The Republic of Uganda

MINISTRY OF WORKS AND TRANSPORT

ROAD DESIGN MANUAL

Volume VI: Urban Roads

PART 1: Design Manual and Appendices

FINAL

JULY 2023

Ministry Of Works & Transport

To provide Reliable, Safe works, Transport Infrastructure & Services

FOREWORD

Background and Objective of the updated 2023 Urban Roads Design Manual

Road transport is the dominant mode of transport in Uganda, presently accounting for over 90 percent of the volume of freight and passenger movement. Uganda has a road network of approximately 159,529km of national, district, urban and community access roads, representing one of the huge national assets, valued at approx. US$ 7.7M, in 2019. Presently, the roads network is largely unpaved with only about 7,149km of the roads paved, thereby representing 4.5% of the total road network.

Uganda's roads network is a critical component for the socio-economic development of the country, as it is vital for people and freight transport that supports production, competitiveness, trade and mobility. Road network development and maintenance are key strategic priorities for national and human development.

In the last 10 years, the numbers of Cities, Municipals and Town Councils have risen rapidly due to creation of new districts, cities and other local government administrative units. By June 2021, the administrative units comprised of 135 Districts, 1 Capital City (Kampala Capital City Authority), 10 Cities, 31 Municipal Councils and 580 Town Councils. The Cities include Soroti, Jinja, Masaka, Mbarara, Arua, Mbale, Fort Portal, Masaka, Hoima and Gulu.

The road network in urban areas constitutes a significant community asset under the management of the Urban Councils. Urban areas, being the commercial and administrative centres countrywide, have their road networks heavily concentrated with large volumes of traffic of all modes, and they play a significant role in respect of mobility and accessibility to the various commercial, administrative, and social facilities and services. In accordance with the Roads Act 2019, the respective urban councils are responsible for the maintenance, operation, improvement, re-planning, and preservation of the road networks, within their areas of jurisdiction for the benefit of the public and road users.

Without appropriate road design, timely maintenance, rehabilitation and upgrades, road infrastructure will deteriorate at a faster rate, which limit its safety and life expectancy, thus depleting its asset value. It is therefore imperative that urban councils get adequately facilitated with financial and human resources that would enable them to manage the road network asset most efficiently and cost effectively for the utmost benefit of the public.

Deficiencies that hinder the preservation of the urban road network asset, however, do exist both at the strategic and operational levels. Key of such deficiencies includes the absence of guidance on standards, designs, planning, and budgeting for road works, contract management and reporting. Government realized this need, and through the Ministry of Work and Transport commissioned M/S Prome Consultants Ltd to undertake the development of an appropriate Urban Roads Design Manual (URDM) in 2009. However, this version, which was produced in six volumes, remained in draft format, and was not widely used, and subsequently became outdated.

Consequently in 2021, the Ministry of Work and Transport with support from the World Bank Funded USMID-AF Program under the MoLHUD, commissioned M/S WSP Group Africa in Association with M/S KOM Consult Ltd and M/S ARG Designs to undertake a review and update of the 2009 version of the Urban Roads Design Manual. The specific objectives were to:

- **Review and update road functional classification for the respective categories of urban councils and propose appropriate road construction standards.**
- **Incorporate new design requirements that considers road-side parking, pedestrian walkways, cycle lanes, street lighting and installation of services and facilities for people with disabilities.**
- **Incorporate new materials, construction methods and specifications for construction of urban roads and produce a set of standard drawings for urban roads infrastructure.**

Composition of the 2023 Urban Roads Design Manual

The structure of the revised URDM has been developed in two parts. Part 1 is six volumes and Appendices, and Part 2 is the Standard Drawings. For ease of use, the six volumes of Part 1 were produced in a largely simplified technical language to enable users with a non-engineering background to understand them.

The URDM consist of the following:

Part 1 – Design Manual

- **Volume 1 contains the Policy and Planning Guidelines. It comprises the road planning philosophy and guidelines that enable the development of realistic prioritized annual roadwork plans.**
- **Volume 2 contains the Design Guidelines. This volume comprises detailed engineering guidelines for use in designing urban roads and other urban roads features.**
- **Volume 3 contains the Standards and Specifications for use in road works.**
- **Volume 4 contains the Standard Bills of Quantities and Guidelines for urban road works.**
- **Volume 5 contains the Construction and Maintenance Management Guidelines, which provides guidelines on how urban councils can manage the construction and maintenance works.**
- **Volume 6 contains the Reporting Guidelines, which presents guidelines for the preparation of annual workplans and budget, quarterly and monthly progress reports etc.**
- **Appendices**

Part 2 – Standard Drawings (separate document)

How to use this Manual

This revised 2023 URDM comprises guidelines to help the reader understand key concepts in Urban Roads Planning, Design, Construction and Management. Some issues are outside the scope of this Manual that require an Urban Engineer's guidance, and in some instances, it is important for the user to refer to other reference standards, manuals, and guidelines. These include among others the Ministry of Works and Transport's Road Design Manuals, 2010 Vol. I-IV, Low Volume Sealed Roads Design and Construction Manual, 2018 NMT Manual 2020, and The Highway Code 2009 for further guidance and technical details.

Further, this Manual is a technical document, which, by its very nature, requires periodic updating from time to time arising from the dynamic socio and technological developments and changes. The Ministry, therefore, welcomes proposals for further development and revision stemming from actual field experience and practice. It is hoped that the comments will contribute to future revisions of the Manual, and is expected to lead to better and more economical designs.

This Manual is the property of the Ministry of Works and Transport, but copying and local distribution is not restricted. We wish to acknowledge the efforts of WSP Africa Group and their partners, and the Joint Project Management Team who assisted and guided the preparation of the updated 2023 URDM. Appreciation also goes to the World Bank funded USMID-AF Program for the financial assistance extended to the Ministry for the development of this Manual.

I am convinced that all stakeholders will find this Manual to be a valuable source of information for the more efficient and effective provision of the design of Urban Roads in the Country.

Eng. Samson Bagonza

Engineer-in-Chief

Ministry of Works and Transport

Kampala, UGANDA

July 2023

Acknowledgements

The authors of this manual were:

Wayne Petersen	Lead Author / Team Leader, WSP Africa Group
Christo Bredenhann	WSP Group Africa
Tali Bruk	ARG Design
Robert Obetia	KOM Consult
Isiah Odongo	KOM Consult
Dr Paul K Musali	KOM Consult
Gladys Maninyitia	KOM Consult

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

Eng. Samson Bagonza	Director of Engineering and Works/Engineer-in-Chief, MoWT
Eng. Isaac Mutenyo	Program Coordinator, USMID-AF, MoLHUD
Eng. Stephen Kitonsa	Commissioner for Roads and Bridges, MoWT

The Joint Project Management Team comprising of the following members:

Eng. Joseph Mukiibi K	MoWT	Chair
Eng. Emmanuel T Ojuka	USMID-AF, MoLHUD	Member
Eng. Joseph Rutaagi	MoWT	Member
Eng. Charles Mukasa Ddungu	MoWT	Member
Eng. Charles Mutemo	MoWT	Member
Eng. Drake Bagyenda	MoWY	Member
Mr John William Ediu	USMID-AF, MoLHUD	Member
Eng. Joel Wasswa	KCCA	Member
Ms. Olive Nalugo	MoLHUD	Member
Ms. Leila Akello Gonasa	NEMA	Member
Mr. Justinian Nuwagaba	MoLG	Member
Eng. Dr Umar Bagampade	CEDAT, MUK	Member

ACRONYMS

AWSC	All-way Stop Control
AADT	Annual Average Daily Traffic
AASHTO	American Association of States Highway and Transportation Officials
AURICS	Annual Urban Roads Inventory, Condition and Traffic Survey
AURWP	Annual Urban Road Work Plan
AWD	Actual Work Done
BDS	Bid Data Sheet
BOQ	Bill of Quantities
BRT	Bus Rapid Transit
CSIR	Council for Scientific and Industrial Research (South Africa)
ECBA	Economic Cost Benefit Analysis
DUCAR	District Urban and Community Access Roads
EIA	Environmental Impact Assessment
ESA	Equivalent Standard Axles
FY	Financial Year
GCC	General Conditions of Contract
GHG	Green House Gasses
GIIP	Good International Industry Practices
HMA	Hot Mix Asphalt
IBD	Inverted Block Drains
ITB	Instructions To Bidders
JICA	Japanese International Co-operation Agency
LOS	Level of Service
LGBFP	Local Government Budgetary Framework Plan
LGDP	Local Government Development Programme
MAP	Measured As Planned
MBC	Measured Before Construction
MDAS	Ministries, Departments and Authorities
MCI	Maintainable Condition Index
MIS	Management Information System
MoWT	Ministry of Works and Transport
MoFEP	Ministry of Finance and Economic Planning
MTCE	Maintenance
MTEF	Medium Term Expenditure Framework
NACTO	National Association of Transport Officials (United Stated of America)
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organisation
NMT	Non-motorised Transport
ORN	Overseas Road Notes
PAF	Poverty Alleviation Fund

PWD	People with disabilities
PPDA	Public Procurement and Disposal Authority
PM	Project Manager
PMI	Periodic Maintenance Interval
PT	Public Transport
QPRs	Quarterly Progress Reports
RE	Resident Engineer
RAMPS	Rehabilitation and Maintenance Planning System
ROW	Right of Way
SCC	Special Conditions of Contract
TDL	Deed Title Owner
TRH	Technical Recommendations for Highways (South African)
TRRL	Transport and Road Research Laboratory (UK)
TC	Town Clerk
TWSC	Two-way Stop control
UCE	Urban Council Engineer
UGX	Uganda Shilling
URDM	Urban Roads Design Manuals
Veh/hr	Vehicles per hour

TABLE OF CONTENTS

TABLES

FIGURES

1 VOLUME 1: POLICY & PLANNING OVERVIEW

Volume 1 Table of Contents

1.1 CHAPTER 1: URBAN ROAD PLANNING PHILOSOPHY

1.1.1 BACKGROUND

Why an urban road design manual? The current population of Uganda is estimated to be 47,6 million based on projections of the latest United Nations data, with an average annual growth rate of 3.3%. It is projected to reach around 100 million by 2050. Approximately 16% of Uganda's population lives in urban areas, and the urban population is growing at an annual rate of 5.4% (2010– 2015 period). This level of population growth and increased urbanisation is rapidly transforming peri-urban villages into secondary cities. Without the requisite planning and implementation of infrastructure, including transport, these cities may become unliveable. In total, the public road network in Uganda, including both classified and unclassified roads, comprises more than 159 529 km. Physical plans completed for these secondary towns utilise a multitude of different road classifications and requires one uniform set of standards.

Motorcycles or boda-boda dominate the motorised vehicles on urban roads, followed by passenger vehicles (buses, minibuses and cars). The number of vehicles is growing rapidly, with an average increase of more than 10% per year. The resultant traffic congestion adversely impacts the quality of life and economic productivity in urban areas. It increases fuel consumption, the cost of travel for persons and freight, the number and frequency of motor vehicle accidents, and the emission of pollutants harmful to human health and the environment.

In addition, urban roads have little or no street lighting and are dotted with potholes. Instead of sidewalks, the edges of the roads are open trenches, forcing pedestrians to walk in the road, particularly where national roads enter a town or city. Non-motorised modes of transport, such as walking and cycling, are common in most parts of the country but are not well supported by infrastructure in urban areas.

The Republic of Uganda's Urban Roads Manuals of 2009 and that of the Kampala Capital City Authority (KCCA) are outdated and have numerous gaps requiring updating. The revised 2023 Manual is standardised with bench-marked regional manuals and introduces best practice guidelines as utilised within the region. Therefore, the Ministry of Works and Transport (MOWT) of Uganda commissioned this updated 2023 Urban Roads Design Manual.

The Manual is a standardised guide and method for road design, maintenance and construction. It goes beyond the conventional road classification system, recognizing that roads and streets fulfil a variety of functions. It also aims to improve safety for vulnerable road users, particularly those with disabilities, pedestrians and cyclists; with inclusive, safer urban road designs for improved mobility and access.

Figure 1.1: Congestion on the roads of Kampala

INSTITUTIONAL STRUCTURE

There are numerous challenges to the development and implementation of urban roads. These vary from the need for better coordination of different agencies at multiple levels of government to uncertainty regarding the hierarchy and levels of street design. Planning for new areas is usually carried out by planning agencies; while the transport departments carry out the implementation, and the maintenance of the roads is carried out by a different agency. Therefore, the need for a coordinated, bench-marked set of guidelines and standards is required.

The Ministry of Works and Transport (MOWT) is the central agency for the transport sector at a national level. The Ministry is mandated to plan, develop, manage, and maintain the transport infrastructure. It is structured into eight departments under the Directorate of Engineering and Works and the Directorate of Transport.

District and municipal authorities determine their own priorities and allocate resources but need to coordinate these within the national framework. Further, the Ministry works alongside several national agencies to implement its overall transportation agenda, see

Table 1.1 (from LEDS Global Partnership: Uganda's National Transport Masterplan: 2018)

It is clear that multiple agencies have a role to play in managing the road environment.

WHO MUST USE THIS MANUAL?

The URDM should be used in practice by city and town councils, municipalities, (engineers and town planners), government organisations, Uganda National Roads Agency (UNRA), public and private developers (residential, commercial and industrial), community groups, and engineering and environmental consultants and other key stakeholders.

The URDM is the standard to guide for users in the maintenance, upgrade, rehabilitation and design of all public and private urban roads.

WHO MUST DESIGN URBAN ROADS?

The design of urban roads must firstly be undertaken by qualified, experienced and professionally registered engineers, approved by same, and lastly the implementation and certification of road projects must be overseen by qualified and experienced engineers.

All urban road designs reports and drawings must be signed off by the design engineer and approver, and must include their full details: name, professional registration number and signature.

Table 1.1 Institutional Structure

State Agencies	Responsibilities in terms of roads
The Ministry of Works and Transport (MOWT)	Plan, develop, manage and maintain the transport infrastructure in Uganda Registers vehicles and maintains a central database
Uganda National Roads Authority (UNRA)	Agency of Government, under MoWT established by the UNRA Act of 2006. Responsible for maintaining, managing and developing the National Road network
Kampala Capital City Authority (KCCA)	Controls planning and development of physical plans and transport plans in Kampala
Ministry of Finance, Planning and Economic Development	Allocation of resources and budgeting for new roads
Ministry of Local Government	Standards and regulations for local governments and monitors compliance
Uganda Police Force- directorate of Traffic and Road Safety	Enforces road transport laws and collects data on traffic accidents
Uganda Revenue Authority	Collects all transport related taxes such as fuel tax
Uganda Road Fund	Finances routine and periodic maintenance of District, Urban and Community Access Roads (DUCAR), Kampala roads, and all other cities to ensure connectivity of communities

FUTURE UPDATES TO THE 2023 URDM

As with any road design manual, technological advancement in design, construction and materials, changes in social and economic needs of the road user and adjacent land owners, will necessitate the update of the manual in future.

Some items to note that may be included in the future manual is the use of artificial intelligence in the design process, SMART mobility, etc.

Users or this URDM should therefore comment on it in the course of future road projects, including identifying gaps and omissions, requirement for additional information and any other matters. The MOWT should keep a record of these inputs for consideration in future updates of the Manual.

FUTURE STUDIES REQUIRED

Below is a list of potential future studies that should be considered to enhance the revision of this Manual:

- The ongoing update of the Traffic Act should consider inclusion of:
  - Road markings and signage for Bus Rapid Transit lanes and stops at kerb and median stations
  - Improved rod marking for pedestrian safety.
  - Revised traffic signal design guidelines
- The development of a national Transportation Impact Assessment guideline, which must include trip generation rates for the majority of urban land uses.
- The development of a national road and street naming convention policy.
- The development of a traffic calming policy for urban roads, to include warrants for when, where and what type of traffic calming may be utilised in the urban environment.

1.1.2 HOW TO USE THIS MANUAL

The URDM is a set of Guides, Codes and Specifications that are specifically created for Uganda's urban areas based on international best practices, regional integration and robust common engineering theory adapted for local conditions.

Its purpose is to show how new transport infrastructure should be designed and constructed, to manage change, introduce international best practices for Uganda, and assist with transforming outcomes within Uganda's Urban environment.

Due to the rapid urbanization occurring within Uganda and the expansion of the secondary towns and villages, the manual provides an easy guide to developing a road network, choosing the appropriate hierarchy for roads, the elements that make up these roads and the appropriate technical designs to follow.

This manual offers guidance on the design of urban roads. It is an explanatory document offering advice on urban design decisions for urban roads.

Accompanying Volume 1 are the following volumes that offer additional technical information. All users are advised to refer to all these Volumes:

- Volume 2: The Design Guidelines
- Volume 3: Technical Specifications
- Volume 4: Bill of Quantities & Tender Documents
- Volume 5: Construction and Maintenance Management Guidelines
- Volume 6: Reporting Guidelines
- Appendices
- Part 2: Standard Drawings (Separate document)

The URDM aims to support policy by providing design guidance and engineering standards to all users for the design of new urban roads as well as the upgrading of existing roads, within a defined hierarchy, that is clear and understandable for all users.

This section of the Manual comprises information and concepts from various agencies and organisations faced with similar transportation issues in East Africa and across the globe. The document acknowledges the existence of other practices and provides information for those responsible for making professional engineering or other design decisions. It is not intended to replace the existing mandatory or advisory standards, nor the exercise of engineering judgment during design by registered professionals.

URBAN ROAD DESIGN PROCESS

For the purpose of this Manual, the process used to achieve the design of urban roads includes the following steps:

- Identify the Context/Land Use character of the road
- Identify the current modes of transportation appropriate for the area.

- Determine the gaps and design elements, facilities, and other transportation components that are necessary for an urban road.
- Determine other priorities.
- Identify the right-of-way width (for illustrative purposes only, this guide uses the narrowest rights-of-way for arterial and collector roads) and determine the appropriate number of vehicular, transit, and bike lanes. Some of these lanes are shared in certain instances.
- Select the appropriate pedestrian and NMT design elements and facilities.
- Refer to the checklist which can be used to check if a design meets the requirements of the Manual.

Refer to Volume 2, Chapter 11 for a high-level worked design example for a typical urban road project.

IMPLEMENTATION STRATEGY

PROJECT TYPES

A strong implementation strategy is essential to the success of the Urban Roads Manual concept.

As such the following opportunities have been identified to implement the guidelines of this document:

- Physical/Spatial Planning of Urban centra
- Private sector applications for new roads
- Transportation infrastructure projects
- Maintenance programmes

PHYSICAL/SPATIAL PLANNING

Physical plans for a city or town articulate the vision for a community. They show the roads, intersections, access points, development parcels (and associated land use), and open space for a community.

The physical plan is the first opportunity to identify roads that need to be given special attention (i.e., those within the central business district or bypass roads for trucks). The defined typologies in the Urban Roads Manual assist in determining the function and land use context of a road. This determination should occur as early in the planning process as possible. All proposed roads should align with the road reserve dimensions for the cross-sections as proposed in the Manual.

PRIVATE SECTOR APPLICATIONS FOR NEW ROADS

When private developers make an application for new developments, there is opportunity to ensure that right-of-way setback is preserved for the future design of the adjacent road. If known, and it is an appropriate time to examine access considerations.

TRANSPORTATION INFRASTRUCTURE PROJECTS

Major transportation infrastructure projects are typically developed by Ministries, Departments and Authorities (MDAS) who are responsible for infrastructure development in the country. Projects can include road and intersection improvements, interchange construction, Bus Rapid Transit (BRT), etc.

This manual should be at the front end of these projects during the planning and design stage, especially with regards to junctions for districts and anu other roads (such as UNRA) entering towns.

OPPORTUNITIES TO IMPROVE MAINTENANCE PROGRAMMES

There are opportunities to improve on existing maintenance programs to better align with the URDM. For example, a road resurfacing project presents an opportunity to implement bicycle lanes by revising the road markings. Specific opportunities to provide complete road elements for these types of projects include:

- Restripe or widen shoulder for bike lanes through intersections
- Install sidewalks for pedestrians (both at intersections and to connect different approaches)
- Provide crosswalks
- Add pedestrian refuges or islands
- Install curb ramp upgrades or additions to comply with universal design standards in the NMT manual
- Incorporate other amenities.

TYPOLOGIES

URBAN ROADS MANUAL FUNCTIONAL CLASSIFICATION

The Urban Roads Manual Road Classification System goes beyond the traditional method of defining road hierarchy as a trade-off between mobility and accessibility, by incorporating the following characteristics:

- Functionality
- Traffic Volume
- Public Transport
- Geometry
- Access spacing
- Non-motorised transport
- Freight
- Traffic Calming

PROPOSED CONTEXTUAL CLASSIFICATION

In the Urban Roads manual, the roads are categorized into broader typologies for use by motorised (vehicles, public transport and boda-boda) and non-motorized road users (pedestrians and bicycles) as well as land use context and environmental factors. They allow for a more comprehensive understanding of a road's existing and desired functions. The manual proposes new road typologies that provide greater nuance than is available through the traditional functional classification system, which defines roads exclusively by their function for automobiles.

See Table 1.2 for the seven urban road classes, and Table 1.3 outlining a summary of the contextual classification. Note the importance of all modes supported on the majority of classes, except general and private vehicles that are not allowed on Class 6 and Class 7 roads.

Table 1.2: Urban Road Classification

Class	Function	Description	Max Speed (km/hr)	Road Reserve – Maximum (m)
1 A & B	Mobility	Trunk Route (with dedicated BRT trunk or Public Transport lanes)	80	60
2 A & B		Major Arterial (with dedicated BRT trunk or Public Transport lanes)	60	40
3 A & B		Minor Arterial (with shared BRT feeder or Public Transport lanes)	50	28
4 A & B & C	Access	Collector Road (Commercial, Residential & Industrial)	50	20
5 A & B		Access Road (Commercial, Residential & Industrial)	40	15
6		Informal settlement Access Way	N/a	8
7		NMT Access Way	N/a	6

Table 1.3: Summary - Contextual Road Classification

Class	Considerations	New Typology	Pedestrians	Bicycles	Public Transport	Motor Vehicles	Goods Vehicles	Emergency Vehicles
Class 1	• The primary function is high mobility; hence principles are applicable primarily in ensuring adequate provision of grade-separated crossingsfor pedestrians and cyclists.	Trunk route with trunk BRT or PT	✓	✓	✓	✓	✓	✓
Class 2	• This class of road represents major arterials. In the context of urban roads, the following needs to be considered: o These routes are the most direct linkages betweenhome and work Centres; hence cyclists are prone to use these routes, therefore provide separate walking and cycling facilities o Some of these roads have low-income residentialsettlements adjacent to them, hence special attention needs to be provided to pedestrian crossing facilities and access to public transport stops o Where these roads form part of a Public TransportNetwork, public transport modes need to be givenpriority.	Major arterial with trunk BRT or PT	✓	✓	✓	✓	✓	✓
Class 3	• Special care needs to be taken in separating motorised vehicles and pedestrians. Separate cycling facilities are appropriate.	Minor arterial with feeder BRT or PT	✓	✓	✓	✓	✓	✓
Class 4	**In CBD areas**: • On-street parking is important, hence special care needs to be taken when providing cycling facilities adjacent to on-street parking. • Minimum sidewalk width is appropriate due to high numbers of pedestrians and the presence of other activities on the verge. **In Industrial Areas** • Curb radii need to accommodate heavy vehicle turning movements, hence the presence of long crossing paths at intersections may not be avoidable.	Collector	✓	✓	✗	✓	✓	✓
Class 5	• Speed reduction measures should be used to keep speeds within acceptable levels for the safe movement of pedestrians and cyclists	Access	✓	✓	✗	✓	✓	✓
Class 6	• Motorised vehicles are not permitted except for emergency vehicles in an emergency situation. Shared road bicycle facilities to be provided.	Informal settlement Access Way	✓	✓	✗	✗	✗	✓
Class 7	• NMT only	NMT only Access Way	✓	✓	✗	✗	✗	✗

NOTE: Also refer to Table 1-6 and Volume 2, Chapter 3

DESIGN CONTROLS/ DESIGN PROCESS

The design process is discussed in this final section. This includes site analysis, stakeholder participation, the design and taking it to construction.

It is impossible to design roads well using only standardised templates or metrics. Road design requires the consideration of many factors that often span various levels of spatial scale.

Understanding the relationships between users, site conditions, transport systems and the urban context is critical to developing appropriate context-sensitive designs.

A decision will need to be made by the designer regarding the type of place that the road will pass through (built form and function), i.e., is it a residential area or is it industrial? The significance of the place must then be assessed. Is it a road that serves just the local area or does it have larger function connecting suburbs or cities?

Then the road form is determined based on these factors. Refer to Table 1.4 for the decision matrix. The class of road is then determined and the elements that will go into the road in that particular area can then be decided upon.

Table 1.4: Design Process to Determine Context

Is it a Rural or Urban Road?	**No: Rural Road**		**Guidelines for Rural Roads**			
	Yes: Urban Road		**Urban Roads Manual**			
Place: What kind of place does the road pass through? Built form and function.	Informal settlement. High number of pedestrians. Only gravel roads.	Residential area. Direct property access onto the road. Many crossings. Car parking on road. Pedestrian priority.	Mixed-use area with commercial and residential. Medium density. Active edges. Walkable. Large pedestrian volumes	Business area. Many levels. Low- medium density. Some mixed use. Many vehicles & boda-bodas. Limited active edges.	Central Business District / City centre destination area. Mixed-use & active edges. Multimodal access. Many pedestrians. May have public transport	Industrial Large scale. Low density, vehicle oriented. wide access
Place: What is the significance of the place?	Local access: Informal settlement access road.	Neighbourhood: Local access road/residential	District: Collector or local commercial access street	Sub-region: Minor arterial	City: Major arterial or BRT Trunk route	Industrial area: Industrial Road
Movement: Road form and function. What is the road intended to do?	Shared roads, restricted vehicles, unpaved roads. Slow movement.	Slower speeds to allow for pedestrians to cross. 40-50km/hr	Local road 40-50km/hr 2 lanes parking < 5,000 vehicles/hr	Allows access to commercial areas 2-4 lanes for vehicles, allows for parking in the road reserve. 5,000-15,000 vehicles/hr	Main road going through the town/city. 40-60km/hr. 2- 4 lanes for vehicles. Limited parking 15,000 vehicles/hr	Arterial 60-80km/hr 4-6 lanes (wider lanes) with parking embayments 20,000 vehicles/hr including large trucks.

1.1.3 DESIGN RESPONSE TO ROAD HIERARCHY & CLASSIFICATION

Throughout this manual, reference is made to the classification of roads, which refers to a hierarchy of roads with different functions, road reserves, cross-sections and speed limits which is provided in detail in Volume 2: Design Guidelines.

In order to determine this classification, a number of physical planning frameworks were assessed to determine the current road hierarchy planning for each area, and to determine the various land use scenarios that affect decisions about road hierarchy. Refer to Table 1.5.

It is evident that many different classification systems, road sizes and terms are used in the draft and final plans of cities and towns, but there is little consistency. Hence, the need for one comprehensive classification system.

A single road classification system can be adopted by both urban and rural local councils across Uganda. This allows for uniformity and provide clarity. This Manual provides guidance on when each of these various road classifications should be used.

For the sake of consistency, urban roads are classified as shown in Table 1.6

Table 1.5: Existing Physical Planning frameworks assessed to determine road classification

City/Town	Road class					Transport mode		
	Highest	**High**	**Medium**	**Low**	**Lowest**	**Pedestrian**	**BRT**	**Light Rail**
Mbale	Proposed Ring Roads	Primary Road	Secondary Road	Local Distributor	Residential Access			
Elegu Border town			Major Road	Access Road				
Busia Structure Plan		Primary Road - Mjanji Road	Local distributor					
Gulu structure Plan		Primary	Secondary	Local				
Entebbe	Entebbe / Kampala Express			Tertiary Roads (12-15m)				
Fort Portal		Major Roads	Minor Roads	Motorable Roads				
Jinja		Primary	Secondary	Tertiary				
Kampala		Primary Route Roads Highways Ring Roads	Activity corridors					
Kira Physical Plan		Arterials Primary Road: 30 - 60m wide roads link the municipality to other regions	Sub arterial: Secondary Roads: 20 - 30m wide e.g., Kira Bypass. These roads link up the divisions in the Municipality	Collector Tertiary Roads: provide the final distribution of traffic to and within the trading centres and residential areas. 20-30m wide		Pedestrian	BRT	Light Rail
Lira	Southern Bypass (30m)	Primary Roads (25-30M)	Secondary Roads (15-20m)	Tertiary Roads (12-15m)				
Masaka		Highway	Major Road	Access Road				
Uganda National Physical Planning Standards and Guidelines, 2011	International Trunk Roads These roads link international important centres and provide connection between the national road system and those of neighbouring countries. (40m)	National Trunk roads						
National Physical Development Plan	Expressways Road network which provides high speeds, high capacities, and protected travel over long distances. Entrance and exits to this roadway are limited and crossings are grade separated for speed and safety.	Highways Existing and improved highway network providing regional connectivity between cities and towns. They provide a balance between mobility and accessibility with access to local road networks. Roads offer significantly lower speed and capacity in comparison with Expressways	Bypass Roads: Road assets which allow for regional and intercity traffic to avoid entering city centres, reducing pollution and safety risks. These roadways also help to reduce urban sprawl as they define the outskirts of urbanizing areas with a hard boundary	Local Roads: Local and urban roads which provide maximum accessibility but low mobility				Passenger /cargo rail

Table 1.6: Road Classification Hierarchy

Class	Name	District Road Works Manual Class*	Function	Description	Max. road reserve width (m)
1	Trunk routes	I	Mobility	Trunk routes with public transport lanes- 80km/h Dual carriageway with 60m max road reserve All sub-classes are similar, just the lane configurations and types of public transport lane varies	60m
2	Major arterial	II		Class 2 – Major arterial routes with public transport lanes - 60km/h Dual carriageway with 40m max road reserve All sub-classes are similar, just the lane configurations and types of public transport lane varies	40m
3	Minor Arterial	III		Class 3 – Minor arterial routes with public transport lanes -50km/h Dual carriageway with 28m max road reserve All sub-classes are similar, just the lane configurations and types of public transport lane varies	28m
4	Collector Routes	IV	Access	Class 4 – Collector routes – 30 to 50km/h Single carriageway with 20m max road reserve All sub-classes are similar, just the lane configurations vary	20m
5	Access routes	V		Class 5 – Access routes – 30 to 40 km/h, Single carriageway with 15m max road reserve. All sub-classes are similar, just the lane configurations vary.	15m
6	Informal settlement Access ways			Single carriageway with 8m max road reserve - 20 km/h	8m
7	NMT only			Non-motorised transport only. Access ways (no set speed limit,NMT only)	6m

*Note the corresponding road classes for Urban Roads as defined in the District Road Works Volume 1, Planning Manuals, Manual A: Functional Road Classification System & Route Numbering, dated June 2002.

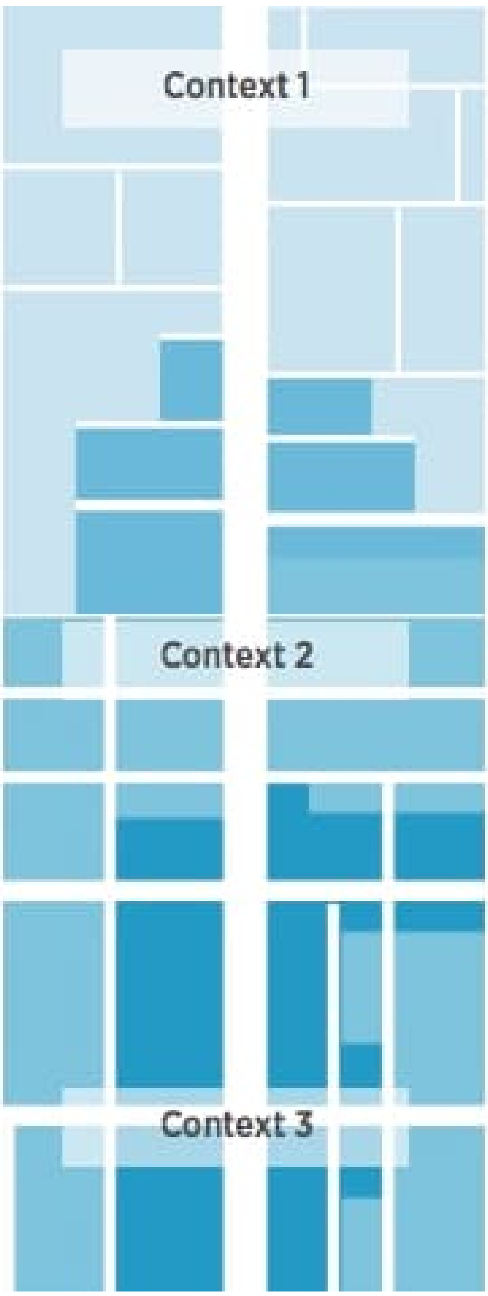
Also refer to Volume 2, Chapter 3 and the Standard Drawings CS-1 to CS-7

DESIGN FOR CONTEXT

Historically, roads had been defined by their functional classification, which relates primarily to vehicle flow. Today, roads are expected to also reflect and support adjacent land uses. Well-designed roads promote appropriate speeds, modes and non-motorised transport activities.

However, roads can change functionality across a town or city. Longer roads that pass through multiple areas of a city can change functionality along their length.

A single road may change road types as the surrounding land uses or as movement functions change.



For example, a road may transition from a Residential access road to a collector as it passes through the commercial centre of a community. Different mode networks merge and diverge, so an arterial may split into collector and local types as it reaches its strategic destination.

There are many roads that have different functions at different points along the extent of the road. Understanding how roads change through the city in response to context is fundamental to the practice of good road design.

Informal Settlement, Kampala

Residential Area, Kampala

Mixed Commercial/ Residential, Kampala

Central Business District, Kampala

DESIGN FEATURES FOR ROAD TYPES

The summary in Table 1.7shows the general characteristics distinguishing each principal road type. Features will vary according to specific network requirements; however, the distinct character of each road should be expressed so that the type is easily recognised by users.

This section shows examples of sub-types that discuss how particular variations in network requirements can be included in road designs.

The classification system and road width are recommended in terms of this Manual.

Table 1.7: Design Features for Road Types

Types of Roads	Suggested Road Features
Class 1: Trunk routes Single-use arterials are defined by low-density urban land uses, lower pedestrian activity and the highest levels of through movement. Of all the road types, this has the highest movement and lowest place values, thus intersections are the least frequent. Pedestrian crossings should be placed near public transport stations and stops. • Highest speed environment (50 - 80 km/h in peri-urban areas with no accesses) • Good parallel routes for local traffic and cycling • No parking • Keep high amounts of visibility • Few intersections.	
Class 2 & 3: Single Use Arterial (Minor and major arterials) Single-use arterials are defined by low-density urban land uses, lower pedestrian activity and high levels of through movement. Of all the road types, these classes have the second highest movement and second lowest place values, thus intersections are less frequent. Pedestrian crossings should be placed near public transport stations and stops. • Highest speed environment (50 - 80 km/h in peri-urban areas with no accesses) • Good parallel routes for local traffic and cycling • No parking • Keep high amounts of visibility • Low intersection density.	

<table>
<tr><th>Types of Roads</th><th>Suggested Road Features</th></tr>
<tr><td>
Class 4 – Collector with mixed public transport lanes - 50km/h

Dual carriageway with 28m max road reserve

All sub-classes are similar, only lane configurations & public transport lanes vary
Median lighting for the roadway and sidewalk lighting

Main road minor arterials are characterised by a high traffic volume, as well as a high density of on-street destinations. They support a high concentration of commercial, retail, cultural and residential activity.

They also act as civic spaces for people. Pedestrian activity is very high on these roads. As such, the footpath must accommodate large volumes and crossings must be frequent.

Cycle access is important, as these roads are destinations. Parking should be limited

Due to spatial constraints and the focus on through movement, public transport is prioritised.

Equal emphasis on the public realm and through movement
Strong public transport and pedestrian focus with frequent crossings
Active road use throughout the day
Lower speed zone (<50 km/h).

</td><td>

</td></tr>
<tr><td>
Class 4 – Collector routes, - 50km/h

Single carriageway with 20 m max right-of-way

All sub-classes are similar, just the lane configurations vary
Single or dual-sided combined roadway & sidewalk lighting required

Example: Commercial – Local Street Centre –higher density local roads that support a variety of land uses, including offices and residential. They tend not to be locations for destinations.
Pedestrians play an important role on this road and the right-of-way sees a mix of all types of traffic.

Slow speeds
Private-public space interaction
Ample public amenities (footpaths,etc.)
Parking is on street.

</td><td>

</td></tr>
</table>

Types of Roads	Suggested Road Features
Class 4- Residential Minor Collector Though not experiencing as much traffic as single-use arterials, traffic volumes along residential minor collectors are still very high. They have a low-intensity land-use context and a mix of all traffic types. Pedestrians and cyclists have separated routes that are well-lit and have ample space for moderate volumes. • Medium speed environment (<40 km/h). • On-street parking near centres • Separated cycle facilities and pedestrian routes to bus stops and centres.	
Class 5 – Access routes: Local Streets (residential) 40 km/h, Single carriageway with 15 m max road reserve. All sub-classes are similar, just the lane configurations vary. Single or dual-sided roadway & sidewalk lighting required Local roads have low traffic volumes, as well as travel speeds of low to 40 km/h. They are largely residential roads with occasional commercial and public uses.These roads have friction (trees, green infrastructure, parking, etc.) on either side of the road to slow speeds and allow for mixed-traffic cycling. Local roads are some of the most important road types, as this is where people live and play.	
Class 6 – Informal Settlement Accessway Local street, Residential Single Carriageway 20 km/h with 8m max road reserve – Local roads have low traffic volumes, as well as travel speeds of low to 20 km/h with many pedestrians utilizing the roadway. These are mainly residential roads and may have some trading on busy corners	

Types of Roads	Suggested Road Features
Class -7- NMT Access way– Wide walking space to cater to the high footfall in the area. Pedestrian streets are only successful in areas that are attractive and lively. They require a critical mass of users. They should form a natural connection route for diverse attractions (tourist activities, shops, offices, etc.), and serve as both a destination and a thoroughfare. Pedestrian streets should have good access to public transport and parking and should be located in a pedestrian-friendly area	

1.1.4 DESIGN PRINCIPLES

It is impossible to design roads well using only standardized templates or metrics. Road design requires the consideration of many factors that often span various levels of spatial scales.

The urban areas of Uganda are experiencing population growth and urbanisation at an unprecedented rate, placing new challenges on existing infrastructure as well as requiring significant additional infrastructure. Addressing the physical, social, and spatial challenges of this population growth requires a closer look at the urban roads and streets, which make up the largest component of the transport system.
Road transport is the dominant mode of transport in Uganda as road transport carries about 95% of the country's goods traffic and about 99% of passenger traffic.

Figure 1.2: Kampala is one of the fastest growing cities in the world
Source: World Urbanisation Prospects

DESIGN FOR ROAD SAFETY

The road safety situation in Uganda has deteriorated rapidly over the last few years, mainly due to the growing vehicle numbers on the roads and the lack of appropriate road safety interventions from the regulatory authorities. In 2020 there were 12 249 traffic accidents in Uganda. Most of the fatalities were pedestrians (34%), these occurred mainly when pedestrians cross over roads when or where it was unsafe, resulting in vehicle/pedestrian collisions. The second largest fatal category is from boda-boda's (31%). There is a clear need to design roads where pedestrians, cyclists, boda-bodas, buses, cars and trucks can cross paths safely. Source: Uganda Police Force Annual Crime Report:2021. Lowering injuries and fatalities, therefore, remains a crucial goal for on all Ugandan national urban and rural roads.

The following principles for road safety apply:

ROAD HIERARCHY

A road network consists of a system of functional types that differs based on the extent of the role they play in relation to the two functions of a road: access and mobility. This document expands on the hierarchy in some detail. In the case of assessing the road safety of an intersection, it is clear that where a difference in intersecting road classes exists, road safety problems can occur due to the difference in function, for instance where a highway enters a town.

ROAD LIGHTING

The provision of road lighting, specifically in urban areas can improve road safety significantly, particularly with reference to pedestrians and cyclists. Road lighting plays an important part in the reduction of night-time accidents. In addition to the road safety benefits it provides, road lighting also acts as a crime prevention measure. Note that road lighting should also be reconcilable with the road function. Care should be taken to ensure that the design, location and type of poles are adequate and safe.

ACCESS MANAGEMENT

A road provides access and mobility. The access control should be reconcilable with the functional classification of the road as access spacing, design and location are based on the functional classification of the road.

ROADSIDE HAZARD MANAGEMENT

Reducing hazards on the roadside will reduce the number of accidents vehicle to vehicle and between pedestrians and vehicles. This can be done through adequate signage regarding hazards and allowing a vehicle to exit a road without hazards such as open ditch drains (see Figure 1.3).

Figure 1.3: Example of an Open Drain

GEOMETRY AND PAVEMENT CONDITION

Geometry and the road traffic safety of a particular location are closely linked as it influences the sight distance, driver expectancy etc. Pavement conditions such as a lack of kerbs and deep ditches for stormwater drainage can also cause accidents.

DESIGN FOR SPEED

Speed plays a critical role in the cause and severity of crashes. There is a direct correlation between higher speeds, crash risk, and the severity of injuries. To reduce fatalities and the severity of accidents, urban areas should utilize speed control mechanisms where applicable that influence driver behaviour and lowers operating speeds. Utilising a proactive design approach on new and existing roads with the goal of reducing speeds may be the single most consequential intervention in reducing pedestrian injuries and fatalities.

The diagrams in Figure 1.4 illustrate the cone of sight of a vehicle at various speeds. The slower the vehicle is travelling the greater its line of sight.

The Non-Motorised Transport Manual for Uganda (2020) provides guidance on traffic calming measures (such as speed humps and rumble strips) and impact angles to reduce speed. The MOWT Road Design Manual, Volume 1: Geometric Design of January 2010 also provides guidance for designers.

A few of the measures are mentioned, however, a comprehensive assessment is provided in the NMT Manual.

Figure 1.4: Visual Perception at Different Speeds

CONTROL IMPACT FORCES AND ATTENTION: TRAFFIC CALMING

Instinctive design creates physical “nudges” for attention in complex urban environments and alertness near conflict points. Properly designed vertical and horizontal shifts in the vehicle path also slow vehicles down to more survivable speeds in accidents for pedestrians outside the vehicle. If driver attention is lacking, the risk is still lower.

REVIEW IMPACT ANGLES FOR ROUNDABOUTS

The survivable speed for vehicle-to-vehicle crashes changes with the angle of impact. Modern roundabouts and on-ramps make use of this life-saving feature.

This is important for intersections where road speeds are 50km/h or higher. Note that this side impact risk is the main reason why vehicle users are still not safe from serious injury in urban areas. Although roundabouts do take up more space than signalized intersections, the advantages are that they reduce the angle, slow down traffic and do not rely on electricity for signals to function. Refer to Volume 2 for further design guidelines.

VEHICLE SPEED WHEN ACCOMMODATING NON-MOTORISED TRANSPORT

This URDM requires all practitioners to comply with and implement the requirements and guidance on non-motorised transportation as contained in the latest version of the Ugandan Non-Motorised Transport Manual, 2020.

The physical design of roads and the provision of sidewalks, crossings, and other infrastructure is crucial to managing motor vehicle speeds and creating a safe walking and cycling environment.
Accommodating non-motorised transport modes safely involves the following basic techniques:

- Systematic traffic calming on smaller roads to reduce motor vehicle speeds and provide safe places for the mixing of pedestrians and other modes.
- Shared lanes are safe for pedestrians, cyclists, and motor vehicles to travel together if speeds are restricted to 15 km/h.
- For speeds up to 30 km/h, separate footpaths should be provided but cyclists can travel in the carriageway.
- Pedestrian and cycle infrastructure that is physically separated from motor vehicle traffic on larger roads, paired with traffic calming or traffic control to facilitate safe crossings.
- Pedestrian footpaths should provide clear space for walking, with other elements positioned in a strategic manner. Similarly, dedicated cycle tracks should be provided, separate from the mixed traffic carriageway.

APPROPRIATELY DESIGNED MOTOR VEHICLE LANES

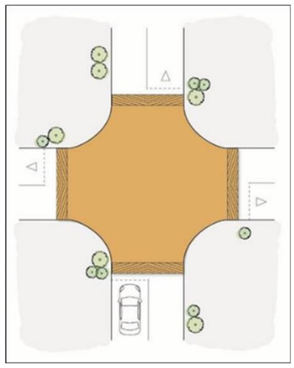
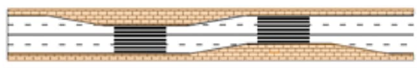
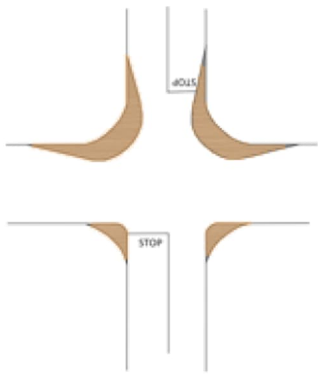
The design of the carriageway should reflect the speed limit. Carriageway lanes should be restricted to a width of 3.5 m per lane on arterial roads.

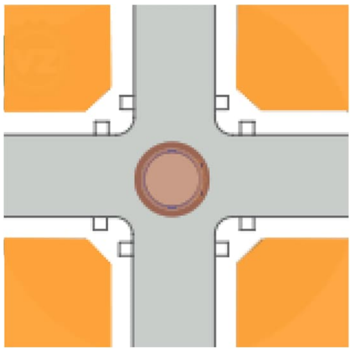
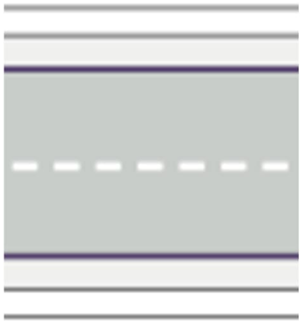
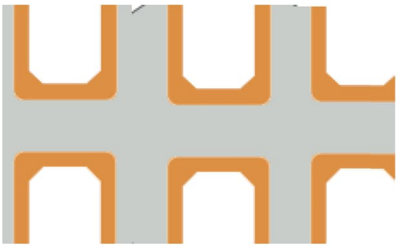
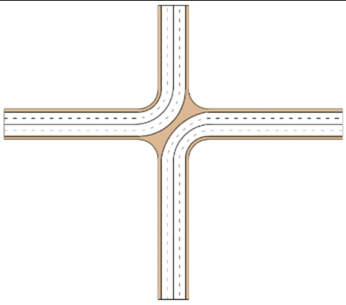
TOOLS TO REDUCE SPEED AND VOLUMES

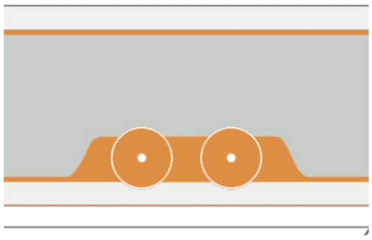
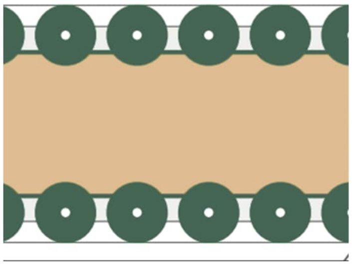
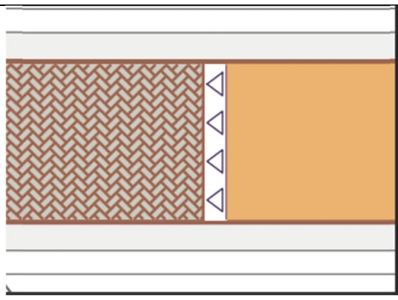
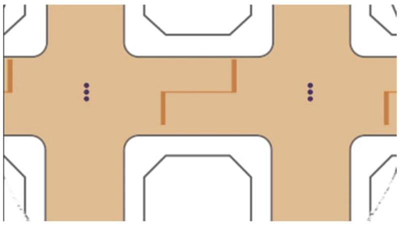
There are a variety of methods to slow vehicle speeds on a street, both when designing new streets and when retrofitting existing streets. The combination of physical and psychological devices enables street designers to proactively design their environment and encourage desired behaviour. The use and suitability of these measures will often depend on a multitude of factors. The effectiveness of devices to maintain the design speed along a street is affected by the spacing of devices, as well as the design of the devices. It is important to design the combination of devices to produce a safe speed.

Table 1.8 provides further examples of tools to reduce speed and volume. These should be read with the Uganda NMT Manual, June 2020.

Table 1.8: Speed and volume reduction tools

Device	Advice	Example
SPEED HUMPS Speed humps or raised tables can be added to a street to vertically deflect traffic (See NMT Manual section 10.2) Adequate road signage and markings of each speed hump is essential.	**Speed hump** height profile is typically between 70–100 mm above the road level. Most effective if used in series at 90-150m spacing. **Speed cushions** gaps to accommodate a wider tyre track for emergency vehicles. **Speed bumps** constructed out of plastic, and are individual spheres placed in staggered rows across the roadway.	
RAISED INTERSECTION Raised pedestrian crossings are effectively plateau speed humps with the road marking provisions for a pedestrian crossing. Raised intersections, 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. These are sometimes implemented adjacent to schools.	
CHICANES/LANE SHIFTS Chicanes require drivers to shift laterally by alternating either parking or kerb extensions along the street. (Often implemented with rumble strips).	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 50 km/h in town. The first curve of the chicane may be designed for 80 km/h and the second curve at 50 km/h.	
KERB EXTENSIONS Kerb extensions narrow down the carriageway and increase awareness of drivers, while shortening crossing distance for pedestrians.	Kerb extensions are typically only applied in an urban setting, where pedestrians are given priority over mobility. In heavily pedestrianized market areas for example.	

Device	Advice	Example
MINI ROUNDABOUTS Mini roundabouts slow speeds by requiring additional attention from drivers at conflict points. Note: these are ineffective in high-speed environments.	Use mini or compact roundabouts, only 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 primary position. The inscribed circle diameter of a mini roundabout should not exceed 15 m.	
PINCH POINTS Also known as chokers, Pinch points narrow the street, restricting drivers from operating at high speeds. Chokers restrict the movement to one lane.	Chokers severely restrict the capacity of the road, so should not be implemented on trunk routes and major arterials. Chokers require advanced warning for the road users, and acceptable taper rates for the kerb extensions, to prevent crashes.	
LANE WIDTHS Narrower lanes correlate with slower speeds. Lane widths should be determined based on the Design and Control Vehicle for any given street.		
BLOCK LENGTHS In addition to improved pedestrian connectivity, shorter block lengths limit the time cars can accelerate between stops.	Implemented at physical planning stage. Cannot be retrofitted.	
DIVERTERS Diverters break up traffic and limit access to cars, while maintaining permeability for pedestrians and cyclists.	There are three types of diverters, namely diagonal-diverters, semi- diverters, and star-diverters. These are usually used to restrict entry to a residential area and limit traffic flow at intersections.	

Device	Advice	Example
FORWARD VISIBILITY Reducing forward visibility is an effective way to slow speeds and increase driver attention. Forward visibility can be reduced with plantings and street alignments.		
STREET TREES Among many other benefits, street trees narrow the driver's line of sight and provide rhythm to a street.	In “shared space” environments trees, textured pavements, and bollards can serve to slow vehicles to speeds such that pedestrians can safely walk alongside and between them. Planting trees along a street can create a sense of enclosure and improve the pedestrian environment.	
MATERIALS The visual perception and the physical characteristics of different materials can denote a slower or guest environment for cars**.**	Special pavement textures (cobbles, bricks, etc.) and markings can designate special areas. 	
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 rumble strips are not meant to not break cars but rather to warn motorists to slow down.	The situations that warrant installation of rumblestrips are: • before a local speed limit e.g., in a trading centre or school zone. • at an approach to a dangerous intersection. • before a sharp bend	
SIGNAL PROGRESSION Signals can be timed to achieve the street's target speed.	Only relevant in areas with existing signalisation.	

DESIGN FOR ALL USERS

All types of people use roads. These include people on foot or small wheels such as scooters and skateboards, people on cycles, boda-boda's, people waking to public transport, minibuses, cars, as well as city services and freight.

Uganda's road network is a perfect example of "share the road", as all road users mostly use the same road space, most of the time, regardless of road hierarchy. This leads to a lot of disorder and exacerbates the risk for conflict." (Source: Urbanet)

A user's spatial requirements greatly impact road design. In order to create a successful road, it is imperative to ensure that the human scale forms the starting point for all road design.

UNIVERSAL ACCESS

Priority must be placed on designing with the city's most vulnerable users in mind, the elderly, the young and people with mobility impairments. That is the core principle of universal access: every road must be accessible by people of any age and any ability.

This manual requires the practitioner to comply with the requirements encapsulated in the Uganda Building Control Act, 2013 which stipulates the use of the accessibility standards for public areas. The Uganda National Action on Physical Disability and Ministry of Gender, Labour and Social Development published Accessibility Standards in 2010. This manual requires the practitioner to give consideration to the implementation of the standards with particular reference to Chapter 15 of the document that deals specifically with Urban Roads.

Block 1 contains an excerpt from the Accessibility Standards, 2010. The requirements of the URDM should be read with the Non-Motorised Transport Manual, 2020, which has a section on universal access.

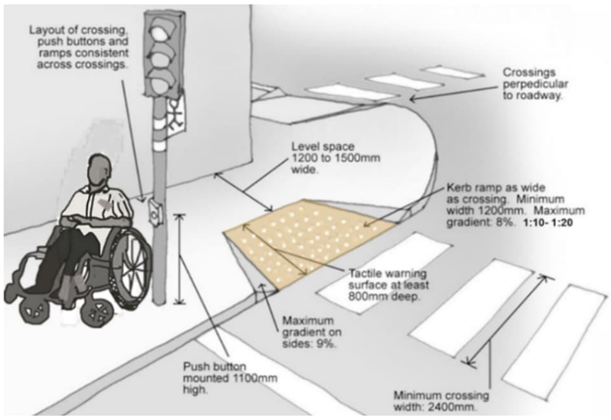


Figure 1.5: Tactile Paving on a Kerb Ramp

Block 1: Extract from Accessibility Standards, 2010

"(15.1) PLANNING PRINCIPLE
To construct roads in the urban settings that enable use, by all users especially blind persons and persons with mobility difficulties, without difficulties.

(15.2) KERB RAMPS
Kerb ramps are used whenever there is a difference in level on pedestrian paths or between sidewalks and road surface at pedestrian crossings, parking areas, bus-stops, or in front of building entrances. The minimum width of the kerb ramp should be 0.9m between two flared sides of minimum width of 1.20m. Kerb ramps should be gently sloping with the minimum slope at a ratio of 1.20 or 1.10 for short kerbs and maximum slope of the flare should be 1.10.

There should be kerb ramps whenever there is a public building along the road to ease access from the main road to the building entrance by a wheelchair user.

Kerb ramps should be made of non-slippery materials.

At zebra/pedestrian crossings, kerb ramps should be provided at both sides of the crossing.

(15.3) KERB STONES
At points where pathways are specifically designed to crossroads with heavy traffic, kerb stones should be avoided. If it they cannot be avoided, distant-placed kerbs with maximum height of 40mm should be used to enable the blind person to recognize the pavements.

Kerb stones should be painted in contrasting colours for easy identification by persons with visual impairment. Lower kerbs should be placed at points where pedestrians cross the road to enable wheelchair users cross the road without any obstructions.

(15.4) PATHWAY
The minimum width of an un-obstructed pathway adjacent to the road should be 0.9m and preferably 1.5m. Pathways should be even, gently sloping and connected to the road by the kerb ramp. This eases access to the pathway by wheelchair users.

The surface of an accessible pathway should be smooth, continuous, firm, and non-slippery. The pathway should be given a different texture and colour finish for differentiation from the main road. Pathways should be filled with tactile clues like Braille blocks as route finders for the blind. It is important to clearly define the edge of the pathway or routes by using different colours and textures.

(15.5) SAFETY
Roads near or adjacent to an institution or facility serving PWDs should be fitted with both a hump and a zebra crossing, with a hump preceding the zebra crossing to slow down speeding vehicles. Zebra crossings should be well connected to the pathway without any inconvenience and accessible to every road user.

Roads should have enough road signs to effectively guide the road user including PWDs. There should be audio signals in addition to traffic lights to alert the visually impaired pedestrians to cross safely.

(15.6) STAGE
This refers to the designated stages of either buses or taxis for passenger boarding.

a) Design at least one accessible route of 0.90m wide and gentle gradient of 1.10 should be provided from the boarding point of the bus stop to the sidewalk or main accessible pathway. Kerbs should be provided along the accessible path from the boarding point to the accessible pathway or to accessible entrance of the building.
b) Location - Stages should be positioned strategically to enable a wheelchair user approach it without any difficulty. Whenever there is a difference in level between the drop- off area of the bus and the sidewalks or pathway, a kerb ramp should be provided.
c) Shelter - A shelter should be provided at the bus stand for protection against rainy and sunny weather conditions. Seats should be provided at the stages for people with reduced mobility. The seat should be positioned with enough free space to allow easy movement of wheelchair users.
d) Information - Clear information on the bus numbers and names of all bus stops should be indicated on the stage area. This information should be in large print, contrasting colour and well illuminated at night.

GENDER-SENSITIVE DESIGN

The URDM requires that practitioners consider and implement the gender-sensitive guidelines described below.

Different genders experience a city or town in different ways. Women often have a higher degree of responsibility for children and make more complex journeys, escorting children to school, fetching water, etc. The involvement of women in street trading is also relatively high. Crossing a road with a child is a different experience from crossing as an adult alone. Strollers/pushchairs require additional space on a sidewalk.

The nature of the trips taken by women involves a higher number of short trips to fetch and carry. Women are disproportionately affected by poverty and violence. Women, living in sprawling informal settlements, are subjected to poor transportation, lighting, electricity, and lack of basic services such as water and sanitation. Therefore, the environment must be supportive of them.

Gender equality in public spaces such as roads can be achieved by accommodating features that improve women's safety (UNIFEM, 2010). Planning and designing should put special focus on the following elements in road design (UCLG, 2016; UNIFEM, 2010):

Proper lighting: Insufficient public street lighting leaves women vulnerable in dark areas where they are at risk of physical and sexual assault. In particular at public places like train stations and markets.

Wide enough sidewalks: Having to negotiate a sidewalk with a stroller is often the prerogative of women. The sidewalk should be wide enough to cater for this function (at least 1,8m).

Landscaping: Use landscaping with a high canopy or a low ground cover, so there is nowhere for criminals to hide and to aid visibility.

Visibility: Place bus stops in areas where women feel comfortable waiting, i.e., public places with lighting and high visibility.

Clean toilets: Public toilets should provide more female toilets as women need to use toilets more often and for longer periods than men.

Safety audits: Women's participation in decision-making is critical. Before planning roads, ensure that safety audits are conducted with women who will use the roads.

Gender mix of staff: Some ways to solve this are greater security personnel presence on buses and at stations, a greater and gender-mixed staff presence from transport officials, and in some cases, women-only carriages.

Access to public transportation: When it comes to BRT, more often women are carrying children or packages when using transit. Deep steps make it difficult to easily board and alight buses.

Bus/PT Only lanes: Stops in bus-only lanes make it possible to reduce delays for the other traffic by concentrating stops in traffic flow to a single lane. This also offers an opportunity to create a safer space where passengers can board buses more calmly. They also contribute to condensing activity to a single point on the sidewalk without affecting the flow of pedestrians.

Signage: Create women-only areas and ensure signage is clear and legible.

Bus stop design: Harassment on public transport is problematic. This issue should influence the design of bus stops/shelters. Shelters should allow for maximum visibility, especially at night.

Safe bicycle paths: Increasingly more women are using bicycles as a means to earn an income as they provide access to the market. Small bicycle taxis are being used to transport women to and from the market in Uganda. The provision of safe bicycle networks and paths will facilitate their use.

Safe and well-lit spaces for women: Female Boda-boda drivers can also contribute to safety for women passengers who prefer to ride with female drivers.

BASIC GENDER AND URBAN TRANSPORT CHECKLIST

1. Has the Urban Transport programme or project identified male and female participants, clients, and stakeholders?
2. Has baseline data been collected on gender relations, roles, and identities in that urban environment?
3. Has the issue of personal mobility for non-drivers (majority of which are women) been thought through, such as emphasis on walking, sidewalks, bicycle paths and lighting?
4. Has the road project design been informed by a gender-responsive social impact assessment?
5. Was a Gender sensitive monitoring and evaluation framework used?
6. Were dedicated funds allocated to gender equality aspects of the road project?

ENABLING LEGISLATION ON GENDER SENSITIVE DESIGN

This section is not comprehensive and highlights the most specific frameworks that the practitioners must consider as a minimum requirement.

The Universal Declaration of Human Rights promotes gender equality. Uganda has signed the Declaration, saying that it will uphold these rights for its citizens.

The Constitution of the Republic of Uganda: Article 21 of the Constitution of the Republic of Uganda prohibits gender discrimination generally and enshrines the principle of equality before the law, regardless of sex, race, colour, ethnicity, tribe, religion, political belief, or social or economic standing.

National Gender Policy, 2007:
The policy gives a clear mandate to the Ministry of Gender, Labour and Social Development and other Line Ministries to mainstream gender in all sectors. It sets priority areas of action at the National, Sectoral, District and Community levels with all levels of planning, resource allocation and implementation of development programs redressing gender imbalances and acting with a gender perspective. The MoWT also prepared a Gender Policy Statement for the Roads Sub-Sector, as well as Guidelines for Mainstreaming Gender in the Roads Sub-sector.

PEOPLE ON FOOT-PEDESTRIANS

Data reported in the UNHS suggest that 64 % of urban dwellers in Uganda walk to work and walking trips are as high as 70% in Kampala. Pedestrians are sometimes not taken into account along the road edges to provide more space for vehicles within the right-of-way.

This occurs in several ways:

- Narrow footpaths squeeze pedestrians together and do not leave sufficient room for people to pass. Deep open stormwater drains are dangerous for pedestrians, especially children.
- Footpaths become cluttered with poles and guardrails, street traders and trading goods or boda-bodas parked on the sidewalk, which obstructs and constrain pedestrian movement and creates visual clutter.
- Footpaths are lined with blank walls and fences that restrict passive surveillance and make pedestrians feel isolated and vulnerable.

These elements can combine to obstruct vulnerable users and at times it is necessary for them to move out onto cycle paths/ lanes and/ or vehicular carriageways in order to progress along the road.

The geometry of roads and footpaths and other kinds of pedestrian facilities depends on the physical dimensions of people and path users. Hence it is important to take note of the average dimensions of a person, to ensure that pedestrian facilities remain human-scaled. The average pedestrian is about 0.65 m wide and will generally require a 0.8 m-long space to manoeuvre when walking. In order to walk safely, a diameter of 0.8 m around the pedestrian is seen as the minimum space needed

These dimensions are different for people in wheelchairs, who require slightly more space. Wheelchair users require a space of around 1.2m to 1.5m long to manoeuvre while moving forward. The recommended space around a wheelchair user is at least 1.8 m. When designing roads for people, the requirements of people in wheelchairs should always be seen as the minimum dimensions of any facility. These dimensions are shown schematically in Figure 1.6

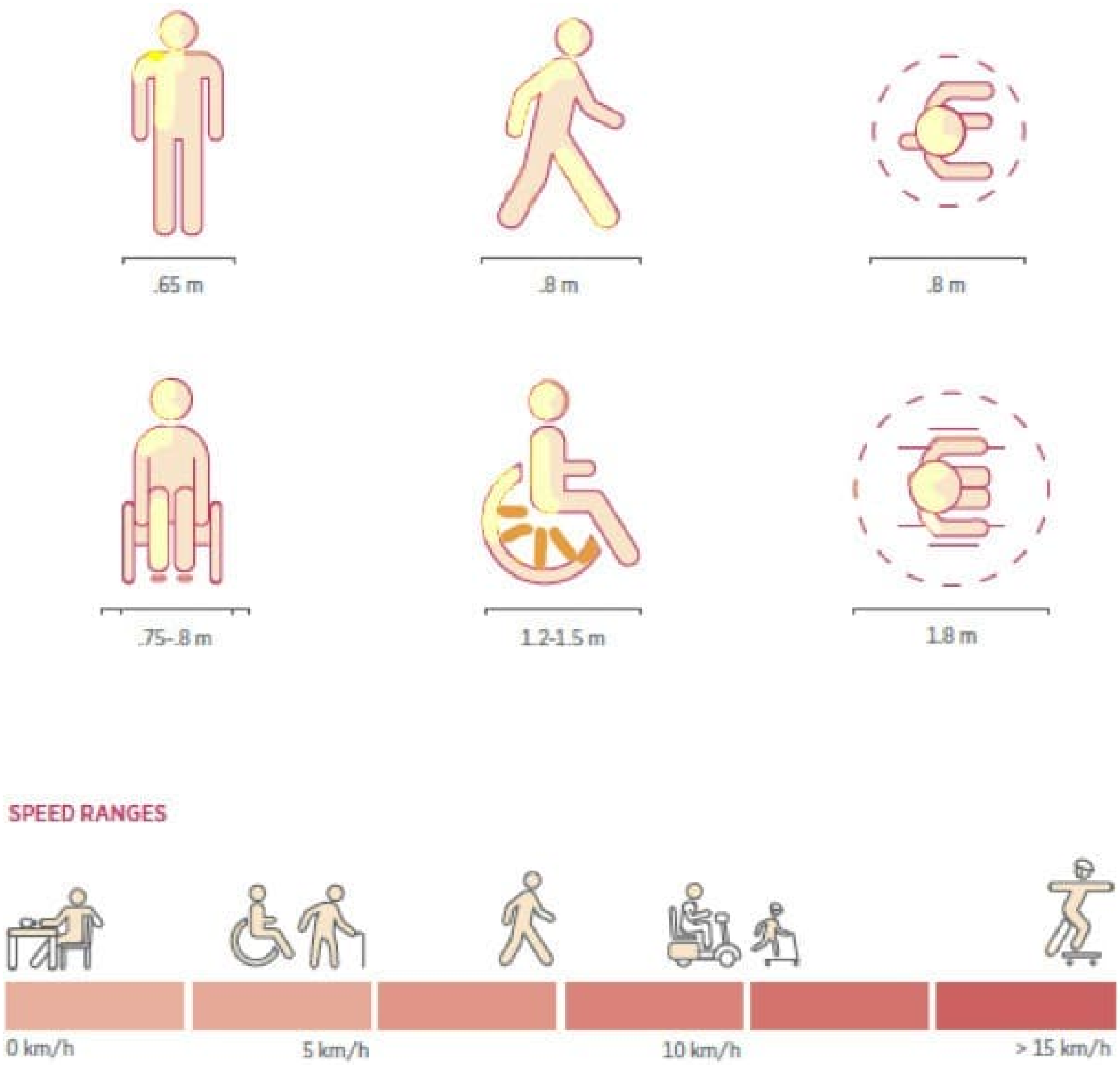


Figure 1.6: Typical Dimensions for Pedestrians

DESIGNING FOR CYCLISTS

Facilities for cyclists should be safe, direct, intuitive, clearly marked on the road surface, and part of a cohesive, connected network to encourage use by people of all ages and confidence levels. Uganda's Non-Motorized Transport (NMT) policy, which was approved in 2020, emphasises the need for the provision of safe facilities for cyclists. A good cycling route is an uninterrupted route that is safe, direct, cohesive, comfortable, and attractive. The more routes interconnect and allow cyclists to freely choose their itinerary, the stronger the network is. Cohesion is a very important feature for cyclists: it is the extent to which they can reach their destination via the route of their choice.

The URDM practitioner is required to actively consider and implement the guidelines regarding cyclists as contained in the NMT guidelines. Two types of cycling facilities are discussed in this NMT Guideline:

- Separated cycle paths: Space is allocated for exclusive cycling use, separated from traffic by buffers, medians, or parked vehicles
- On-street facilities: Including cycle lanes and mixed-traffic roads, these are facilities where cyclists ride in or next to motorised traffic. Cyclists can be seriously injured in even a minor collision with motorised traffic

SEPARATED LANE/CYCLE PATHS

In general, new cycling facilities should be separated from motorized traffic where travel speeds exceed 30 km/h, as cycling near fast-moving traffic is uncomfortable and more dangerous for most cyclists. The buffer width should be 0,6m or more allowing pedestrians to pause here.

Where vehicular speeds reach up to 50 km/h and more than 6,000 vehicles pass by each day, bike lanes must be protected from car traffic with heavy-duty physical separators such as kerbs, bumpers, bollards or barriers.

Typical design considerations are:

- A 3.5m road width is desirable, but an absolute minimum of 2.5m could be considered.
- Provide 0.5m lateral clearance and at least 2.5m vertical clearance.
- Place on commuter and recreational routes where there is adequate space for greenway development.
- Preferably separated from pedestrians but could be designed as multi-use pathways.
- Typically having grade separation at intersections.
- There are limited accesses and junctions, and cyclists are required to behave as pedestrians rather than vehicles at junctions.
- Provide a smooth pavement.
- Ensure connectivity through the development of a bicycle master plan.

SHARED ROADS/ON-STREET CYCLE LANES

Local roads with shared cycle lanes in mixed traffic. Shared facilities are most fitting on quieter roads with lower speeds (< 30km/hour) and low traffic volumes.

Painted cycle lanes indicate an allocation of road space for cyclists. Due to the lack of physical separation, these are not the preferred choice in busy urban areas in Uganda. Cycle lanes should be at least 1.8m wide for one way. If there is space in the road, consider placing the cycle lane between the kerb and the allocated parking area.

Typical design considerations are:

- A 3.0m two-way lane width is desirable, but an absolute minimum of 2.5m could be considered.
- A 1.8m one-way lane width is desirable, but an absolute minimum of 1.5m could be considered.
- Provide 0.5m lateral clearance where no property access is present, otherwise 3.0m is required.
- There are limited accesses and junctions, and cyclists are not required to behave as pedestrians but rather like vehicles at junctions.
- Ensure continuity of routes.
- Provide sufficient sight distance at intersections and accesses.
- Preferably separated from pedestrians but could be designed as multi-use pathways.
- Provide smooth pavement.
- Ensure proper maintenance, especially pavement edges.
- Provide a smooth transition from pavement to the gutter pan.

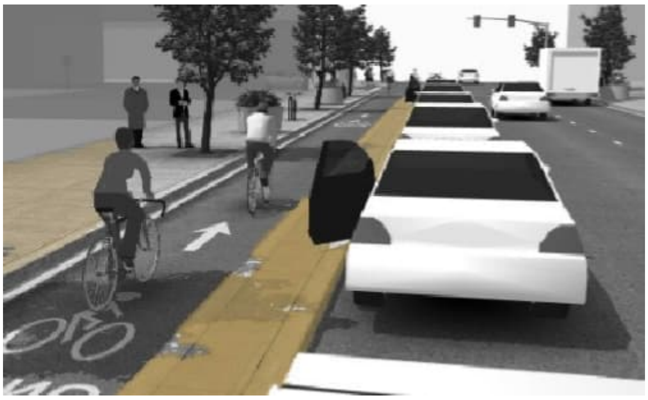


Figure 1.7: Separated Lane/Cycle Path Example

Figure 1.8: Shared Roads/On-Street Cycle Lanes Example

LOCAL PATHS

Local paths are quiet roads, routes through parks and short connections that improve walking and cycling connectivity. They form the local catchment areas of the wider cycleway network.

