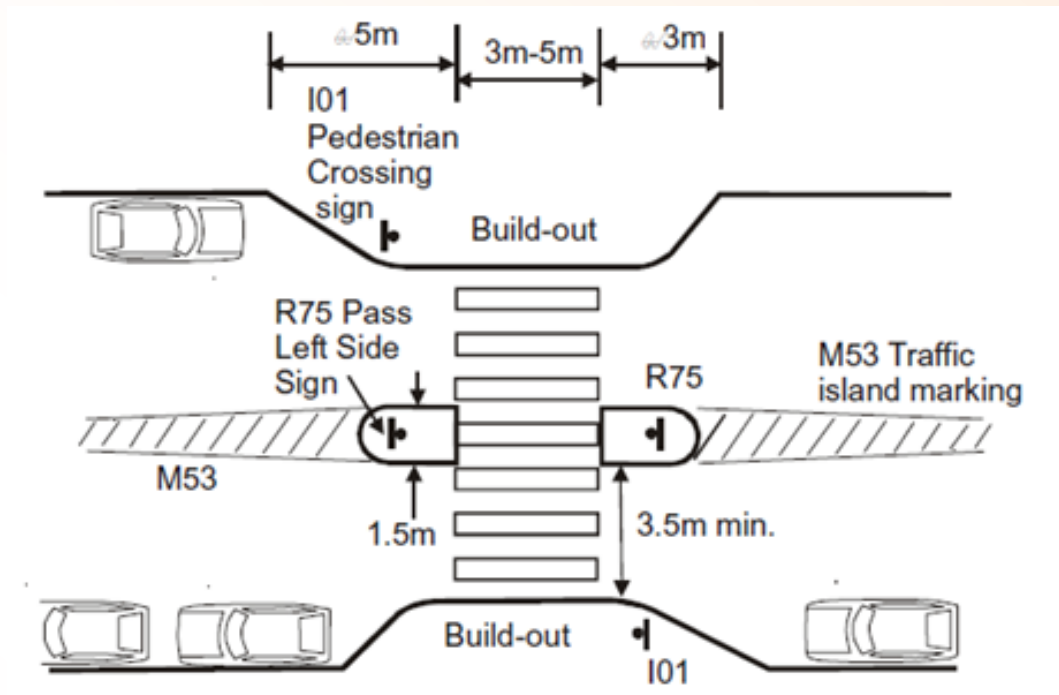
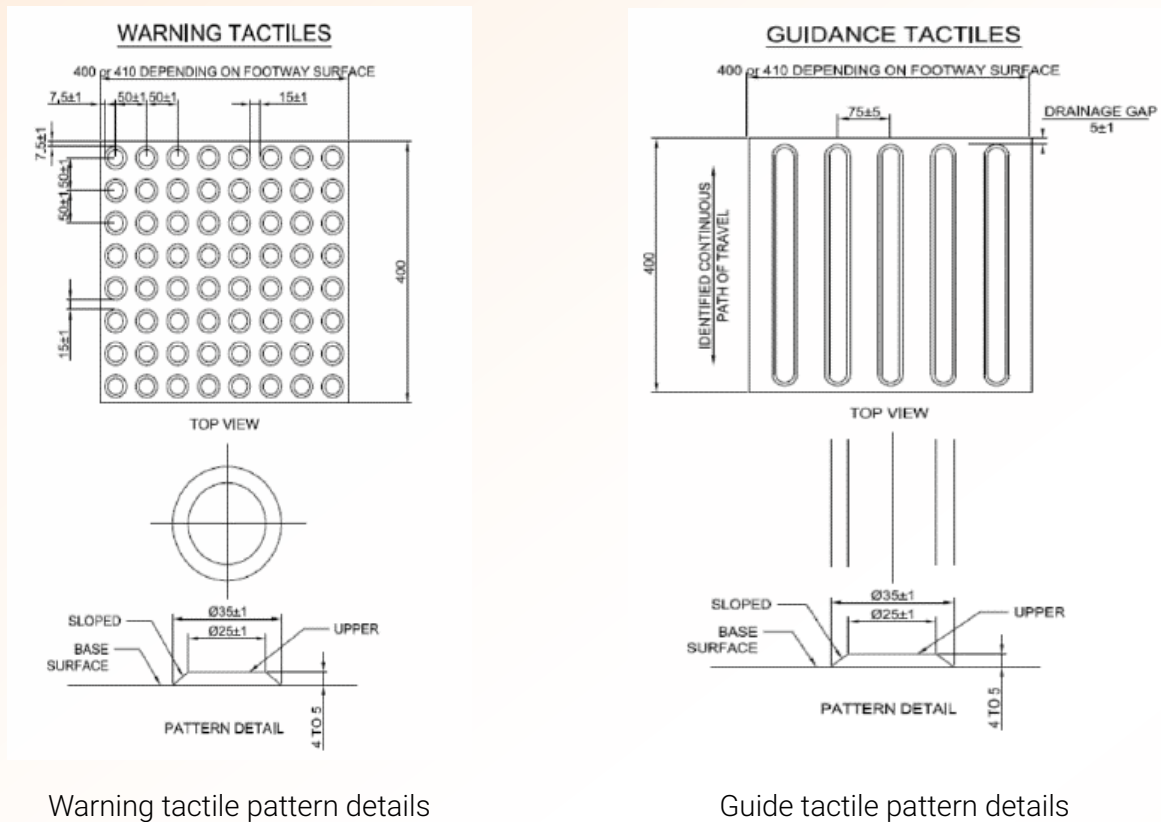


Figure 6-14: Example of an uncontrolled refuge island crossing facility

6.10 Tactile Paving Principles at Crossings

Various designs for tactile paving implementation are available, but Tactile Walking Surface Indicators (TWSI) should be designed in accordance with the stipulations of the relevant country standards. Uganda does not have a standard for tactile paving, so this Manual has included regional best practice, that of South Africa, SANS 748: 2008 – Design for access and mobility – Tactile Indicators. These TWSIs are required to guide partially sighted or blind people to safely and independently cross an intersection.

Two types are available: directional guidance tiles and warning tiles as shown in **Figure 6-15**.



Warning tactile pattern details

Guide tactile pattern details

Figure 6-15: Details of tactile paving patterns

Usually, people with visual disabilities or impairments need guidance when using pedestrian areas, especially where the footway crosses wider open spaces. This tactile pattern detail is typical where the usual guidance given by the edge of the footpath or building base is not available, or when pedestrians need guidance around obstacles. It is important that whichever tactile pavers are used for guidance or warning, they should be used consistently to avoid confusion. The different texture can be followed by people using a long or white cane and can also be detected underfoot by others with low vision. Typical characteristics of guide tactile paving blocks include that they are to:

- Be laid in straight continuous lines and indicate the correct paths/route to follow;
- Be laid in a simple and logical manner;
- Not be located close to manholes or drains to avoid confusion;
- Have a colour which contrasts with the surrounding surface;
- Form a continuous path in the direction of pedestrian travel; and
- Be maintained to ensure that the profile does not erode away.

A distance of 600 mm is to be maintained from the edge of the footpath/boundary wall/any obstruction to navigate persons with vision impairment. Provide tactile paving in the line of travel avoiding obstructions such as utility channels/tree guards / lamp posts and at raised crossings.

Typically warning tiles are installed just behind the kerb along the bell mouth radii. There is a common concern that in these situations partially sighted or blind pedestrians are directed towards the centre of the intersection and not in line with the alignment of the pedestrian crossing. Accordingly, care should be taken when installing tiles to ensure that the TWSI's direct blind pedestrians in line with the pedestrian crossing lines. Install warning tiles at 90-degree angles to the alignment of the pedestrian crossing.

Warning blocks provide warning signals to screen off obstacles, drop offs or other hazards, to discourage movement in an incorrect direction and to give warning of a corner or junction. Place the 300 mm wide warning blocks at the beginning and end of the ramps, stairs and entrance to any door, and 600 mm wide warning blocks across the entire footpath where crossing occurs.

Provide a warning block strip along the inner edge of a footway where there is a break in the line of the corridor e.g. at a garage forecourt or a gap in a building façade or an archway. In addition, provide tactile paving at intersections, turnings, building entrances, and railway platforms. A typical warning tactile paving block is shown in the **Figure 6-16** below (KCCA, 2019).

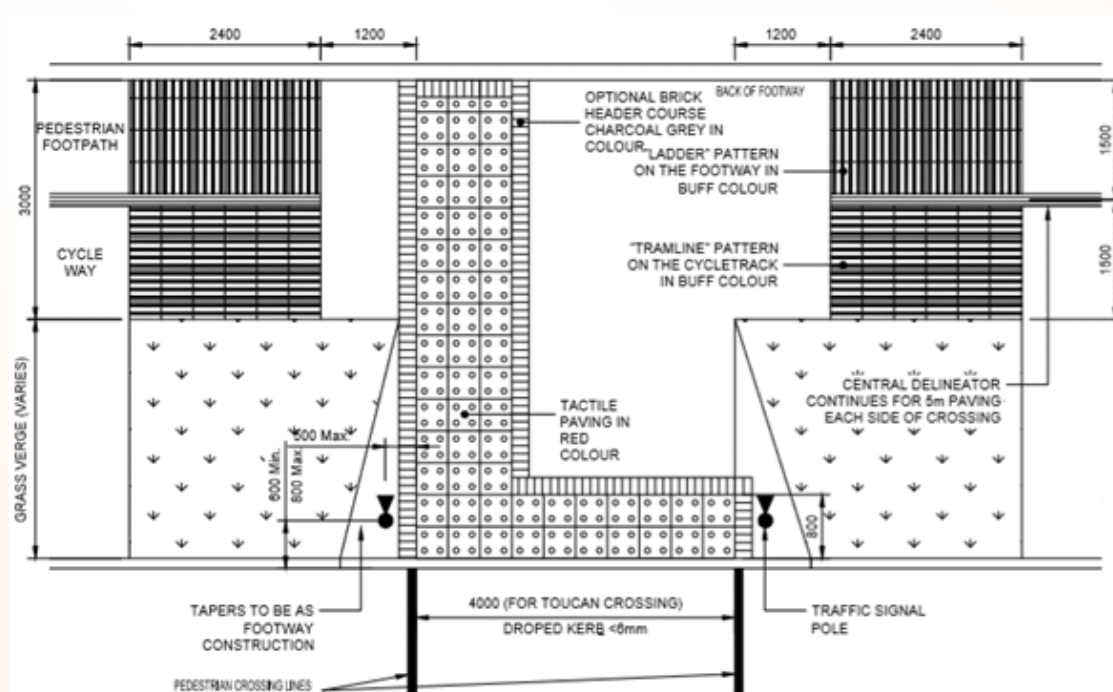


Figure 6-16: Tactile paving plan for controlled crossings

The **Figure 6-17** shows a typical arrangement of guidance and warning tactile paving:

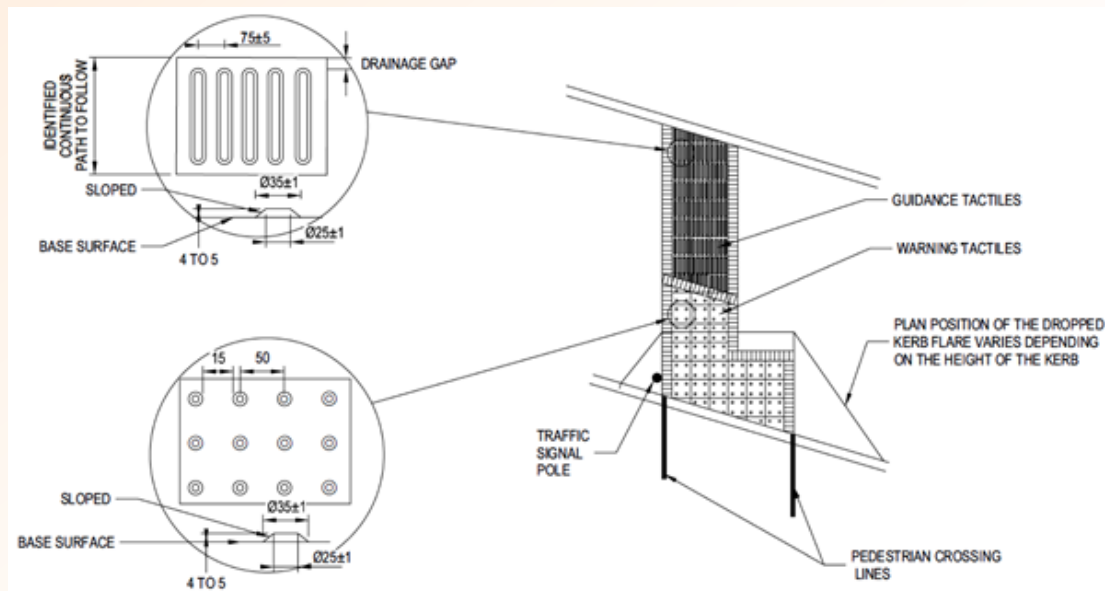


Figure 6-17: Tactile paving plan for a controlled pedestrian crossing

Note:

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 traffic signal pole must be placed on the visually impaired person's right-hand side when they are facing the road to cross (maximum 500 mm from the person) to ensure that the pole can be reached without moving off the tactile surface.



Wrong



Correct

Figure 6-18: Photographs showing examples (both good and poor) of warning tactile paving

Signage and Road Markings

7 SIGNAGE AND ROAD MARKINGS

7.1 Signage

The primary role of signage on NMT infrastructure is to provide information to pedestrians and cyclists regarding the location and safe use of a given facility. The guidelines presented have been aligned to the Ministry of Works Traffic Signs Manual, Volume 1 (MoWT, 2004). However, whereas the Traffic Signs Manual presents an array of road signs intended for use on roads, minimal attention has been accorded to the signs crucial for the safety of NMT users. The traffic signs Manual does not comprehensively provide signage for NMT. Some of the missing signage that is relevant for universally accessible NMT facilities includes; bicycle parking facilities, shared pedestrian and bicycle facilities, scholar patrol locations, and additional road markings necessary to ensure that NMT facilities are safe, universally accessible, and user-friendly.

This section, therefore, discusses the following aspects regarding NMT signage with reference to the international best practice:

- Which sign to use in a given scenario;
- When to use the sign;
- The layout or design of the sign;
- The size of the sign; and
- Where the sign should be placed.

The same main classification framework of road signs as specified in Section D.2 of the Traffic Signs Manual for Uganda (2004), as shown in **Figure 7-1** has been adopted for NMT infrastructure.

Table 7-1: Classification of road signs

Sign classification	Description	Typical design
Warning signs	Warn NMT users of dangers / difficulties along their path	
Regulatory signs	Tell NMT users what they must do or must not do	
Guidance signs	Assist NMT users to locate their destinations and other amenities	
Information signs	Assist users to find places of interest	
Supplementary plates	Give supplementary information to the main sign	

The schedule of warning signs to be adopted for NMT infrastructure is as shown in **Table 7-2**.

Table 7-2: Warning traffic signs applicable to NMT infrastructure

Sign	Description	Remark
	Danger ahead/Accident zone ahead	Coded as W21 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Narrow bridge	Coded as W26 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Pedestrian crossing	Coded as W43 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Pedestrians on road	Coded as W44 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Children on the road	Coded as W45 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Cyclists on road	Coded as W46 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Scholar patrol	Temporary for school children crossing

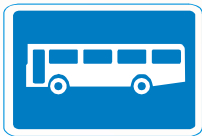
The schedule of regulatory signs to be adopted for NMT infrastructure is as shown in **Table 7-3**.

Table 7-3: Regulatory traffic signs applicable to NMT infrastructure

Sign	Description	Remark
	No entry for motor vehicles	Coded as R02 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	No entry for cycles	Coded as R08 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	No entry for Pedestrians	Coded as R09 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	No entry for animal-drawn vehicles	Coded as R10 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Stop	Coded as R61 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Give way	Coded as R62 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Route for bicycles only	Coded as R82 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Route for Pedestrians only	Coded as R83 in the MoWT Traffic Signs Manual, Vol 1 (2004)

The schedule of information traffic signs to be adopted for NMT infrastructure is as shown in **Table 7-4**.

Table 7-4: Information traffic signs applicable to NMT infrastructure

Sign	Description	Remark
	Bus stop	Coded as I05 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Telephone	Coded as I23 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Hotel	Coded as I27 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	Restaurant	Coded as I28 in the MoWT Traffic Signs Manual, Vol 1 (2004)
	People with disabilities	Universal signage Indicating facilities for people with disabilities and special needs (note – this does not indicate only wheelchair facilities)
	People with sight impairments	Universal signage indicating facilities for the Blind
	Bicycle parking	Universal signage providing for facilities for bicycle parking
	Shared pedestrian and cyclist facility	Universal signage providing for shared pedestrian and cyclist facilities
	Woonerf Street	Universal signage indicating shared street spaces

The siting and sizing of the signs shall be in accordance with the guidelines specified in tables D.2, D.3, D.4, D.5, D.6, and D.7 of the Ministry of Works and Transport Traffic Signs Manual (MoWT, 2004).

Below are general recommendations for the design and placement of signage for NMT Infrastructure:

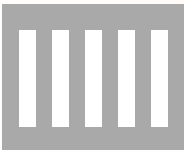
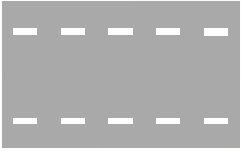
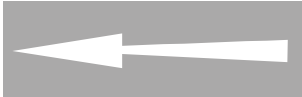
- The design, colours, fonts, and positioning of signage shall be in accordance with the Uganda Traffic Signs Manual (MoWT, 2004);
- Ensure that signs do not hinder movement and are clearly visible to all road users;
- Install signage at the edge of footways in the furniture zone and not within the footway walking zone (refer to zoning section of this manual);
- The vertical clearance of the road sign should be a minimum of 2.1 m from the final ground level;
- Minimise signboard clutter;
- Place signs so that they do not conflict with services and trees on roads, obstruct access to properties or obstruct pedestrian flow;
- The design and pattern for various types of signage should be uniform so that they are easily identifiable and legible by all road users;
- Clean and maintain signs to ensure visibility and illumination at night; and
- Ensure that signs are vandal-proof e.g., by use of one-way bolts and nuts during installation that cannot be unscrewed.

7.2 Road Markings

The purpose of road markings is to control, warn or guide road users according to MoWT, Road Safety Audit Manual (2004). They may be used to supplement other traffic signs, or they may be used alone. The main advantage of road markings is that they can give a continuing message to the road user. Clear road markings and road delineation are essential for road users to know what they are expected to do, that way traffic laws can be effectively enforced. Appropriate road delineation can increase safety for all users. For example, on roads where the volume of NMT users is very low, which doesn't warrant the provision of a sidewalk, and the pedestrians have to walk on the road shoulder.

A schedule of NMT appropriate road markings is given in **Table 7-5**.

Table 7-5: NMT appropriate road markings

Marking	Code	Description
	M33	Uncontrolled pedestrian crossing
	M34	Controlled pedestrian crossing
	M35	Hump
	M41	Lane arrow – ahead only
	M42.1	Lane arrow – left turn only
	M42.2	Lane arrow – right turn only
	M43.1	Lane arrow – ahead or left turn
	M43.2	Lane arrow – ahead or right turn
	M62	Stop
	M36	Cycleway

7.3 Wayfinding

Navigating streets and public transport services can be a serious challenge for pedestrians and cyclists, since NMT users face a constant stream of obstacles to mobility and access, including poorly designed footways, non-existent or obscure transport information, lack of signage, and wayfinding.

Wayfinding placement and programming direction should be intuitive, consistent, and enhance navigability. A key attribute of an environment favourable for walking and cycling is that it should be conspicuous i.e., the walking routes should clearly have directional signs, approximate distances to key destinations, and clearly visible street names and place names (taking into account multiple eye-levels and possible obstructions).

A well-planned, attractive and effective wayfinding system enhances NMT functionality and some of the NMT way finding contributors include:

- Local area street maps and timetables for public transport systems;
- Static directional signage including street names and distances to key destinations;
- Variable message signs that update in real-time;
- Internet websites or oral instructions from local information kiosks;
- Building identification signage where possible; and
- Orientation points where relevant.

Directional signs and information maps should be accessible to users and they should use internationally recognisable symbols to reduce the language barrier often associated with written signage. Typefaces should be clear and simple, and easy to read. Colours should be selected bearing in mind the visually impaired.

Tactile wayfinding can be adopted to guide the visually impaired users and complement the directional way-finding implemented along pedestrian routes and public transport facilities. These must be installed in consultation with a UA specialist.

Wayfinding can be placed on seats, refuse bins, bollards, flooring (in stations, bus terminals, etc.) as well as on traditional signage posts. **Figure 7-1** shows examples of signage and directional information that improves wayfinding. Depending on the type of NMT user, appropriate signage should be used. The signage should be at a level visible to children and people in wheelchairs. Note that these are not necessarily accessible to people with visual impairments.

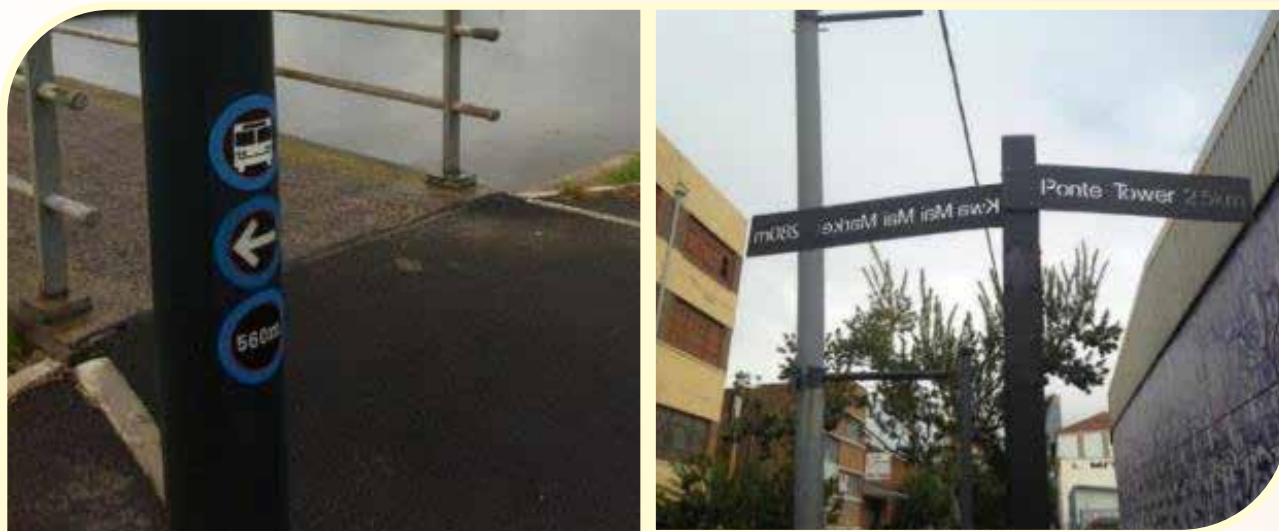


Figure 7-1: Examples of signs and directional information to improve wayfinding

In conclusion, besides improving the safety of the NMT users, traffic signs and road markings also play an important role in improving wayfinding and the use of the facility.

Intermodal Transport and Building Access

8 INTERMODAL TRANSPORT AND BUILDING ACCESS

8.1 Principles of NMT and Public Transport Integration

By and large, the principles of NMT access are the same whether the mode is light or heavy rail, motorcycle staging points, or sea, road- or water-based. One of the challenges of planning NMT access to public transport stations (light rail, rail, or motorcycle), stops, and ports, is that pedestrians are more likely to behave unpredictably (in ways that motorists do not expect), as they might run across roads (without paying attention to signals or vehicles) to get to trains or taxis. For these reasons, it's better to place at-grade crossings as close to the entrances as possible and make sure that the sightlines for both pedestrians and motorists are unobstructed by signage or vegetation.

For effective implementation, the following broad principles for pedestrian access to public transport need to be established:

- i) The location of public transport stops/stations and pedestrian networks should be developed in relation to each other at both network-wide and local levels. Preferably this should be through the medium of a local transport plan.
- ii) The location of the stops/stations should be carefully chosen, preferably at a safe focal point in the area. This requires assessment at a local level with to make the walking element as short, safe, and convenient as possible. There may be particular value in locating stops by main pedestrian routes, where these exist.
- iii) The location and form of pedestrian crossing points should be matched to maximise the convenience of catching a bus. Vehicle-pedestrian conflict points should be minimised by placing public transportation stops just beyond crossing points.
- iv) It is important to have adequate comfortable waiting space and facilities. Where shelters are provided the area should be well lit wherever possible. In all cases, public transport stops should be lit or placed to take advantage of local street lights.
- v) In town centres and other commercial locations, buses and other public transport modes should be able to set down and pick up passengers as close as possible to main destinations.
- vi) Pedestrian islands should be at least 2 m wide and include non-mountable kerbs.