Roads that form part of a local path network must meet the performance standards for low-stress cycling: low traffic volumes (< 2,000 average daily traffic) and slow speeds (< 30 km/h). In some cases, interventions are required to create roads that are suitable for mixed-traffic cycling.

The typical dimensions for Cyclists and boda-bodas are shown schematically in Figure 1.9.

Typical cross-sections of cycle lane and footway combinations are shown in Figure 1.10 to Figure 1.14. These are extracts from the Non-motorised Transport Manual, 2020.

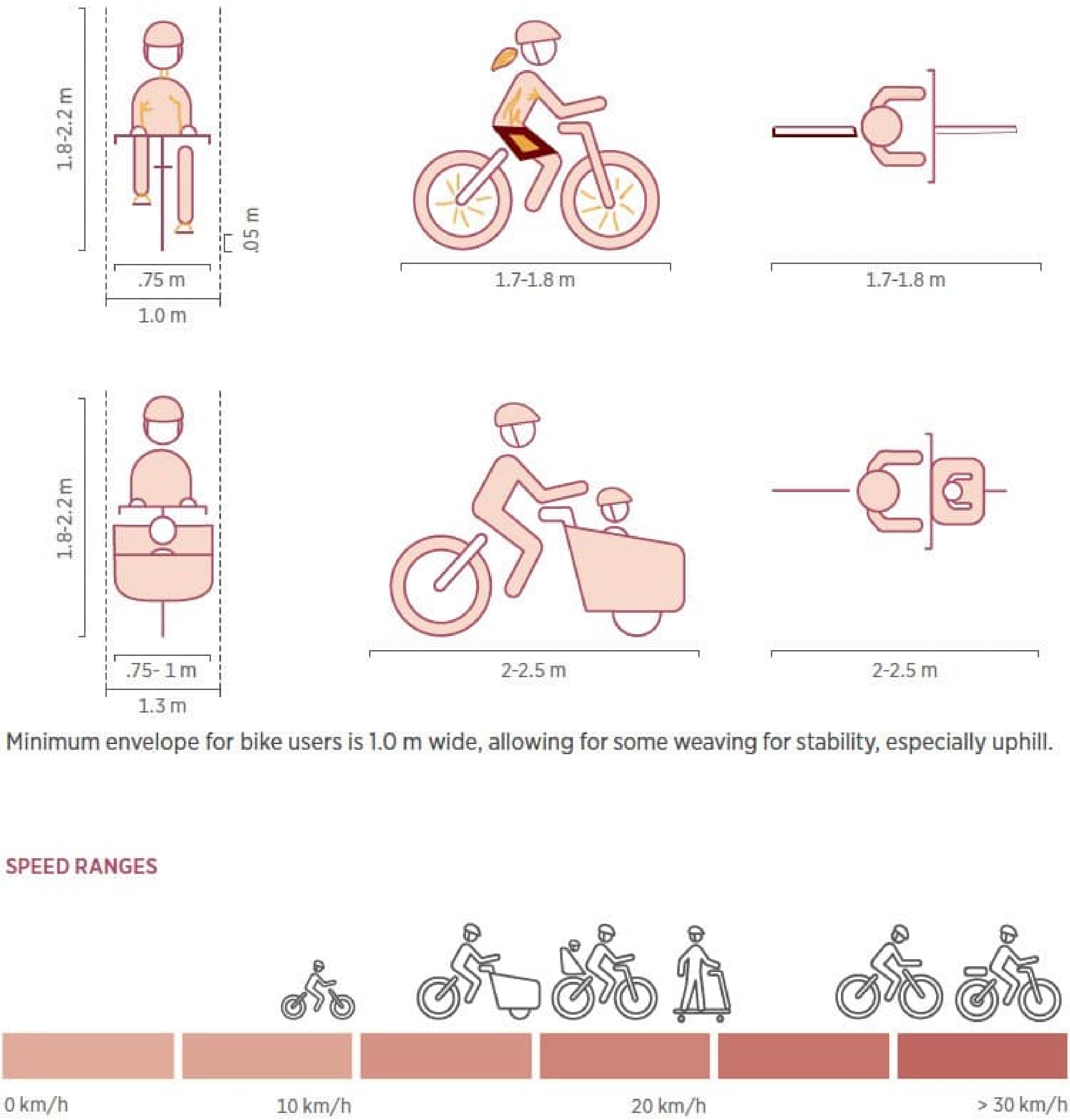


Figure 1.9: Typical Dimensions for Cyclist & Boda-boda's

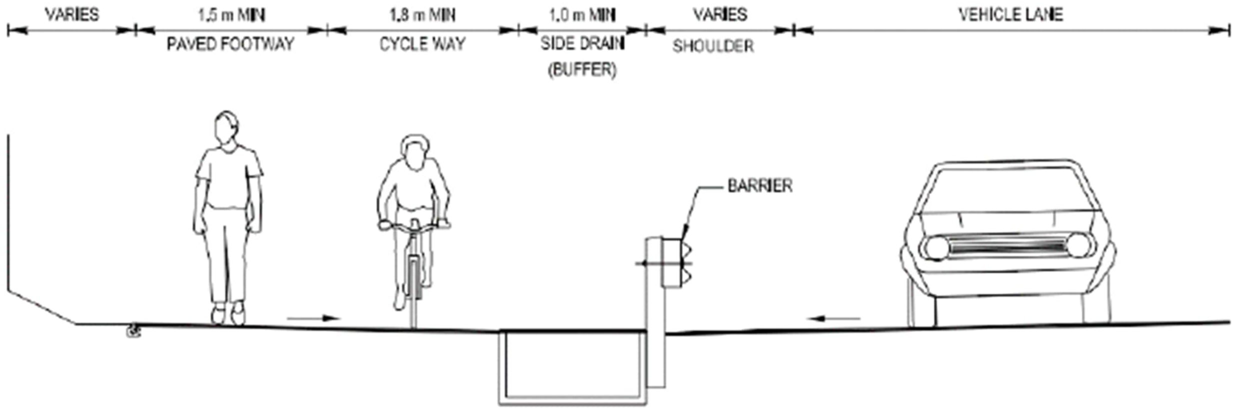


Figure 1.10: Extract from NMT Manual showing kerb protected footway and cycle lane

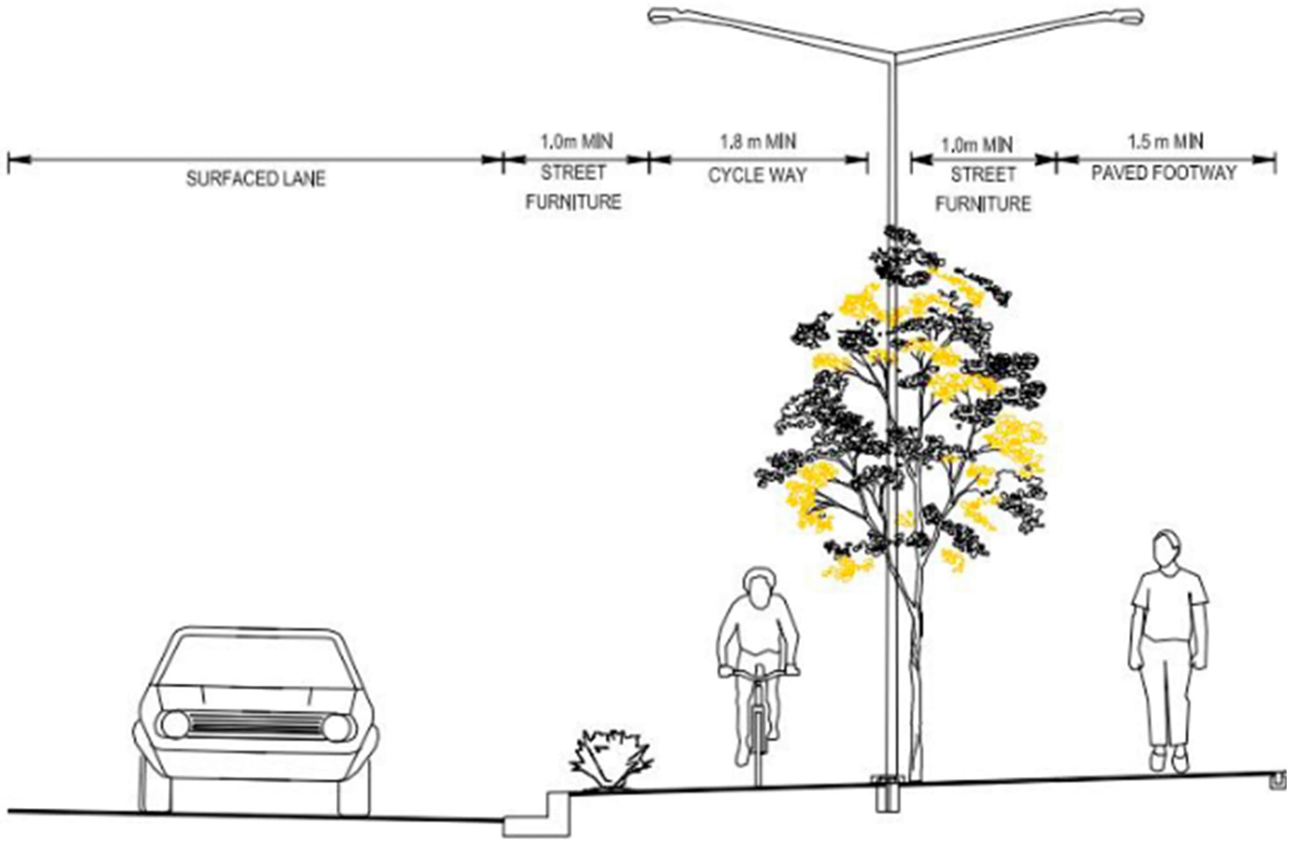


Figure 1.11: Extract from NMT Manual Typical cross-section of kerbed separation (Class 3) (Extract from NMT Manual))

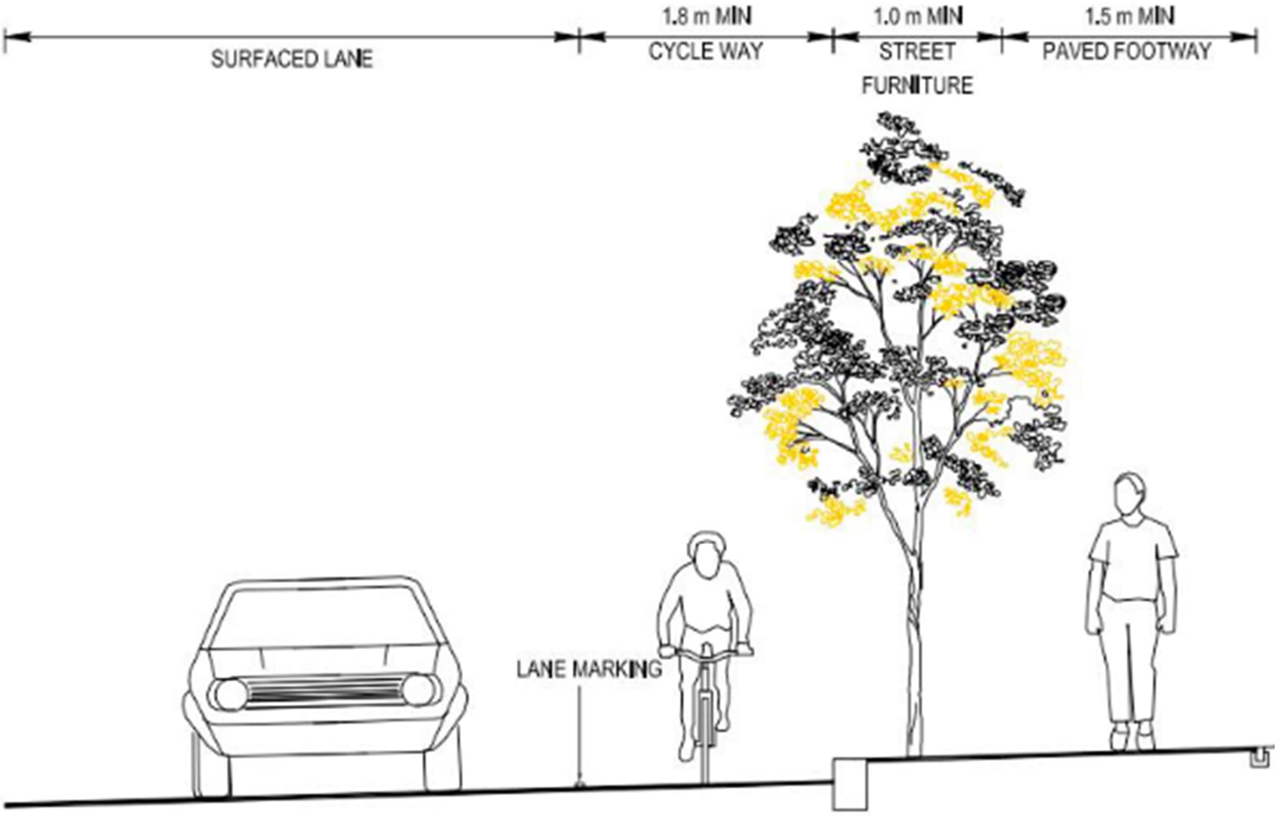


Figure 1.12: Typical cross-section-kerbed separation of pedestrians, line marking separated cycleway (Extract from NMT Manual)

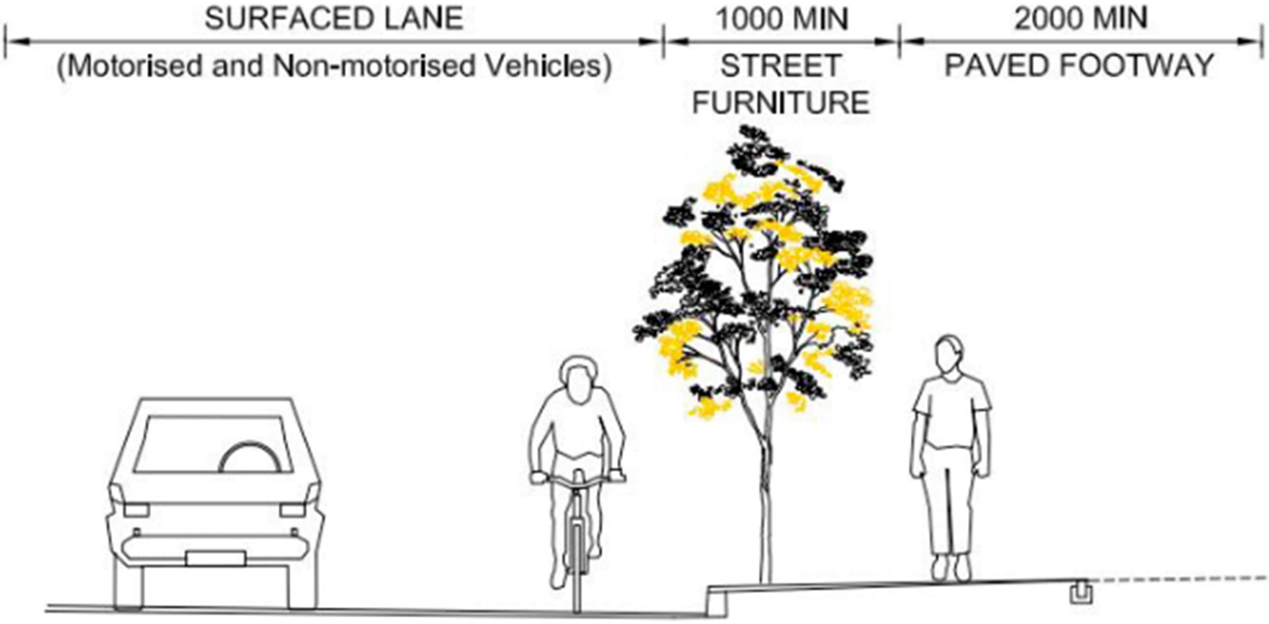


Figure 1.13: Kerb-protected footway (Class 4)
(Extract from NMT Manual)

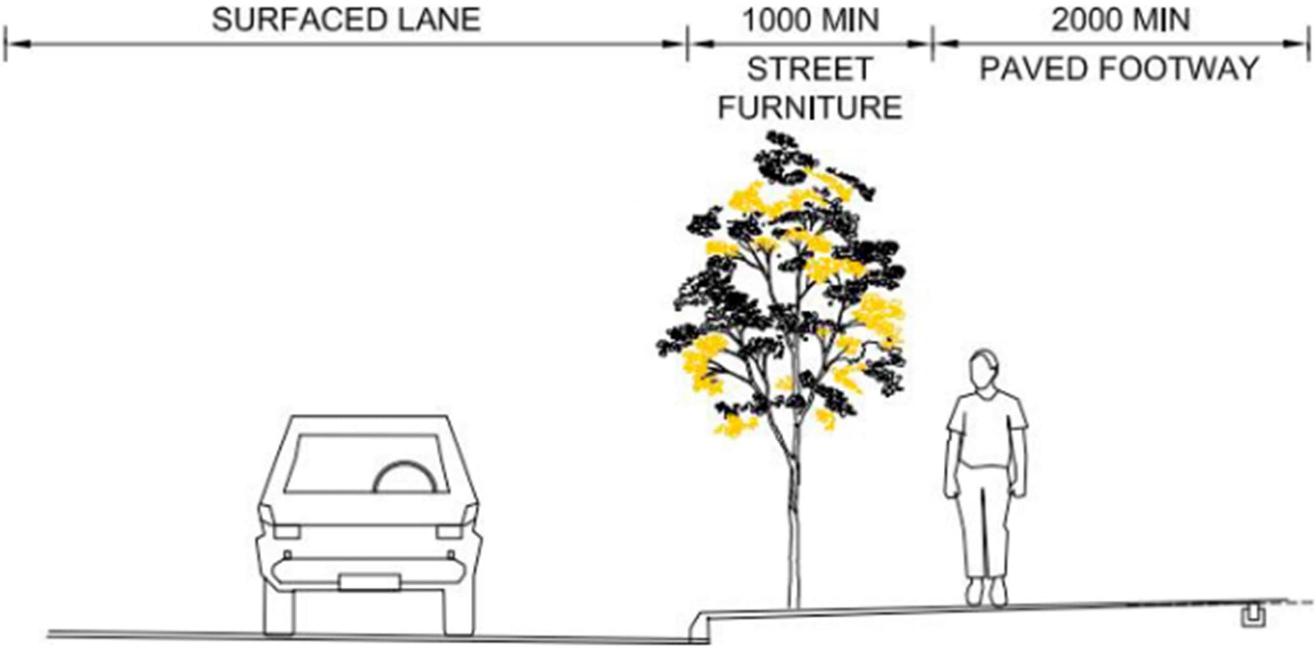


Figure 1.14: Kerb protected footway only (Class 5) (Extract from NMT Manual))

DESIGNING FOR PUBLIC TRANSPORT

The public transport system in Uganda is largely informal, comprised largely of taxis (14-seater minibuses) and boda-bodas (motorcycle taxis). Most people walk or use boda-bodas to get around, while taxis are mainly used for longer distances between towns.

These forms of transport are unregulated and inefficient – catering to a few passengers per vehicle. The industries are fragmented with a large number of owners, a major oversupply and a lack of coordination and enforcement Taxis lack any formal predetermined routes and stops.

Authorities should plan for the introduction of mass transit services in the high travel volume corridors, with taxis and boda-bodas continuing to serve as feeder or last route connections.

Although Public Transport can be integrated into a full variety of urban streetscapes, from one-lane shared roads to multi-lane dual carriageway boulevards, future planned mass transit, (such as light rail or Bus Rapid Transit) should be located along the main arterial routes where possible.

The following principles demonstrate ways to efficiently integrate on-street public transport facilities, bus and other stops and stations, boda-boda, pedestrian and bicycle infrastructure, and general traffic lanes in a variety of road sizes and types. They also illustrate how road design elements work together to form a vibrant streetscape.

Road networks underpin the efficiency and sustainability of public transport and, consequently, the ability to facilitate higher development densities along public transport corridors.

Permeable networks which maximise connectivity will assist in achieving this objective.

Consider the implementation of bus priority measures. These ensure that buses can move through congested networks with minimal delays.

Designers must have regard for the location of bus services as a strategic network issue. In general: Public Transport services should primarily be directed along the Main Arterial Routes as these will be the most direct routes between destinations with the greatest number of connections.

Special BRT/Public Transport lanes should be provided on roads which cater for higher frequency services such as in the Central Business District of a City.

On lower frequency routes, or in less congested networks, bus lanes that allow buses to move towards the front of queuing traffic at junctions may suffice. This approach may also be preferred on existing roads in Ugandan towns where the right-of-way is constrained.

SIGNAL PRIORITY

Widely used on prioritised busways in many cities, public transport signal priority allows public transport vehicles to extend a green phase or shorten a red phase, without interfering with the phase sequencing or overall signal timing. The time difference is made up for in the subsequent cycle when the bus has passed. All other signal operations remain intact.

Using an in-vehicle transponder, public transport vehicle drivers can trigger a signal change on their approach to an intersection, ensuring that they have a green light. This minimises waiting times at the intersection or eliminates it altogether. This reduction of delays allows public transport to stay on schedule and it minimises platooning, which is an unscheduled reduced headway between buses. Refer to Figure 1.15

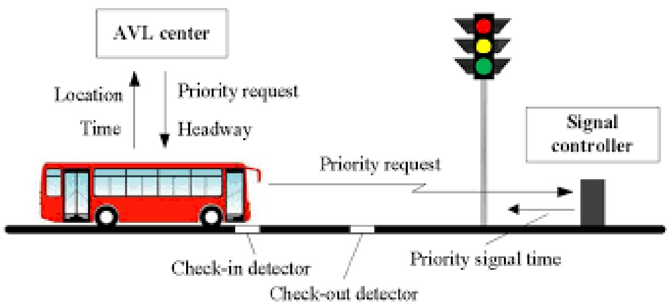


Figure 1.15: Signal Priority – Working Diagram

PUBLIC TRANSPORT ROUTES

Public transport routes include service routes as well as routes vehicles use to and from the depot. At intersections with very frequent bus turning movements (>12 buses/hour), roads should be designed for the 12.6m urban bus.

The intersection principles established above are especially relevant to public transport routes, as they are likely to have high levels of people on foot, as well as multiple, competing interests in the road reserve. In order to maintain compact intersections along frequent bus routes (> 12 buses an hour), the techniques to accommodate large vehicle movements should be used.

The following public transport strategies should also be considered to maintain compact intersections:

- Minimise bus route turning movements
- Consolidate turning movements at one intersection (instead of at multiple adjacent intersections)
- Consider right turning patterns for bus routes (to minimise intersection geometry).

Other public transport design considerations:

- Consider the mutual benefits of public transport priority elements (bus lanes, queue jumps, signal advance, etc.) in intersection design
- Consideration should also be given to private transport operators in areas where large tourist buses and vans are likely to conduct business on a regular, basis.

Typical Bus Route Diagram, different colours per route

DEDICATED BUS LANES, SHORT APPROACH LANES, QUEUE JUMPS

Continuous bus lanes, short approach lanes and queue jump lanes provide a by-pass for public transport vehicles to reach the front of the intersections. These are used in conjunction with active signal priority to give buses a head start into a receiving public transport lane or a general traffic lane.

1.1.5 DESIGN ELEMENTS

The elements that make up urban roads, from sidewalks to travel lanes to kerbs to landscaping are all tools that the road designer can use to create appropriate roads. Once the appropriate class has been chosen, the elements can be added based on the nature of the road and surrounding land uses as well as the available road reserve space.

FOOTPATHS

Footpaths make up the majority of the network of pedestrian facilities. The clear through route on any footpath should never be less than 1.8 m wide. Footpaths should have hard, even paving and cross-fall of 2% (not more than 3%). Footpaths should include a buffer between the clear path and traffic; presenting a good place for street furniture, utilities and service covers and tree pits.

VENDORS AND TRADERS

Street vendors are broadly defined as traders that use their bodies, wheelbarrows, handcarts, bicycles, temporary shades, trees, fences, mats, tables, and racks to carry, display, and sell their commodities. Planning authorities should consider ways of designing and delivering urban infrastructure to support productivity in the informal economy.

Making basic infrastructure such as running water and toilets available to vendors and consumers would help keep street markets more hygienic.

Issues that affect vendors include inter alia:

- Access to running water for hygiene and drinking water
- Access to public bathroom facilities
- Access to solid waste disposal- dustbins
- Proper lighting/safety
- Shelter from the elements
- Access to storage facilities

Note, the cross sections developed in the URDM makes provision for on-street vending areas within the road reserve (right-of-way). Due to the planned function of the road per class, the location of the road in terms of adjacent land use, and the total cross-section width available, not all cross-sections make provision for on-street vendors.

It remains the decision of the local authority to include street vending space within the cross-section of a road. There may be road sections and areas where the authority does not allow on-street vendors due to factors such as the availability of dedicated market areas for vendors, or very high NMT volumes that requires wider walkways or cycle lanes.

In this case the space available on the standard cross-sections for vendors can be utilised for either wider NMT lanes, areas for trees/planting, or additional on-street parking.

UTILITIES FOR VENDORS (TOILETS, WATER, WASTEBINS)

Lack of facilities such as shelter, road drainage, potable water, toilets and storage causes major problems for vendors.

- Toilet and water facilities impact directly on cleanliness and crime prevention
- Build toilet facilities in small blocks so that toilet facilities are well distributed throughout an area.
- Attention should be paid to lighting in the toilets with maximum use being made of natural light.
- The fittings and finishings must be robust and easy to clean.
- Establish water points near meat cooking activities, which need a lot of water.
- The water points should be housed in robust lockable cabinets containing a tap and water-meter.
- No unsupervised installation can prevent vandalism. Even with the most vandal-resistant appliances, an unsupervised facility will eventually become sub-standard. Regular maintenance of all facilities must be included in the management of the facilities.
- The management of these water points could be outsourced to traders as a small business opportunity.

SOLID WASTE

The draft Developing municipal solid waste management strategy for the municipal local governments of Apac, Busia, Kamuli, Kasese, Kitgum, Lugazi, Mubende and Ntungamo, 2021 (JBN) 2021 describes a number of issues and recommendations for waste management that impact the design or urban roads in Uganda. These include:

- Low level waste collection
- Inaccessible areas for solid waste collection
- Absence of effective bylaws to enforce illegal dumping, collection, etc.
- Waste storage and collection: Inadequate numbers of waste storage bins per site.
- Inadequately maintained road network, especially the routes to the informal settlements.

The strategy states that there is a requirement for appropriate collection points and an improved road network. In addition, sensitization of the public through inter alia signage and communication strategies is required.

This can be achieved through an improvement in the road network and adequate placement of waste bins on roads. Advice on the placement of bins is provided below. Advice on solid waste management during construction is provided in Volume 2, Section 2.77.

- Waste bins must be coordinated with seating and placed in areas of pedestrian activity such as informal vending areas, along pedestrian routes, at bus and taxi stops and in public parking areas.
- Waste bins must be weatherproof and fireproof
- Waste bins must have removable inner linings (bags) to promote ease of emptying
- Waste bins must have full or partial covers to contain smells and insects
- Bins should not occupy more than 1m² of space and located at intervals of not more than 200m.
- Bins should ideally be located along sidewalks and footpaths accessible to pedestrians but must not obstruct the routes.
- It is critical that a schedule is developed and maintained, and updated if required, to ensure that the waste bins are emptied regularly. Note that the schedule may require updates to ensure that areas, where waste bins fill up fast, are either cleaned/emptied more regularly, or more and/or bigger bins are supplied.

IMPROVING STREET LIGHTING

Lighting up the streets is an obvious way to make them safer for pedestrians and traders alike, see Volume 2, Section 2.3.15.

CLEANING

The importance of drained, hardened, durable paved surfaces in areas that encourage street trading. Good stormwater drainage is essential. In some instances, specialised drainage solutions are required, such as sumps for cooking waste

DEDICATED MARKETS

Dedicated market spaces with roof cover; toilets, storage (unless the market is locked at night), and a management structure is important parts of the spectrum of infrastructure provision and have some distinct advantages for both municipalities and traders (assuming the location is good for business).

Clearance distances from the kerb for street vendors:

- Vendors/traders should not obstruct a public road, footway or public place. Enough space must be provided adjacent to traders for pedestrians to walk.
- Vendors should not be located in an area that obscures a shop window and traffic signs.
- Vendors should not obscure a fire hydrant or the entrance or exit to a building.

When located in the furniture zone of a sidewalk, vendors and stalls should be placed at least:

- 0.5m from kerb edges
- 2.0m from street furniture such as benches and fire hydrants.
- 1.5 m from trees and planters.
- 2.5m from transit stops, boarding zones, and loading zones.
- 3.0m from pedestrian crossings
- 6.0m from building entrances.

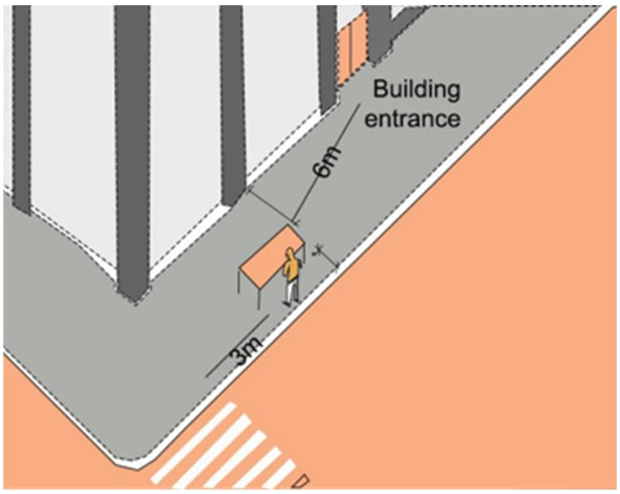


Figure 1.16: Typical Sidewalk Arrangement for Traders

Factors to consider in the spatial design for street vendors

- Any urban redesign needs to be informed by the nature of existing trading activities – what is sold where and how it is displayed, as well as pedestrian flows.
- Pedestrian counts are important in calculating how many street traders can be accommodated in any one area.
- Although there may be no official figures, transport authorities normally have estimates. If these are not available, then estimates can be made by spending time on the roads.
- The viability of the majority of street trading businesses is about ‘passing feet’. Any redesign that changes pedestrian flows needs to bear this in mind. Certain trades are not so dependent on foot traffic. Trades, where customers specifically seek out products or services, can be accommodated in less busy areas.
- Well-located and designed storage facilities benefit both traders and local government. They are convenient for traders; they change the amount and range of goods traders can display and sell, and they reduce damage to goods and therefore help to increase trader incomes. For some, this also means that they do not have to sleep in the streets to guard their goods.
- For local government these storage facilities improve the general appearance of the city or town. These should not be provided on roads, but in dedicated market areas adjacent to roads.

No street furniture

Makeshift covers over open stormwater drains

No pedestrian walking space

No or too few public facilities (washrooms)

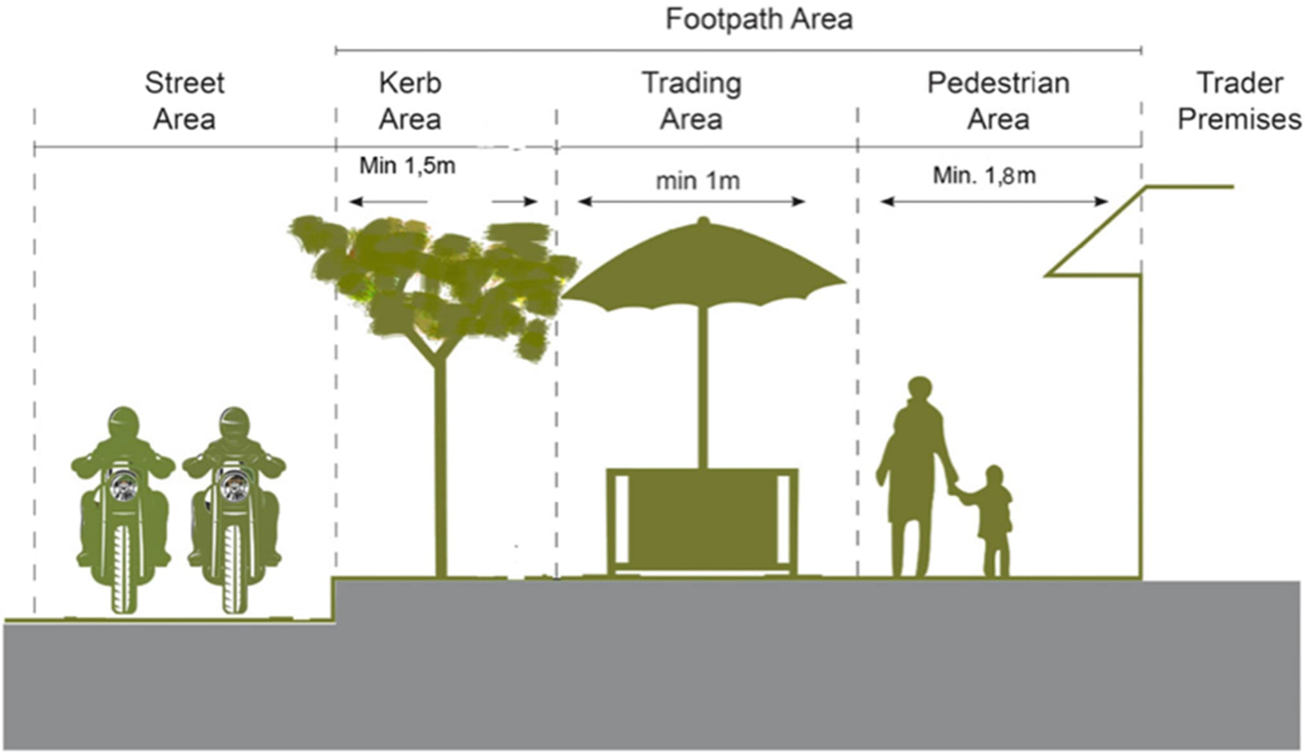


Figure 1.17: Typical Cross-Section with Space for Traders and NMT

KERBS

Kerbed roads have a significant effect on driver behaviour. Kerbing affects the distance that drivers align their vehicles from the edge of a road and acts as a physical and psychological barrier that discourages them from leaving the road surface. Generally, lateral placement of vehicles varies with kerb height and steepness as well as the location of other obstructions outside the kerb-line. Kerbing improves the delineation of road edges and contributes to the appearance and safety of the road. The URDM practitioners are required to comply with and implement the guidelines contained in the Uganda NMT Manual, 2020 which has a full section on kerbs (Section 10.4.6).

The main purposes for kerb construction are:

- To assist drainage.
- To improve channelling and delineation of traffic flows.
- To protect pedestrians.
- Improvement of aesthetic values of the road alignment.
- To reduce maintenance of shoulders.
- To provide a boundary to landscaping treatments.
-
- The use of kerbing to control vehicle movements is generally recommended in urban environments particularly at intersections because it is most effective at low speeds and small angles of impact.

Refer to the Standard Drawings and Figure 1.18 for typical kerb types, namely:

- Barrier kerbs
- Mountable kerbs

Kerbs provides vertical separation from the roadway, protecting pedestrians from vehicle encroachment. Kerb height should be 150mm from channel to top of kerb. Kerb alignment and design have implications for use by pedestrians, notably with regard to kerb crossings and kerb extensions. Kerb crossings mediate the transition from the footpath to the carriageway at pedestrian crossings. They are critical for people in wheelchairs and people with prams or trolleys. Any ramps should be at a 90° angle to the kerb, aligned with the crossing facility.

Kerb extensions can be used as traffic calming devices, as they physically and visually narrow the carriageway, increase driver awareness and encourage reduced vehicle speeds.

They shorten the crossing distance and increase the visibility of waiting pedestrians.

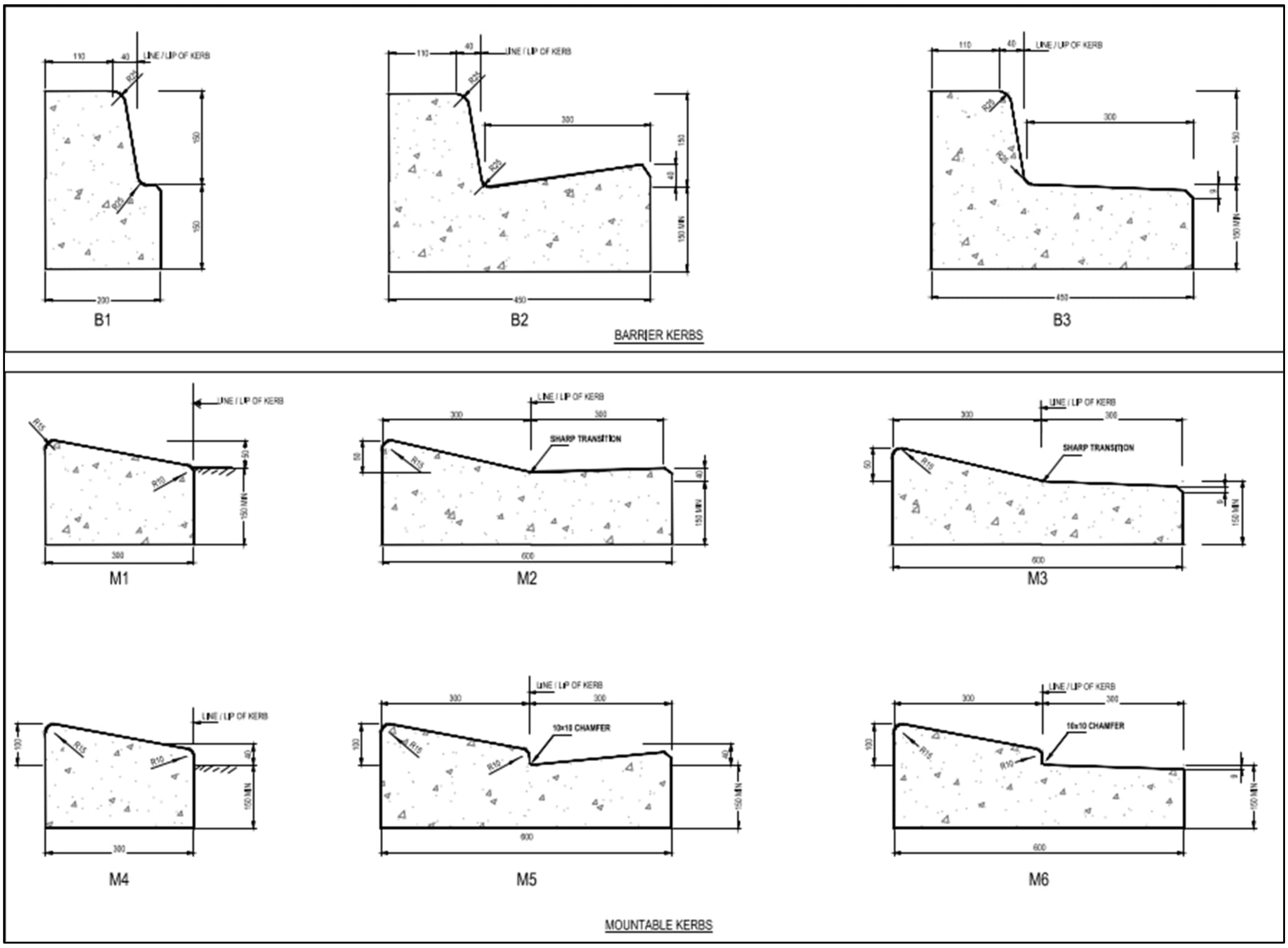


Figure 1.18: Typical Kerb Types

Construction of kerbing may significantly affect the cost of a project. Therefore, the construction of kerbing should be justified in the following situations:

- Limited road reserve (introduction of kerbing reduces the cross-section width). This is particularly relevant in Uganda where road reserves are narrow and land tenure is an issue for purchasing land.
- Deep cuttings (to assist drainage). Most of the urban roads within Kampala fall within this category.
- Special environmental requirements (control accidental spills, drainage of bridges etc.).
- Structural requirements (to protect high embankments from scouring)

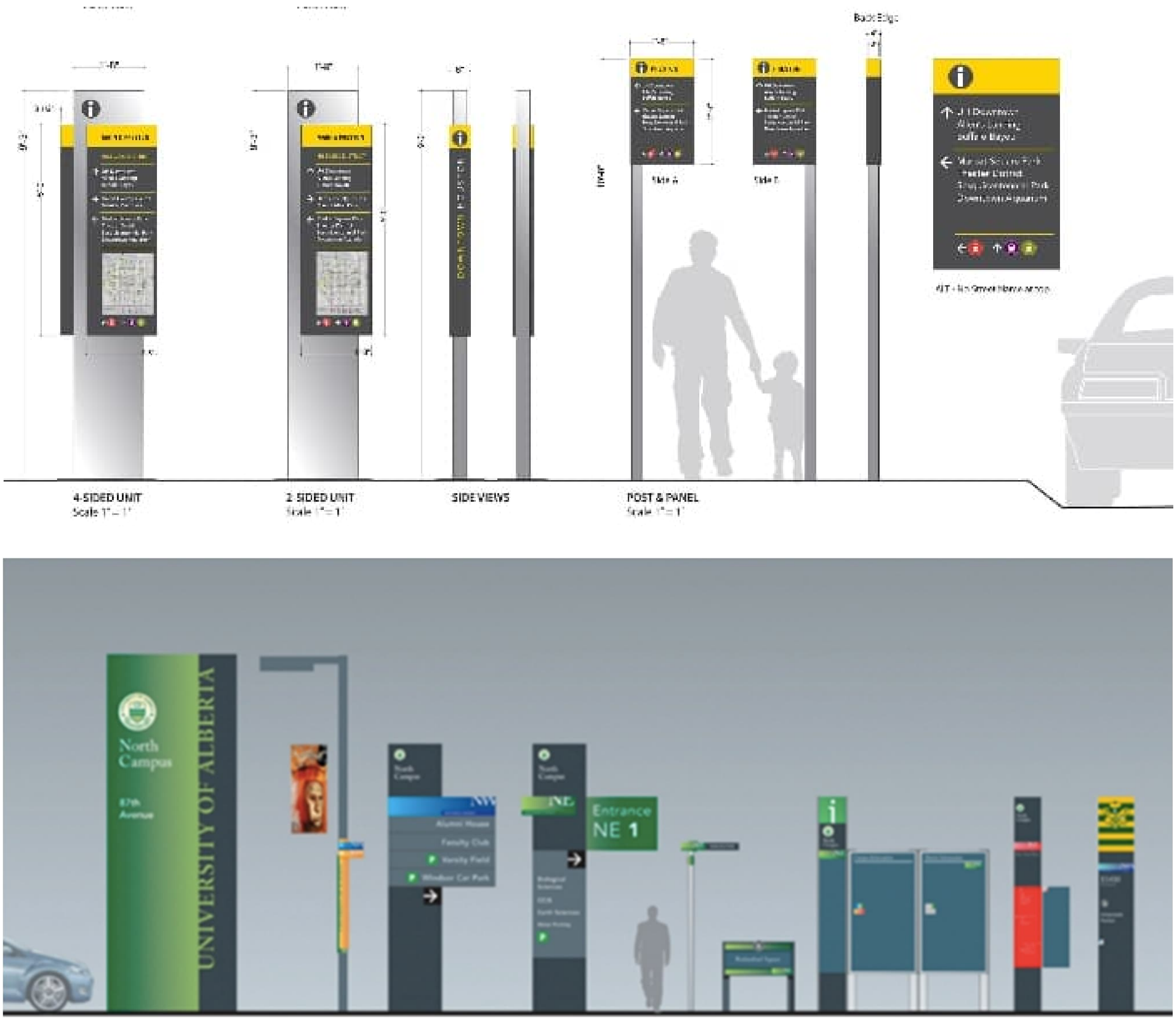
WAYFINDING AND TRAFFIC SIGNAGE

Wayfinding signs help pedestrians to navigate around the city. They should use a consistent, easily understood visual language, and ideally include the walking distances measured both in walking time and absolute distance.

- Best practice wayfinding also provides information on where to switch modes, aiding those who are using public transport.
- Traffic signs are all the signs, traffic signals, road markings, and other devices used by the road authority to regulate, warn, or guide traffic. They are essential for the safe, smooth movement of all road traffic.

Also refer to Section 7 of the Uganda NMT Manual, 2020.

Figure 1.19: Example of Existing Road Sign in Kampala



Examples of a consistent family of wayfinding signage for a city or town

LANDSCAPE DESIGN GUIDELINES

The purpose of this section is to set down minimum landscape design standards for all urban road projects undertaken in Uganda to ensure that the landscape is:

- Integrated into the project and built fabric of the area
- Ecologically appropriate
- Appropriately designed
- Functional
- Safe and easy to maintain
- Cost-effective and low maintenance.

This section is intended for road designers and landscape contractors as well as project managers. It is not a comprehensive manual on landscape design, but concentrates on providing guidance for decision-making. It should be read in conjunction with the National Physical Planning Guidelines 2011 (or as amended) the relevant extracts of which are indicated below. It should also be read in conjunction with Section 4.2 of the Uganda NMT Manual, 2020.

The URDM practitioners are required to consider and apply the relevant guidelines from the National Physical Planning Guidelines, an extract relating particularly to the landscaping of roads is provided in Block 2.

KEY ISSUES TO BE AWARE OF:

- When landscaping is designed and managed poorly it can become a problem:
- Overly complicated designs can look inappropriate and are expensive to maintain.
- Poor plant selection can result in damage to road infrastructure, interfere with utilities, obstruct signage and create maintenance problems.
- Vegetation can result in injuries to drivers of vehicles from driving into trees.
- Landscape should be safe:
- Safe sight distances must be applied according to the design speed.
- Landscaping should not create hidden public spaces with poor surveillance.
- Landscaping must not obscure signage.

Block 2: Extract from National Physical Planning Guidelines

PARKING LOTS:
All off street parking facilities and parking lots should be landscaped in accordance with the local authority byelaws or be screened within or behind buildings or be sited at the side. This leaves the front of the building open to view from the street, and gives pedestrians direct and safe access to the main entrance. Large unbroken expanse of tarmac is unattractive. It is recommended instead that, all car parks be subdivided into sections, which are small in relation to the total size of the parking area. The landscaping should include lawn, shrubs, hedges, trees, or other acceptable materials that may be used as visual amenities. However, care must be taken on the choice of species, construction of planting box, etc; to avoid cracking the car park surface through root action. Trees that tend to easily succumb to winds, drop heavy leaves (like certain types of palm trees), or branches should also be avoided. 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 of the local authority.

INDUSTRIAL BUILDINGS:
The front of any industrial plot must be landscaped for amenity reasons. Landscaping shall apply whenever any proposed building/structure or development activity requires the submission of a Site Plan application or a Special Permit application. All portions of the property that are not required for buildings, structures, parking, driveways, or sidewalks shall be suitably landscaped with monuments, ground cover, trees and evergreen shrubs. Planted areas adjacent to the building shall be at a minimum of 1.8 m from the building. Loading bays shall also be screened with any combination of walls, berms, and or landscaping.

TREE BELTS:
The provision of tree belts improves the appearance of the road and can make a useful contribution to meeting the urban area’s fuel wood requirements (tree belts should be a minimum of 10 m wide). See table below for guidance on which roads should have tree belts. In all cases the provision of a single line of trees adjacent to the footway is strongly recommended to provide shade for pedestrians.

LANDSCAPE DESIGN APPROACH

Step 1: Understand the context

The first step is understanding the context of the area and what is appropriate and important about the local character. How wide is the road reserve? Is it going through an industrial area, residential local road, or is it a highway? Is it in the mountains, lowlands or on a wetland? What plants are doing well in this area already?

Step 2: Set objectives

The designers need to be clear about the objectives of the landscape design. Is it to beautify an area? Stop erosion, reduce pollution, create a barrier for oncoming traffic? Or just to be cost-effective.

Step 3: Define the principles

The principles then need to be defined for the project.

- Low maintenance,
- indigenous or hardy etc.
- Waterwise

Step 4: Develop design

The concept and detailed design then need to be developed. Translating the objectives and principles into physical form.

Step 5: Monitor Implementation

The designers must monitor the implementation of the design. It is inevitable that there will be changes during construction.

Step 6: Monitor Maintenance

The maintenance of the landscape needs to be monitored particularly at the outset when the plants are establishing in the ground.

The landscape must then be managed in the long term in line with the landscape objectives.

GUIDANCE ON UNDERSTANDING CONTEXT

Trees in urban landscapes provide a range of ecosystem services, including habitat, refuge, food, and corridors for other fauna and flora. The loss of trees is occurring at an alarming rate in Uganda, especially on hilltops and lowland areas in this tropical landscape known for dense vegetation and tree canopy. The department responsible for road trees is the Environment Unit Ministry of Works and Transport. In Uganda, tree planting roads dates far back to the colonial days when Kangugulu promoted the planting of trees in Eastern Uganda, along roads

Street trees are also an integral part of road design as they contribute to the sense of enclosure, act as a buffer to traffic noise/ pollution and enhance a sense of place. A traffic calming effect can also be achieved, where trees are planted in continuous rows and their canopies overhang, at least in part, the vehicular carriageway. Road trees can also be used to enhance legibility by highlighting the importance of connecting routes and distinguishing one area from another through variations in size and species selection. The desirability of trees along different road classes is shown in Table 1.9.

Table 1.9: Desirability of Tree Belts from Physical Planning Standards

Class of Road from this Manual	Class name from the Physical Planning Standards	Tree belt
Class 1	Trunk Roads (Arterial/Freeways including Town Bypasses)	Desirable
Class 2	Primary Distributor	Desirable
Class 3	Secondary Distributor	Desirable
Class 4	Tertiary (Local Distributor)	Desirable
Class 5A	Access Roads	
Class 5A	(a) Industrial Road	Desirable
Class 5A	(b). Primary Residential Road	Desirable
Class 5A	(c)Secondary Residential Road	Desirable
Class 5B	(d). Primary shopping Road (Heavy commercial)	-
Class 5A	(e). Secondary Shopping Road (Average commercial)	-
Class 6	(f). Service Lanes	-

How much space is there?
Landscaping needs space. Overly steep cuttings and narrow strips will result in poor landscaping outcomes. Enough space needs to be provided when planning new roads.

Minimise choice in Urban environments
Keep the landscaping simple. Utilise one or two dominant tree or shrub species where possible. The simple repetition of one species can have a powerful impact.

Provide good visibility in urban areas
Trees with low ground cover are preferred to trees with shrubs.

Design for a 40-year lifespan
In urban areas, plants selected should have a 40-year lifespan.

Costs
In general, the costs for landscaping should be between 1,5-2% of the project costs for Urban Areas.

Landscaping Road Medians:

- The road median should be designed to benefit and enhance an area. It should be densely planted and simple in appearance.
- Planting should be neat and structured with lower groundcovers next to the road followed by taller species.
- Landscaping should consist of hardy and durable groundcovers or shrubs planted into a mulched bed at a density greater than 1 plant per m^3. Planting should be setback 500mm from the road edge to avoid overhanging of the carriageway.
- All areas to be grassed should be turfed using low-maintenance turf such as Kikuyu Grass (see grass lists).
- There should be a 300mm wide concrete margin around the edge of the median to provide a neat, easy-to-maintain edge.
- Due to problems of maintenance and plant survival, the minimum width for the provision of vegetation should be 2m at lower speeds and 4m at higher speeds.

HOW TO SELECT TREE SIZES

In general, the size of the species selected should be proportionate to the width of the street reserve. For example, larger species, with a canopy spread greater than 6m will be best suited to wider streets, such as Class 1 to 3 streets.

Smaller species with a canopy spread of 2 to 6m will be best suited to narrower streets such as Local streets. Designers may seek to vary this approach in keeping with the characteristics of a place. For example:

- Sparse planting may be more appropriate in a Centre, enhancing its urban qualities.
- Smaller species may be more appropriate where buildings are located in close proximity to the street edge carriageway (i.e., to take account of overshadowing, growth restrictions).
- Larger species may be desirable within Suburbs, to enhance the greener character associated with these places.

Refer to Figure 1.20 . To be effective, trees should be planted at intervals of 14-20m. This may be extended periodically to facilitate the installation of other street facilities, such as lighting. Designers should also consider the impact of root growth.

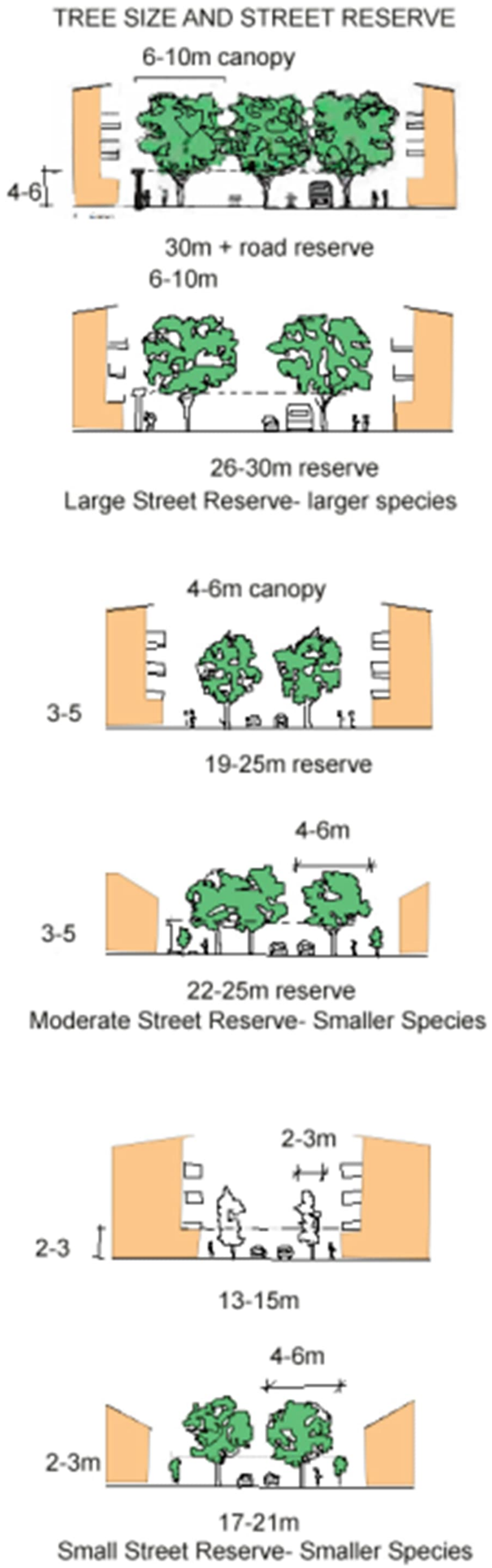


Figure 1.20: Tree Size and right-of-way Guidance

ROOT GROWTH

Tree roots may need to be contained within individual tree pits, continuous soil planting strips or using other methods to restrict growth under pavements/toward services. See a typical tree pit example in
Figure *1.21*.

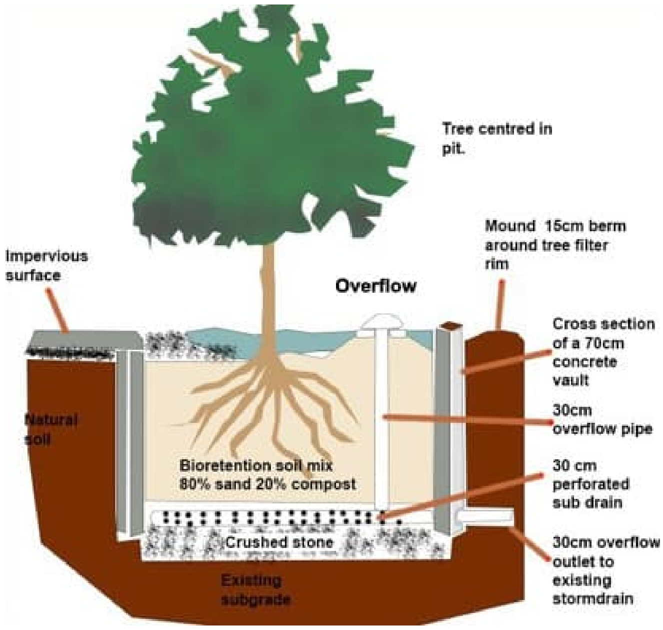


Figure 1.21: Typical Tree Pit Example

TREES AT INTERSECTIONS

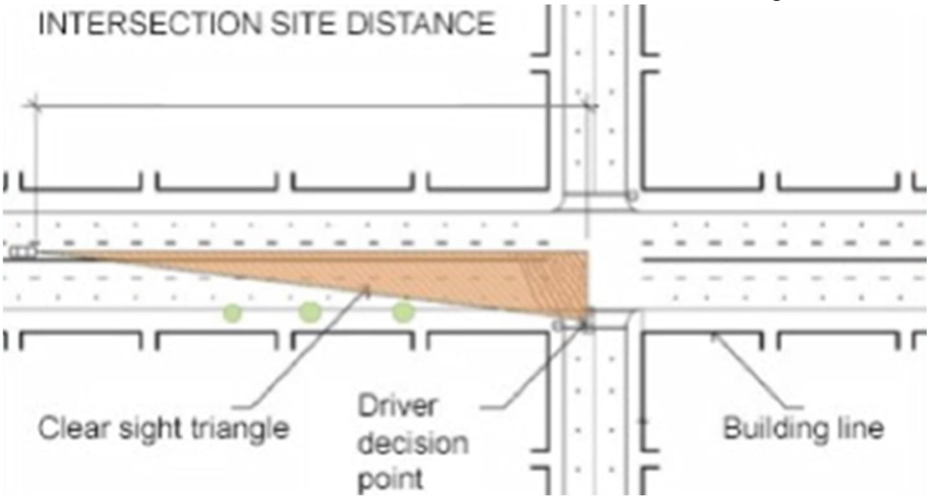
The following should be considered when placing trees at intersections:

- Street trees must not be planted where they will obstruct the views of stop signs or traffic signals
- Street trees must not be planted where they will obstruct the views of other road users such as traffic approaching from other directions.
- Trees are not to be planted within 50cm distance from the side kerb face to the first road tree.
- Street trees must be placed to allow for visibility of all information signs on the road.
- Informational signs and street trees shall not occupy the same area

Further guidance is given in
Figure 1.22 and Figure 1.23,which illustrates the position of trees relative to intersections. Minimum clearances between trees and elements in the right-of-way are provided in

Table 1.11.

Figure 1.23: Graphic Illustration of Minimum Tree Planting Distances from other Road Elements



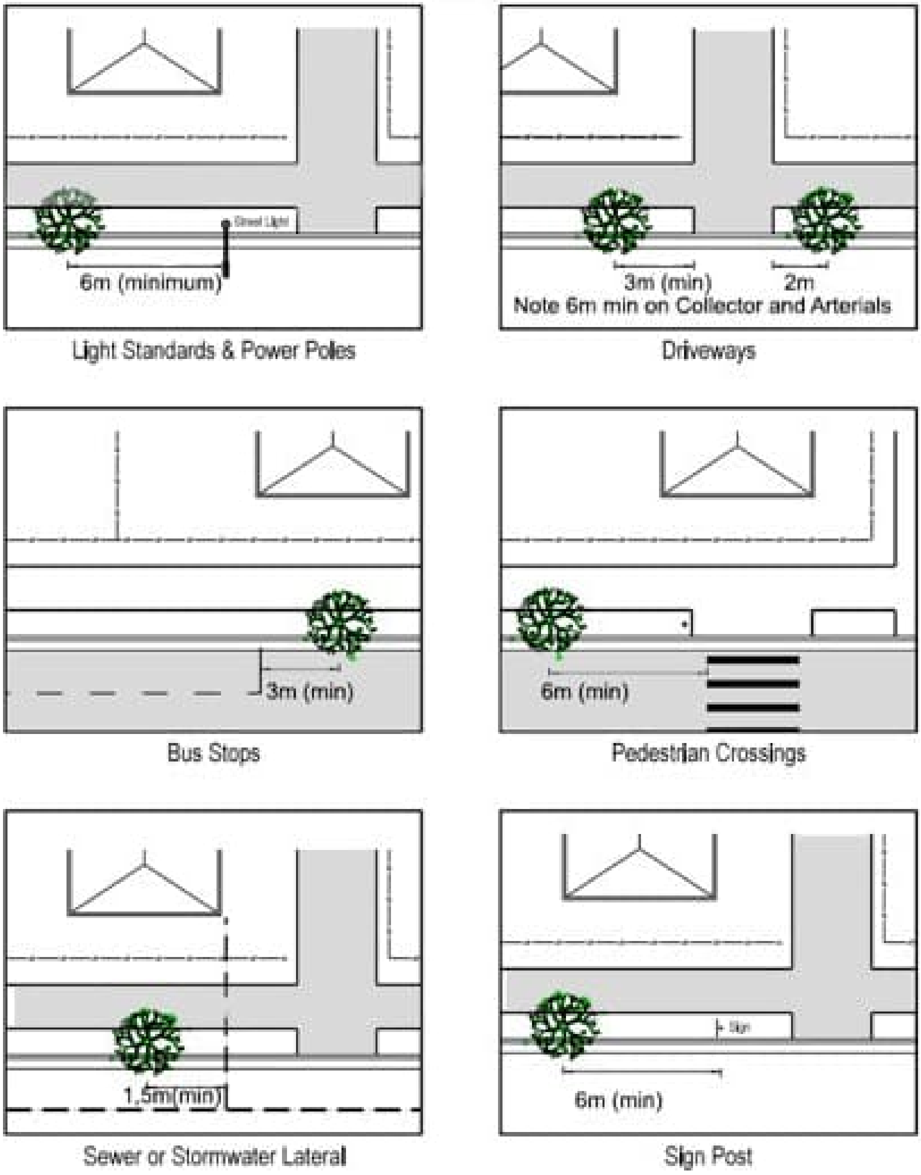


Figure 1.22: Minimum Distances for Trees at Intersections

Table 1.10 indicates the size of tree guards based on the location on a street and the type of tree. Note: A tree guard is a physical barrier to protect the trunk from physical damage.

Table 1.10: Tree Guard Size (Extract from NMT Manual, 2020)

Type of Tree	Location on Street	Size of Tree Guard (m)
Columnar, Conical	Shoulder	0.6 x 0.6
Columnar, Conical, Vase Shaped	Multiple use zone (MUZ)	0.6 x 0.6
Columnar, Conical, Vase Shaped, Broad Upright	Parking / Shoulder / MUZ	0.6 x 0.6
Broad Upright, Broad Oval	Parking / Shoulder / MUZ	0.75 x 0.75
Broad Upright, Broad Oval, Broad Spreading	Parking / Shoulder / MUZ	(0.75x0.75) - (2x2)

Table 1.11: Minimum Clearance of Roadside Elements for Tree Planting

<table>
<tr><th rowspan="2">Roadside Elements</th><th colspan="2">Required Minimum Clearance of Roadside Elements from Proposed:</th></tr>
<tr><th>Small & Medium Trees</th><th>Large Trees</th></tr>
<tr><td>Splay Corner of: Entrance culvert, bin centre access, substation access, MDF room access, fire engine access</td><td>1,5m</td><td>2,5m</td></tr>
<tr><td>Pipe/drain</td><td>1,5</td><td>2,5</td></tr>
<tr><td>Lamp post</td><td>3,0</td><td>6,0</td></tr>
<tr><td>OG Box</td><td rowspan="8">2,0</td><td rowspan="8">2,5</td></tr>
<tr><td>Tas Manhole</td></tr>
<tr><td>Electrical Post</td></tr>
<tr><td>Fire Hydrant</td></tr>
<tr><td>SCV Box</td></tr>
<tr><td>Lighting control box</td></tr>
<tr><td>Traffic control box</td></tr>
<tr><td>Traffic light</td></tr>
<tr><td>Pedestrian crossing, bus stop, signpost</td><td>3m</td><td>6m</td></tr>
<tr><td>Commercial driveways</td><td>300cm</td><td></td></tr>
<tr><td>Residential driveways</td><td>150cm</td><td></td></tr>
<tr><td>Underground electrical, Sewer mains, water mains</td><td>1,5m laterally (min).</td><td>2,5m</td></tr>
</table>

VOLUME OF SOIL SPACE REQUIRED FOR TREES PER CANOPY SIZE

The diagram below illustrates the volume of soil space required in cubic metres for a tree per canopy size.

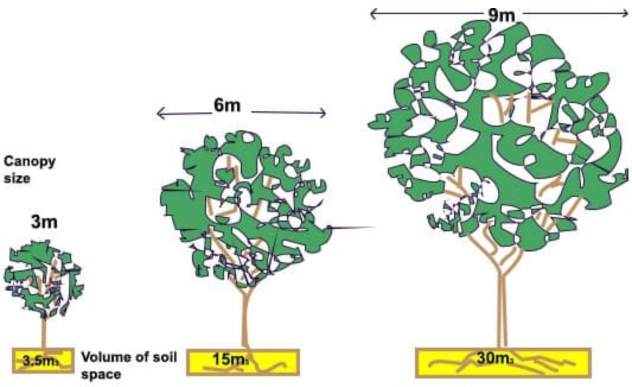
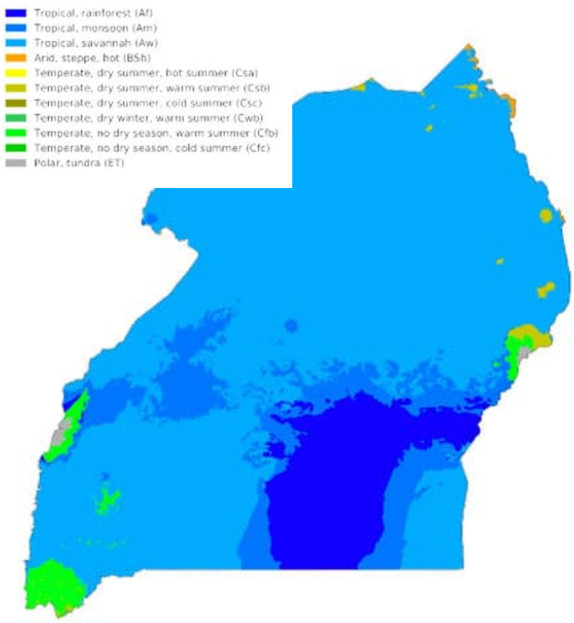


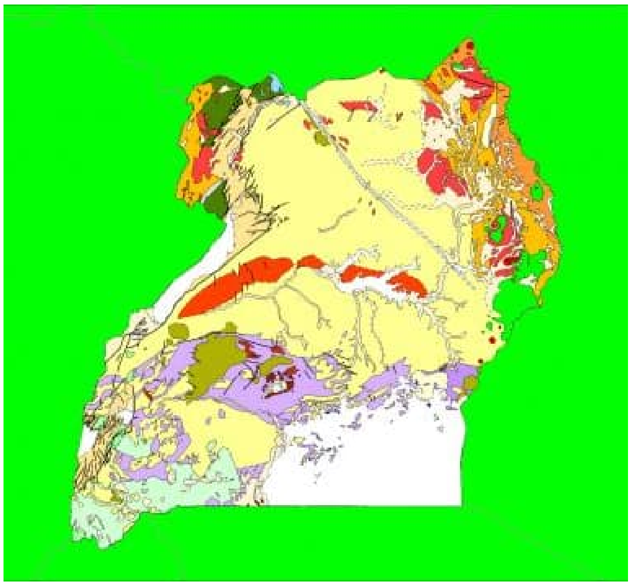
Figure 1.24: Volume of Soil Space Per Tree Canopy Size

CLIMATE OF UGANDA AND ITS INFLUENCE ON TREE SPECIES CHOICE

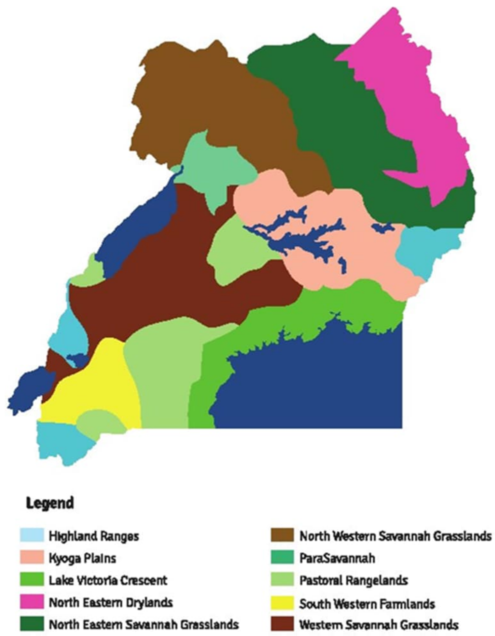
Most of Uganda is located within a Tropical Savannah climate. The specific location of the road within Uganda will determine the final tree species choice based on the local climate, geology and landscape type. However, the trees listed below provide generally appropriate tree species for urban roads throughout Uganda.



Uganda Climate Chart



Uganda Geology map



Uganda Landscape type map

The following tree species are proposed for roadside planting in Uganda, based on their size and ability to thrive in the local climate. However, the list is not exhaustive and local tree species are preferred when available.

Major Invasive Alien Species in Uganda (avoid)

- Bidens pilosa (herb) Beggars Tick
- Dalbergia sissoo (tree) North Indian rosewood or shisham
- Leucaena leucocephala (tree) Lead Tree/Horse Tamarind
- Prosopis spp. (tree, shrub) Mesquite
- Psidium guajava (tree, shrub) Guava Tree
- Rubus niveus (shrub) Mysore Raspberry

- Salvinia molesta (aquatic plant, herb) Kariba Weed/water fern
- Setaria verticillata (grass) bur bristlegrass
- Water hyacinth (Eichhornia crassipes)
- Prickly pear (Opuntia spp.)
- Mexican marigold (Tagetes minuta)
- Lantana (Lantana camara)
- Morning glory (Ipomoea spp.)
- Wild garlic (Allium vineale)

Other species to avoid (not promulgated)
- Azadirachta indica (Neem Tree)

This tree can invade shrublands, open woodlands, grasslands, floodplains, riparian zones (banks of watercourses), coastal sites and other disturbed natural vegetation.

Large Trees

Large-sized trees are generally recommended for planting along major roads and expressways with a planting verge greater than 3.0m in width.

Table 1.12: Species - Large Trees

Species (large trees)	Height(m)	Spacing roadside (m)	Open Space (m)
Couroupita guianensis (Cannon Ball Tree)	20	8	12
Erythrina variegata orIndica (Variegated Coral Tree)	15	12	18
Eucalyptus camaldulensis	25	8	12
Filicium decipiens (Fern Tree)	24	12	16
Mesua ferrea (Ceylon Ironwood)	20	12	18
Peltophorum perocarpum (Yellow Flame)	20	12	18
Tabebuia rosea (Pink Poui)	18	12	18
Tectona grandis (Teak)	20	12	18

Medium Trees

Medium-sized trees are generally recommended for planting along major roads and some minor roads with planting verges between 1.5m to 3.0m.

Table 1.13: Species - Medium Tree)

Species (medium trees)	Height(m)	Spacing roadside (m)	Open Space (m)
Bauhinia blakeana (Hong Kong Bauhinia)	8	8	12
Cananga odorata (Kenanga)	15	8	10
Cassia fistula (Golden Showers)	18	8	12
Cinnamomum iners (Wild Cinnamomum)	12	8	10
Eugenia cumini (Jambolan)	15	8	12
Lagerstroemia speciosa (Rose of India)	12	8	12
Melia indica (Nim Tree)	15	8	12
Plumeria spp (Frangipani)	8	8	10
Podocarpus rumphii	15	6	12
Tamarindus indica (Tamarind Tree/ Asam)	12	8	12
Eugenia oleina	10	8	12
Eugenia spicata	12	8	12
Eugenia longifolia	12	8	12

Small Trees

Small-sized trees are generally recommended for planting along minor roads with narrow/restricted planting verges less than 1.6m in width.

Table 1.14: Species - Small Trees

Species (Small trees)	Height (m)	Spacing roadside (m)	Open Space (m)
Brassaia actinophylla (Australian Ivy Palm)	10	6	6
Callistemon citrinus (Bottle Brush Tree)	6	6	8
Callistemon viminalis	8	6	8
Carallia brachiata	8	6	6
Erythrina glauca (Coral Tree)	8	6	10
Melaleuca genistifolia cv Golden Gem	6	6	8
Encephalartos whitelockii (cycad) indigenous to southwest Uganda.			

Shrubs

Table 1.15: Sample List of Shrubs Suitable for Roadside Planting

No.	Scientific Name	Common Name	Photograph	Criteria for selection
1	Bougainvillea spectabilis	Bougainvillea		Evergreen climbing shrub producing stems up to 10m long, Ornamental.
2	Vernonia angustifolia	Common ironweed		Drought tolerant, ornamental, stalks are 1m tall
3	Tecoma stans	Yellow bells		Commonly known as a roadside weed, ornamental, adapts well in tropical and subtropical environments
4	Hibiscus Syriacus	Rose of Sharon		Deciduous shrub 3m height An excellent hedge plant It grows best in areas where annual daytime temperatures are within the range of 15 - 28°c,

Grasses

Table 1.16: Sample List of Grasses Suitable for Roadside Planting

No.	Scientific Name	Common Name	Photograph	Criteria for selection
1	Boutelouagracilis	Sideoats grama/ mosquito grass		Excellent drought tolerance
2.	Sporobolus	Prairie dropseed		Perennial grass with hairlike leaves.
3.	Pennisetumclandestinum	Kikuyu grass		Very fast-growing grass, good shade tolerance, excellent cold tolerance, and has the ability to smother weeds.
4.	Stenotaphrumsecundatum	Pemba grass/ buffalo grass/ St.Augustine grass		Excellent shade tolerance, coarse, hardy perennial grass that rarely produces seed but spreads rapidly by means of its short-branched rhizomes.
5.	Chloris gayana	Zimbabwe grass		Shade tolerant grass Suitable for weed and erosion control. High maintenance
6.	Cynodon dactylon	Couch grass, quick grass		Tolerant of high levels of salt, which can be deposited by stormwater runoff Used in erosion control,
7.	Penninsetum purpureum	Elephant Grass		Tolerant of high pollution levels and high levels of salt. Can be invasive.

FOOTPATHS/FOOTWAYS, VERGES AND STRIPS

A strong sense of enclosure and active-street edges contribute to a pedestrians/cyclist's sense of security and comfort by creating roads that are overlooked, animated, and sheltered from the rain. Well-designed footpaths are free of obstacles and wide enough to allow pedestrians to pass each other safely and in comfort. For this purpose, the footpath is divided into three areas:

- **Footway:** this is the main area along which people walk.
- **Verges:** These provide a buffer between pedestrians and the vehicle carriageway and provide space for street furniture and street trees as well as overflow space for pedestrian movement
- **Strips(frontage):** describes the section of the sidewalk that functions as an extension of the building, whether through entryways and doors or sidewalk cafes. These spaces, provided directly to the front of a building, may be occupied by activities generally associated with retail/ commercial uses such as stalls or outdoor seating. Strips may be incorporated into the private space of a dwelling.

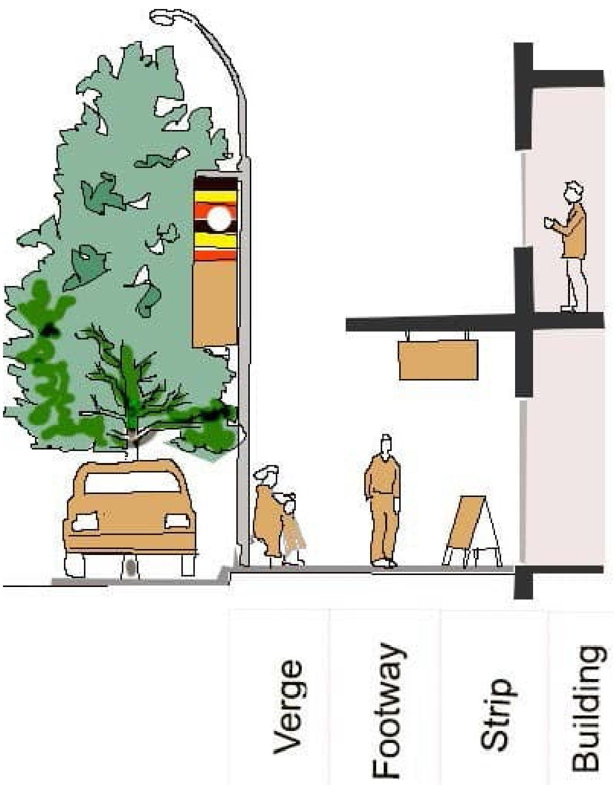


Figure 1.25: Diagram Illustrating Various Components of a Sidewalk

FOOTWAYS/FOOTPATHS

Minimum footway widths should be based on the space needed for two wheelchairs to pass each other (1.8m). In densely populated areas and along busier roads, additional width must be provided to allow people to pass each other in larger groups. In this regard:

- The width of footways should increase from suburbs (lower activity) to neighbourhood (moderate activity) and to Town/City centres (higher activity) and as development densities increase.
- The width of footways should increase according to function from Local (lower activity), Link (moderate activity), to Arterial roads (moderate to higher activity) as connectivity levels increase.
- The footway should be maintained at a consistent width between junctions and should not be narrowed to accommodate turning vehicles

The Uganda NMT Manual, 2020 provides a table, which shows the minimum width of footpaths. Table 3-3: Minimum space requirements for pedestrian and bicycle facilities. An extract pertaining to footpaths is provided in Table 1.17 (Please refer to the NMT manual for further guidance) In addition, the following should be considered.

Residential Road Footpaths (Class 5 & 6 Roads) - Low Activity

As mentioned above, footpaths in residential neighbourhoods vary in width, depending on their context.

- A clear path width of at least 1.8 m should preferably be provided, where possible.
- Footpaths may feature a berm or strip of planting on either side of the clear path. For these roads, a strip of 1 metre between the footpath and property boundary is recommended.
- A planting strip between the footpath and the kerb can accommodate a tree pit (1.5m minimum width).
- In denser areas, where the footpath directly borders a building, a clear path width of 2.4m should be provided. An absolute minimum of 1.8m should only be considered for narrow roads.

Neighbourhood/Main Road footpaths (Class 2 to 4 Roads) - moderate

For neighbourhood/ main roads, various configurations are possible.

- Where the clear path sits directly adjacent to the building edge, a width of at least 2.4m is suggested.
- Commercial activity (such as outdoor seating), which should be allowed for on neighbourhood main roads, may take up at least 2.1m.
- On narrower roads, where it might not be possible to provide tree pits, the buffer strip adjacent to the kerb might be used to provide planters or other landscaping features and should be at least 1m wide.
- Where the clear path is not situated directly adjacent to the building's edge, a small zone (1.5m) of commercial activity might be situated directly in front of the building.

On busier neighbourhood main roads, a clear path width of at least 3m is suggested, as are street trees to provide a buffer between higher pedestrian volumes and traffic. This furniture zone might be widened to 2.4 m to provide for bus stops, seating, and other uses.

Table 1.17: Recommended Footway Width (Extract from NMT Manual)

Facility	Parameter	Accepted minimum for existing road upgrades	Recommended minimum	Optimal space
Pedestrian footway total separation	Min width	1.2	2.0	3.0
Pedestrian footway kerb/barrier	Min width	1.2	2.0	3.0
Pedestrian footway	Max gradient	01:15	01:20	01:25
Pedestrian footway	Min corner splay	2.0	3.0	5.0

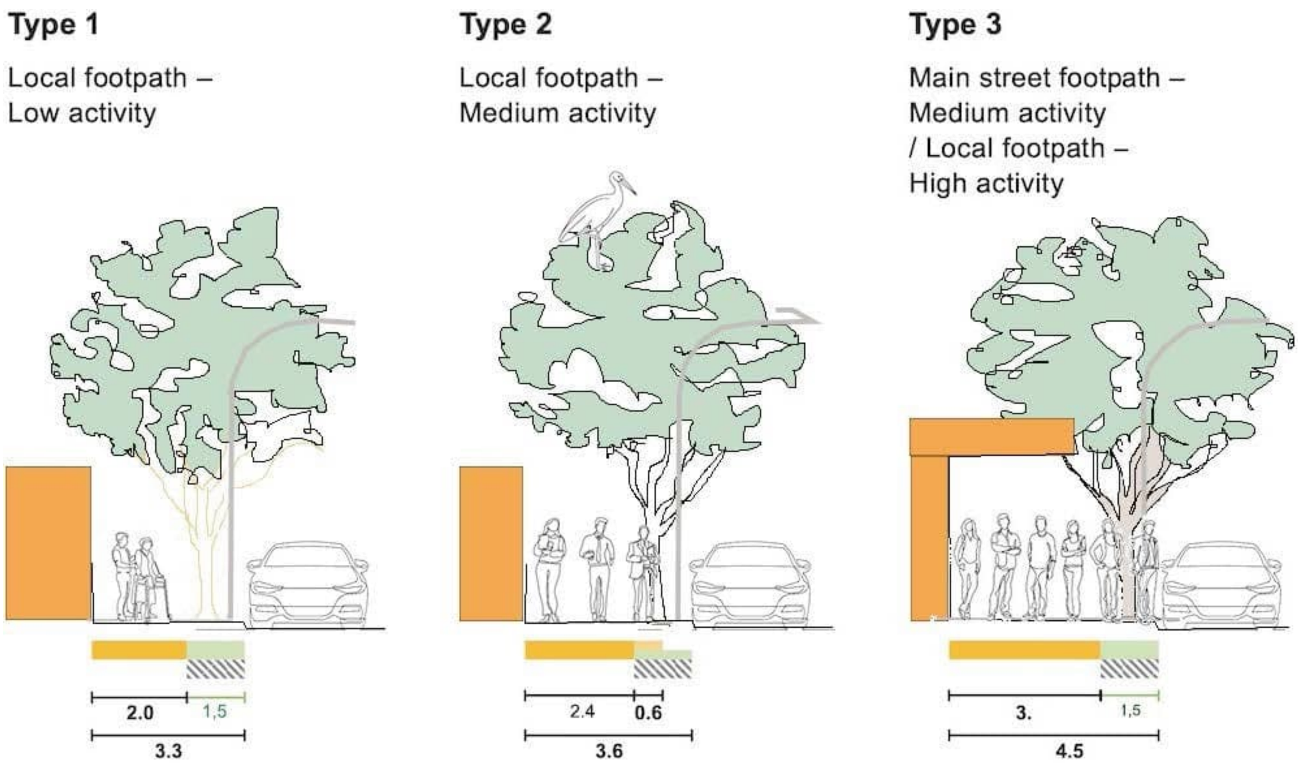


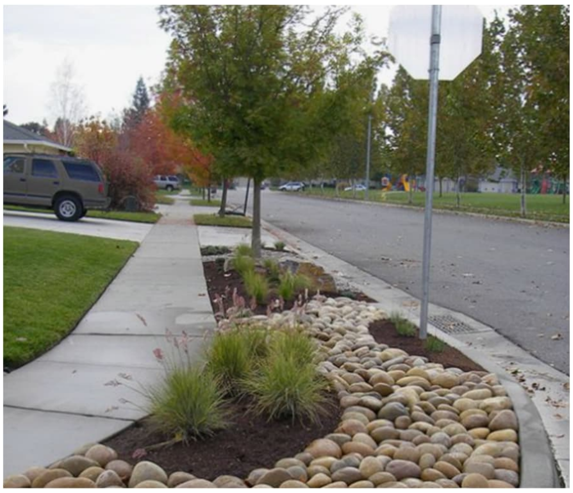
Figure 1.26: Footpath Width Based on Level of Activity

VERGES

A verge is the area of the right-of-way between the back of the kerb and the adjoining property border. The need and size of the verge will largely be dependent on the function of the road and the presence of on-road parking, cycle lanes, footways and on-street trading areas.

In general:

- On Arterial and Link roads with no on-road parking a verge of 1.5-2.0m should be provided as a buffer to facilitate the planting of large street trees and items of street furniture.
- Where on-street parking is provided, the width of the verge will generally correspond to the width of car parking spaces.
- A verge should be provided where cycle tracks are located adjacent to the parking spaces.



Combined footpath and landscaping

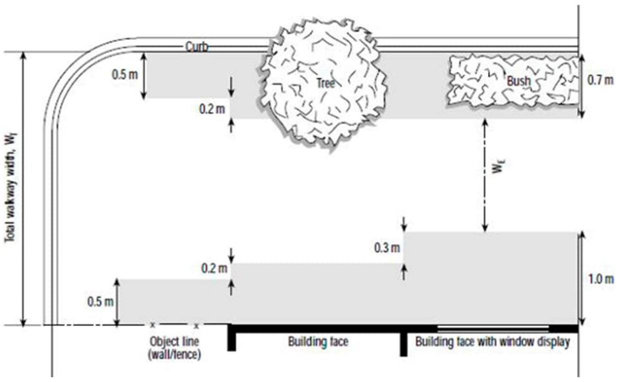
Combined footpath with benches and landscaping

STRIPS/FRONTAGE ZONES

Strips, also called frontage zones, may be provided as a designated zone that further animates the street and, in the case of a residential property, provide a buffer between the footway and the private residence. With regard to areas of commercial activity:

- Where outdoor seating is provided the minimum width of a strip should be 1.2m.
- Outdoor seating may also be provided within a verge area, where the footway runs between the shop front and seating area.
- A designated strip may also be considered within town centres on shopping streets to provide additional space for window-shopping.

Typical shared urban sidewalk
Source: UN Habitat Institute for Transport and Development Policy.



Varying footway widths at frontage zones

NMT CROSSINGS

Crossings are one of the most important aspects of road design as it is at this location that most interactions between pedestrians, cyclists and motor vehicles occur. Well-designed and frequently provided crossings are critical to the balancing of movement priorities. The design of crossings, and the frequency at which they are provided, will have a significant impact on pedestrian/ cyclist mobility and comfort and the flow of vehicular traffic.

CROSSING SELECTION

Crossings are referred to as controlled, such as zebra or signalised crossings or uncontrolled. Uncontrolled crossings include less-formal types such as courtesy crossings and/or those identified by a dropped kerb.

At junction locations, the type of crossing used will generally be determined in conjunction with the form of junction control that is used to manage traffic. Also refer to Chapter 6 of the NMT Manual, 2020.

Pedestrian crossings

Designers need to be guided by pedestrian demands, safety and vehicle flows. In this regard:

- In general, signalised crossings should be provided on busy Arterial and Link roads and/or where cyclists are likely to cross.
- Zebra crossings provide greater pedestrian priority and may be used on Arterial and Link roads within lower-speed environments, such as CBDs. Zebra crossings are also highly effective where both levels of pedestrian and vehicular activity are more moderate and may also be used more generally, such as on Link streets in Suburban areas.
- Courtesy crossings, which are generally defined by a change in material and/ or vertical deflection allow pedestrians to informally assert a degree of priority over drivers and are particularly effective at promoting pedestrian priority. They may be used in lower-speed environments (and will also assist in making such environments self-regulating).
- Zebra crossings or courtesy crossings should be considered where pedestrian demands are higher.

Controlled pedestrian crossing

Controlled crossings provide pedestrian priority at specific points, either mid-block or at intersections. Controlled crossings are a critical part of the walking network, as they allow universally accessible opportunities for pedestrians to crossroads that may otherwise present a barrier to movement. Approaching vehicles should be managed to limit them to survivable speeds at the crossing point. Two types of controlled crossings are used:

Zebra crossings should be on raised tables and give pedestrians the right of way at any time and are denoted by a combination of carriageway markings, signage, kerb extensions, pedestrian refuges and/or lights.

Example of a painted zebra crossing

Signalised crossings are also denoted by carriageway markings and give pedestrians the right of way in dedicated signal phases. The frequency and length of pedestrian crossing phases determine pedestrian delay and have a major influence on the level of service for people travelling on foot.

Signalised pedestrian crossing at intersection

Uncontrolled pedestrian crossings allow movement across roads where no controlled facility is provided. As pedestrians do not have right of way, they rely on a greater level of pedestrian awareness and care, making them unsuitable for some road users. Crossings occur in two forms. Pedestrian refuges provide a protected place for people to wait halfway across the road and allow pedestrians to look for traffic in one direction at a time.

Uncontrolled pedestrian crossing

Raised pedestrian platforms can be used at intersections, in low-speed streets and in town centres to indicate suitable places for pedestrians to cross. They may take the form of raised tables or changes in materials across a street to encourage slower vehicle speeds.

The pedestrian experience is improved by traffic calming devices such as kerb extensions, narrow vehicle lanes and street trees. Approaching vehicles should be managed to limit them to survivable speeds at any point where people are encouraged to cross a road.

The carriageway is the paved or unpaved surface of the road, excluding the shoulders, normally used by traffic. The larger the vehicles utilizing the lane, the larger the widths should be. Therefore, industrial areas which accommodate large trucks should be designed to have larger lane sizes.

Carriageways on urban roads should not be wider than three lanes or 9.0- 11,1 m per direction. Refer to the road classification section in Volume 2 for widths of lanes.

Raised pedestrian crossing

There are typically 4 main design considerations to take into account for a raised pedestrian crossing, namely:

- Accessibility
- Height
- Width
- Crossing distance

These factors are described and shown schematically in Figure 1.27.

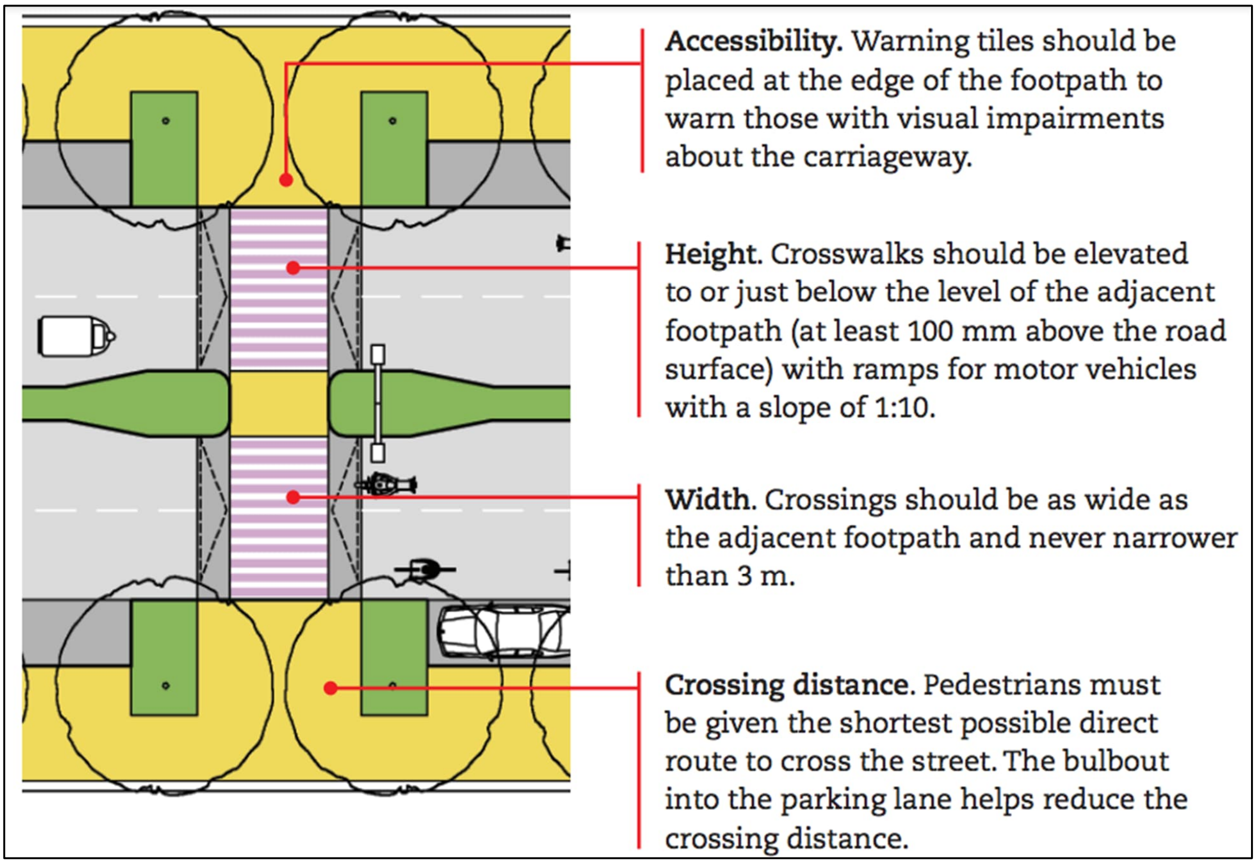


Figure 1.27: Pedestrian Crossing Considerations

TACTILE PAVING

Uganda does not have a standard for tactile paving, therefore the NMT Manual has included regional best practices of South Africa, SANS 748: 2008 – Design for access and mobility–Tactile Indicators.

Usually, people with visual disabilities or impairments need guidance when using pedestrian areas, especially where the footway crosses larger 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.

Two tactile patterns are implemented, these are shown schematically in Figure 1.28
:

1. Warning tactile pattern
2. Guide tactile pattern

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, take care in 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 these 300 mm at the beginning and end of the ramps, stairs and entrance to any door, and 600 mm wide 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 Figure 1.29 (KCCA, 2019).

Figure 1.30 shows a typical arrangement of guidance and warning tactile paving.

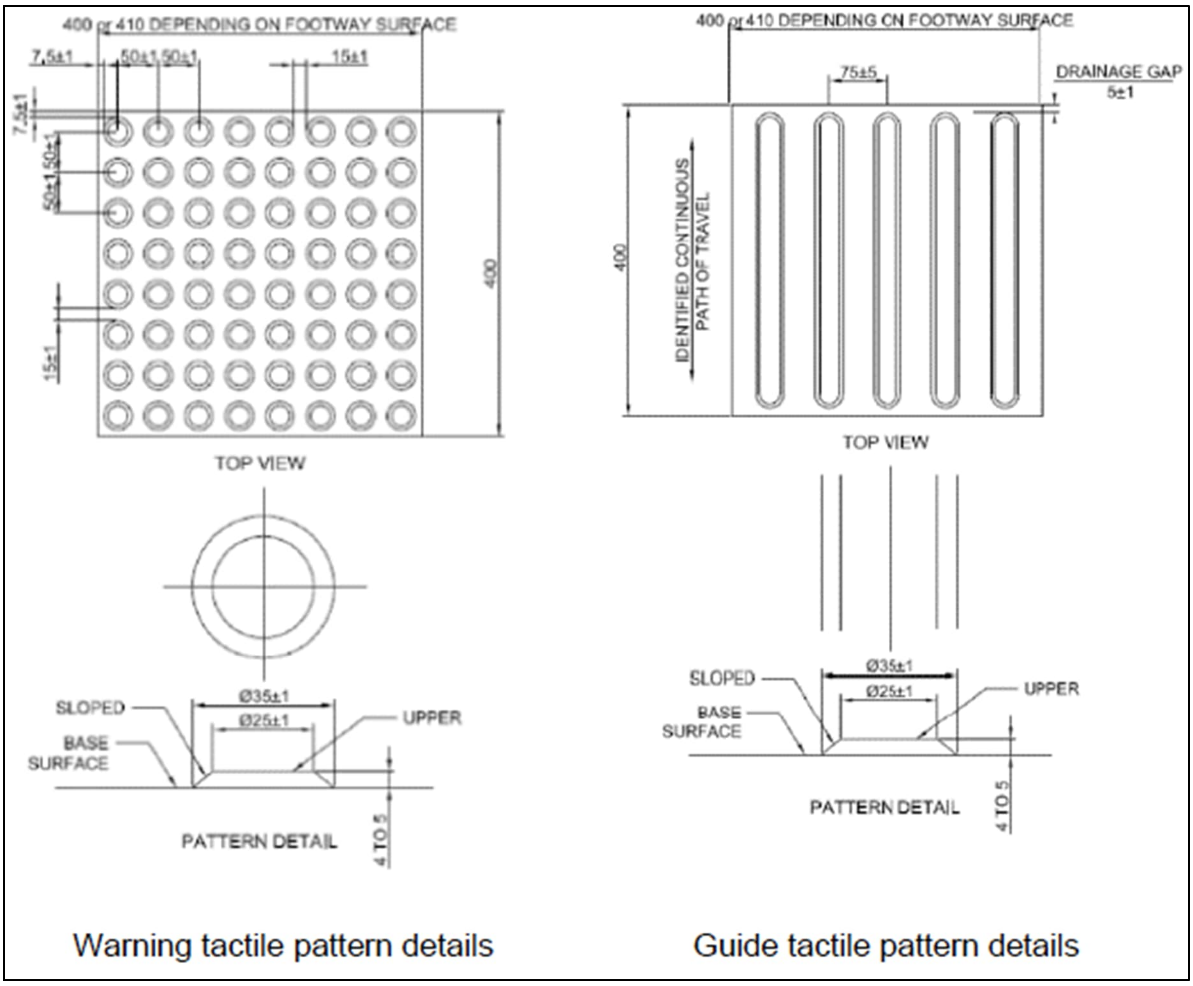


Figure 1.28: Tactile Pattern Details

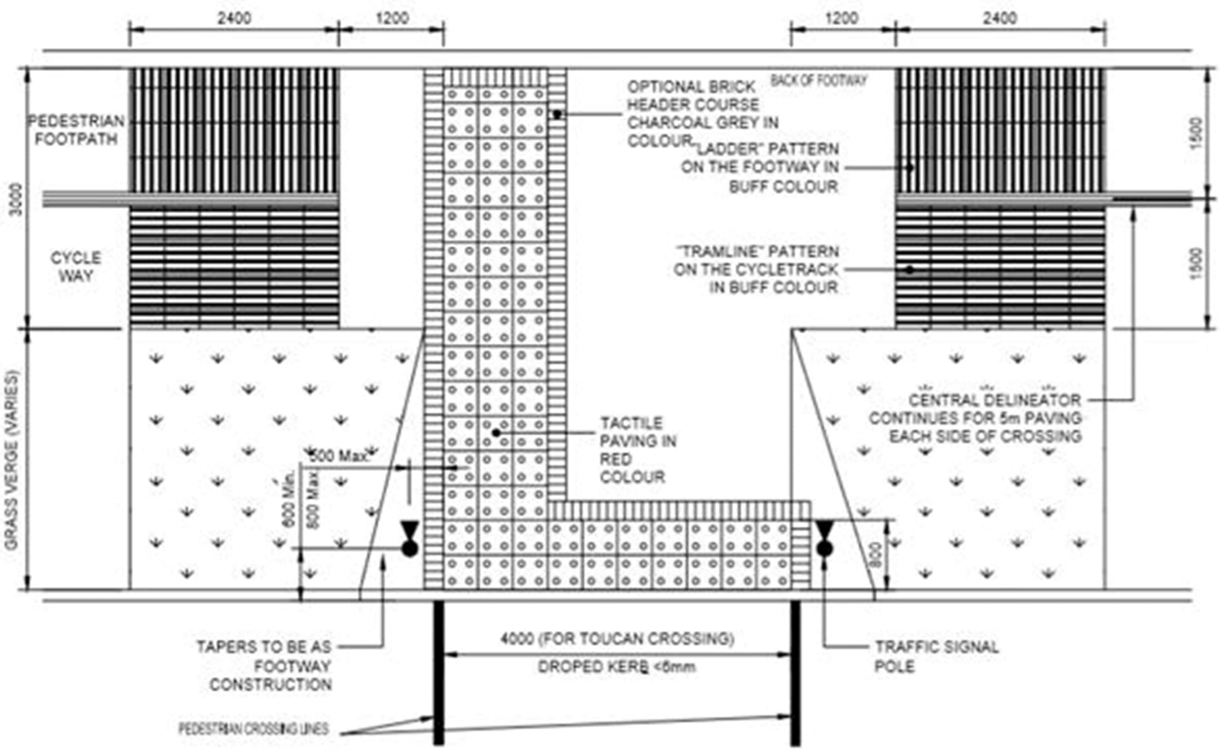


Figure 1.29: Tactile paving plan for controlled intersections

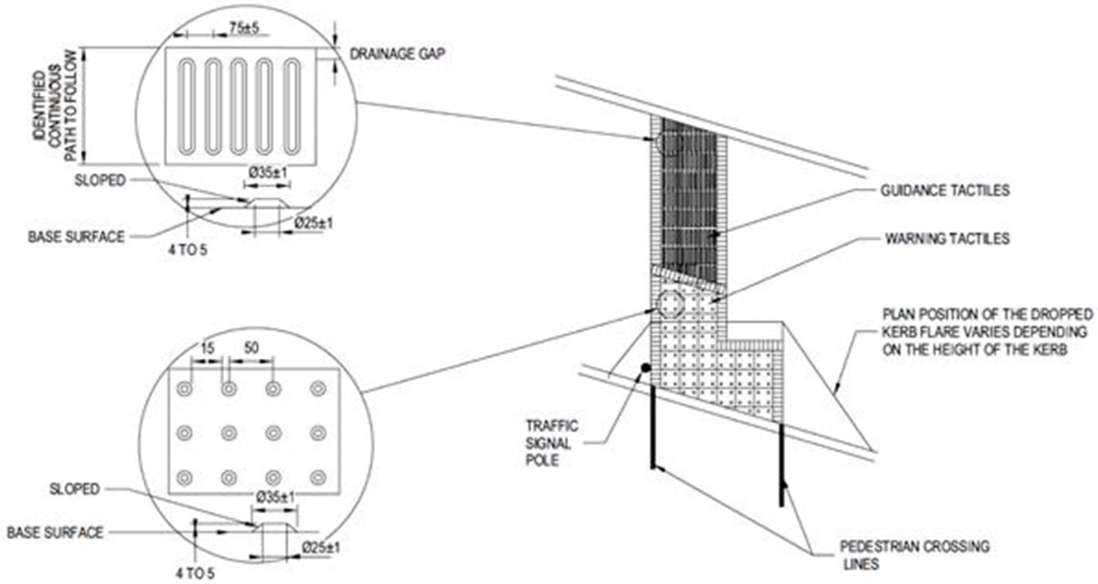


Figure 1.30: Tactile paving plan for a controlled pedestrian crossing

Notes from the NMT Manual

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.

Figure 1.31: Tactile paving plan for a controlled pedestrian. Examples (good and poor)

The square-grid warning tactile is used wherever people might be crossing the road and the kerb is flush with the road - it could be at a dropped kerb (ramp) or where the road (or a cycle track) is brought up to footway level. Warning tactiles should always be provided in pairs as we are sending the message to people with reduced or no vision that they are about to enter a road.

For zebra crossings and signalised crossings, warning tactile paving is normally used and in an 'L' shape.

L-shape red warning tactile paving

The warning tactile is a series of "bars" with round tops. It is intended to mean "proceed with caution" and is best used at the top and bottom of steps but is also used at the bottom of a ramp leading up to on-road BRT to warn that people are about to walk onto a platform and where a footpath joins a shared-use (unsegregated) cycle track.

Warning tactile pavers

PUBLIC TRANSPORT

In this manual, only road-based public transport systems are considered since they can be implemented alongside conventional road design. Other public transport systems require specialised design and are not covered in this manual.

The types of road-based public transport that can be implemented on existing and future roads, based on the road class, are detailed in Table 1.18.

The design and implementation of public transport services (Light rail commuter transit, Bus Rapid Transit (BRT), conventional bus and taxi) is a specialist work stream that is not covered in this Manual.

General notes:

- BRT and conventional bus services should only be allowed on surfaced roads in urban areas due to the dust generation of these vehicles on unsurfaced roads.
- Taxi services should ideally only be allowed on surfaced roads unless an urban area does not have surfaced roads along the required routes.
- Taxi services on access roads should only be allowed on limited routes, for which they should be licensed to operate on.
- Boda-bodas perform a crucial transport service and should be allowed on licenced routes of all classes, except Class 6 & Class 7.

Table 1.18: Public Transport Provision per Road Class

Class	Description	Public transport types	Infrastructure required
1	Trunk Route	• BRT trunk – dedicated lanes • Conventional bus - dedicated lanes or mixed traffic • Taxis in mixed traffic • Light rail commuter transit	• Median side BRT lanes and median stations • Kerb-side bus lanes and stops with or without shelters
2	Major Arterial	• BRT trunk – dedicated lanes • Conventional bus - dedicated lanes or mixed traffic • Taxis in mixed traffic • Light rail commuter transit • Boda-boda on limited licensed routes only	• Median side BRT lanes and median stations • Kerb-side bus lanes and stops with or without shelters
3	Minor Arterial	• BRT feeder – mixed traffic • Conventional bus – mixed traffic • Taxis in mixed traffic • Light rail commuter transit • Boda-boda on limited licensed routes only	• Kerb side BRT lanes and median stops with shelters • Kerb-side bus lanes and stops with or without shelters
4	Collector Street	• Conventional bus – mixed traffic • Taxis in mixed traffic • Boda-boda on limited licensed routes only	• Kerb-side bus lanes and stops with or without shelters
5	Access Street	• Taxis on limited licensed routes only • Boda-boda on limited licensed routes only	N/A
6	Informal settlement Access Way	• Not allowed	N/A
7	NMT Access Way	• Not allowed	N/A

INFORMAL PUBLIC TRANSPORT

Uganda's passenger transport system is dominated by its large paratransit industry, primarily informally operated minibuses ("taxis") and motorcycle taxis ("boda-bodas"). In common with most major African cities, Kampala being Uganda's largest urban area, has roads that are highly congested. At certain times of day, during bad weather or in response to any sort of disruption, traffic is practically at a standstill.

CONVENTIONAL BUS SERVICES

The provision of public transport facilities on the road network is not only aimed at enhancing public transport but also to improve traffic flow and road safety. Such facilities reduce the number of conflicts on mobility roads and can therefore make a significant contribution to the reduction in collisions.

Conventional bus services are the simplest mode to implement:

- It makes use of existing road infrastructure, sharing the road with private vehicles and other informal transport services (i.e., minibuses or boda-bodas)
- The vehicles can be sized to match the design standards and demand on the route. Vehicles can typically fall into one of four categories: minibuses (6-8m in length), Regular busses (10-12m in length), Articulated busses (16-18m in length) and Double-decker busses (double volume and contains stairs)
- Bus stops and shelters should be implemented along the route.

BUS STOP DESIGN

Bus stops should be an integrated component of the streetscape and include shelter, places to sit, rubbish bins, cycle parking and shade trees.

Social safety and security can be improved through proximity to all-hours activities, human-scale lighting, and transparent and non-enclosed shelters.

BUS STOP LOCATION, SIZE AND DESIGN

Bus stops should be strategically located close to the centre of action. Bus stops should be as compact as possible to minimise displacing other uses and activities. Bus stops should be integrated into the wider streetscape

The catchment of every stop should be as walkable as possible to support public transport. Public transport must be easily accessible by people on foot if it is to be successful. This means providing safe crossing opportunities at each bus stop and ensuring that there is a safe and direct walking route to all potential origins and destinations.

Bus stop infrastructure such as shelters and poles should not block the footpath, and a minimum width of 1.8m needs to be retained to allow unimpeded movement for pedestrians not waiting for the bus.

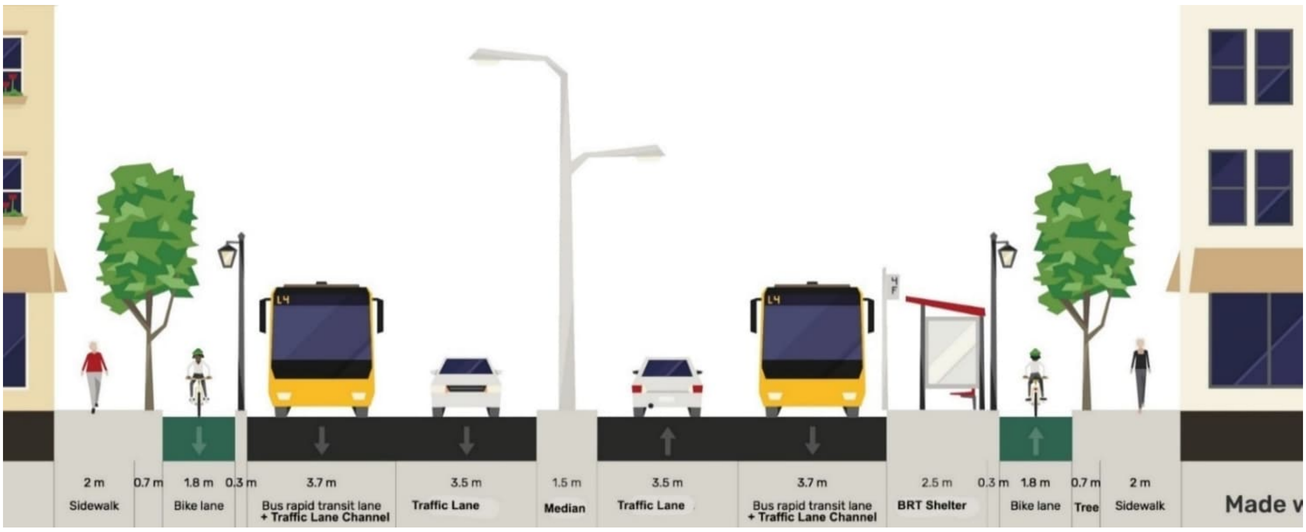


Figure 1.32: One Example of a Minor Arterial Road Cross Section with a PT Shelter/stop

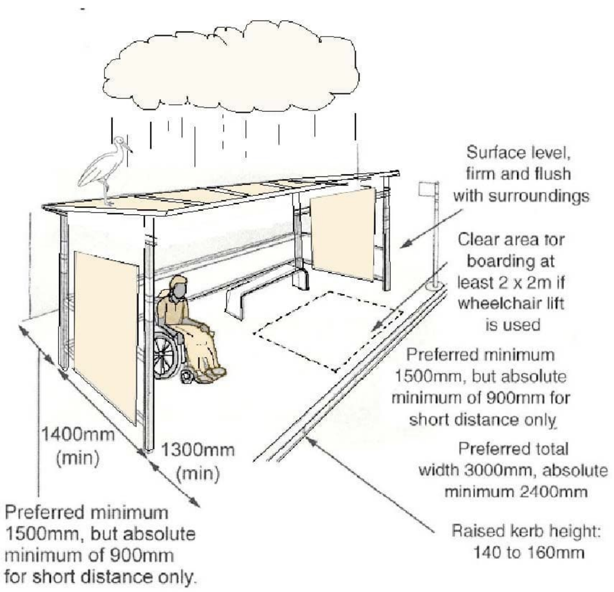


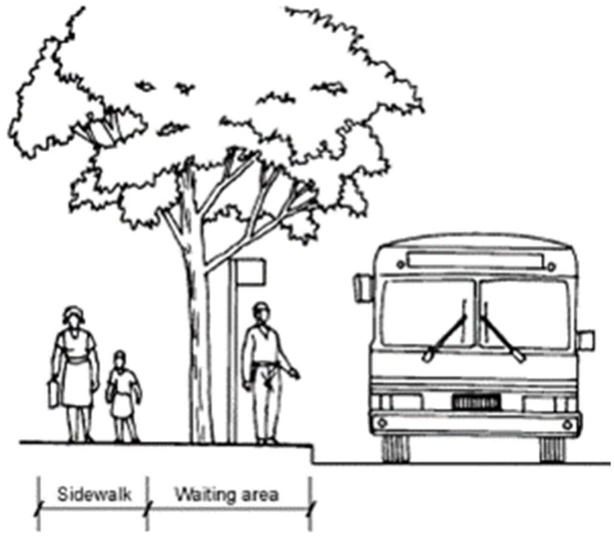
Figure 1.33: Typical bus shelter design example

According to the NMT Manual for Uganda, the following design considerations should be implemented for shelters: 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:

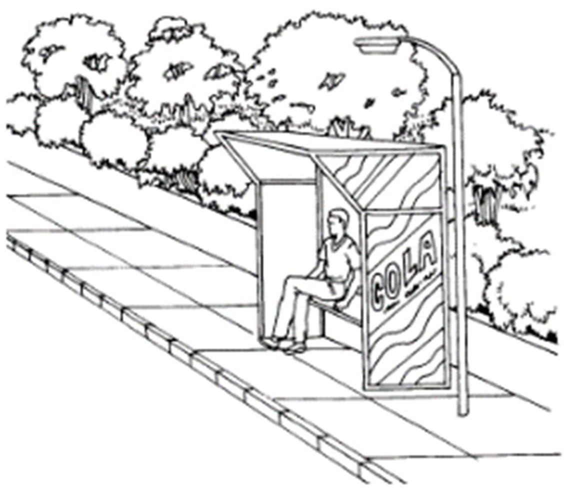
- Shelters are desirable at high-volume stops and bays. Shelters provide protection from wind and rain and should be well-lit with unobstructed access points.
- Provide route names and numbers on the shelters where applicable. provide a seat, litter bin, and transparent sides for better safety. Provide access at two points.
- Provide a continuous strip of 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.

Bus/mini-bus shelters at boarding stops and bays 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 the 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.



Typical sidewalk and waiting area at bus and minibus stops (from NMT Manual)



Typical bus shelter with adequate lighting provided (From NMT Manual)

CONSISTENCY OF DESIGN

Bus stop designs should be consistent to ensure drivers and customers are familiar with the layout. (See section 8.2.1 of the NMT Manual, 2020)

BUS OPERATIONS

Stops must be designed so buses can pull in and out of the stop efficiently and stop close to and parallel with the kerb.

In-lane kerbside bus stops allow buses to stop and re-enter traffic flow easily.

Other vehicles can often pass the bus (especially on lower volume roads); however, the traffic will need to slow down to do so safely.

Kerbside stops need to be marked clearly to ensure cars do not park in them, or park too close, making entry to or exit from the stop difficult.

Bump-out bus shelters involve building out the footpath to meet the traffic lane. This allows buses to stop in the traffic lane, which further reduces bus delays compared with other stop designs, and also makes it much easier for the bus to park parallel to the stop. They have the added benefit of providing a wider bus passenger waiting area clear of the footpath.

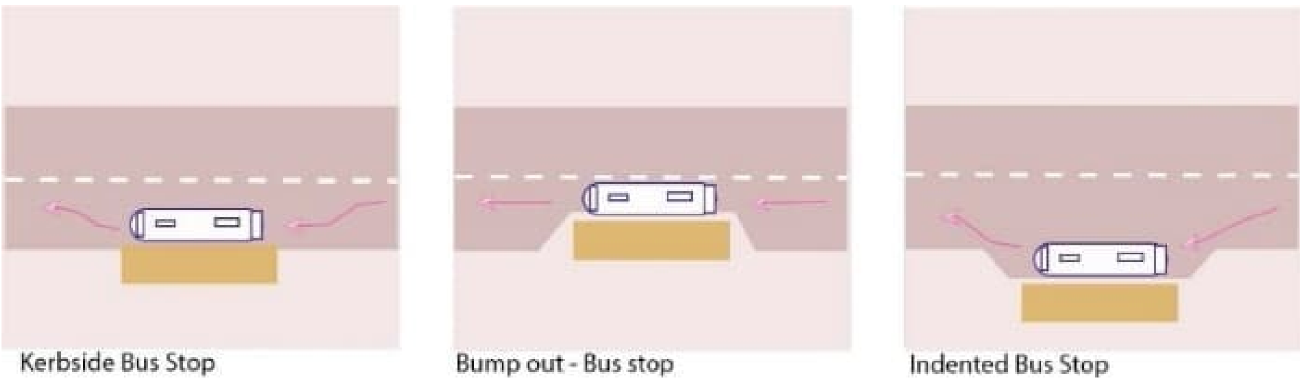
Bus boarders should be considered in town centres on high-frequency bus routes where both bus passengers and shoppers will benefit from the added space.

Indented stops allow a bus to stop clear of the nearside traffic lane. They can be important on high-frequency bus routes with bus lanes to enable buses to pass each other unhindered.

However, where general traffic is permitted to use the kerb side lane, indented stops lead to significant delays to buses when attempting to re-join the flow of traffic. They should only be used where special circumstances call for their use.

STEP HEIGHT AND HORIZONTAL GAP

Platform height and width must meet the requirements of users in wheelchairs. (See NMT Manual, 2020 Table 4.2)



Example of kerbside bus stop types

BUS RAPID TRANSIT SERVICES

Bus Rapid Transit (BRT) is a high-quality bus-based transit system for fast, comfortable, and cost-effective services at metro (urban)-level capacities. BRT operates on dedicated right-of-way lanes, with busways and iconic stations typically located on the median of a dual carriageway high-order road.

Fare collection is usually with an electronic system, such as a bank-type card with pre-purchased and loaded fares (off-board fare collection.

BRT services are further characterised by faster travel times than mixed traffic, and frequent operations: multiple buses per corridor per direction, with short headways, especially during the peaks.

BRT contains features similar to a light rail or metro system, can be more reliable and convenient, and is faster than regular bus services.

A typical BRT system has the following characteristics.

- BRT Trunk Routes normally have an intersection spacing of 500m.
- Speeds up to 80km/h
- Roadway widths are 3.3-3.5m wide within a road reserve width of max. 60m.
- Public Transport stops should only be allowed at BRT stations.
- Pedestrian footways are required, and cycle lanes can be added on the verge.

BRT CORRIDORS

A BRT corridor is a section of road or contiguous roads served by a bus route or multiple bus routes, usually with a minimum length of 3 kilometres of dedicated bus lanes.

ROUTE & VEHICLE TYPES

BRT services are broadly operated with two complimentary types of services:

Trunk services

Trunk services are operated on dedicated, segregated lanes, usually along the median of a carriageway. Trunk services use high-capacity buses (standard and articulated), and passengers board at median stations. Trunk services are used to serve high-volume routes.

Refer to Figure 1.34 to Figure 1.37 for examples of trunk routes and buses.

Figure 1.34: Articulated trunk bus
Source: Dar Es Salaam BRT

Figure 1.35: Articulated BRT bus and median station
Source: Cape Town BRT

Figure 1.36: Standard BRT bus and median station
Source: Cape Town BRT

Figure 1.37: Standard BRT bus and median station
Source: City of Tshwane BRT

Feeder routes (complimentary service to BRT)
Feeder services are operated in mixed traffic without right of way or dedicated lanes. Feeder buses are normally lower volume, smaller buses, that operate less frequently. Passengers can board kerb-side (similar to conventional bus services), or at median trunk stations.

Refer to Figure 1.38 and Figure 1.39 for examples of feeder routes and buses.

Figure 1.38: Feeder bus at a kerb-side stop
Source: Cape Town BRT

Figure 1.39: Feeder bus at a median station
Source: Cape Town BRT

BRT STATION TYPES

BRT services are broadly operated with two station types:

Median Stations (Trunk Services)
Trunk stations can be in-line with single or multiple units. Tandem stations are also used where space is constrained and side-by-side stopping and passing lanes are not possible.

Refer to the figures herewith for some examples of median stations.

Figure 1.40: Multi-unit median station, dual side boarding
Source: Cape Town BRT

Figure 1.41: Median station, single side boarding
Source: Cape Town BRT

Figure 1.42: Multi-unit median station, dual side boarding
Source: Cape Town BRT

Figure 1.43: Multi-unit median station, single side boarding
Source: Cape Town BRT

Figure 1.44: *Single-unit median station, dual side boarding*
Source: Cape Town BRT

Figure 1.45: *Dual median station, passing/stopping one side only*
Source: Cape Town BRT

Kerb-side stations & stops (feeder services)
Refer to the figures for some examples of kerb-side feeder stops and stations.

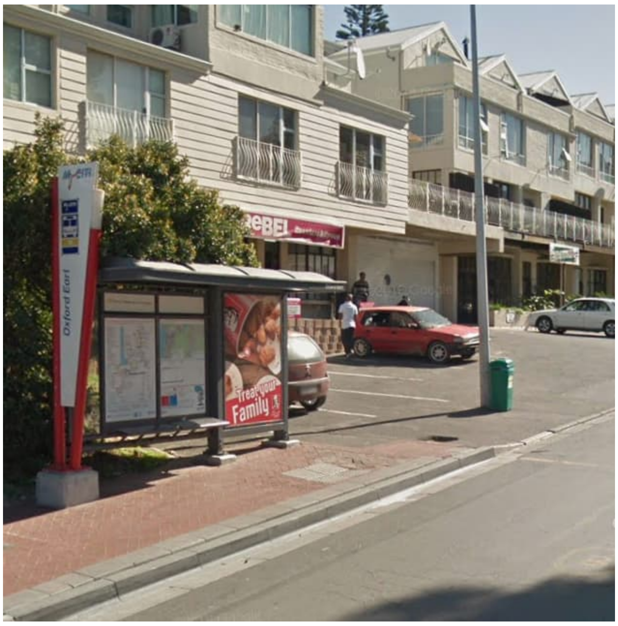


Figure 1.46: Kerb-side feeder stop
Source: Cape Town BRT

Figure 1.47: Kerb-side feeder stop with build-out
Source: Cape Town BRT

Figure 1.48: Kerb-side feeder station
Source: Cape Town BRT

PUBLIC TRANSPORT INTERCHANGES

Interchanges between public transport services are a key part of the network structure. Stops that have an interchange function need to be designed to ensure this interchange is as legible, protected, and direct as possible.

OTHER GROUND-BASED PUBLIC TRANSPORT

Other types of ground-based public transport that may be implemented are heavy and light rail and electric trams. The design and implementation of these services is a specialist work stream that is not covered in this Manual.

General notes:

- Light and heavy rail should be operated along corridors with dedicated rail reserves in which the railway lines are located.
- Heavy rail can be utilised for passenger and freight transport
- Level crossing of railway lines with roads of any class should be avoided, and where such crossings exist, they should be converted to grade-separated crossings.
- Electric trams can be operated in dedicated rail reserves, or in some circumstances within the road reserve on high-class roads only.

ABOVE GROUND (ELEVATED) PUBLIC TRANSPORT

The types of above-ground public transport that may be implemented in future are:

- Elevated bus and BRT systems (viaducts)
- Monorail
- Elevated light or heavy rail

The design and implementation of these services is a specialist work stream that is not covered in this Manual.

General notes:
Elevated bus, BRT, monorail and light rail systems can be operated on elevated viaduct structures. These can be located where required, including within (above) road reserves on higher order roads (Class 1 & 2)

The cost of elevated heavy rail systems makes their use unfeasible, except for short sections where constraints are present such as topography, densely populated areas etc.

UNDERGROUND TRANSPORT

The types of underground public transport systems that may be implemented in future are:

- Underground railway systems
- Underground car parks
- Urban underground roads and expressways
- Underground freight transport
- Underground pedestrian systems

Note that the urban road network and specifically the sub-surface beneath the road reserves may be utilised for underground public transport services. However, due to the alignment requirements of railway lines with larger horizontal and vertical curves than roads, these lines can generally not be located directly beneath roadways for extended sections.

The design and implementation of these services is a specialist work stream that is not covered in this Manual and must include the involvement of the developer/operator of the system. A specific planning regime must be developed to create reserved underground corridors with ground-level reserves to accommodate stations. The location of underground stations and their above-ground access can be located within the reserves of high-order roads (Class 1 - 3).

STREET FURNITURE

Street furniture is items placed within the road with the purpose of directing movement and/or enhancing its place value, including public art, lighting, bollards, guardrails, seating, and cycle parking. Other amenities may be considered for inclusion in the road corridor, including opportunities for play, public toilets, and kiosks. These elements improve vitality and encourage people to spend time and interact socially on the street. All street furniture should be located outside the pedestrian clear path.

Street furniture contributes to public life by facilitating social interaction and catering to the convenience and comfort of pedestrians.
Section 4 of the Uganda NMT Manual provides further guidance for street furniture.

The table extracted from the NMT manual is shown herewith.

Street furniture dimensions and location

Furniture type	Dimensions		Location and frequency
	Footprint (m)	Height (m)	
Bench	2.4 x 0,75	0,4 to 1.0	At least 0.5 m from theedge of a footway Every 50 m in commonly used pedestrian areas At bus stops andshelters
Bollard	0,3m dia.	0,6 to1.2	As required but not more than 1.4 m apart 0.3 m from the kerb
Bus stopshelter	2.6 x y1,4	2.5	As required by busservices
Bicycle locker	2.0 x1.9	2.1	At transport interchanges andstops.
Bicycle rack	0,75 x 0.05	0.75	At transport interchanges andstops.
Drinking Fountain	0.3m dia.	0.6	As required and onlywhere/if potable water is available.
Rubbishbin	0,8m dia.	1.3	Area where litter may be generated e.g., at bus stops andrestaurants
Parkingmeter	0.3 x 0.15	1.5	As required
Planter	Varies	Varies	As required
Lightingpole	0.6 x 0.6	Varies	See rule of thumb andin figure and volume 2
Public Transport sign	0.065 dia. pole	2.1	
Parking sign	0.065 dia.pole	1.5	
Street name sign	0.065 dia. pole	2.1	As required

STREET LIGHTING

Lighting is provided on urban streets to improve safety at night and allow street users to be clearly seen. Businesses on lit streets see increases in revenue as they can operate for longer hours after sunset.

Streetlights are commonly installed on poles along the edge of the road. Their power can be supplied via an underground connection to the power grid, or by solar panels attached to the poles. Solar-powered street lighting has lower costs for local authorities.

Street lighting for vehicles is ideally coordinated with street lighting for pedestrians, as the groups have different needs in terms of lighting. All lighting should be directed and only illuminate the required area of the street, not emit light up or out.

DESIGN CRITERIA FOR STREET LIGHTING

- The spacing between two light poles should be approximately three times the height of the fixture
- Poles should be no higher than 12m. Especially in residential areas, they should be significantly lower than 12m to reduce undesirable illumination of private properties.
- Additional lighting should be provided at conflict points.
- The placement of street lighting should be coordinated with other street elements so that trees or advertisement boards do not impede proper illumination.
- Lighting design should ensure that there are no dark spots along a road or sidewalk.

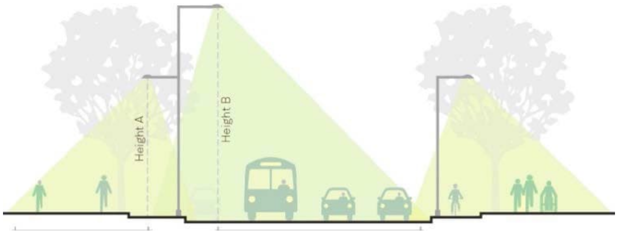


Figure 1.49: Rule of Thumb for Designing Street Lighting

The detailed electrical/lumen specifications can be found in Volume 2, Section 2.3.15.

SEATING

Seating should be provided at regular intervals and should be a mix of shaded and non-shaded seats.

It is recommended that half of the provided seating has comfortable backrests, and armrests to assist people in standing up. Movable chairs are desirable in public spaces, as they allow people to customise seating arrangements. The best locations for benches are places where there is heavy pedestrian use: retail shopping corridors, transit stops, plazas, spaces outside cultural institutions, etc; poor locations are areas where there is little activity, such as in front of offices that close early or buildings without windows.

Concrete benches

Where possible seats should be located in line with other street furniture so as not to cause an obstruction and must be installed a minimum of 450mm from the kerb to allow access from parked cars. In all cases at least 1.8m of clear footway must be maintained increasing to 2m in areas of high pedestrian flow.

A number of different seating styles will be used across Uganda, and these will vary according to which is most appropriate to the location, in terms of climate and available materials.

Figure 1.50: Examples of concrete street furniture by Adler Olesch

WATER FOUNTAINS

Water fountains should be provided at suitable locations on walking and cycling routes. The safety of the piped municipal water supply to feed the water fountains must however be acceptable.

A concrete water fountain

WASTE/RUBBISH BINS

Strategically placed litter bins are convenient for pedestrians and help maintain a clean and pleasant public realm.

The most common error in placing waste bins is putting them wherever there is an empty space, instead of in places where people will use them. If they are not placed appropriately, they will remain empty while the surrounding space becomes dirtied: people will not change their habitual walking path to find a rubbish bin, so the proper placement of these items of furniture is crucial.
Waste bins should be highly visible and accessible in order to minimize littering. They should be located where they are most likely to be used, in crowded areas like busy intersections, close to crosswalks, beside take-out food shops or vendors, at bus stops, in plazas, outside building entrances such as offices, and homes, and near other items of street furniture like benches, seats, shelters, walls, and fences.

Appropriate Locations The following points must be considered prior to placing a waste bin: whether the placement will obstruct the passage of any vehicles, cyclists or pedestrians; whether the motorists' view will be obscured by the waste bin; whether the waste bin presents an obstruction or physical hazard; the length of time proposed for the placement on-site; and the need to maintain the safe and efficient operation of the roadway.

On streets in the city centre, 2-4 waste bins per block are usually sufficient: one should be at each end of the block next to the crosswalk, and one or two more in the middle of the block if there are benches or food stalls along it.

Waste bins are usually spaced at 30m intervals, unless there is an increased need in a particular area such as close to pubs, clubs, cafes and takeaways, at transport hubs and bus stops, in some commercial areas, car parks or unused land. More bins are also required near schools and colleges, and along roads that connect these places to shops.

Figure 1.51: Example of waste bins, Metal, Plastic, Concrete, lockable with rotating top.

MATERIALS FOR STREET FURNITURE

Furniture selection and design should take into account weather effects such as sunlight, expansion and contraction, wind stress and moisture.

The best designs usually incorporate strong, simple shapes, local materials, and natural finishes, generally in black, greys, and earth tones, accented with bright colours.

SOLID WATSE MANAGEMENT GENERAL REQUIREMENTS

It has been estimated, that typically 33% to 66% of the waste generated in urban centres in Uganda is not collected on a regular, programmed basis. Source: Solid Waste Management Study in Bwaise II Parish, Kawempe Division - Briefing Paper. Acording to the Kampala Capital City Authority. It is estimated that the per capita generation of general residential, industrial and commercial waste is one kilogram per day. With a population of approximately 1.5 million inhabitants, waste generation is approximately 1 500 tons per day. Approximately 40% to 50% of this is collected. (Source: KCCA website).

The following regulations provides some guidance for solid waste management in Uganda:

- The Public Health Act, Cap.281
- The Public Health Act, Cap.281
- KCC Solid Waste Management Ordinance (SWMO), 2000
- Solid Waste Management Strategy (SWMS), December, 2002, revised in 2006
- Local Governments Act (1997), revised in 2004
- The Constitution of Uganda 1995, amended in 2005
- The National Environment (Waste Management) Regulations, S.I. No 52/1999.

In terms of S29 of the National Environmental Waste Management Regulations, S.I. No 52/1999 a local government shall provide waste receptacles at public places, including public recreational areas, public transport commuter parks and other heavily visited areas.

The responsibility of collection of solid waste is in the hands of municipalities, either by its agents, servants or licensed collectors to ensure that solid waste is collected and conveyed for treatment (sites/centres) or approved disposal places.

The following are the areas where waste collection intersects with urban roads/streets:

- Waste from residential streets
- Waste from commercial streets
- Waste from Industrial streets
- Waste from street-side markets

A national solid waste management policy for Uganda is required to deal with solid waste management.

The draft Developing Municipal Solid Waste Management Strategy for the municipal local governments of Apac, Busia, Kamuli, Kasese, Kitgum, Lugazi, Mubende and Ntungamo, 2021 (JBN) 2021, describes a number of issues and recommendations for solid waste management that impact the design or urban roads in Uganda.

These include:

- Low levels of regular waste collection
- Inaccessible areas for solid waste collection
- Absence of effective by-laws to enforce illegal dumping, collection, etc.
- Waste storage and collection: Inadequate numbers of waste storage bins per site.
- Inadequately maintained road network, especially the routes to the informal settlements.

The strategy states that there is a requirement for appropriate collection points and an improved urban road network. In addition, sensitization of the public through inter alia signage and communication strategies is required.

This can be achieved through an improvement in the road network and adequate placement of wastebins on roads. Guidance on the placement of waste bins is provided below. Advice on solid waste management during construction is provided in Volume 2, Section 2.77

WASTE BIN PLACEMENT ALONG PUBLIC ROADS

- Waste bins must be coordinated with street side seating and placed in areas of pedestrian activity such as informal vending areas, along pedestrian routes, at bus and taxi stops and in public parking areas.
- Waste bins must be weatherproof and fireproof
- Waste bins must have removable inner linings (bags) to promote ease of emptying
- Waste bins must have full or partial covers to contain smells and deter insects and rodents
- Waste bins should not occupy more than 1m² of space and should be located at intervals of not more than 200m along a road
- Waste bins should ideally be located along sidewalks and footpaths accessible by pedestrians, but must not obstruct the routes or the sight distance for drivers at intersections

It is critical that a waste collection schedule is developed and maintained and updated if required to ensure that the waste bins are emptied as regularly as required. The schedule must be updated to ensure that areas where waste bins fill up fast, they are either cleaned/emptied more regularly, or more and/or bigger bins are supplied.

SUMMARY OF STEPS IN DETERMINING SOLID WASTE MANAGEMENT PLAN

<u>Determine type and volume of recycling and waste streams that will be generated in a particular area</u>

The first step involves assessing the types of waste and recyclable materials that are most likely to be produced in a suburb or district. Local authorities should monitor the waste generation and keep records of types and quantities of waste.

<u>Determine the recycling and waste collection vehicles available for use</u>

The size of vehicle varies according to the collection service. Thus, it is impossible to specify what constitutes the most appropriate waste removal truck per area.

In the larger municipalities, box body trucks and tipper trucks with compactors are used to pick-up and transport solid waste. These are specifically designed for solid waste transportation. The larger solid waste vehicles may require larger radii at entrances to accommodate them safely.

If utilising a compactor type heavy vehicle, they should only be used on class 1- 4 roads and preferably surfaced roads only. Where there are no roads, or the roads are too narrow to accommodate heavy waste collection vehicles, waste collection points should be centralized on accessible higher order roads.

Example of a rear load compactor truck for door-to-door waste collection

Example of a smaller vehicle used to collect and transport waste from centrally located waste bins & skips.

Calculate the number and type of containers required

The quantity of waste containers required depends on the type of collection service the city or town provides. The following table is an example of the types of bins that can be used in different urban environments.

RESIDENTIAL- APARTMENTS	Waste type	No. of units	Collection schedule
	Non recyclables	1 cart for every five residential units or apartments.	360 litres collected weekly
RESIDENTIAL DOOR TO DOOR			
	Non recyclables	1 per house	120L Weekly
COMMERCIAL (SKIPS)			
	Non recyclables	Number per site is dependent on volume of waste generated.	Size and collection dependent on amount of waste generated.
COMMERCIAL STREET FURNITURE – LITTER BINS			
 	Non recyclables	2 to 4 per City block in Main Streets and pedestrian environments.	Bi-weekly collection.

Determine access route for collection vehicles and turning radius requirements

The following design elements address the need to allow a collection vehicle to enter a residential or mixed-use area, collect the recycling and garbage and exit without having to reverse on a public road, as this poses risks of pedestrian and vehicle accidents.

ELEMENT	DESIGN GUIDELINES
Entry and Exit	• Allow collection vehicles to enter an area, collect waste and recycling, leave the site in a forward motion only or via the use of a turnaround/cul-de-sac that allows a three-point turn of no less than one truck length • If reversing (backing up) is the only option, it must not compromise traffic operations and safety
Driveway Access	Minimum width of 6 metres at the points of entrance and exit for the area
Slope	• Ensure slope of access road/driveway does not exceed 6%
Vehicle Access Route	• Minimum width of 4.5 metres for the full route
Vehicle Clearance	• Maintain a minimum vehicle clearance of 4.5 metres throughout the entire access route
Turning Radius	• Provide the collection vehicle a minimum turning radius of 12.5 metres throughout the entire access route

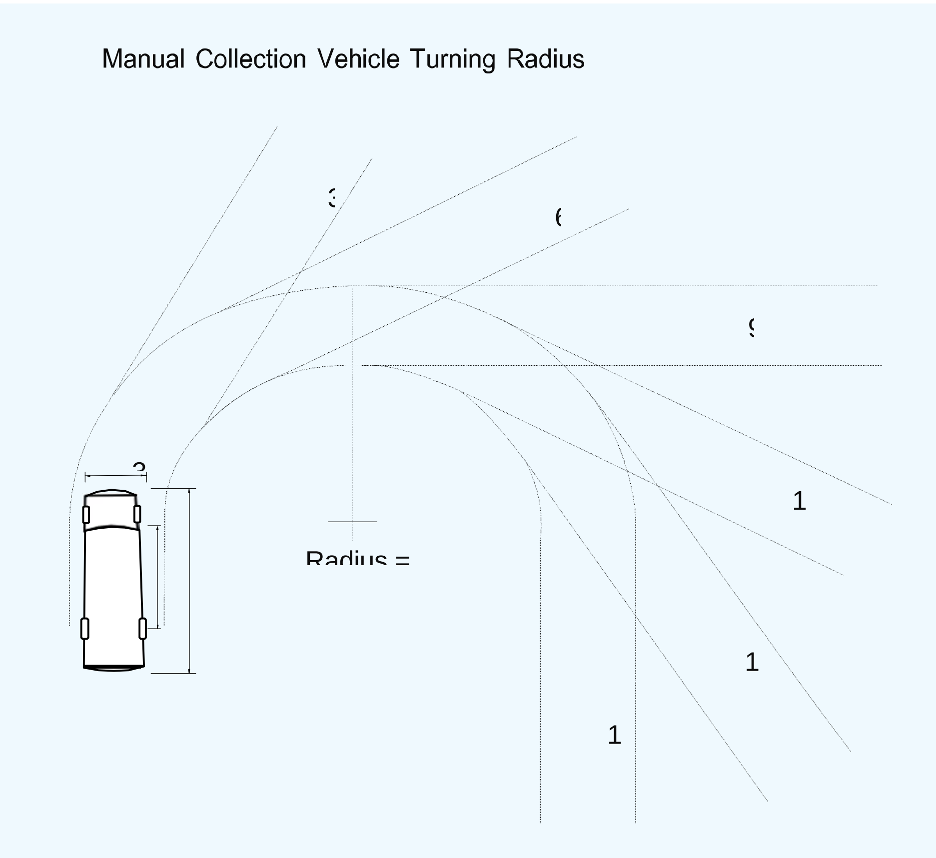


Figure: Turning radii required for waste vehicles

Designing for waste collection movement

The consideration for waste collection is an important aspect in the planning of any new development. Road layouts and reserve widths should be designed to accommodate typical waste collection vehicles. Designs should base layouts on the expected waste collection vehicle that will be utilised. However, it is neither necessary nor desirable to design new streets to accommodate larger waste collection vehicles than can be used within existing streets in the area.

Like all street design efforts, designing for waste truck movements should be done to accommodate general waste vehicles and any other heavy vehicles that will utilise the road. In general, providing for truck movements through the city/town's various industrial, commercial, and residential areas follows standard design principles for different classes of roads.

Residential: Most trucks entering residential areas are smaller-sized delivery trucks and the occasional moving van or waste truck. Design for waste truck movements is intended to provide for slow speeds and loading that occurs on-street.

Commercial Centres and Higher order Roads: provide access for trucks serving businesses located within these districts. Designing for waste truck movements should not conflict with the needs of pedestrians, bicyclists, transit users, and motorists in these areas. Adjacent to higher order roads, a suitable loading bay dedicated for waste trucks can be provided, however these are generally not recommended due to the following:

- Dedicated parking bays for waste loading will be utilised for only a few minutes per week, pending the waste removal schedule. The cost of constructing these bays and their space requirements that could be used for general vehicle parking, versus their limited usage, is regarded as wasteful.
- These bays will in all probability be occupied by other vehicles, including boda-boda's, unless constantly policed to keep them clear.

The minimum requirement for a bay is a fully constructed on-street bay with minimum dimensions of 10.5 m x 2.5 m plus (+) 45^0 splays on either side to allow for safe entry and exit from the public street. Refer to Figure 1.52.

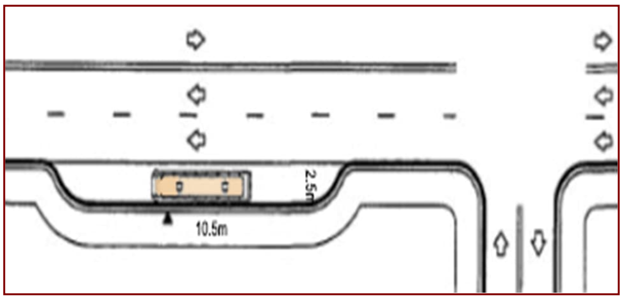


Figure 1.52: Example of an on-street waste loading bay.

Informal settlements are characterized by narrow travel lanes and limited curb radii, which can impede heavy vehicle movements. Refuse vehicles should not enter NMT pedestrian only routes or Class 6 informal settlement routes unless these roadways are designed for such vehicles with ample provision for turning. where large turning circles are not practical due to space constraints. Central waste collection points need to be provided adjacent to the roadway at the nearest passing point. As a rule, the distance from the collection point to the furthest service point should not be more than 45m. A typical collection point can consist of a demarcated and surfaced or paved area behind the road kerb, at least 1.5m wide with a length equal to the number of service points in meters. Such collection areas should be carefully selected to avoid being too close to or opposite residential frontages or accesses, and to ensure that sight lines for road users are not obstructed.

STORMWATER MANAGEMENT AND THE ENVIRONMENT

Stormwater management is based on:

- the need to protect the health, welfare, and safety of the public, and to protect property from flood hazards by safely routing and discharging stormwater from developments.
- the quest to improve the quality of life of affected communities.
- the opportunity to conserve water and make it available to the public for beneficial uses.
- the responsibility to preserve the natural environment.

STORMWATER ON SURFACED ROADS

The main function of urban roads is the carrying of vehicular, cycle and pedestrian traffic. However, they also have a stormwater management function. During minor storm events, the two functions should not be in conflict. During major storm events, the traffic function will be interrupted, the flood control function becomes more important, and the roads will act as channels. A good road layout can substantially reduce stormwater system and road maintenance costs. The Uganda Green Growth Strategy promotes green and sustainable design for city-making.

- Stormwater should not be located under the road carriageway as access is required for maintenance.
- Green infrastructure that increases the permeability of the surface is preferred.
- Stormwater pipe sizes should be based on the local hydrology data.
- Open stormwater drains adjacent to carriageways are dangerous.
- Access points for the stormwater drains should not conflict with NMT movement.

There are a variety of green stormwater design elements, such as bioretention swales (Figure 1.53), which must be selected, sized, and configured to meet the goals and context of the project site. Multiple green elements may be sited and combined within the street to realize the full potential to manage stormwater runoff, improve multi-modal mobility, enhance street aesthetics, and achieve the full performance value of living infrastructure.

EXISTING OPEN DRAINS

Open stormwater drains that have been constructed adjacent to roads entering towns in Uganda are a safety and health hazard.

The NMT Manual, 2020 states that in cities and urban centres where road space is limited, side drains can be covered to better utilise road spaces.