- vii) Ensure adequate sight distance between vehicles and pedestrians.
- viii) Pay careful attention to the siting of pedestrian entry and exit points to interchanges; generally, vehicles leaving an interchange travel more slowly than those arriving, so potential conflict points are better placed at vehicle exit points.

BRT systems have used the opportunity of reconstructing corridors for exclusive busways to invest in upgrading the environment for pedestrians and cyclists. This is partly to support sustainable transportation options, but it is also less of a cost burden to the system to have people arrive at the station by foot or bicycle than by a feeder bus.

A minimum footway width of 2 m unobstructed (by trees, vendors, lighting poles, street furniture) should be considered, but where moderate to high pedestrian flows are predicted the width of the sidewalk should be increased to 2.5 to 3 m (or wider) if the road reserve width exists.

To accommodate cyclists, cycleways should be provided directly on the corridor or parallel (but close) to the corridor in line with the guidelines given in chapter 3.

Grade-separated access reduces the exposure risk to pedestrians, but significantly increases their inconvenience: 'pedestrian overpasses or underpasses are usually designed with the primary aim of getting pedestrians out of the way of vehicle traffic – not to enhance the safety and convenience of pedestrians' (ICE, 2009); When stairs are the only station access, many potential passengers might not be able to make use of the infrastructure, especially people with mobility impairments and disabilities, like parents with strollers who might lose access to the public transport system if elevators are not provided. For this reason, provide station access at grade. At-grade accesses are preferred because they integrate the public transport system within the environment and make it easily accessible to special needs users. Where overpasses or underpasses are unavoidable the widths of these facilities should be determined considering peak user volumes – refer to demand-based sizing in Section 3.7.

When stations are placed mid-block, pedestrian crossings should include elements that signal to drivers that they are approaching pedestrian crossings, such as signs, lighting, vertical markers, and overhead indicators. An elevated crosswalk or other traffic calming measure placed before the crossing, helps to force motorists to slow down. Pedestrian-refuge islands between lanes and narrower lane widths also reduce pedestrian-exposure time. Using different surface colours and textures will further draw the attention of motorists.

8.1.1 Separation of Vehicles and NMT Users

To improve road safety, it is essential that pedestrians are separated from vehicular traffic as much as possible. During the design of a public transport facility, the following elements should be considered in terms of separating NMT users from motor vehicles:

- At off-street interchanges such as rail or bus stations, focus on maintaining separation between people walking (or cycling) to public transport, and the public transport vehicles themselves, preferably by use of raised kerbs;
- Use design to facilitate the separation between passengers arriving and leaving, where possible;
- Clearly define the queuing and walking areas;
- Use design to encourage one-way vehicle movement within the public transport interchange as shown in **Figure 8-2** (ITDP, 2019); and
- Use design to strongly discourage reversing in and out by both public transport and other vehicles.

Figure 8-1 below shows how pedestrians are separated from the vehicles through a footbridge and a footway to a median public transport stop. In this illustration, bicycle accommodation is not shown, but bicycle parking facilities should be located within the vicinity of the bus stop (ITDP, 2019). Pedestrians make use of a footbridge link to a median public transport stop.



Figure 8-1: Example of NMT-vehicle separation at a public transport interchange

Figure 8-2 and **Figure 8-3** provide examples of one-way enforcement at public transport interchanges. **Figure 8-2** is an example of pedestrian accommodation on a kerbed footway within a parking environment. Note that parking flow is limited to one-way direction only on either side of the footway. **Figure 8-3** an example of pedestrian accommodation on a kerbed footway within a parking environment in an urban environment with parking flow limited to one-way direction through the parking facility. Provision for street lighting of both the road and

parking is made.



Figure 8-2: Example of pedestrian accommodation on a kerbed footway within a parking environment

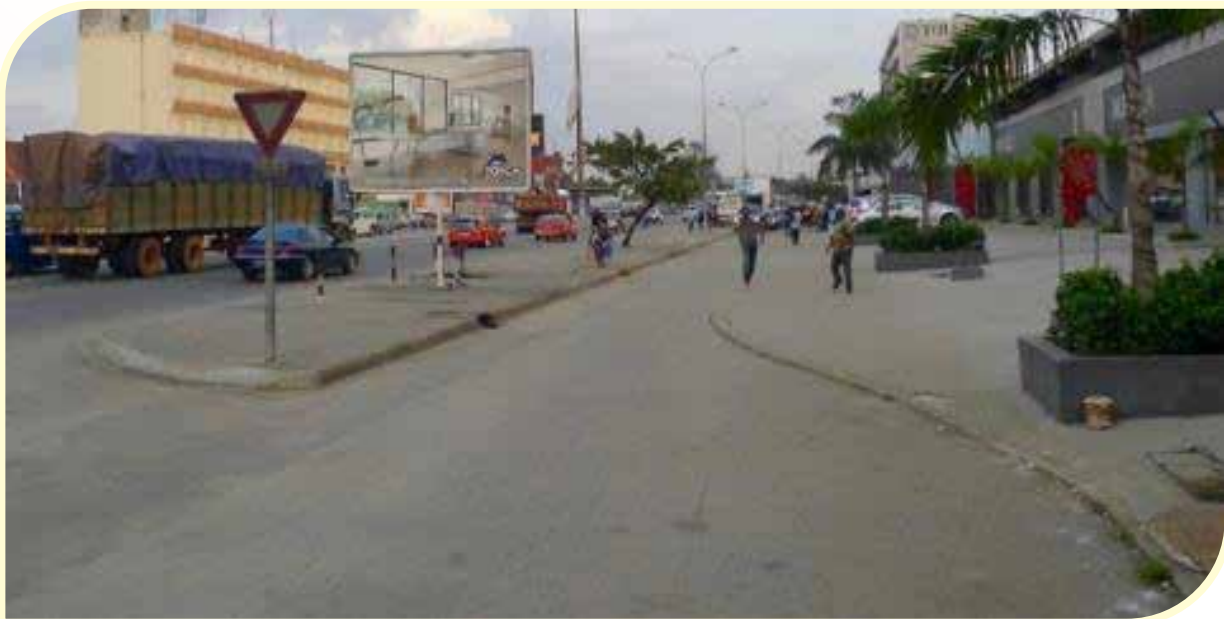


Figure 8-3: Example of pedestrian accommodation on a kerbed footway within a parking environment in an urban environment

8.2 NMT Design at On-street Multi-modal Transport Facilities

Generally, facilities at on-street transport stops need to be based on the alighting and boarding demand at the particular location. Facilities should be an integral part of the pedestrian network, and highly visible, and do not require pedestrians to walk more than 400 m along a route to access a public transport stop.

8.2.1 Shelters and Waiting Areas

Shelters and waiting areas are generally recommended at not only public transport terminals

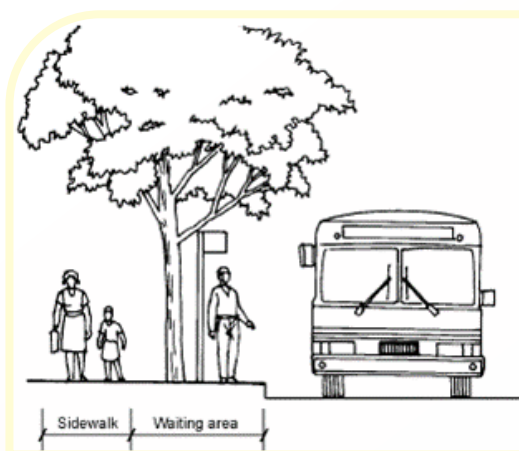
where high passenger volumes exist but also at every designated public transport stop in case space is available. For the efficient design of shelters and waiting areas, consider the following in the design:

- Shelters are desirable at high-volume stops and bays. Shelters provide protection from wind and rain and should be well-lit with unobstructed access points.
- Provide route names and numbers on the shelters where applicable. provide a seat, litter bin, and transparent sides for better safety. Provide access at two points.
- Provide a continuous strip of a non-slip paved surface along the entire length of the public transport stop (at least 2.5 m wide).
- Make provision for ample space for passengers to wait and board without obstructing other pedestrians. The width of the waiting area should not be less than 1.5 m and its length not shorter than 2.7 m.
- Set street furniture back from the kerb and outside of the waiting areas for the case of bus stops.

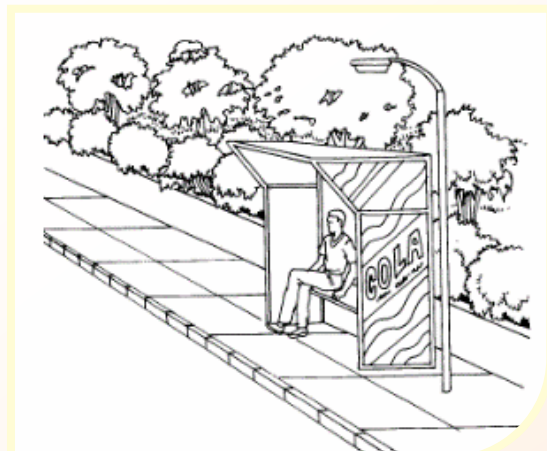
For Bus/mini-bus shelters at boarding stops and bays. A shelter must have:

- 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.

Figure 8-4 shows typical illustrations and pictures of an ideal bus shelter/ waiting area.



Typical sidewalk and waiting area at bus and minibus stops.



Typical bus shelter with adequate lighting provided.



Example of a bus shelter at a well-protected bus stop. Source: (ITDP, 2019).



Example of good practice of a bus shelter at a bus stop not interfering with the walkway/ cycleway.

Figure 8-4: Examples of the principles of shelters and waiting areas

8.2.2 Bus and Taxi Embayment

Taxi or bus bays (or any public transport bay) at on-street facilities should have at least a 3 m sidewalk and paved waiting areas separated by non-mountable kerbs. Extra care should be taken of the following to ensure the safety of NMT users:

- i) Pedestrian priority zone behind the bus stop where cyclists are expected to look out for pedestrians and reduce their speed to walking speed (see **Figure 8-6**);
- ii) Speed reduction strips for cyclists should be provided in pedestrian priority zones (see **Figure 8-6**); and
- iii) 'SLOW' road marking should be provided to further make cyclists more alert.

Figure 8-5 and **Figure 8-6** below show typical layouts of NMT treatment at a bus stop/bay

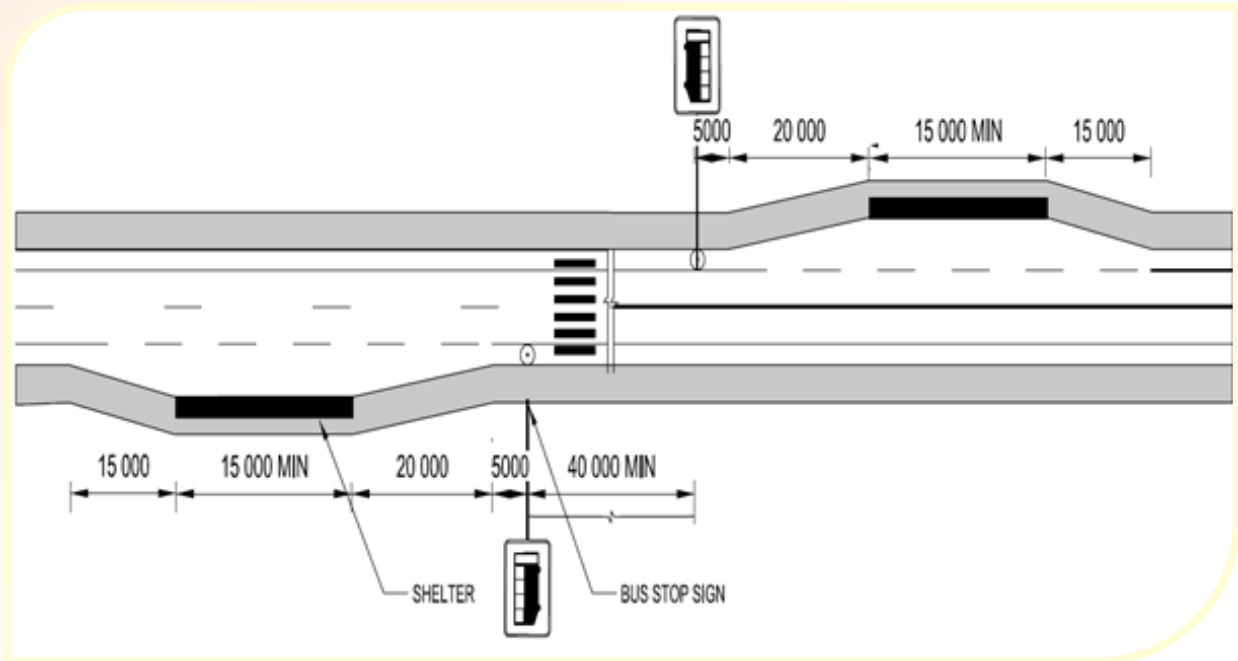


Figure 8-5: Typical layout of NMT treatment at a bus bay

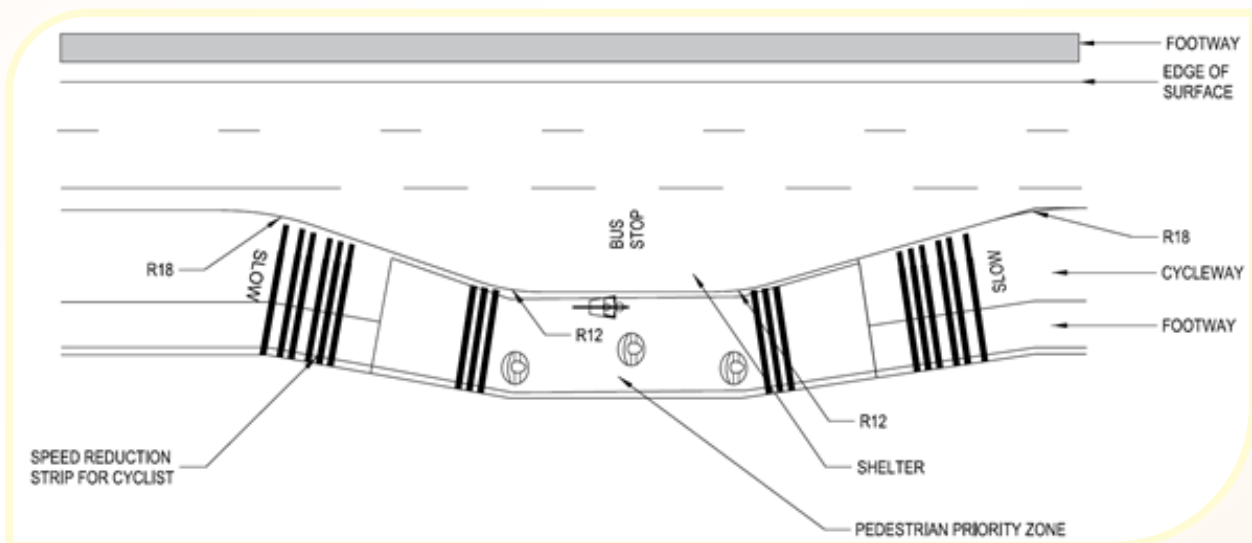


Figure 8-6: Typical road marking of NMT at a bus bay

Figure 8-7 (ITDP, 20019) shows an example of a well-planned cycleway exclusively separated at a bus stop with no conflict points between cyclists and buses or motorised vehicles. Cyclists and buses are not in conflict with motorised vehicles in this arrangement. **Figure 8-8 :** (ITDP, 2018) shows both the bad and proper layout of the bus shelter in terms of the footway at an on-street facility. Footways and cycleways should be placed behind the shelter and should remain continuous for the ongoing cyclists and pedestrians.



Figure 8-7: A well-planned cycleway separation at a bus stop

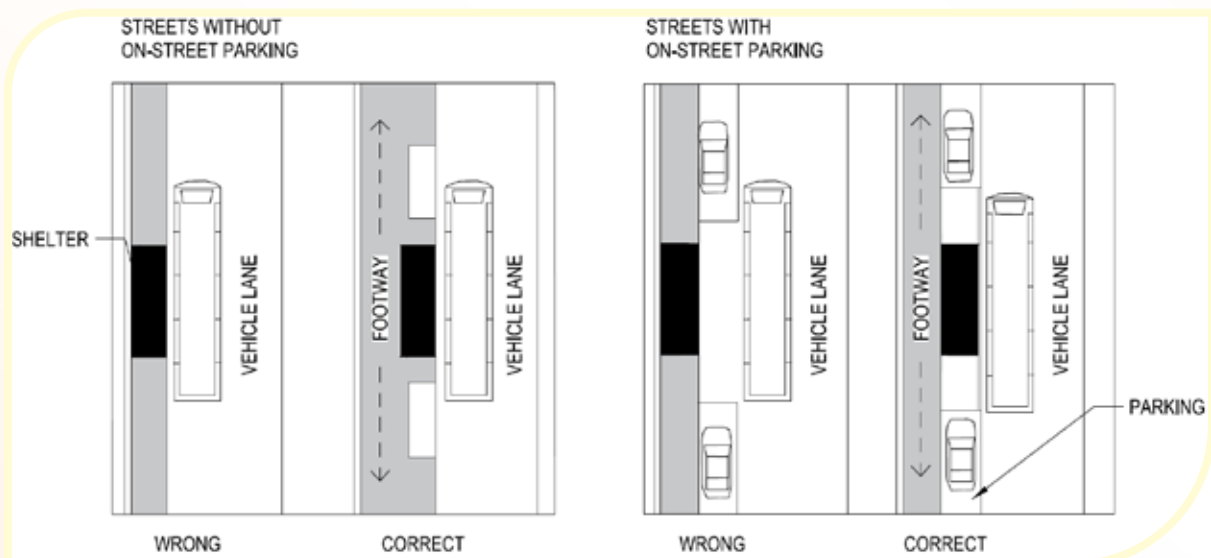


Figure 8-8: Typical details of bus-bicycle treatments with and without on-street parking

The pedestrian footway and cycleway should be maintained behind the shelter/waiting area for continuity of the pedestrians and cyclists moving past the bus stop. These fall within the pedestrian priority zone as shown in **Figure 8-9**.

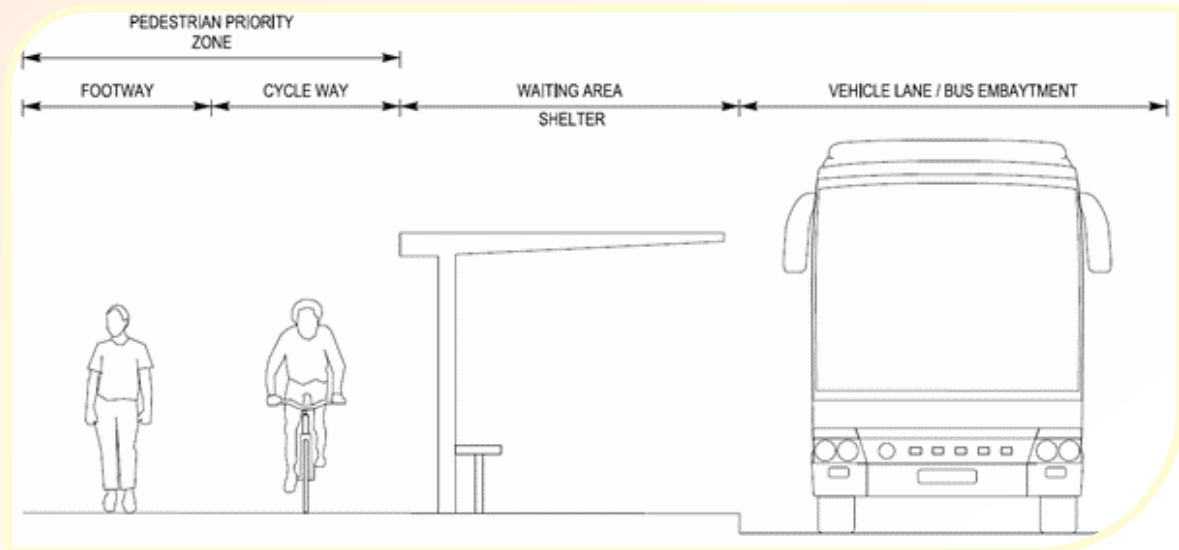


Figure 8-9: Typical cross-section showing the pedestrian priority zone at bus stops

8.2.3 Access Points and Crossings

The following guidance is provided when planning out and designing public transport access points and crossings leading to public transport interchanges.

- Sidewalks that lead to transport interchanges should be at least 2.0 m wide;
- Pay particular attention to pedestrian crossings within the vicinity of the public transport stop. The movement of passengers from stops to public transport vehicles must be coherent and seamless. This will usually require mid-block pedestrian crossing facilities;
- Raised and signalised crossings may also be required; and
- Raised pedestrian crossings slow traffic and provide safer access to the buses/taxis.

8.3 Median Public Transport Stations

Median public transport stations are mostly associated with Bus Rapid Transit (BRT), a system intended to not only offer a higher-quality service to all current public transport or taxi users but also to attract private car users onto public transport. For this reason alone, it is essential that high-quality walking and cycling facilities, with associated wayfinding, extend well beyond the immediate station access and to offices and residences within 2–3 km.

Although it might be tempting to provide grade-separated crossing facilities to reach the median, street-level/at grade facilities are always the most convenient for pedestrians and cyclists, and the most likely to provide Universal Access. Refer to chapter 9 for guidance on how to improve the safety of at-grade crossings.

Pay attention to the principles of Universal Access at every point, in consultation with a UA specialist. One of the key advantages of BRT is that it is particularly able to provide public transport to people living with disabilities. Accessible buses are worthless if people with disabilities are

not able to access stations and move with ease.

Station platforms need to be at least 5.0 m wide, with an entrance length of at least 15 m, to include kiosks, ablutions, and access control, among other facilities.

Provide NMT facilities across the entire trunk network for any BRT service, and access to the station (in a catchment area of at least 2 km) should be an integral part of this network. Sidewalks or footways at a BRT and public transport facility should be at least 3.0 m wide, with 1.5 m wide bicycle lanes (see also Section **8.6** on **Bicycle Parking**).

Ensure that traffic signal poles are no more than 3.0 m from stop lines, and include pedestrian buttons.

Staggered pedestrian crossings are more common at median stations, as they provide better visibility of pedestrians to vehicles at intersections.

Figure 8-10 shows a typical example of a median BRT bus stop with an at-grade pedestrian crossing facility. Note for the general vehicular traffic a raised pedestrian crossing has been implemented, and that bollards have been placed at entrances to deter vehicles from mounting sidewalk. Source: (ITDP, 2018).



Figure 8-10: Photograph showing NMT access at a median public transport station

8.4 Bus and Taxi Parks

Overall, the same principles as discussed in Section 8.1 apply for NMT access to bus and taxi parks (and indeed other public transport modes such as light rail). However, keep these additional pointers in mind:

- Provide covered, lighted foot/walkways within the park where possible.
- Each bus/taxi park should be as close as possible to other public transport access points.

Figure 8-11 below shows an example of how pedestrians have been integrated within a public transport facility (Bus/taxi park). Note the means of pedestrian accommodation are all at grade and demarcated using line marking. It is good practice to completely separate pedestrians from vehicular traffic, where possible,. Source: (ITDP, 2019).



Figure 8-11: Photograph showing integration of pedestrians within a bus/taxi park

8.5 Driveway Accesses / Aprons

The design of adjoining driveway accesses and aprons cutting through a footway or cycleway should put the following concepts into consideration.

- Driveway treatments should try to maintain the footway or sidewalk grade consistently with a crossfall maintained at 1:50 across the driveway.
- The existing width of the footway should preferably be maintained at 2.0 m throughout.
- With verge constraints, the sidewalk width traversing the driveway should not be less than 900 mm.
- Only in cases of driveway ramp gradients exceeding 1:10 in the furniture or frontage zones, should a ramp, or partially ramped sidewalk be considered.

8.6 Bicycle Parking at Transport Interchanges

A lack of safe, convenient bicycle parking is a significant deterrent to people choosing to cycle as a mode of transport.

Provide bicycle parking along all NMT corridors and at all key destinations, such as shopping malls, public buildings, schools, other education centres, transport interchanges, etc.

This Manual updates the 2011 Ministry of Lands, Housing and Urban Development (MoLHUD) National Physical Planning Standards and Guidelines (2011) with regard to bicycle parking facilities. While the former guidance suggests that bicycle facilities be screened within or behind buildings, stations or bus parks, or sited at the side of buildings, regional and international best practice suggests instead that bicycle parking should be highly visible and sited as close to destinations as possible.

Bicycle parking should be:

- Visible – to discourage theft;
- Securely fixed to a paved surface;
- Outside of the footway or sidewalk (it must not be an obstruction);
- Fit for purpose and easy to use. Bicycle users should be able to lock the frame and the wheels to the parking rack; and
- At least 1.0 m apart, for easy access when parking bicycles.

Figure 8-12 below shows a typical widely used U-bar bicycle stand and the respective bicycle signage.