Informal cover of an open stormwater drain for trading space, Kampala

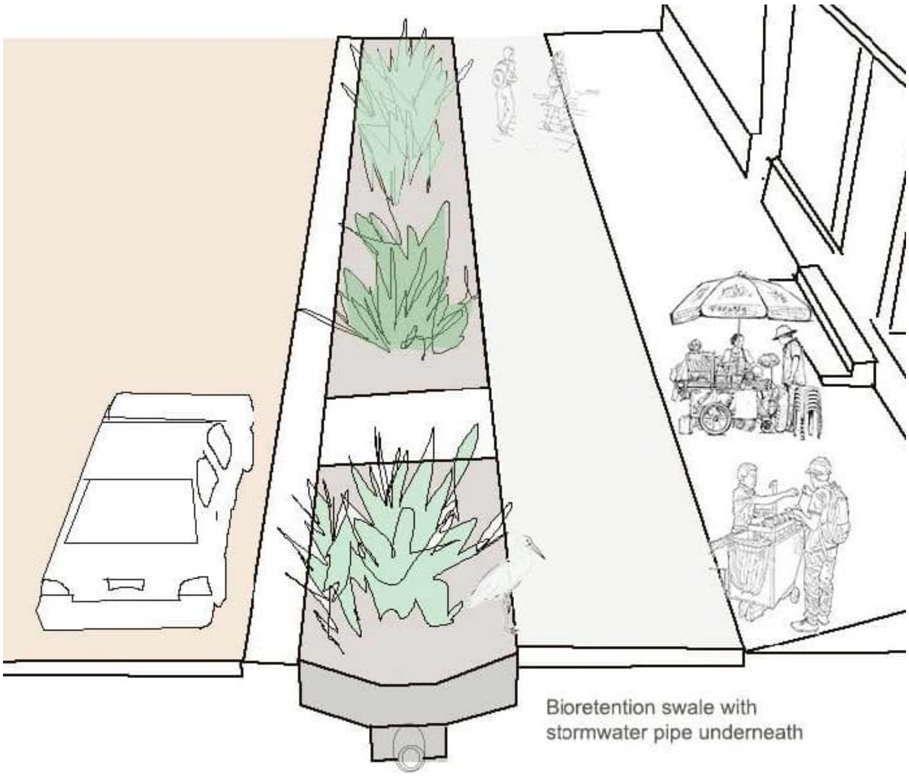


Figure 1.53: Bioretention Swale


Hazard created by an open drain in Mbale

GREEN INFRASTRUCTURE

Green infrastructure in urban streets complements traditional piped water drainage systems.

Vegetation, soils, and natural processes capture and infiltrate or evaporate water before it enters the piped system. Green infrastructure can help reduce flooding and water pollution by absorbing and filtering stormwater. It simultaneously provides a natural relief to the built environment, improves the street aesthetic, and delivers benefits to the community.

Green infrastructure must be carefully coordinated to avoid conflicts with utility placement, high water table levels, and subterranean conditions such as the location of bedrock.

PARKING STANDARDS

CURRENT PARKING STANDARDS

In urban areas, the URDM practitioner is required to consider and implement the guidelines of the Traffic and Road Safety (Parking of Motor Vehicles) Regulations, 2001. National Physical Planning Standards and Guidelines: Chapter 4: Standards for Vehicle Parking, Roads, Footways And Cycle–Ways.

Where these guidelines conflict with the URDM, then the requirements of the URDM take preference, only in urban areas.

ON-ROAD PARKING

On-road parking and loading refers to spaces that are directly adjacent to and accessible from the main vehicular carriageway.

It is a common practice to park vehicles on the street. This is sometimes acceptable if the street is wide enough and lightly trafficked. Elsewhere, on-street parking should be discouraged because it reduces the traffic flow and is a cause of accidents.

Where on-street parking can be permitted, it will usually take the form of parking parallel to the kerb. Parking at an angle to the kerb is often more convenient but there is a greater likelihood of accidents so it should only be used where the pedestrian and vehicular traffic is very light. In order to encourage the best use of the space, it is advisable that on-road parking spaces should be marked by the responsible local authority as per their master plans on the carriageway in colour specified by the local authority or district engineer.

GUIDELINES FOR ON–ROAD PARKING

The following guidelines for on-road parking are recommended to promote a safe and efficient transport system with the different user activities.

- The priority for on-road parking should be the availability of safe, convenient, and appropriate parking that supports the primary activities in the street resulting from the desired land uses for each area within the local authority's Physical Development Plan.
- Priority should be accorded to on-road parking space by ensuring sufficient space for public transport to encourage large numbers of visitors to the city to use public transport.

- On-road parking should be time limited to provide “turnover” of parked vehicles and to encourage visitors to the city by equitably sharing the available on-road parking space.
- “Time limit” parking should be available at a cost that reflects the convenience of on-road parking as comparable to off-road parking charges and encourage greater use of long-stay off-road parking.
- There is a need to cater for the special parking needs of residents, their visitors, and people with disabilities through schemes specifically designed for these groups of people.
- On-street stopping, and parking controls should be simple and easily understood by the general public.
- On Arterial and Access streets on-street parking spaces should be provided in a series of bays that are parallel to the vehicular carriageway. Provide on streets with operating speeds less than 50km/h.
- Traffic lanes wider than 3.3 m can have 2.1 m wide parking bays. Otherwise, standard bays should be 2.5m by 6.1m. (see Figure 1.54)
- Perpendicular or angled spaces may be provided in lower speed environments such as Local streets. They may be applied more generally in Centres to cater for increased demands around shopping areas.
- On-street parking on public streets should not be allocated to individual dwellings. This allows for a more efficient turnover of spaces and, as such, fewer spaces are needed overall.
- To reduce the visual impact of parking the number of parking spaces per bay should generally be limited to three parallel spaces (including loading areas) and six perpendicular spaces.
- Perpendicular parking should generally be restricted to one side of the street to encourage a greater sense of enclosure and ensure that parking does not dominate the streetscape.
- To reinforce narrower carriageways (particularly when spaces are empty) each parking/ loading bay should be finished so that it is clearly distinguishable from the main carriageway.
- Kerb buildouts, or similar treatment, should be provided to separate each bank of parking/ loading. These will enable space for the planting of road trees and other facilities (such as lighting or bike racks).

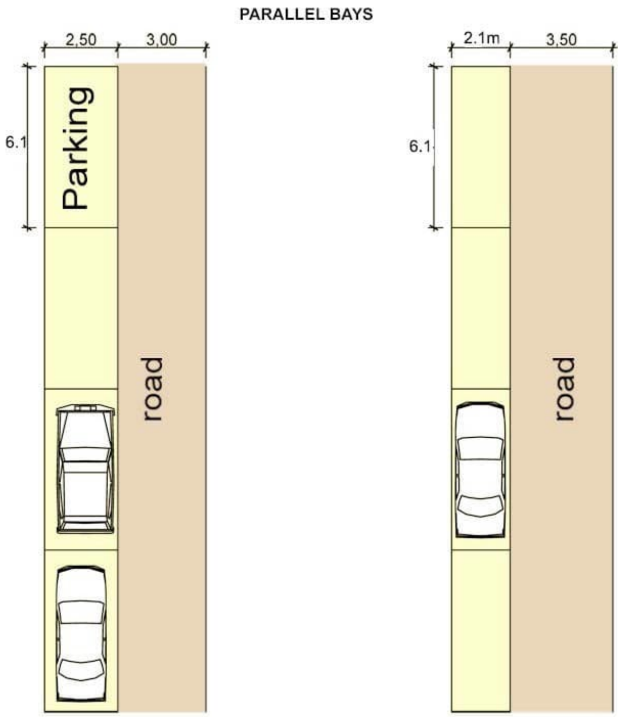


Figure 1.54: Typical Parallel Parking Bay Dimensions

On-road parking, when well-designed can:

- Calm traffic by increasing driver caution, visually narrowing the carriageway and reducing forward visibility.
- Add to the vitality of communities by supporting retail/commercial activities that front onto roads through the generation of pedestrian activity as people come and go from their vehicles.
- Contribute to pedestrian/cyclist comfort by providing a buffer between the vehicular carriageway and foot/cycle path.
- Reduce the need or temptation for drivers to kerb mount and block foot/cycle paths.
- Provide good levels of passive security as spaces are overlooked by buildings.
- The quantity of on-road parking that is needed in a given area depends on a number of factors, but is most closely related to proximity to Centres, the availability of public transport and the density, type, and intensity of land use.
- Notwithstanding these factors, on-road parking has a finite capacity, depending on the per unit parking requirements.

The major principle, however, is that on-road parking should only be provided once pedestrians, trees, cycle paths and vending spaces have been catered for.

GUIDANCE FOR MOTORCYCLE PARKING

- The number of motorcycle parking spaces provided should be developed from demand surrogates, such as total motorcycle registrations. The following are recommended when motorcycle size data is not available: a 1.5m by 2.5m stall and 60° parking angle (90° in low-traffic environments). See Figure 1.55 and Figure 1.56.
- The development of uniform motorcycle parking signs should be considered, to inform motorcyclists of legal parking locations.
- The installation of rails, hoops, or posts adjacent to parking stalls for motorcycle security is also recommended.

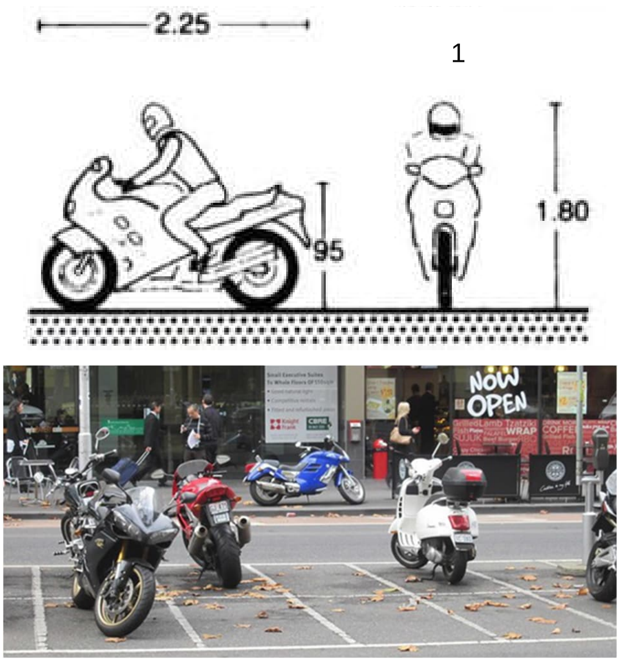


Figure 1.55: 90-degree Parking for Low Traffic Environments

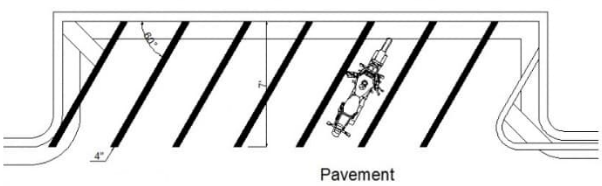


Figure 1.56: Typical 60-degree Parking Angle for Motorcycles in Higher Traffic Environments

LOADING ZONES

Loading zones are designated for the loading of goods and passengers and are generally accommodated in the parking lane.

Considerations:

- Loading facilities should preferably, be provided off the road. However, this is not always possible or desirable within older centres and/or where it would lead to an excessive number of access points to driveways.
- Do not encroach onto the sidewalk.
- Provided lower-order streets, but not in residential areas.
- Should not impact pedestrian movements.
- Should not encroach onto bicycle lanes.
- Located away from intersections and crossings to improve sight lines.
- Use should be limited to a predefined duration and/or time period.
- Some trucks using the facility could intrude onto sidewalks or bike facilities

SERVICES AND UTILITIES

Utilities are, for the purposes of this section, defined as engineering services including water, sanitation, storm-water drainage, energy supply and communications cables. Road designers need to provide setbacks, spacing, and depth of cover guidelines in accordance with municipality and utility requirements. The depth of cover is measured from the top of the pipe or conduit to the finished grade. Coordination with the utility suppliers is crucial to prevent abortive work.

Figure 1.57: Digging Trenches for Water Pipes, Gulu

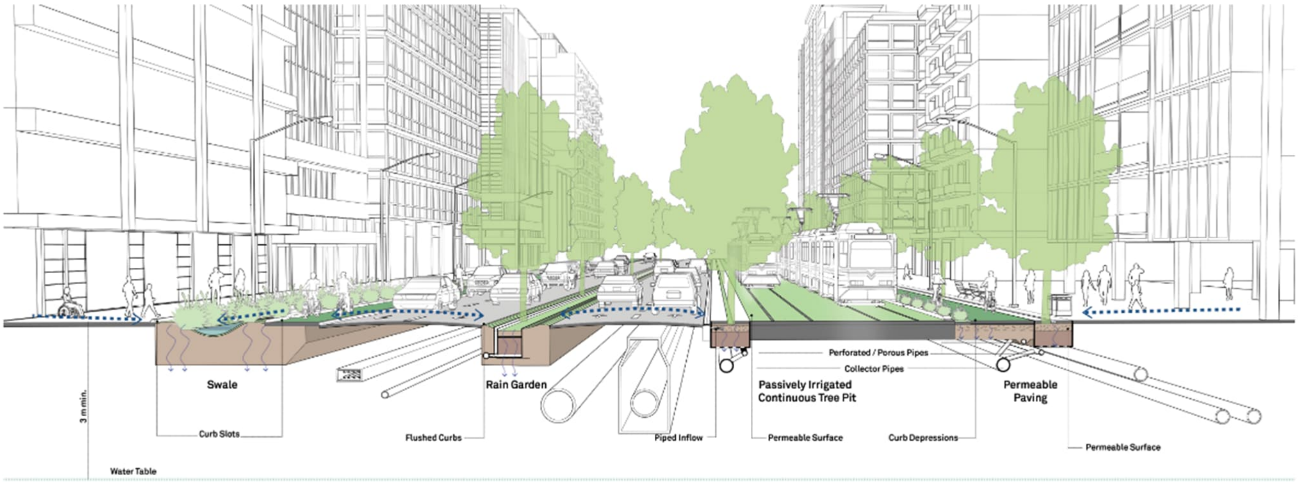


Figure 1.58: Example of sub-surface services location

There are two options for installing utilities in the street, briefly described here.

OPTION 1: INSTALL UTILITIES IN THE ROADBED

Advantages

- Reduces construction time
- Land acquisition savings
- Allows compact, walkable streets

Disadvantages

- Repair may cause disruption to transit, cycle lanes and traffic
- Additional protection (expense) may be required due to continuous traffic loading

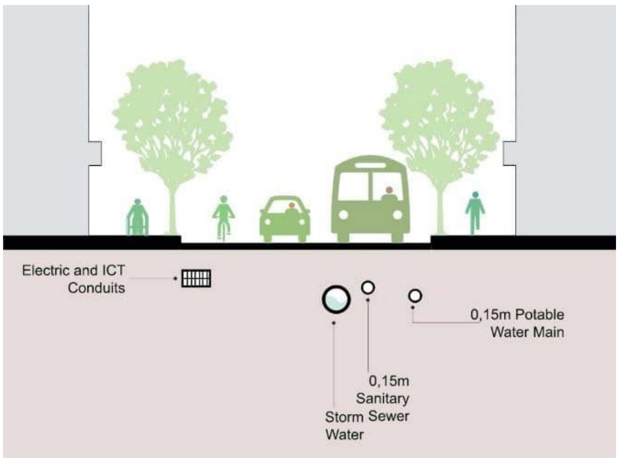


Figure 1.59: Utilities in the Roadbed

OPTION 2: INSTALL UTILITIES ADJACENT TO THE ROADBED

Advantages

- Prevents closure of traffic lanes during construction and repair
- Requires less protection due to lower traffic volume loading
- May reduce the need to acquire land for future roadway expansion

Disadvantages

- Greater space requirement
- Loss of pedestrian area during repair and maintenance.

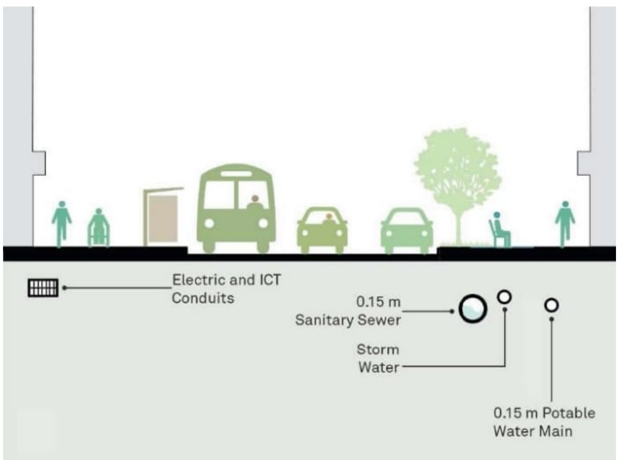


Figure 1.60: Utilities Adjacent to the Roadbed

INTERSECTIONS

The geometry of an intersection can be enhanced by considering a number of design treatments. The most important techniques are discussed below. Please refer to Volume 2, Chapter 2.3 for a more in-depth discussion and guidelines. Also refer to the NMT Manual, 2020, Chapter 6.

TURNING RADIUS

When designing intersections, it is critical to consider the elements that create the effective turning radius. The effective radius is the curve that vehicles follow when turning. The effective radius is influenced by kerb extensions, parking, cycle lanes, medians and receiving lanes. Where on-street parking and/or bicycle lanes are present, the effective turn radius is increased, refer to Figure 1.61

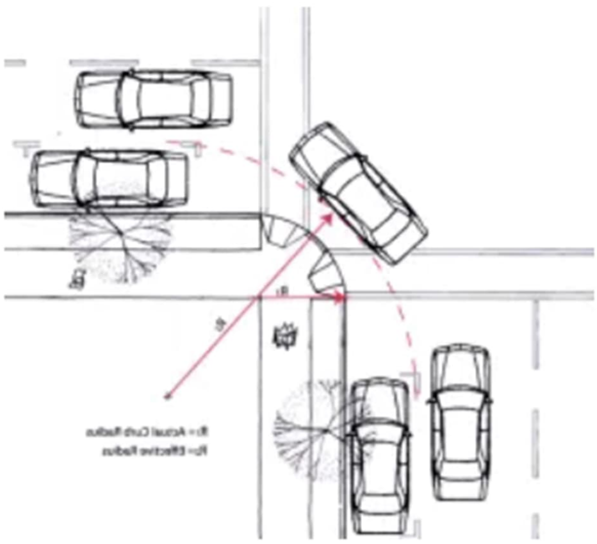


Figure 1.61: Effective Turning Radius

Many drivers will turn into the centre-most lane to minimise centrifugal force. In order to create the desired conditions of a street type, e.g., slow turning speeds, the effective turning radius must be considered when establishing the actual kerb radius.

Two standard design vehicles are recommended for use in the design of urban roads. The passenger car should be used for speed-related standards and a standard bus for standards relating to manoeuvrability, typically at intersections and local accesses. The bus design vehicle also dictates the maximum permissible gradient. Designs must be checked to ensure that larger vehicles, such as articulated vehicles, can be accommodated within the total width of the travelled way, even though they may encroach on adjacent or even opposing lanes. Should these larger vehicles comprise more than 10% of the traffic stream, it will be necessary to use them as the design vehicle.

The minimum turning radii for a range of design vehicles are shown in Table 1.19

Table 1.19: Minimum Turning Radii
Source: CSIR Chapter 7 Volume II Roads

Vehicle	Min Radius (m)
Passenger vehicle	6.2m
Single Unit	12.8m
Single unit + trailer	14m
Single Unit Bus	13.1m
Semi-trailer	13.7m

Different vehicles also have different turning "envelopes" which should also be considered in the design. A vehicle envelope includes the movement of the body of the vehicle and not only the wheel path. Diagrams of the vehicle envelope for a passenger vehicle and a single unit truck are included for illustrative purposes, compare Figure 1.62 and Figure 1.63. (Source: SFBetterstreets.org)

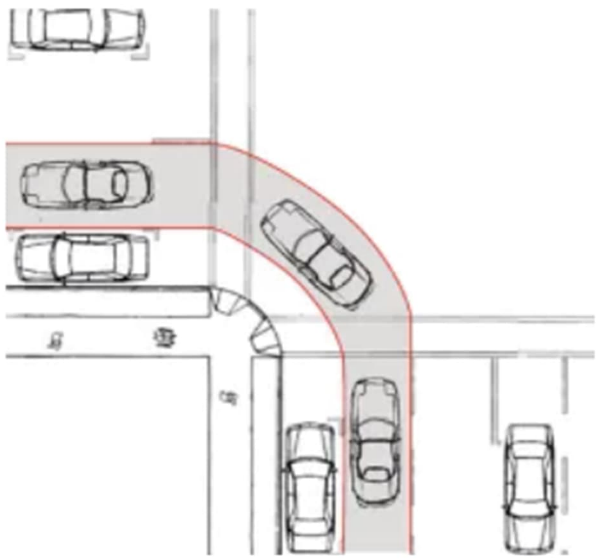


Figure 1.62: Passenger Vehicle Turning Envelope

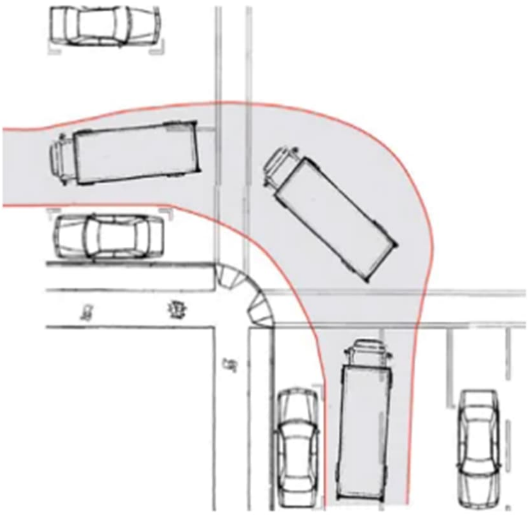


Figure 1.63: Single Unit Truck Turning Envelope

CROSSWALKS & PEDESTRIAN INTERSECTIONS

A pedestrian should only cross a public road at a designated pedestrian crossing or where allowed to at an intersection. The driver of a vehicle should then yield for the pedestrian right of way. A pedestrian should never walk into the path of a vehicle that is so close that it can't slow down to stop in time. Refer to the Uganda NMT Manual, 2020.

A pedestrian crossover is specifically indicated by pavement markings, signs and pedestrian signals. A pedestrian crosswalk, on the other hand, is usually a part of a roadway at an intersection. These are indicated with stop signs, traffic signals and pedestrian signals.

- Stripe all signalized crossings to reinforce the yielding of vehicles turning during a green signal phase. The majority of vehicle-pedestrian incidents involve a driver who is turning.
- Stripe the crosswalk as wide as or wider than the walkway it connects to. This will ensure that when two groups of people meet in the crosswalk, they can comfortably pass one another. Crosswalks should be aligned as closely as possible with the pedestrian through zone.
- Inconvenient deviations create an unfriendly pedestrian environment
- High-visibility ladder, zebra, and continental crosswalk markings are preferable to standard parallel or dashed pavement markings. These are more visible to approaching vehicles and have been shown to improve yielding behaviour.
- Accessible curb ramps are required for people with disabilities, see Section 1.1.4.
- Keep crossing distances as short as possible using tight corner radii, curb extensions, and medians.

Source: SFBetterstreets.org

Figure 1.64: Zebra Crossing: Gulu

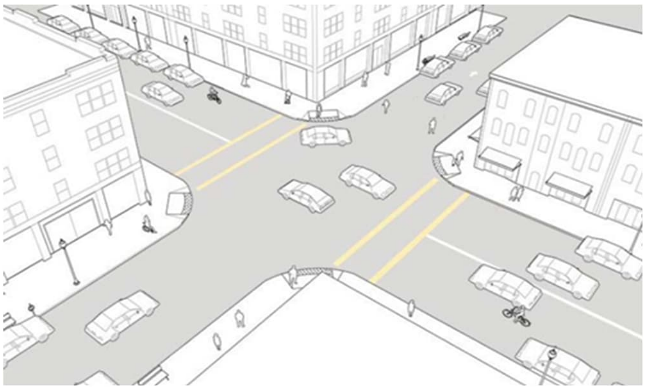


Figure 1.65: Conventional Intersection
Source: NACTO

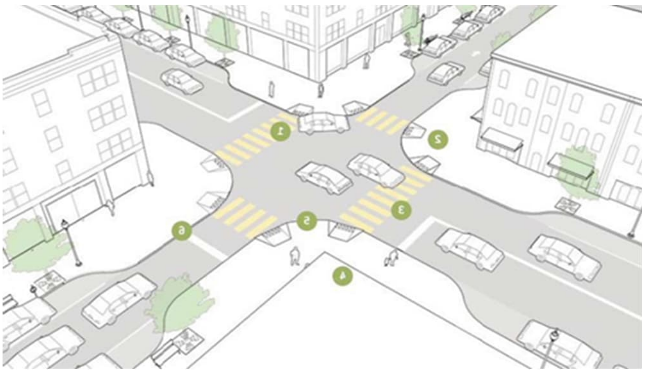
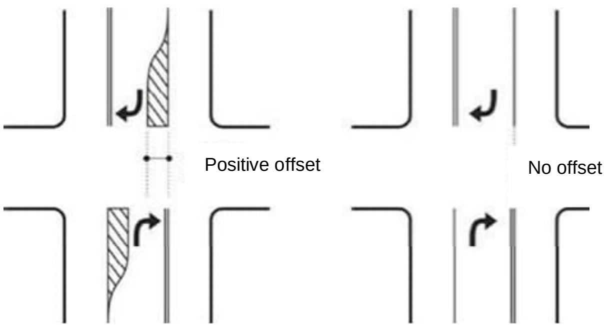


Figure 1.66: Reconstructed Crosswalk
Source: NACTO

RIGHT TURN POCKETS

A right-turn pocket is a special traffic lane for turning purposes within the street right-of-way that is designed and installed in accordance with City specifications.

Right turning pockets for vehicles can be beneficial as it reduces the risk of tail-end crashes and traffic backing up. However, these should only be implemented if there is a space for a wider & contiguous road reserve which is not always possible in already built-up areas.

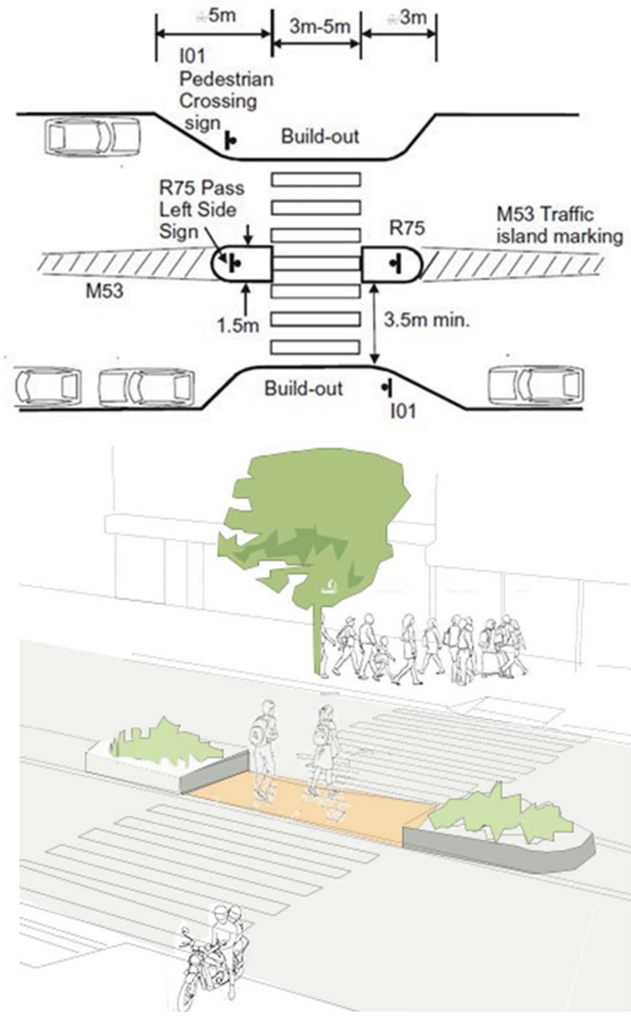


Right turn pocket examples

REFUGE ISLANDS AND MEDIANS

Median refuge islands are protected spaces placed in the centre of the street to facilitate bicycle and pedestrian crossings. Crossings of two-way streets are facilitated by allowing bicyclists and pedestrians to navigate only one direction of traffic at a time.

Pedestrian refuge islands should be at least 1.8m in depth, with a preferred depth of 2.4 m. See Section 6.9 of the NMT Manual, 2020 for further details.



Examples of Median refuge islands

BOLLARDS

A bollard is a short post used to create a protective or architectural perimeter. When installed primarily as a visual guide, they guide traffic and mark boundaries. The NMT Manual, 2020 provides guidance on bollards. Gaps between bollards should be around 1.2 m to provide for bicycles, but not motorised vehicles.

Traffic bollards come in four main types:

1. Embedded Bollards

Embedded Bollards are bollards which are embedded deep into the ground. This is usually for added strength and security. Embedded bollards can be made out of any common bollard material, be it steel, concrete or even wood, however the bollard will only be as strong as the foundation in which it is buried.

2. Surface Mounted Bollards:
This type of bollard uses some sort of anchor system, usually mechanical, to mount the bollard to the surface. Although this is an inexpensive method of installation, it also is not a very secure method.

3. Rebounding bollards:
These bollards use energy absorption technology to provide the strength of some embedded bollards, with the low installation costs and flexibility of surface mounted bollards. When a rebounding bollard is impacted, it is allowed to tilt as some mechanism, be it an elastomer or spring system, more slowly absorbs and dissipates the energy of the vehicle.

Figure 1.67: Rebounding Bollard

4. Retractable/removable bollards:
These are designed to allow the owner or a potential traveller access to the area normally denied by the bollard. This is typically done in one of several ways. The lowest technology is the pipe-in-a-tube method where a socket is created in the ground. The bollard can then be removed from the socket when access is to be granted. This is inexpensive but requires manual intervention to access the area.

A second way is through the use of pivoting bollards. A locking pin is used to hold the bollard upright under normal circumstances which is removed to allow the bollard to lay flat when a vehicle is to pass over it. These bollards are generally flat in shape to allow for vehicle clearance. Often, the pin is locked in place with a padlock to prevent unauthorized access.

Finally, the most expensive method is the automatic retractable bollard. Usually hydraulic powered, the bollard retracts straight down into the ground and becomes flush with the surface to allow vehicle access.

Figure 1.68: Retractable Bollards

BICYCLE BOXES

A bicycle box is a designated area at the head of a traffic lane at a signalized intersection that provides bicyclists with a safe and visible way to get ahead of queuing traffic during the red signal phase.

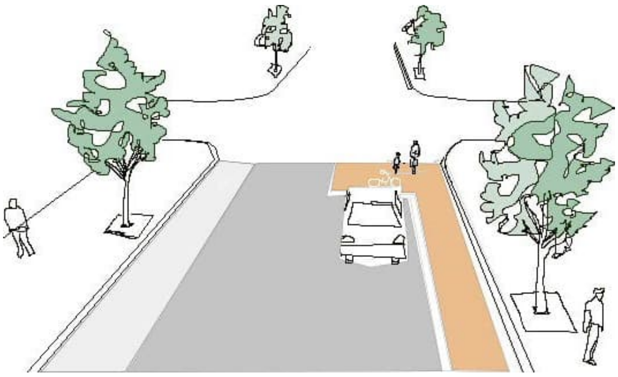


Figure 1.69: Example of a Bicycle Box

ROUNDABOUTS

A roundabout (modern traffic circle) is a type of circular intersection or junction in which road traffic is permitted to flow in one direction around a central island, and priority is typically given to traffic already in the junction.

Roundabouts are the preferred safe intersection type in some instances. This is because they reduce the number of potential conflicts between road users, and lower speeds and angles where conflicts may occur.

The most important design features are as follows:

- Entering traffic yields to circulating traffic
- Entering traffic aims at the centre of the central island and is deflected slowly around it
- Upstream roadway often flares at entry, adding lanes

The traffic flow is usually better at smaller roundabouts, as approaching drivers only need to wait for a gap in traffic in order to enter the roundabout (as opposed to having to wait to get a green signal).

Because of this, exhaust emissions and noise levels are lower at roundabouts. Roundabouts take up more corner space but less approach lane space than conventional intersections. Internationally, roundabouts are widely used instead of intersections, because of their safety benefits Traffic flow on roundabouts depends on the amount of traffic on the approach roads. Where traffic on these roads is balanced, a good traffic flow on the roundabout is ensured. Vehicles circulate around the central island in one direction at speeds of 25–40 km/h.

An approach speed of 30 km/h is considered appropriate for a roundabout.

To ensure this approach speed, the roundabout should meet certain design requirements, such as featuring consecutive bends that motor vehicles have to follow when approaching and driving on a roundabout, or ramped approaches.

Note that multilane roundabouts require specialist design. Also refer to Section 2.3.6 Intersection control in the Geometric Manual as well as section 6.5 and section 6.6 of the Uganda NMT Manual, 2020.

Figure 1.70: Kasese Central Roundabout, Uganda

TRANSITION FROM URBAN ROAD STANDARDS

Urban roads may connect to roads owned and operated by other authorities, most notably UNRA. Roads may also transition from an UNRA standard road as it enters a town (urban area) and transition back to UNRA standard as it exists the town.

The use of UNRA standards within an Urban environment is not recommended, therefor a distance of 200m should be considered to transition between the standards. An abrupt change in standards, such as road width and number of lanes, must be avoided.

Care must however be taken as the urban edge may move as a town expands over time. To change to transition area will be costly and unnecessary. It is therefore recommended that the standard change is undertaken well outside the urban area.

1.1.6 THE DESIGN PROCESS

The design team should include a broad range of professionals with varying levels of technical expertise in streets/road design. The final make-up of a design team will depend on the resources available and the scale of the project.

A project manager should be appointed to oversee sizable or complex projects. The project manager may come from any background associated with the design of the built environment. It is recommended that the project manager has extensive experience in critically analysing and evaluating advice from a range of design professions.

ANALYSE THE SITE

The first stage of a process should be to undertake an analysis and establish the objectives for the project so that the design team has a clear understating of the task ahead.

Collecting information for a site analysis will generally consist of two parts:

- a desktop study where all relevant plans, policies and previously collected information about a project is collated and reviewed.
- an on-site study where observations are made, and data is collected.

Key information for the process includes:

- Plans and policies (relevant national, regional, and local plans).
- Spatial characteristics (such as land uses, destinations, densities, and activity generators).
- Movement patterns (such as user mobility, key desire lines, obstructions, and public transport).
- Built form (enclosure, interface, street, geometry).
- Traffic Surveys (such as traffic counts, and car parking).
- Topography and landscape (such as slopes, planting and ecology, climate and relevant tree species, rainfall, and available materials).
- Heritage and conservation (where appropriate).

A key outcome of the analysis process should also be the identification of the Context(s) of the project and the planned function(s) of the street/street network.

ISSUES WITH LAND TENURE

At present, current investments in infrastructure, particularly those involving road construction, face a number of challenges, including persistent delays and high costs resulting from issues related to land acquisition. In a country where most land is privately owned, public projects that require land face major costs related to compensation, especially where new roads are being constructed or existing ones are extended. In addition to the cost of compensation, these projects face major delays caused by the need to resolve issues related to land acquisition, with these delays further increasing the cost of construction.

“The land tenure regime in Uganda is considered to be one of the most complex in the world, particularly in Kampala where four different land tenure systems operate alongside each other. This has had a significant impact on growth and investments in the city. It has also made planning more challenging.”

The four types of tenure systems are:

1. Leasehold land: managed by the Kampala District Land Board under the Ministry of Lands, Housing and Urban Development (MLHUD).
2. Freehold land: owned by private individuals as well as other public institutions, NGOs, religious organisations, and charities and managed by the Uganda Land Commission.
3. Customary land comprising land held under customary law.

4. Mailo land: established under the 1903 Buganda Land Agreement, owned by the Buganda Kingdom, and managed by the Buganda Land Board, further divided into:
    - o Private mailo, which is held by individuals.
    - o Public mailo owned by the Buganda Kingdom.

Communities and households lack stability with repeated relocation and transition. On the City's periphery, beyond the outer ring of towns and suburbs, there is effectively an unlimited supply of vacant land, be they nominally cultivated or not, but these are effectively inaccessible and lack basic infrastructure and services.

Once a road is planned or developed these lands become the immediate target of speculation, raising prices and restricting supply.

The Kampala Physical Plan recommends:
Definition, statutory approval, and implementation of an effective, economic Land Acquisition System for infrastructure and public service provision - with a combination of stream-lined compulsory acquisition procedures, reasonable compensation (financial or other), effective property taxation, investment recovery fees, property allocation mechanisms and/ or alternative mechanisms, at the national and/or municipal levels.

There is an urgent need to ensure the adequate supply of land for infrastructure, public facilities, and public open space to meet the requirements of the long-term demand, and not just the short to medium-term requirements.

For future road construction, it is recommended that all government land should be registered. In addition, the Government has residual authority to control land use in the public interest. Thus, under laws enacted by parliament and in accordance with evolving government policies, the Government may regulate the use of land in the public interest. The Ministry of Lands, Housing and Urban Development is the relevant authority and needs to empower the local authority to acquire land for roads.

ENGAGE ALL STAKEHOLDERS

Several stages of consultation may be undertaken by designers depending on the type and scale of a project. It is recommended that designers undertake consultation as early as possible. Designers may engage with a community and/or roads authority prior to any conceptual or detailed design work taking place, to identify further issues and to gauge the aspirations of the community (to further refine the objectives for the project). As mentioned the Ministry of Lands, Housing and Urban development needs to empower the local authority to acquire land for roads and must be consulted early on in the process.

Both the design team and the local authority should ensure that this occurs within a multidisciplinary environment to ensure that a broad range of issues are considered. The design team should ensure that all relevant design disciplines are present. The local authority should ensure that all relevant disciplines are represented.

Listen to what people have to say about an area; many of them use the streets every day and know them more intimately than other stakeholders. Engage relevant agencies and local organizations to develop a shared project vision. Understand how they shape and use streets and what matters most to them.

Create an opportunities and constraints map and report.

Likely Stakeholders
The list below is the minimum stakeholders that must be engaged in road projects. Note that the list is not exhaustive.

- City and town councils and municipalities (engineers and town planners)
- Statutory approvers such as National Environmental Management Authority (NEMA) and other government organisations
- Uganda National Roads Agency (UNRA)
- Law enforcement Agencies such as the Uganda Police Force-directorate of Traffic and Road Safety
- Engineering consultants responsible for the design and implementation of the project.
- Environmental and social impact consultants
- Public and private developers (residential, commercial and industrial)
- Adjacent and/or affected land owners
- Any identified interested and affected parties and community groups affected by a road project

Identify Opportunities: Identify important destinations where people gather on a daily basis, such as schools, markets, open spaces, commercial corridors, and transit hubs as they can present valuable sites for street reconstruction and traffic calming.

Determine Constraints:
Balance the big-picture goals with an understanding of what is realistic given the existing constraints, practices, procedures, and budgets.

PROJECT VISION AND CONCEPTUAL DESIGN

With a thorough understanding of the existing site conditions, various stakeholder interests, and project constraints, develop a vision for the street's look, feel, and function in the future. Identify best-practice street design strategies and innovative examples that are most applicable to the local context.

Use visual renderings, drawings, and metrics to show and explain what is possible, and test ideas with local stakeholders. Ensure the project vision aligns with citywide goals and community priorities for public health and safety, quality of life, and environmental and economic sustainability.

The scale of a street is a primary determinant of overall costs, as wide streets that run for longer distances cost more than narrow profiles. It is also critical for long-term planning to consider the overall balance of up-front capital costs with lifecycle costs, including operation, maintenance, repair, and replacement. Investing in quality design and materials early in a project will save costs over its lifecycle.

DESIGN REVIEW

The optimal solution is rarely achieved on a first attempt and is likely to emerge over many drafts, having been informed by a solid analysis and appropriate level of consultation.

A thorough design process is likely to include:

- Production of strategic level drawings that illustrate the key routes and links within a street/street network
- Typologies or conceptual individual street designs.
- Initial detailed design and refinement prepared to a professional/technical standard.
- Design finalisation and formal consent process.
- Economic analysis of the project to test the feasibility of the design in terms of the available budget. Various analysis tools such as the World Bank developed HDM-4 software or spreadsheet-based analysis tools can be utilised to undertake an economic analysis. The purpose of the analysis is to compare various design options to determine the most economically feasible design in terms of the return on investment.

The optimal time to undertake an audit process is when the design has reached a stage where the outcomes can be clearly evaluated, such as after initial refinement and prior to finalisation. This will also allow the design to be formally tested against the objectives of the project and with regard to other critical matters such as safety

FINAL DESIGNS

Once the design is finalised and all the relevant approvals have been granted it must not be retrospectively revised in a manner that would contradict the approved plan at a later stage. Any potential future changes related to design geometry and layouts should be fully resolved as part of the consent process.

CONSTRUCTION AND MONITORING

The design phase will largely conclude once any relevant approvals have been granted and all technical specifications have been formalised, it is recommended that the design team participate in the project through to its completion and periodically monitor its performance.

During the construction phase, it is recommended that the design team and planning authorities carry out periodic inspections to ensure that the project is being carried out in accordance with the approved design. This will not only assist in ensuring the objectives of the project are fully implemented but will reduce the potential for error and abortive or wasteful work.

1.1.7 DESIGN CHECKLIST

Refer to Appendix 28 for the MOWT checklist for design review and independent check of road upgrading and rehabilitation projects.

1.2 CHAPTER 2: THE URBAN ROAD PLANNING PROCESS

1.2.1 INTRODUCTION

This Planning guidelines consist of a step-by-step process which is to be used by the Urban Councils to plan and make an informed decision on the preparation of the Annual Urban Roads Work Plan (AURWP) for the maintenance and improvement of the urban road network, specifically, data collection, information gathering and analysis.

1.2.2 THE LEARNING OBJECTIVE

At the end of reading these Planning Guidelines, the user will have understood the following:

- The main steps in the Urban Roads Planning Process
- The importance of Planning in Roads maintenance and improvement
- The Information and Data used for the Urban Roads Planning.
- The need for Standards in Urban Roads Planning.
- The role of Urban Councils in Urban Roads planning.

1.2.3 THE NEED FOR URBAN ROADS PLANNING

Urban Roads Planning is deemed necessary for all Urban Authorities for the following reasons:

- In order for the urban councils to monitor and supervise urban roads maintenance and improvements, there must be targets through which actual performance has to be measured against within a given period. This must be done through an effective planning system.
- The resources provided for urban roads maintenance and improvements are limited compared to the overall road network. This calls for prioritized yet effective utilization planning for the resources available.
- The Urban Councils are faced with challenges of growing demand for service delivery given the growing urban populations. It is, therefore, necessary to plan how to maintain the existing infrastructure and provide improvements for future expansion.

1.2.4 PROCEDURE OF THE PLANNING PROCESS

The planning process is aimed at preparation of the annual urban road work plan, and it involves the following steps:

- Road Inventory and Condition Survey
- Comprehensive Traffic Surveys
- The requisite road maintenance and improvement measures and their costing per km
- Prioritisation for road maintenance and improvement works
- Preparation of Annual Urban Roads Work Plan.

Figure 1.71 provides an outline of the above-mentioned processes.

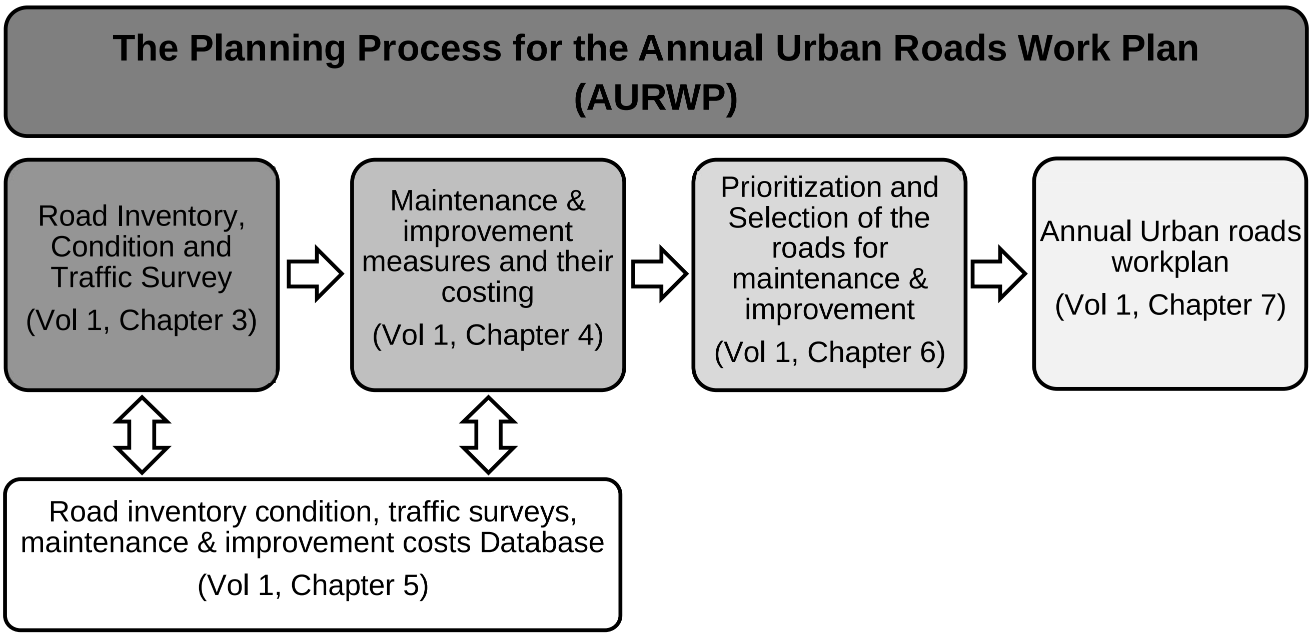


Figure 1.71: The AURWP Planning Process

1.2.5 THE PLANNING CYCLE

At this stage, it is important to understand the routine planning and implementation cycle that Local Governments go through in a financial year in order to undertake urban road works.

The cycle is a system based on the Financial Year divided into 4 Quarters. This begins from 1st July to 30th June. The Urban Councils routinely follow the cycle beginning from the Local Government Budget Framework Paper (LGBFP) to the implementation of the works as shown in Table 1.20.

Table 1.20: The Planning Cycle

Activity	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Approval of AURWP	X			
Releases of Funds	X	X	X	X
Procurement process	X			
Implementation of - **1. Routine Maintenance Contracts** **2. Periodic Maintenance Contracts** **3. Rehabilitation Contracts** **4. Spot Repair Contracts**	X	X X X X	X X X X	X X X X
LGBFP process		X	X	
AURICS process		X	X	
AURWP process			X	X

1.3 CHAPTER 3: ROAD INVENTORY, CONDITION AND TRAFFIC SURVEYS

1.3.1 INTRODUCTION

Road Inventory, Condition and Traffic Surveys data are important inputs in the road planning process. It provides the data and information and also acts as a basis for the other inputs. The output of the road inventory, condition and traffic surveys are the Annual Road Inventory, Condition and Traffic Survey report, commonly called AURICS. The information needed is summarised in Figure 1.72.

1.3.2 ROAD INVENTORY SURVEY

The purpose of road inventory is to give each road link a specific identity for the purpose of guiding both the road user and the responsible agencies.
Road inventory involves clearly establishing the road links or sections. This helps to locate and also determine the identity and length of the road. All road links or sections have start and end points (identity) and the distance between these two points determines its length. Links are lengths of road where traffic volume is reasonably uniform, and Sections are normally lengths of road that are uniform in terms of their physical characteristics. Sections should be selected to have homogeneous characteristics, with the following being typically uniform for the section:

- Road Class
- Road Geometry
- Drainage and Structures
- Pavement type
- Other administrative data considered appropriate, i.e., administrative boundaries, etc.

For definitions of the various road terms refer to Appendix 1.

The numbering system commonly known as route numbering is then applied to each road link. Each road link is then identified by a four-digit number; the first two or more digits being those of the Urban Council national administrative code, and the second two or more digits being those assigned to the road link by the Urban Councils. Each road link is then assigned a name, such names are usually approved by the local councils/authorities.

A road register consisting of a list of road links to define the road network should be prepared and it is convenient that the start and end of sections are identifiable physically on the road.

The form used to select the urban council national codes and a road register are provided in Appendix 2 and Appendix 3 respectively.

1.3.3 ROAD CONDITION SURVEY

It is essential to assess the existing conditions of all the road features in order to facilitate in identification of the core road network, and the subsequent selection and prioritization of those road works that must be planned for and maintained/improved during the forthcoming financial year in order to conserve the network in a condition that ensures basic yet reliable all-weather access to economic and social services for the maximum possible number of road users.

Road Condition Survey is conducted using standard forms. The forms are supported by Look-up Tables. The prescribed form and look-up table for conducting road condition surveys on paved and unpaved roads are shown in Appendix 4.

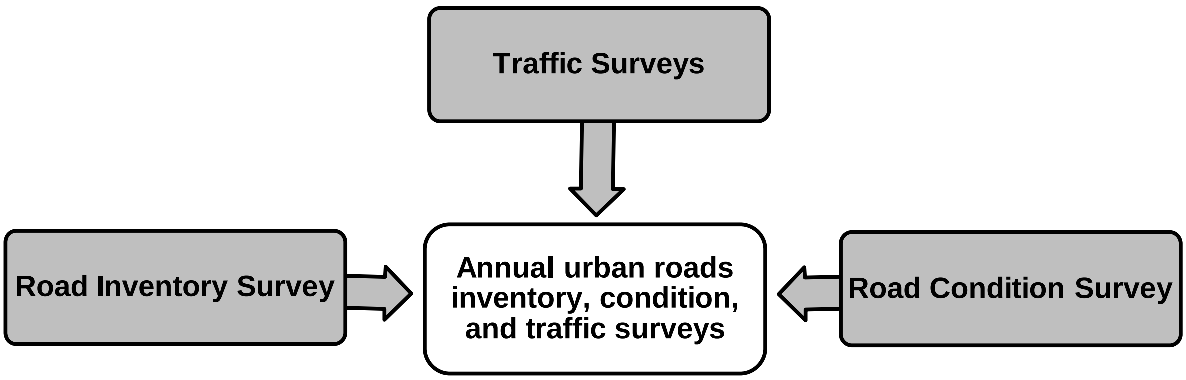


Figure 1.72: Survey requirements of the AURICS Process

PROCEDURE FOR CONDUCTING ROAD CONDITION SURVEYS

The procedure for conducting a road condition survey involves at least two technical personnel driving or walking, in case of short road links, over the road network and using the forms as shown in Appendix 4.

The survey will as well involve interviewing the local people. It is important to involve the users of the road since valuable information can be obtained from these sources on various physical characteristics, for example, the likelihood of flooding of certain sections of the road, the adequacy of existing culverts, weak materials, and other deficiencies. In addition, the Urban Engineer should be able to collect a range of historical information on topography, drainage and materials, and records of traffic accidents in the region.

Horizontal distance travelled is measured using vehicle-mounted odometers or wheel/tape measures. The survey team will undertake the following assignment:

1. Divide each road link into sub-sections of relatively uniform terrain, alignment, materials, drainage features and road surface conditions.
2. Record the width of the carriageway and shoulders and the basic types of construction.
3. Note any horizontal and vertical alignment inadequacies particularly from a safety viewpoint and in the case of vertical alignment note sections, which require engineering check for the steepness of the grade.
4. Note the rehabilitation/improvement requirements of side drainage and cross drainage provisions.
5. Note any requirements for new cross drainage structures.
6. Record condition of any existing culverts, kerbstones, footway, side drains, road signs, guard rails and retaining walls.
7. Drift crossings, causeways, or bridges. Their lengths, widths, and conditions.
8. Identify any existing borrow areas along the road.
9. Photograph each sub-section.
10. Note all existing development and socio-economic features, such as schools, markets, churches, mosques, hospitals, banks, and administrative centres, visible from the road and record land use adjacent to the road.
11. Rate the surface conditions for any specific road degradation problems such as rutting, cracking, potholes, width loss etc., for paved roads.
12. Rate the surface conditions for any specific road surface erosion or degradation problems such as rutting, loss of camber, ravelling, potholes, erosion etc., for unpaved roads.
13. Note notable material types and the existing wearing course performance such as gravel loss
14. Design a road condition rating and service index based on its condition (good, fair, poor, and bad) to be included in the road register.

1.3.4 TRAFFIC SURVEYS

Traffic surveys are important as they provide the types (modes), volume, and density of the traffic on roads. This is an important determinant in road management (planning of new roads, maintenance and upgrades). Refer to Appendix 5 for the forms used to collect traffic survey data.

Traffic volumes can be used to classify roads into categories for maintenance management purposes. In addition, it is used to estimate the annual average daily traffic (AADT) for the maintenance classification and provide the distribution of axle loads needed to design pavement renewal works. The procedure of how to record the counts is explained in the traffic survey forms in Appendix 5.

Traffic survey data is also utilised to determine the Level of Service (LOS) of a road link, which informs the upgrade requirements, for example to reduce congestion by increasing capacity. Traffic surveys are also utilised to determine the capacity requirements of an intersection based on the peak demand. Refer to Volume 2, Chapter 2.3.7.

ESTIMATION OF AADT FROM TRAFFIC SURVEYS

The determination of volumes from the count surveys is shown on the count form in Appendix 5, and the results are recorded for every road and entered into the AURICS forms in column (xix) for both paved and unpaved roads.

The following should be noted for undertaking traffic surveys:

- Traffic volumes are affected by inclement weather such as heavy rainfall, obstructions that cause delays such as accidents, traffic signals out of order, localised flooding from heavy rainfall, temporary road closures, road works and public and school holidays

- Where any of these issues affect the traffic surveys, additional days should be surveyed in order to obtain more accurate traffic volumes.

The following should be noted for the traffic calculations:

- Conversion factors must be applied to all types of traffic mode volumes before calculations are undertaken. The conversion factors result in more accurate calculations due to the different transport modes with different characteristics (vehicle dimensions, axle load, etc.).
- The conversion factors per mode are listed on the traffic survey form.
- Average Daily Traffic (ADT) should be calculated from the average of 7 consecutive days of traffic counts. This is to account for the variations in weekday and weekend traffic patterns.
- Annual Average Daily Traffic (AADT) is the estimate of the total traffic volume passing a point of a road (in both directions) for a year, divided by the number of days (365) in the year. AADT must be calculated from the ADT volumes (average over 7 consecutive days).
- The traffic group factor in column (xix) on the AURICS form (Appendix 4) is as follows:
    - 1 - Very light: < 20 vehicles/day
    - 2 - Light: 20 – 30 vehicles/day
    - 3 - Medium: 30-40 vehicles/day
    - 4 - Heavy: > 40 vehicles/day

UPDATING OF RECORDS AND SETTING UP A DATABASE

Road Inventory, Condition and Traffic Surveys are to be conducted annually as stated in the Sector Guidelines document. Information on changes to the network, such as new surfacing and reconstruction works need to be entered into the item inventory annually. This means a Database has to be set up and maintained to record these changes. The Database should be in a spreadsheet format, stored on a computer. Refer to Appendix 12.

1.3.5 TRAFFIC IMPACT ASSESSMENTS

The public or private development or redevelopment of any properties within urban areas must include a Transportation Impact Assessment (TIA). The main purpose of a TIA is to determine the transportation infrastructure and/or upgrades to the existing infrastructure required to support the development.

A TIA must determine the impact on the local road network and propose mitigating measures required to ensure that the affected transport networks will provide the necessary capacity to support the development.

In the absence of a Uganda TIA guideline, international best practices should be utilised to draft, review and implement the findings of the TIA. There are numerous standards available for this purpose, briefly noted here:

- KCCA Guidelines for preparation of Traffic Impact Assessments
- African Development Bank, Traffic Impact Assessment (TIA) Guideline for Cities in Africa, 2021. Note this guideline includes an MS Excel spreadsheet with trip generation rates for various land uses and income areas
- South African Committee of Transport Officials (COTO) TMH16, Volume 1 & 2, South African Traffic Impact and Site Traffic Assessment Manual Version 1.0, August 2012
- South African Committee of Transport Officials (COTO) TMH17, Volume 1, South African Trip Data Manual Version 1.0, September 2012 (Note the trip generation rates must be used with caution, as they are for SA conditions).

1.4 CHAPTER 4: DETERMINATION OF ROAD MAINTENANCE AND IMPROVEMENT WORKS FROM AURICS

1.4.1 INTRODUCTION

Having collected the data during the AURICS process, the next step is the determination of the road maintenance and improvement measures and their unit costs on each road/link in the network.

It is essentially the planners' decision as to which type of road improvement and maintenance measures should be undertaken on a given road section on the basis of the conducted road condition survey. Routine maintenance and Periodic maintenance are the two types of maintenance works that can be carried out on the roads. Upgrade from one surface class e.g., from gravel to bitumen standard, or Rehabilitation of a road from one service level to another are the type of Improvement works that may be carried out on urban roads. Figure 1.73 provides a brief explanation of each of the different types of maintenance and improvement works.

Note that the implementation of new roads on new alignments are covered in Volume 2.

1.4.2 IDENTIFICATION OF MAINTENANCE AND IMPROVEMENT WORKS

Information is needed about where the network is defective in order to assess the maintenance and improvement needs. The comparison between measured road condition, determined during AURICS, and pre-defined standards provides a basic statement of shortfall in serviceability, which can be translated into maintenance or improvement needs. Figure 1.74 illustrates the procedure to be adopted in identifying the needs for maintenance and improvement works on a road link.

The procedure involves using data from the AURICS data to carry out the necessary calculations/analysis using the tools to obtain the outputs.

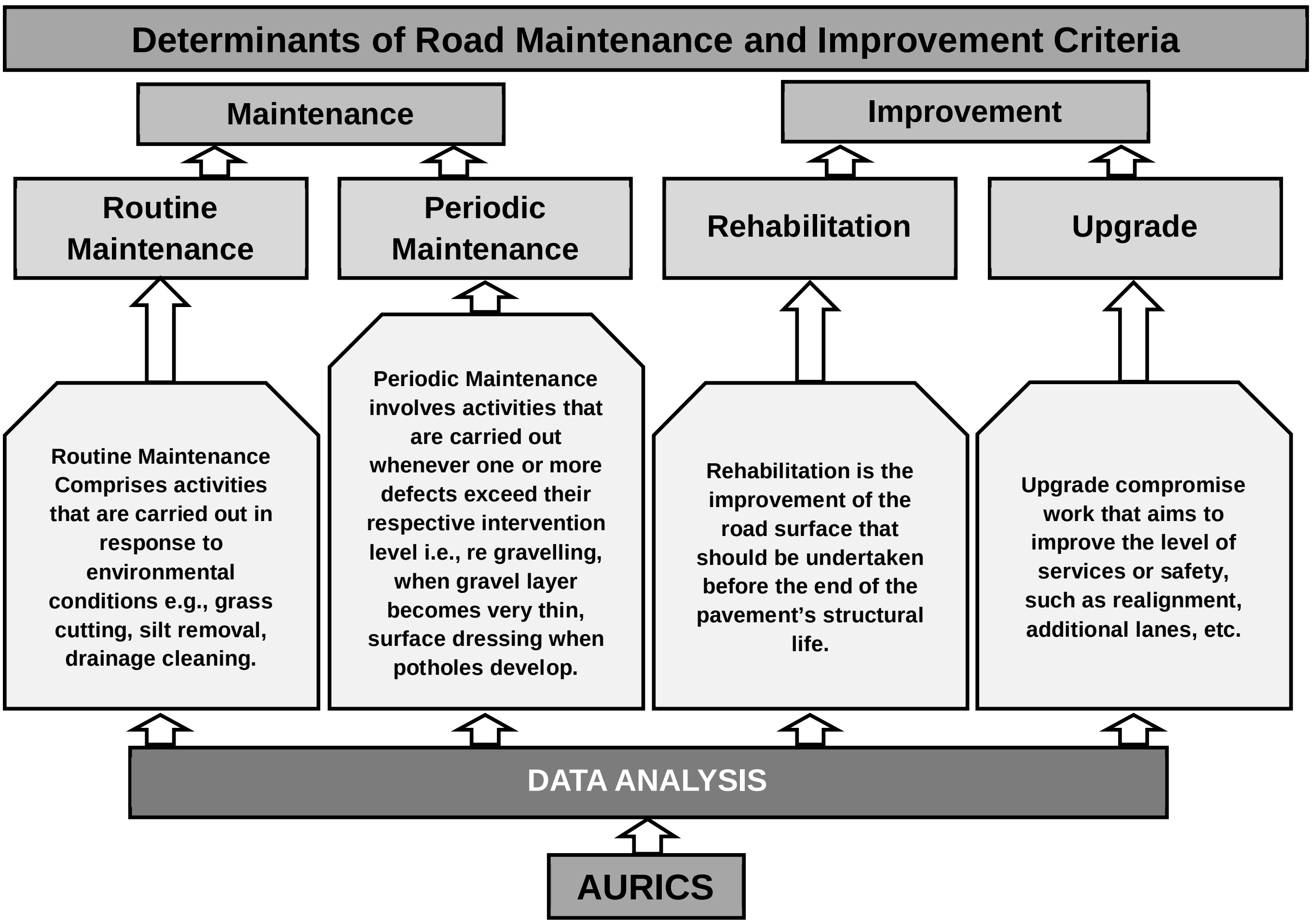


Figure 1.73: Determinants of Roads Maintenance and Improvement Criteria

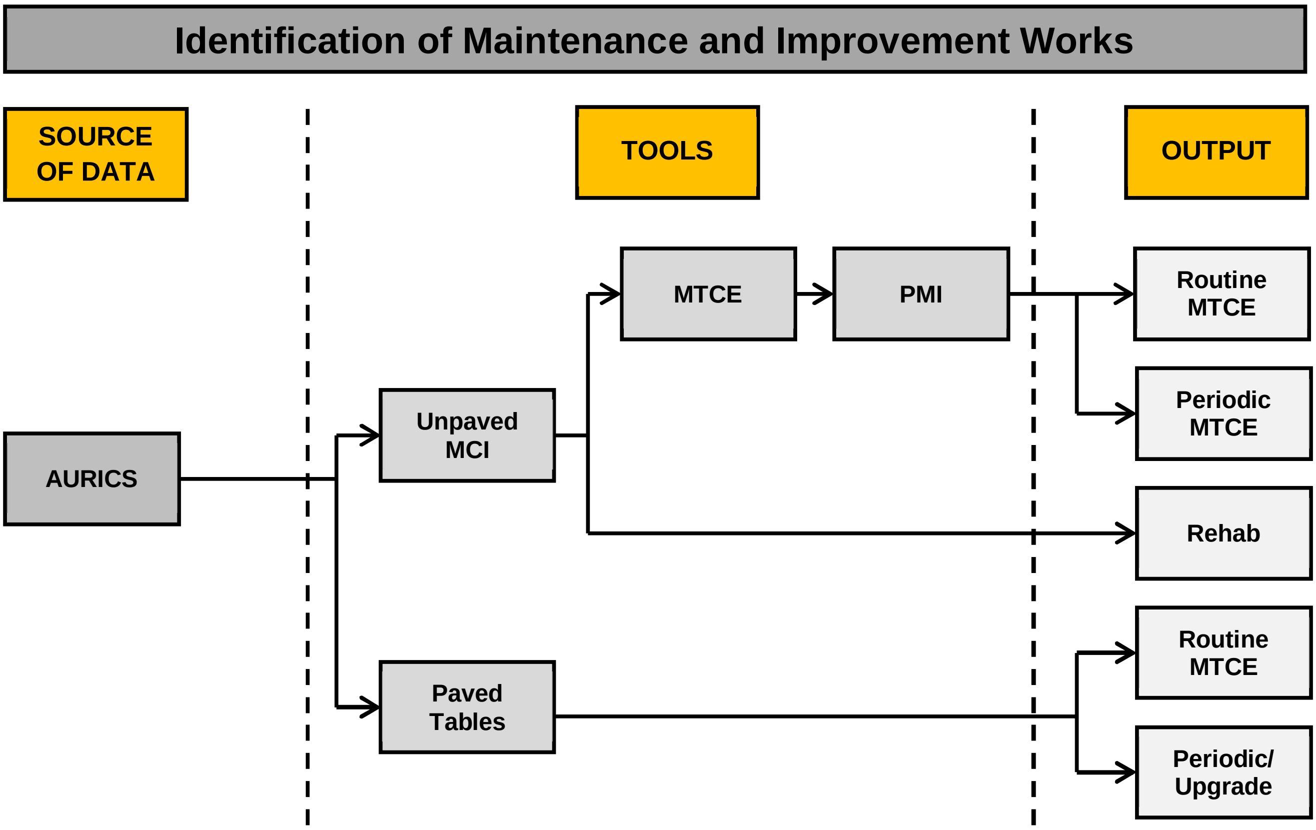


Figure 1.74: Identification of Maintenance and Improvement Works

The Tools comprise the use of Rehabilitation and Maintenance Planning Systems (RAMPS) comprising the Maintainable Condition Index (MCI) and Periodic Maintenance Interval (PMI) to analyse data for unpaved roads and standard tables to analyse data from paved roads.

The Maintainable Condition Index is defined in RAMPS as an index based on the surface condition, shoulder condition and drainage condition factors of a road section. In other words, the maintainability of every section of the road is determined by these three conditions each contributing certain percentages. The MCI, therefore, defines whether a road should be rehabilitated or maintained. In addition, if a road has been found to be maintainable, the results are subjected to further analysis using a Tool called the Periodic Maintenance Interval (PMI) in order to ascertain whether the road requires routine or periodic maintenance.

Periodic Maintenance Interval is defined as the number of years between surfacing and resurfacing of an unpaved road. This period depends on the traffic volume on the road and the surface materials used on the road. It should be noted that Figure 1.74 is a magnification of what takes place inside the Data Analysis Box shown in Figure 1.73.

DETERMINANTS OF ROUTINE MAINTENANCE WORKS

Based on Figure 1.74, and as stated in Section 1.4.2 above, routine maintenance requirements for unpaved roads are derived from the MCI and subsequently the PMI based on RAMPS.

Appendices 6 and 7 are tables of the determinants for routine maintenance for unpaved and paved roads respectively.

DETERMINING PERIODIC MAINTENANCE WORKS

In terms of Figure 1.74, periodic maintenance requirements for unpaved roads are derived from MCI and PMI. The determinants of periodic maintenance requirements for paved roads are based on Standard Tables.

Appendices 8 and 9 are tables of the determinants for periodic maintenance requirements for unpaved and paved roads respectively.

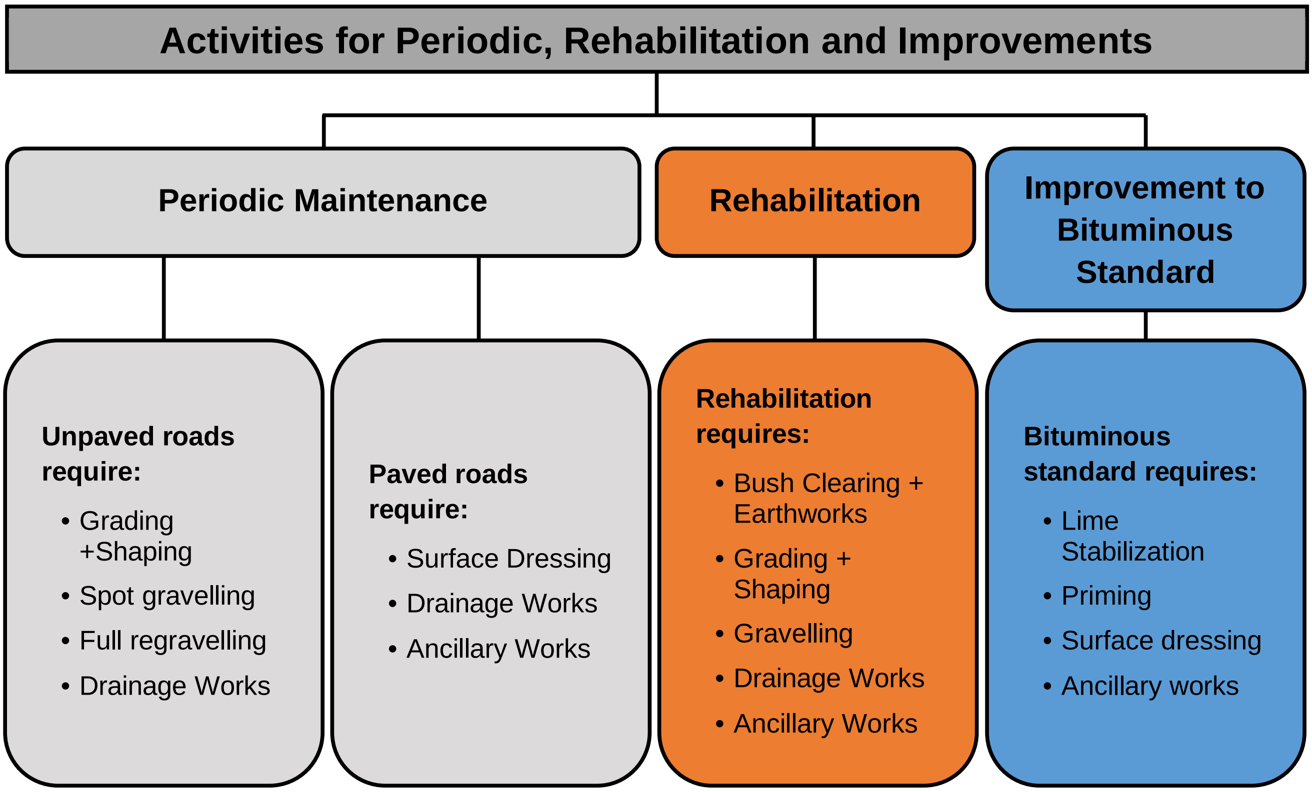


Figure 1.75: Activities for Periodic, Rehabilitation and Improvement Works

1.4.3 DETERMINING REHABILITATION WORKS

The rehabilitation requirements for unpaved roads are determined by the MCI as shown in Figure 1.74. Appendix 10 provides the details of determining rehabilitation requirements for unpaved roads.

1.4.4 ACTIVITIES FOR PERIODIC, REHABILITATION AND UPGRADE WORKS

Using the AURICS data and the tables in Appendices 6, 7, 8 and 9, the interventions and activities that are required to correct the defects on a road link under routine and periodic maintenance are determined. These activities are summarised in Figure 1.75 together with those for rehabilitation and upgrade works. These activities when translated into items of the BoQ provide the basis for costing of the maintenance and improvement works on a particular road link.

1.4.5 COST ESTIMATES FOR MAINTENANCE AND IMPROVEMENT WORKS

Having defined the activities for maintenance and rehabilitation, the next step is to determine the cost estimates of the interventions (rehabilitation, periodic and routine maintenance) of the road works.

Each urban council needs to establish the cost of maintenance and improvement works on the basis of the cost of the previous and ongoing works.

The cost component shall consist of the following:

- Materials costs
- Equipment costs
- Labour costs
- Indirect costs (overheads, risks, and profit margins)

Below is a simple guide on the costing method to be used for purposes of preparing the Annual Urban Roads Work Plan (AURWP).

ROUTINE MAINTENANCE

For routine maintenance, the quantity of work to be carried out is usually difficult to estimate and therefore the amount of work to be done is usually estimated in terms of day-works or worker-days. AURICS maintainable condition index helps determine for every road section the degree of difficulties in maintaining the road section. These two relationships can be expressed in the equation below:

Total Worker-days/km/year = MCI x100

The total worker-days/km/year represents a total of worker-days for all the activities of routine maintenance to be carried out under on that particular road section/link per km in a year.

COSTING OF REHABILITATION AND PERIODIC MAINTENANCE WORKS

Activities for Rehabilitation and Periodic Maintenance are quantified under the various bill items in Volume 4. The estimated cost of each activity is derived from the previous and ongoing cost of road works shown in Appendix 10. In addition, the rehabilitation or maintenance budget shall include overheads allocated in the Local Government Budgetary Framework Plan (LGBFP) to various activities other than actual operations. These sums must be taken into consideration when calculating the resources available for road works in addition to the following items:

Preliminaries for works; Road network management activities such as conducting AURICS, surveys, designs, procurement, and operational costs; Administrative tasks such as bank charges and accounts, records; Training of the technical staff; Emergencies, etc.

UPDATING OF RECORDS

The cost estimates for all the interventions on all the road networks need to be calculated and entered into the Database. Changes in the cost need to be updated annually and entered into the Database. Note, Appendix 11 shows the following:

- Approximate % breakdown of the cost of intervention per Bill Item for Periodic Maintenance
- Approximate breakdown of the cost of intervention per Bill Item for Rehabilitation
- Approximate breakdown of the cost of intervention per Bill Item for Upgrades

The indicative costs of maintenance and improvements of urban roads are not provided in Appendix 11, this is due to the values becoming outdated too soon and the cost variations in different regions of Uganda.
Recent and ongoing road maintenance and upgrade projects in a region should be referenced to estimate cost ranges.

1.5 CHAPTER 5: ROAD WORKS PLANNING DATABASE

1.5.1 INTRODUCTION

A road works planning database is an important element in planning it enables the urban councils to know their road network, their conditions, and the costs of maintenance and improvements when required. This helps in the decision-making process on which roads to maintain/improve when funds are available. It is therefore important that every urban council sets up a simple road planning database.

1.5.2 CONTENTS OF THE DATABASE

The contents of the road planning database need to be simple and should comprise the following:

- The road network and length
- Summary of the condition of each road link (maintainable or not maintainable)
- Year last maintained or improved/maintenance history
- Traffic Condition
- Cost per km of maintenance or improvement.

The database needs to be electronically stored in a spreadsheet.

1.5.3 UPDATING OF THE DATABASE

Information stored in the database requires updating from time to time. For the road works database, it is advisable to update the records annually. Since, for example, a new road may have been added to the network during the year, the condition of the road or the traffic volume may have changed during the year.

Appendix 12 is a sample format of the database comprising the road and traffic conditions, the year the road section or link was last maintained/improved, the estimated cost of the current interventions, and the cost per km required for carrying out the necessary maintenance or improvement.

1.6 CHAPTER 6: PRIORITISATION OF ROAD MAINTENANCE AND IMPROVEMENT WORKS

1.6.1 INTRODUCTION

Due to the limited resources provided by the resource's envelope, it is important to prioritise the roads for maintenance and improvement. The task before the Urban Council is to realistically undertake the prioritisation process.

1.6.2 THE ROAD PRIORITISATION PROCESS

The prioritisation process shall involve the stakeholders who will meet and agree upon the criteria to be used for prioritising the works. The Urban Councillors, who are the policymakers, should be involved in undertaking this exercise. The stakeholders will be guided by the following:

- The database of the road conditions and the type of intervention recommended and the expected cost of the works
- The prioritisation criteria
- Budget ceiling

DATABASE

The database developed in Chapter 4, will guide the stakeholders in identifying the roads, their conditions and the type of interventions recommended, the previous interventions carried out on the road if any, and the cost of the works to be done.

DEVELOPMENT OF THE PREFERABLE/IDEAL ANNUAL ROAD WORKS SCHEDULE

Schedule of Road Works interventions as derived in Chapter 4 shall be developed for each road link under the four road works classifications, namely:

- Routine Maintenance
- Periodic Maintenance
- Rehabilitation
- Improvement to Bituminous Standards

This will in addition guide the prioritisation process.

PRIORITISATION CRITERIA

The interventions defined for each road are then subjected to the under-listed criteria to determine their ranking separated under road works classification. The prioritisation factors to are described below:

1. Previous Interventions

It is important to note that previous interventions on a particular road are an important aspect in the prioritisation of road maintenance and improvement. This is mainly with the view of preserving the previous investment made on the road link.

2. Service delivery

Service delivery is a factor that is important when prioritising road maintenance and improvements. These may be roads connecting to markets, administrative centres, and social amenities.

3. Relieving a capacity problem

Roads serving as by-pass or shot cut could relieve major roads of traffic congestion due to the additional capacity it provides.

4. Population density

Roads leading to highly populated areas and serving socio-economic facilities such as markets, offices, schools, and business areas will be considered are viable. Such roads carry the heaviest loads of traffic and are normally the most important parts of the network from an economic standpoint. They are also the roads that are likely to deteriorate most rapidly from tear and wear.

5. Economic development and poverty alleviation

Roads leading to urban agricultural areas could be given some priority since they have the potential for future growth.

6. Economic Analysis

An Economic Cost Benefit Analysis (CBA) should be undertaken during the conceptual design phase of a road project. A CBA determines the most economical solution for a road project by comparing the total life-cycle cost of a project where different design solutions are under consideration. Furthermore, a CBA compares all the costs (capital, maintenance, rehabilitation, upgrade) minus the expected economic savings to both the authority and the road user (reduction and saving in travel time, fuel, vehicle costs, reduced accidents, etc.)

There are numerous software packages available to undertake a CBA, from basic spreadsheet-type analysis to advanced packages such as HDM-4, co-developed by The World Road Association (PIARC).

7. Summary

The above factors are assigned weights and the defined interventions for each road are evaluated according to agreed criteria. The defined measures for each road are then given weights and ranked beginning with that road which has scored the highest marks. Table 1.21 is an example of how to weigh each of the criteria depending on the type of intervention. The Urban Councils are advised to define its own weighing value for each criterion.

Figure 1.76 shows the factors that affect the prioritization of urban road improvements.

1.6.3 THE ROAD UPGRADE PATH

The upgrade of urban roads may be required in the course of the design life of the road or sections thereof due to various reasons, briefly discussed herewith. Note that the normal maintenance of roads, such as resurfacing, is not necessarily an upgrade.

Road upgrades may be required when:

- Unmade (unsurfaced) roads requires an upgrade to engineered (unsurfaced) standard due to e.g., increased traffic volumes, a deteriorated roadway, etc.
- Unsurfaced (engineered) roads reach their traffic volume capacity and require an upgrade to surfaced standard
- An unsurfaced road has deteriorated due to lack of maintenance, floods or other damage, and maintenance alone will not resolve the issue. The road requires an upgrade to unsurfaced (engineered) or surfaced standard
- A surfaced road has deteriorated due to lack of maintenance, floods or other damage, and maintenance alone will not resolve the issue. The road requires a full reconstruction to surfaced standard
- Roads are sub-standard in terms of their functionality and requires an upgrade to a higher class, e.g., a Class 4 road upgraded to a Class 3.
- The capacity of a surfaced road, road section or intersection is reached or exceeded, and an upgrade is required to increase capacity.

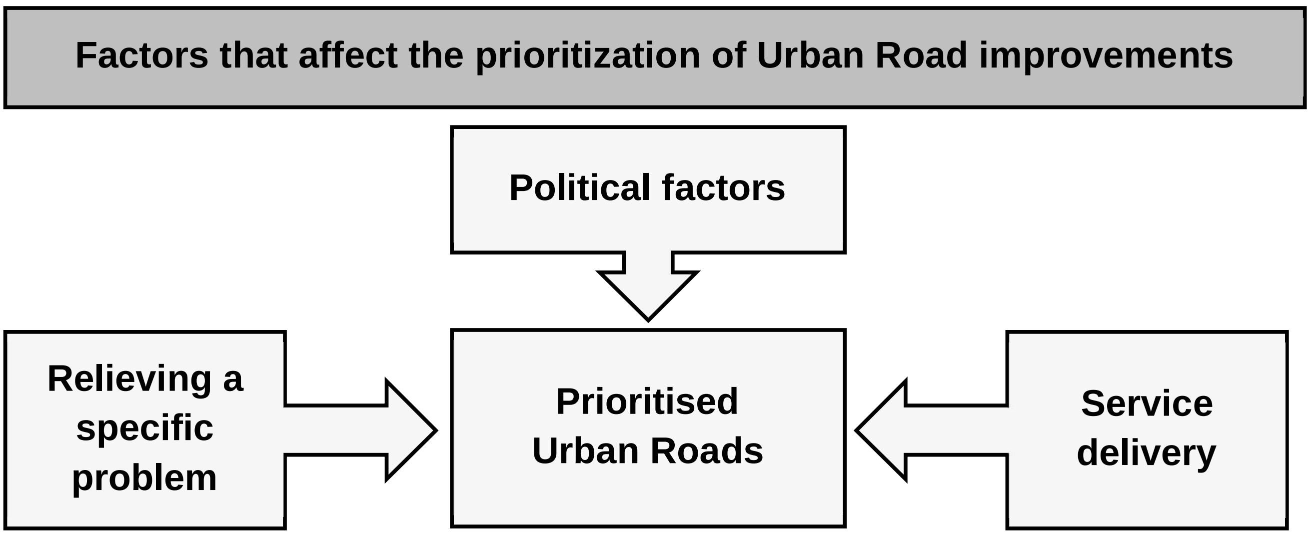
The upgrade methodology broadly includes:

- Determine the road class (if undetermined)
- Determine if the alignment has to be revised, including expropriating property
- Geometric design
- Drainage design
- Pavement design
- Road safety assessment
- Intersection design
- The procurement process (BOQ, tendering, award, etc)
- Construction

IMPORTANT NOTES:

The initial road class determination is critical to ensure that the road reserve, land requirements (if any), alignment, cross-section and geometric design will result in a road that will serve the correct mobility or access purpose for the design life of the road.

Figure 1.76: Prioritisation Factors



It is also important that the class and road reserve of the road will allow future upgrades if required. Future upgrades may include widening within the road reserve to increase capacity.

The road classification must adhere to the requirements of the local area structure plan and/or spatial plan. Where a structure plan is not in place, and the road class has not been determined, this should be undertaken by the relevant urban council to ensure that the correct road class is chosen, and that the road will serve its intended mobility or access function up to the planning horizon year.

The urban council should furthermore, in line with the requirements of the Annual Urban Road Work Plan (AURWP), plan the upgrade of all roads within their town/city, broadly as follows:

- Unsurfaced (unmade) roads upgraded to unsurfaced (engineered) standard, with drainage and non-motorised transport provision (made sidewalks)
- Deteriorated roads (surfaced or unsurfaced) upgraded to standard.
- Unsurfaced (unmade) roads upgraded to surfaced standard.
- Upgrade to correct standard (surfaced or unsurfaced)

Notes:

- An unsurfaced and unmade road is a road that has not been constructed, improved or shaped in any significant way. An example of an unmade road in the urban context is where vegetation has been intentionally cleared or is simply the result of vehicles travelling along a path over a period of time.
- An unsurfaced engineered or made road is where a road has been constructed with for example layer works or grading and shaping.
- The prioritisation of upgrades must be undertaken as described in Volume 1, Chapter 7.

COST ESTIMATES OF PRIORITISED INTERVENTIONS ON THE ROAD NETWORK

The prioritisation process results in cost estimates per type of intervention. The next step is for the urban councils to prepare the cost estimates for each type of intervention on each road derived from the road conditions.

This information is required to finally determine which road and the type of intervention is required to be included in the AURWP.

BUDGET CEILING FOR URBAN ROAD WORKS

Lastly, in order to get further guidance on the limits of their selection, the stakeholders need to know the Budget Ceiling in order to decide on how many and which roads would be considered in the current financial year. The Budget Ceiling and the conditions of utilisation of the funds/type of intervention are obtained from the Local Government Budgetary Framework Plan (LGBFP) for the forthcoming financial year and this information guide the urban council to determine from the above tables the cut-off point of roads required for maintenance and improvement.

Table 1.21: Maintenance, Rehabilitation and Upgrade Weighting

Evaluation Factor	Weighted Value
A. ROUTINE MAINTENANCE	
(i) Previous Intervention	15 – 25
(ii) Effect of long-term traffic flow Constraint removal	15 – 25
(iii) Population Density	30 – 40
(iv) Interconnection	10 – 15
(v) Economic Development and Poverty Alleviation	15 – 20
B. PERIODIC MAINTENANCE	
(i) Previous Intervention	15 – 25
(ii) Effect of long-term traffic flow Constraint removal	20 – 35
(iii) Population Density	30 – 40
(iv) Interconnection	10 – 15
(v) Economic Development and Poverty Alleviation	15 – 20
C. REHABILITATION	
(i) Previous Intervention	20 – 35
(ii) Effect of long-term traffic flow Constraint removal	20 – 35
(iii) Population Density	15 – 25
(iv) Interconnection	15 – 20
(v) Economic Development and Poverty Alleviation	10 – 20
D. UP-GRADING TO BITUMINOUS STANDARD	
(i) Previous Intervention	20 – 35
(ii) Effect of long-term traffic flow Constraint removal	20 – 35
(iii) Population Density	30 – 40
(iv) Interconnection	15 – 20
(v) Economic Development and Poverty Alleviation	10 – 20

1.7 CHAPTER 7: PREPARATION OF ANNUAL URBAN ROADS WORK PLAN (AURWP)

1.7.1 INTRODUCTION

In preparing their annual road work plans, the Urban Councils are expected to use these Guidelines in conjunction with the Poverty Alleviation Fund (PAF) Guidelines and the Medium- Term Expenditure Framework (MTEF). The work plans should therefore be a natural progression from those prepared for the current financial year and take into account the lessons learnt in the implementation of the previous financial year's work plan. This means that over time, work plans will become increasingly more realistic and easier to implement. Figure 1.77 illustrates the information flow for developing the Annual Urban Roads Work Plan (AURWP).

1.7.2 FACTORS TO BE CONSIDERED DURING THE PREPARATION OF AURWP

RESOURCE ENVELOPE

During the budget framework process of the Local Government Budgetary Framework Plan (LGBFP), the resource envelope for roads maintenance and improvements is provided by the Central Government and it is within this budget that the urban councils are to fit the cost of maintenance and improvements of their roads.

BILL OF QUANTITIES

The budget derived from the Bills of Quantities (BOQ) of all the maintenance and improvement works prioritised for a particular financial year must be within the resource envelope.

SCHEDULING OF ACTIVITIES

The Annual Urban Roads Work Plan is the timetable within which the proposed maintenance and improvement works are scheduled to take place. The following are the factors that ought to be considered when developing the schedule for the planned road works:

- Prioritisation of roads to be upgraded
- Release of funds; delay of funds from the Central Government
- Procurement process
- Weather conditions

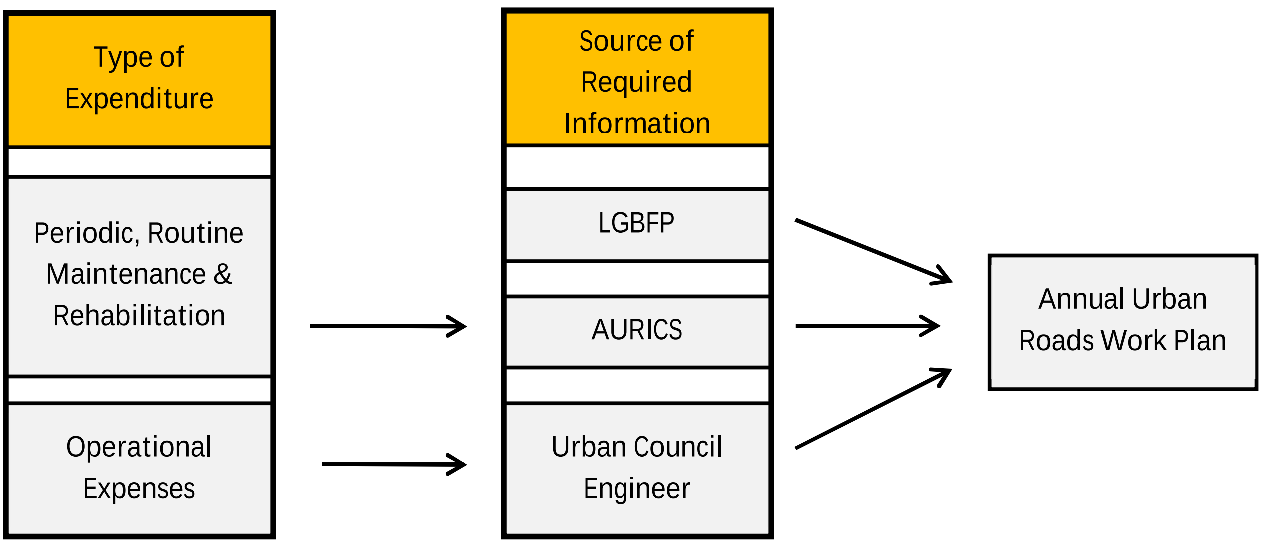


Figure 1.77: Information sources for developing AURWP

RELEASE OF FUNDS

Refer to Volume 5.

The release of funds determines when the implementation process commences. It is therefore important to make a good forecast of when this will commence. Delay in the release of funds usually leads to a delay in the commencement of road works.

PROCUREMENT PROCESS

Refer to Volume 4.

WEATHER CONDITIONS

Weather conditions influence road works progress. It is recommended that some road works be avoided during the rainy season as it will interfere with the work progress. The scheduling should therefore take this into consideration.

1.7.3 CONTENTS OF AURWP

When preparing the AURWP a number of standard formats shall be adopted to ensure that all essential and relevant information is included.

The contents of the AURWP include the following:

- Introduction: a general/brief descriptive overview of the urban road network including its extent, current condition, and overall funding needs for each of the four types of interventions planned during the forthcoming financial year
- Overview of the urban council development objectives and priorities, constraints together with a performance review of physical and financial progress during the current financial year
- Prioritised list of works planned for each of the four types of interventions
- Cost estimates for supervision and other operational expenditures
- Specific sources of funding for all works planned for each of the four types of interventions
- Works Implementation schedule for all works planned for each of the four types of interventions
- Expenditure schedule for all works planned for each of the four types of interventions

1.7.4 THE STANDARD FORMATS FOR SUBMISSION OF AURWP

There are four standard format forms wherein the planning information is summarised. These consist of the following:

- Form E1, Annual Urban Road Work Plan – Expenditure Schedule
- Form E2, Annual Urban Road Work Plan – Works Implementation Schedule
- Form E3, Annual Urban Road Work Plan – Budget Summary
- Standard Covering Letter Format

Appendix 13 is the standard form and Appendix 14 is the standard covering letter for the submission of the Annual Urban Work Roads Work Plan.

1.8 CHAPTER 8: STATUTORY PERMIT REQUIREMENTS

Refer to Table 1.22 for the Statutory Permit Requirements to be obtained prior to and during any road construction project.

Table 1.22: Statutory Permit Requirements in Road Construction

No.	Permit / Authorization	Issuing Organizations	Purpose
1	Environmental and Social Impact Assessment Certificates	NEMA	Ensure compliance with National Regulations
3.	Approval of Valuation report for Right of Way Acquisition	Office of the Chief Government Valuer. Ministry of Lands, Housing and Urban Development	Ensure that project-affected persons get fair compensation.
2	Registration of workplace	Ministry of Gender, Labour and Social Development	Regulate working conditions at workplaces
3	Ground Water(borehole) and surface water abstraction Permits	Directorate of Water Resources Management (Ministry of Water and Environment)	Monitor underground water extraction Monitor and regulate surface water use
4	Wastewater Discharge Permit	Directorate of Water Resources Management (Ministry of Water and Environment	Monitor discharge of pollutants from facilities
5	Noise Standards and Control Permit	NEMA	Regulate workplace noise levels for OHS
6	Permission to construct across water courses	Directorate of Water Resources Management (Ministry of Water and Environment	Regulate and monitor works on surface water courses to manage possible pollution
7	Hazardous waste storage, transportation and disposal license	NEMA	Onsite storage of hazardous waste (e.g., used oil).
8	Noise Standards and Control Permit	NEMA	Regulate workplace noise levels for OHS
9	Permission to construct across water courses	Directorate of Water Resources Management (Ministry of Water and Environment	Regulate and monitor works on surface water courses to manage possible pollution.
10	Statutory certification of lifting equipment	Department of Occupation Health and Safety Ministry of Gender, Labour and Social Development	Ensure safety and functionality of the equipment
11	Work Permits for all foreign workers	Directorate of Citizenship and Immigration Control. Ministry of Internal Affairs	Regularize foreign project staff
12	Owners Transport Vehicles (OTV) license	Transport Licensing Board Ministry of Works and Transport	Permit Owner to operate passenger services
13	Explosive Storage Permit	Ministry of Internal Affairs	Permission to transport and handle explosives
14	Blasting Certificate	Ministry of Internal Affairs	Certificate held by certified blaster
15	Petroleum storage permit and petroleum operating license.	Petroleum Supply Department, Ministry of Energy & Mineral Development	Transport, onsite storage and dispensing of petroleum fuel during road construction
16	Hazardous waste storage, transportation and disposal license	NEMA	Onsite storage of hazardous waste (e.g., used oil).

1.9 CHAPTER 9: SUMMARY

The planner should be able to have the necessary competence in terms of skills, knowledge, and experience in order to participate in the work plan development process. Essentially, the planner must be in a position to understand key issues involved in the planning process by asking the questions provided in Table 1.23, which helps to summarise the outcomes of the planning process.

Through sound planning, the decision on how and when to improve and maintain the urban road network is best achieved. The planned decisions are provided in the form of a prioritised annual road work plan within the constraints of available budgets. In order to have a realistic work plan, it is essential that data and the information required is collected and analysed, and the outcome of the work plans should effectively reflect this.

This Volume has provided the answers to the key planning issues:

- Urban road design planning philosophy
- Information sources for the planning process
- Standards to be used and complied with in the planning process
- The factors to consider when planning for Urban roads maintenance and improvements
- The planning processes steps for Urban roads maintenance and improvements

Table 1.23: Summary of Questions for the Urban Roads Planner

What information does a planner need for the Urban Roads Work Plan?	**Where do I get this information from?**	**What are the standards used in Urban Road Works Planning?**	**What is the outcome?**
1. Road Inventory, Road Condition, and traffic surveys	Data from the field	Standard Forms Appendix 4.	AURICS
2. Selection of the type of interventions	The type of maintenance and improvement needed for the Urban roads	Standard guidelines for rehabilitation and maintenance planning systems	Type(s) of maintenance and improvement works
3. Prioritisation	Urban Council meetings	Previous interventions, service delivery or relieving bottlenecks	Prioritised roads for improvement/maintenance
4. Budgeting	Amount in the Resource envelope	Bills of Quantities PAF Guidelines	Budget for Road Maintenance and Improvements
5 Schedule of Maintenance and Improvements	Previous year's data on releases of funds, weather, and procurements	AURWP Forms Appendix 13.	Annual Urban Roads Work Plan (AURWP)

2 VOLUME 2: THE DESIGN GUIDELINES

Volume 2 Table of Contents

2.1 CHAPTER 1: INTRODUCTION

2.1.1 INTRODUCTION

This Volume contains guidelines for the selection of an appropriate type of road (e.g., road reserves, road cross-sections, drainage, alignments etc) to be appropriately used in the design of urban roads. The Volume is to be used not only during the design, construction and maintenance phases but also during the planning process of urban road works.

This Volume consist of the following chapters:

- Chapter 1: Introduction
- Chapter 2: Data collection, field surveys & Engineering Standards Review
- Chapter 3: The Design Standards
- Chapter 4: Geometric Design Guidelines
- Chapter 5: Pavement Design Guidelines
- Chapter 6: Drainage Design Standards
- Chapter 7: Design of road bridges
- Chapter 8: Environmental and Social Standards
- Chapter 9: Environmental and Social Impact Assessments
- Chapter 10: Preparation of drawings and design reports
- Chapter 11: Summary
- Chapter 12: List of Standard Drawings

Important note: This Volume must be used with Part 2 , the Standard Drawings, which illustrates where each of the designs are applicable.

This Volume, the Appendices and the Standard Drawings are **complementary** to the Uganda Road Design Manual, namely:

- Road Design Manual: Vol. I Geometric Design, January 2010, Ministry of Works and Transport
- Road Design Manual: Vol. II Drainage Design, January 2010, Ministry of Works and Transport
- Road Design Manual: Vol. III Pavement Design, January 2010, Ministry of Works and Transport
- Road Design Manual: Vol. IV Bridge Design, January 2010, Ministry of Works and Transport
- General Specifications for Road and Bridge Works, October 2004, Ministry of Works, Housing and Communications

These manuals must be considered and implemented to the extent applicable to the urban road designs. Where there is a conflict in the design criteria then the Uganda Urban Roads Design Manual takes precedence only as applicable in urban areas.

2.1.2 THE OBJECTIVES OF THE GUIDELINES

The objective of this Guideline is to standardize and enable uniformity in the design of urban road works. The use of this Volume 2 enables the user to understand the following:

- The selection of an appropriate design of key road features such as road class, number of lanes, right of way width, etc.
- The importance of the use of Standard Designs in implementing all Major and Minor works.
- The relationship between the Design, Technical Specifications and Bills of Quantities and Tender Document Guidelines.

2.1.3 ROAD DESIGN ELEMENTS

WHAT IS ROAD DESIGN?

Roads are designed and built to meet the demands of operational comfort and capacity of transportation of people and goods. However, they must also be safe, environmentally friendly, and economical. The design guidelines describe how to design roads to achieve operational comfort and capacity considering safety and economy and, to some extent environment Thus, all these considerations and features are built into the principles, criteria and values for the various design elements given in the guideline.

THE ROAD DESIGN PROCESS

The Design process is subdivided into the following steps, refer to Figure 2.1:

- Data Collection, Field Survey, Engineering Standards Review and Selection of Design Standards.
- Feasibility stage (Optional) - Conceptual design
- Detail design of cross-sections, alignments, drainage structures, pavement, road furniture and preparation of drawings.

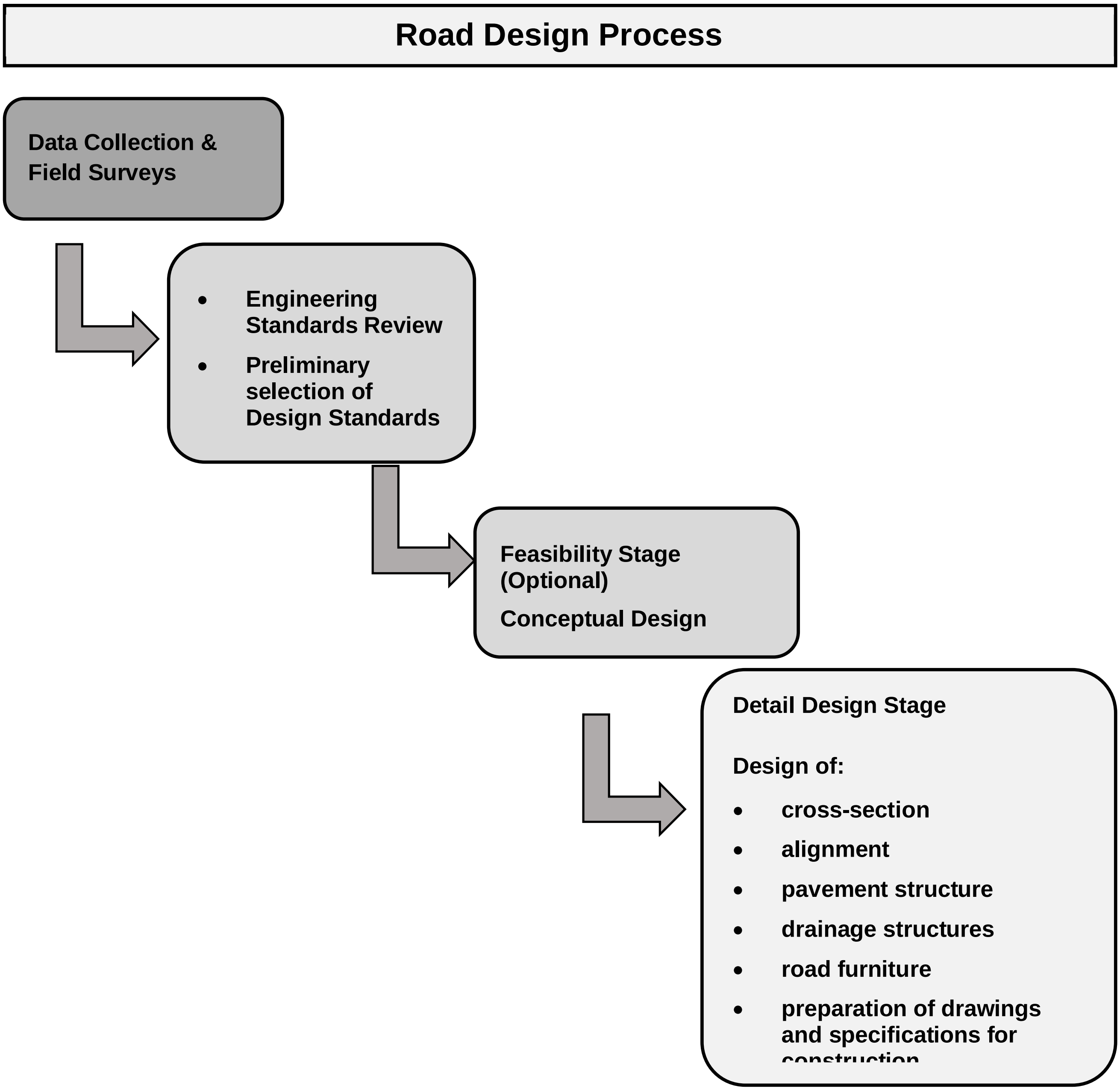


Figure 2.1: The Road Design Process

THE ROAD DESIGN APPROVAL PROCESS

The road design approval process is summarised below:

- Conceptual design stage – approval by the road designer and direct supervisor, the required stakeholders (e.g. the local authority), the implementing agent (MOWT USMID or others) and lastly the funder (If different from the implementing agent).
- Detail design stage – approval by the road designer and direct supervisor, the required stakeholders such as the local authority), the implementing agent (MOWT, USMID or others) and the funder (If different from the implementing agent).
- Statutory approval such as the National Environmental Management Authority and any other required organisations
- Final approval: the MOWT Engineer-in Chief

Important note: The design engineer must be a suitably qualified, experienced and professionally registered engineer.

Accountability of approvers:

- The designer and his/her superior who signs off the designs are responsible as professionally registered engineers.
- The Engineer-in-Chief is ultimately responsible for the overall design and implementation of road projects.
- The engineering representative is responsible for the implementation (construction) of the works to the design and relevant standards.

DEVIATION FROM ROAD DESIGN STANDARDS

The deviation from road design standards may in some cases be required due to various factors such as land availability, right of way restrictions, funding constraints or other factors. Any deviations from the standards must be avoided whenever possible.

Note that any deviations from standards must be approved by the Engineer-in-Chief.

2.2 CHAPTER 2: DATA COLLECTION, FIELD SURVEYS & ENGINEERING STANDARDS REVIEW

2.2.1 INTRODUCTION

This Chapter introduces the user to the steps used in the selection of the design standards. The steps include:

- Confirmation and alignment to planning considerations and imperatives. This process (described in Volume 1) allows the practitioner to determine the context and classification of the road. It confirms all planning imperatives applicable to the proposed road design.
- Data collection to obtain as much information as possible about the project road links and the prevailing environmental conditions through which it passes. This data is obtained from field surveys and from other departments like the Metrological and Mapping Departments, this data is required for the designs of various road features.
- The Engineering Standards Review is required to get an overview of which design standard should be adopted.

Refer to Volume 1 of the Uganda Geometric Road Design Manual, dated January 2010, developed by the Ministry of Works and Transport for further guidance.

2.2.2 DATA COLLECTION AND ROAD SURVEYS

A detailed field reconnaissance survey to study the local conditions along the project roads and its area of influence should be undertaken. The objective of this detailed reconnaissance survey is to define the scope of the ensuing investigation activities. On this field reconnaissance visit, alternative design options have to be identified using available mapping.

2.2.3 ENGINEERING STANDARD REVIEW

The Ministry of Works and Transport has the appropriate geometric, pavement and drainage design standards as listed in Section 2.1.1. These Design Standards, and this Urban Roads Design Manual, are considered of paramount importance to selecting the most beneficial technical option, which would then be justifiable in socio-economic terms.

Selecting appropriate design and construction standards is considered vital to adopting the most appropriate and beneficial improvement alternatives. The reviews at this early stage will include engineering standards review and data stated below for analysis.

Data requirements for analysis:

- All available mapping
- All available photography
- Geological maps and reports of the areas
- Rainfall records
- Hydrological records
- Existing traffic data including all available counts
- Recent contract rates for road construction
- Reports from earlier relevant studies
- Details of all Urban and sub-Urban development plans (town and spatial planning)

2.2.4 ALIGNMENT IDENTIFICATION, INVESTIGATION AND ANALYSIS

The alignment options will be confirmed such that the horizontal and vertical geometry of the selected alignments can be designed at an acceptable level of detail.

The design addresses the following aspects:

- Preferred methods of construction
- Minimising disruption to developed land and established communities
- Minimising conflict points and maximising road safety
- Maximising the use of the natural terrain for drainage of the road and disposal of the collected water
- Minimising the need to traverse unsuitable subgrade soils
- Minimising excessive gradients and undesirable vertical curves
- Minimising the requirement to cut in rock

The design must be undertaken against the selected engineering standards. It will establish the Right of Way (road reserve), cross-sections of carriageways, shoulders, side slopes, drainage, landscaping, non-motorised transport and transverse profile.

The conflicting criteria between economic constraints, requirements of access, maintenance capabilities, services, environmental impact and community and social impacts will all be balanced without compromising the basic criteria of maintaining safety.

When all have been resolved at feasibility stage, working from established basic design policies with respect to traffic, capacity, geometric design criteria, access control and stage construction the horizontal and vertical alignment will be designed in detail.

The design will take into account the sight distance requirements, minimum horizontal and vertical curves, restriction on combining the curves, clearance and intersections. The cross-sectional elements comprising carriageways, shoulders, side slopes, ditches and drains and transverse profile will all be designed. Intersections, rest areas, lay byes and bus bays will also be designed. The design will take note of clearance requirements as necessary.

2.3 CHAPTER 3: THE DESIGN STANDARDS

2.3.1 INTRODUCTION

This Chapter guides the user on the steps in the design of roads, and the subsequent selection of the appropriate designs in the Standard Drawings.
The steps in the design include:

- Selection of the Design Standards using the road function, road classes, volume of traffic and terrain criteria.
- Selection of road alignments and the appropriate road reserve width which comprises the cross-section and medians, drainage and other road features such as road shoulders/sidewalk, road markings, traffic signs and other road safety measures.
- Selection of an economical pavement type using the design criteria specified in Section 2.3.13.

2.3.2 SELECTION OF ROAD DESIGN STANDARDS

INTRODUCTION

Roads are expected to reflect and support adjacent land uses. Well-designed roads promote appropriate speeds, modes and non-motorised transport activities. This context sensitive approach considers and enhances the existing built, natural and heritage elements, seeking to reveal and celebrate a city and town's identity.

The roads in an urban network can be broadly classified into two functional categories:

"Mobility roads" are higher order roads, generally operating at higher speeds, carrying higher traffic volumes over longer distances.

"Access roads" are lower order roads, generally characterised by operating at lower speeds with shorter travel distances in order to provide connections to the higher-order roads or individual properties.

Urban roads are defined as all roads within urban areas that are owned and maintained by the local authority. Note that some roads within urban areas are owned and maintained by other authorities such as the Uganda National Road Agency (UNRA). These roads are not explicitly required to adhere to the standards of this Manual.

The Urban Road Classification System described in this Urban Roads Design Manual was adapted from current international best practise, specifically the Auckland Transport: 2021 Urban Street and Road Design Guide Version 1:
"Functional classification is the process by which roads and highways are grouped into classes according to the land use, service function, traffic volume and speed, flow characteristics, vehicle type, and connections."

ROAD CLASSES & TYPICAL FEATURES

The Uganda District Roads Manual (UDRM) Volume A, contains an outdated urban road classification and a description of relationship between Urban Roads and District Roads:

This Urban Roads Design Manual expands the previous District Roads Manual's road classification system into a more comprehensive functional road classification system with additional classes. The additional two classes are for use by non-motorised transport only, and informal settlement access ways for use by non-motorised transport and limited vehicle types (emergency and refuse vehicles).

The expanded road classes are described in Table 2.1, also refer to Volume 1, Chapter 1.1.2.

Road classification aids the channelisation of travel within the network in a logical and efficient manner. Roads within each class are expected broadly to provide a similar level of service. It is therefore important that the road to be designed should fall under any of the 7 class categories and their sub-classes.

Table 2.1: Functional Road Classification System

Class	Function	Description	Road reserve - maximum (m)
1	Mobility	Trunk Route (with dedicated BRT trunk or Public Transport lanes)	60
2		Major Arterial (with dedicated BRT trunk or Public Transport lanes)	40
3		Minor Arterial (with shared BRT feeder or Public Transport lanes)	28
4	Access	Collector Road (Commercial, Residential & Industrial)	20
5		Access Road (Commercial, Residential & Industrial)	15
6		Informal settlement Access Way	8
7		Non-motorised transport Access Way	6

The functional description of the classes are as follows:

Class 1 Trunk roads: 60m (max) road reserve
Trunk routes provide general mobility to the whole metropolitan/urban area but can also be used to serve important economic activity centres such as routes to international airports. Class 1 roads should also be used as connectors to rural trunk routes as defined by the Uganda District Roads Manual (UDRM). Class 1 routes are typically designed as higher speed roads with limited access and intersection control due to the high traffic volumes carried on these routes. Class 1 roads must be constructed with paved roadways.

Various sub cross-sections are included for Class 1 roads:

- Class 1A (1): dual median BRT trunk lanes, maximum 3 vehicle lanes per direction
- Class 1A (2): dual median BRT trunk passing lanes, stopping lanes, median BRT station, maximum 3 vehicle lanes per direction
- Class 1A (3): dual kerb-side BRT trunk lanes, single kerb-side BRT station and single BRT stopping lane
- Class 1B (1): dual kerb-side PT lanes, maximum 3 vehicle lanes per direction (high-density areas)
- Class 1B (2): dual kerb-side PT lanes, maximum 3 vehicle lanes per direction, (outside high-density areas)
- Class 1B (3): dual kerb-side PT lanes and a bus stop lane on one side

It is possible to reduce the road reserve width but preserving the Class 1 functionality as follows:

- 2 traffic lanes per direction
- Omit trading areas
- Reduce the widths of the sidewalks and planters
- Combine lighting and tree areas

The road reserve widths that can be achieved are:

- Class 1A (1): 42.8m
- Class 1A (2): 45.6m
- Class 1A (3): 45.5m
- Class 1B (1): 39.6m
- Class 1B (2): 39.6m
- Class 1B (3): 42.3m

Due to the width of the road reserve, Class 1 roads can be reconfigured to accommodate future light rail public transit with the reduction of the number of lanes.

Class 2 Major arterial roads: 40m (max) road reserve
In larger towns and cities, urban major arterial routes are typically used to provide general mobility between regions of the city, while in smaller cities, these routes can provide general mobility to the whole urban area. Class 2 routes can also be used to serve important economic activity centres not served by Class 1 routes and to connect to District Class 1 routes for continuity.

Class 2 routes must be constructed with paved roadways.

Various sub-cross sections are included for Class 2 roads:

- Class 2A (1): dual median BRT trunk lanes, maximum 2 vehicle lanes per direction
- Class 2A (2): dual median BRT trunk lanes, tandem median station with a BRT stopping on one side only, maximum 2 vehicle lanes per direction
- Class 2A (3): dual median BRT trunk lanes, median station and with dual BRT stopping lanes, maximum 2 vehicle lanes per direction
- Class 2B (1): dual kerb-side PT lanes, maximum 2 vehicle lanes per direction
- Class 2B (2): dual kerb-side PT lanes and a bus stop lane on one side, maximum 2 vehicle lanes per direction

It is possible to reduce the road reserve width but preserving the Class 2 functionality as follows:

- Reduce to 2 traffic lanes per direction
- Omit trading areas
- Reduce the widths of the median, sidewalks and planters
- Combine lighting and tree areas

The road reserve widths that can be achieved are:

- Class 2A (1): 34.5m
- Class 2A (2): 38m
- Class 2A (3): 39.7m
- Class 2B (1): 33.3m
- Class 2B (2): 38.9m

Note that the road reserve reduction is limited where the cross-sections include a bus stop or median bus station with a bus stopping and passing lane.

Class 2 roads may accommodate future on-road light rail systems such as trams.

Class 3 Minor arterial roads: 28m (max) road reserve

In cities and larger towns urban minor arterials are used to provide connections between districts of the city or town and from the last leg of the journey on the mobility road network (Class 1 & 2 routes), bringing traffic to within one kilometre of its destination. In small towns, they are used to provide general mobility for the whole town. The minor arterials can also be used to serve economic activity centres that are not served by Class 1 or 2 routes. Class 3 routes can also connect to District Class II routes for continuity purposes.

Class 3 routes must be constructed with paved roadways.

Various sub-cross sections are included for Class 3 roads:

- Class 3A (1): dual kerbside mixed BRT feeder and traffic lanes, dual median side traffic lanes
- Class 3A (2): dual kerbside mixed BRT feeder and traffic lanes, dual median side traffic lanes and kerbside BRT stop on one side
- Class 3A (3): dual kerbside mixed BRT feeder and traffic lanes, dual median side traffic lanes and right-turning lane at intersections
- Class 3B (1): dual kerbside mixed PT and traffic lanes, dual median side traffic lanes
- Class 3B (2): dual kerbside mixed PT and traffic lanes, dual median side traffic lanes and kerbside PT shelter on one side
- Class 3B (3): dual kerbside mixed PT and traffic lanes, dual median side traffic lanes and right-turning lane at intersections

It is possible to reduce the road reserve width but preserving the Class 3 functionality as follows:

- Omit cycle lanes, planters and trees
- Reduce the widths of the sidewalks

The road reserve widths that can be achieved are:

- Class 3A (1): 20.1m
- Class 3A (2): 22.0m
- Class 3A (3): 22.4m
- Class 3B (1): 20.4m
- Class 3B (2): 20.9m
- Class 3B (3): 22.5m

Note that the road reserve reduction is limited where the cross-sections include a BRT or Public Transit bus shelter.

Note that class 3 roads cannot accommodate light rail (tram) public transit services.

Class 4 Collector roads: 20m (max) road reserve

Collector roads are used to collect (and distribute) traffic between local roads and the arterial road networks. Class 4 routes can be categorised based on the development in the area it serves i.e., commercial, industrial, and residential subclasses. A collector road should not carry any through traffic and should not be quicker to use than one of the mobility routes.

Class 4 routes can be constructed with a paved or unpaved roadways, except in industrial areas where roads must be paved due to heavy vehicle volumes.

Various sub-cross sections are included for Class 4 roads:

- Class 4A (1P) Commercial & mixed-use areas: dual kerb-side parking (Paved)
- Class 4A (2P) Commercial & mixed-use areas: no parking & right turn lane at intersections (Paved)
- Class 4A (1G) Commercial & mixed-use areas: dual kerb-side parking (Unpaved)
- Class 4A (2G) Commercial & mixed-use areas: no parking & right turn lane at intersections (Unpaved – Dual crossfall)
- Class 4A (3G) Commercial & mixed-use areas: no parking & right turn lane at intersections (Unpaved – Single crossfall)
- Class 4B (1P) Residential areas: dual kerb-side parking (Paved)
- Class 4B (2P) Residential areas: no parking & right turn lane at intersections (Paved)
- Class 4B (1G) Residential areas: dual kerb-side parking (Paved)
- Class 4B (2G) Residential areas: no parking & right turn lane at intersections (Unpaved – Dual crossfall)
- Class 4B (3G) Residential areas: no parking & right turn lane at intersections (Unpaved – Single crossfall)
- Class 4C (1P) Industrial areas: dual kerb-side parking (Paved)
- Class 4B (2P) Industrial areas: no parking & right turn lane at intersections (Paved)

It is possible to reduce the road reserve width but preserving the Class 4 functionality as follows:
Omit planters and trade areas
Reduce the widths of the sidewalks and combine with lighting areas

The road reserve widths that can be achieved are:

- Class 4A (1P): 16.6m
- Class 4A (2P): 15.8m
- Class 4A (1G):18.2m
- Class 4A (2G): 15.2m
- Class 4A (3G):14.0m
- Class 4B (1P): 16.8m
- Class 4B (2P): 15.3m
- Class 4B (1G): 18.8m
- Class 4B (2G): 16.9m
- Class 4B (3G):15.3m
- Class 4C (1P):18.6m
- Class 4B (2P): 15.6m

Class 5 Access roads: 15m (max) road reserve
Access roads provide access to individual properties and can be categorised based on the development in the area it serves i.e., commercial, industrial, and residential subclasses. Furthermore, dead end access roads are classified as cul-de-sacs and there is no separate cross-section design required.

Class 5 routes can be constructed with a paved or unpaved roadways, except in industrial areas where roads must be paved due to heavy vehicle volumes.

Various sub-cross sections are included for Class 5 roads:

- Class 5A (1P) Commercial, mixed-use & residential areas: dual kerb-side parking (Paved)
- Class 5A (2P) Commercial, mixed-use & residential areas: no parking & right turn lane at intersections (Paved)
- Class 5A (1G) Commercial, mixed-use & residential areas: dual kerb-side parking (Unpaved)
- Class 5A (2G) Commercial, mixed-use & residential areas: no parking & right turn lane at intersections (Unpaved)
- Class 5B (1P) Industrial areas: dual kerb-side parking (Paved)
- Class 5B (2P) Industrial areas: no parking & right turn lane at intersections (Paved)

It is not recommended to reduce this road reserve width, except in special circumstances where the available land is restricted. In these cases, the sidewalks can be reduced to an absolute minimum of 1.2m, and the trading areas can be omitted.

Class 6 Informal settlement access road: 8m (max) road reserve
Access lanes providing formalised access for emergency and other service such as refuse removal and non-motorised transport. Limited private vehicles access is possible, with no parking allowed. These roads are intended where no formal road network is present.

Class 6 routes can be constructed with a paved or unpaved roadway.

It is not recommended to reduce the road reserve width of this road class.

Class 7 NMT only access routes: 6m road reserve

This class is a non-motorised access way restricted for use by non-motorised transport such as pedestrians and cyclists only. Non-motorised transport access ways can be used to provide walkways with pedestrian priority and "shortcuts" for pedestrians to access public transport facilities, and to reduce the walking distance to and from public transport stops.

Class 7 routes can be constructed with a paved or unpaved carriageway.

It is not recommended to reduce the road reserve width of this Class.

ROAD CLASSIFICATION MATRIX

The Functional Classification matrix includes all the typical features for each road class. The road reserve or right of way is a strip of land that should be kept clear of development in order to provide suitable access roads for the surrounding developments, and mobility roads to other towns and/or developments. The road reserve should have sufficient space to allow for future upgrades.

The lane (or roadway) widths provided are the widths of the travelled way, excluding storm water channels and/or kerbs.

The provision of public transport stops as described in this Manual is only to determine a framework wherein a public transport system can be developed. A distance of 500m between stations and stops are recommended, however, the location of public transport stops and/or stations should be determined as a part of the design of the public transport network.

The different intersection controls considered in this manual are: All-way Stop control (AWSC) and Two-way Stop-control (TWSC), roundabouts, traffic signals and grade-separated intersections. The intersection controls are described in detail in Chapter 2.3.5.

Refer to the following for more detailed road classification information:

- Road Functional Classification Matrix: Table 2.2 to 2.5
- Standard Drawings No. CS-1 to CS-7.
- Detailed cross-section elements: Table 2.6 to Table 2.11.

Intersection Spacing: The spacing of intersections is measured between the centre points of neighbouring intersections and/or accesses. The intersection spacing requirements shown in the matrix is for full intersections, partial and marginal access's may be allowed at a reduced spacing to relieve congestion, reduce excessive travel distances or remove the need for a full intersection. It is recommended that intersection spacing for T-junctions, partial and marginal accesses should not be less than half of the distance for full intersections.

Access control standards: Vehicle access to private and commercial properties is only allowed from low order roads (Class 4, 5 and 6). Access to properties from mobility routes are not recommended, but may be allowed if the following conditions are met:

- The property must be significantly large.
- There is no future need for a public road at/close to the access location.
- Access (intersection) spacing requirements are met.
- There are no alternative roads to provide access

Parking as described in the matrix is on-road parking. On-road parking has a significant impact on the capacity and safety of a road and is therefore not recommended on mobility routes. On-road parking may be allowed on access roads (Class 4 and 5) if the following conditions are met:

- The road must not carry any through traffic.
- A maximum speed limit of 50km/h must be in place
- Sufficient sight distance must be maintained at all times. Parked vehicles may not obstruct sight distances at intersections and accesses.

The operating **speed** is normally higher on higher order roads than on low order roads. Operating speed should decrease in denser developed areas and can be increased along routes with less roadside development. Recommended operating speeds are provided in the matrix. Note that speed reduction should be implemented for safety reasons at large pedestrian generator such as shopping centres, schools, etc.

The provision of **non-motorised transport facilities** described in Volume 1 includes, but are not limited to, walkways (paved and unpaved), cycle lanes and road crossings.

Refer to Figure 2.2 to Figure *2.35* for examples of stylised typical cross-section drawings for the main road classes.

Note the following:

- The stylised drawings are not engineering drawings, therefore details such as drainage and sub-surface utilities are not shown.
- Refer to the engineering drawings of the cross-sections in Part 3, Standard Drawings.
- Stylised drawings for gravel/unpaved cross-sections could not be included due to the limitations of the design software used here. The engineering drawings, also found in the Standard Drawings, were therefore included here.
- Cross-sections drawings for reduced road reserves has not been included, these must be specifically designed for limited space availability or other constraints that requires narrower widths of the road elements.

Refer to Figure 2.36 to Figure 2.39 for examples of 3D views of urban blocks of the lower order road classes. Note only some examples are included, as there are numerous design options available per road class.

.

Table 2.2: Road Class Matrix, Class 1 & 2

DESCRIPTION				REQUIREMENTS				FEATURES										
Class		Description	Surface type	Intersection Spacing (minimum)		Direct access to Property	On-road parking	Max Speed	Intersection Control	No. of lanes per direction		Lane Width (m)		Road Reserve (m)		Public Transport		NMT Facilities
				Ideal	Range					Traffic	BRT/PT	Ideal	Range	Ideal	Range	Allowed	PT Stops	
1	A (1 - 3)	Trunk Route with BRT trunk service	Paved only	2.4km	1.6 – 3.6km	No May be allowed if conditions are met	No	80km/h	Stop	2 or 3	1 lane or 1 stop & 1 passing lane	3.5m	3.3 – 3.5m	60m	42.8m - 60m	Yes	Median or Kerb stations	Crossings at intersections
									Traffic Signal									Walkways segregated from road
									Grade Separated									Bike lane segregated from road
	B (1 - 3)	Trunk Route with PT route	Paved only	2.4km	1.6 – 3.6km	No May be allowed if conditions are met	No	80km/h	Stop	2 or 3	1 lane or 1 stop & 1 passing lane on one side only	3.5m	3.3 – 3.5m	60m	39.6m - 60m	Yes	Kerb stops	Crossings at intersections.
									Traffic Signal									Walkways segregated from road
									Grade Separated									Bike lane segregated from road
2	A (1 - 3)	Major Arterial with BRT trunk service	Paved only	800m	680 – 920m	No May be allowed if conditions are met	No	60km/h	Stop	2	1 lane or 1 stop & 1 passing lane on 1 or both sides	3.5m	3.3 – 3.5m	40m	34.5m -40m	Yes	Median stations	Crossings at intersections.
									Traffic Signal									Walkways segregated from road
									Grade Separated									Bike lane: segregated from road
	B (1 - 2)	Major Arterial with PT route	Paved only	500m*	400-600m	No May be allowed if conditions are met	No	60km/h	Stop	2	1 lane or 1 stop & 1 passing lane on 1 side only	3.5m	3.3 – 3.5m	40m	33.3m - 40m	Yes	Kerb stops	Crossings at intersections.
									Traffic Signals									Walkways segregated from road
																		Bike lane: segregated from road

Table 2.3: Road Class Matrix, Class 3

DESCRIPTION				REQUIREMENTS				FEATURES										
Class		**Description**	**Surface type**	**Intersection Spacing (minimum)**		**Direct access to Property**	**On-road parking**	**Max Speed**	**Intersection Control**	**No. of lanes per direction**		**Lane Width (m)**		**Road Reserve (m)**		**Public Transport**		**NMT Facilities**
				Ideal	**Range**					**Traffic**	**BRT/PT**	**Ideal**	**Range**	**Ideal**	**Range**	**Allowed**	**PT Stops**	
3	A (1 - 3)	Minor Arterial with BRT Feeder service	Paved only	600m	480 – 720m	No May be allowed if conditions are met	No	50km/h	Stop	1	1 shared BRT & traffic	3.5m	3.3 – 3.5m	28m	20.1m – 28m	Yes	Kerb stops	Crossings at intersections.
									Traffic Signals									Walkways segregated from road
									Roundabouts									Bike lane segregated from road
	B (1-3)	Minor Arterial with PT route	Paved only	500m	400-600m	No May be allowed if conditions are met	No	50km/h	Stop	1	1 shared PT & traffic	3.5m	3.3 – 3.5m	28m	20.4m – 28m	Yes	Kerb stops	Crossings at intersections.
									Traffic Signals									Walkways segregated from road
									Roundabouts									Bike lane segregated from road

Table 2.4: Road Class Matrix, Class 4

DESCRIPTION				REQUIREMENTS				FEATURES										
Class		**Description**	**Surface type**	**Intersection Spacing (minimum)**		**Direct access to Property**	**On-road parking**	**Max Speed**	**Intersection Control**	**No. of lanes per direction**		**Lane Width (m)**		**Road Reserve (m)**		**Public Transport**		**NMT Facilities**
				Ideal	**Range**					**Traffic**	**BRT/PT**	**Ideal**	**Range**	**Ideal**	**Range**	**Allowed**	**PT Stops**	
4	A (1 - 2)	Collector Road (Commercial & mixed-use)	Paved	>150m	100m – 150m	Yes	Yes	50km/h	Stop Traffic Signal Urban Compact Roundabout	1	N/a	3.7	3.5m – 3.7m	20m	15.8m - 20m	Minibus taxi only	Kerb stops	Walkways segregated from road Cycle on road
			Gravel	*>150m*	100m – 150m	*Yes*	*Yes*	*50km/h*	Stop	*1*	*N/a*	3.5	3.3m – 3.5m	20m	*14m - 20m*	*Minibus taxi only*	*Kerb stops*	Walkways segregated from road Cycle on road
	B (1 - 2)	Collector Road (Residential)	Paved	>150m	100m – 150m	Yes	Yes	50km/h	Stop Traffic Signal Urban Compact Roundabout	1	N/a	3.7	3.5m – 3.7m	20m	15.3m - 20m	Minibus taxi only	N/a	Walkways segregated from road Cycle on road
			Gravel	*>150m*	100m – 150m	*Yes*	*Yes*	*50km/h*	Stop	*1*	*N/a*	3.5	3.3m – 3.5m	20m	*15.3m - 20m*	*Minibus taxi only*	*N/a*	Walkways segregated from road Cycle on road
	C (1 - 2)	Collector Road (Industrial)	Paved only	>150m	100m – 150m	Yes	Yes	50km/h	Stop Traffic Signal Roundabout	1	N/a	3.7	3.5m – 3.7m	20m	15.6m - 20m	Yes	Kerb stops	Walkways segregated from road Cycle on road

Table 2.5: Road Class Matrix, Class 5 - 7

DESCRIPTION				REQUIREMENTS				FEATURES										
Class		**Description**	**Surface type**	**Intersection Spacing (minimum)**		**Direct access to Property**	**On-road parking**	**Max Speed**	**Intersection Control**	**No. of lanes per direction**		**Lane Width (m)**		**Road Reserve (m)**		**Public Transport**		**NMT Facilities**
				Ideal	**Range**					**Traffic**	**BRT/PT**	**Ideal**	**Range**	**Ideal**	**Range**	**Allowed**	**PT Stops**	
5	A (1-2)	Access Road (Commercial, mixed-use & residential)	Paved	50m	30m – 50m	Yes	Yes	40km/h	Stop Mini Roundabout	1	N/a	3.3m	3.0 m – 3.3m	15m	N/a	Minibus taxi only	Kerb stops	Walkways segregated from road Cycle on road
			Gravel	50m	30m – 50m	*Yes*	*Yes*	*40km/h*	Stop	1	N/a	3.5m	3.0m - 3.5m	15m	N/a	Minibus taxi only	Kerb stops	Walkways segregated from road Cycle on road
	B (1-2)	Access Road (Industrial)	Paved only	50m	30m – 50m	Yes	Yes	40km/h	Stop Mini Roundabout	1	N/a	3.5m	3.3-3.5m	15m	N/a	Minibus taxi only	Kerb stops	Walkways segregated from road Cycle on road
6		Access way: Informal Settlement	*Paved* *Gravel*	*N/a*	*N/a*	*Yes*	*No*	30km/h	Stop	1	N/a	4.4m	4.0m – 4.4m	8.0m	7.0m – 8.0m	No	*NA*	Walkways segregated from road Cycle on road
7		Access Way: NMT only	*Paved* *Gravel*	*N/a*	*N/a*	*Yes*	*No*	N//A	N//A	1	N/a	3.0m	2.5m–3.0m	6.0m	5.0m – 6.0m	No	*NA*	Shared walkway & Cycle lane

Table 2.6: Class 1: Cross-Section Elements

Sub-class	**1A (1) - Trunk route (with BRT lanes)**																							
Width (m)	3	4.1	0.5	1.8	1.8	0.8	2	3.5	3.5	3.5	3.5	4	3.5	3.5	3.5	3.5	2	0.8	1.8	1.8	0.5	4.1	3	**60**
Element	Trade	Sidewalk	Lighting	Trees	Cycle	Planter	Shoulder & Channel	Drive	Drive	Drive	BRT	Median & lighting	BRT	Drive	Drive	Drive	Shoulder & Channel	Planter	Cycle	Tree	Lighting	Sidewalk	Trade	
Sub-class	**1A (2) - Trunk route (with median BRT station & dual passing lanes)**																							
Width (m)	3.8	0.5	1.8	1.8	0.6	2	3.5	3.5	3.5	3.5	3.5	4	3.5	3.5	3.5	3.5	3.5	2	0.6	1.8	1.8	0.5	3.8	**60**
Element	Sidewalk	Lighting	Tree	Cycle	Planter	Shoulder & Channel	Drive	Drive	Drive	BRT - Pass	BRT - Stop	Median PT Station	BRT - Stop	BRT – Pass	Drive	Drive	Drive	Shoulder & Channel	Planter	Cycle	Tree	Lighting	Sidewal k	
Sub-class	**1A (3) - Trunk route (with single kerb-side BRT station & passing lane)**																							
Width (m)		4.5	0.4	1.8	1.8	0.5	4	3.7	3.5	3.5	3.5	3.5	4	3.5	3.5	3.5	3.7	2	0.6	1.8	1.8	0.4	4.5	**60**
Element		Sidewalk	Lighting	Tree	Cycle	Planter	Station	BRT - Stop	BRT - Pass	Drive	Drive	Drive	Median & lighting	Drive	Drive	Drive	BRT	Shoulder & Channel	Planter	Cycle	Tree	Lighting	Sidewal k	
Sub-class	**1B (1) - Trunk route (with dual kerb-side PT lanes - high density areas)**																							
Width (m)	3	4.1	0.5	1.8	1.8	0.8	2	3.5	3.5	3.5	3.5	4	3.5	3.5	3.5	3.5	2	0.8	1.8	1.8	0.5	4.1	3	**60**
Element	Trade	Sidewalk	Lighting	Tree	Cycle	Planter	Shoulder & Channel	PT	Drive	Drive	Drive	Median & lighting	Drive	Drive	Drive	PT	Shoulder & Channel	Planter	Cycle	Tree	Lighting	Sidewalk	Trade	
Sub-class	**1B (2) - Trunk route (with dual PT lanes - outside high-density areas)**																							
Width (m)	3.6	3.5	0.5	1.8	1.8	0.8	2	3.5	3.5	3.5	3.5	4	3.5	3.5	3.5	3.5	2	0.8	1.8	1.8	0.5	3.5	3.6	**60**
Element	Verge	Sidewalk	Lighting	Tree	Cycle	Planter	Shoulder & Channel	PT	Drive	Drive	Drive	Median & lighting	Drive	Drive	Drive	PT	Shoulder & Channel	Planter	Cycle	Tree	Lighting	Sidewalk	Verge	
Sub-class	**1B (3) - Trunk route (with dual kerb-side PT lanes & stop on one side only)**																							
Width (m)	2	3	0.5	1.8	1.8	0.8	2	3.5	3.5	3.5	3.5	4	3.5	3.5	3.5	3.5	3.7	2.5	0.8	1.8	1.8	0.5	3	2	**60**
Element	Trade	Sidewalk	Lighting	Tree	Cycle	Planter	Shoulder & Channel	PT	Drive	Drive	Drive	Median & lighting	Drive	Drive	Drive	PT	PT Stop lane & Channel	PT Shelter	Planter	Cycle	Tree	Lighting	Side walk	Trade	

Table 2.7: Class 2: Cross-Section Elements

Sub-class	**2A (1) - Major arterial (with median BRT trunk lanes)**																		
Width (m)		3	1	1	1.8	0.5	0.2 + 3.5	3.5	3.5	4	3.5	3.5	3.5 + 0.2	0.5	1.8	1	1	3	**40**
Element		Sidewalk	Tree	Lighting	Cycle	Planter	Channel + Drive	Drive	BRT	Median	BRT	Drive	Drive + Channel	Planter	Cycle	Lighting	Tree	Sidewalk	
Sub-class	**2A (2) - Major arterial (with tandem median BRT station - stopping & passing lane one side only)**																		
Width (m)	1.5	1	0.8	1.8	0.4	0.2 + 3.5	3.5	3.5	4	3.5	3.5	3.5	3.5 + 0.2	0.4	1.8	0.9	1	1.5	**40**
Element	Sidewalk	tree	Lighting	Cycle	Planter	Channel + Drive	Drive	BRT	Station	BRT - Stop	BRT - pass	Drive	Drive + Channel	Planter	Cycle	Lighting	tree	Sidewalk	
Sub-class	**2A (3) - Major arterial (with median BRT station - stopping & passing lane on both sides)**																		
Width (m)		1.7	0.4	1.8	0.3	0.2 + 3.3	3.3	3.5	3.5	4	3.5	3.5	3.3	3.3 + 0.2	0.4	1.8	0.3	1.7	**40**
Element		Sidewalk	Lighting	Cycle	Planter	Channel + Drive	Drive	BRT - pass	BRT - Stop	Station	BRT - Stop	BRT - pass	Drive	Drive + Channel	Planter	Cycle	Lighting	Sidewalk	
Sub-class	**2B (1) - Major arterial (with kerb-side PT lanes)**																		
Width (m)	2	2.4	1	1.8	0.8	0.5	0.2 + 3.5	3.5	3.5	2.1	3.5	3.5	3.5 + 0.2	0.8	1.8	1	2.4	2	**40**
Element	Trading	Sidewalk	tree	Cycle	Lighting	Planter	Channel + Bus	Drive	Drive	Median	Drive	Drive	Bus +channel	Lighting	Cycle	Tree	Sidewal k	Trading	
Sub-class	**2B (2) - Major arterial (with PT shelter & bus stopping lane on 1 kerb-side)**																		
Width (m)			2.4	1.8	0.8	0.5	0.2 + 3.5	3.5	3.5	2.1	3.5	3.5	3.5	3.5 + 0.2	2.5	0.8	1.8	2.4	**40**
Element			Sidewalk	Cycle	Lighting	Planter	Channel + Bus	Drive	Drive	Median	Drive	Drive	Bus	Bus stop +channel	Shelter	Lighting	Cycle	Sidewalk	

Table 2.8: Class 3: Cross-Section Elements

Sub-class	**3A (1) - Minor arterial (with BRT feeder route)**														
Width (m)	2.5	1	1.8	1	0.2 + 3.3	3.5	1.5	3.5	3.3 + 0.2	1	1.8	0.9	2.5		**28**
Element	Sidewalk	Tree	Cycle	Lighting	Channel + BRT/Drive	Drive	Median	Drive	BRT/Drive + Channel	Lighting	Cycle	Tree	Sidewalk		
Sub-class	**3A (2) - Minor arterial (with BRT feeder & Stop)**														
Width (m)	2	0.7	1.8	0.3	0.2 + 3.5	3.5	1.5	3.5	3.5 + 0.2	2.5	0.3	1.8	0.7	2	**28**
Element	Sidewalk	Tree	Cycle	Lighting	Channel + BRT/Drive	Drive	Median	Drive	BRT/Drive + Channel	BRT shelter	Lighting	Cycle	Tree	Sidewalk	
Sub-class	**3A (3) - Minor arterial (with BRT feeder & turning lane)**														
Width (m)	2	0.5	1.8	0.3	0.2 + 3.5	3.5	3.4	1	3.5	3.5 + 0.2	0.3	1.8	0.5	2	**28**
Element	Sidewalk	Planter	Cycle	Lighting	Channel + BRT/Drive	Drive	Turn	Median	Drive	BRT/Drive + Channel	Lighting	Cycle	Planter	Sidewalk	
Sub-class	**3B (1) - Minor arterial (with PT route)**														
Width (m)	2.5	1	1.8	0.8	0.2 + 3.5	3.5	1.4	3.5	3.5 + 0.2	0.8	1.8	1	2.5		**28**
Element	Sidewalk	Tree	Cycle	Lighting	Channel + PT/Drive	Drive	Median	Drive	PT/Drive + Channel	Lighting	Cycle	Tree	Sidewalk		
Sub-class	**3B (2) - Minor arterial (with PT route & shelter on one side)**														
Width (m)	2.2	0.5	1.8	0.3	0.2 + 3.5	3.5	1.4	3.5	3.5 + 0.2	2.5	0.3	1.8	0.5	2.3	**28**
Element	Sidewalk	Planter	Cycle	Lighting	Channel + PT/Drive	Drive	Median	Drive	PT/Drive + Channel	PT Shelter	Lighting	Cycle	Planter	Sidewalk	
Sub-class	**3B (3) - Minor arterial (with PT route & turning lane)**														
Width (m)	2	0.5	1.8	0.3	0.2 + 3.5	3.5	3.4	1.1	3.5	3.5 + 0.2	0.3	1.8	0.4	2	**28**
Element	Sidewalk	Planter	Cycle	Lighting	Channel + PT/Drive	Drive	Turn	Median	Drive	PT/Drive + Channel	Lighting	Cycle	Planter	Sidewalk	

Table 2.9: Class 4: Cross-Section Elements

Sub-class	**4A (1P) - Collector (Commercial & mixed-use, parking both sides) - PAVED**									
Width (m)	2.4	0.4	0.2 + 2.5	3.7	3.7	2.5 +0.2	0.4	2	2	**20**
Element	Sidewalk	Planter	Channel + Parking	Drive	Drive	Parking + Channel	Lighting	Sidewalk	Trade	
Sub-class	**4A (1G) - Collector (Commercial & mixed-use, parking both sides) - GRAVEL/EARTH**									
Width (m)	2.4	1.6	2.5	3.5	3.5	2.5	1.6	2.4		**20**
Element	Sidewalk	Drainage	Parking	Drive	Drive	Parking	Drainage	Sidewalk		
Sub-class	**4A (2P) - Collector (Commercial & mixed-use, no parking & turning lane) - PAVED**									
Width (m)	2.4	0.4 + 3.5	3.5	3.5 + 0.4	0.4	0.4	3	2.5		**20**
Element	Sidewalk	Channel + Drive	Turn	Drive + Channel	Lighting	Planter	Sidewalk	Trade		
Sub-class	**4A (2G) - Collector (Commercial & mixed-use, no parking - GRAVEL/EARTH - Dual crossfall**									
Width (m)	3.1	1.6	4	4	1.6	3.1	2.6			**20**
Element	Sidewalk	Drainage	Drive	Drive	Drainage	Sidewalk	Trade			
Sub-class	**4A (3G) - Collector (Commercial & mixed-use, no parking - GRAVEL/EARTH -Single crossfall**									
Width (m)	3.5	1.6	4.2	4.2	3.5	3				**20**
Element	Sidewalk	Drainage	Drive	Drive	Sidewalk	Trade				
Sub-class	**4B (1P) - Collector (Residential, parking both sides) - PAVED**									
Width (m)	2.8	0.4	0.4	0.2 + 2.5	3.7	3.7	2.5 + 0.2	0.8	2.8	**20**
Element	Sidewalk	Planter	Lighting	Channel + Parking	Drive	Drive	Parking + Channel	Tree	Sidewalk	
Sub-class	**4B (1G) - Collector (Residential, parking both sides) - GRAVEL/EARTH**									
Width (m)	2.4	1.6	2.5	3.5	3.5	2.5	1.6	2.4		**20**
Element	Sidewalk	Drainage	Parking	Drive	Drive	Parking	Drainage	Sidewalk		
Sub-class	**4B (2P) - Collector (Residential, no parking & turning lane) - PAVED**									
Width (m)	3.5	0.4	0.4	0.4 + 3.5	3.5	3.5 + 0.4	0.9	3.5		**20**
Element	Sidewalk	Planter	Lighting	Channel + Drive	Turn	Drive + Channel	Planter	Sidewalk		

Sub-class	**4B (2G) - Collector (Residential, parking 1 side) - GRAVEL/EARTH - dual crossfall**									
Width (m)	3.4	1.6	3.8	3.8	2.5	1.6	3.3			**20**
Element	Sidewalk	Drainage	Drive	Drive	Parking	Drainage	Sidewalk			
Sub-class	**4B (3G) - Collector (Residential, parking 1 side) - GRAVEL/EARTH - single crossfall**									
Width (m)	3.3	1.6	3.8	3.8	2.5	3	2			**20**
Element	Sidewalk	Drainage	Drive	Drive	Parking	Sidewalk	Trade			
Sub-class	**4C (1P) - Collector (Industrial, parking both sides) - PAVED**									
Width (m)	2.4	0.4	0.2 + 3.5	3.7	3.7	3.5 + 0.2	2.4			**20**
Element	Sidewalk	Lighting	Channel + Parking	Drive	Drive	Parking + Channel	Sidewalk			
Sub-class	**4C (2P) - Collector (Industrial, no parking & turning lane) - PAVED**									
Width (m)	3.7	0.4	0.2 + 3.7	3.8	3.7 + 0.2	0.6	3.7			**20**
Element	Sidewalk	Lighting	Channel + Drive	Turn	Drive + Channel	Planter	Sidewalk			