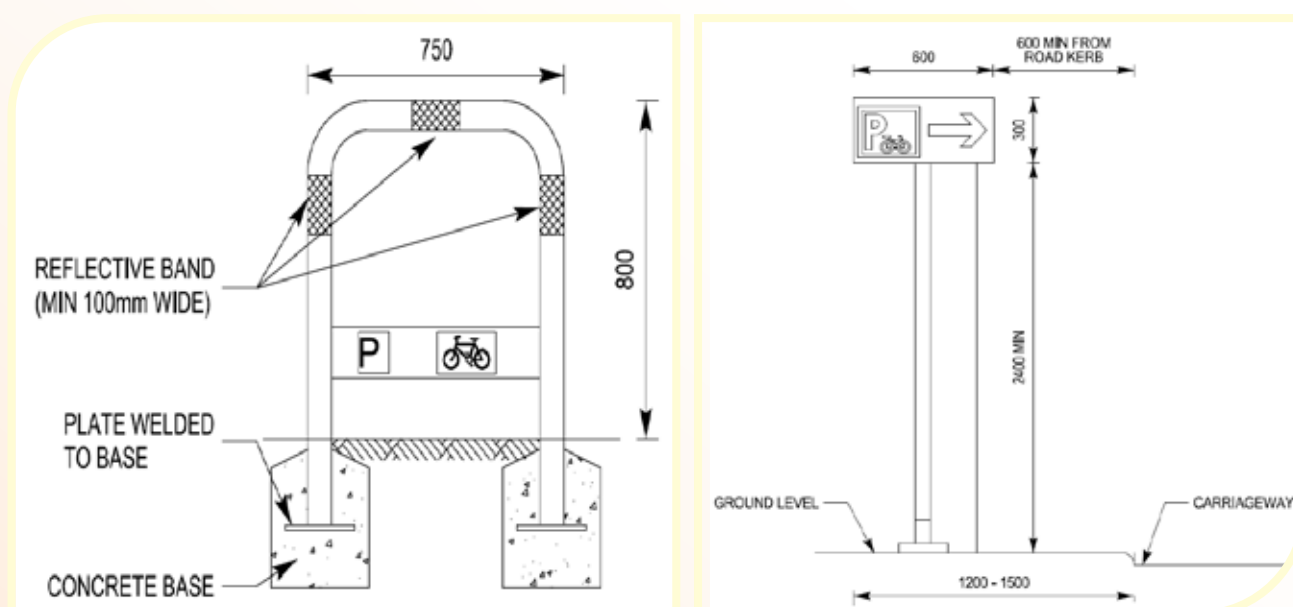


Figure 8-12: Typical U-bar bicycle stand and recommended bicycle parking signage

The recommended bicycle parking layout is shown in **Figure 8-13** below.

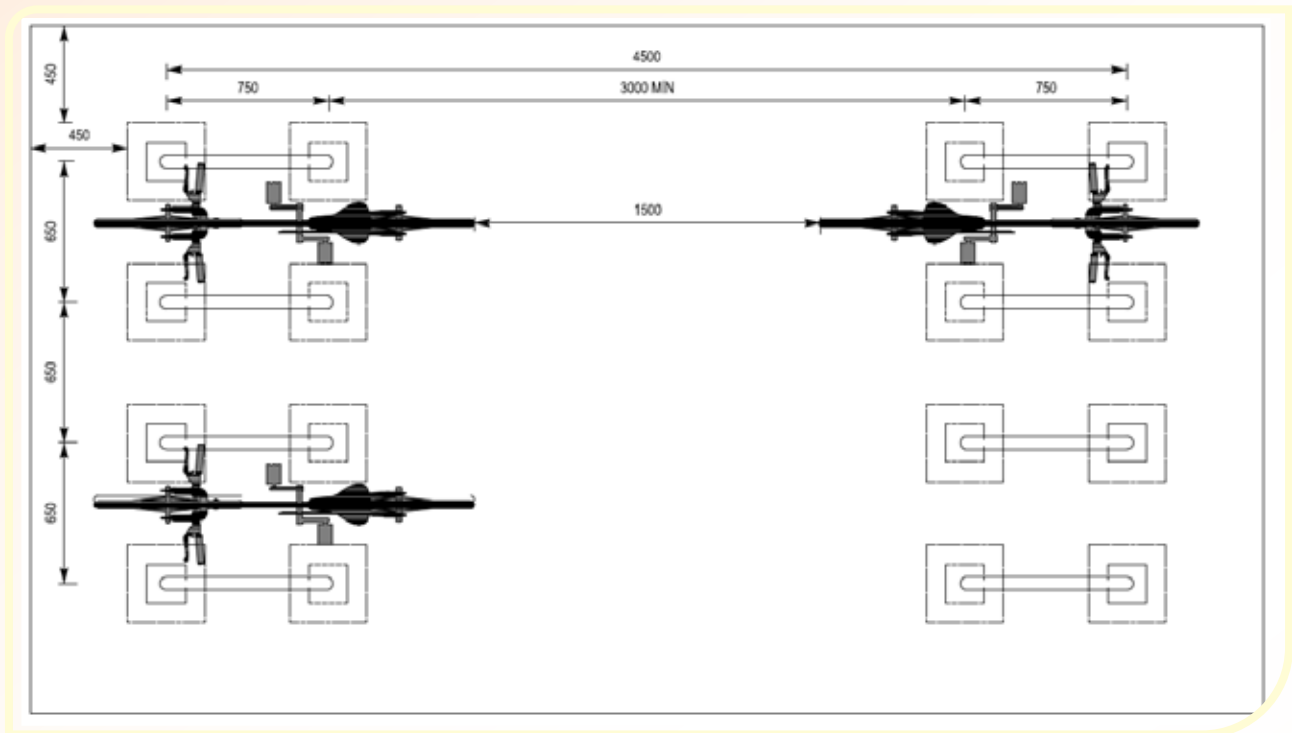


Figure 8-13: Bicycle parking layout

8.7 NMT Design for Building Access

The Uganda MoLHUD National Physical Planning Standards and Guidelines (2011) provide guidance regarding access to buildings in Uganda; these guidelines offer additional and more expansive design suggestions.

Overall, the same principles apply for NMT access to commercial buildings as for access to transport interchanges described in Section 8.1 above. However, keep these additional pointers in mind:

- Keep footways or sidewalks at the same level as ramps for vehicles across driveways or vehicle entrances;
- Provide vehicle ramps in the street furniture zone;
- Footways must be continuous at all property entrances (i.e, not interrupted by kerbs or different levels);
- Use bollards to prevent vehicles from parking in NMT space, in consultation with a UA specialist;
- Pay attention to frontage zones in commercial and high-intensity commercial zones and ensure sufficient pedestrian space;
- Physically link shade/rain canopies of at least 2.0 m on building frontage so pedestrians have continuous weather protection; and

- Pedestrian zones beyond the canopy zone should be at least 2.5 m in commercial areas, and 4.0 m in areas of high-intensity commerce.

Figure 8-14 (ITDP, 2018) below shows a good example of footways at a building access connection point that maintains a constant level through property entrances (ITDP, 2018). These are convenient for pedestrians to use, and vehicles make use of a ramp, which helps to reduce speeds.



Figure 8-14: Typical example of building access

8.8 NMT Design for School Access

Access to schools is made particularly dangerous by high-traffic speeds, illegal turning at access points, inexperienced road users (children), uncoordinated and unplanned traffic movement, and lack of pedestrian and cycling facilities.

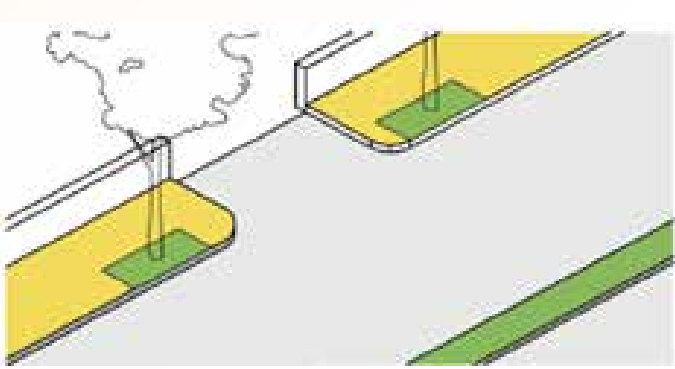
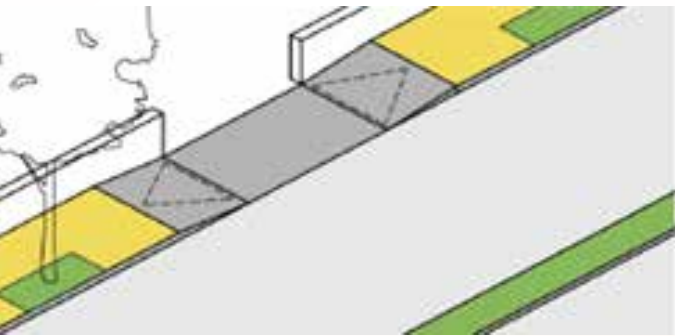
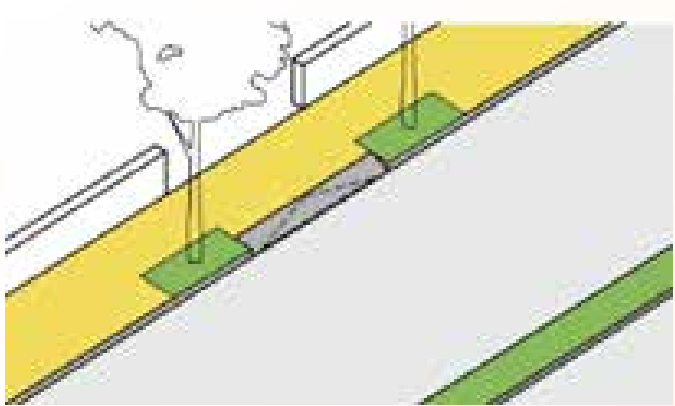
These challenges can be mitigated by enforcement, as well as through improved traffic calming, raised pedestrian crossings, refuge islands at crossings, and improved public transport stops in the vicinity of schools.

- The following measures can be put in place to improve safety at school access points:
- Provide a sidewalk or footway at least 500 m from the school entrance;
- Clearly direct school goers to pedestrian crossings by means of signage, fences, bollards, and other safety elements; and

- Limit vehicle speeds around schools to 30 km/h using traffic-calming measures to attain this low speed.

Table 8-1 below shows some examples of school access NMT treatments (ITDP, 2018).

Table 8-1: Examples of access treatments

Description	Illustration
A footway that abruptly ends with kerbs. This renders the footway inaccessible for many pedestrians and gives priority to vehicular access.	
An example of a footway being lowered over the entire portion of the access to the level of the carriageway. While this may provide continuity to pedestrians this is unacceptable as property entrances may become waterlogged.	
An example of best practice where vehicle ramps are provided within the furniture zone on a footway to an access. Depending on the anticipated volume of vehicles to the access, bollards can be installed within the footway to protect and demarcate/warn users of the access while still facilitating all modes of NMT movement.	

Safety Considerations

9 SAFETY CONSIDERATIONS

Road safety is a vital element of any planning and implementation project, especially in the case of NMT projects, due to the speed differential between a motor vehicle and a pedestrian that can result in serious injuries. This chapter deals with the various road safety principles and design elements that should be considered on NMT projects.

Figure 9-1 below depicts a driver's cone of vision for various speeds and provides a visual representation of how a driver's visual focus diminishes as speed increases. As the speed increases from 40 km/h to 70 km/h, the cone of vision reduces from 100 degrees to 65 degrees.

The cone further reduces to less than 40 degrees when the speed increases to 100 km/h. Road safety can be improved through better visibility, managing road user expectations and reducing vehicle speeds. This chapter describes some of the ways of improving road safety.

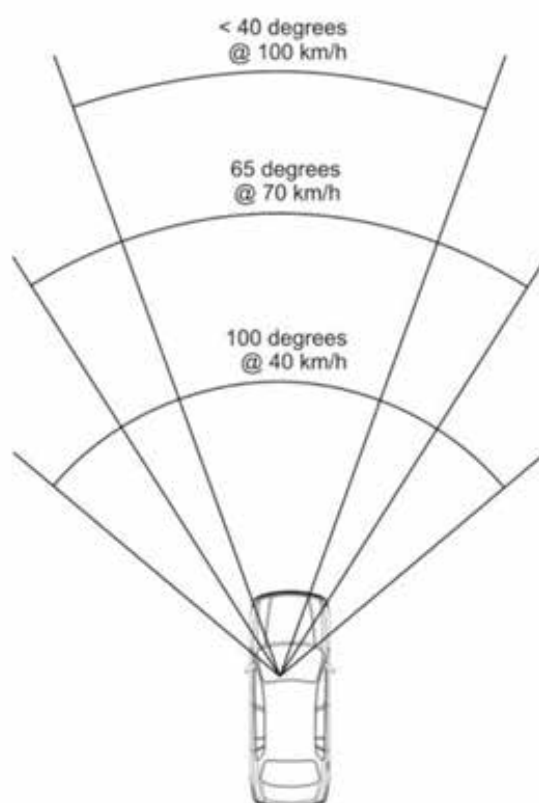


Figure 9-1: Relationship between vehicle speed and cone of vision

9.1 Sound Alerts/ Audible Signals

Audible signals may be used to indicate to visually impaired pedestrians that the green figure signal head is provided at a controlled pedestrian crossing. Audible signals emit various types of sounds to aid the visually impaired in crossing the street. The signal is sounded for a short duration at the start of the green light signal for pedestrians.

The challenge associated with audible signals is noise pollution, however, this is addressed by carefully adjusting the volume of the audible signal. A provision can be made to automatically adjust the signal volume according to the ambient sound levels.

The problem of identifying which crosswalk has the walk signal can be addressed by using different tones or signals. Standardised signal tones may be adopted at various junctions and crossings in an area to indicate crosswalk directions. Verbal messages may also be given indicating the name of the street that can be crossed. The audible signal should only operate when the walk indication is displayed. It can either be actuated or through a push-button, in conjunction with the pedestrian walk signal.

There are no standards for where to implement audible signals as yet. It is proposed that NMT corridors and NMT facilities near hospitals, clinics, and facilities for people with disabilities be prioritised. **Figure 9-2** below shows an audible signal installed at a pedestrian crossing.



Figure 9-2: Pedestrian crossing with a sound device installed

9.2 Lighting

Driving, riding, cycling, or walking on or across any roadway is less safe in darkness than in a lighted area due to the reduced visibility of potential hazards. Lighting significantly improves the visibility of the roadway, increases sight distances, and makes roadside obstacles more noticeable to the road user, and more avoidable.

Roadway lighting is a proven safety measure, and refers to the application of illumination systems along roadways, primarily to improve safety by increasing visibility of roadside hazards and reducing the effects of glare from other light sources in the visual environment. In addition to safety, adequate lighting provides clear benefits in terms of clear wayfinding for the user, reduces the accident risk, and reduces crime incidents at night. Lighting often serves the purpose of safeguarding personal safety for pedestrians and cyclists as they travel along and across footways and cycleways.

Well-lit footways and cycleways are crucial for safety and visual comfort for pedestrians and cyclists. In some cases, 'spill' light from adjacent streets or roadways may be sufficient for the footways and cycleways. However, if this spill light does not provide enough illumination to allow visual identification of other pedestrians, cyclists, or objects, then proper roadway lighting will be required.

Streetlights are designed for vehicles due to their higher speeds and safety implications, as compared to NMT users. Hence the street lighting should be designed for vehicles, as per the standards prescribed by the Road Design Manual. However, one should be mindful of the NMT users. The NMT considerations that need to be taken into account are further described in the following sections.

There are several off-the-shelf software packages available to design street lighting. The following section highlights the design principles that need to be considered.

9.2.1 Design Principles

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.

However, too much bright light at times also causes a visual discomfort called glare. Glare refers to the temporary visual sensation caused by excessive and uncontrolled brightness that can be disabling or simply uncomfortable. As we look into the lighting design principles, it is important to bear in mind that there should be a balance between providing enough illumination while limiting the amount of glare. The following should be considered when providing lighting:

Continuous lighting should be provided along the entire length of the facility, connecting major origin-destination;

- Any conflict areas between NMT facilities and other modes should be well lit. Example, junctions or intersections, interchanges, railway crossings, bridges, tunnels, sharp curves, and areas where there is activity adjacent to the road such as markets, public transport stops, and community halls;
- Sufficient lighting should be provided where large volumes of pedestrians gather. Example: ferry landings, bus stops, boda-boda staging areas, community facilities, police station, and hospitals;
- Proper lighting to promote an ambient and friendly NMT environment should be provided.;
- Sufficient light balance should be promoted to meet the minimum safety lighting requirement as well as enhance the evening environment aesthetics;
- The spacing between the luminaires (light poles) should be uniform along a facility;
- The light fixtures should be easy to maintain, durable, and able to withstand extreme weather conditions; and
- The mounting height should be carefully selected to avoid glare.

9.2.2 Design Elements

Lighting is designed by electrical engineers who, by and large, use specific lighting design packages to compute lighting decisions based on inputs such as the width of the road reserve, roadway, pedestrian and cycleways, types of lighting, etc. The design packages are pre-programmed with the country's design criteria and standards.

Of importance to the NMT designer is that lighting is required for personal and road safety; and that there is more lighting at intersections and public transport facilities.

The standard lighting design criteria for Uganda however is not be up to date with international standards when people with disabilities are considered.

The following geometric design parameters are to be considered by electrical engineers when providing lighting for NMT infrastructure.

a) Mounting height

When the height of the light source is increased, the light scatters across a wider road surface, however, the intensity of the light or illumination reduces. If the height of the light source is reduced, a smaller surface area of the road is illuminated however, the surface is better illuminated and may cause glare. It is recommended that the luminaires be mounted at a height between 10.0 and 15.0 m as recommended (MoWT, 2010).

If lighting columns (poles) are placed on the median, then additional lighting may be required along the sidewalks. It is recommended that the NMT facility lights be placed at a height between 3 and 4 m.

b) Layout

Columns can be on just one side of the road or both sides. Pairs of columns can either be placed opposite each other on either side of the road or in a staggered manner. Lighting columns should be placed behind vertical kerbs whenever practical. The appropriate distance is 0.5 m behind the kerb for roads with a design speed of 50 km/h or less, and 1.2 m or greater for roads with a design speed of 80 km/h or greater (MoWT, 2010).

c) Spacing

The spacing of the lighting columns affects the consistency of the light as one walks or cycles. If the poles are too far apart, there may be dark spots on the road. If they are spaced too close to each other, this results in too much light resulting in a glare. There should be a fine balance between these two elements.

Care should be taken to ensure that the vegetation and landscape do not block the light or cause a shadow on the facility. Typically, the lighting is designed for motor vehicles. Lighting should be designed as per the standards in the MoWT Road Design Manual Vol 1 (2010). On roads where the design speed is higher than 80 km/h, additional lighting for the NMT facility may be required to eliminate dark spots.

d) Type of lamp and luminaire

The actual luminaire chosen has to be suitable for the lamp type and power. LED lights are generally preferred for their energy efficiency. In rural areas, where there is limited access to electricity, solar-powered LED lights may be a viable option. Metal Halide lights are also used although not as popular as LED lights.

e) Aesthetics

Streetlights can also offer ambiance, adding more beauty and appeal to a space. Street lighting can be used to accent a historic district, business area, or residential neighbourhood. Streetlights (poles and light fixtures) along with other street furniture such as the benches and pavement material can add to the ambiance. Lighting can be used to highlight aesthetic features such as a fountain, garden or statue. White light is preferred to yellow light as one can see objects and features more clearly hence recommended from a safety standpoint.

9.2.3 Minimum Standards

Table 9-1 provides the recommended lighting levels for the respective NMT facilities. To maintain the lighting level specified in the above classes, the lights must be cleaned, maintained, and replaced when necessary.

Table 9-1: Recommended lighting levels for NMT

Movement and traffic	Typical example	Minimum maintained average horizontal illuminance (Lux)	Glare limit (Unified Glare Rating)
Pedestrian only	Individuals	5	55
	Small crowds	10	50
Slow moving vehicle	Bicycle facility	10	50
	Car park	20	55
	Regular vehicle traffic	20	45
	Public transport facility	100 – 150 depending on how busy the facility is	

Traffic Calming

10 TRAFFIC CALMING

Traffic calming is the use of physical design and traffic management strategies to balance the vehicular traffic and other uses of a street. Historically, there was a view that roads were designed for motorised vehicles. However, over the last decade or two, the views have begun to change. There is a growing view of shared road space. Traffic calming aims at bringing about that balance between motor vehicles and vulnerable road users such as pedestrians and bicyclists. Traffic calming is particularly important on streets where the NMT volumes are high or when the NMT – vehicular conflict volumes are high. Higher vehicle speeds result in more severe pedestrian or cyclist injuries.

Traffic calming aims at reducing either vehicle speeds or volume or the number of conflict points and thereby improving safety. Several traffic calming measures can be implemented, with each having its advantages and disadvantages.

Some of the factors to be considered when implementing or selecting a traffic calming measure include the functionality of the road, design vehicle that needs to be accommodated, volume of vehicles, and NMT users. It should be noted that by implementing a specific traffic calming measure, the operating speed on the road would reduce. This could result in an unintended consequence of traffic congestion elsewhere in the road network due to the traffic rerouting to avoid the street with the traffic calming.

It is also important that through the master planning process the hierarchy and functionality of the road network are established. Corridors may be prioritised as mobility routes, public transport routes, NMT priority routes, or freight routes. It is important to note that traffic calming measures that severely restrict traffic are not implemented on mobility corridors. Care should be taken to incorporate Universal Access design principles where applicable.

The traffic calming measures that can be implemented are:

- Horizontal deflection;
- Vertical deflection;
- Physical obstructions; and

- Other interventions:
 - Textured pavement;
 - Narrower lanes;
 - Speed limits; and
 - On-street parking.

These traffic calming measures are explained further in the sections below.

10.1 Horizontal Deflection

Traffic calming measures in this category focus on slowing vehicular traffic by either diverting the travel path horizontally, or by narrowing the available roadway width. By causing a diversion to a travel path, the traffic slows down to safely navigate the obstruction. Some of the horizontal deflections that may be implemented include:

- Kerb extension or smaller kerb radii;
- Chicanes or chokers;
- Neckdowns; and
- Roundabouts, traffic circles, and mini-circles.

These measures are described further in the sections below.

10.1.1 Kerb Extension or Smaller Kerb Radii

This measure is commonly used at intersections as a means of narrowing the available roadway width, and thus has been known to influence vehicle speeds. The kerb line is extended out for a short length which widens the footway and reduces the roadway width. By reducing the width of the roadway, the pedestrian crossing time is reduced. This could improve the capacity of a signalised intersection. Kerb extensions, with appropriately designed universally accessible kerb drops, benefit NMT activity and safety.

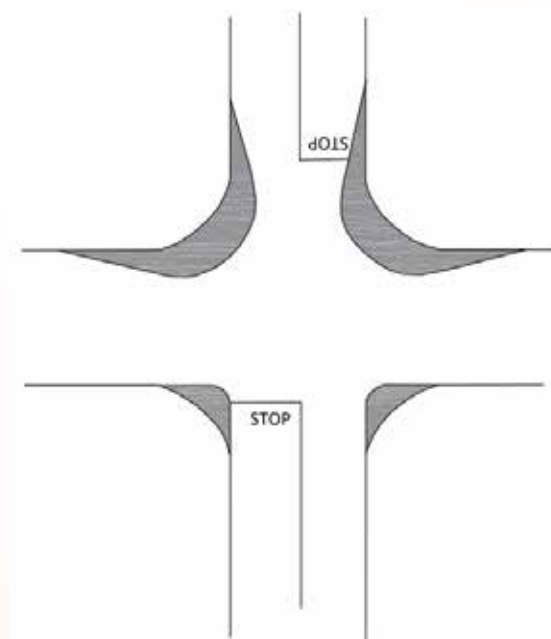
Similarly, the width of the lanes may be reduced, which causes discomfort to the driver, forcing the driver to slow down. Sufficient taper lengths should be provided to allow the driver sufficient time to react to the narrowing of the road. The minimum taper lengths should be as per the recommendations in the MoWT Road Design Manual (2010).

Kerb extensions are typically only applied in an urban setting, where pedestrians are given priority over vehicle mobility. The advantages and disadvantages of kerb extensions and smaller kerb radii are summarised in **Table 10-1**.

Table 10-1: Advantages and disadvantages of kerb extensions and smaller kerb

Advantages	Disadvantages
Improves pedestrian visibility and safe crossings	May cause congestion as turning lanes are reduced
Reduces pedestrian crossing distance	May impact large vehicle turning paths
Reduces vehicle speeds	May impact bicycle lanes
Easily and affordably implemented	May impact drainage design
Prevents illegal parking at intersections	Reduces the number of available parking spaces
Improves universal accessibility	
Promotes better sight distance at intersections	

Kerb radius reductions involve modifying the radius size at an intersection to create a sharper corner and thus a sharper turning circle. **Figure 10-1** below illustrates kerb extensions and kerb radius reductions.