Table 2.10: Class 5: Cross-Section Elements

Sub-class	**5A (1P) - Access (Commercial, mixed-use, residential - parking both sides) - PAVED**							
Width (m)	1.9	2.3	3.3	3.3	2.3	1.9		**15**
Element	Sidewalk	Parking & Channel	Drive	Drive	Parking & Channel	Sidewalk & Lighting		
Sub-class	**5A (1G) - Access (Commercial, mixed-use, residential - parking 1 side) - GRAVEL/EARTH**							
Width (m)	2	1.6	3.5	3.5	2.3	2.1		**15**
Element	Sidewalk	Drainage	Drive	Drive	Parking	Sidewalk & Lighting		
Sub-class	**5A (2P) - Access (Commercial, mixed-use, residential - no parking & turning lane) - PAVED**							
Width (m)	2.5	3.5	3.1	3.5	0.4	2		**15**
Element	Sidewalk	Drive & Channel	Turn	Drive & Channel	Lighting & planters	Sidewalk		
Sub-class	**5A (2G) - Access (Commercial, mixed-use, residential - no parking) - GRAVEL/EARTH**							
Width (m)	2.8	1.6	3.5	3.5	2.4	1.2		**15**
Element	Sidewalk	Drainage	Drive	Drive	Sidewalk	Trade		
Sub-class	**5B (1P) - Access (Industrial - no parking) - PAVED ONLY**							
Width (m)	2.4	1.4	3.5	3.5	1.4	0.4	2.4	**15**
Element	Sidewalk	Shoulder & Channel	Drive	Drive	Shoulder & Channel	Lighting & planters	Sidewalk	
Sub-class	**5B (2P) - Access (Industrial - no parking & turning lane) - PAVED ONLY**							
Width (m)	1.9	3.7	3.5	3.7	0.3	1.9		**15**
Element	Sidewalk	Drive & Channel	Turn	Drive & Channel	Lighting & planters	Sidewalk		

Table 2.11: Class 6 & 7: Cross-Section Elements

Sub-class	**6P- Access way: Informal settlement - PAVED**				
Width (m)	1.8	4.4	1.8		**8**
Element	Sidewalk	Drive & Channel	Sidewalk & lighting		
Sub-class	**6G - Access way: Informal settlement - GRAVEL/EARTH**				
Width (m)	1.2	1	4.4	1.4	**8**
Element	SW	Open drainage	Drive	Sidewalk & lighting	
Sub-class	**7P - Access way: NMT only - PAVED**				
Width (m)	1.3	3	1.7		**6**
Element	Verge	NMT & Channel	Verge & lighting		
Sub-class	**7G - Access way: NMT only - GRAVEL/EARTH**				
Width (m)	0.8	1	3.2	1	**6**
Element	Verge	Open drainage	NMT	Verge & lighting	

STYLISED ROAD CROSS-SECTIONS

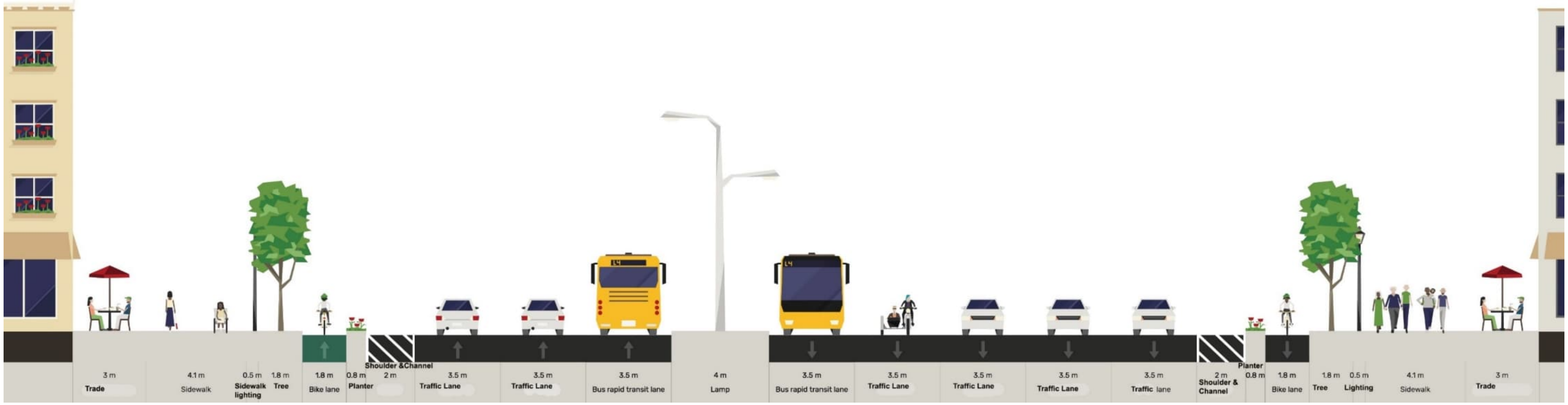


Figure 2.2: 1A (1) - Trunk Route (with BRT lanes)

Figure 2.3: 1A (2) - Trunk Route (with median BRT station & dual passing lanes)

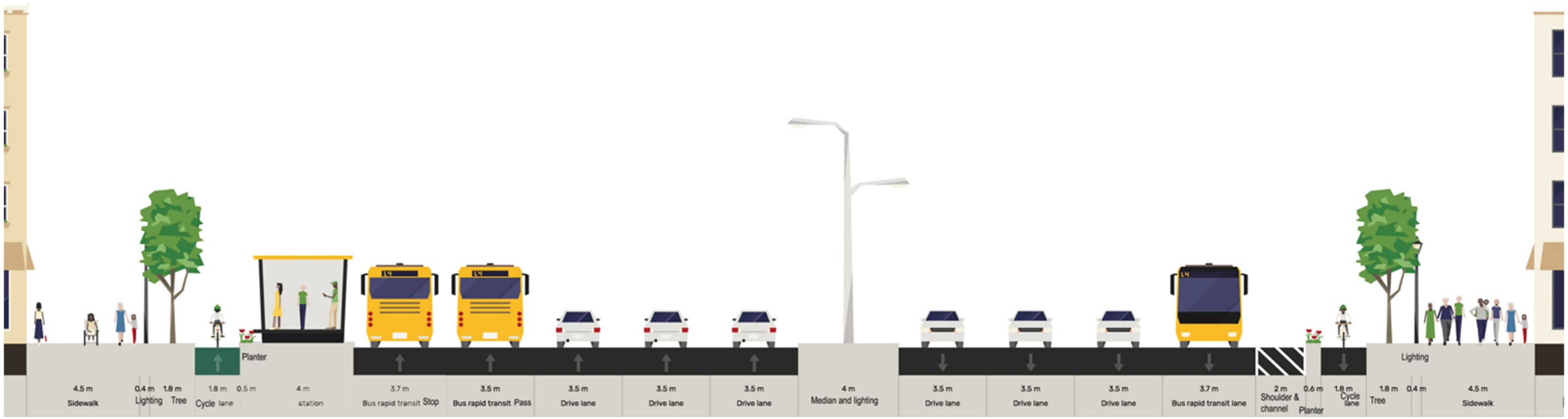


Figure 2.4: 1A (3) - Trunk route (with single kerb-side BRT station & passing lane)

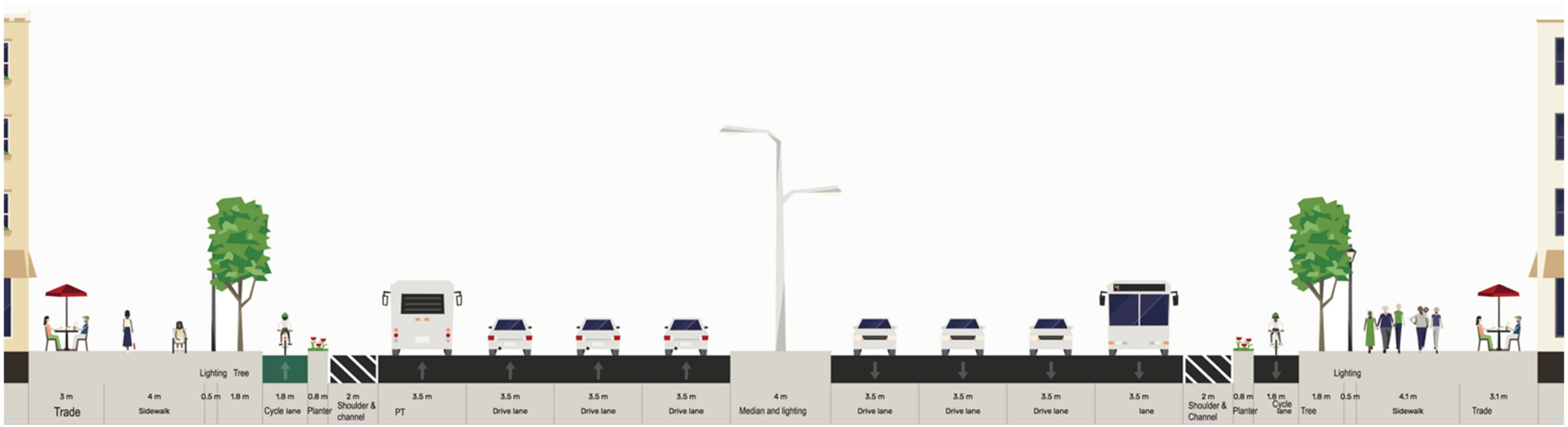


Figure 2.5: 1B (1) - Trunk route (with dual kerb-side PT lanes - high density areas)

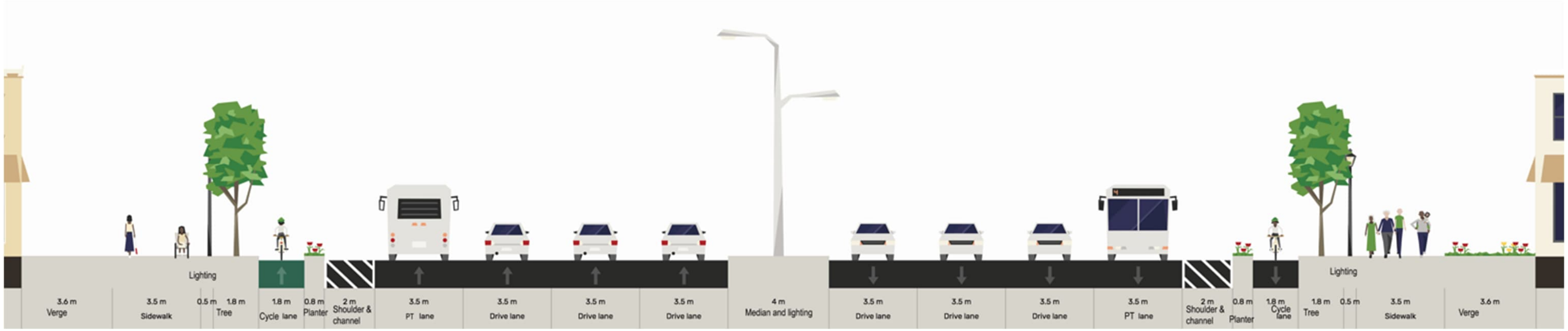


Figure 2.6: 1B (2) - Trunk route (with dual PT lanes - outside high-density areas)

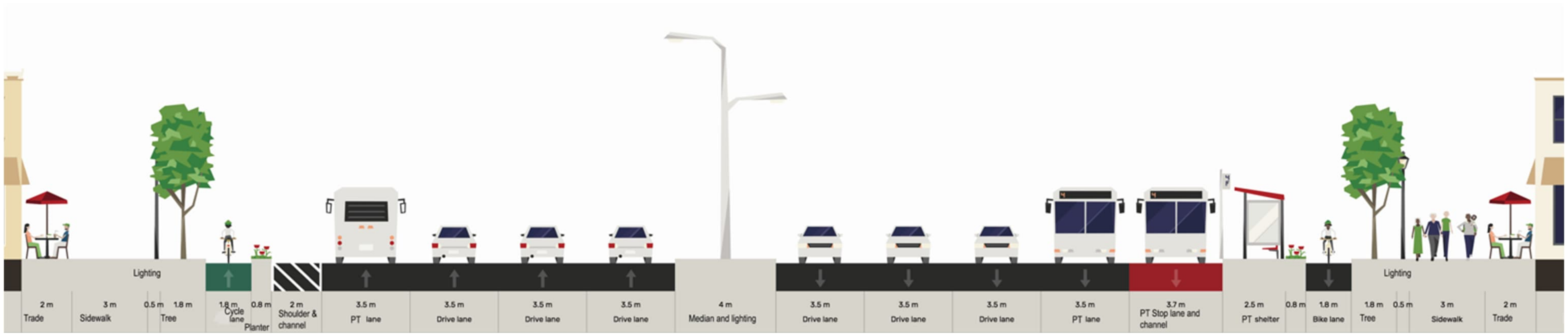


Figure 2.7: 1B (3) - Trunk route (with dual kerb-side PT lanes & stop on one side only)

Figure 2.8: 2A (1) - Major arterial (with median BRT trunk lanes)

Figure 2.9: 2A (2) - Major arterial (with tandem median BRT station - stopping & passing on 1 side)

Figure 2.10: 2A (3) - Major arterial (with median BRT station - stopping & passing lane on both sides)

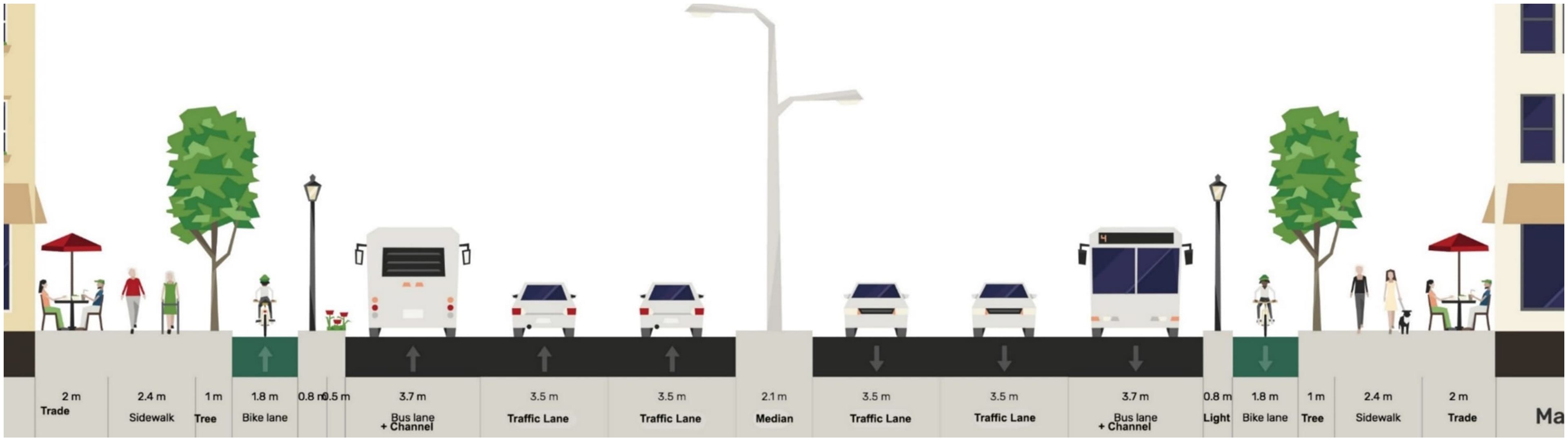


Figure 2.11: 2B (1) - Major Arterial (with kerb-side PT lanes)

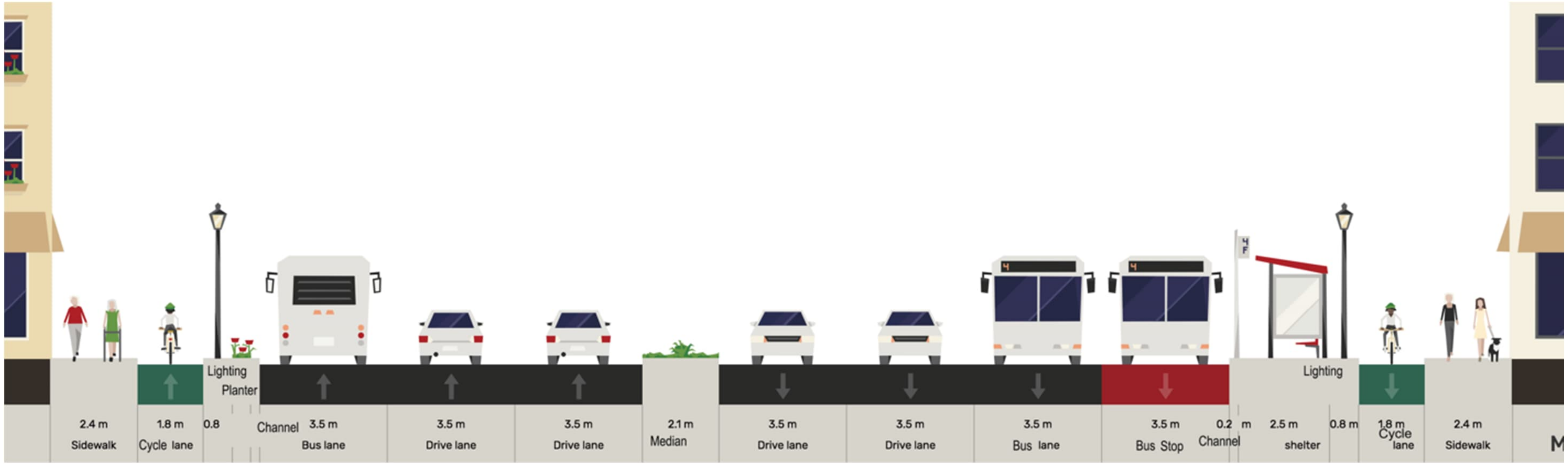


Figure 2.12: 2B (2) - Major arterial (with PT shelter & bus stopping lane on 1 kerb-side)

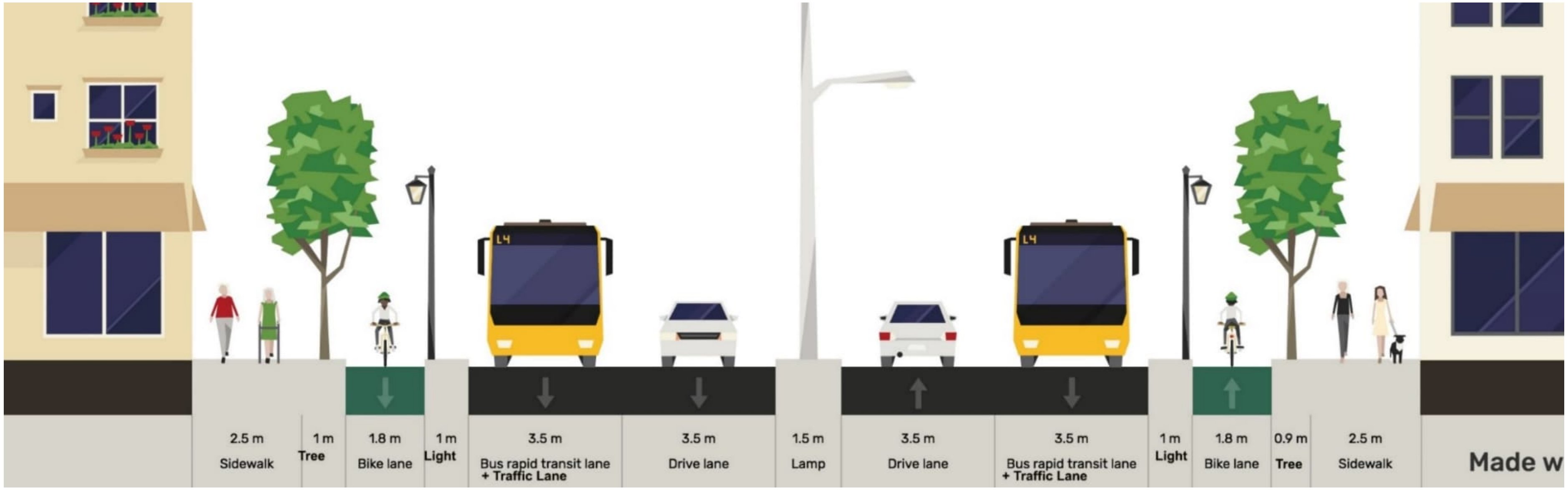


Figure 2.13: 3A (1) - Minor Arterial (with BRT feeder route)

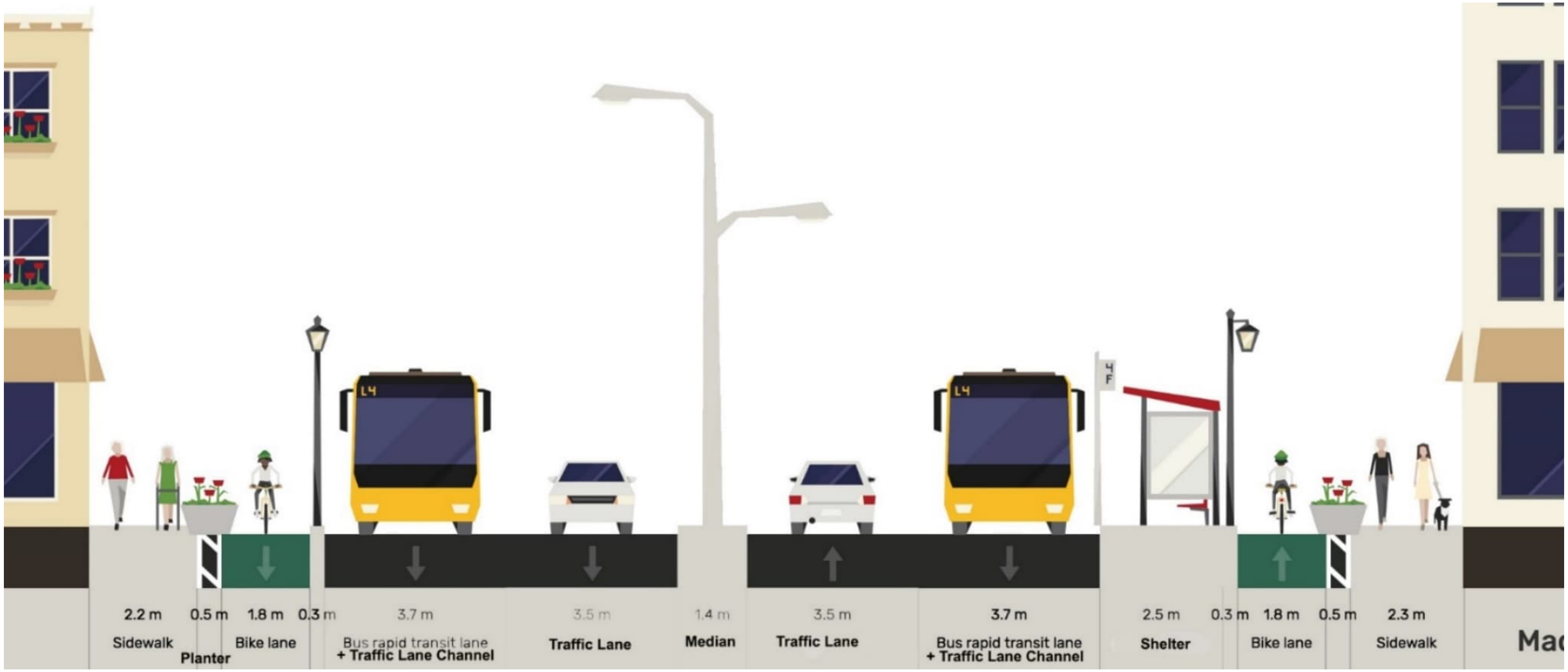


Figure 2.14: 3A (2) - Minor Arterial (with BRT feeder & Stop)

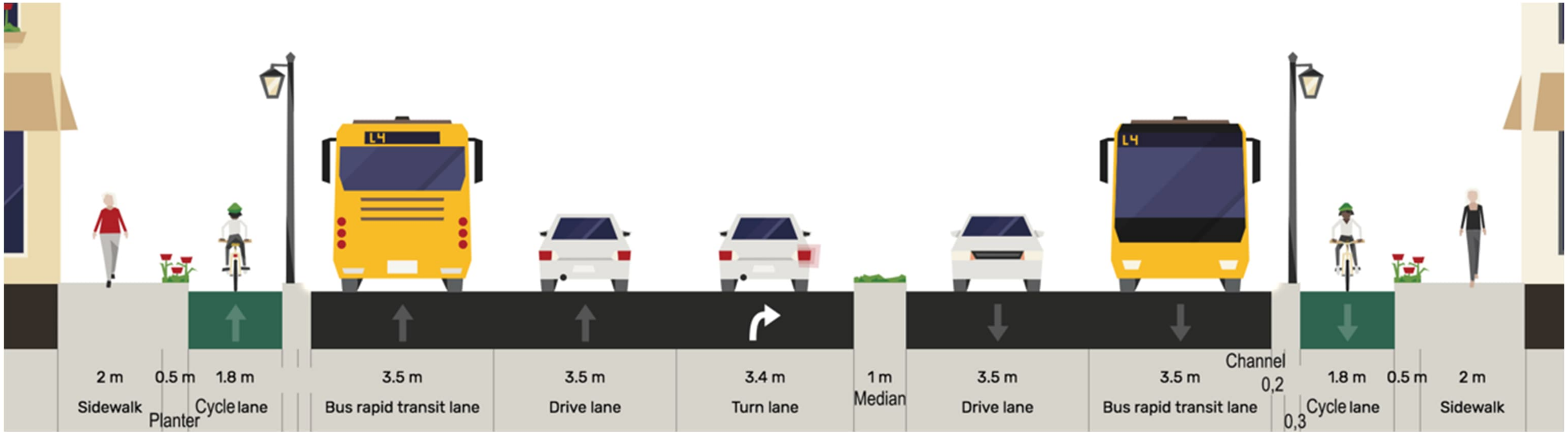


Figure 2.15: 3A (3) - Minor arterial (with BRT feeder & turning lane)

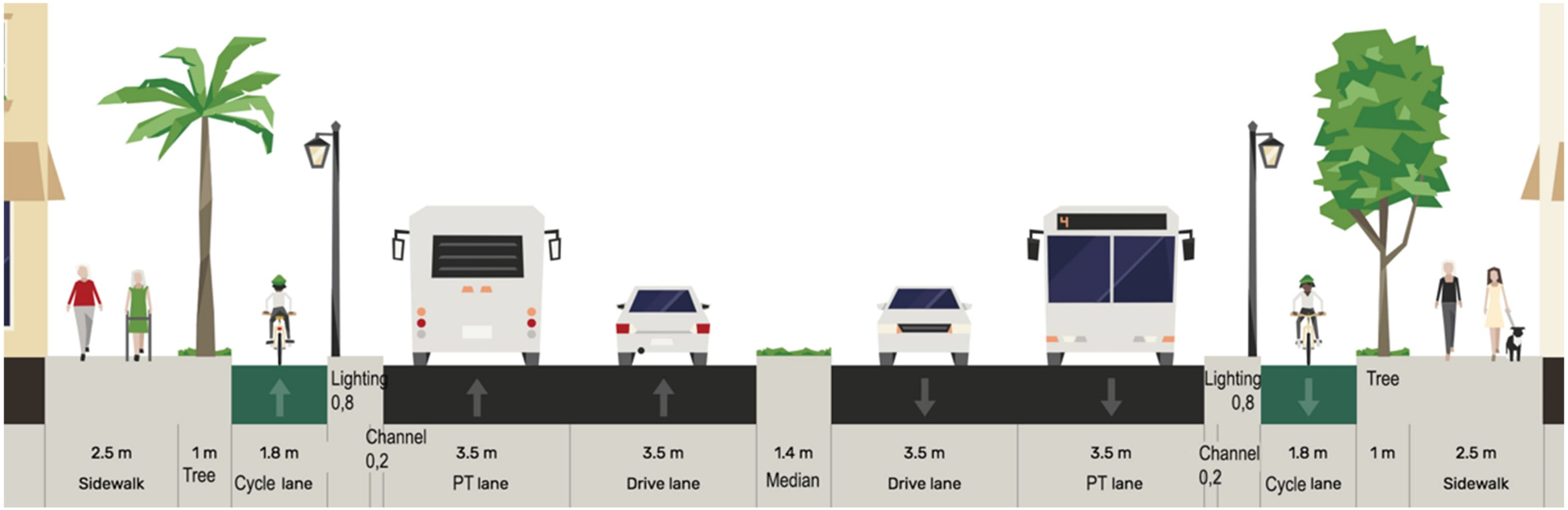


Figure 2.16: 3B (1) - Minor arterial (with PT route)

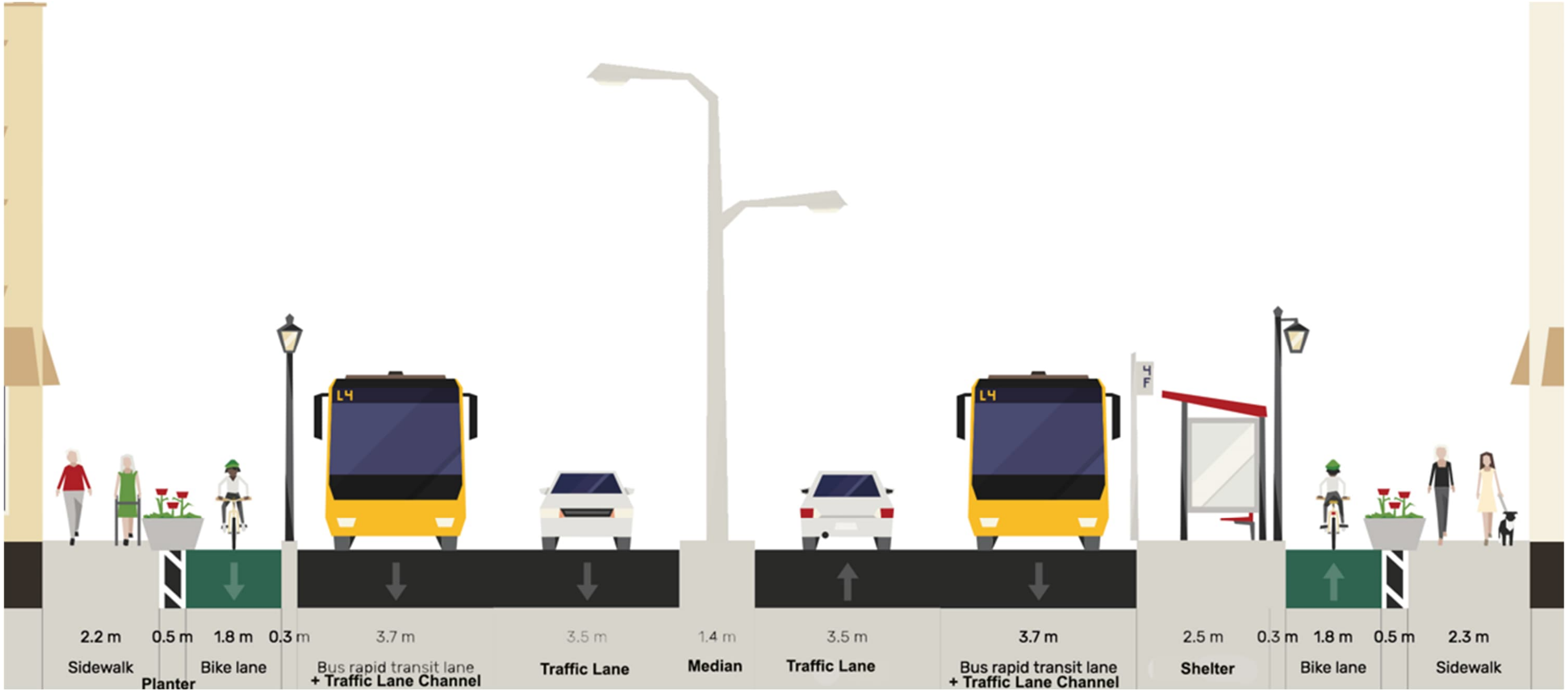


Figure 2.17: 3B (2) - Minor Arterial (with PT route & shelter on one side)

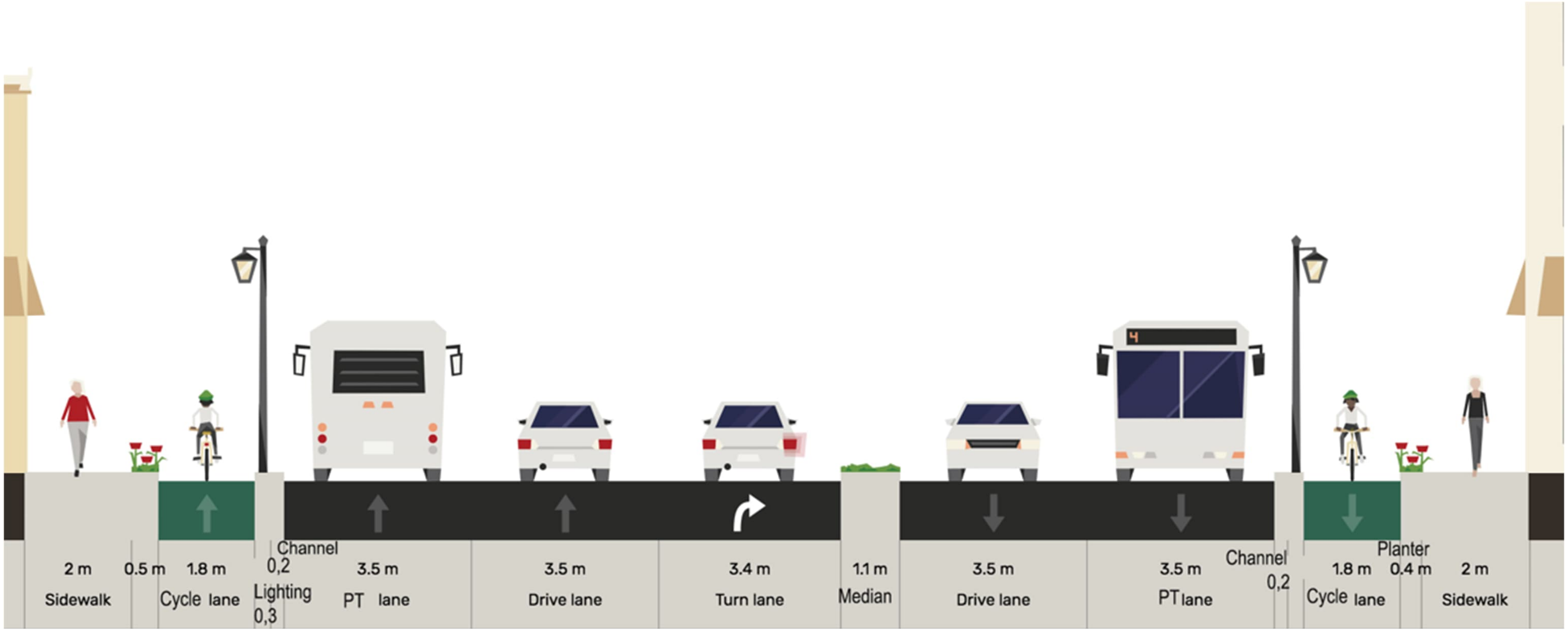


Figure 2.18: 3B (3) - Minor arterial (with PT route & turning lane)

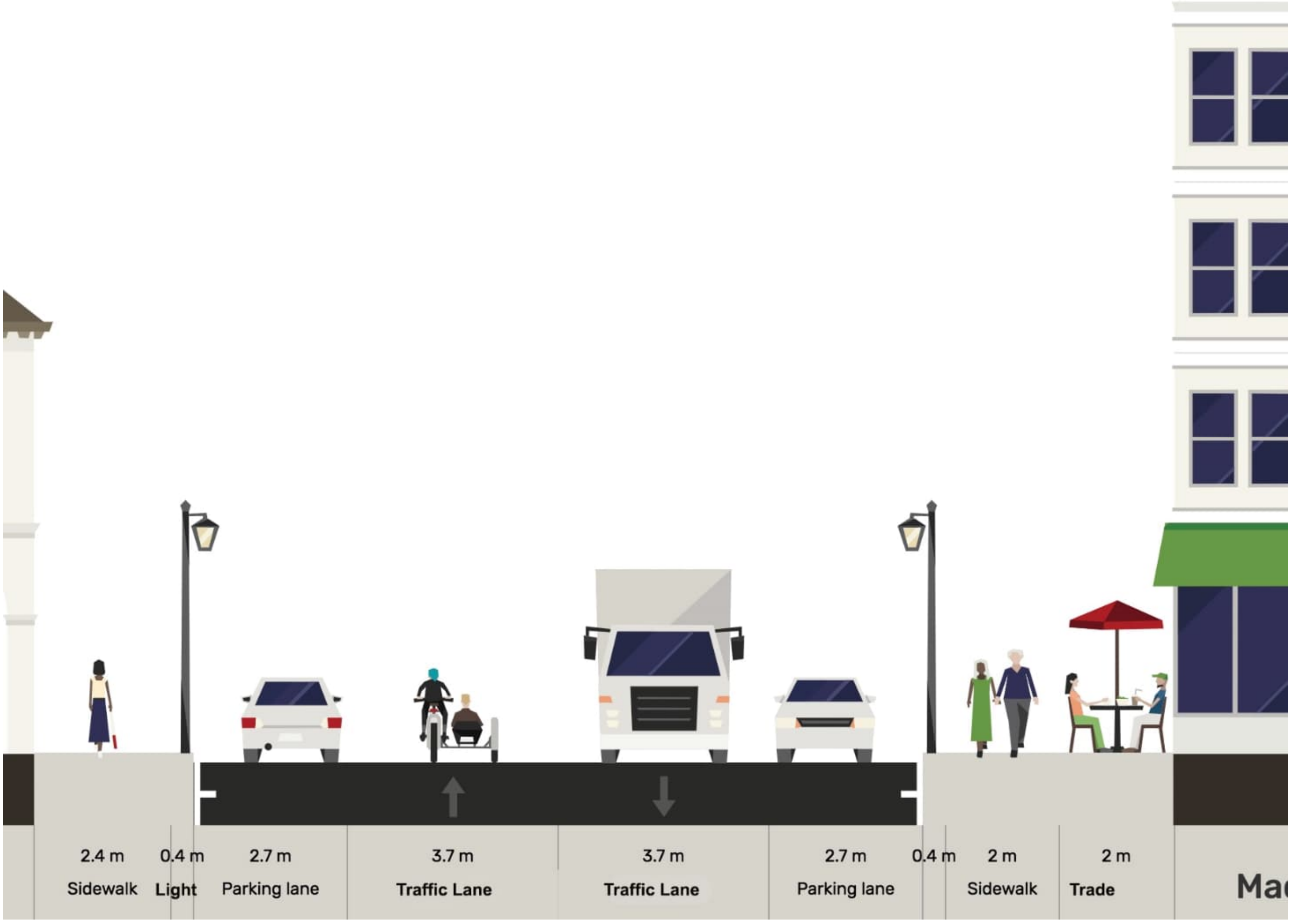


Figure 2.19: 4A (1P) - Collector (Commercial & mixed-use, parking both sides) - PAVED

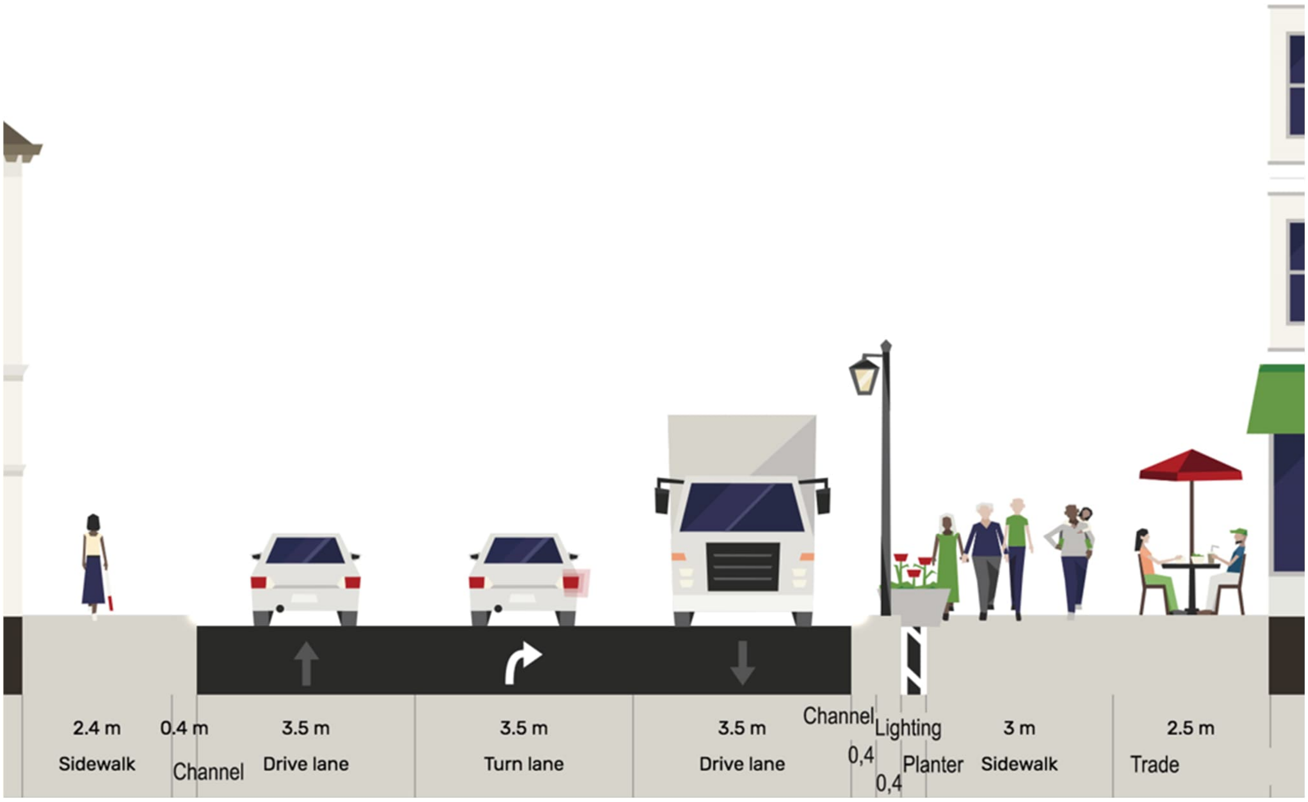
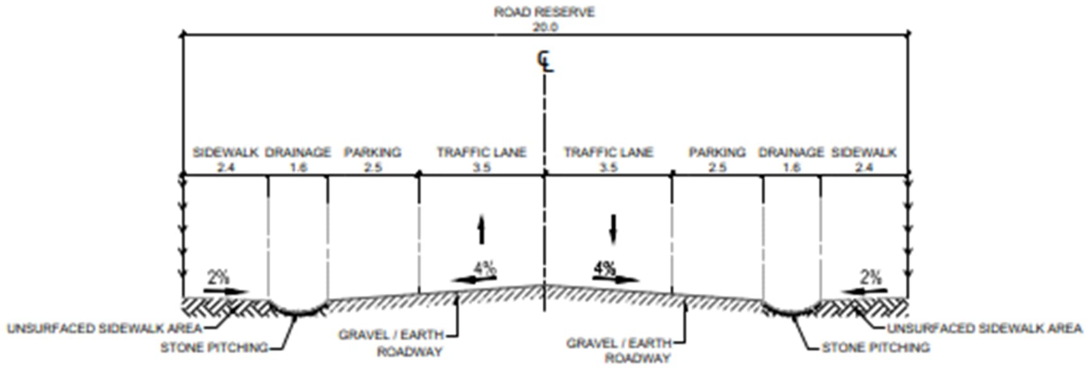
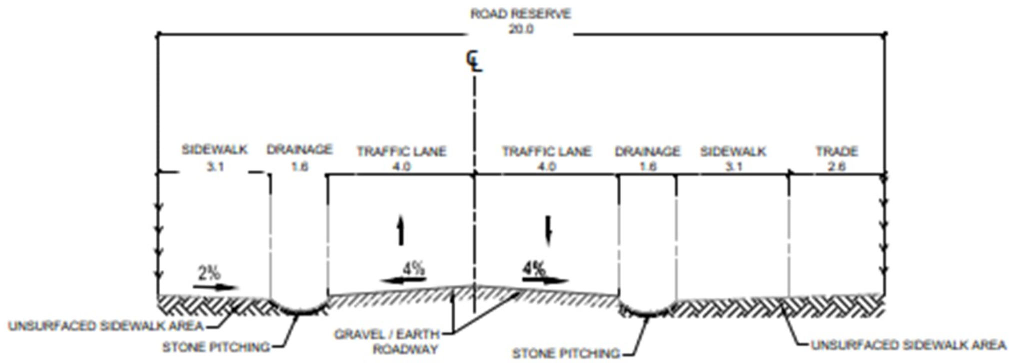


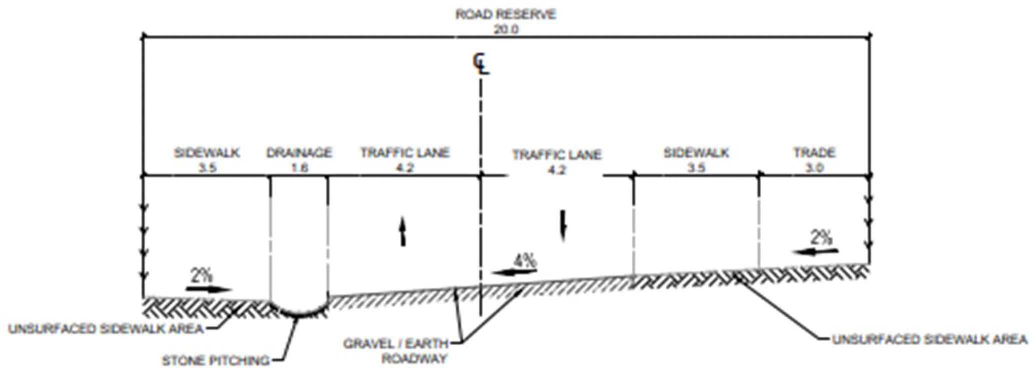
Figure 2.20: 4A (2P) - Collector (Commercial & mixed-use, no parking & turning lane) - PAVED



4A (1G) - COLLECTOR (COMMERCIAL & MIXED-USE) - GRAVEL / EARTH



4A (2G) - COLLECTOR (COMMERCIAL & MIXED-USE) - GRAVEL / EARTH DUAL CROSS FALL



4A (3G) - COLLECTOR (COMMERCIAL & MIXED-USE) - GRAVEL / EARTH SINGLE CROSS FALL

Figure 2.21: 4A (1G to 3G) - Collector (Commercial & mixed-use) GRAVEL

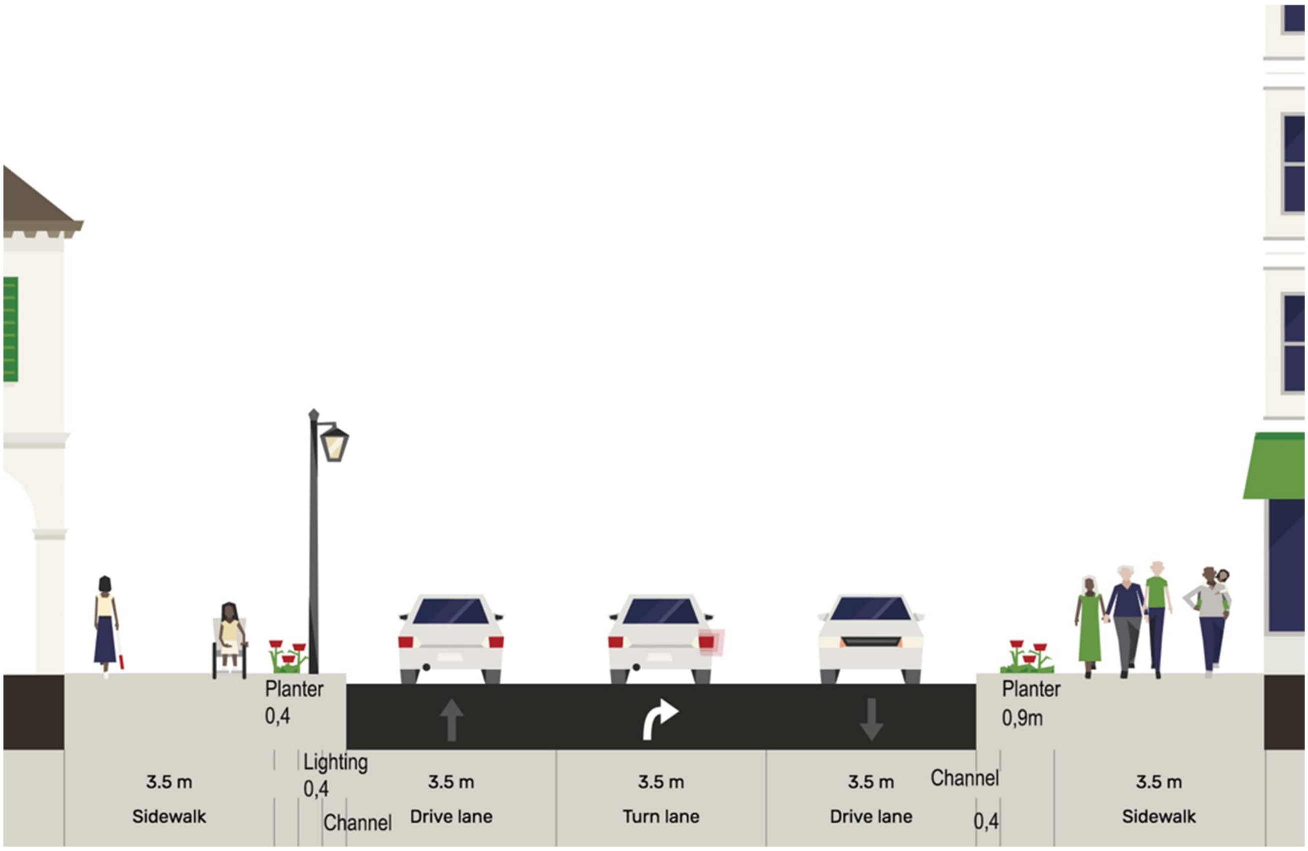


Figure 2.22: 4B (1P) - Collector (Residential, parking both sides) – PAVED

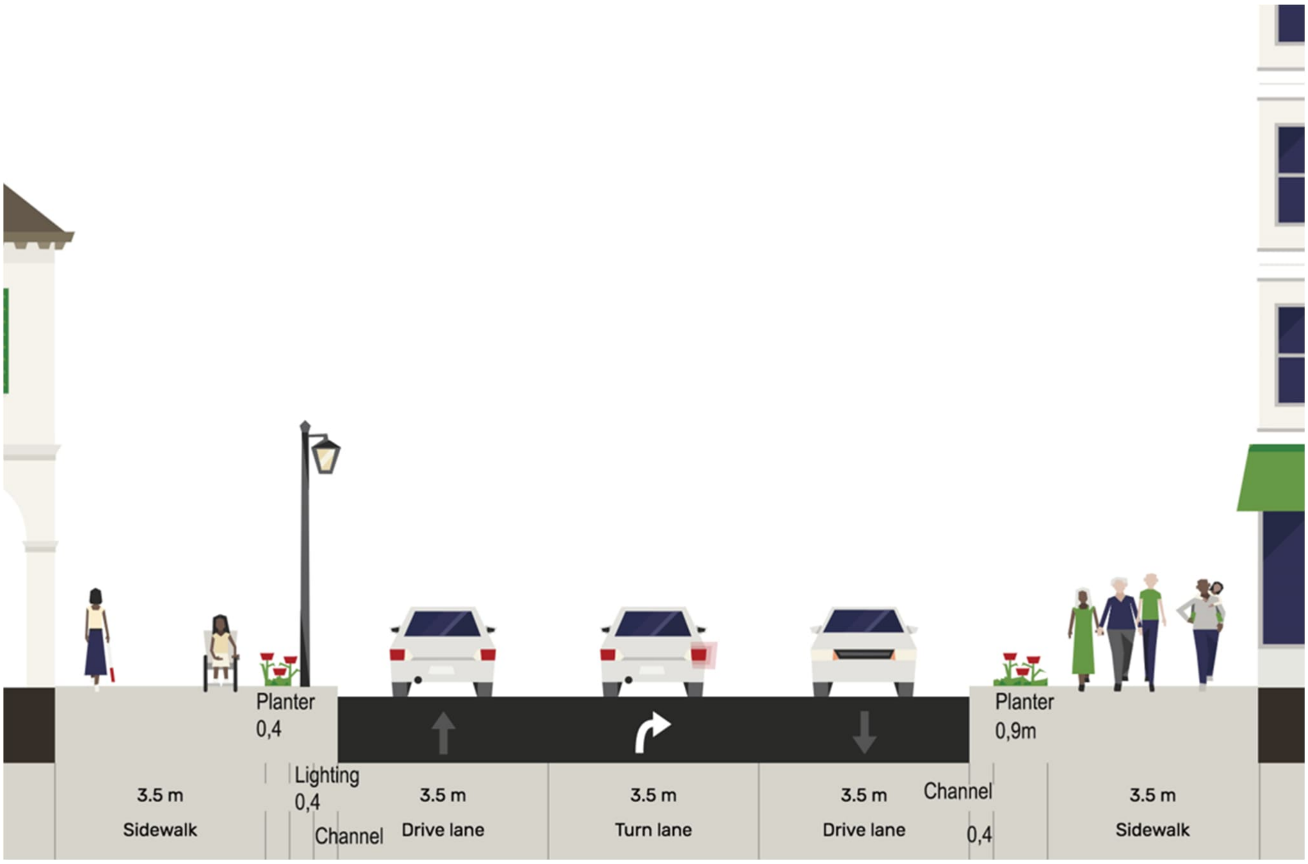


Figure 2.23: 4B (2P) - Collector (Residential, no parking & turning lane) - PAVED

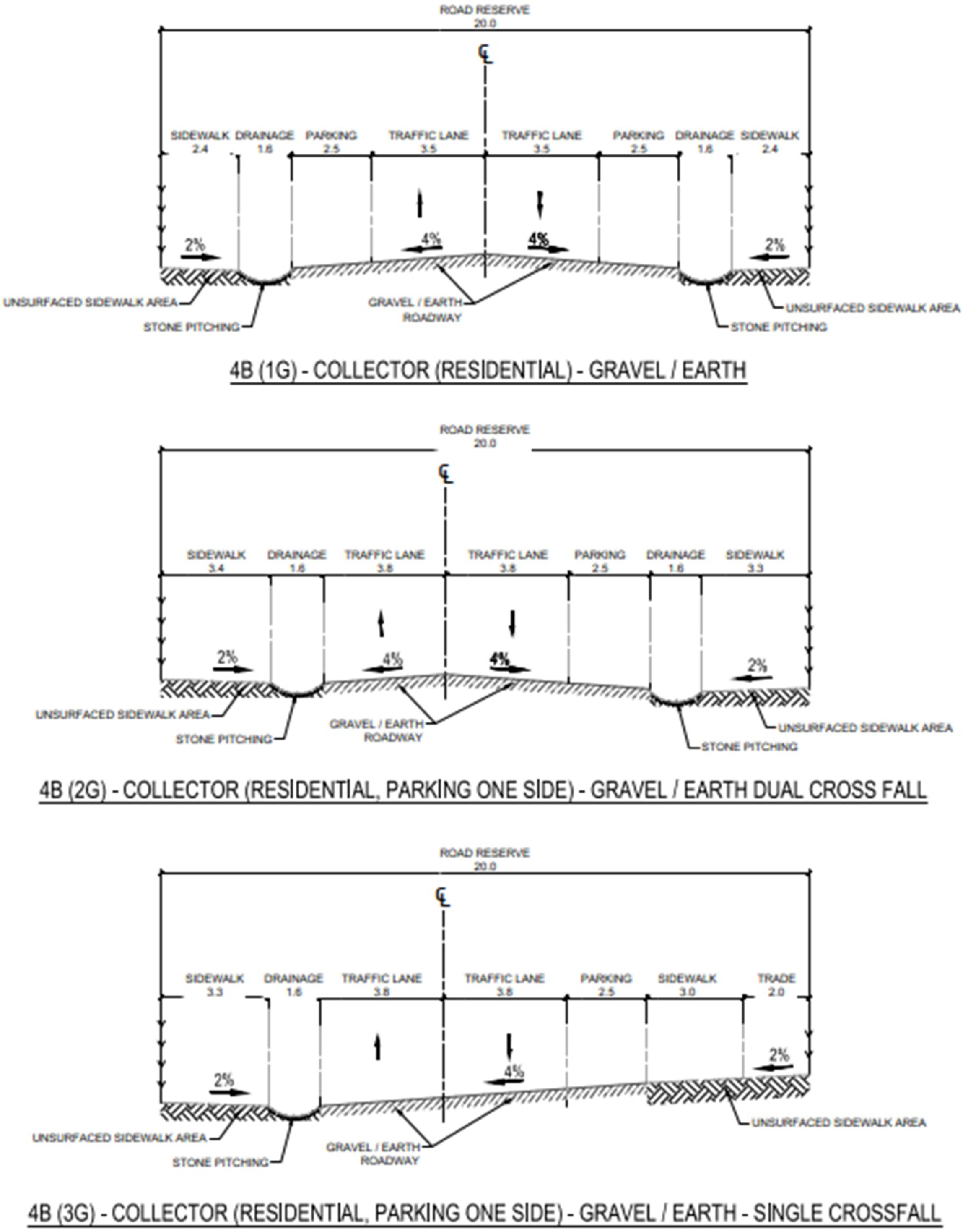


Figure 2.24: 4B (1G to 3G) - Collector (Residential) - GRAVEL

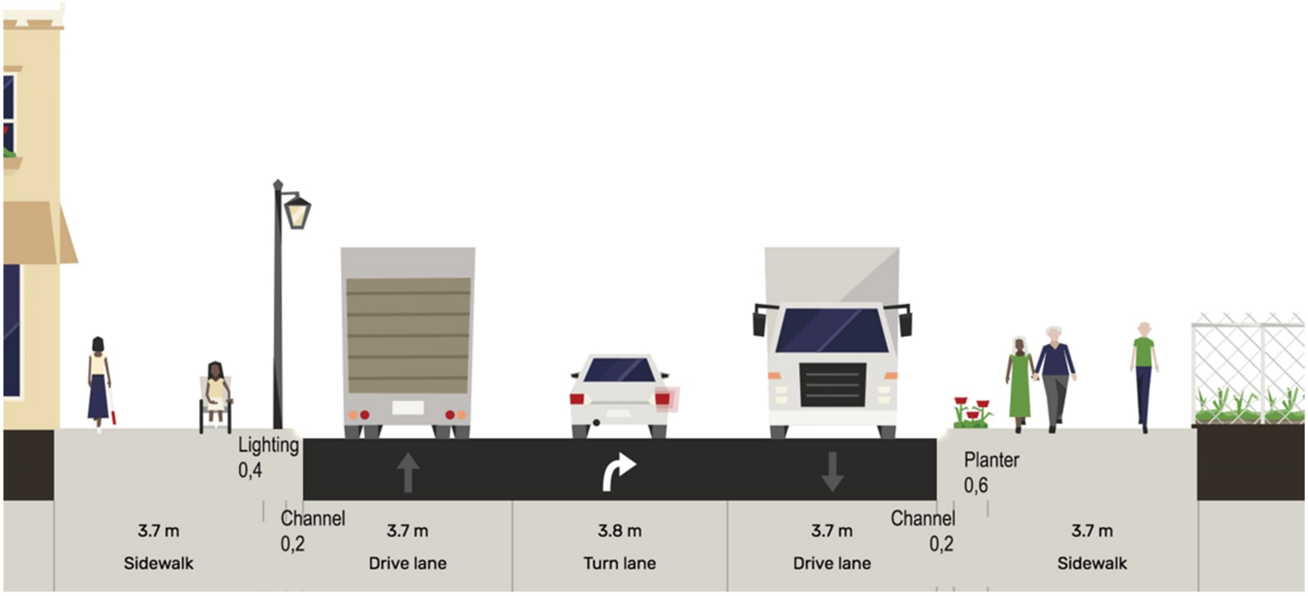


Figure 2.25: 4C (2P) - Collector (Industrial, no parking & turning lane) - PAVED

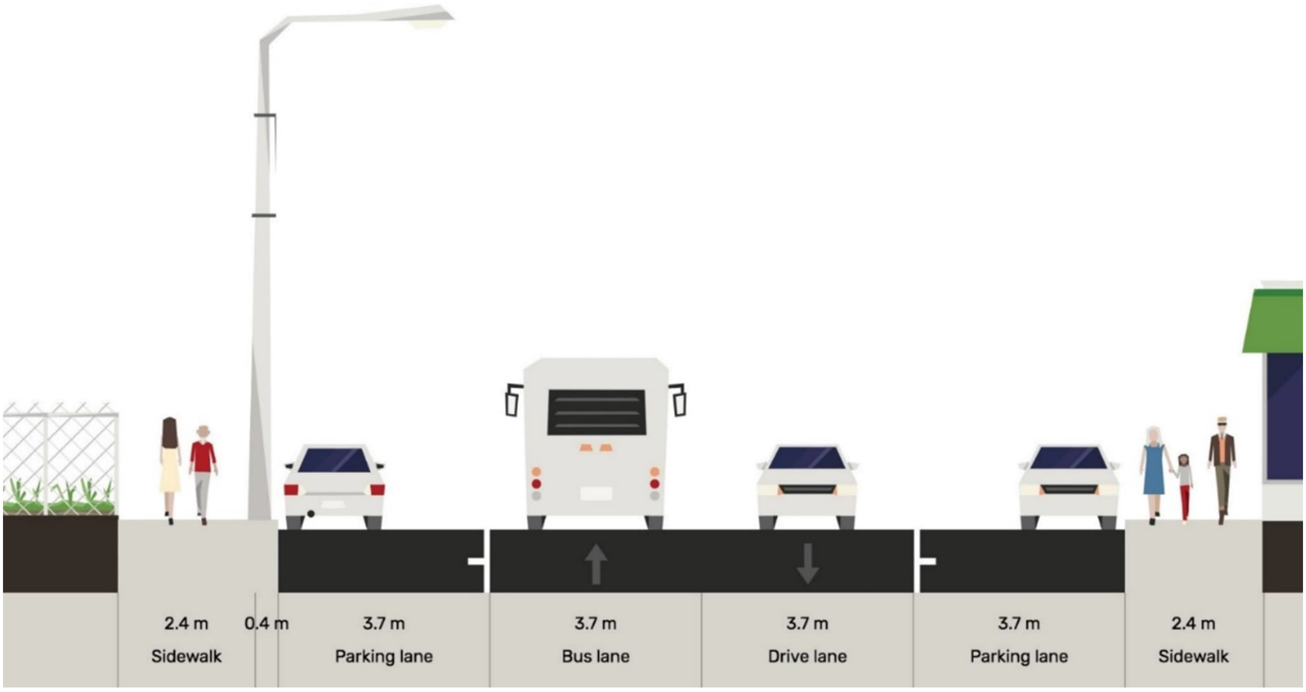


Figure 2.26: 4C (1P) - Collector (Industrial, parking both sides) - PAVED

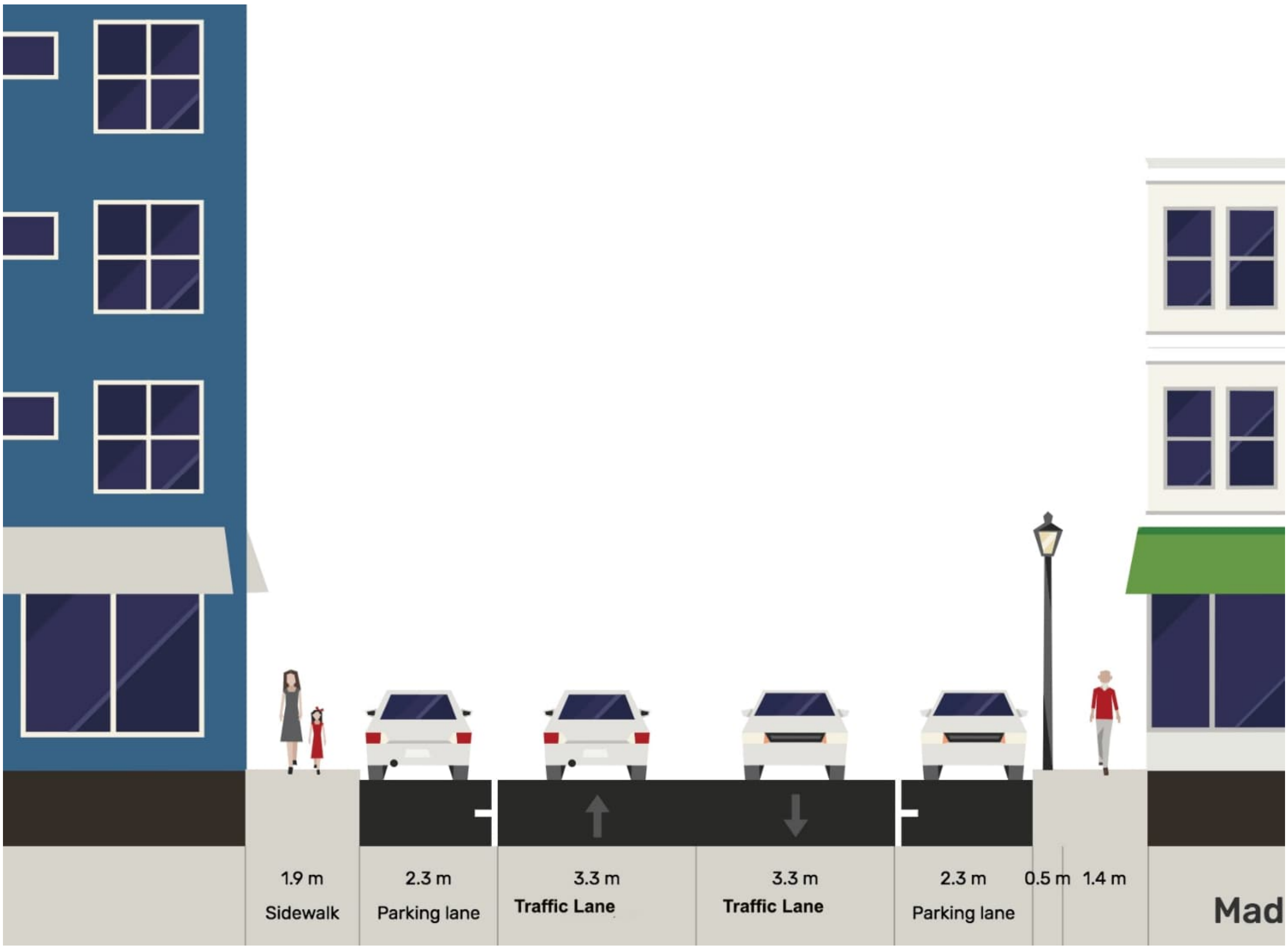


Figure 2.27: 5A (1P) - Access (Commercial, mixed-use, residential - parking both sides) – PAVED

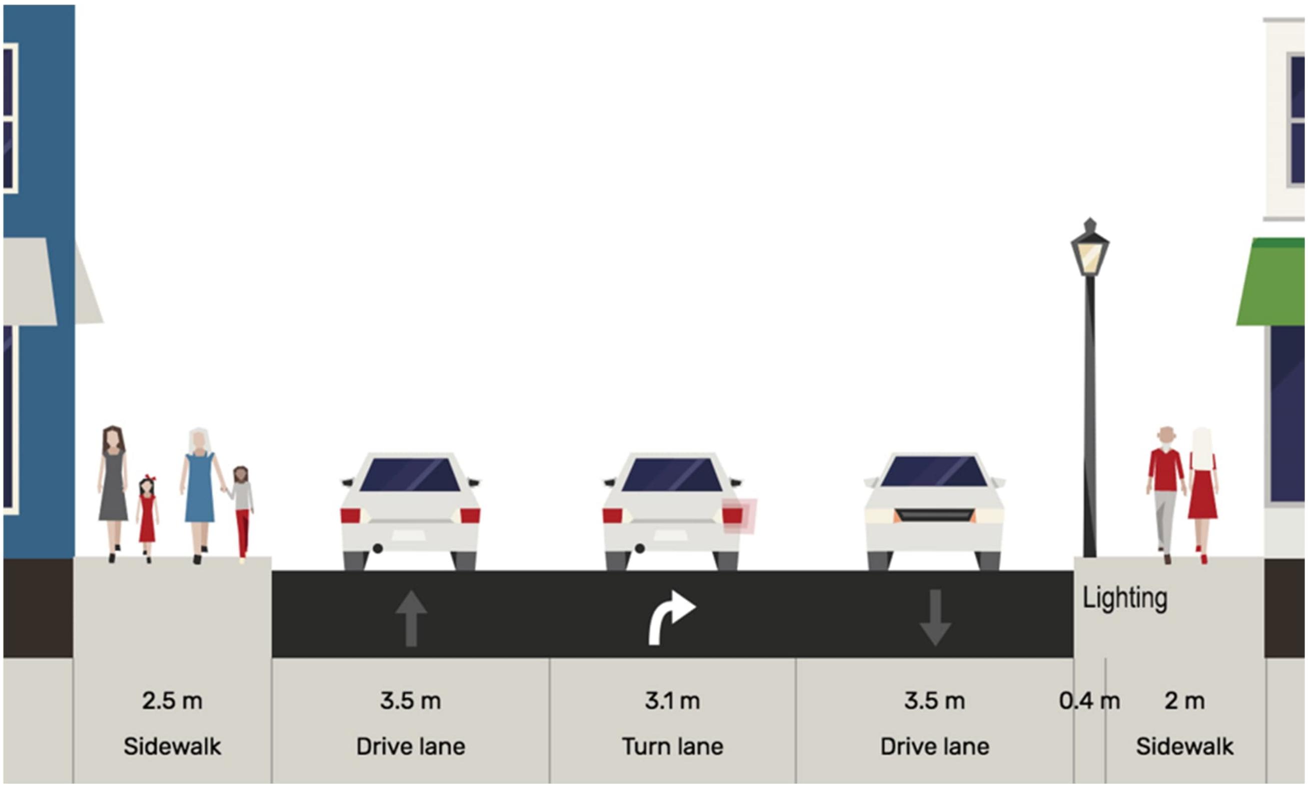
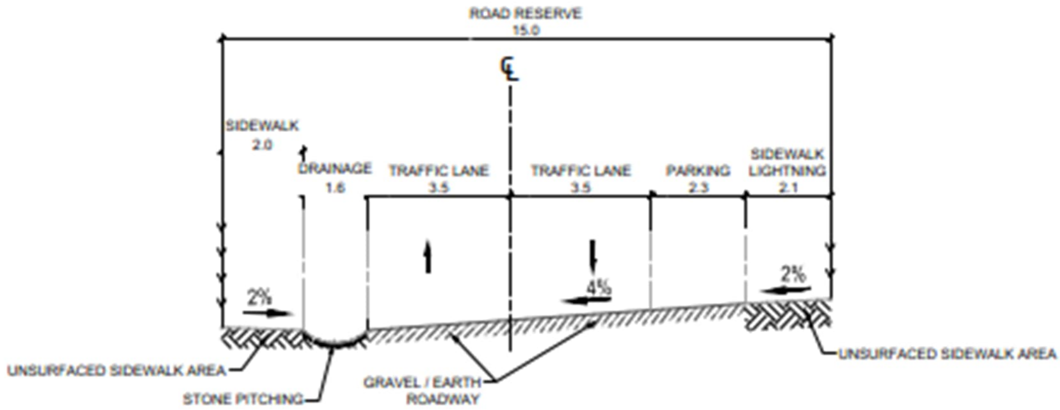
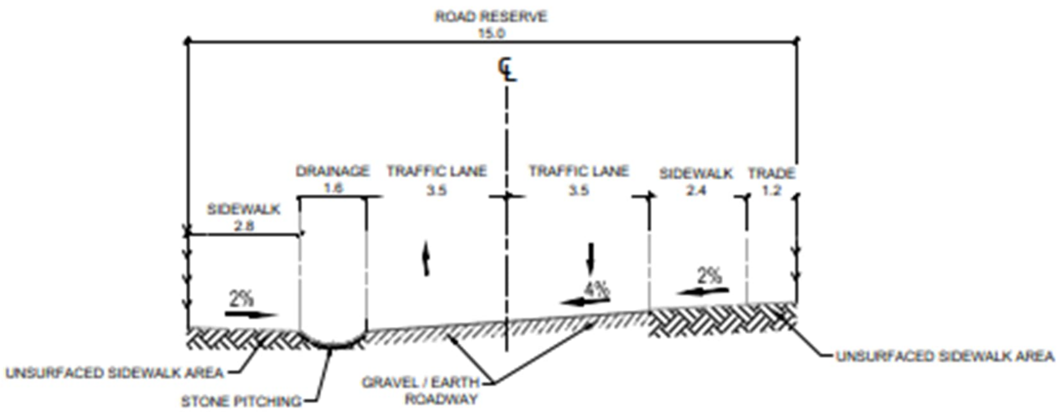