**Figure 10-1: Illustration of kerb extensions and kerb radius reductions**

10.1.2 Chokers or Chicanes

The terms chicane and chokers are often used interchangeably. These are two similar interventions that essentially bring about a reduction in vehicle speeds. Both operate on the same principle of extending the kerb-line outwards (into the roadway) to narrow the available roadway width.

The term choker refers to placing kerb extensions directly opposite each other on each side of the roadway to effectively narrow the roadway to a single lane at the given point. Vehicles

are forced to slow to yield as the choker only allows the passage of one vehicle at a time. It should be noted that chokers severely restrict the capacity of the road, so they should not be implemented on trunk routes and major arterials.

In geometric design, a chicane refers to an S curve or a reverse curve – two horizontal curves that bend in the opposite direction. For example, a left-hand curve immediately followed by a right-hand curve. As described earlier, horizontal curves are quite effective in bringing about speed reduction. The smaller the curve radius, the lower the design speed. Chicanes are typically implemented when a rural highway enters a town or village. For example, when the speed limit has to change from 100 km/h on the highway to 60 km/h in town. The first curve of the chicane may be designed for 80 km/h and the second curve at 60 km/h. The vehicle traveling at 100 km/h is forced to slow down to 60 km/h before entering the town. Chicanes may be implemented along with other traffic calming interventions such as rumble strips.

Chicane in an urban setting refers to alternating kerb extensions in a staggered pattern, to create an S-shape weaving path for the road user. Both chicanes and chokers require an warning to the road users, and acceptable taper rates for the kerb extensions to prevent crashes.

Figure 10-2 below shows an illustration of a chicane.

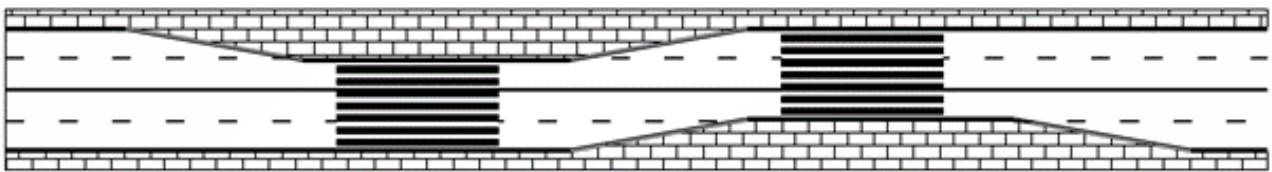


Figure 10-2: Illustration of a chicane

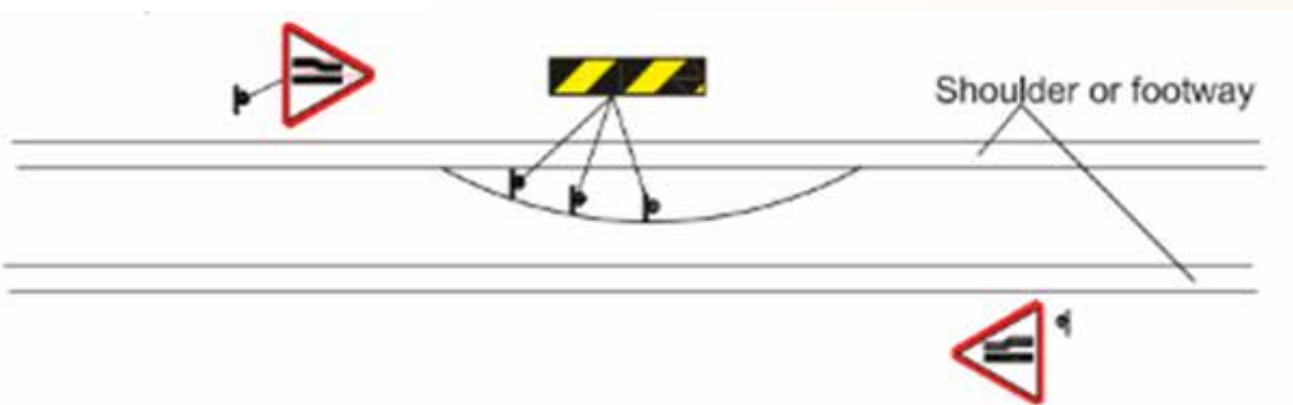


Figure 10-3: Warning signage proposed at chokers

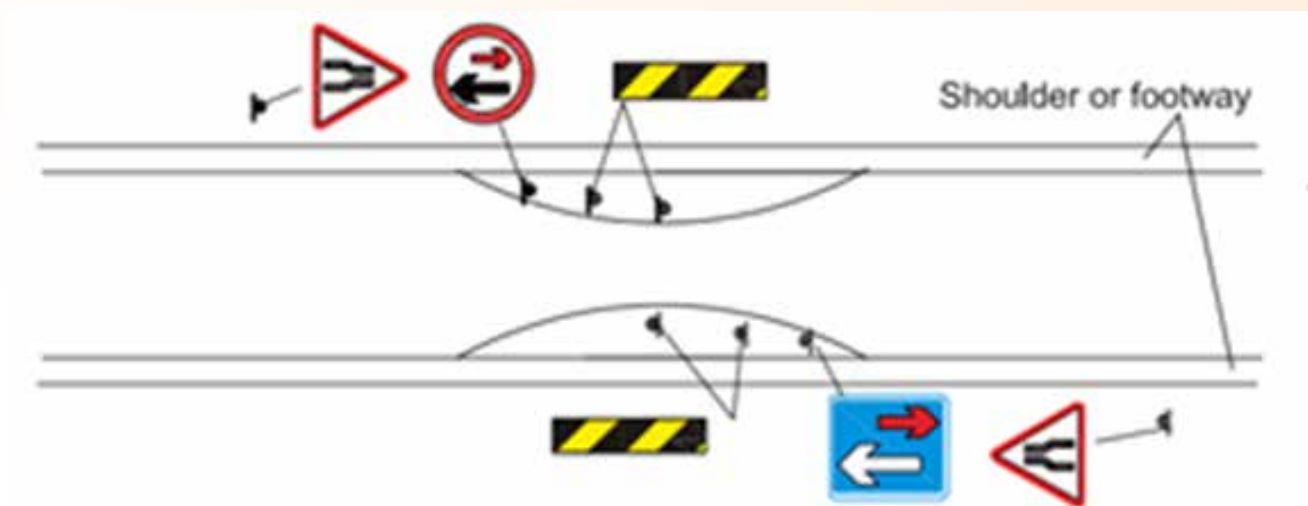


Figure 10-4: Warning signage proposed at chicanes

The advantages and disadvantages of chicanes and chokers are tabulated in **Table 10-2** below.

Table 10-2: Advantages and Disadvantages of chicanes and chokers

Advantages	Disadvantages
Discourages rat-running or cut-through traffic	Unfavorable for cycleways
Reduces speed	Chicanes only suitable for medium traffic volumes Chokers only suitable for low to medium traffic volumes
Minimises inconveniences to local traffic	Possible increase in vehicle – vehicle collision
Easily and affordably implemented	

10.1.3 Neckdowns

Neckdowns are essentially kerb extensions that are implemented mid-block in order to shorten mid-block pedestrian crossing distance. The reduced roadway width changes the drivers' perspective; therefore, the driver reduces the vehicle speed. Neckdowns require that the roadway width is reduced to the bare minimum. Where possible, it is recommended that the roadway be reduced to 3.0 m at the location of the neckdown (MoWT, 2010). The onus is on the Engineer to ensure that the design vehicle can still be accommodated through the neckdown, without colliding with the road furniture or pedestrians. Alternatively, a bypass route should be provided for the design vehicle.

Neckdowns should only be implemented in urban areas where a high volume of pedestrians cross midblock. The advantages and disadvantages of neckdowns are as detailed in the **Table 10-3**.

Table 10-3: Advantages and disadvantages of neckdowns

Advantages	Disadvantages
Reduces distance for pedestrians to cross the road	Not favourable for cycle ways
Reduces vehicle speed	Only suitable for medium traffic volumes
Easily and affordably implemented	Possible increase in crashes
	Not suitable on routes with high truck volumes

10.1.4 Roundabouts or Circles

Roundabouts, traffic circles, and mini-circles are very similar, in the sense that there is a raised island constructed in the centre of an intersection, forcing traffic to flow in a clockwise circular direction around it. However, in terms of their functionality, design and safety, they are quite different from one another.

A modern roundabout is a type of intersection control where the geometry of the circle and the approaches are designed in a specific way to limit the entry speed, circulating speed and existing speeds. These make a roundabout safer than a conventional circle. In a traffic circle, the traffic circulates in a clockwise direction, however, the speeds are not controlled through the geometry of the approaches and the circle itself. Mini-circles are a smaller version of a traffic circle, usually implemented only in residential areas.

Well-designed roundabouts are safer than other intersection control types for the following reasons:

- Due to the geometry, the operating speeds through a roundabout are slower than that of other intersection control types;
- Since the vehicles entering the roundabout have to yield to the traffic that is already in the roundabout. It also forces the vehicles entering the roundabout to slow down; and
- The number of vehicle-vehicle conflict points is reduced.

The US Federal Highway Administration publication 'Roundabouts: An informational Guide' highlights the difference between a roundabout and a traffic circle (USFHA, 2000). It also highlights the safety and design features of a roundabout. Due to the size of the splitter islands and slow-moving traffic, they accommodate NMT users better than other intersection control types besides being an effective traffic calming measure. A roundabout should be designed as per the standards prescribed in the Road Geometric Road Design Manual (MoWT, 2010). **Figure 10-5** shows an illustration of NMT at a roundabout with a separated cycleway.



Figure 10-5: Example of a roundabout showing NMT facilities with a separated cycleway

Table 10-4 below highlights the advantages and disadvantages of a roundabout.

Table 10-4: Advantages and disadvantages of a roundabout

Advantages	Disadvantages
Fewer conflict points	Could restrict large vehicle movements
Reduces speed through horizontal deflection	May be expensive to construct – due to the large diameter, if land has to be expropriated.
May reduces delays at an intersection (depending on the approach volumes)	Requires balanced traffic flows, or low volume roads
	May cause driver confusion

10.2 Vertical Deflection

This category of traffic calming measures uses vertical displacement to cause discomfort to the driver, thus slowing traffic. Obstructions are placed in the travel path which vehicles are able to travel over, however at considerably lower speeds, in order to avoid damage to the vehicle. Vertical deflections, as with horizontal deflections, target traffic speed reduction and not traffic volume. Vertical deflections can also contribute to improved pedestrian safety at crossings. These measures are not recommended along bus routes, or highly utilised emergency vehicle routes, due to the vertical clearance these vehicles require.

Vertical deflections are not ideal on roads of a higher design class or mobility routes (e.g. international trunk roads), due to the limiting functionality of the measures impose on the road. Vertical deflections need to be accompanied along with proper signage to warn the driver well ahead so that the driver can start slowing down. Vertical deflection should only be implemented on roads with design speeds lesser than 50 km/h or lower, as prescribed in the Road Design Manual (2010). Vertical deflections are difficult to maintain on gravel roads and cannot be

marked accordingly, hence they should not be implemented unless absolutely necessary. Proper signage must be provided and maintained at all times.

Several types of vertical deflections may be implemented, including:

- Speed humps, speed bumps and speed cushions; and
- Raised pedestrian crossings.

These measures are further described below.

10.2.1 Speed Humps, Speed Cushions or Speed Bumps

Although these terms are often interchanged, these are three separate traffic calming measures. Speed humps are the most commonly utilised traffic calming measures and are often mistakenly used when describing all traffic calming measures. Speed humps are raised devices that span across the entire roadway width and are parabolic in shape. The length varies with the roadway width, and the height profile is typically between 70–100 mm above the road level.

Speed cushions have a similar design to speed humps; however, they do not raise the roadway continuously across the lane but rather have gaps to accommodate a wider tyre track. This allows vehicles with a wider axle, particularly emergency vehicles, to traverse the speed cushions with no impact. Only consider this measure for use in a high emergency area or routes with very high public transport vehicles.

Speed bumps are much smaller than speed humps, with minimal width measured along the travel path, and have a drastic slowing effect. They have a similar impact as semi-spheres, which are often constructed out of plastic, and are individual spheres placed in staggered rows across the roadway. Both options are not favourable for bicycles or motorcycles due to the irregular and slippery surface. Only use speed bumps or semi-spheres in areas where speeds are already significantly reduced, and not on public roads. The advantages and disadvantages of speed humps, cushions, and bumps are detailed in **Table 10-5** below.

Table 10-5: Advantages and disadvantages of speed humps, cushions and bumps

Advantages	Disadvantages
Reduces speed extremely effectively	Slows emergency response (alleviated with speed cushions)
Minimal impact on cyclists and motorcyclists (excluding speed bumps or semi-spheres)	Creates noise and air pollution
Relatively inexpensive	Heavy vehicles may struggle to traverse them

These interventions should be designed as per the standards prescribed in the Road Geometric Design Manual.

10.2.2 Raised Pedestrian Crossings or Plateau Speed Humps

Raised pedestrian crossings are effectively plateau speed humps with the road marking provisions for a pedestrian crossing. They follow the same design as speed humps, however with a larger width, measured in the direction of travel, and a flattened section in the middle. The effectiveness in speed reduction is less than that of a speed hump, although the improved pedestrian safety may outweigh this. **Table 10-6** below shows cross-sections of a circular speed hump and a raised pedestrian crosswalk and

Table 10-7 shows the advantages and disadvantages of pedestrian crosswalks.

Table 10-6: Cross-section of a circular speed hump & a raised pedestrian crosswalk

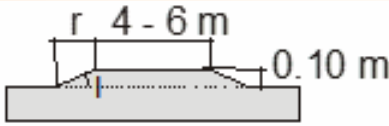
Design profile	Length profile
Circular speed hump	
Raised pedestrian crosswalk	

Table 10-7: Advantages and disadvantages of raised pedestrian crossings

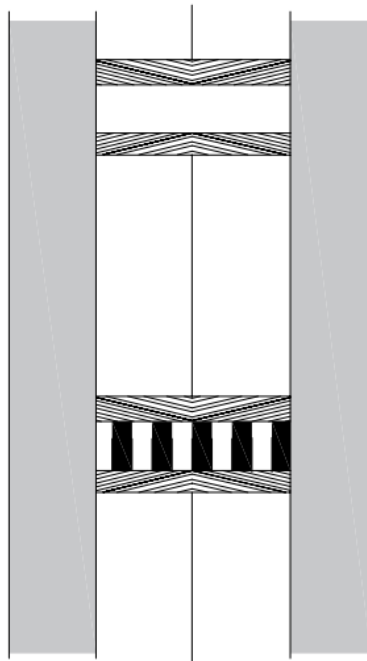
Advantages	Disadvantages
Reduces speed	Slows emergency response
Minimal impact on cyclists and motorcyclists	Creates noise and air pollution
Improves pedestrian visibility and crossing safety	Heavy vehicles may struggle to traverse them
	More expensive to install than speed humps

The typical cross-section details of a raised pedestrian crossing are shown in **Table 10-8**.

Table 10-8: Design dimensions of plateau humps

		
Car (truck) operating speed (km/h)	Ramp length, r (m)	Grade i (%)
25 (5)	0.8	12.5
30 (10)	1.0	10
35 (15)	1.3	7.5
40 (20)	1.7	6
45 (25)	2.0	5
50 (30)	2.5	4
(35)	3.3	3
(40)	4.0	2.5

A typical layout showing an arrangement of traffic calming measures under vertical deflection is shown in **Figure 10-6** below.

**Figure 10-6: Illustration of a raised pedestrian crossing**

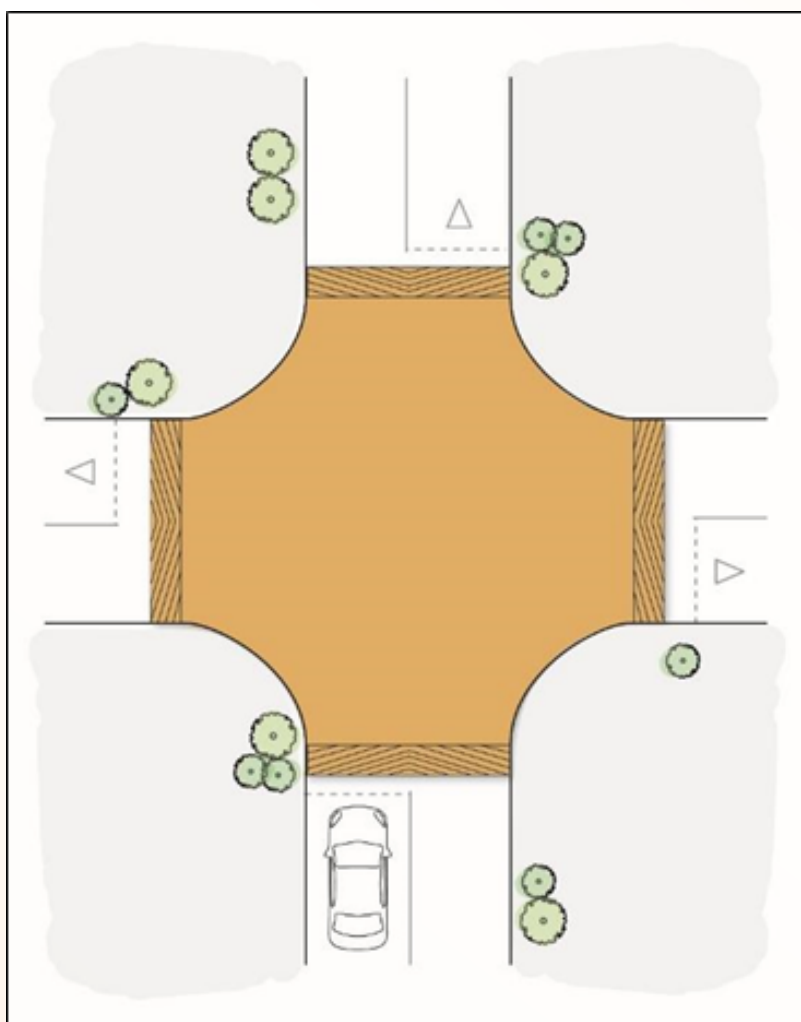
10.2.3 Raised Intersections

This measure can be considered the same as a raised pedestrian crossing, however, the plateau extends across the entire intersection. Raised intersections increase the driver awareness of the presence of an intersection and can facilitate safer pedestrian crossing movements. **Table 10-9** weighs the advantages and disadvantages of raised intersections.

Table 10-9: Advantages and disadvantages of raised intersections

Advantages	Disadvantages
Reduces speed	Slows emergency response
Minimal impact on cyclists and motorcyclists	Creates noise and air pollution
Improves pedestrian visibility and crossing safety dependent on approach controls	Heavy vehicles may struggle to traverse them
Increases awareness of an intersection	Expensive to install
	Interferes with priority controls
	Requires maintenance

A typical layout of a raised intersection is shown in **Figure 10-7** below.

**Figure 10-7: Illustration of a raised intersection**

10.2.4 Rumble Strips

Rumble strips are transverse strips across the road used to alert and warn drivers with a vibratory and audible effect before a hazard. The situations that warrant the installation of rumble strips are:

- i) Before a local speed limit e.g. in a trading centre or school zone;
- ii) At an approach to a dangerous intersection; and
- iii) Before a sharp bend.

The principles for use of rumble strips as prescribed in the MoWT Geometric Road Design Manual (2010) are:

- i) Group rumble strips in groups of 4 strips;
- ii) Strips should be no more than 10–15 mm high;
- iii) The strip width should be 0.5 m;
- iv) One set of rumble strips is usually enough within 50 km/h sections;
- v) Locate the last or only strip 30–50 m before the hazard;
- vi) Locate pre-warning sets, if used, 20–80 m before the hazard depending on speeds;
- vii) Lay yellow thermoplastic lines across the top of rumble strips for better visibility; and
- viii) Continue strips across the full width of the carriageway, including the shoulders, but terminate them before they interfere with drainage.

The advantages and disadvantages of rumble strips are detailed in the **Table 10-10** below.

Table 10-10: Advantages and disadvantages of rumble strips

Advantages	Disadvantages
Good means to draw the drivers' attention. For example, to draw attention to supplementary signage	The rate at which deterioration of material will occur is linked to traffic volumes and the vehicle
Minimal impact on cyclists and motorcyclists	Creates noise and air pollution (increases fuel consumption)
Increases awareness of a hazard	Requires maintenance

Rumble strips should be installed as per the standards prescribed in the MoWT Geometric Road Design Manual (2010) and a typical layout is shown in **Figure 10-8**.

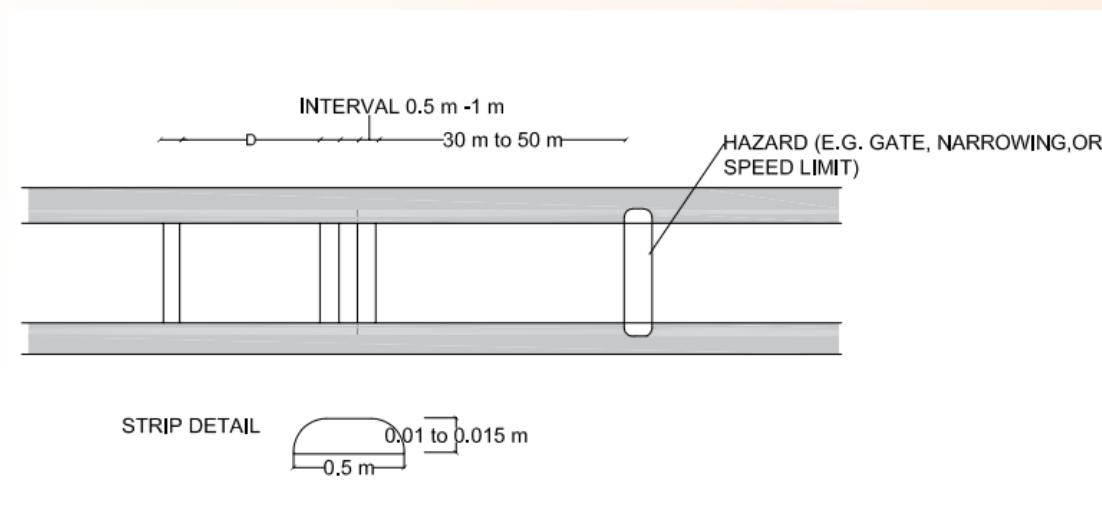


Figure 10-8: Illustration of rumble strip application

10.3 Physical Obstructions

Physical obstructions target reducing traffic volumes by redirecting through-traffic to more suitable roads. This is done through blockading or restricting vehicular access to roads or portions of roads. These measures are the most severe and have the largest network impacts. NMT can be accommodated, if required, by providing dropped kerbs.

One should be careful when recommending physical obstructions, as the impact may be felt heavily by residents and businesses. They have to deal with the consequence of the closure on a daily basis. One should avoid implementing physical obstructions on major arterials and trunk routes, as the rerouting of traffic may have an enormous impact on the traffic in the larger road network. Various types of physical obstructions can be built including:

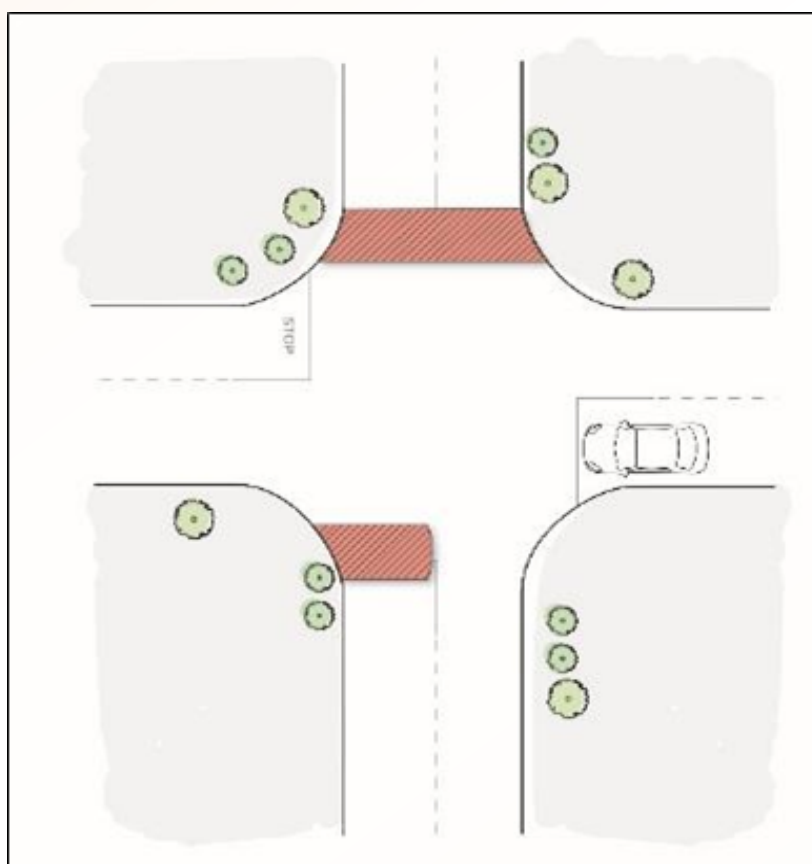
- Road closure (partial or full);
- Diverters; and
- Raised median through intersections.

10.3.1 Partial or Full Road Closures

The road in question is blocked from vehicular traffic either in both directions (full road closure) or in one direction (partial road closure) by placing a barrier across the roadway to the extent required. The barrier may be in the form of a kerb extension, or with a barricade as illustrated in Figure 10-9. The **Table 10-11** summarises the advantages and disadvantages of a road closure and **Figure 10-9** illustrates a typical partial and full road closure.

Table 10-11: Advantages and disadvantages of road closures

Advantages	Disadvantages
Reduces through-traffic	Slows emergency response
Reduces the number of conflict points	May increase trip lengths for residents
	Reduces access for residents
	May cause network traffic issues

**Figure 10-9: Illustration of a full and partial road closure.**

10.3.2 Diverters

This measure is used to restrict access through intersections. There are three types of diverters, namely diagonal-diverters, semi-diverters, and star-diverters.

Diagonal-diverters divide the intersection in question diagonally, creating two separate road systems. All through movements are prevented, thus eliminating conflict points. Semi-diverters are a reduced version of diagonal-diverters, and extend partially into the intersection rather than across the entire diagonal. In comparison to the diagonal-diverters, semi-diverters allow additional turning movements, however, the number of conflict points is still drastically reduced.

Star-diverters are barriers placed in the centre of an intersection to allow only left-turning movements. All other movements are prevented, eliminating all conflicts. **Table 10-12** below summarises the advantages and disadvantages of diverters.

Table 10-12: Advantages and disadvantages of diverters

Advantages	Disadvantages
Eliminates through-traffic	Slows emergency response
Drastically improves intersection safety	May increase trip lengths for residents
	Increased trip lengths result in more traffic on the network and higher greenhouse gas emissions
	Reduces access for local residents and businesses
	May cause network traffic issues
	Illegal U-turns

Typical layouts of a diagonal diverter, semi-diverter and star diverter are shown in **Figure 10-10**, **Figure 10-11**, and **Figure 10-12** below.

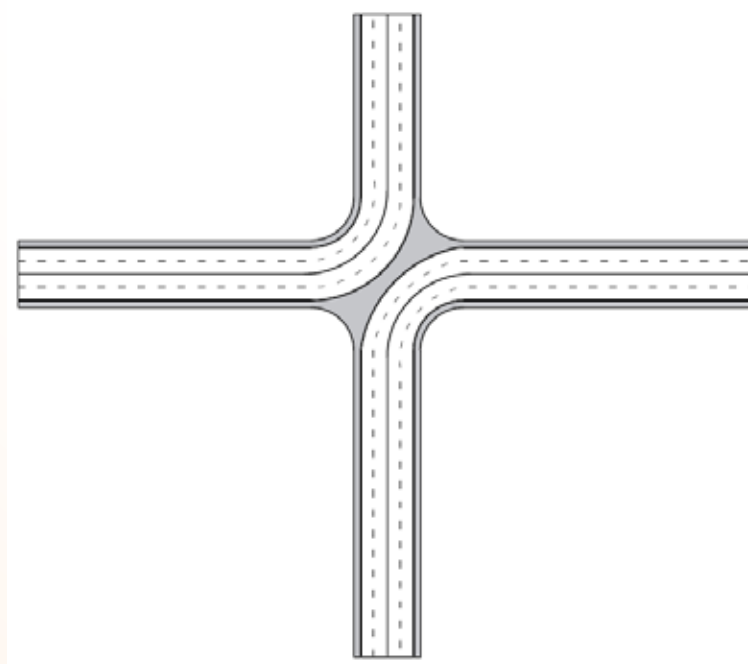


Figure 10-10: Illustration of a diagonal diverter

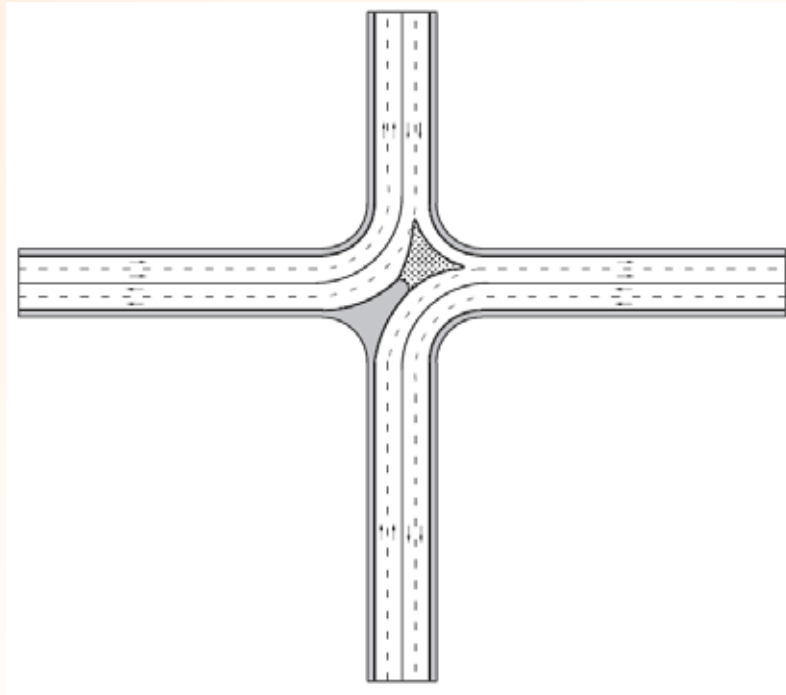


Figure 10-11: Illustration of a semi-diverter

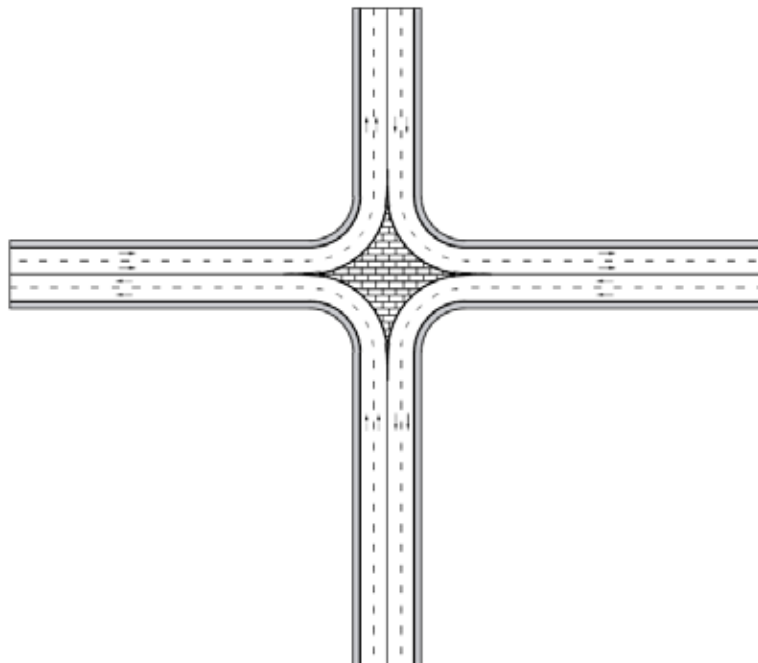


Figure 10-12: Illustration of a star diverter

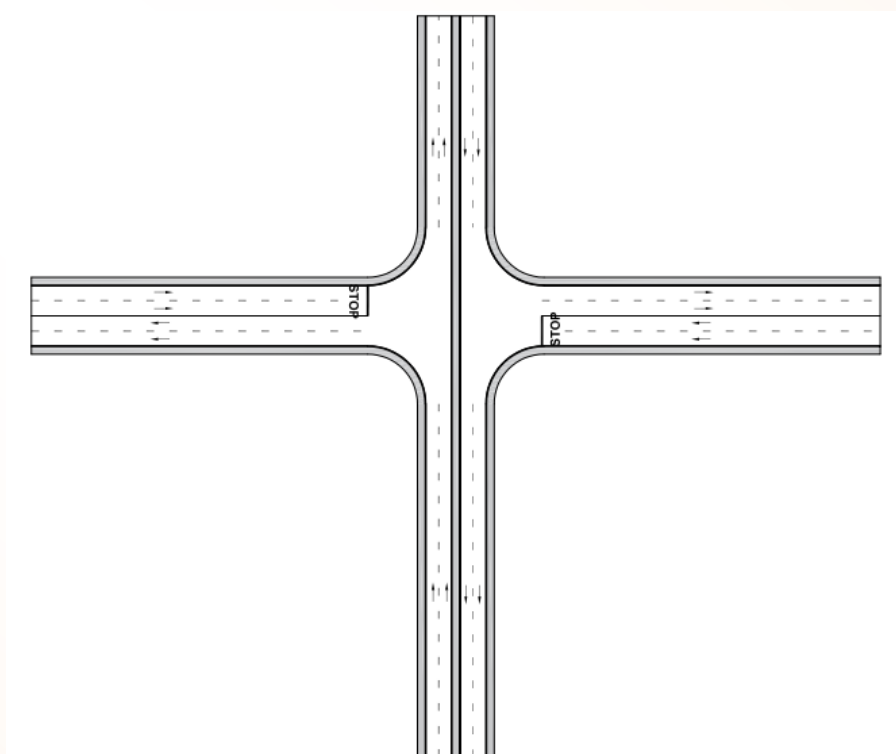
10.3.3 Raised Medians through Intersections

Raised medians through intersections combine the design of median islands with the purpose of diagonal diverters. As the name indicates, this measure is the placement of a median along the centre line of a road through the intersection, dividing the intersection into two T-junctions. Through-traffic in one direction is allowed, however many movements are still prevented. This is a helpful device to prohibit through-traffic in a residential area.

Table 10-13: Advantages and disadvantages of raised median through intersections

Advantages	Disadvantages
Reduces through-traffic	Slows emergency response
Reduces the number of conflict points	May increase trip lengths for residents, resulting in increased network traffic and carbon emissions
Provides pedestrian refuge	Reduces access for local residents and businesses
	May cause network traffic issues

A typical layout of a median through an intersection is shown in **Figure 10-13** below.

**Figure 10-13: Illustration of a raised median through an intersection**

10.4 Separation Elements

The various separation elements that can be used to separate motorised traffic from non-motorised traffic are provided here below.

10.4.1 Concrete Wall

A rigid concrete wall is one of the most effective longitudinal traffic barriers where pedestrians walk adjacent to a road. Such a wall not only serves to protect pedestrians from conflict with vehicles but can also be used to prevent pedestrians from crossing the road at undesirable locations.

Concrete barriers do not easily deflect and are the best solution for shielding pedestrians along the road. The disadvantage of concrete walls is that they are expensive to install, however, require little maintenance. **Figure 10-14** below shows a typical concrete barrier.

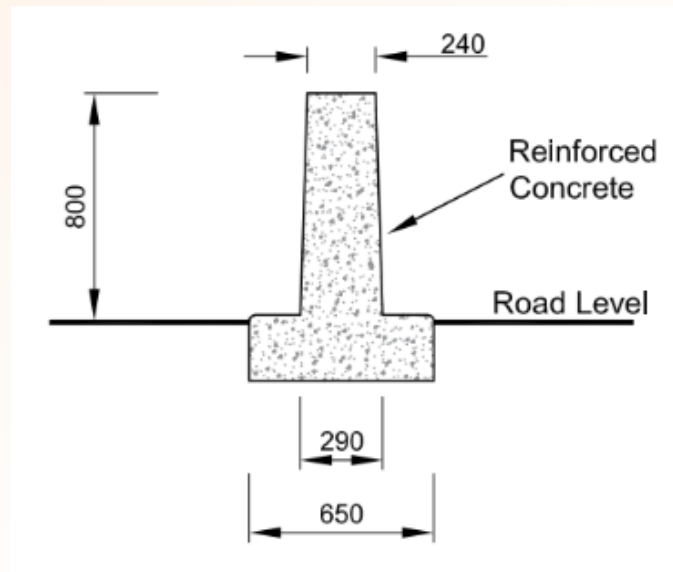


Figure 10-14: Typical concrete barrier

10.4.2 Road Shoulders

Road shoulders are able to serve as buffer zones, where there is marginal pedestrian and cyclist use; however, it is always preferable to plan for NMT separation more specifically.

The recommended separation of the effective footway from the roadway kerb-line, as suggested in the SADC-Road Traffic Signs Manual is:

- 1–2.0 m for 60 km/h operating speed;
- 2–4.0 m for 80 km/h; and
- 5–9.0 m for 120 km/h.

10.4.3 W-shaped Guardrail/Steel Beam Strong Post Guard Rail

A steel beam strong post guardrail is the most common type of safety barrier used in developing countries and is available from many sources.

As guardrails tend to deflect after a vehicle collision, designers must try to allow, at least, a 1.0 m gap between the footway and the back of guard rail element.

Due to the nature of operation and function of guardrails in which they absorb energy from a collision, periodic maintenance is required to ensure that the guardrail element is in good working order.

The basic design details are given in **Figure 10-15** below (MoWT, 2010).

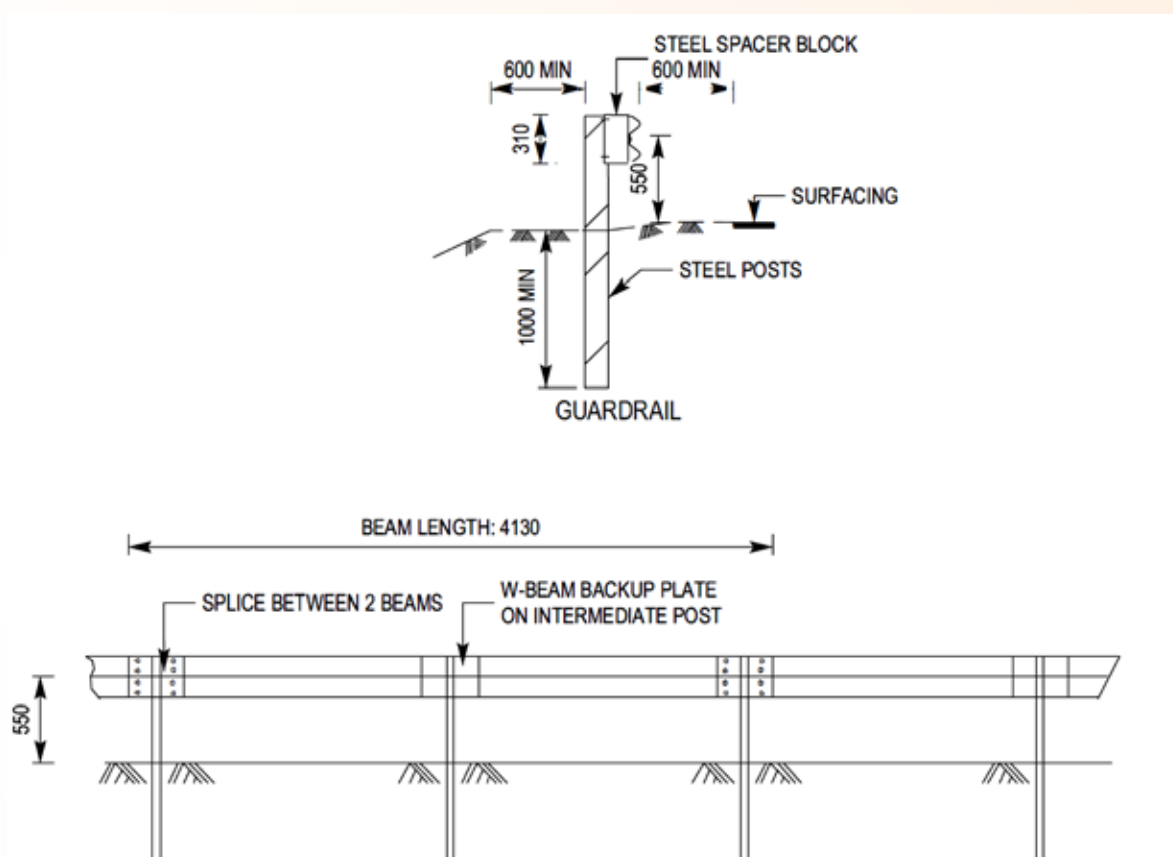


Figure 10-15: Typical detail of a guardrail installation

The concern with a guardrail installed between a sidewalk and a roadway is that pedestrians often attempt to climb across the guardrail to cross the road. This creates the danger that a pedestrian may trip and fall in front of an oncoming vehicle.

10.4.4 Bollards

Bollards provide a measure of protection for pedestrians and prevent motorists from entering footways, although in many instances they provide challenges for people with mobility impairments.

When considering the installation of bollards, take a holistic approach to ensure an appropriate level of physical protection is provided whilst minimising any negative impact on pedestrian movement. Bollards spaced 1.2 m apart have a minor effect on pedestrian convenience. Arrange bollards parallel to the flow movement of pedestrians, e.g. along a kerb edge, to promote efficient flow. An illustration of a bollard is shown in **Figure 10-16**.

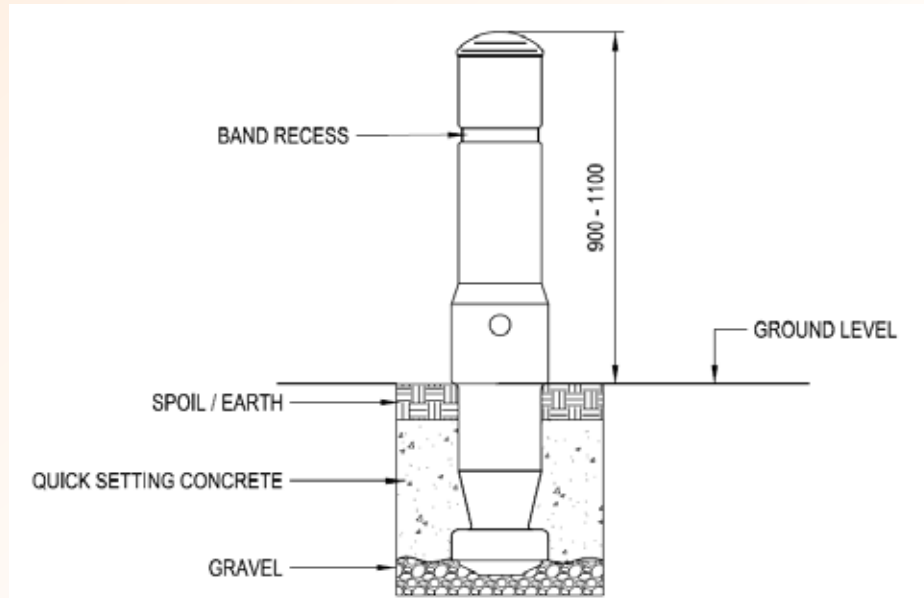


Figure 10-16: Typical detail for bollards

Retractable bollards are valuable when it might be necessary to allow for motorised access, for example, in emergency situations.

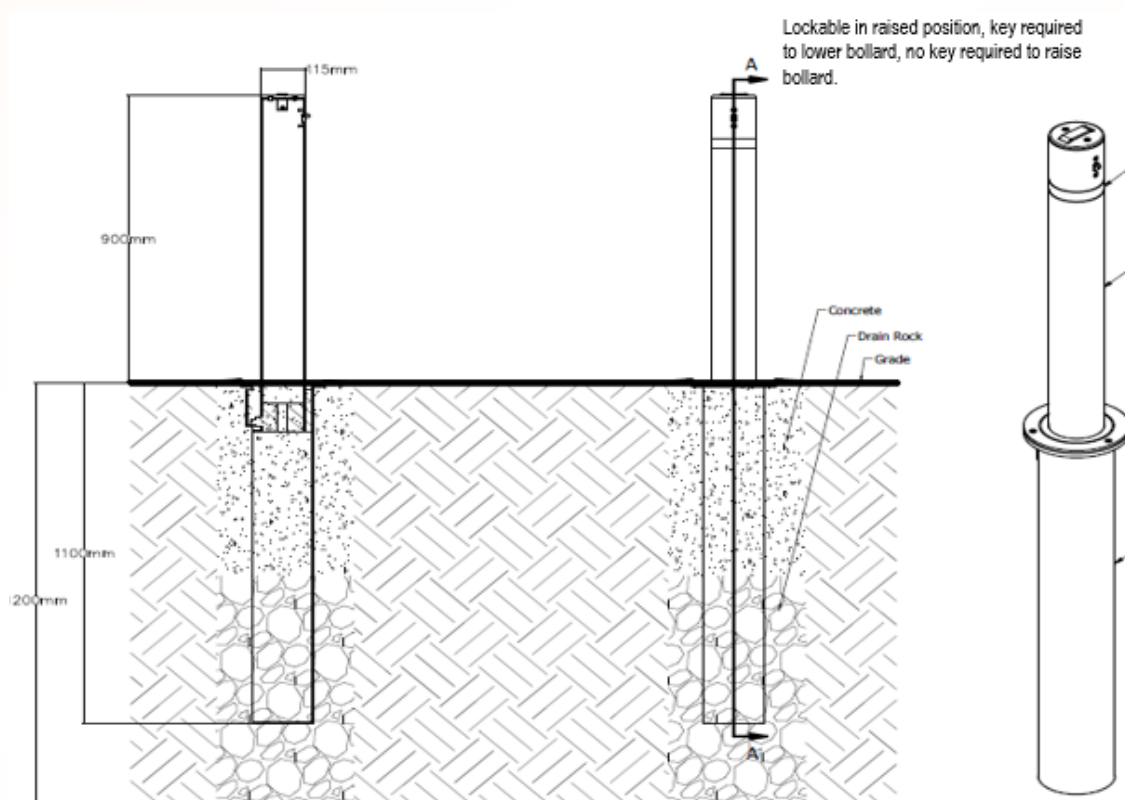


Figure 10-17: Typical detail of a retractable bollard

10.4.5 Barricades and Fences

Pedestrians exposed to serious safety hazards along a road may need channelling to areas where there is less risk. Barricades and fences are used to prevent undesirable and unsafe pedestrian and cyclist movements either across or along a road.

Barricades and fences should be considered in the following scenarios:

- Where there are high vehicle speeds and flows;
- Where visibility of pedestrians is obstructed, and the obstruction cannot be removed;
- In cases where there are complex vehicle movement patterns;
- Adjacent to pedestrian crossing points;
- In areas drivers do not expect pedestrians;
- Where there is a severe change of gradient; and
- In areas where there are hazards such as watercourses and railways.

Pedestrian barricades and fences however have the following disadvantages:

- Pedestrian routes may be made longer;
- When installed along footpaths they reduce effective width;
- Create a feeling of confinement;
- Create a hazard for errant vehicles; and
- May encourage drivers to increase speed.

Typically recommended pedestrian fence detail is given in **Figure 10-18** below.

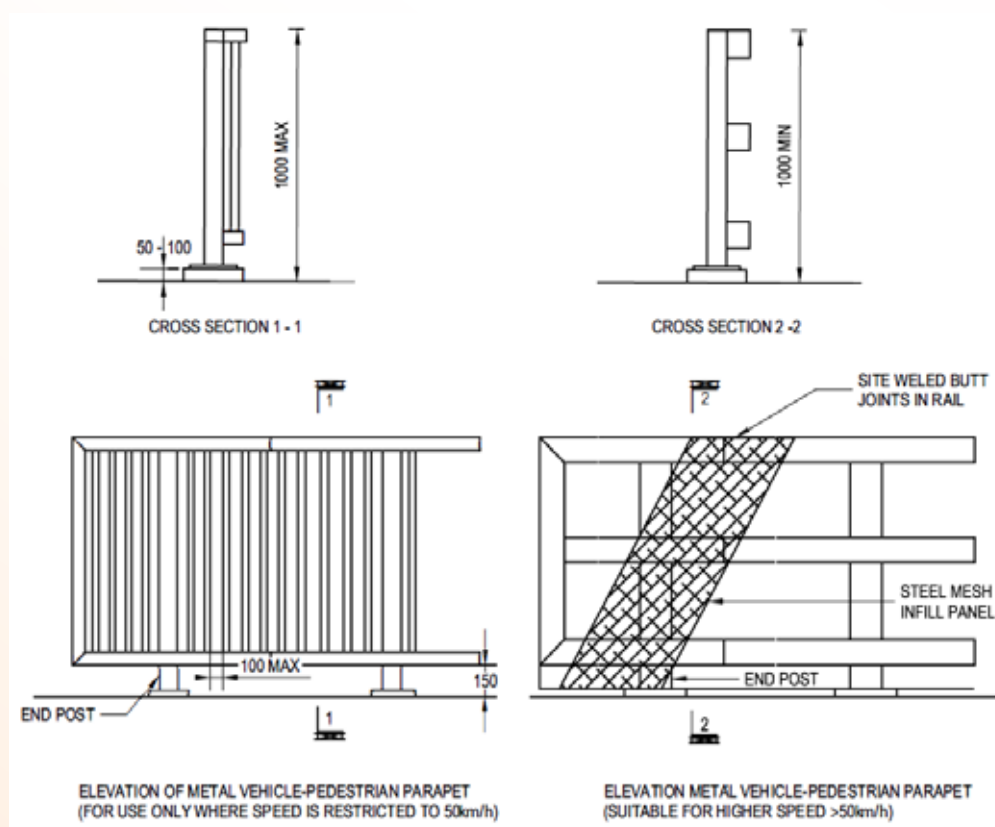


Figure 10-18: Pedestrian parapets

The design requirements of a pedestrian parapet are:

- It has a sufficient height of 1-4.0 m to prevent people from climbing over it;
- It should not have footholds that could assist a person to climb over it;
- It should be able to withstand vandals and thieves; and
- A barricade must not restrict visibility between pedestrians and drivers.