Figure 2.28: 5A (2P) - Access (Commercial, mixed-use, residential, no parking, turning lane) - PAVED



5A (1G) - ACCESS (COMMERCIAL, MIXED-USE, RESIDENTIAL) - GRAVEL / EARTH



5A (2G) - ACCESS (COMMERCIAL, MIXED-USE, RESIDENTIAL) - GRAVEL / EARTH

Figure 2.29: 5A (1G – 2G) - Access (Commercial, mixed-use, residential) - GRAVEL

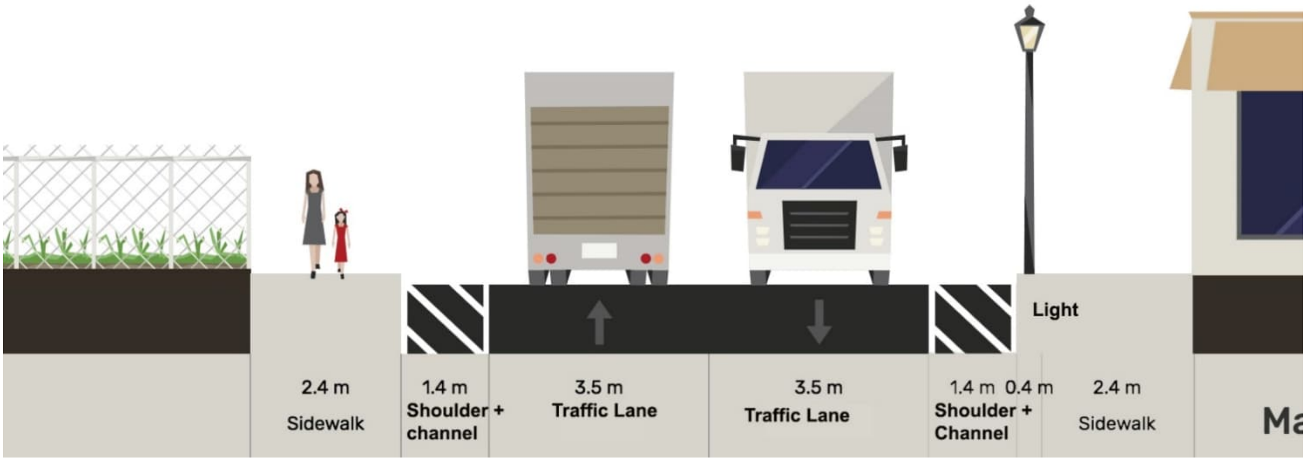


Figure 2.30: 5B (1P) - Access (Industrial - no parking) - PAVED

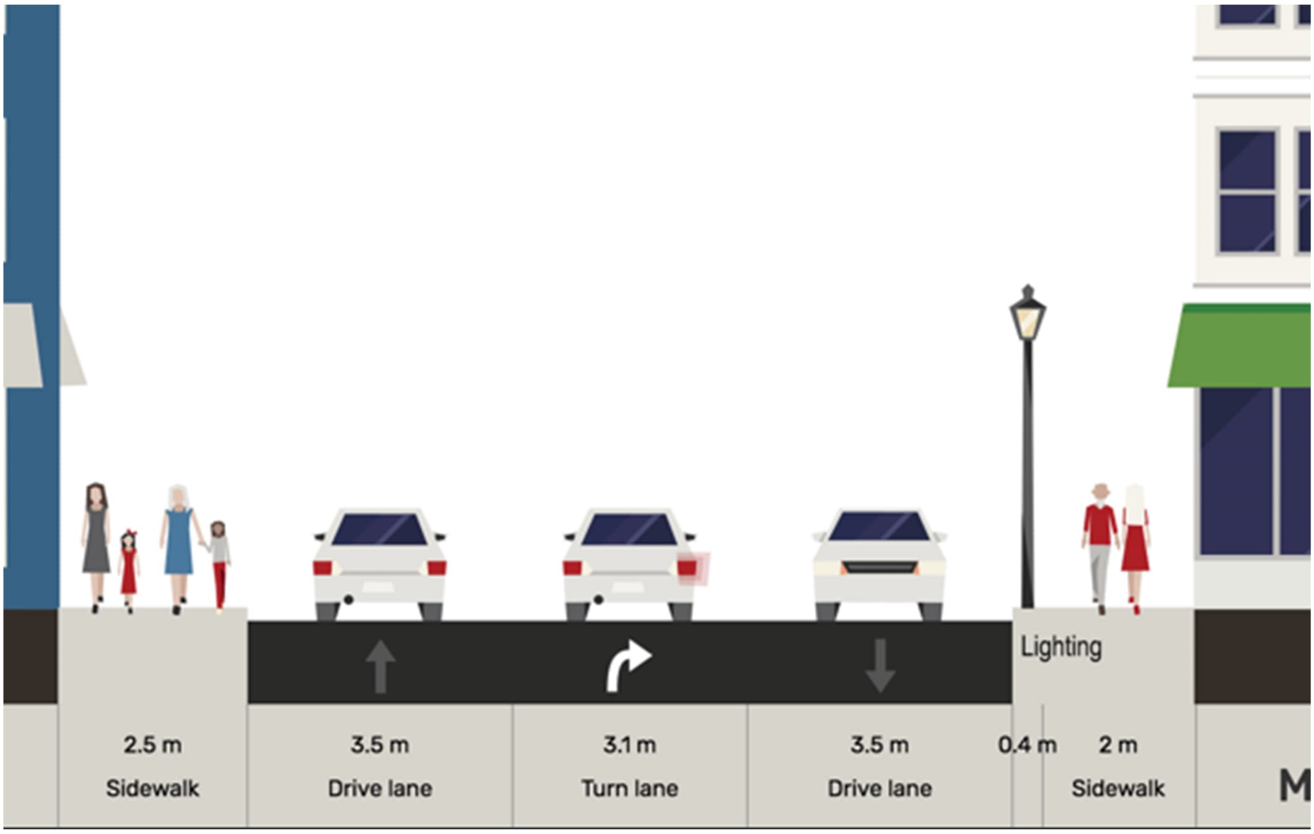


Figure 2.31: 5B (2P) - Access (Industrial - no parking & turning lane) - PAVED

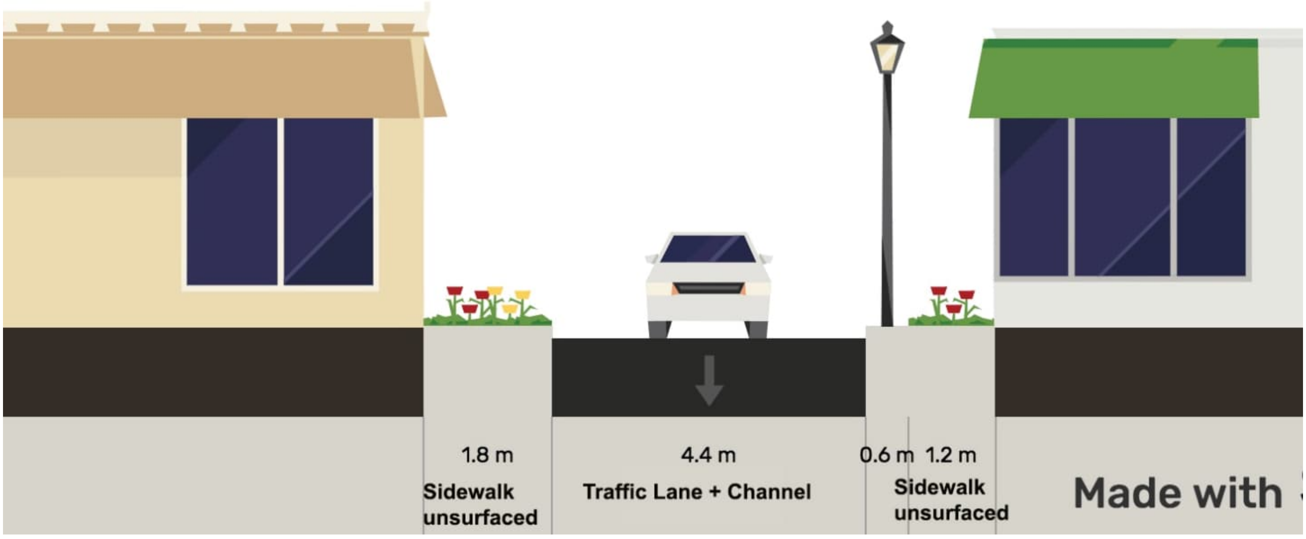


Figure 2.32: 6P- Access Way: Informal Settlement - PAVED

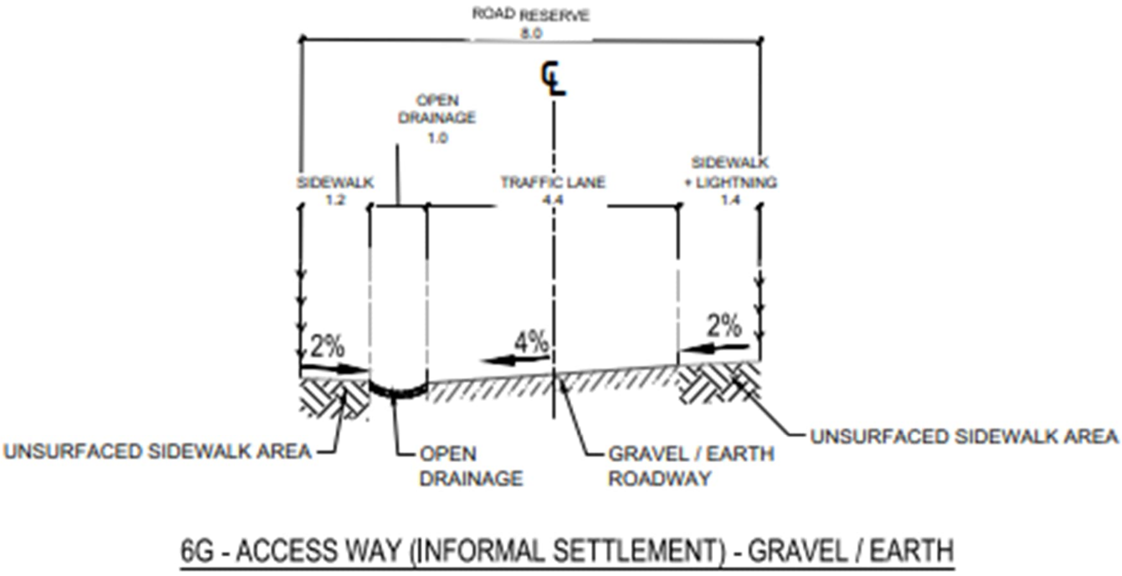


Figure 2.33: 6G- Access Way: Informal Settlement - GRAVEL

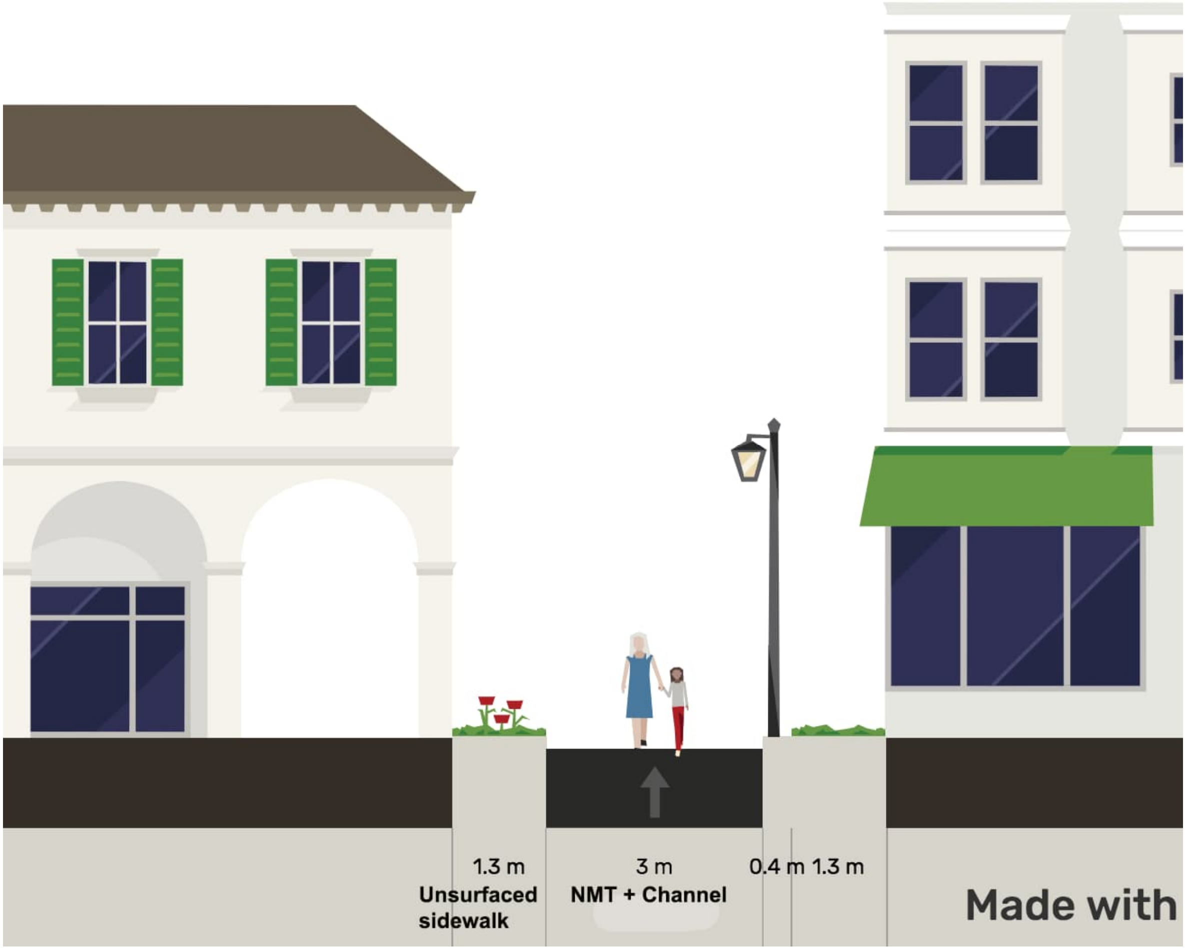


Figure 2.34: 7P - Access Way: NMT only - PAVED

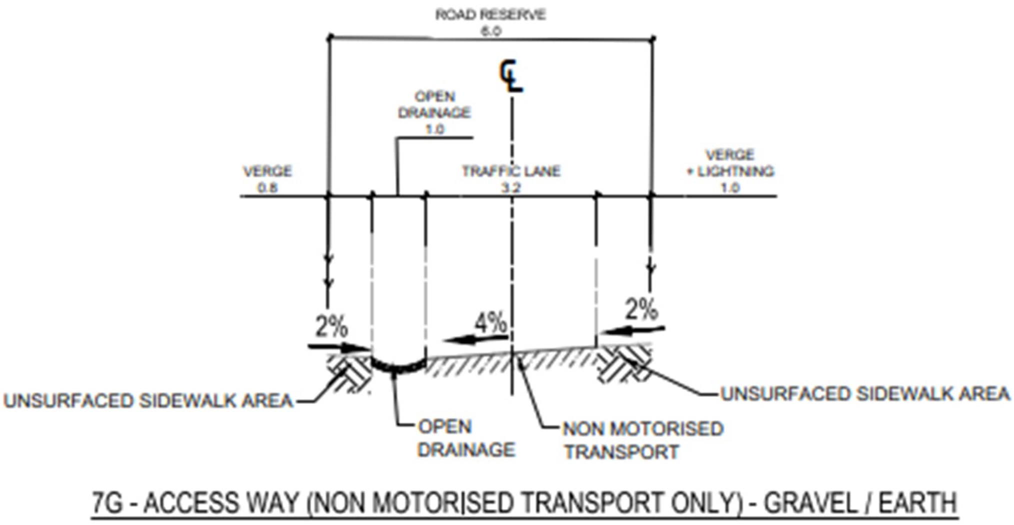


Figure 2.35: 7G - Access Way: NMT only - GRAVEL

EXAMPLE 3D STREET VIEWS FOR LOWER ORDER ROADS

Figure 2.36: Street view – Class 3B (1), Minor arterial with PT

Figure 2.37: Street view – Class 4A (1P), Collector-Commercial & mixed-use & parking


Figure 2.38: Street view- Class 4B (1P), Collector-Residential & parking


Figure 2.39: Street view -Class 5A (1P), Access-Commercial, mixed-use, residential & parking

2.3.3 DESIGN OF THE ROUTE ALIGNMENT

Minimum horizontal and vertical curvatures are governed by maximum acceptable levels of lateral and vertical acceleration and minimum sight distances required for safe stopping and passing manoeuvres. These design parameters are, in turn, related to the vehicle speeds assumed in the design per road class. Curvature standards are thus either explicitly or implicitly dependent on an assumed design speed.

Refer to the Ministry of Works and Transport Road Design Manual: Vol. I Geometric Design, January 2010, for the full geometric design guidelines.

Note that in this Manual the design speeds range from 30km/h to 80km/h for urban centres. However, it must be emphasised that the speeds are intended to provide an appropriate consistency between geometric elements rather than as indicators of actual vehicle speeds at any particular location on a road section.

2.3.4 ROLE OF THE ROAD RESERVE IN ROAD DESIGN

After selection of the required road class, cross-section and geometric alignment, the road reserve is determined from the range provide per class. The edge of the road reserve should ideally be fenced to prevent stray animals on the road in areas prone to this.

The road reserve must further be protected in terms of encroachment (buildings), overhead space (air rights) and underground space. This needs to be covered in legislation, i.e., to protect servitude rights for future transportation tunnels and elevated transit systems.

The road reserve must include the acquisition of land necessary for the full width required.

2.3.5 CROSS-SECTION REDUCTION

There may be instances where a road of a specific class is planned, either an upgrade to an existing road or on a new alignment, but the land availability constrains the required road reserve and cross-section widths. Where the class of the planned road cannot be reduced within the town planning requirements, it may therefore be necessary to reduce the overall road reserve and associated cross-section widths.

ROAD RESERVE REDUCTION

The reduction of the road reserve must always be undertaken in a case-by-case design. The following general guidelines are noted:

- The space between the outer kerb lines and the road reserve edge must be sufficient to support as an absolute minimum a non-motorised transport lane of 1.5m. Sidewalks of less than 1.5 m wide are too narrow to safely accommodate pedestrians, cyclists and road furniture such as street lighting and road signs.
- Areas designated for trees, planters and street vendors may be omitted.
- Cognisance must be taken of the potential need to widen the road in future for increased capacity (additional lanes) or the provision of road based public transport lanes. By allowing a reduced road reserve width at implementation stage may make it difficult and expensive to widen a road in future. Additional land acquisition will be required.

CROSS SECTION REDUCTION

The reduction of the cross-section of a road must also be undertaken in a case-by-case design. The following general guidelines are noted:

- Vehicle lane widths must not be reduced to less than 3.3m on lower order roads.
- Lane widths must not be reduced less than 3.5m on higher order roads.
- Parking lanes of less than 2.5m are unsafe, as vehicles will have difficulty to park within them and not obstruct vehicles in the adjacent passing lane.
- A non-motorised transport lane of a minimum of 1.5m must be retained on both sides of the road.
- The areas for street vending, trees and planters can be omitted.

2.3.6 ROAD BASED PUBLIC TRANSPORT

The Urban Road classes has been tailored to make provision for road based public transport services. Refer to Volume 1, Chapter 1.1.5 for a brief discussion of public transport as a road design element.

The design and implementation of road based public transport services (Light rail commuter transit, Bus Rapid Transit (BRT), conventional bus and taxi) is a specialist work stream that is not covered in this Manual.

2.3.7 INTERSECTION CONTROL

INTRODUCTION

Intersections and accesses, including driveways, may be provided as follows:

- Full intersections or accesses
- Partial intersections or accesses
- Marginal intersections or accesses

Full intersections allow for all possible movements (turning and through movements).

Partial intersections (T-junctions) only allow left-in, left-out and right-in movements and can only be provided at-grade. Partial intersections are not permitted on rural roads and in urban areas they should be limited to Class 1, 2 and 3 roads, but could also be considered on lower order roads if medians are present.

Marginal intersections only allow left-in and left-out movements. Marginal intersections and accesses in urban areas should only be considered on Class 1, 2 and 3 roads but could also be considered on lower order roads with medians. On one-way roads, marginal intersections may also be provided on to allow right-in / right-out movements.

On roads on which partial or marginal intersections are provided, consideration must be given to the provision of U-turn facilities along the main road in order to accommodate directions of travel not provided for by these accesses.

ANGLE OF INTERSECTION

Intersecting roadways should cross at or as close as practically possible to a right angle (90º) to each other at T-junctions and 4-way intersections. Intersections with approached at acute angles have the following disadvantages:

- Larger areas are required to accommodate turning movements
- Heavy vehicle turning movements result in vehicles crossing over adjacent and/or opposite lanes, which reduces safety
- Sight distance may be reduced, which reduced safety

The recommended minimum angle for a side road approach is 70º.

TWO-WAY STOP CONTROL

Two-way stop controlled (TWSC) or Priority Stop-controlled intersections have stop control (i.e., stop signs and markings) on the minor road approach/es. The major road approaches are free-flowing.

TWSC intersections can be used at T-junctions and 4-way intersections.

Typical TWSC intersections are shown schematically in

Table 2.12. The basic design elements are also indicated.

Table 2.13 provides the typical geometric standards for a TWSC intersection, these values may not be appropriate in all contexts and the design of an intersection should be evaluated by a geometric design engineer.

Table 2.12: TWSC Typical Intersection Layouts

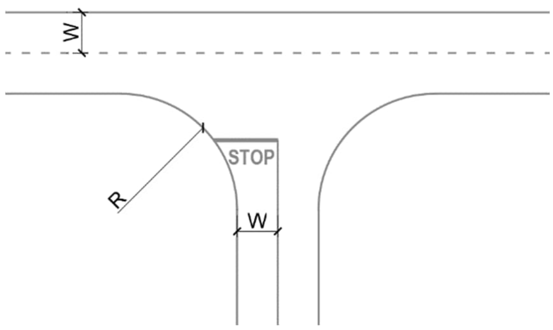
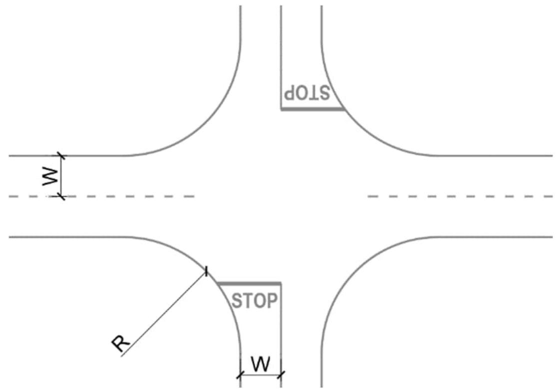
T-Junction	**4-way Intersection**
	

Table 2.13: TWSC Typical Geometric Standards

Class		Description	Kerb Return Radius (R)	Lane Width (W)
1	A & B	Trunk Route	15 – 20m	3.3 – 3.7m
2	A & B	Major Arterial	12 – 15m	3.3 – 3.7m
3	A & B	Minor Arterial	10 – 12m	3.3 – 3.7m
4	A	Collector Road (Commercial & mixed-use)	10 – 12m	3.3 – 3.5m
	B	Collector Road (Residential)	10 – 12m	3.0 – 3.3m
	C	Collector Road (Industrial)	12 – 15m	4.0 – 5.0m
5	A	Access Road (Commercial, mixed-use & residential)	6 – 10m	2.8 – 3.0m
	B	Access Road (Industrial)	12 – 15m	3.7 – 5.0m
6		Informal settlement access way	Not applicable	3.7m
7		NMT only	Not applicable	

ALL-WAY STOP CONTROL

All-way stop controlled (AWSC) intersections have stop control measures (i.e., stop signs and markings) on all approaches, requiring all vehicles approaching the intersection from any direction to stop before proceeding.

An AWSC intersection control can be implemented on both T-junction and 4-way intersections.

A typical AWSC intersection is shown schematically in Table 2.14 The basic design elements area also indicated.

Table 2.15 provides the typical geometric standards for an AWSC intersection, these values may not be appropriate in all contexts and the design of an intersection should be evaluated by a geometric design engineer.

Table 2.14: AWSC Typical Intersection Layouts

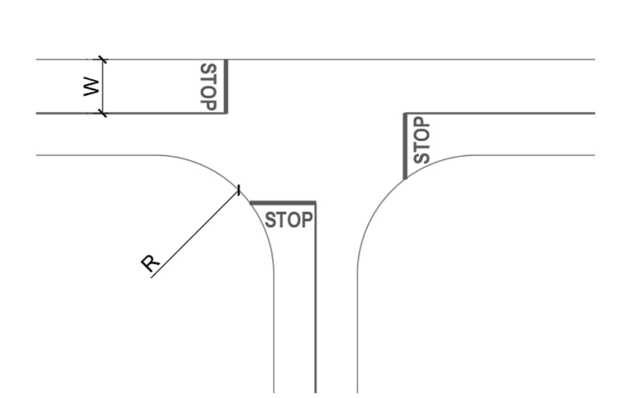
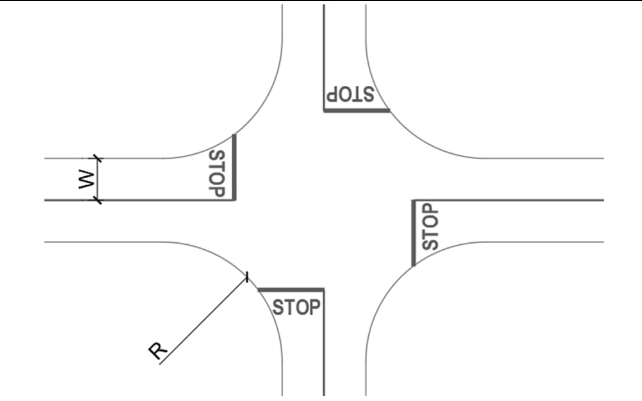
T-Junction	4-way Intersection
	

Table 2.15: AWSC Typical Geometric Standards

Class		Description	Kerb Return Radius (R)	Lane Width (W)
1	A & B	Trunk Route	15 – 20m	3.3 – 3.7m
2	A & B	Major Arterial	12 – 15m	3.3 – 3.7m
3	A & B	Minor Arterial	10 – 12m	3.3 – 3.7m
4	A	Collector Road (Commercial & mixed-use)	10 – 12m	3.3 – 3.5m
	B	Collector Road (Residential)	10 – 12m	3.0 – 3.3m
	C	Collector Road (Industrial)	12 – 15m	4.0 – 5.0m
5	A	Access Road (Commercial, mixed-use & residential)	6 – 10m	2.8 – 3.0m
	B	Access Road (Industrial)	12 – 15m	3.7 – 5.0m
6		Informal settlement access way	Not applicable	3.7m
7		NMT only	Not applicable	

SIGNALISED INTERSECTIONS

The basic objectives for installing traffic signals are:

- To ensure improved traffic flow they decrease the delay time that occurs due to unorganized traffic movement, and thereby flow at a junction is improved.
- To enhance traffic safety as the pedestrian and vehicles have their own dedicated green time to safely cross the junction.
- To improve environmental conditions due to the decrease in vehicle delay times. This reduces total fuel consumption of the waiting vehicles and reduces CO_2 emissions

Two-way Stop-controlled (TWSC) and All-way Stop-controlled (AWSC) intersections should be upgraded to traffic signal-control before or once they reach capacity. The geometric layout of traffic signal-controlled intersections therefore does not differ significantly from Two-way Stop-control or all way Stop-controlled intersections.

Signalised intersection designs must be based on geometric standards and capacity requirements as determined by a capacity analysis.

The advantage of traffic signals is that they create gaps in the traffic flow to allow turning movements to occur, either at the end of a normal phase or with the implementation of a turning phase.

Refer to the figures below for examples of signalised intersections. Note that the road markings shown are indicative, and the Uganda Traffic Signs Manual Volume 1 dated July 2004, or the latest version must be referred to for the correct road markings and road signage.

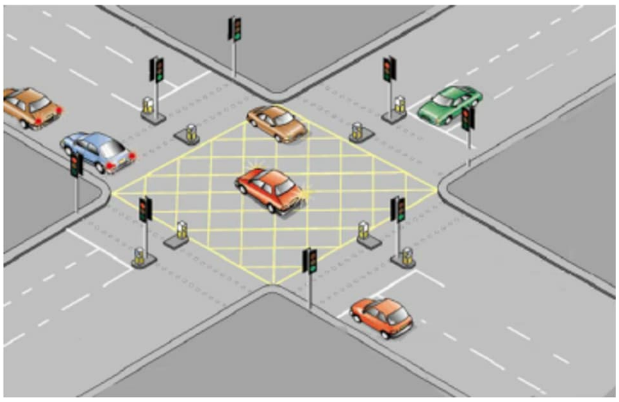


Figure 2.40: Typical 4-way signalised intersection with central block-out

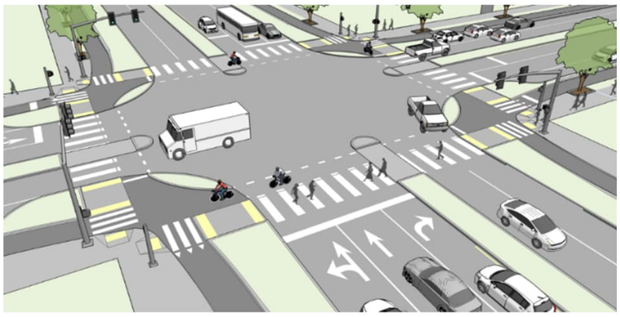


Figure 2.41: Typical 4-way signalised intersection

Traffic signals should only be implemented if one of the following three warrants are met:

- **Warrant 1:** The average length of ANY individual queue equals or exceeds four (4) over any one hour of a normal day.
- **Warrant 2:** The SUM of the average lengths of all queues equals or exceeds six (6) over any one hour of a normal day.
- **Warrant 3:** The SUM of the average lengths of all queues equals or exceeds four (4) over each of any eight hours of a normal day (the hours do not have to be consecutive, but they may not overlap).

Traffic signals should not be installed on roads with a speed limit exceeding 80km/h. Where signalised intersections are required on higher speed roads, the speed limit must be reduced to a maximum 80km/h on the approaches to the intersection.

The aim in designing signal installations is to maximise capacity and to minimize overall delay while maintaining a high degree of safety. It is important to keep as much traffic moving as practicable at the same time. Detailed advice on signal control is outside the scope of this Manual but some of the guiding principles are:

- Use the lowest practicable number of stages (changes) in the signal cycle (complete sequence of stages)
- The signal cycle should preferably not exceed 120 seconds
- Ensure that each approach can carry the maximum predicted traffic flow
- Ensure that the time allocated to each stage is appropriate to the actual traffic flow (a control system that can automatically vary the duration of the green signal according to actual traffic flow is highly desirable on both efficiency and safety grounds)
- If appropriate, link adjacent sets of signals so that groups of vehicles can pass through the intersections without stopping (platoon movements through signal synchronisation)
- The duration of the amber signal should normally be 3 seconds
- The inter-green period (the period between the end of the green signal for one approach and the start of the green signal for a conflicting approach) must be sufficient to enable vehicles to clear the intersection safely. It is normally a minimum of 4 seconds, but it should be extended at large intersections or on high-speed approaches. Note that long inter-green periods are wasteful and may be abused by drivers
- It is highly desirable for right-turn movements to be fully controlled (called a protected right turn) by means of separate signals (green arrow and, if possible, red, and amber arrows)
- When green arrow signals are lit drivers should be able to proceed in the direction of the arrow without having to merge or give way to conflicting traffic streams.
- Drivers must not be permitted to turn left when the main signal is on red, unless there is a green arrow signal that allows them to do so.

Refer to the Ministry of Works, Housing and Communication's Traffic Signs Manual, Volume 1, dated July 2004 (or any future versions) and the KCCA Manual on Traffic Signal Design and Installation, May 2017 for further guidelines.

ROUNDABOUTS

Roundabouts are circular intersections that has the following key features:

- A circular island at the centre
- Yield control for traffic entering the roundabout
- Channelised approaches
- Geometric curvature to reduce approach speeds

Roundabouts have a number of key dimensions that can be defined, depending on the road class and use of the roundabout. The key dimensions is indicated in Figure 2.42. Refer to the MOWT Volume 1 Geometric Design Manual, 2010 for the full design guidelines.

The dimensions of roundabouts are defined by the following radii and widths shown in Figure 2.42:

- Edge of carriageway radius, Re
- Central island radius, Rc
- Inner central island radius, Ri
- Circulating carriageway width, B and,
- Traversable area (small roundabouts only).

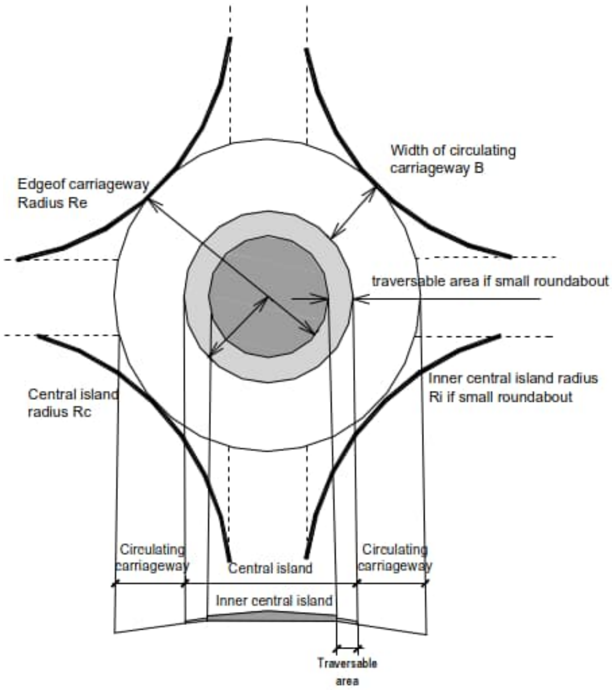


Figure 2.42: Typical Roundabout Features

Roundabouts can be designed to fit a number of different intersection configurations. This section contains the basic design details for roundabout designs.

- Roundabouts should not be implemented on steep gradients. The desired maximum grades for the implementation of a roundabout are as follows:
    - o The entry/approach gradient to a roundabout should not exceed 3%, with a recommended maximum of 2%.
    - o The maximum exit gradient for a roundabout is 4%.
- Similar to unsignalized intersections, when traffic flows on an approach exceed +/- 85% of the capacity, delays and queue lengths become significant. It is recommended that roundabouts are designed to operate at less than 85% of their capacity.
- Roundabouts should only be considered where the traffic flows on the approaches are fairly balanced during peak periods. Unbalanced flows result in poor performance as busier traffic streams may be delayed by lower volume traffic streams due to the yield to all traffic approaching from the right operation of a roundabout.
- Roundabouts should not be installed on roads with a speed limit exceeding 80km/h or where the traffic volumes on the approached volumes in traffic

MINI ROUNDABOUTS

The main differentiating characteristic of a mini-roundabout is that the central island as well as the splitter islands are usually mountable. The design vehicle for a mini-roundabout is typically a single unit truck.

The typical values for the key dimensions of a mini-roundabout are provided in Table 2.16.

Table 2.16: Mini Roundabout Key Dimensions

Feature	Recommended Dimension
Inscribed Circle Diameter	13m – 25m
Central Island Diameter	4m – 16m
Circulatory Roadway Width	4.5m – 5.5m
Approach Width	As per road class requirements
Departure Width	As per road class requirements
Entry width	3.4m min
Exit width	2.7m min.
Entry radius	12m min
Exit radius	12m min

URBAN COMPACT ROUNDABOUTS

Urban compact roundabouts are typically located on collector roads and should therefore be designed to accommodate both single unit trucks and busses.

The typical values for the key dimensions of an urban compact roundabout are provided in Table 2.17.

Table 2.17: Urban Compact Roundabout Key Dimensions

Feature	Recommended Dimension
Inscribed Circle Diameter	25m – 30m
Central Island Diameter *Apron width (if applicable, included in CID)*	17m – 22m *1.5m – 2m*
Circulatory Roadway Width	4m – 5m
Approach Width	As per road class requirements
Departure Width	As per road class requirements
Entry width	3.7m min
Exit width	3.4m min.
Entry radius	30m min
Exit radius	30m min

URBAN SINGLE LANE ROUNDABOUT

Urban single lane roundabouts are typically located on minor arterial routes and is expected to carry higher traffic volumes, including heavy vehicle transport routes, and should therefore be designed to accommodate a semi-trailer vehicle.

The typical values for the key dimensions of an urban single lane roundabout are provided in Table 2.18.

Table 2.18: Urban Single Lane Roundabout Key Dimensions

Feature	Recommended Dimension
Inscribed Circle Diameter	30m – 45m
Central Island Diameter *Apron width (if applicable, included in CID)*	19.2m – 34.2m *1.8m – 2.0m*
Circulatory Roadway Width	5.4m
Approach Width	As per road class requirements
Departure Width	As per road class requirements
Entry width	4.3 – 4.9m
Exit width	3.7m min.
Entry radius	35m – 55m
Exit radius	30m – 60m

Refer to the figures herewith for examples of 1-lane roundabout layouts. Note that road markings shown are indicative, and the Uganda Traffic Signs Manual Volume 1, dated July 2004 must be referred to for the correct road markings and road signage to use at these intersections.

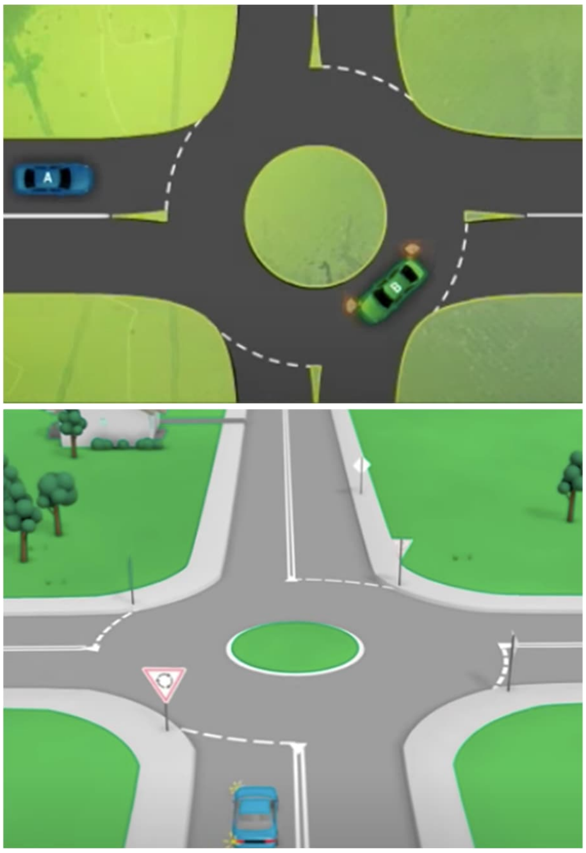


Figure 2.43: Standard 1-lane roundabout layouts

URBAN DOUBLE LANE ROUNDABOUTS

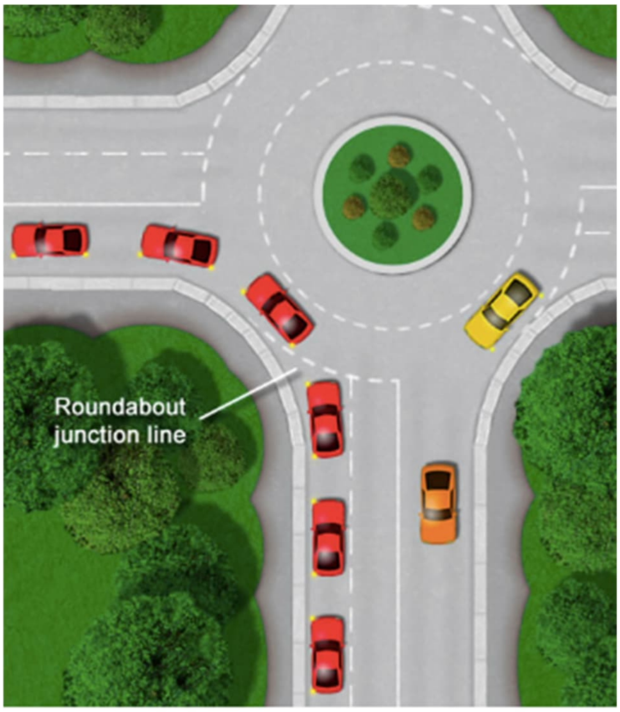
Urban double lane roundabouts have the highest capacity by providing two circulating lanes. Urban double lane roundabouts are typically located on minor arterial routes and is expected to carry higher traffic volumes, including heavy vehicle transport routes, and should therefore be designed to accommodate a semi-trailer vehicle.

The typical values for the key dimensions of an urban double lane roundabout are provided in Table 2.19.

Table 2.19: Urban Double Lane Roundabout Key Dimensions

Feature	Recommended Dimension
Inscribed Circle Diameter	55m – 65m
Central Island Diameter *Apron width (if applicable, included in CID)*	36.8m – 46.8m *NA*
Circulatory Roadway Width	9.1m
Approach Width	7.4m (2x 3.7m lanes)
Departure Width	7.4m (2x 3.7m lanes)
Entry width	7.4m (2x 3.7m lanes)
Exit width	7.4m (2x 3.7m lanes)
Entry radius	35m – 75m
Exit radius	30m – 80m

Refer to the figures herewith for examples of two-lane roundabout layouts. Note that road markings shown are indicative, and the Uganda Traffic Signs Manual Volume 1 (July 2004) must be referred to for the correct road markings and road signage to use.



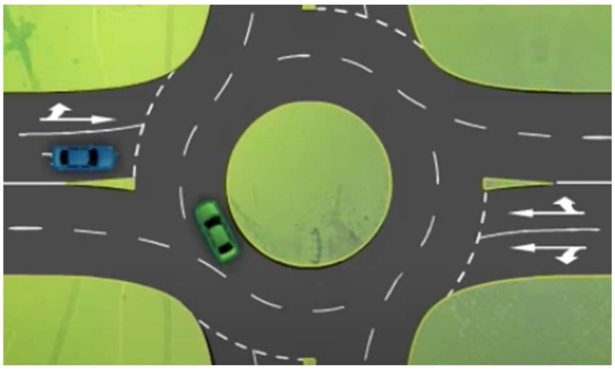


Figure 2.44: Standard 2-lane roundabout layouts

INDUSTRIAL AREA ROUNDABOUTS

Roundabouts for industrial areas should be designed to accommodate the turning movements of the most prevalent heavy vehicles in the area.

The typical values for the key dimensions of roundabout for an industrial area is provided in Table 2.19.

Table 2.20: Industrial Area Roundabout Key Dimensions

Feature	Recommended Dimension
Inscribed Circle Diameter	35m – 45m
Central Island Diameter *Apron width (if applicable, included in CID)*	19.2m – 34.2m *1.8m – 2.0m*
Circulatory Roadway Width	5.5m – 6.5m
Approach Width	As per road class requirements
Departure Width	As per road class requirements
Entry width	4.5 – 5.5m
Exit width	4.5 min
Entry radius	30m – 50m
Exit radius	30m – 50m

SPLAYS

At intersections, splays must be provided to accommodate the following elements:

- Bellmouths for turning movements.
- Meet sight distance requirements.
- Pedestrian walkway and buffer strip as well as space to accommodate pedestrian queues.
- Engineering services.
- Fills and cuts, natural water streams, drains, etc.

Where roundabouts are proposed, sufficient road reserve width must be available or provided to accommodate the size of the proposed roundabouts. Provision must also be made for a minimum verge width of 2.0 m to accommodate pedestrians, although a minimum of 3.0 m is preferable to provide a buffer between the sidewalk and the roundabout.

Refer to Figure 2.45 for standard intersection splay layouts, and Figure 2.46 for large intersection splay layouts.

Typical dimensions for splays are shown in Figure 2.47.

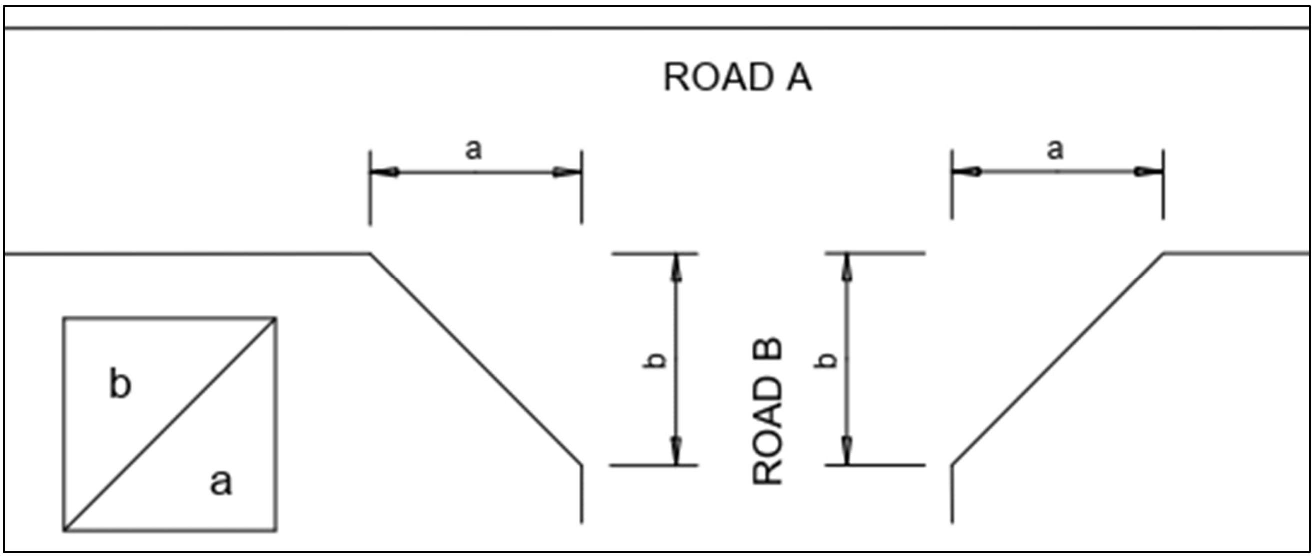


Figure 2.45: Standard Intersection Splay Layout

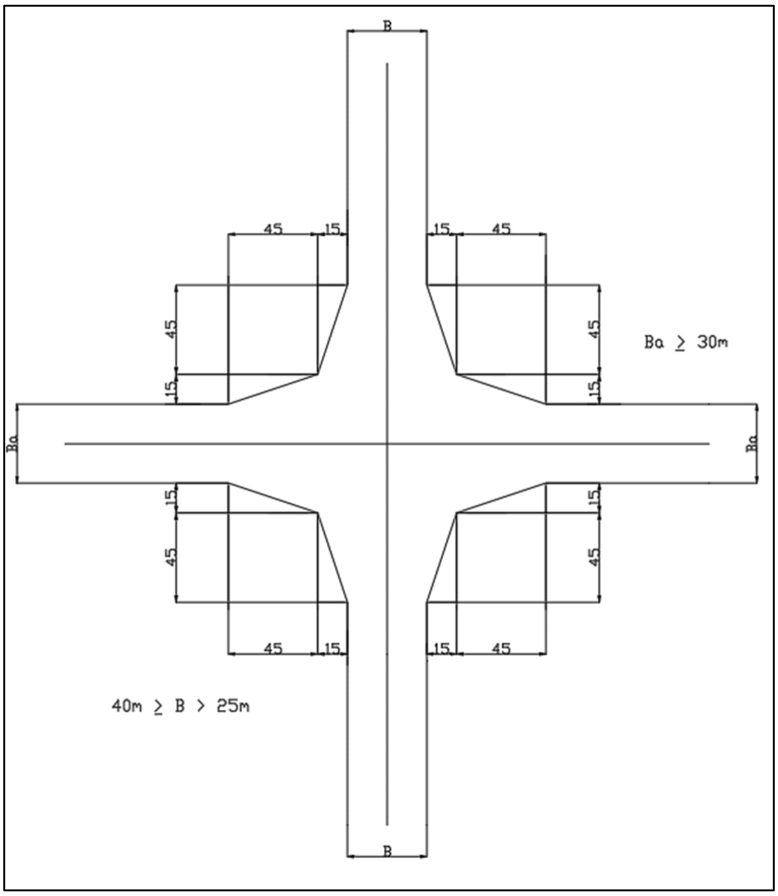


Figure 2.46: Large Intersection Splay Layout

ROAD A (Major Road)	ROAD B (Minor Road): 8m	15m	20m	28	40m	60m
8m	5 / 5	5 / 5	5 / 5	- / -	- / -	- / -
15m	5 / 5	5 / 5	5 / 5	5 / 15	5 / 20	- / -
20m	5 / 5	5 / 5	5 / 5	5 / 15	5 / 20	- / -
28	- / -	15 / 5	15 / 5	15 / 15	15 / 20	15 / 45
40m	- / -	20 / 5	20 / 5	20 / 15	20 / 20	* / *
60m	- / -	- / -	15 / 45	15 / 45	* / *	* / *

* See Large Intersection Splay layout

Figure 2.47: Typical Splay Dimensions

GRADE SEPARATED INTERSECTIONS

Grade separated intersections or interchanges should only be implemented when all other intersections and control types cannot meet the capacity requirements.

The American Association of State Highway and Transportation Officials (AASHTO) defines an interchange as "a system of interconnecting roadways in conjunction with one or more grade separations that provides for the movement of traffic between two or more roadways or highways on different levels".

An interchange should only be implemented on higher order roads or where lower order roads cross higher order roads, with or without access between the routes.

An interchange solves conflicts between traffic movements by separating opposing traffic streams using grade separation. Two types of interchanges exist:

- **Access Interchange:** An access interchange is typically provided at the intersection of a Class 1 and Class 2 road. The two routes are typically separated by grade and ramps are provided to/from the Class 1 road the ramps intersect at grade with the Class 2 road.
- **Systems Interchange:** A systems interchange is typically provided at the intersection of two high-volume Class 1 routes or where one Class 1 route splits into two. All traffic movements are usually free-flow and all directional movements are provided with directional ramps and/or overpasses. System interchanges are rarely used in the Urban road context, as they are more suited to Class 1 roads with high conflicting traffic volumes. They are also expensive in terms of construction and land requirements.

GENERAL TERMS

- Main road: Road element of an interchange with the highest class and average highest traffic volume
- Minor road: Road element of an interchange with the lowest class and average lowest traffic volume
- Ramps: A short section of road that allows vehicles to enter or exit a controlled-access highway.
- Off-ramp: A road section that departs from the freeway/main road.
- On-ramp: A ramp that merges with the freeway/main road
- Loop – Circular ramp that can be used for both on-ramp and off-ramp movements
- Directional ramp: Typically, a curved ramp with a large radius that can accommodate high speed traffic movements.
- Directional ramp: A ramp that curves toward the desired direction of travel, i.e., a ramp that makes a left turn exits from the left side of the roadway (a left exit)
- Semi-directional ramp: A ramp that exits in a direction opposite from the desired direction of travel, then turns toward the desired direction.
- Ramp terminal: Intersection where ramps meet, example where an on-ramp meets a cross-road at a 4-way at-grade intersection.
- Collector/Distributor (C/D) roads: roads parallel to the freeway/main road to facilitate weaving movements. The ramps connect to the C/D road rather that the freeway/main road, improving operating conditions on the main road.
- Weaving: A potential unsafe and undesirable situation where traffic entering and exiting a road must cross paths with other vehicles within a limited distance

SUITABILITY OF USE OF INTERCHANGE TYPES

When considering an upgrade from at-grade to an interchange, there are a number of factors to consider, mainly:

- Cost: grade separated interchanges are significantly more expensive to construct than at-grade intersections and should only be considered when other intersection types will not be able to provide the required capacity.
- Space availability: for example, a Diamond interchange typically have a smaller footprint than a Cloverleaf interchange.
- Traffic volumes: the road with the highest Road Class and traffic volumes should be considered the main road and should have free-flowing traffic movements. The traffic on the lower order (class) road can be controlled at intersections at the ramp terminals. Where both roads are Class 1 and have very high traffic volumes, free-flow interchanges such as a Cloverleaf should are preferred.

Interchange capacity is increased with the number of free-flow ramps and the speed at which these movements can occur, larger radius ramps will have higher operating speeds which improves capacity.

The typical interchange types listed from lower to higher capacity are:

1. Diamond interchange (any configuration)
2. Parclo interchange
3. Cloverleaf interchange

ACCESS INTERCHANGES

Access interchanges can be designed in two typical forms: a Diamond and Partial Cloverleaf (PARCLO). Examples of Diamond interchange layouts are shown in Figure 2.48 to Figure 2.54 and Partial Cloverleaf interchange examples are included in Figure 2.55.

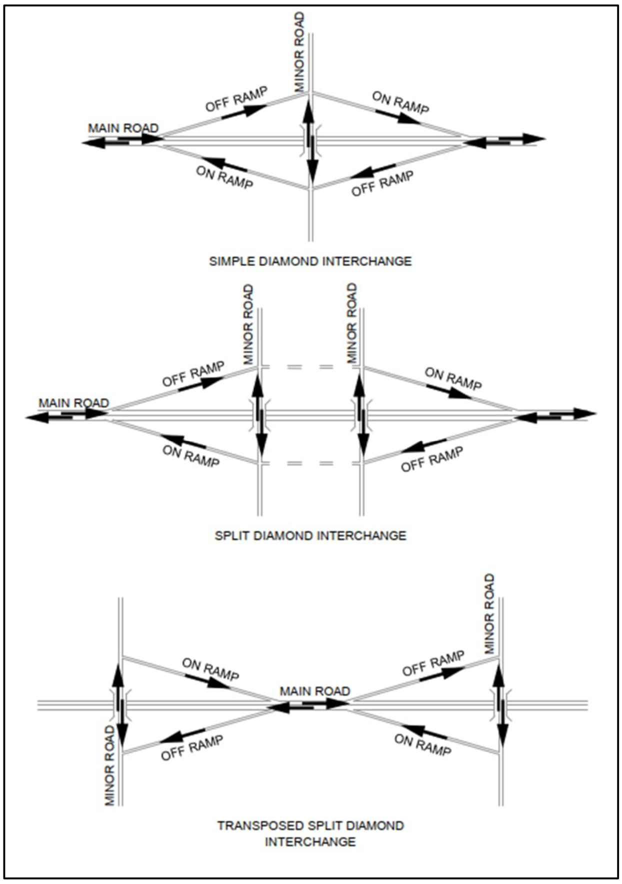


Figure 2.48: Typical Diamond Interchange Layouts

Figure 2.49: Grade separated intersection with a quarter link

Figure 2.50: Grade separated narrow diamond, main road over minor road

Figure 2.51: Grade separated narrow diamond, minor road over main road

Figure 2.53: Typical Diamond Interchange with separate roundabout terminals
Source: UNRA, Kampala

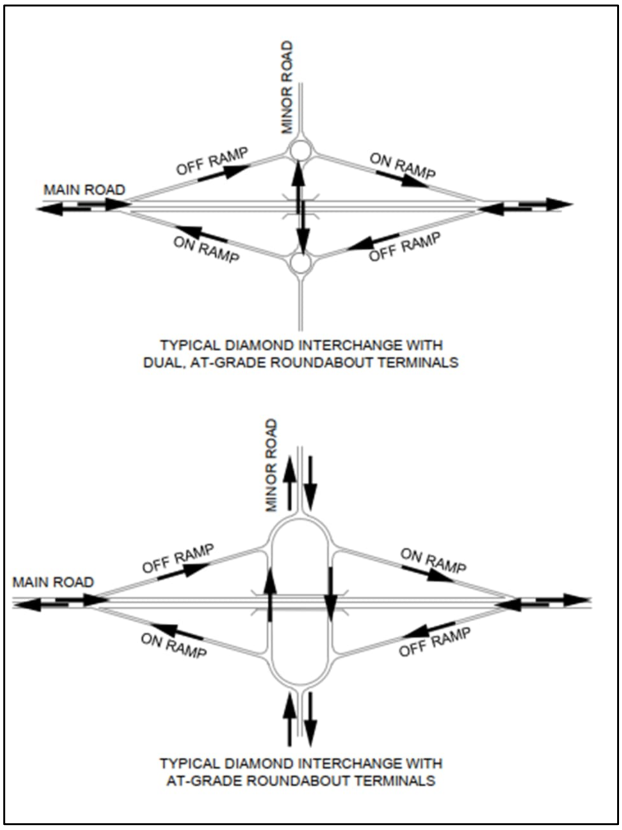


Figure 2.52: Typical Diamond Interchange with roundabout terminals

Figure 2.54: Diamond interchange with combined at-grade roundabout terminal
Source: UNRA, Kampala

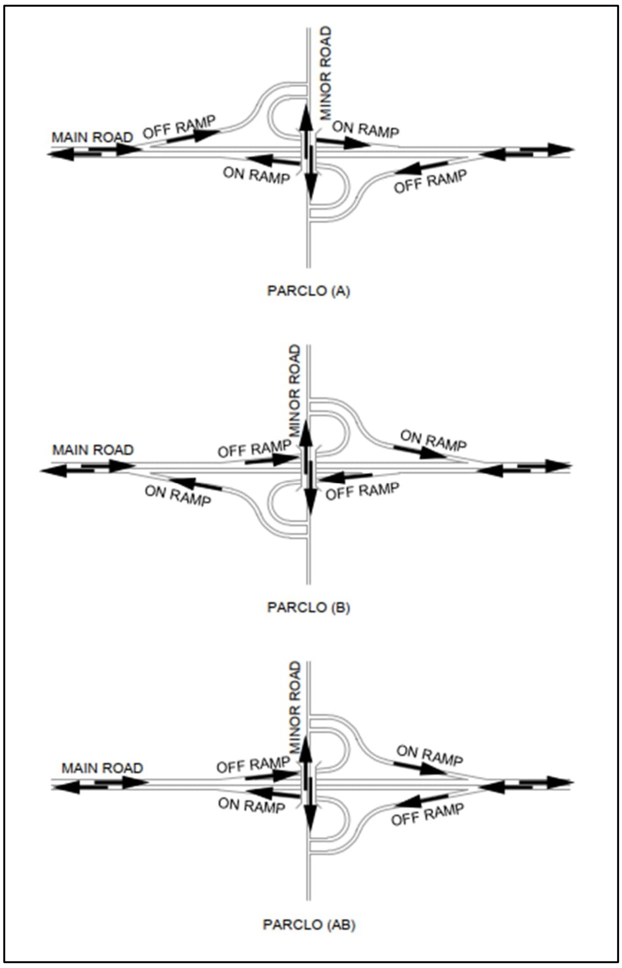


Figure 2.55: Typical Partial Cloverleaf Interchange Layouts

SYSTEMS INTERCHANGES

Systems interchanges can be designed in two typical forms: Full Cloverleaf and Directional Interchanges. Examples of Full Cloverleaf layouts are shown in Figure 2.56.

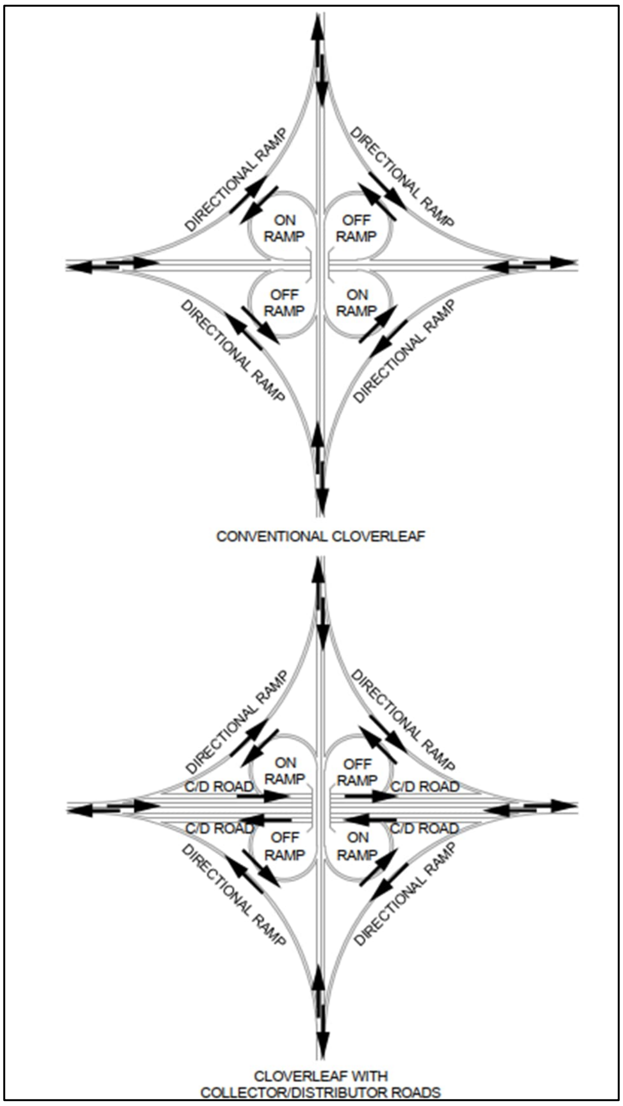


Figure 2.56: Typical Full Cloverleaf Interchange Layouts
Source: UNRA, Kampala

CUL-DE-SACS

Cul-de-sacs are dead-end roads with a turning facility to allow vehicles to turn around safely. Vehicles should be able to make an unobstructed turn within the facility, without conflict with other vehicles or pedestrians.

The use of symmetrical or asymmetrical facilities that allows a forward moving vehicle turn is preferred to hammerhead facilities where vehicles have to make a 3-point turn with reverse movements. Cul-de-sacs must always be properly provided with the correct road signage to warn motorist when they approach a dead-end road.
Typical turning facilities and hammerhead details are shown in the Standard Drawings VT-01, VT-02 and VT-03.

2.3.8 INTERSECTION DESIGN AND UPGRADE WARRANTS

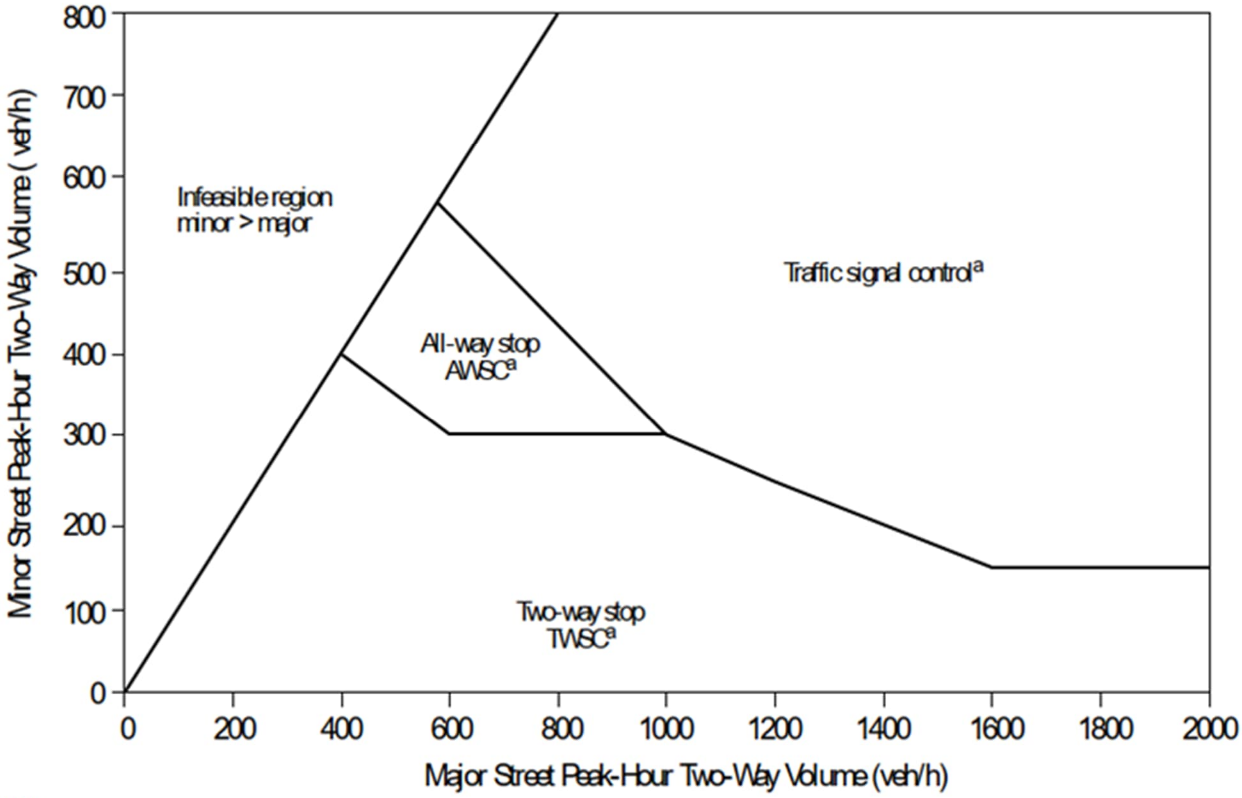
In order to design a new intersection or upgrade an existing intersection appropriately the correct standards for the context it will be used in should be taken into account. To facilitate the decision-making process, three decision trees have been developed:

- The “Start Here” decision tree will assist the user in obtaining the required information in order to evaluate the intersection being considered. Refer to Figure 2.35
- The “Intersection Capacity” decision tree will assist the user in evaluating an intersection and to determine if the intersection has sufficient capacity or if upgrades would be required. Refer to *Figure 2.59*.

- The “Intersection Control” decision tree will assist the user to find an alternative intersection control type if the current intersection control type does not have sufficient capacity. Refer to Figure 2.60.

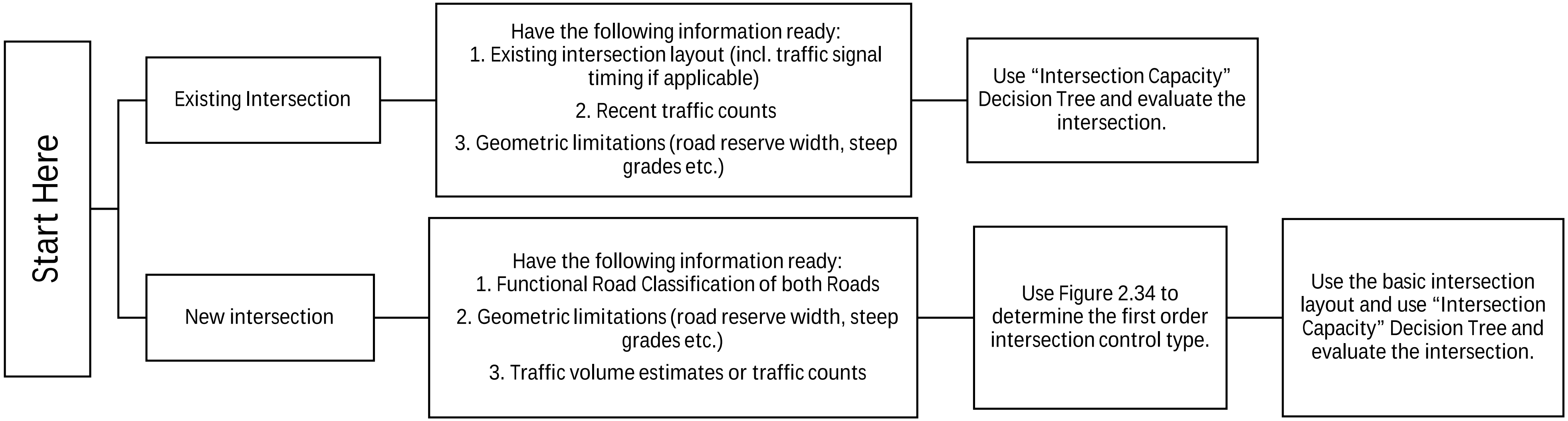
The graph in Figure 2.57 can be used in conjunction with the “Start Here” decision tree to obtain a first order estimate of the control type required for the intersection in question.

EXHIBIT 10-15. INTERSECTION CONTROL TYPE AND PEAK-HOUR VOLUMES
(SEE FOOTNOTE FOR ASSUMED VALUES)



Notes
a. Roundabouts may be appropriate within portion of these ranges.
Source: Adapted from *Traffic Control Devices Handbook* (*8*, pp. 4–18) - peak-direction, 8-h warrants converted to two-way peak-hour volumes assuming ADT equals twice the 8-h volume and peak hour is 10 percent of daily. Two-way volumes assumed to be 150 percent of peak-direction volume.

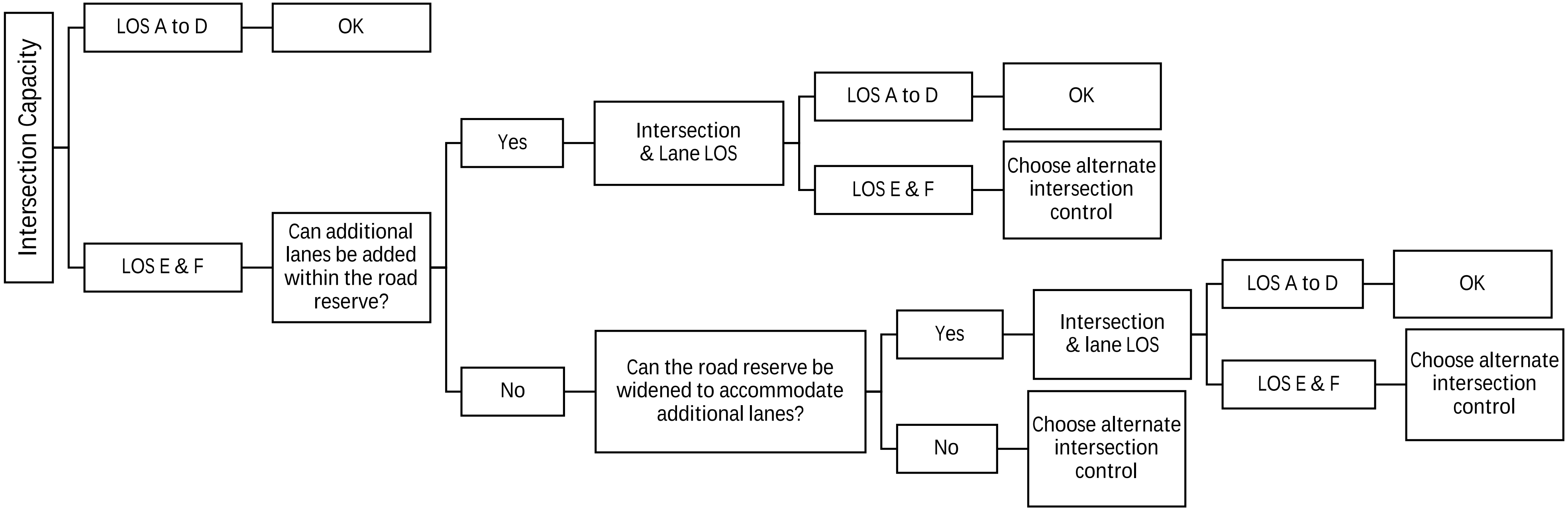
Figure 2.57: Intersection Control Type and Peak-hour Traffic Volumes
Source: HCM 2000



Notes:

- Traffic volumes should be for the design horizon year (5/10/15 years).