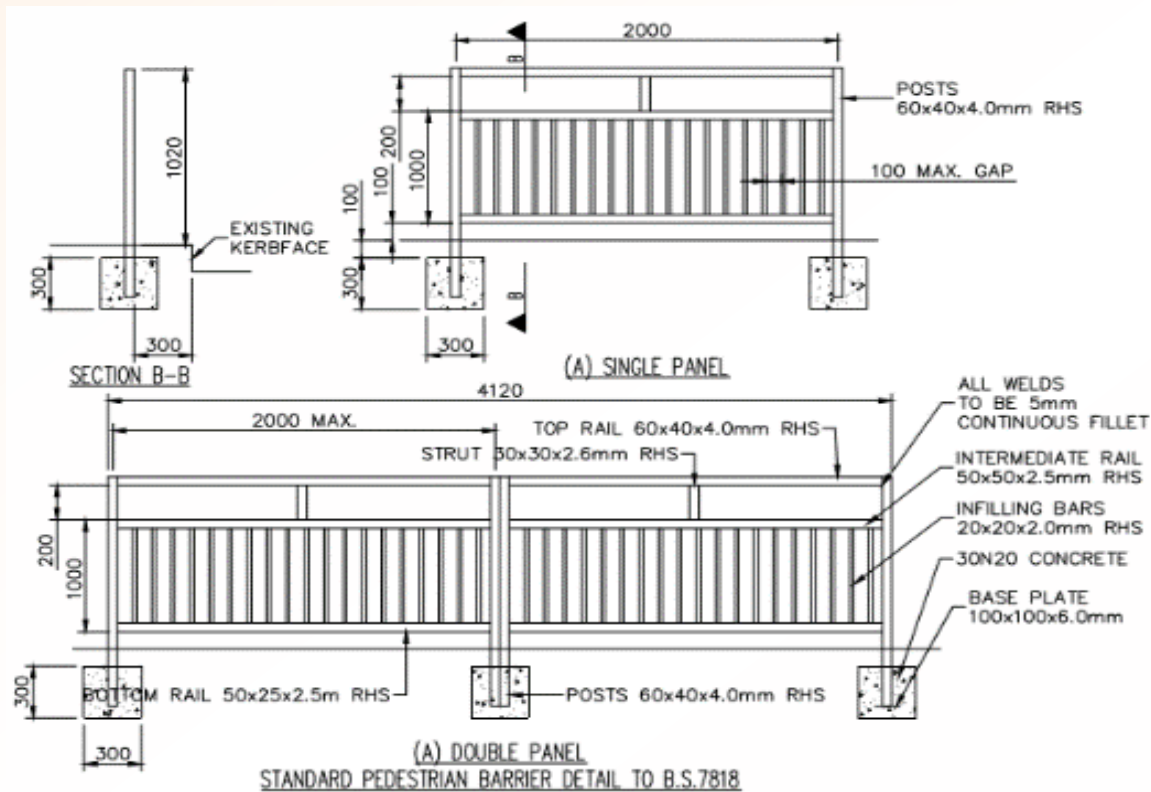


Figure 10-19: Typical fence detail

10.4.6 Kerb Treatments

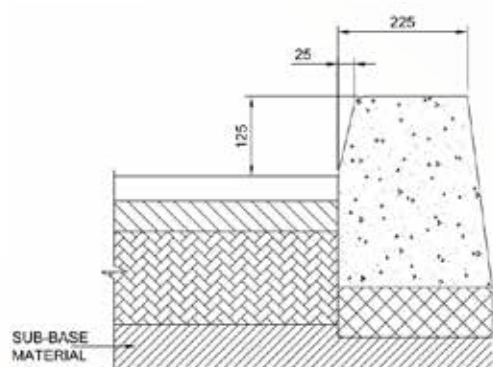
a) Concrete kerbs

Concrete kerbs are suitable for low-speed roads and are typically located in urban areas. The function of kerbs is to define the edge of traffic lanes, traffic islands, and footways.

Section 12 of Volume 1 of the MoWT Road Design Manual (2010) specifies five types of concrete kerbs:

- Barrier kerbs;
- Semi-mountable kerbs;
- Mountable kerbs;
- Flush kerbs; and
- Kerbs with integral drains.

Barrier kerbs are more applicable to NMT infrastructure. This type of kerb is used to provide protection to footways, traffic islands, pedestrian guardrails, and traffic signs. On footways, the recommended height of barrier kerbs is 125–150 mm above road level. A typical barrier kerb as taken from the (MoWT, 2010) is shown on the left of **Figure 10-20** below. The figure also shows a typical dropped kerb application at a signalised mid-block pedestrian crossing.



Typical details of bedding of kerbs and dropped kerbs at pedestrian crossings

An example of a typical dropped kerb application at a signalised mid-block pedestrian crossing.

Figure 10-20: Typical barrier kerb details

b) Dropped Kerbs at Un-signalised Locations

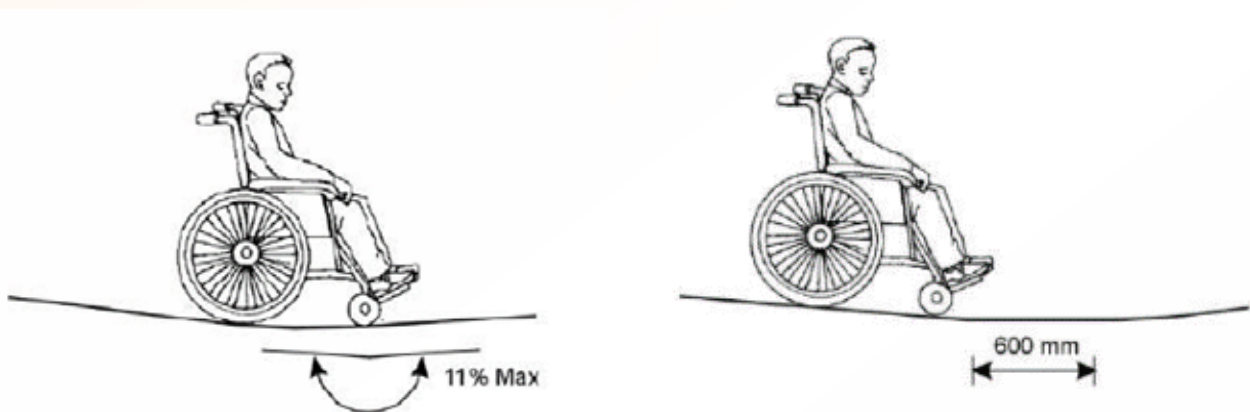
Dropped kerbs and kerb ramps are examples of good Universal Design at crossings, accesses to buildings, bus terminals, railway and port platforms, and other connecting points with different grades. Provide ramps and dropped kerbs at all pedestrian crossing points in urban locations and/or where kerbed sidewalks are provided.

The following should be considered in the design:

- The dropped kerbs must be level with the channel – there should be no stormwater lip;
- The algebraic difference between the ramp gradient and the channel should also be less than 11% as shown in Figure 10-21 (SANDoT, 2003);
- Install tactile paving at the end of the kerb ramp to aid people with visual impairments. Take guidance from a Universal Access specialist in this regard;
- Introduce a 300 mm flat precast channel;
- Kerb ramps should not project into the roadway, and be free from obstructions such as signposts. Locate them to as to prevent obstruction and/or intrusion by vehicles that are

parked along the road;

- A dropped kerb is at least 1.5 m wide however it can be reduced to 1.2 m where inadequate space is available and the ideal kerb ramp slope is 1:20. If the available space does not allow for this slope, a steeper slope can be applied, but not steeper than 1:12;
- Kerb ramps require flared sides for a transition between the ramp and the adjacent pavement. The gradient of the flared side should not exceed 1:10;
- In case a slope of 1:12 is not possible without sacrificing the landing, the whole sidewalk needs to be dropped; and
- International best practice recommends a landing at the top of the kerb ramp of width 1.2–1.5 m to provide for pedestrians and for wheelchairs to change direction. Orientate the kerb ramp perpendicular to the kerb lining.



Algebraic difference in gradients should be a maximum of 11%.

Provide a 600 mm level strip if algebraic difference exceeds 11%.

Figure 10-21: Algebraic difference between adjoining surfaces

Figure 10-22 shows photographs of a dropped kerb installation with protective bollards and a dropped kerb median break with bollard protection. Note that this particular bollard placement is a hindrance to people with mobility impairments.



Figure 10-22: Dropped kerb with bollard protection

c) Angled Dropped Kerb Treatment

All other design guidance applies for the provision of angled dropped kerbs, with the additional requirement that hazard warning tactile paving needs to follow the kerb line. Do not use other materials to fill corners, among others, as this undermines UA principles.

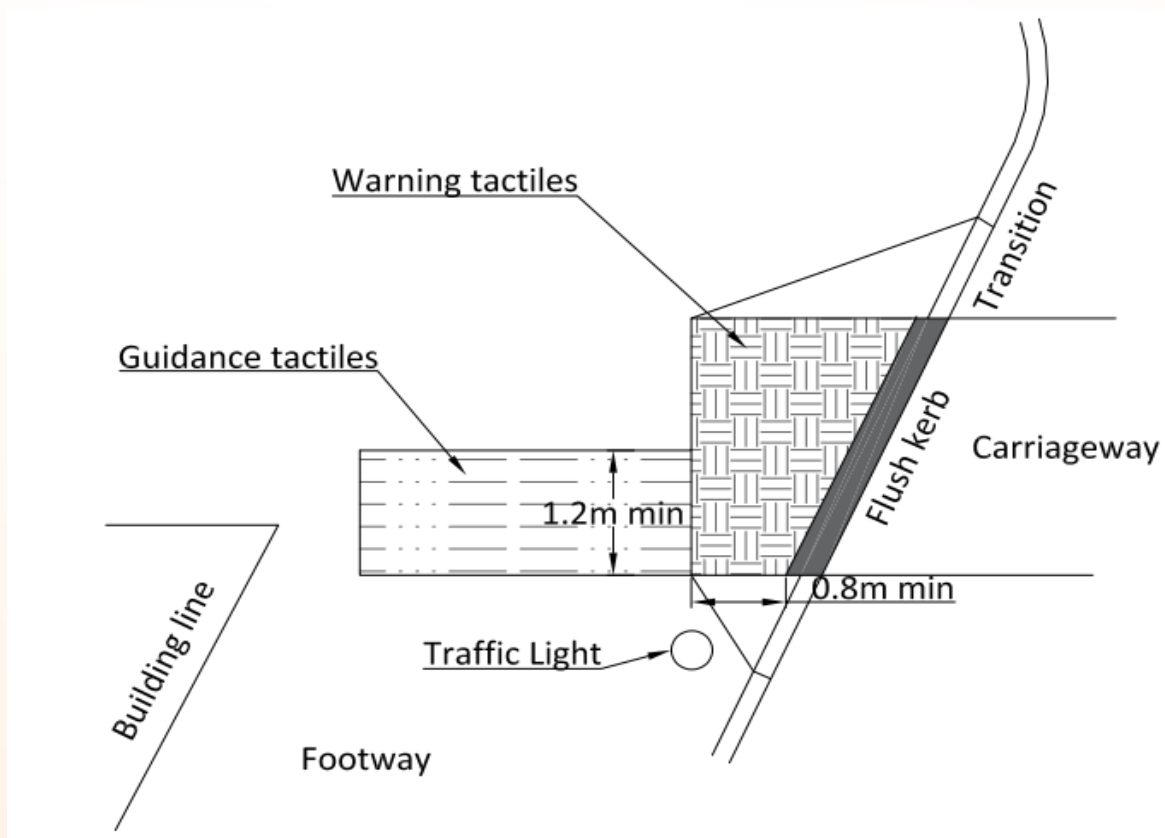


Figure 10-23: Typical layout of an angled dropped kerb treatment with warning tactile pavers at a signalised intersection (SANDoT, 2014).

d) Dropped Kerbs at Signalised Intersections

All other design guidance applies for the provision of dropped kerbs at signalised intersections, with the added provision that linear pavers are provided up to the building line, to guarantee that people with visual impairments will locate the guidance paving.

Linear paving is positioned in such a way that people with visual impairments can locate the push button location. Audible signals can assist people even further, providing specific sounds for the various traffic controller colours. The buffer strip must not protrude from the road surface (SANDoT, 2014). A typical kerb ramp plan for a signalised junction is shown in **Figure 10-24** below.

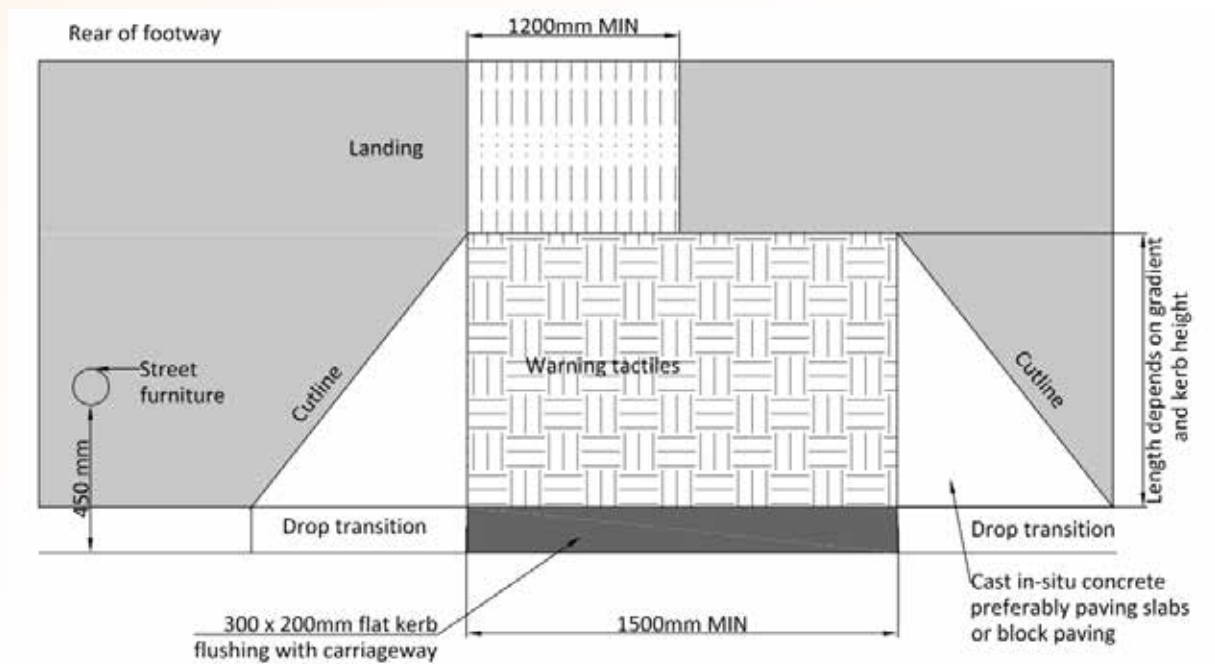


Figure 10-24: Illustration showing a dropped kerb treatment with tactile warning and directional paving

NMT Pavement Design

11 NMT PAVEMENT DESIGN

11.1 Guiding Principles of Pavement Design

The performance of a footway or cycleway is strongly influenced by the pavement materials and quality control during construction. Where possible, make maximum use of local materials to gain experience in their performance, minimise costs, and better blend with the environment. In selecting the pavement and surface type of an NMT facility, the following key factors need to be considered:

- Presence of expansive soils;
- Future maintenance costs;
- Drainage and moisture conditions;
- User needs;
- Availability of materials;
- Service level required; and
- Facility service life.

The conceptual NMT pavement design process is summarised in **Table 11-1** below.

Table 11-1: NMT pavement design process

Step	NMT pavement design process
1	Estimation of loading
2	Determination of sub-grade strength
3	Selection of pavement material type considering economics, materials, and aesthetics
4	Execution of pavement design
5	Pavement surfacing

11.2 Estimation of Design Traffic Loading

The loading regimes for NMT pavement design that have been considered for this manual are:

- Pedestrian and bicycle traffic only; and
- Vehicle traffic.

The pedestrian and bicycle traffic-only loading regime assumes that loading resulting from NMT traffic i.e. pedestrians, bicycles, skateboards, carts, etc., and similar loadings are all that will occur on the pavement during its life. NMT footways may at some point be accessed by motorised traffic e.g. during emergency situations. This loading regime is therefore only feasible in cases where no access to even emergency vehicles is available.

The vehicle traffic loading regime is applicable where there is a possibility of the NMT facility being accessed by motorised traffic. In this case, the traffic loading shall be estimated in terms of equivalent single axles (ESAs) which shall be projected and cumulated over the design period to give the design traffic loading. Under this loading regime, the ESAs shall be derived from the Annual Average Daily Traffic following the guidelines laid out in Section 2.2: Design Traffic Loading of the Flexible Pavement Design Manual (MoWT, 2010). Having determined the design traffic loading the design traffic class shall be selected using the Traffic Class Designation Table 112 below. The design traffic class shall then be used as an input in the design of the different NMT pavement types as discussed in Section 11.3.

It is paramount to note that when the loading regime of pedestrian and bicycle traffic-only is considered, the Traffic Class T1 shall be considered for the pavement design. **Table 11-2** below is an extraction of the traffic classes as taken from the Flexible Pavement Design Manual (MoWT, 2010).

Table 11-2: Traffic class designation

Traffic class designation								
Traffic ranges (million ESAs)	T1	T2	T3	T4	T5	T6	T7	T8
	<0.3	0.3-0.7	0.7-1.5	1.5-3	3-6	6-10	10-17	17-30

11.3 Determination of Subgrade Strength

Subgrade strength is an important factor that governs a pavement's structural configuration. Subgrade strength determination is based on geological and soil property assessments, in conjunction with other physical assessments such as the Dynamic Cone Penetrometer (DCP) test or in situ bearing tests, or any other means that allows realistic delineation.

The subgrade strength shall be defined by the California Bearing Ratio (CBR) and will be determined according to the procedure specified under BS 1377: Part 4: 1990. The range of CBR values representing weak to very strong soils will be 2% to 15%. The procedure detailed

in BS 1377 Part 4 aims at determining the strength of the subgrade under the wettest moisture conditions that will likely occur during the design life of the pavement.

The subgrade strength categories as detailed in the guide to bikeway pavement design for South Australia (DPTI, 2015) have been matched with the respective subgrade classes as specified in the Flexible Pavement Design Manual (MoWT, 2010) as shown in **Table 11-3** below.

Table 11-3: Subgrade strength categories

Strength category	CBR	Classification as per MOWT Flexible Pavement Design Guide (2010) Table 3-1
Low strength	>2%	S1-S2
Moderate strength	>5%	S3
High strength	>10%	S4-S6

Low strength subgrades typically comprise soils that, if in their weakest condition at the time of construction, would require pre-treatment to enable the pavement to be constructed. This pre-treatment may comprise the following:

- Removal and replacement with stronger fill material to provide a better construction platform;
- In-situ stabilisation, if soil conditions are compatible; and
- Use of a geosynthetic as a support and separation layer.

11.4 Pavement Material Type

Having ascertained the traffic loading the subgrade strength, the designer can go ahead to select an appropriate pavement using the pavement choice criteria shown in **Table 11-4**.

Table 11-4: Pavement type choice criteria

Type of pavement criteria	Unsurfaced pavement	Pavers	Rigid pavement	Flexible pavement
Comfort level and levelling	●	●●	●●●	●●●●
Material locally available	●●●	●●●	●●●	●●●
Labour-intensive construction	●●	●●●●●	●●●	●●●
Construction cost/ m ³	●	●●●	●●●	●●●●●
Maintenance cost /m ²	●●●	●●	●	●
Friction/traction	Dependent on gravel material & weather condition		●●●	●●
Recyclable material	●●●	●●		●●●●●
Stability		●●	●●	●●●

11.5 Execution of Pavement Design

11.5.1 Unsurfaced Pavement

An unsealed granular or gravel footway or cycleway may be considered as the first stage of the development of a route and usually exists before a facility is upgraded to a rigid or flexible pavement.

This pavement option may be considered where the expected volume of cyclists in particular is low and the gradients are relatively flat. Unsurfaced cycleways have higher rolling resistance and are not as easy/safe for cyclists to traverse as compared to asphalt or concrete paths, particularly in wet periods; further, not all types of bicycles can travel on such surfaces. While construction costs for unsurfaced pavements are lower, weed control and regular surface grading and replenishment with additional material generally result in higher maintenance costs.

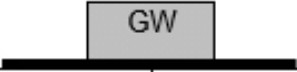
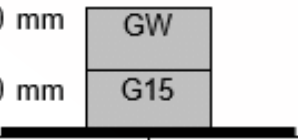
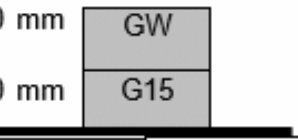
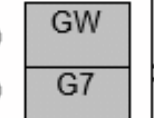
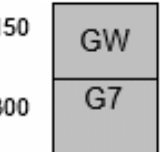
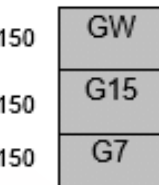
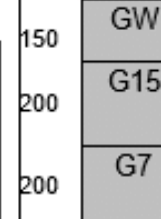
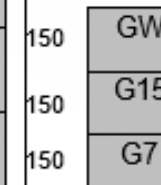
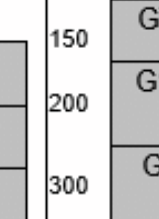
Gravel is never a suitable surface for small-wheeled devices such as in-line skates, skateboards, wheelchairs, or those with high tyre pressures, and is more appropriate for recreational routes or where bicycles with wider tyres are more popular.

The elements of an unsurfaced pavement are:

- i) Roadbed;
- ii) Capping layer if required;
- iii) Subgrade; pavement; and
- iv) Gravel wearing course.

The design of an unsurfaced pavement involves the determination of the gravel material thickness that will avoid excessive compressive strain on the subgrade and will compensate for gravel loss for the period between the re-gravelling operations. **Table 11-5** below, adapted from the MoWT Gravel Road Design Manual (2010), shall be used to select an appropriate pavement configuration for an unsurfaced pavement.

Table 11-5: Unsurfaced pavement design configurations

	AADT ¹ _{design}					
	<50		50 - 100		100 - 300	
S15	150 mm 		150 mm 		150 mm 	
S7	150 mm 		150 mm 100 mm 		150 mm 150 mm 	
S3	Dry/Moderate zones	Wet Zones	Dry/Moderate zones	Wet Zones	Dry/Moderate zones	Wet zones
	mm 	mm 	mm 	mm 	mm 	mm 

11.5.2 Flexible Pavement

Flexible pavements generally have a structure that deflects or flexes under load. They include sprayed sealed pavements and asphalt pavements. There are two types of flexible pavements to be considered for NMT.

i) Granular pavement with sprayed treatment

This type of pavement is formed by spraying a sealant over one or more gravel layers which prevent vertical penetration of surface water runoff into the gravel pavement layer.

The sealant material shall be any of the following as per MOWT General Specifications for Roads and Bridge Works (2010):

- MC 30 cut back bitumen;
- MC 70 cut back bitumen; and
- Bitumen emulsion.

Sprayed seal surfacing may not be suitable for small wheeled devices such as in-line skates, skateboards, etc. Although considered to be a practical surfacing for cyclists, sprayed seals are less preferred than either concrete or asphalt surfacing due to their inherent coarser or more variable surface texture.

ii) Graded asphalt granular pavement

This type of pavement consists of dense graded asphalt or asphaltic concrete. Asphalt concrete is a graded mixture of coarse and fine graded aggregates, mineral filler and bituminous binder which is produced, placed and compacted whilst hot.

The standard black bitumen can be coloured with heavy dosages of oxide to produce a coloured asphalt with a limited range of colours. Suffice to mention that these processes are expensive compared to the cost of normal asphalt.

Asphalt pavements are observed to have good rideability and serviceability for all wheeled and pedestrian traffic.

A design period of 15–20 years is to be adopted for flexible pavement design as per the flexible pavement design manual (MoWT, 2010). For flexible pavements, the design traffic loading shall be used to select the design traffic class as discussed in Section 11.2 above. Geotechnical investigations shall be conducted to determine the subgrade strength. The design catalogue given in Appendix C of the MoWT Flexible Pavement Design Guide (2010) shall be used to select an appropriate pavement structure putting into consideration the Climatic region of the facility being designed. Figure 11-1 below shows an excerpt of Chart W1 from Appendix C of the MoWT Flexible Pavement Design Guide (2010). If for a given NMT facility the Subgrade Class S1 and Traffic Class T2 is derived and the facility is located in a wet climatic region, the most appropriate pavement structure shall be; surface dressed seal with 150 mm base, 225 mm subbase and 300 mm subgrade.

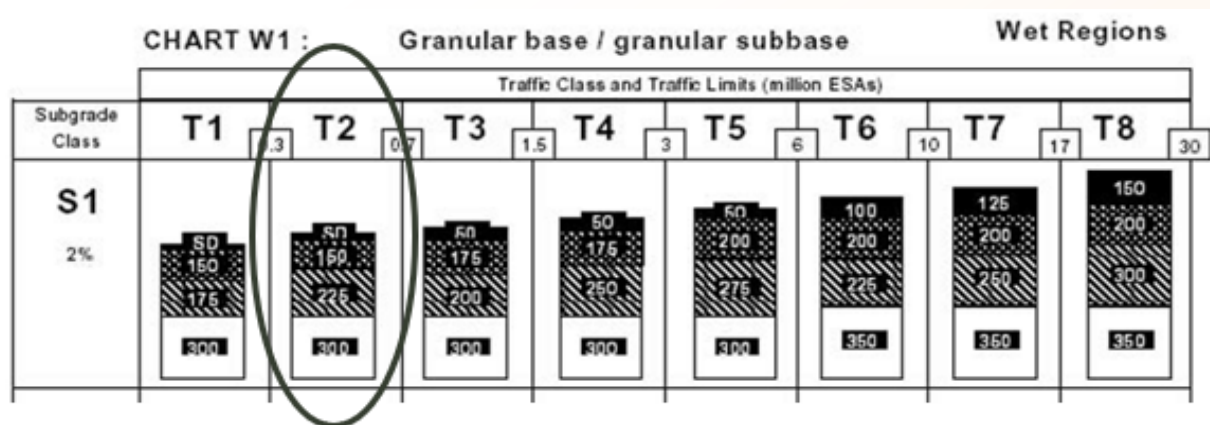


Figure 11-1: Excerpt of Chart W1 from the Design Catalogue

The surface dressed seal can be of 3 types, namely:

- i) Single surface dressing;
- ii) Double surface dressing;
- iii) Sand seal; and
- iv) Slurry seal

The designer shall select the type of seal based on the availability of materials, equipment, and the technical expertise of the implementing agency. The material specifications and construction methodology for each of the aforementioned seals shall be in line with series 4400, 4500, and 4600 of the MoWT General Specifications for Roads and Bridgeworks (2010).

11.5.3 Rigid Pavement

Rigid pavements have a rigidity associated with their slab and comprise cement-bound concrete pavements. The structural design procedure differs fundamentally from that used for flexible pavements.

A design period of 20–40 years is to be adopted as specified for rigid pavements in Section 6.2 of the MoWT Rigid Pavement Design Guide (2010). For rigid pavements, the estimated traffic loading shall be analysed to determine the thickness, joints' spacing as well as the reinforcement of the concrete slab using Figures 7.4 and 7.5 of the MoWT Rigid Pavement Design Guide (2010).

Rigid pavements (concrete pavements) are rigid and considerably stronger in compression than in tension. One of the main characteristics of rigid pavements is that a relatively thin pavement slab distributes the load over a wider area due to its high rigidity (MoWT, 2010). Concrete pavement can be installed in form of concrete slabs.

Concrete slab pavements types that are suitable for NMT facilities are:

- Jointed unreinforced concrete pavements (JUCP): a succession of cast-in-place unreinforced concrete slabs separated by joints to prevent expansion from developing stresses and to control cracks. The minimum thickness of concrete for this type of pavement shall be 125mm due to the minimal vehicular traffic loads expected along NMT pavements and 50mm if motorised vehicles are not expected to access the pavement at any one time.
- Jointed reinforced concrete pavements (JUCP): a succession of cast-in-place reinforced concrete slabs separated by joints to control cracks. The slabs are linked together by tie bars or dowels to transmit the vertical stresses. This type of pavement shall be considered for facilities shared between NMT traffic and motorised traffic and the minimum thickness of concrete of 200mm shall be adopted. The purpose of distribution steel in JRCP pavement is for crack control. Temperature steel will not prohibit the formation of cracks but acts as a

tie member, which controls the width of the crack opening. It holds tightly closed any cracks that may form, thus maintaining the pavement as an integral structural unit.

Selection of the type of rigid pavement for an NMT facility depends on factors such as traffic loading, existing soil conditions, weather, available material, and environment among others.

Rigid pavements generally consist of a subbase, and a concrete slab constructed above the subgrade constituted of the roadbed or embankment and a capping layer. A capping layer shall be installed on top of the subgrade if the CBR of the subgrade is less than 15%. A subbase shall be provided under a concrete pavement when the CBR of the subgrade is less than 30% for the following reasons:

- To provide a stable 'working platform' for the construction equipment;
- To provide a uniform concrete slab support;
- To help in the control of excessive volume changes in roadbed soils susceptible to such phenomena; and
- To prevent 'pumping' at joints and slab edges.

For the simplified experience-based design procedure exposed in this manual, the assumption is made that the materials used for construction (cement, aggregate, steel, concrete) meet the standard requirements as defined in the relevant sections of the General Specifications for Road and Bridge Works (MoWT, General Specifications for Roads and Bridges, 2005). The concrete is required to have a 28-day minimum acceptable characteristic compressive strength of 37.5 MPa, and a characteristic minimum yield strength value of 430 MPa is specified for steel reinforcement bars.

11.5.3.1 Concrete Block Pavers

Interlocking concrete block pavers of various types are used for a range of footway and cycleway pavements. They are often selected for their aesthetic appeal and placed in local recreational areas with substantial foot and cycle traffic. Coloured pavements can also be easily achieved using concrete paving blocks by applying oxides and pigments on the topping. Pavers are to be placed over one or more granular layers of not less than 25 mm of bedding sand. Jointing sand is required to assist the mechanics of interlock.

The pavement structure for concrete block pavers presented in this manual (Table 11-6) has been developed by analysing the minimum designs presented in Table 12.1 of the Bikeway pavement design, construction and Maintenance for South Australia together with the material properties presented in Series 3000 of the MoWT General Specifications for Roads and Bridge Works (2005).

Table 11-6: Pavement design of concrete block paving

Soil Strength (CBR%)	Pavement structure	
	Footway and cycle way traffic (no vehicle access)	Footway and cycle way traffic (occasional vehicle access)
2–5%	60 mm CBP 25 mm sand 150 mm G45	80 mm CBP 25 mm sand 250 mm G80
5–10%	60 mm CBP 25 mm sand 50 mm G45	80 mm CBP 25 mm sand 125 mm G80
>10	60 mm CBP 25 mm sand 50 mm G45	80 mm CBP 25 mm sand 100 mm G80

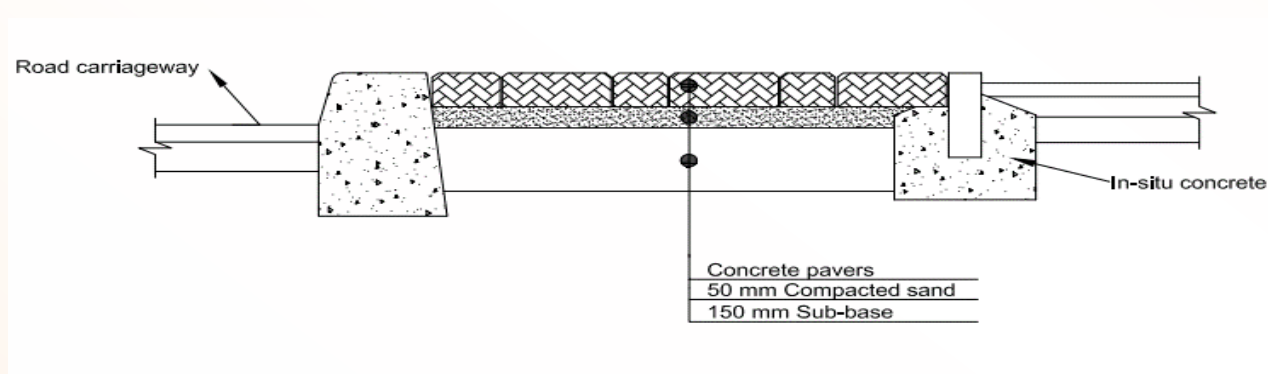


Figure 11-2: Typical block paving pavement detail

11.6 Pavement Surfacing

Surfaces for footways and cycleways must be stable (unchanged by contaminants or applied force), firm (resisting deformation either by indentations or by particles moving on its surface), and slip-resistant (sufficient frictional counter forces to the forces exerted in walking). Irregularities along a pavement could result in users tripping and falling. Surface irregularities pose greater danger to people with disabilities in the following ways:

- i) For persons in wheelchairs, irregularities in the pavement surface may cause jerks in the person's body that could be painful and result in muscle spasms.

- ii) For persons with crutches, irregularities may cause problems in the placement of the crutches.
- iii) For blind persons using canes, a sufficiently large irregularity may catch the tip of the cane, which could be potentially dangerous to such persons.

It is because of the above that concrete is a preferred material of choice for footways in urban areas as it provides a smooth, long-lasting and durable finish that is easy to construct and maintain.

The pavement should be fairly smooth and well maintained, without potholes and other undulations, which make it difficult for pedestrians and cyclists to use.

11.7 Drainage

Construct NMT facilities so that stormwater does not pond on the surface and there is no deposit of debris onto the path during rainstorms. The drainage design for footways and cycleways is, therefore, a crucial part of the design of NMT facilities. For this reason, ensure that the facilities have adequate crossfall along with drains to collect the stormwater runoff and avert water and waste from flowing onto the facilities. In low-lying areas, it may also be required to elevate the facilities to increase the level of flood protection.

On paved facilities, a crossfall of between 2–3% may be adopted as it is adequate to effectively drain the surface run-off and result in less accumulation of soil and debris. In case of an unpaved NMT facility, provide a crossfall of 5% to ensure proper drainage. However, where the facilities are shared with impaired pedestrians, provide a maximum crossfall of 2.5%.

Take into consideration the possibility of run-off flowing from the surface or adjacent catchment areas depositing soil and debris over the facilities' surfaces. Therefore, use fencing, catch drains, or other structures to trap debris before it reaches the paths.

Where the facilities are adjacent to the roadway, design and construct kerbs so that they aid in channelling the stormwater run-off to the nearest drain. Analyse the road drainage system (existing or proposed) to ensure that it is adequately sized. In cases where utility channels are provided along the footways and cycleways, ensure that covers are flush with the surface to allow for smooth movement of pedestrians and cyclists.

Lastly, the design of the NMT facilities' cross-sections should prevent the flow of surface run-off across the footways or cycleways as it damages the surface material and reduces the service period of the facilities.

Requirement of drainage and management of stormwater through an interconnected stormwater management system is very important for an NMT facility to perform efficiently and

satisfactorily throughout its design life. The high proportion of the cost of providing drainage, which in some instances is 20% of the overall cost of the upgrading works, is an indication of the importance that should be attached to the design of stormwater drainage systems.

The drainage design should focus mainly on design options for the environment and conditions of the project area. The metrological and climatic conditions should be used to establish the options optimal for the project area. Land use and the land cover pattern will be considered in determining the best drainage model practice to be undertaken in the design.

The drainage design should consider the following aspects:

- Stormwater drainage and appurtenance;
- Road surface drainage;
- Disposal of stormwater; and
- Operation and maintenance.

The hydrological analysis should be carried out as per the Uganda Ministry of Works and Transport Guidelines, Road Design Manual Volume 2: Drainage Design (2010). With regards to the flooding estimation, the following methods will be adopted in cases where there is no river that is gauged in the project area:

- Rainfall Run-off models of SCS;
- TRRL East Africa Flood Model; and
- Rational methods for catchments less than 0.8 km².

The hydraulic calculations will be based on the design floods as estimated and by adopting the following Manning – Strickler roughness coefficients.

- Concrete pipe culverts $n = 0.013$
- Concrete box culverts $n = 0.015$
- Grassed channels $n = 0.03$

In designing the appropriate sizes for the culvert structures, the parameters considered include Headwater depth, culvert alignment, gradients and minimum sizes to adopt. A culvert shall be aligned along the natural drainage line. Where conditions call for skewed alignments, a reduced degree of skew angle shall be investigated in order to shorten the culvert and reduce costs.

The culvert skew shall not exceed 45° as measured from a line perpendicular to the roadway centreline. Velocity is associated with gradient and therefore a minimum of 2% slope and a

maximum of 10% gradients have been used to ensure an acceptable range of velocities. Inlet and outlet structures are required to prevent scouring of the roadway embankment, to provide a transition from a channel to the culvert, and to improve the hydraulic performance of the culvert. The end type structure shall consist of a Composite headwall/wingwall/apron structure. The design of side drains will consider the recommendation of the MoWT Guideline (2010) and a return period of 10 years be adopted. While the rational method will be considered for flood estimation.

Construct NMT facilities so that stormwater does not pond on the surface and there is no deposit of debris onto the path during rainstorms. The drainage design for footways and cycleways is therefore a crucial part of the design of NMT facilities. For this reason, ensure that the facilities have adequate crossfall along with drains to collect the storm water runoff and avert water and waste from flowing onto the facilities. In low-lying areas, it may also be required to elevate the facilities to increase the level of flood protection.

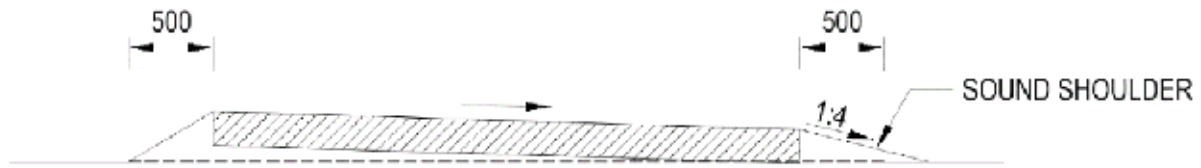
On paved facilities, a crossfall of between 2–3% may be adopted as it is adequate to effectively drain the surface run-off and result in less accumulation of soil and debris. In case of an unpaved NMT facility, provide a crossfall of 5% to ensure proper drainage. However, where the facilities are shared with impaired pedestrians, provide a maximum crossfall of 2.5%.

Take into consideration the possibility of run-off flowing from the surface or adjacent catchment areas depositing soil and debris over the facilities' surfaces. Therefore, use fencing, catch drains, or other structures to trap debris before it reaches the paths.

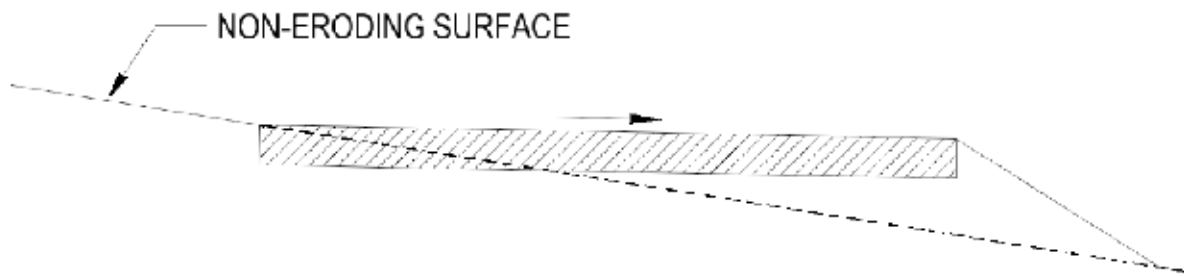
Where the facilities are adjacent to the roadway, design and construct kerbs so that they aid in channelling the stormwater run-off to the nearest drain. Analyse the road drainage system (existing or proposed) to ensure that it is adequately sized. In cases where utility channels are provided along the footways and cycleways, ensure that covers are flush with the surface to allow for smooth movement of pedestrians and cyclists.

Lastly, the design of the NMT facilities' cross-sections should prevent the flow of surface run-off across the footways or cycleways as it will damage the surface material and reduce the service period of the facilities.

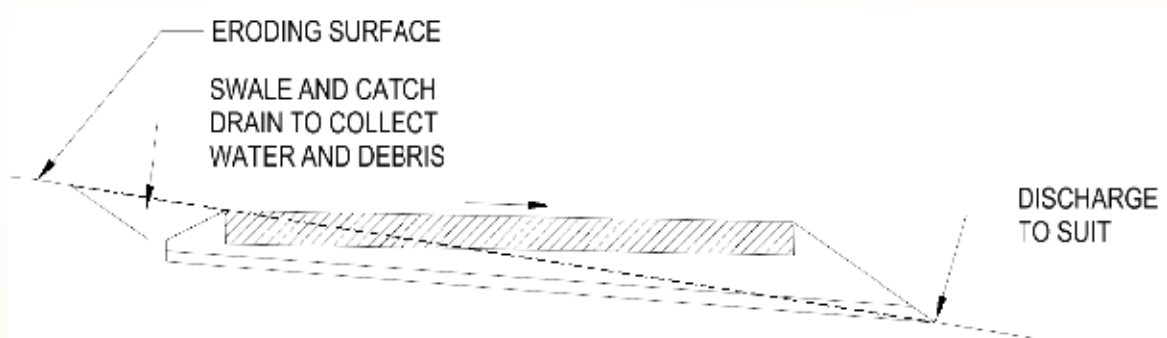
Figure 11-3 show typical cross-sections of drainage patterns on different NMT facilities:



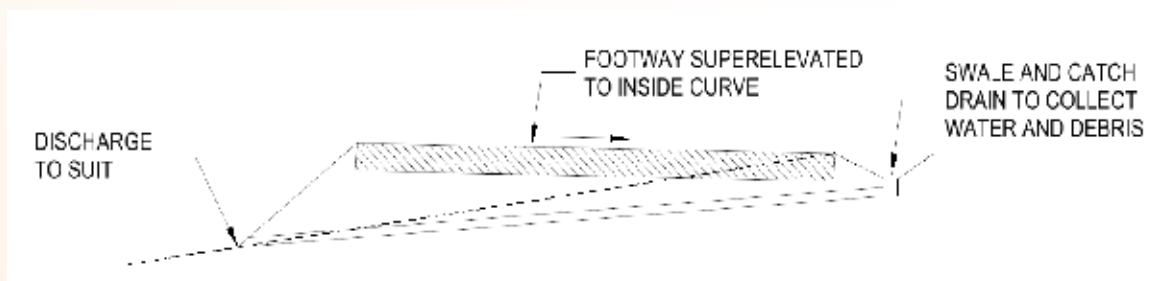
A typical cross-section where the elevated footway is in a flat terrain.



A typical cross-section where the footway slope is flatter than the existing terrain.



A typical cross-section where the footway slope is flatter than the existing terrain with a drainage channel.



A typical cross-section where the footway slope is super-elevated to the inside curve with a drainage channel.

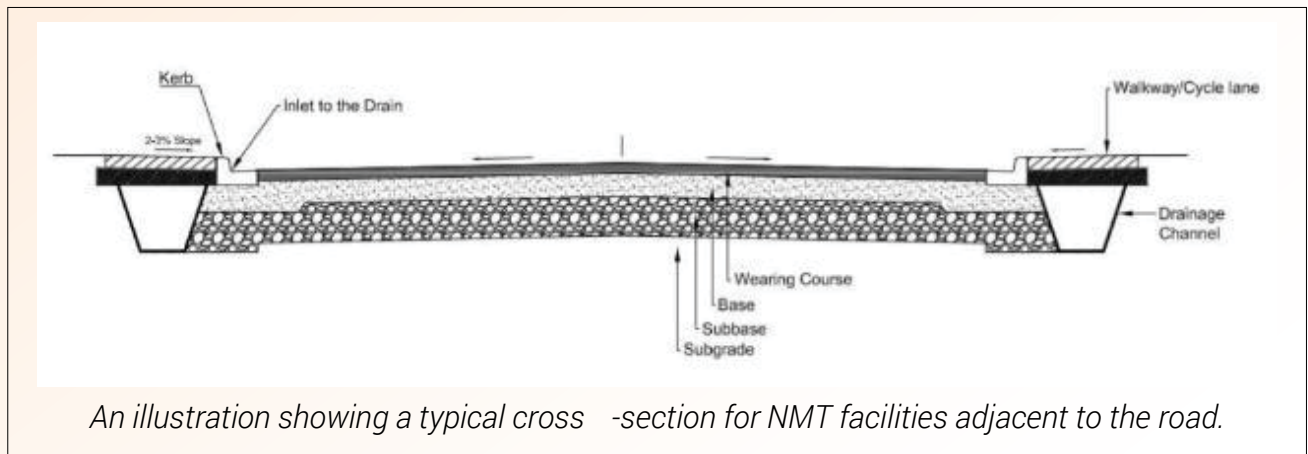


Figure 11-3: Typical drainage treatments

11.7.1 Maintenance of Drainage Facilities

The capital cost involved in the construction of drains is less than that of the total expenditure involved in providing that infrastructure in the form of carriageway footpath medians streetlights and other furniture. Like any other capital asset, stormwater drainage systems also need constant maintenance if the investment is to serve the purpose meant for.

The system of maintenance can be classified into the following three categories:

- Continuous regular maintenance;
- Periodic maintenance; and
- Special maintenance /repair for improvement.

Proper operations and maintenance are crucial for any system to be functional to the designed capacity and its durability as well. The principal activities in maintenance are:

- Desilting;
- Removal of solid waste;
- Periodic cleaning; and
- Drain inlet connectivity.

Some of the common deficiencies encountered in road drainage facilities and suggested remedies are given in **Table 11-7**.

Table 11-7: Common Road drainage deficiencies

Deficiency	Cause	Remedy
Ponding	Inadequate cross-section, formation of depression or settlement in bed, bed erosion	Deepening the drain Re-filling eroded or depressed area
Silting	Invert slope inadequate, excess soil entry into the system, less flow compared to the design section	Improvement in slope if possible. Check entry points for silt rubbish etc. provision of grating at entry points
Blockage due to debris vegetation etc.	Uneven drain bed absence of maintenance and cleaning	De-silting and cleaning Provision of grating at entry points
Erosion of bed and cross-section	Steep invert slope caving in of sides because of lack of lateral support	Provide a flatter slope with drops if needed. Adequate side support, re-alignment if required.

11.8 Grates

Wherever possible, place grates in the furniture zone. When this is not possible, grates are to be level with the surrounding footway surface and orientated to ensure the grating gaps are compliant with the practice below.

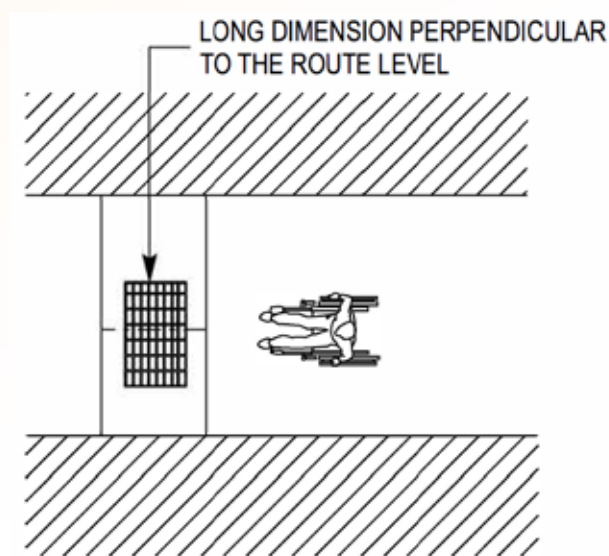


Figure 11-4: Illustrations of good grate treatment within a footway

11.9 Case study

Design Example 1

An unsurfaced footway is being planned along a community access road in a wet climate region with an AADT of 30 vehicles per day. Geotechnical investigations have revealed a subgrade CBR of 5%. What would be the most applicable pavement structure?

Step 1: Determination of the subgrade strength category.

Using **Table 11-3** the subgrade strength category for this road is S3

Step 2: Selection of an appropriate pavement structure

Using **Table 11-3**, an appropriate pavement structure is selected by reading off the values of the subgrade strength category and the traffic volume as shown below.

	AADT ¹ _{design}					
	<50		50 - 100		100 - 300	
S15	150 mm GW		150 mm GW		150 mm GW	
S7	150 mm GW		150 mm GW 100 mm G15		150 mm GW 150 mm G15	
S3	Dry/Moderate zones	Wet Zones	Dry/Moderate zones	Wet Zones	Dry/Moderate zones	Wet zones
	mm 150 150 GW G7	mm 150 300 GW G7	mm 150 150 GW G15 G7	mm 150 200 GW G15 G7	mm 150 150 GW G15 G7	mm 150 200 GW G15 G7

The appropriate pavement structure shall be 150mm Gravel Wearing Course and 300mm Base composed of G7 material.

Design Example 2

An NMT exclusive facility is envisaged through an urban marketplace. The subgrade strength has been determined to be 10%. If the Urban municipal council intends to use a flexible pavement, what pavement structure should be implemented for this facility.

Step 1: Determination of the traffic Loading.

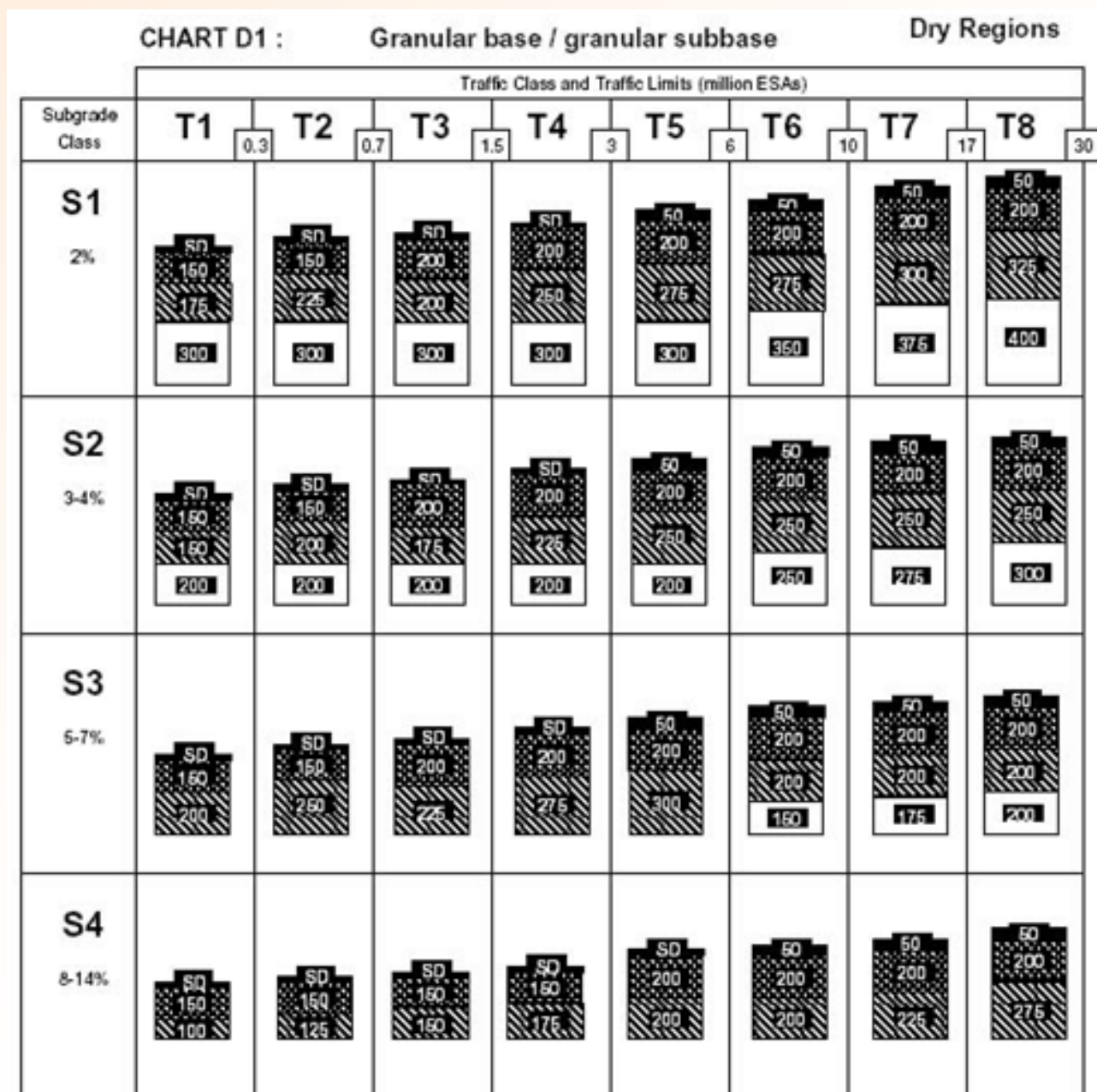
Since it is an NMT exclusive facility, a pedestrian and bicycle traffic only loading regime is appropriate and the lowest traffic loading is adopted for design i.e. T1.

Step 2: Determination of the Subgrade strength category.

Using table 11-3, the subgrade strength category is read off as S4

Step 3: Selection of the appropriate pavement structure using the design charts.

Assuming the facility is located in a Dry Climatic region, the appropriate flexible pavement structure shall be selected from Chart D1 in the MoWT Road Design Manual Vol 3, Part 1: Flexible pavements.



From the chart above the appropriate pavement structure shall be Surface dressing for the wearing surface, 150mm granular base and 100mm granular sub-base.

Design Example 3

A footway and cycleway are to be constructed within a university. It is envisaged that both the footway and cycleway shall occasionally be accessed by vehicles delivering supplies to the university. If for aesthetic reasons the university desires to use concrete block pavers, what would be the recommended structure of the pavement assuming a subgrade strength of 5%? The appropriate pavement structure shall be selected from **Table 11-6**.

Soil Strength (CBR%)	Pavement structure	
	Footway and cycle way traffic (no vehicle access)	Footway and cycle way traffic (occasional vehicle access)
2–5%	60 mm CBP 25 mm sand 150 mm G45	80 mm CBP 25 mm sand 250 mm G80
5–10%	60 mm CBP 25 mm sand 50 mm G45	80 mm CBP 25 mm sand 125 mm G80
>10	60 mm CBP 25 mm sand 50 mm G45	80 mm CBP 25 mm sand 100 mm G80

Construction Works and Maintenance

12 CONSTRUCTION WORKS AND MAINTENANCE

The construction of NMT projects and the maintenance thereof albeit similar to other roadworks have a few unique characteristics that will be eluded to in the section below.

12.1 Construction Works

Construction and Construction supervision of NMT projects shall be guided by the Ministry of Works General Specifications for Roads and Bridge works. The aforementioned document is structured into seven series as detailed below;

- Series 1000: General
- Series 2000: Drainage
- Series 3000: Earthworks and Pavement Layers of Gravel or Crushed Stone
- Series 4000: Bituminous Layers and Seals
- Series 5000: Ancillary Roadworks
- Series 6000: Structures
- Series 7000: Tolerances, Testing and Quality Control

All relevant requirements of these general specifications for a particular Item of work shall be complied with under the supervision of the Engineer.

12.2 Maintenance

When construction of an NMT facility has been completed and handed over to the client, this marks the start of the operational and maintenance stage when the facility is in use and the benefits are realised.

Maintenance in basic terms involves the process of preventing something from breaking down or bringing something back to working order. Other objectives of maintenance include maintaining a safe, aesthetically pleasing, and acceptable level of service. NMT infrastructure is often unmaintained, and if the facility is not well maintained at regular intervals, it is likely to fail or disintegrate. The cost of repairing or rehabilitating or even replacing the asset would far outweigh the maintenance costs. Maintenance of these facilities is therefore required to keep

the facilities in good condition, as close to the original (design) standard as possible without any major investments. This enables uninterrupted movement of pedestrians and cyclists safely and efficiently.

NMT facility maintenance provides the following benefits:

- Provides a continuous acceptable condition of the NMT facility to allow for convenient, uninterrupted, safe, and efficient travel of pedestrians and cyclists along a route;
- Protects the adjacent resources and user safety;
- The least long-term costs for the road agency, because by avoiding premature deterioration, high rehabilitation costs will be saved; and
- The environmental effects of maintenance are less than those of rehabilitating or replacing the infrastructure.

Maintenance of NMT facilities requires proper management to maximise the life of the facility and should be carefully planned and implemented by the responsible authority.

Maintenance works for roads and NMT facilities by designated agencies shall be based on technical standards set in the road maintenance management manual (MoWT, 2010), Road maintenance specifications, (MoWT, 2010), pavement rehabilitation manual, (MoWT, 2010), general specifications for roads and bridges, (MoWT, 2005) and District Road Works manuals.

12.2.1 Guiding Principles

The maintenance works on NMT infrastructure are categorised into four categories; i.e. routine, recurrent, periodic, and urgent maintenance. The activities involved in each of the aforementioned maintenance categories are presented in **Table 12-1**.

Table 12-1: Maintenance Categories

Maintenance category	Definition	Activities
Routine maintenance	Maintenance is required continually on every road despite its engineering characteristics or traffic volume. It may be carried out manually (cyclic maintenance activities conducted throughout the year involving simple but vital tasks) or mechanised (recurrent or reactive maintenance activities that are undertaken at least once a year)	Cleaning of the pavement Cleaning and replacement of luminaire for street lighting Grass trimming Pavement repair Repair of damaged signs Repair of damaged culverts Vegetation control Shoulder recharging Drainage repairs for paved and unpaved facilities Desilting and cleaning of drainage channels and culverts Spot gravelling
Recurrent maintenance on paved roads	Maintenance is required at intervals during the year with a frequency that depends on the volume of traffic using the road.	Sealing of cracks Pothole repair Repair of road edges Replacement of damaged paving blocks
Periodic maintenance on paved roads	Maintenance required only at intervals of several years. To improve surface and structural integrity	Resealing Re-gravelling Pavement re-marking Waterproofing
Urgent maintenance	Maintenance is needed to deal with emergencies and problems calling for immediate action when a road is blocked.	Removal of obstacles such as vehicle accident wreckage Placement of warning signs Creation of diversions

In order to manage the NMT assets, it is recommended that an asset management system is maintained. These management systems enable a systematic approach to monitoring the operations and condition of the NMT facilities and determining the necessary maintenance required to allow the infrastructure to continue to operate efficiently. Critical activities required for efficient management of maintenance include:

i) Monitoring of assets and updating the asset register

NMT infrastructure should be continuously monitored to confirm whether it conforms to the pre-set user standards. NMT inspections should be conducted and assessment of the facility should be based on the condition, function and ambiance of the facility with condition surveys collecting data on clearly defined indicators. The condition survey should assess the general condition of the NMT facility, identify critical sections in terms of surface area, depth of damage, thickness, type, extent, and severity of damage; diagnose defect causes; and determine the maintenance needs of the road network. This will enable the preparation of detailed operation plans for routine and periodic maintenance.

ii) Determining maintenance feasibility

Maintenance of an asset could, sometimes, prove to be unfeasible. Before conducting maintenance, the solution should be first evaluated to determine whether it is a feasible solution or not. If there is a feasible solution, maintenance should be conducted. If it is not feasible to maintain the asset should be rehabilitated or replaced.

iii) Conducting maintenance

This involves the execution of the necessary maintenance activities on a facility. Feasible periodic and preventative maintenance should be conducted regularly. A maintenance plan should be developed and followed to allow for the longest possible service life of an asset.

iv) Rehabilitation where necessary

It might not always be feasible to continue maintaining the NMT facility. As the facility gets old, the cost of maintenance will keep going up. At a certain point in time, the cost of replacing or rehabilitating an asset will outweigh the cost of maintaining the asset. For example, there may be excessive maintenance that has been conducted on a cycleway which leads to poor riding quality. In this case, the cycleway may be rehabilitated.

v) Road Safety aspects of maintaining NMT

There is an even greater need to maintain NMT facilities as compared to road infrastructure, due to the very nature of vulnerable road users using NMT facilities. For example, even though a vehicle can more easily negotiate a few missing pavement bricks or a tree root lifting the road surface or some water damming in the road, but the above creates a real hazard to a pedestrian or cyclist that needs to step aside, swerve and cause serious injury.

For this reason, special attention needs to be given to maintaining NMT facilities to a safe standard. Regular inspections to include notes of the following:

- Potholes;
- Missing paving bricks;

- Tripping hazards like movement in concrete;
- Overgrown landscaping that can obscure or hurt pedestrians and cyclists;
- New structures or signs added that can interfere with the straight movement of the NMT user; that can obscure the view or create a walk-in hazard; and
- Drainage problems.

12.2.2 Maintenance Planning

Having an effective maintenance strategy that eliminates not value-added activities, maximises condition-based maintenance and focuses resources on the critical assets of vital importance. The execution of a maintenance activity of an NMT asset can be summarised in the schematic

Figure 12-1 below.

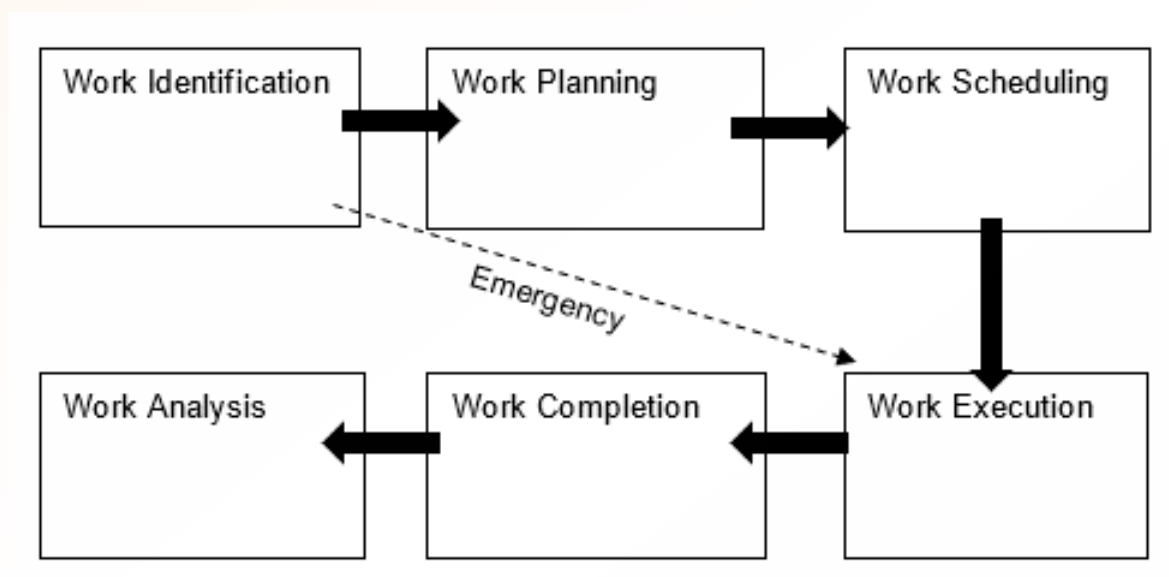


Figure 12-1: Schematic representation of maintenance planning and Implementation

The maintenance planning principles applicable to NMT infrastructure are:

i) Set up a separate department

Maintenance planning should be in a separate department / team to facilitate specialisation in planning and scheduling techniques while focusing on future work.

Focus on future work

Maintenance planners should focus on future work. This allows the execution teams to work primarily on planned work.

ii) Maintain an asset database

Planners should maintain a simple and secure asset database for each of the facilities under their management. The database should contain to detailed information on each of the

assets including all past maintenance activities. This allows the planners to efficiently prepare work activities for future maintenance. Planners should use both their work experience and information from the database to develop work plans.

iii) Recognise the skills of the workforce

The work plans for maintenance activities should be highly detailed for the minimally skilled and less detailed for the highly skilled workforce.

iv) Performance assessment

After execution of the maintenance activity, planners should assess whether the activity yielded the desired results on the facility.

12.2.3 Condition Assessment

In order to set targets for maintenance, specific agencies managing NMT infrastructure will be required to undertake condition assessments of the infrastructure. The condition assessments will be executed through field surveys through which useful data shall be obtained by:

- Measuring the size and extent of the asset;
- Identifying locations of culverts, bridges, road furniture, and other key elements;
- Identifying the location of defects both in the pavement and other NMT elements; and
- Determining the size or scope of infrastructure to be maintained.

The information that shall be collected includes geometry (flat, rise or fall); type of surface and construction; pavement (type, thickness, age); cross-section (width of the facility or shoulders width and type, ditches dimensions); structures (culverts, bridges, other structures); road furniture (road signs, guard rails); junctions (location and type); alignment (horizontal and vertical); land use (soil type, towns, farmlands, forests); pedestrian traffic and bicycles; and maintenance intervention on the NMT facility under review (history, present and future). Typical forms capturing inventory data include diagrammatic and strip maps; tabulated structured forms and indexing systems as provided by the pre-set operational guidelines for designated agencies implementing maintenance.

The condition survey should assess the general condition of the NMT network; identify critical sections in terms of percent of surface area, depth of damage, thickness, type, extent and severity of damage; diagnose defect causes; and determine the maintenance needs of the road network. This will enable the preparation of detailed operation plans for routine and periodic maintenance.

The Pavement Rehabilitation Guide (MoWT, 2010) provides design procedures for the rehabilitation of both flexible and rigid pavements. The following aspects adopted and applicable

to NMT infrastructure include the following:

- A Pavement Management System (PMS) shall be employed to assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a given period. The PMS shall be defined in 2 levels i.e. (i) the network management level and (ii) the project level. At a network management level, the system shall deal with network level where key administrative decisions that affect programs for the NMT network are made. At the project level, detailed pavement conditions of a specific NMT facility are assessed. The results of the assessment are used to design technical solutions for routine and periodic maintenance or rehabilitation in line with the management priorities.
- Maintenance is work performed from time to time to keep a pavement, under normal conditions of traffic and forces of nature, as nearly as possible in its as-constructed condition. The maintenance works on NMT infrastructure shall be in four categories; i.e. routine, recurrent, periodic and urgent.
- To extend the life of the pavement of an NMT facility, pavement rehabilitation activities can be executed. These include overlays and pre-overlay repairs, complete removal and reconstruction of the existing pavement, or recycling of part of the existing materials. In the context of pavement management at a project level several rehabilitation alternatives are available after technical evaluation, and need to be compared. For flexible pavements, asphalt overlays can correct both surface and structural deficiencies. Alternative rehabilitation methods other than overlays include the following:
 - Reconstruction: in this category, little or no contribution is expected from the existing pavement materials and the materials needed for rehabilitation will be new materials.
 - Recycling: the rehabilitation takes advantage of the existing pavement materials, which are reused in part or as a whole in the construction of the rehabilitated pavement.
- The design and placement of Asphalt pavement overlays for both rigid and flexible pavements shall be in accordance with specifications defined in Section 4.1 and 4.2 of Volume III, Pavement Design Manual, Part 4: Pavement Rehabilitation Guide (2010).
- Pedestrian bridge maintenance shall include all maintenance works on bridges that aim to repair or restore a bridge and its various components to the original specification. Upgrading by widening or improving a pedestrian bridge beyond its original design shall be included under development activities.

In order to properly set targets for specific agencies managing the various network types, the agencies are required by the MoWT to undertake NMT asset inventory and condition surveys. Data recorded in an NMT inventory shall be obtained by:

- Measuring the size and extent of the asset;

- Identifying locations of culverts, bridges, road furniture and other key assets; and
- Determining the size or scope of infrastructure to be maintained.

12.2.4 Compliance with Safety Regulations

Besides the cost benefits, one of the other major reasons for maintaining infrastructure is to ensure that it is safe for the road user. It is the responsibility of the transport authority that their infrastructure is safe to use at all times. During the maintenance process, the safety of the maintenance workers is of importance. Necessary precautionary steps need to be taken to ensure that infrastructure is safe to use during the maintenance process.

This includes preventing the use of the facility or reducing the volume or speed of the users. Temporary traffic signs may be erected to warn the road users to proceed with caution. The use of safety vests and helmets when working within the road reserves or on bridges increases the visibility and safety of the workers on site. The workers should be well trained on safety matters and should be familiar with evacuation or emergency procedures. The maintenance equipment should be well maintained and in good working condition.

Further details may be obtained in the MoWT Road Maintenance Management Manual (2010) and the MoWT Road Maintenance Specifications (2010).

Bibliography

13 BIBLIOGRAPHY

DPTI. (2015). *Guide to Bikeway Pavement Design, Construction and Maintenance for South Australia*, Dept. of Planning & Transport Infrastructure.

ICE. (2009). *Cycling Inclusive Policy Development: A Handbook of Sustainable Urban Transport Project, Interface for Cycling Expertise*.

Iganga Foundation. (2014). *Smart Moving Kampala; Design of NMT Zone in Namirembe Road and Luwum Street*.

ITDP. (2013). *Footpath Design*.

ITDP. (2018). *Streets for Walking and Cycling*.

ITDP. (2019). Retrieved from www.itdp.org: www.itdp.org

Jarnhammer, J. (2019). *Planning our Towns: A Toolkit for inclusive urban development in Kenya*. SymbioCity, Kenya.

Jennings. (2016). *Global Outlook on Walking and Cycling: Policies and Realities from around the World*. UN Environment (UNEP), Nairobi.

Kajuna. (n.d.). Presentation on NMT Initiatives in Uganda, MoWT,.

KCCA. (2019). *Detailed design of NMT schemes*.

Larsson, P. D. (2010). The need for a systems theory approach to road safety. *Safety Science*, 48(9).

Ministry of Works Housing and Communication. (2005). *Road Design Manual Volume 3: Pavement Design Part II: Rigid Pavements*.

Ministry of Lands Housing and Urban Development. (2011). *National Physical Planning Standards and Guidelines*.

MoFPED. (2017). *Public Investment manual for Project Preparation and Appraisal*.

MoLHUD. (2006). *National Land Use Policy*.

MoWHC. (2004). *Uganda Road Safety Audit Manual*.

- MoWT. (2004). *Road Safety Audit Manual*.
- MoWT. (2004). *Traffic Signs Manual, Volume 1*.
- MoWT. (2005). *General Specifications for Road and Bridge Works*.
- MoWT. (2010). *MoWT Road Design Manual, vol 3-Part II, Rigid Pavements*.
- MoWT. (2010). *Pavement Rehabilitation Guide*.
- MoWT. (2010). *Pavement Rehabilitation Manual*.
- MoWT. (2010). *Road Design Manual, Vol 1: Geometric Design*.
- MoWT. (2010). *Road Design Manual, Vol 3, Flexible Pavement Design*.
- MoWT. (2010). *Road Design Manual, Vol 3: Pavement Design, Part III: Gravel Roads*.
- MoWT. (2010). *Road Maintenance Management Manual*.
- MoWT. (2010). *Road Maintenance Specifications*.
- MoWT. (2012). *Non-Motorised Transport Policy*.
- MoWT. (2018). *MoWT Annual Sector Performance Report FY 2017/18*.
- MoWT. (2019). *Uganda Roads Act*.
- NCHRP. (2010). *National Cooperative Highway Research Program: Crossing Solutions at Roundabouts and Channelized Turn lanes for Pedestrians with Vision Disabilities*.
- NEMA. (1998). *National Environmental Impact Assessment Regulations*.
- NEMA. (2019). *National Environment Management Act , No.5*.
- Ngabirano, A. (2015). *Policy and Public Initiatives towards Promotion of Walking and Cycling in African Cities*. Nairobi: UNEP.
- NPA. (2019). *National Land Transport Strategy*.
- NZTA. (2009). *Pedestrian Planning and Design Guide*, New Zealand Transport Agency.
- SADC, RTSM. (1997). *South African Development Community, Road Traffic Signs Manual, Vol 1*.
- SANDoT. (2003). *Pedestrian and Bicycle Facility Guidelines: Engineering manual to plan and design safe pedestrian and bicycle facilities*.
- SANDoT. (2014). *NMT Facility Guidelines: Policy and Legislation, Planning, Design and Operations*.
- SANDoT. (2019). *Rural Transport Strategy Implementation Guidelines*.
- SARTSM. (2012). *South African Road Traffic Signs Manual, Vol 3, National Department of Transport, NDoT*.

Scottish DOT. (n.d.). *Departmental Advice Note TA 12/81*.

SLoCaT. (2019). *Sustainable Low Carbon Transport*.

Stanek. (2017). Retrieved from www.researchgate.net/figure/bicycle-conflict-points-for-typical-roundabout-design_fig2_316885128: www.researchgate.net/figure/Bicycle-conflict-points-for-typical-roundabout-design_fig2_316885128

Sustrans. (2014). *Sustrans Design Manual: Handbook for cycle-friendly design*.

Talvitie, A. (1996). *Functional Classification of Roads*.

Transportation Research Board. (2000). *Highway capacity manual 2000*.

TRB. (2000). *Highway capacity manual 2000*.

USFHA. (2000). *Roundabouts: An informational guide, US Federal Highway Administration*.

WorldBank. (2015). *Sub-Saharan Africa Transport Transport Policy Program Annual Report*.

WRI. (2019). *World Resources Institute Annual Report*.

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