Figure 2.58: Intersection Type Decision Tree



Notes:

- LOS should be for the worst vehicle movement.
- Additional lanes can be added in sequence, i.e., if LOS for right turn movement is E-F, add a short right turn lane and analyse, add subsequent lanes until road reserve is fully utilised.

Figure 2.59: Intersection Capacity Decision Tree

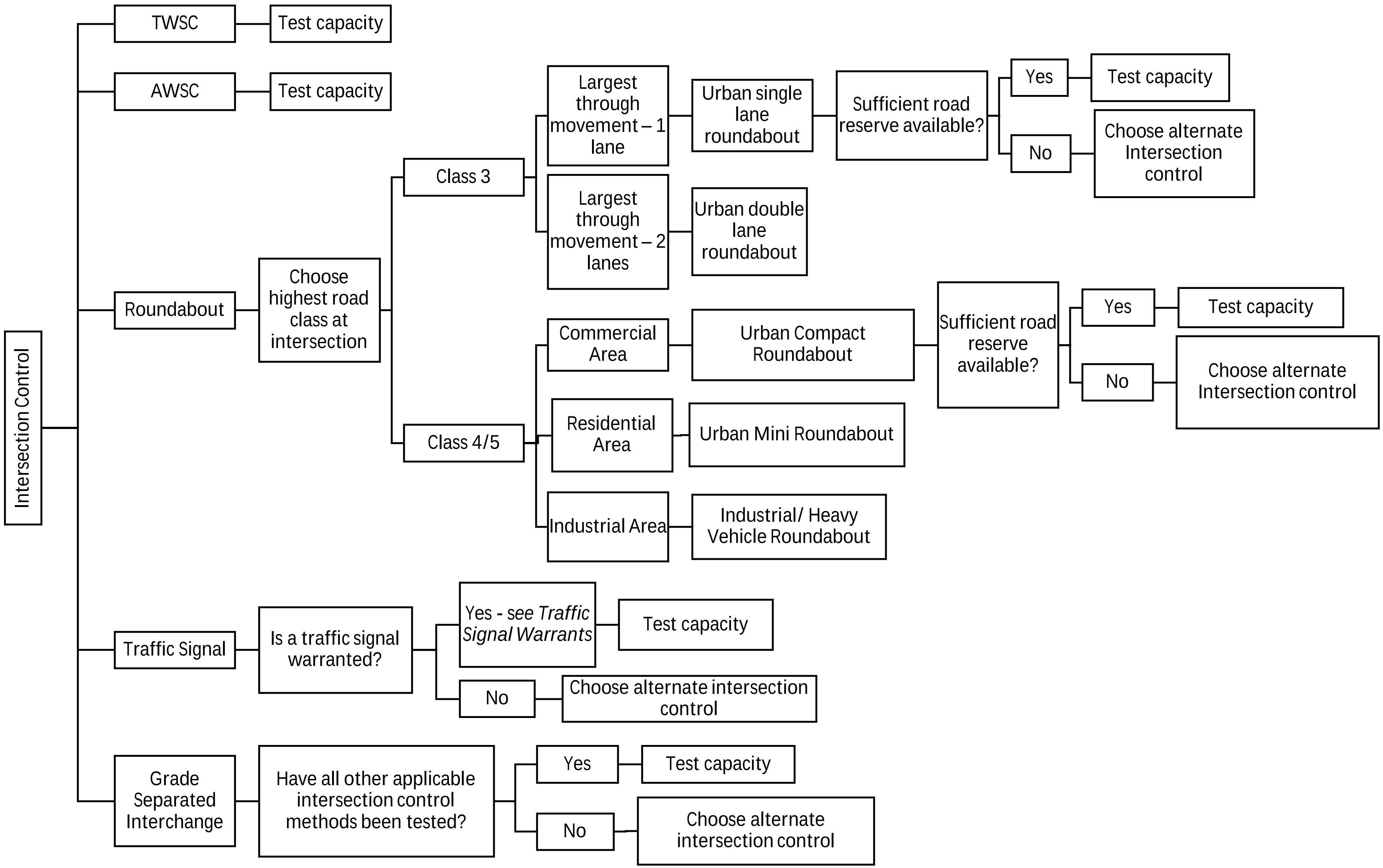


Figure 2.60: Intersection Control Decision Tree

INTERSECTION LEVEL OF SERVICES

Signalized intersection level of service (LOS) is defined in terms of the average total vehicle delay of all movements through an intersection. Vehicle delay is a method of quantifying several intangible factors, including driver discomfort, frustration, and lost travel time. Specifically, LOS criteria are stated in terms of average delay per vehicle during a specified time period (for example, the afternoon (PM) peak hour).

Vehicle delay is a complex measure based on many variables, including signal phasing (i.e., progression of movements through the intersection), signal cycle length, and traffic volumes with respect to intersection capacity. Table 2.21 shows LOS criteria for signalized intersections, as described in the Highway Capacity Manual, 2016.

Table 2.21: Level of Service Criteria for Signalized Intersections

LOS	Average Control Delay (sec/veh)	General Description (Signalized Intersections)
A	≤ 10	Free Flow
B	>10 – 20	Stable Flow (slight delays)
C	>20 – 35	Stable flow (acceptable delays)
D	>35-55	Approaching unstable flow (tolerable delay, occasionally wait through more than one signal cycle before proceeding)
E	>55-80	Unstable flow (intolerable delay)
F	>80	Forced flow (jammed)

Unsignalized intersection LOS criteria can be further reduced into two intersection types: all-way stop-controlled and two-way stop-controlled. All-way, stop-controlled intersection LOS is expressed in terms of the average vehicle delay of all of the movements, much like that of a signalized intersection. Two-way, stop-controlled intersection LOS is defined in terms of the average vehicle delay of an individual movement(s). This is because the performance of a two-way, stop-controlled intersection is more closely reflected in terms of its individual movements, rather than its performance overall. For this reason, LOS for a two-way, stop-controlled intersection is defined in terms of its individual movements. With this in mind, total average vehicle delay (i.e., average delay of all movements) for a two-way, stop-controlled intersection should be viewed with discretion. Table 2.22 shows LOS criteria for unsignalized intersections (both all-way and two-way, stop-controlled).

General notes on intersection capacity analysis:

- To account for the large volume of boda-bodas, it is recommended to utilise a factor of 0.2 to convert the number of boda-bodas to equivalent passenger car volumes.
- Intersection capacity analysis should be undertaken with specialised software, and care must be taken to ensure that the software is calibrated for local conditions

Table 2.22: Level of Service Criteria for Unsignalized Intersections

LOS	Average Control Delay (sec/veh)
A	0 - 10
B	>10 – 15
C	>15 – 25
D	>25 – 35
E	>35 – 50
F	>50

2.3.9 ROAD SIGNS & MARKINGS

All road signs and marking on urban roads should be designed, manufactured, installed and maintained in accordance with The Highway Code, published by the Ministry of Works and Transport, dated March 2009, (or the latest version), and the Traffic Signs Manual Volume 1, published by the Ministry of Works, Housing and Communication in July 2004 (or the latest version).

The Traffic Signs Manual is the national standard that incorporates all requirements for traffic signs (purpose, classification, sizes, siting and mounting, materials, manufacturing, maintenance), road markings (types, materials) and traffic signals (purpose, classification, pedestrian and railway crossing signals). This Manual must be used for all signage, markings and signal related work for all urban roads in Uganda.

Important note: any future updates of the above listed reference documents must be used when they are released by the relevant authorities.

2.3.10 ROAD FURNITURE

Road furniture comprises amongst other road signage, pedestrian railings, pedestrian crossings, guard rails, kerbs, lighting, seating and public transport shelters.

The standard design of these is detailed in the Standard Drawings, only as applicable to roads in urban areas. Other standard elements such as roadside parking, bus, taxi and loading bays are also included.

In addition, other road safety consideration should be reviewed and should aim to envisage the completed road from point of view of all road users' safety like drivers of cars and light vehicle, truck and buses, cyclist, and pedestrians. The review should assess the horizontal, vertical, and cross-sectional geometry, traffic signs, road marking, road lighting, other road furniture and other objects within the road corridor.

Refer to Volume 1, Chapter 1 for detailed roadside furniture guidelines.

2.3.11 PEDESTRIAN AND VEHICLE ACCESS OVER OPEN SIDE DRAINS

Standard specifications have been developed to close existing open side drains where conventional sub-surfaced drainage cannot be implemented.

The specifications include the dimensions of the footings, slabs, handrails and vehicle bollards.

These are categorised as follows:

- NMT crossing only: 0 to 2 m span
- NMT crossing only: 2 to 3m span
- Vehicle and NMT crossing: 0 to 2 m span
- Vehicle and NMT crossing: 2 to 3m span

Refer to the Standard drawings for the typical examples.

2.3.12 SREET LIGHTING

Street lighting is provided to improve the safety and personal security of all road users. Priority should be given to provide lighting to areas with a high proportion of night-time pedestrian and vehicle volumes, as these areas are more prone to vehicle/pedestrian accidents. These areas include pedestrian crossings, high-volume pedestrian generators such as markets, retail and entertainments centres, sports facilities such as stadiums, public transport facilities and hospitals.

Lighting should be provided on at least all Class 1 to Class 4 roads in urban areas.

Statistics indicate that the night-time accident rates are generally higher than during daylight hours, which may be attributed to impaired visibility of road users. In urban areas, where there are concentrations of pedestrians and junctions, fixed source lighting tends to reduce accidents.

To minimize the effect of glare and to provide the most economical lighting installations, luminaries should be mounted at a height of at least 8 meters. High mounted luminaries provide greater uniformity of lighting and mounting heights of 12 meters can be used. High mast lighting (special luminaries on masts of 30 meters) is used to illuminate large areas such as intersections. This type of lighting gives a uniform distribution of light over the whole area and thus illuminates the layout of the intersection.

Lighting columns can be a hazard to errant vehicles. The lighting scheme must minimize the number of lighting columns and ensure that the poles are not located in vulnerable positions. Standards for lateral clearance and clear zones must be respected.

Lighting columns (poles) should be placed behind vertical kerbs whenever practical. The appropriate distance is 0.5m behind the kerb for roads with a design speed of 50 km/h or less, and 1.2m or greater for roads with a design speed of 80 km/h or greater. Where poles are located within the clear zone, regardless of distances from the edge of the carriageway, they should be designed to include an impact attenuation feature or be protected by barriers such as new-jersey barriers. However, these types of poles should not be used on roads in densely populated areas, particularly with busy sidewalks or cycle lanes. When struck, these poles may collapse and cause injury to pedestrians or damage adjacent property.

Because of lower speeds and parked vehicles on urban roads, there is much less chance of injuries to vehicle occupants from striking fixed poles as compared to higher speed roads.

On dual carriageway road, lighting is recommended on the median to illuminate both carriageways, and additional lighting should be provided to illuminate the sidewalks and cycle lanes. With median installation, the cost is generally lower, and illumination is higher on the high-speed inner lanes of the carriageways. On median installations, dual mast arms should be used, for which 12-meter mounting heights are favoured. Median lights should be protected with a suitable safety barrier.
On narrow medians, it is preferable to place the lighting poles so that they are integral with the median barrier, if present.

When it is intended to install road lighting in the future, the provision of the necessary conduits/ducts as part of the initial road construction or upgrade will provide considerable savings as opposed to retrofitting these later.

Refer to the tables herewith for the recommended lighting values of the 7 road classes.

Table 2.23: Recommended Lighting Values for Class 1 – 4 Roads (SANS 10098-1)

Lighting Category: Types of Road	Road Cross Section																							
	Without Median												With Median											
	Maximum traffic volume during darkness (motor vehicles per hour per lane)																							
	>600				300				100				>900				600				200			
	Ln	Uo	UL	TI	Ln	Uo	UL	TI	Ln	Uo	UL	TI	LN	Uo	UL	TI	LN	Uo	UL	TI	LN	Uo	UL	TI
Class 1: Freeway and expressway with median, free of level crossings, for speed limits exceeding 90km/h	2	0,4	0,7	15	1,5	0,4	0,7	20	1	0,4	0,6	20	2	0,4	0,7	15	1,5	0,4	0,7	20	1	0,4	0,6	20
Class 2: Arterials, speed limits not exceeding 90km/h	1.5	0,4	0,7	20	1	0,4	0,6	20	0,8	0,4	0,5	20	1.5	0,4	0,7	20	1	0,4	0,6	20	0,8	0,4	0,5	20
Class 3: Urban roads, speed limits not exceeding 60km/h	1	0,4	0,6	20	0,6	0,4	0,5	20	0,5	0,4	0,5	20	1	0,4	0,6	20	0,8	0,4	0,5	20	0,5	0,4	0,5	20
Class 4: Connecting roads, local distributor roads, residential major roads	0,75	0,4	0,5	20	0,5	0,4	0,5	20	0,3	0,3	0,5	25	0,75	0,4	0,5	20	0,5	0,4	0,5	20	0,3	0,3	0,5	25

Notes: a) The values apply to straight sections of the roads, and to curves and intersections.

b) The luminance values apply to a dry road surface of any material

c) Ln = Minimum luminance cd/m2

Uo = Overall luminance uniformity

UL = Longitudinal luminance uniformity; and

Ti = Threshold increment, %

Table 2.24: Recommended Lighting Values for Class 5 – 7 Roads (SANS 10098-1)

Lighting Category	Type of Road	Minimal Average Horizontal Illuminance ($E_{H\ av}$)	Minimal Horizontal Illuminance ($E_{H\ min}$)	Minimum semi cylindrical illuminance ($E_{ac\ min}$)
B1	Class 5 Residential streets with medium to high volume traffic	5 lux	1 lux	2 lux
B2	Class 5 Residential streets with medium volume traffic	3 lux	0.6 lux	1 lux
B3	Class 5 Residential streets with low volume traffic	2 lux	0.4 lux	0.6 lux
C1	Class 6 & 7 NMT and informal access ways	10 lux	3 lux	7.5 lux

Notes

a) *Horizontal illuminance values apply across the carriageway on footways up to 2m from the edge of the carriageway*
b) *For areas requiring higher security, semi-cylindrical illuminance values as stated can be used as a supplementary criterion. They apply on the footways parallel to the kerbs in both directions.*

Source: SANS 10098-1 (SABS 098-1), Public lighting – Part 1: The lighting of public thoroughfares

STREET LIGHTING OPTIONS

Listed below are the advantages and disadvantages of the options being considered to power urban road lights. They include the following:

- Low vs. high wattage light fittings
- Solar only vs. a combination of solar and conventional electric power

The advantages and disadvantages of each option must be considered in terms of the intended location of the lights on a road section and issues such as the available budget, (capital and maintenance). For example, in an area prone to high crime levels and vandalism, the use of low wattage systems may not be ideal due to their susceptibility to vandalism.

LOW WATTAGE VS. HIGH WATTAGE LIGHT FITTINGS

OPTION 1 LOW WATTAGE

Solar pole lights only (Based on low wattage luminaires – 60W, Pole height - 8m, distance -12m)

Advantages:

- 100% Clean renewable energy
- Low maintenance cost
- Low wattage generally equals cheaper fittings
- Lower wattage generally equates to longer life span of light fitting, so less frequent replacements.
- A lower voltage design will require less battery storage which may reduce costs

Disadvantages:

- 100% Weather dependent
- Solar energy storage can be expensive
- Pole height too low, can make the lighting system susceptible to theft
- Poles to closely spaced to each other can increase the possibility of pole-vehicle collisions

OPTION 2 HIGH WATTAGE

Solar pole lights only (Based on higher wattage luminaires – 120W, Pole height - 12m, distance - 25m)

Advantages:

- 100% Clean renewable energy.
- Low maintenance cost.
- Higher pole height decreases the likelihood of theft and power tapping.
- Larger spacing between poles will result in overall less poles and light fittings which can be more cost-effective.
- Large spacing between poles may result in reduced vehicle/pole accidents.

Disadvantages:

- 100% Weather dependent
- Solar energy storage can be expensive
- Solar generally utilizes lower voltage so light fittings for high wattage might be difficult to acquire.

SOLAR ONLY VS. A COMBINATION OF SOLAR AND CONVENTIONAL ELECTRIC POWER

OPTION 1: SOLAR AND POWER (BASED ON LOW WATTAGE)

Advantages:

- Not fully dependent on either solar or electrical supply so a more reliable system.
- Also includes advantages of ‘Solar only’ listed above.

Disadvantages:

- A more complex design will be required which will cost more.
- Cost of power reticulation is expensive
- Possibility of cable theft and electrical equipment theft.
- Also includes disadvantages of ‘Solar only’ listed above.

OPTION 2: SOLAR AND POWER (BASED ON HIGHER WATTAGE)

Advantages:

- Not fully dependent on either solar or electrical supply.
- Also includes advantages of ‘Solar only’ listed above.

Disadvantages:

- A more complex design will be required which will cost more.
- Also includes disadvantages of ‘Solar only’ listed above.

SPECIFICATIONS FOR SOLAR LIGHTING

CLASS 1 TO 4 ROADS (TYPE A)

The below Electrical Specifications is based on SANS 10098-1.

- IP Rating: IP66
- ED lifetime: 100 000 hours
- Batteries lifetime: 5 years
- Solar panel lifetime: 25 years
- Solar Charging Time: 6-8 hours
- Ln – Luminance: >2.03cd/m²
- Uo – Total Uniformity: >0.398
- Ul – Longitudinal Uniformity: >0.83
- T1 – Disability Glare: <7%
- Height of Pole: 12,0m
- Average Spacing: 25,0m
- Pole depth below ground level: 4,0m (Minimum, depending on soil conditions)

CLASS 5 ROADS (TYPE B)

The below Electrical Specifications is based on SANS 10098-1.

- IP Rating: IP66
- LED lifetime: 100 000 hours
- Batteries lifetime: 5 years
- Solar panel lifetime: 25 years
- Solar Charging Time: 6-8 hours
- Ln – Luminance: >2.03cd/m²
- Uo – Total Uniformity: >0.398
- Ul – Longitudinal Uniformity: >0.83
- T1 – Disability Glare: <7%
- Height of Pole: 12,0m
- Average Spacing: 20,0m
- Pole depth below ground level: 3,0m (Minimum, depending on soil conditions)

CLASS 6 & 7 ROADS (TYPE C)

The below Electrical Specifications is based on SANS 10098-1.

- IP Rating: IP66
- Capacity: 2.6AH/PC
- Efficiency: 190lm/W
- Lighting Time (rainy day): >10 days
- Battery Charging Time: 7 Hours
- Lumens Brightness: 30,000
- Power: 16.2V/18.75W
- LED (OSRAM): 3030 42pcs
- Installation Height: 3.0m - 3.5m
- Average Spacing: 12-14m
- Pole depth below ground level: 0.5m (Minimum, depending on soil conditions)
- Ln – Luminance: 3000 Lumens
- Uo – Total Uniformity: 3 lux
- Ul – Longitudinal Uniformity: 3 lux
- T1 – Disability Glare: >11-12%

SPECIFICATIONS FOR CONVENTIONAL LIGHTING

CLASS 1 TO 5 ROADS (TYPE A AND B)

The below Electrical Specifications is based on SANS 10098-1.

- IP Rating: IP66
- LED lifetime: 50 000 hours
- Ln – Luminance: 544 cd/klm
- Luminaire: 30345 lm
- Luminaire Wattage: 200.9 W
- Height of Pole: 12,0m
- Average Spacing: 40,0m
- Pole depth below ground level: 1,5m (Minimum, depending on soil conditions)
- Lightning Protection: Surge Protection up to 10kV

CLASS 6 & 7 ROADS (TYPE C)

The below Electrical Specifications is based on SANS 10098-1.

- IP Rating: IP66
- Power: 50.0W
- LED lifetime: 50 000 hours
- Installation Height: 6.0m
- Average Spacing: 30m
- Pole depth below ground level: 1.0m (Minimum, depending on soil conditions)
- Ln – Luminance: 6520 lm
- Luminous Intensity: 636 cd/klm
- Lightning Protection: Surge Protection up to 4kA

Refer to Appendix 17 (Bill 5 Ancillary) for the main BOQ items to consider for road lighting.

Note the following abbreviations used in the BOQ:
- ABC- Aerial Bundle Conductor
- BCEW- Bare Copper Earth Wire
- Al- Aluminium
- Cu- Copper

PROTECTION AGAINST LIGHTING (SOLAR & CONVENTIONAL)

Since most street light types are tall masts and may comprise of metal, a conductive material, they essentially act as lightning rods and may be struck by lightning regularly. To protect against direct lightning strikes the pole should be designed with down conductors and ground nets, this will act as an external lightning protection system. In the event of a lightning strike, the conductor will safely conduct the lightning to earth.

For internal protection, to protect the internal circuitry, an equipotential connection can eliminate the destructive potential difference caused by a lightning strike. This can be done by using overvoltage protectors for the connection lines and metal pipes.

2.4 CHAPTER 4: GEOMETRIC DESIGN GUIDELINES

The requirements of the Urban Roads Design Manual (URDM) are applicable to all roads within the urban area. The URDM makes reference to several existing Uganda guidelines, manuals and standards as they remain applicable to the road designs. Where there is a conflict between the URDM and other referenced documents, then the requirements of the URDM takes precedence in all urban areas.

2.4.1 DESIGN CONTROL AND CRITERIA

INTRODUCTION

The choice of design controls and criteria is influenced by the following factors: the functional classification of the road; the nature of the terrain; the design vehicle; the traffic volumes expected on the road; the design speed; the density and character of the adjoining land use; and economic and environmental considerations. Roads in urban areas are designed with a flexible approach to meet the needs of the suburban, urban, and core urban contexts.

The aforementioned factors affecting road design may vary along a route of some length, the design does not have to be constant for the whole length of a road. On the contrary, changes in the design are usually required in order to obtain proper correlation between the road layout and the above factors, whilst maintaining construction costs at realistic levels.

This is especially important for urban roads as major improvement of existing arterials can be extremely costly, particularly where multiple utilities require relocation and additional rights-of-way need to be acquired through highly developed areas. Accordingly, it is often appropriate to apply flexibility in selection of design elements, controls, and criteria that are below the values used where sufficient right-of-way is available or can be acquired economically.

THE DESIGN VEHICLE

Both the physical characteristics including turning capabilities of vehicles and the proportions of variously sized vehicles using the road are positive controls in geometric design. Therefore, it is necessary to examine all vehicle types, select general class groupings, and establish representatively sized vehicles within each class for design use.

Vehicle characteristics affecting design include power to weight ratio, minimum turning radius, travel path during a turn, vehicle height and width. The main road elements affected are gradient, road widening in horizontal curves and junction design. In the design of road facility, the largest design vehicle likely to use that facility with considerable frequency or a design vehicle with special characteristics that must be taken into account in dimensioning the facility is used to determine the design of such critical features as radii at intersections and radii of horizontal curves of roads.

The present vehicle fleet in Uganda includes a high number of four-wheel drive passenger/utility vehicles, buses and trucks.

Table 2.25: Dimensions of Design Vehicles

Design Vehicle type	Symbol	Overall (m)			Overhang (m)		Wheelbase (m)	Minimum design turning radius (m)	Minimum inside radius (m)
		Height	Width	Length	Front	Rear			
4X4 Passenger car	DV-1	1.3	2.1	5.8	0.9	1.5	3.4	7.3	4.2
Single unit truck	DV-2	4.1	2.6	9.1	1.2	1.8	6.1	12.8	8.5
Single unit bus	DV-3	4.1	2.6	12.1	2.1	2.4	7.6	12.8	7.4
Semitrailer combination large	DV-4	4.1	2.6	16.7	0.9	0.6	6.1 & 9.1	13.7	5.8
Interstate Semitrailer	DV-5	4.1	2.6	21.0	1.2	0.9	6.1 & 12.8	13.7	2.9

The five design vehicles in Table 2.25 will be used in the control of geometric design until a major change in the vehicle fleet is observed and detailed information on the different vehicle types using the roads in Uganda becomes available.

TRAFFIC CHARACTERISTICS

The design of a roadway or any part of it, should be based upon factual information including factors related to traffic. It should be based on traffic volumes, which the road will have to accommodate. Traffic directly affects the geometric features of design such as width, horizontal and vertical alignments, and indicates the need for improvement.

A. Traffic Volume

Traffic data for road design include volumes for days of the year and times of the day as well as distribution of vehicles by types and weights. The data also includes information on trends from which the designer may estimate the traffic to be expected in the future.
Volume of traffic is expressed as a rate of flow, usually either as vehicles per hour (veh/h), in particular the peak hour demand on the road, or vehicles per day (Veh/day), often converted into the value “AADT” (Annual Average Daily Traffic).

By definition, AADT can be known definitively only from a continuous count over a full year. However, factors for modifying short period counts to estimate AADT can be developed using long period counts for a limited number of sites which are chosen to represent the main types of roads in the network. The annual counts at the sample sites will indicate seasonal, daily and hourly variation and hence the factors which relate traffic volumes (measured at any specific time) to the AADT, for that class of road.

For low volume roads the design control is AADT in the “design year”, while for more high-volume roads and streets (typically in urban areas) it would be more appropriate to use “design hour” volumes as the design control.

In urban areas peaks in traffic demand arise primarily because of home-to-work trips, occurring typically at the beginning and end of the normal working day. The `peak hour factor' expresses peak hour volume on a route as a proportion of the AADT. The peak hour factor for a particular route is often a consideration in classifying routes by type. As a rule of thumb, on urban roads the peak hour traffic is usually around 10 per cent of AADT (Note that the US Highway Capacity Manual defines peak hour factor in a different way - TRB, 1985).

<u>Design Volume</u>

The volume of traffic estimated or expected to use the facility during the design year (which is typically 10-20 years in the future).

<u>Average Annual Daily Traffic (AADT)</u>

The total volume for the year divided by 365. For a two-lane rural road, the total traffic in both directions is taken.

<u>Average Daily Traffic (ADT)</u>

The total volume of traffic during the given time period (in whole days), greater than 1 day and less than one year, divided by the number of days in that time period. For two lane rural road, the traffic volume for both directions of flow are taken.

Knowledge of ADT for a road is important for many purposes such as determining annual usage as justification for proposed expenditure and for design of structural elements of the road. However, it is direct use in geometric design of road is not appropriate because it does not indicate the variation of traffic occurring during the various months of the year, days of the week and hours of the day.

<u>Peak-Hour Traffic and Design Hourly Volume</u>

Peak-Hour Traffic is the traffic volumes for an interval of time, usually one hour. It would be wasteful to base the design on the maximum peak-hour traffic of the year. This is because this traffic volume would occur only during a few hours of the year, and the traffic in most of the year would not be high enough to make full use of the resulting facility. On the other hand, the use of the average hourly traffic would result in an inadequate design. The hourly traffic volume used in design should not be exceeded very often or by very much.

<u>Composition of Traffic</u>

For design purposes, the composition of traffic (the percentage composition of each of the different types of vehicles and trucks during peak hours) should be known. Besides being heavier, trucks generally are slower and occupy more roadway space and consequently impose a greater traffic effect on roads than passenger vehicles do. Vehicles in the truck class are normally those having 4000kg or greater gross vehicle mass (GVM) rating of the manufacturer and vehicles having dual tires on rear axle.

Speed

Speed is a design control and criteria and is one of the most important factors to the traveler in selecting alternate routes or transportation modes. The attractiveness of a public transportation system and a new road are each weighed by the traveler in terms of time, convenience, and money saved and this is directly related to speed.

Design Speed

Geometric design elements such as vertical and horizontal alignment, sight distances and superelevation, are directly related to design speed. It may be defined as the maximum safe speed that can be maintained over a given section of the road where conditions are so favorable that the design features of the road govern. It must be emphasized that the design speed adopted for a particular section of road is intended to provide an appropriate consistency between geometric elements rather than being an indicator of actual vehicle speeds at any location on the road system. It depends on topography and should be logical with respect to the adjacent land use, and functional classification of road.

Operating Speed

Operating speed is the highest overall speed at which a driver can travel on a given road under favorable weather conditions and under prevailing traffic conditions without at any time exceeding the safe speed as determined by the design speed on a section-by-section basis.

B. Capacity

The ability to accommodate vehicular traffic is one of the primary considerations in the planning, design and operation of roads and streets.

In the context of a vehicular roadway, Capacity can be defined as the maximum number of vehicles per unit of time that can be handled by a particular roadway component or section under the prevailing conditions. Road capacity information are useful for (a) transportation planning studies to assess the adequacy or sufficiency of existing road network to service current traffic and to estimate the time in the future when traffic growth may overtake capacity; (b) it is important in design of road dimensions, number of lanes and minimum length of weaving length; (c) in traffic operation analysis in improvement of traffic operation.

The traffic flow at capacity level is unstable and minor disturbances in the traffic streams may cause stop-go operations. Consequently, a Design Capacity is instigated which is less than the maximum capacity and is related to a “Level of Service”. Level of Service expresses the effectiveness of the road in terms of operating conditions. It is a qualitative measure of the effect of traffic flow factors, such as speed and travel time, interruptions, freedom of manoeuvre, driver comfort and convenience, and indirectly, safety and operation costs.

The choice of level of service shall generally be based on economic considerations. Volume 1 of the Ministry of Works and Transport Design Manual defines six levels of service for roadways and the criteria that must be met to achieve any particular one.

TERRAIN

The geometric design elements of a road depend on the transverse terrain through which the road passes. Transverse terrain properties are categorized into four classes as follows:

Flat: Level or gently rolling country which offers few obstacles to the construction of a road having continuously unrestricted horizontal and vertical alignment (transverse terrain slope around 5%).

Rolling: Rolling, hilly or foothill country where the slopes generally rise and fall moderately gently and where occasional steep slopes may be encountered. It will offer some restrictions in horizontal and vertical alignment. (20% ≥ transverse terrain slope >5%).

Mountainous: Rugged, hilly, and mountainous country and river gorges. This class of terrain imposes definite restrictions on the standard of alignment obtainable and often involves long steep grades and limited sight distances (70% ≥ transverse terrain slope > 20%)

Escarpment: In addition to the terrain classes given above, a fourth class is added to cater those situations whereby the standards associated with each of the above terrain types cannot be met. Escarpment situations are those places where it is required switchback road alignments or side hill traverse sections where earthwork quantities are huge (transverse terrain slope >70%).

THE DRIVER

Research (Pretorius 1976, Brafman Bahar 1983) has indicated that 95% of passenger car drivers have an eye height of 1.05 m or more, and 95% of bus or truck drivers an eye height of 1.8 m or more. These values have accordingly been adopted for use in these guidelines.

A figure of 2.5 seconds has been generally adopted for reaction time for response to a single stimulus. American practice also makes provision for a reaction time of 5,7-10,0 seconds for more complex multiple-choice situations. These extended times make provision for the case where more than one external circumstance must be evaluated, and the most appropriate response selected and initiated.

SIGHT DISTANCE

Sight distance is a fundamental criterion in the design of any road. It is essential for the driver to be able to perceive hazards on the road, with sufficient time in hand to initiate any required action safely. On a two-lane two-way road, it is also necessary for him or her to be able to enter the opposing lane safely while overtaking. In intersection design, the application of sight distance is slightly different from that applied in design for the rest of the road or system, but safety is always the chief consideration.

STOPPING SIGHT DISTANCE (SSD)

Stopping distance involves the ability of the driver to bring the vehicle safely to a standstill and is thus based on speed, driver reaction time and skid resistance. The total distance travelled in bringing the vehicle to a stop has two components:
the distance covered during the driver's reaction period; and the distance required to decelerate to 0 km/h.

The stopping distance is expressed as:

$$s = 0.694v + v^2/254f$$

Where: s is total distance travelled (m)
v is speed (km/h)
f is brake force coefficient

Stopping sight distances are based on operating speeds. The brake-force coefficients quoted in Table 2.26 have been adopted for design, and the calculated stopping sight distances are given in Table 2.27.

Table 2.26: Brake Force Coefficients

Speed (km/h)	Coefficients
20	0.47
40	0.37
60	0.32
80	0.30
100	0.29
120	0.28

Table 2.27: Stopping Sight Distance on Level Roads

Design Speed (km/h)	Stopping Sight Distance (m)
30	30
40	50
50	65
60	80
70	95
80	115
90	135
100	155
110	180
120	210

Stopping sight distance is measured from an eye height of 1.05 m to an object height of 0.15 m in the case of the higher-order roads. This object height is used because an obstacle of a lower height would not normally represent a significant hazard. In residential areas, the object height can be increased to 0.6 m. This greater height provides a practical design with an adequate margin of safety for the protection of children, pets and other obstacles typically encountered on this class of road.

Object height is also taken into account because, if the sight distance were measured to the road surface, the length of the vertical curve required would be substantially increased.

This could result in roads being significantly above or below natural ground level. In the urban environment where there is a need for access to adjacent properties at relatively short intervals, this is not acceptable.

The gradient has a marked effect on the stopping distance requirements. Figure 2.61 is an expansion of Table 2.27 demonstrating this effect.

Stopping sight distance can also be affected by a visual obstruction such as a garden wall or shrubbery next to the lane on the inside of a horizontal curve, as shown in Figure 2.62.

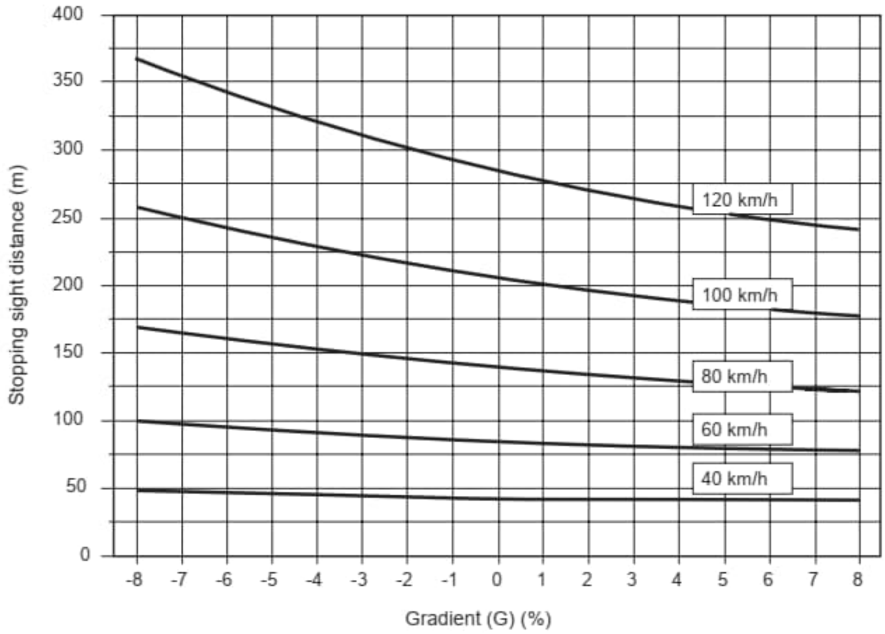


Figure 2.61: Stopping Sight Distance on Gradients

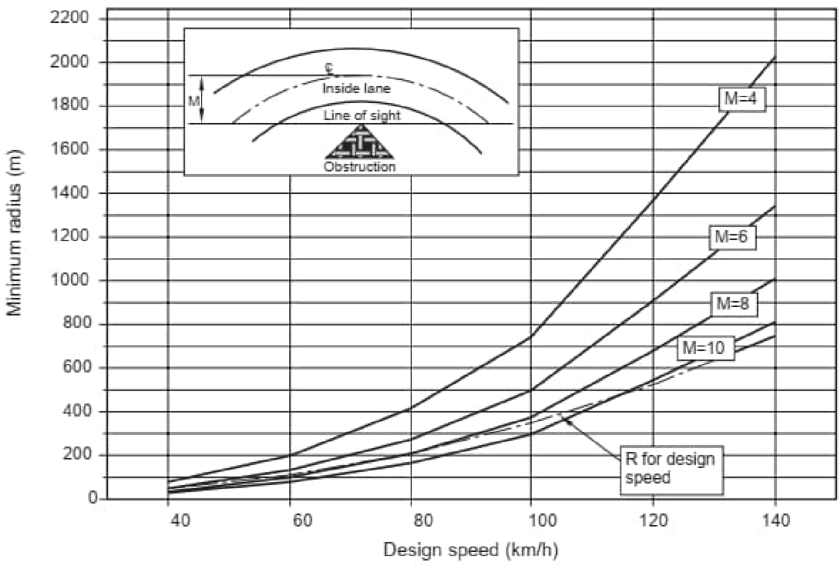


Figure 2.62: Minimum Horizontal Radius for Stopping Sight Distance

BARRIER SIGHT DISTANCE (BSD)

Barrier sight distance is the limit below which overtaking is legally prohibited. Two opposing vehicles travelling in the same lane should be able to come to a standstill before impact. A logical basis for the determination of the barrier sight distance is therefore that it should equal twice the stopping distance, plus a further distance of 10m to allow an additional safety margin. The values given in Table 2.28 reflect this approach.

Barrier sight distance is measured to an object height of 1.3 m, with eye height remaining unaltered at 1.05 m. The greater object height is realistic because it represents the height of a low approaching vehicle.

Table 2.28: Barrier Sight Distance

Design Speed (km/h)	Barrier Sight Distance (m)
40	110
60	170
80	240
100	320
120	430

Hidden dip alignments are commonly considered to be poor design practice. They typically mislead drivers into believing that there is more sight distance available than exists. In checking the alignment in terms of barrier sight distance, the designer should pay detailed attention to areas where this form of alignment occurs, to ensure that drivers are made aware of any inadequacies of design.

Because of the low speeds involved and the typically short lengths of lower-order mixed-usage roads, the passing operation is of little significance so that barrier.

DECISION SIGHT DISTANCE (DSD)

The best visual cue to the driver is the roadway ahead. For this reason, it is necessary in certain circumstances for the road surface itself to be visible to the driver for a given distance ahead. This is to allow sufficient time for the assimilation of a message and the safe initiation of any action required. An example is the marking that allocates specific lanes at an intersection to turning movements. Warning of this must be given sufficiently far in advance of the intersection to permit a lane change that does not detrimentally affect the operation of the intersection itself.

Decision sight distance, as given in Table 2.29 is related to the reaction time involved in a complex driving task. The reaction time selected for this purpose is 7.5 seconds, which is roughly the mean of values quoted in American practice. These calculated values are based on stopping sight distance to allow for the condition where the decision is to bring the vehicle to rest.

Table 2.29: Decision Sight Distance on Level Roads

Design Speed (km/h)	Stopping Sight Distance (m)
40	130
60	190
80	240
100	300
120	350

This has the effect of increasing the normal reaction time of 2.5 seconds by a further five seconds of travel at the design speed of the road. Decision sight distance is measured from an eye height of 1.05 m to the road surface, i.e., to an object height of 0 m.

PASSING SIGHT DISTANCE (PSD)

In the case of vehicles-only and higher-order mixed usage roads, passing sight distance is an important criterion indicative of the quality of service provided by the road. The initial design is required to provide stopping sight distance over the full length of the road, with passing sight distance being checked thereafter. A heavily trafficked road requires a higher proportion of passing sight distance than a lightly trafficked road to provide the same level of service. Insufficient passing sight distance over a vertical curve can be remedied, for example, either by lengthening the vertical curve to provide passing sight distance within the length of the curve itself, or by shortening the curve to extend the passing opportunities on either side. Horizontal curves can similarly be lengthened or shortened. A further possibility is the provision of a passing lane.

Passing sight distance can be calculated on one of two bases, being either the sight distance required for a successful overtaking manoeuvre or that required for an aborted manoeuvre. The former

could be described as being a desirable standard and the latter as the minimum. Values quoted for the successful manoeuvre are taken from AASHTO (1994) and for the aborted manoeuvre from Harwood and Glennon (1989), who base these distances on the vehicles involved being a passenger car passing a bus or a truck.
Table 2.30 lists passing sight distances in respect of both successful and aborted manoeuvres.

Table 2.30: Passing Sight Distance on Level Roads

Design Speed (km/h)	Passing Sight Distance (m)	
	Successful Manoeuvre	Aborted Manoeuvre
40	290	-
60	410	226
80	540	312
100	670	395
120	800	471

Passing sight distance in respect of a successful manoeuvre allows adequately (according to Harwood and Glennon 1989) for an aborted manoeuvre in the case of a bus or truck attempting to pass another. As in the case of barrier sight distance, passing sight distance is not a consideration in the design of lower order mixed-usage roads.

INTERSECTION SIGHT DISTANCE (ISD)

At a stop-controlled intersection, the driver of a stationary vehicle must be able to see enough of the through-road to be able to carry out one of three operations before an approaching vehicle reaches the intersection, even if this vehicle comes into view just as the stopped vehicle starts to move.

These three operations are to:

- turn to the left in advance of a vehicle approaching from the right.
- turn to the right, crossing the path of a vehicle approaching from the right and in advance of a vehicle approaching from the left.
- to move across the major highway in advance of a vehicle approaching from the left.

In the first case, the assumption is that the turning vehicle will accelerate to 85% of the design speed of the through-road and a vehicle approaching on the through-road will decelerate from the design speed also to 85% of the design speed, leaving a two-second headway between them at the end of the manoeuvre. According to AASHTO, the intersection sight distance required for the right turn is only about one metre less than that required for the left turn, given the same assumptions as made in the first case.
In the case of the vehicle crossing the through- road, the distance the crossing vehicle must travel is the sum of:

- the distance from the stop line to the edge of the through carriageway.
- the width of the road being crossed; and
- the length of the crossing vehicle.

This manoeuvre must be completed in the time it takes the approaching vehicle to reach the intersection, assuming that the approaching vehicle is travelling at the design speed of the through-road. For safety, the time available should also include allowance for the time it takes for the crossing driver to establish that it is safe to cross, engage gear and set his or her vehicle in motion: a period of about two seconds is normally used.

Intersection sight distances recommended in accordance with the principles outlined above are given in Figure 2.63 and Figure 2.64. Before a lower value is adopted in a specific case, the implications of departing from the recommended values should be considered.

The line of sight is taken from a point on the centre line of the crossing road, 2.4 m back from the edge of the through-road to a point on the centre line of the through-road. The setback is intended to allow for a pedestrian or cycle track crossing beyond the Stop line.

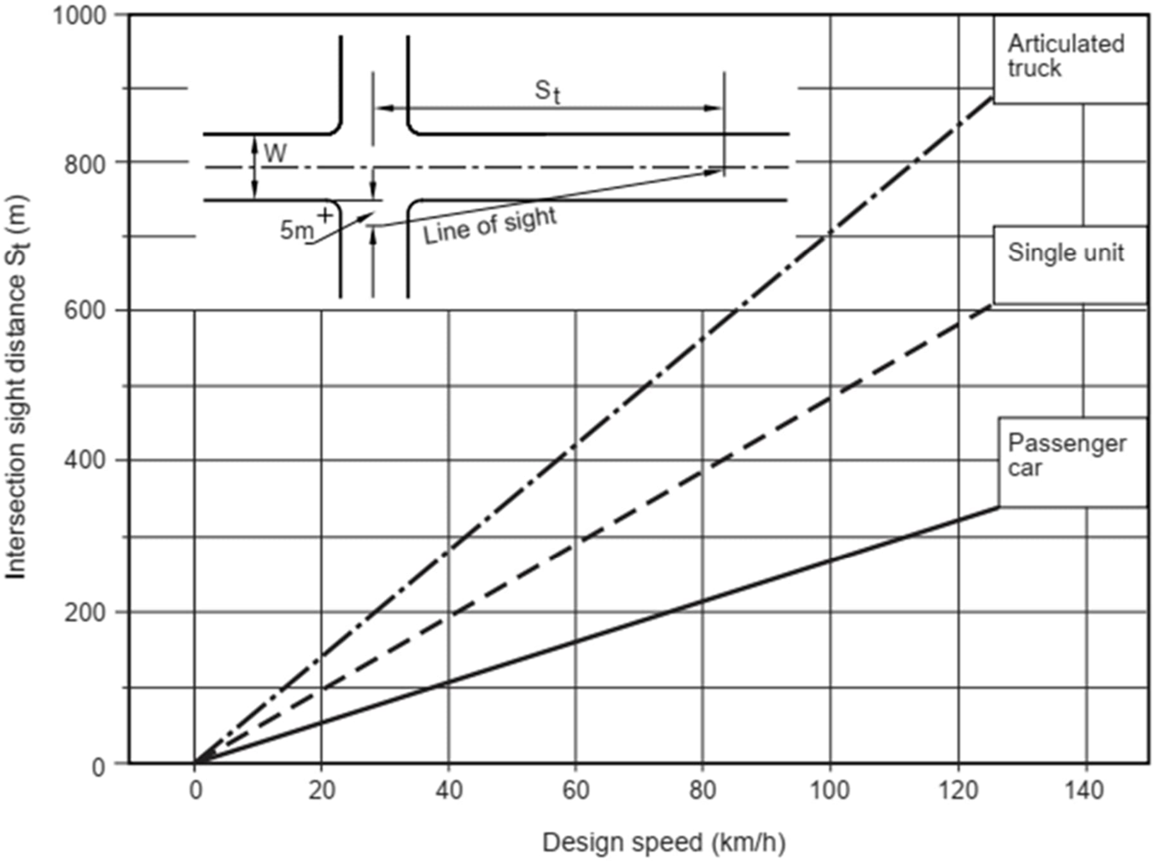


Figure 2.63: Intersection Sight Distance per Vehicle Type

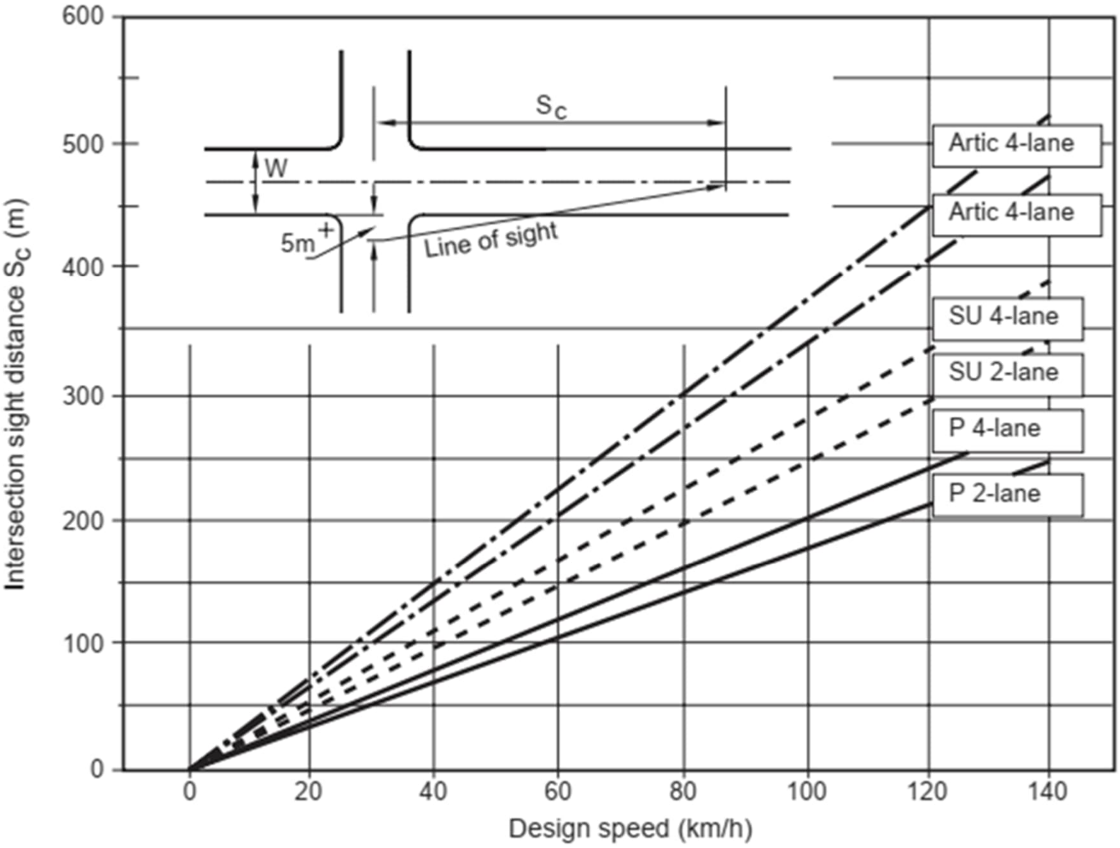


Figure 2.64: Intersection Sight Distance per Lane

The object height is 1.3 m. The eye height is 1.05 m for a passenger car and 1.8 m for buses and all other design vehicles. There should not be any obstruction to the view in the sight triangle, which is defined as the area enclosed by the sight line and the centre lines of the intersecting roads.

Where an intersection is subject to yield control, the unobstructed sight triangle must be larger. If it is assumed that the vehicle approaching the intersection on the minor leg will be travelling at 30 km/h, a distance of 30 m would be required to stop the vehicle. If the driver is already preparing to stop, allowance for reaction time is no longer necessary and a distance of 10 m is required to bring the vehicle to a standstill. If the approach speed is 60 km/h, the required distance is 45 m.

The sight triangles required for yield control based on an approach speed of 60 km/h are so large that the probability of their being found in an urban area is remote.

If the driver does not stop but turns to travel in the same direction as a vehicle approaching at the design speed of the through-road, the driver of the latter vehicle will be forced to slow down to match speeds at a safe following distance.

The intersection sight distance for this manoeuvre is shown in Figure 2.65.

Because the driver approaching the yield sign may be required to stop, intersection sight distance as defined and measured for the stop condition must also be available.

Intersections are, typically, the points at which pedestrians would want to cross the through-road. Pedestrians must therefore be provided with adequate sight distance to ensure that they can cross the through-road in safety. This case is precisely analogous to that of the vehicle at the intersection, because the principle involved is that the sight distance provided is directed towards what the pedestrian must be able to see rather than the sight distance available to drivers of vehicles on the through-road.

Pedestrian sight distance is measured from an eye height of 1.0 m to an object height of 1.3 m. It is assumed that the pedestrian is located on the left side of the intersecting road with the oncoming vehicle approaching also from the left.

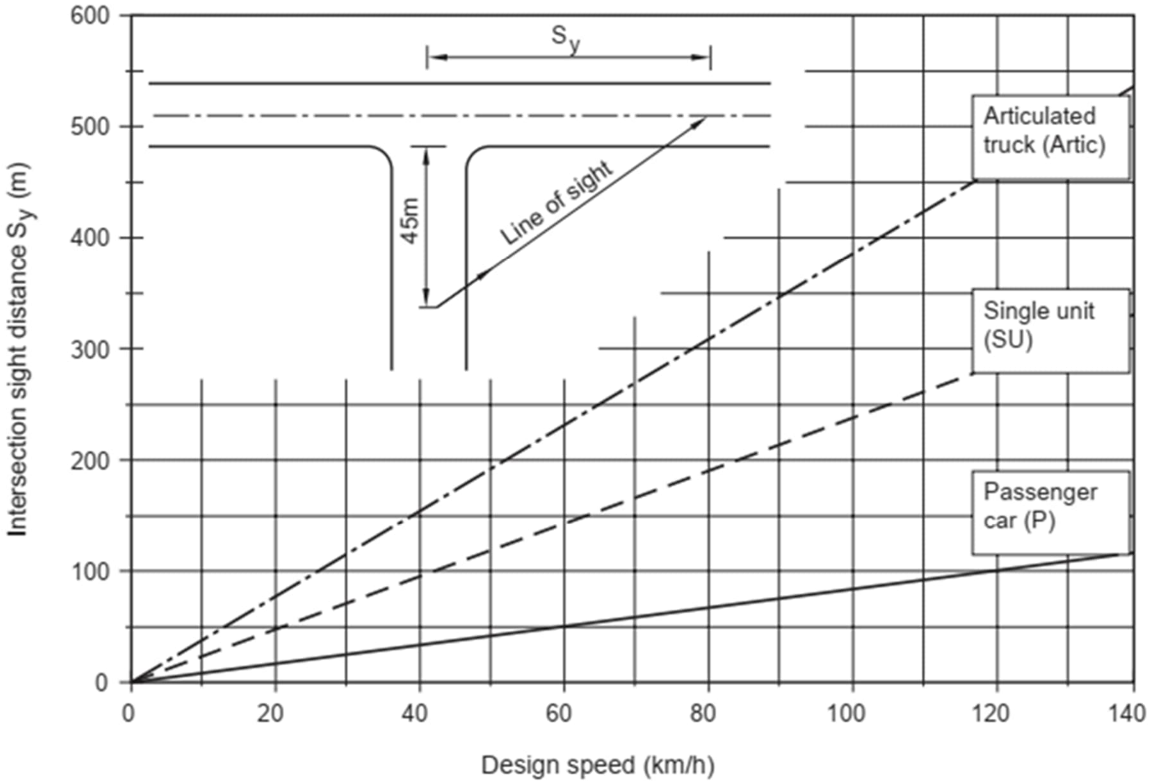


Figure 2.65: Intersection Sight Distance for Yield Control

This represents the longest crossing distance before a situation which is at all safe is achieved, because the further assumption is that the pedestrian will not be required to pause on the centreline of the through-road. The distances shown in Table 2.31 would be adequate for crossing a two-lane road.

Table 2.31: Pedestrian Sight Distance

Design Speed (km/h)	Sight Distance (m)
40	130
60	190
80	240
100	300
120	350

If adequate sight distance is not available, it may be necessary to provide a signalised crosswalk, thus forcing through vehicles to stop. Furthermore, if an adequate gap in the through-traffic does not present itself at intervals not exceeding one minute, a signalised pedestrian crossing should also be considered.

ELEMENTS OF DESIGN

The alignment of an arterial in an urban area should be developed in accordance with its design speed, desired operating speed, and context, particularly where a principal arterial is to be constructed on a new location and is not restricted by right-of-way constraints. However, there are many situations, especially in urban environments, where this is not practical. It is desirable to use the best alignment design practical since curves on arterials in urban areas are often not superelevated in the low-speed range.

HORIZONTAL ALIGNEMNT

The design elements of a horizontal alignment are the tangent (straight section), the circular curve, the transition curve (spiral curve) and the superelevation sections.

For all urban roads with a design speed of 50 km/h or less, the horizontal alignment may be based on straights and circular curves. Lane lines and kerb lines shall be determined or confirmed by the use of vehicle tracking / swept path.

On roads that may continue to have a higher design speed than 50 km/h in future, the designer may introduce transition curves applicable to the higher design speed. Transition curves must be calculated as outlined in the Road Design Manual Volume 1: Geometric Design and presented in the sections that follow.

The minimum radius for curves must be calculated as outlined in the Road Design Manual Volume 1: Geometric Design, the summary is shown below.

Circular Curves

The basic principle of horizontal curve design is derived from application of the kinematics equation, according to which the total lateral acceleration, applied through pavement superelevation and tyre pavement friction on a vehicle negotiating a circular curve, should be equal to the centripetal acceleration due to vehicle movement. For calculation of the minimum horizontal radius, R min, for a particular design speed, the following equation shall be used:

$$R_{min} = \frac{V_D^2}{127(e + f)}$$

Where VD is Design Speed (km/h)
e is Maximum superelevation (%/100)
f is Side friction coefficient

In principle, the side friction factor may be considered to be the lateral force developed by the driver on a level road. The technical evidence indicates that lateral accelerations, and hence side friction factors, increase with reduced radii of curvature and increased speed. Side friction coefficients are dependent on vehicle speed, condition of texture or roadway surface, weather conditions, and type and condition of tires. The range is considerable, and values of “f” found from road measurements have varied from just over 0.1 for high-speed roads to over 0.5 on lower speed roads. The results of empirical studies have indicated 0.22 as a value of “f” above which passengers experience some discomfort.

In urban areas the maximum superelevation shall be limited to 5%. This maximum superelevation in urban areas is influenced by the need to accommodate at-grade junctions and accesses, which are very common in an urban environment.

Table 2.32: Minimum Radii for Horizontal Curves: 4% Superelevation (Urban roads)

Design Speed V_D (km/h)	20	30	40	50	60	70	80
Min. Horiz. Radius R (m)	15	35	60	100	150	21	320
Side Friction Factor (f)	0.4	0.32	0.25	0.22	0.19	0.17	0.14

Compound Curves

Compound curves are horizontal curves of different radii turning in the same direction with a common tangent point. The use of compound curves is not favoured due to drivers not perceiving the change in curvature and not anticipating a change in side friction demand. To minimize the operational problems, the curves should be designed requiring a consistent side friction demand. Where practicable, designers should try and replace compound curves with a single circular curve. Where it is found necessary to use compound curves, the following guidelines apply to their use:

- radii less than 1000 m are undesirable.
- where radii less than 1000 m are unavoidable, the design speed for each curve should desirably be within 5 km/h and remain above the minimum operating speed for the section of road.
- there should be no more than two curves of diminishing radii.
- diminishing radii should be avoided on steep downgrades.
- on a one-way roadway, a smaller curve preceding a larger curve is preferable.

The change in friction demand between the curves of different radii can cause instability problems for motorcycles and trucks (or any other vehicle with a high centre of gravity). Riders of motorcycles are not able to anticipate the change in friction if they are unable to perceive the change in curve radii, which is common with compound curves. If deceleration is likely to be required for trucks, allow sufficient distance for drivers to react and decelerate.

Broken Back Curves

Broken back curves are adjacent curves of the same direction which are separated by a short length of straight or in some cases by a large radius curve (Figure 2.66). They may be necessary on roads where alignment is constrained by hilly or mountainous terrain.

In general, broken back curves should be avoided wherever possible because lane discipline is poor, their appearance is unsightly, it is virtually impossible to provide the correct amount of superelevation throughout the curves, and it is equally difficult to produce a pleasing grading of the pavement edges.

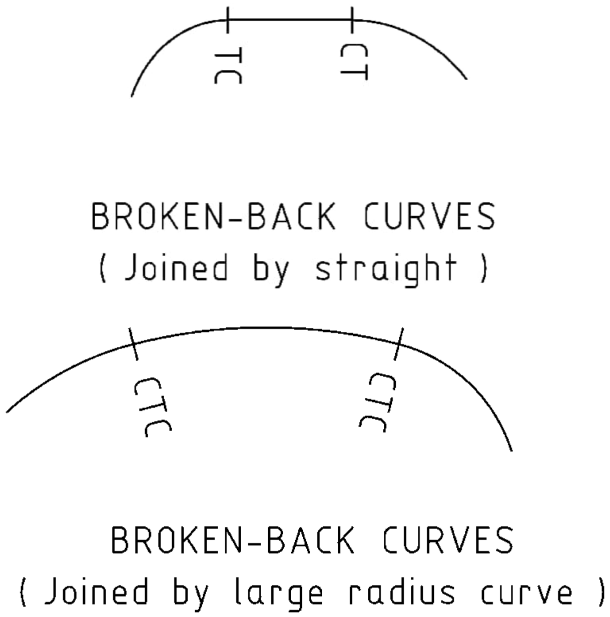


Figure 2.66: Broken Back Curves

Reverse Curves

A reverse curve is a section of road alignment consisting of two adjacent curves turning in opposite directions. The occurrence of abrupt reverse curves (having a short tangent between two curves in opposite directions) should be avoided since such alignment make it difficult for the driver to remain within his lane. It is also difficult to super-elevate both curves adequately, and this may result in erratic operation.

If it is unavoidable to use reverse curves, there must be sufficient distance between the curves to introduce full superelevation of the two curves and provide not greater than the standard rate of change of crossfall for the particular design speed. This is important for driving comfort and safety.

Transition Curves

The characteristic of transition (spiral or clothoid) curve is that it has a constantly changing radius. Transition curves may be inserted between tangents and circular curves to reduce the abrupt introduction of the lateral acceleration. They may also be used to link straights or two circular curves.

It is normal practice for horizontal curves to be transitioned, with the transition length based on the superelevation runoff length for the recommended combination of speed, radius, and superelevation. This length criterion provides the advantages given below whilst minimising the negative effects on driver perception, braking and overtaking that are associated with long transitions. The provision of transition curves:

- allows for proper truck tracking on low radius curves by reducing transient conditions with lateral movement and roll moment (Blue & Kulakowski 1991)
- avoids a kinked appearance where a circular curve connects to a straight, which is particularly obvious where the carriageway edge is defined by kerb and channel.
- provides a close match between the transitioning radius and superelevation appropriate to the design speed.
- if too long, may mislead drivers as to the true radius of the circular curve and its starting point, thus creating a potential hazard.
- is not necessary in a design line on urban works where the frequency of turn lanes and islands is such that the kerb alignment has little relationship to the design line.
- allows a convenient and desirable location for superelevation runoff (Section 7.7.6) such that the change in crossfall can be affected in a manner closely matching the radius-speed relationship for a vehicle traversing it.

Table 2.33: Widening on Curves and High Fill

Transition curves may not necessarily be required for large radius horizontal curves, where operating speeding is less than 60km/h.

Widening On Curves

Widths should be increased on certain horizontal curves (a) to allow for the swept paths of trucks; (b) to allow drivers to manoeuvre when approaching other vehicles; (c) to make operating conditions on curves comparable to those on tangents. Widening is needed on certain curves due to (a) The vehicle or truck occupies a greater width because rear wheels generally track inside front wheel (off-tracking) in rounding curves, or (b) the driver experience difficulty in steering their vehicles in the centre of the lane.

The required amount of widening is dependent on the characteristics of the vehicles using the road, the radius and length of the curve and lateral clearances. Carriageway widening is also necessary to present a consistent level of driving task to the road users, to enable them to remain centred in lane and reduce the likelihood of either colliding with an oncoming vehicle or driving onto the shoulder.

The following levels of widening are recommended.

Widening for curve should be applied on the inside of a curve and be gradually introduced over the length of the transition and should be attained gradually over a length sufficient to make the whole of the carriage way fully usable; and also ensure a reasonably smooth alignment of the edge of the carriageway. Fill widening shall be applied on both sides of the road.

Table 2.34: Widening on Curves and High Fill

Radius of Curve (m)	Curve Widening		Fill Widening	
	Single Lane	Two Lane	Height of Fill (m)	Widening (m)
20 - 40	0.6	1.5	0.0 - 3.0	0.3
41 - 60	0.6	1.2	3.0 - 6.0	0.6
61 - 120	0.0	0.9	6.0 - 9.0	0.9
121 - 250	0.0	0.6	> 9.0	0.9
>250	0.0	0.0		

Sight Distance on Horizontal Curves

Another element of horizontal alignment is the site distance across the inside of curve. Where there is sight obstruction (such as walls, cut slope, buildings and longitudinal barriers) on the inside of curves, a design to provide adequate sight distance may require adjustment in the normal road cross section or change in alignment if the obstruction could not be removed.

The sight distance is measured along the line of sight which is the chord line of the inside lane.

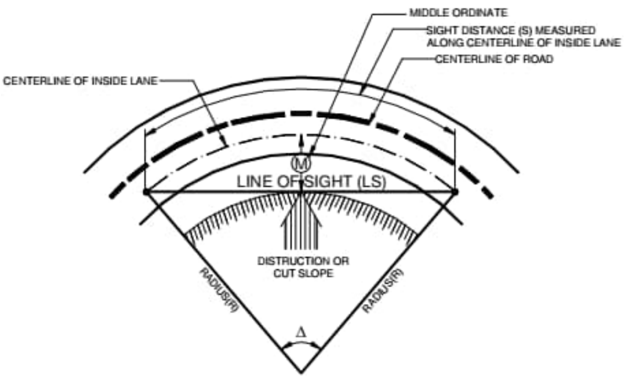


Figure 2.67: Sight distance on horizontal curve

Line of sight (LS) = 2R Sin(Δ/2)
Where Δ is the maximum deflection angle subtended by line of sight and the radius (^{0})

Middle ordinate (M) = R(1 – Cos (Δ/2)) [a]
Middle ordinate (M) = R(1 – Cos(28.65S/R)) [b]

S = stopping sight distance for the corresponding design speed

To satisfy the required stopping sight distance for any design speed, the middle ordinate calculated per the relationship [b] should not be less than that of [a]. This means that the available sight distance should not be less than the required sight distance for the specific design speed.

VERTICAL ALIGNMENT

The two major aspects of vertical alignment are vertical curvature, which is governed by sight distance criteria, and gradient, which is related to vehicle performance and level of service. Vertical alignment should ensure that no features such as bends, intersections or crossings are obscured beyond a crest curve that cannot be clearly observed and understood by an approaching user in sufficient time to adjust their approach path and speed appropriately.

Vertical Curves

Vertical curves are required to provide smooth transitions between straight gradients. The simple parabola is recommended for these as it provides a constant rate of change of curvature and hence acceleration and visibility along its length and it has the form:

$$r = \frac{g_2 - g_1}{L}$$

$$y = \frac{rx^2}{2} + g_1 \times BVC_{elevation}$$

Where r is rate of change of grade per section (%)
g1 is starting grade (%)
g2 is ending grade (%)
L is length of curve (horizontal distance[m])
y is elevation at point of the curve
x is distance in stations from the BVC (beginning of vertical curve) [meters/100]
$BVC_{elevation}$ is elevation of the beginning of vertical curve
EVC is end of the vertical curve

The formulae for design of crest and sag vertical curves can be rather complex to apply, and thus the design is best accomplished through the application of a computer program, or by use of design charts.

The minimum lengths of crest and sag curves have been designed to provide sufficient stopping sight distance. The design is based on minimum allowable "K" values, as defined by the formula:

$$K = L / A$$

Where K is limiting value, horizontal distance required to achieve a 1% change in grade
L is length of vertical curve (m)
A is Algebraic difference in approach and exit grades (%)

Minimum lengths of crest and sag vertical curves have been recommended based on design speeds and stopping sight distance requirements. They provide for ride comfort, appearance, and safety. These are shown in Table 2.35 and Table 2.36 respectively, in terms of “K” values. Minimum length of vertical curves must be calculated as outlined in the Road Design Manual Volume 1: Geometric Design.

Table 2.35: Minimum Values for Crest Vertical Curves

Design Speed (km/h)	Rate of Vertical Curvature, K for Stopping Sight Distance	K, for Passing Sight Distance
20	2	10
30	3	50
40	5	90
50	10	130
60	18	180
70	31	250
85	60	350
100	105	480
120	210	680

Table 2.36: Minimum Values for Sag Vertical Curves

Design Speed (km/h)	Rate of Vertical Curvature, K for Stopping Sight Distance	K, for Passing Sight Distance
20	2	10
30	4	50
40	8	90
50	12	130
60	18	180
70	25	250
85	36	350
100	51	480
120	74	680

Minimum Lengths of Vertical Curves

Where the algebraic difference between successive grades is small, the intervening minimum vertical curve becomes very short, and, particularly where the adjacent tangents are long, the impression of a kink in the grade line is created. Where the difference in grade is less than 0.5%, the vertical curve is often omitted. In Table 2.37 a minimum length of curve for algebraic differences in grade greater than 0.5% is suggested for purely aesthetic reasons.

Where a crest curve and a succeeding sag curve have a terminal point in common, the visual effect created is that the road has suddenly dropped away. In the reverse case, the illusion of a hump is created. Either effect is removed by inserting a short length of straight grade between the two curves and, typically, 60m to 100 m is adequate for this purpose.

Table 2.37: Minimum Length of Vertical Curves

Design Speed (km/h)	Length of Curve (m)
40	80
60	100
80	140
100	180
120	220

Grades

The grades selected for an arterial in an urban area may have a significant effect on its motor-vehicle operational performance and can also affect pedestrian and bicycle operations. Flatter grades should be considered on arterials in urban areas having large numbers of trucks to avoid considerable speed reductions.

Bicyclists will slow substantially on uphill grades, making provision of dedicated bicycle facilities desirable.

It is desirable to provide the flattest grades practical while providing 0.3% minimum (0.5% desirable) gradients to provide adequate longitudinal drainage. Where topography prevents this, a maximum grade over route length of 8% may be acceptable.

Gradient steeper than 8% will require treatments for pedestrian routes alongside the road. These steeper gradients should only be used where acceptable alternative accessible path routes are provided. Gradients should not be steeper than 8% but may be increased above 8% where topographical constraints exist.

Maximum gradients for different design speeds and types of topography are suggested in Table 2.38. It is stressed that these are guidelines only. Optimization of the design of a specific road taking the whole-life economy of the road into account, may suggest some other maximum gradient.

Table 2.38: Maximum Gradients on Major Roads (%)

Design Speed (km/h)	Topography		
	Flat	Rolling	Mountainous
40	7	8	9
60	6	7	8
80	5	6	7
100	4	5	6
120	3	4	5

On local roads, maximum gradient has a significant effect on the cost of township development. Where possible, road alignment should be designed to minimise the extent and cost of earthworks and to avoid problems with access and house design. It therefore has to be accepted that short sections of steep gradients may be necessary in some settlement developments.

Where a residential road is also a bus route, the gradients recommended in Table 2.38 should not be exceeded. Where this is not possible, a maximum gradient of 12.5% may have to be considered.

On higher-order mixed-usage roads, the recommended maximum gradient is 10% but, on sections not longer than 70 m, the gradient can be increased to 12.5%. On purely residential roads, the maximum gradient should be 12% and on sections not longer than 50 m the gradient could be increased to 14%.

Notwithstanding the values given, the following points should be taken into consideration:

- Gradients should be selected in consultation with the stormwater design engineer.
- Steep gradients on short access loops and cul-de-sac could result in properties being inundated.
- Multiple-use surfaces which serve both vehicular access and recreational purposes, including playing space for children, should be relatively flat and not provided with barrier kerbs (they are, in fact, shared surfaces)
- Where cycling is an important mode of travel, it will be necessary to consider the effects of gradient on cycling in deciding on the road alignment.
- It is difficult to construct roads on gradients steeper than about 12% by conventional means. 12/14-ton rollers may not easily climb gradients this steep. They also tend to damage the base course while attempting to stop after a downhill pass. At steeper grades, consideration should be made for construction of rigid pavements. Such can be reinforced concrete, brick or interlocking road stones/blocks. The last-mentioned surface is not recommended where speeds in excess of about 60 km/h are anticipated, as the partial vacuum created behind a passing tyre tends to suck out the sand from between adjacent stones and thus destroy the integrity of the surface.

Minimum Gradients

If the cross-section of the road does not include kerbing, the gradient could be 0% because the camber is continued across the adjacent shoulder, thus allowing for adequate drainage of the road surface. The verge (and subsurface drainage system) will have to accommodate the drainage both of the road reserve and of the surrounding properties. The decision to accept a zero gradient would thus have to be informed by the stormwater drainage design. Zero gradient is not recommended as a general rule and the preferred minimum is 0.5%.

CLIMBING LANES

Application of Climbing Lanes

Climbing lanes are auxiliary lanes added outside the through-lanes. They have the effect of reducing congestion in the through-lanes by removing slower-moving vehicles from the traffic stream. As such, they are used to match the Level of Service on the rising grade to that prevailing on the level sections of the route. In the urban situation, climbing lanes may be used on vehicles-only and higher-order mixed-usage roads. They have no application on local residential roads.

Warrants for climbing lanes

As implied earlier, the maintenance of an acceptable level of service over a section of the route is one of the reasons for the provision of climbing lanes. Another reason is the enhancement of road safety by the reduction of the speed differential in the through-lane. The warrants for climbing lanes are therefore based on both speed and traffic volume.

A bus/truck speed profile should be prepared for each direction of flow. It would then be possible to identify those sections of the road where speed reductions of 20 km/h or more may warrant the provision of climbing lanes.

The traffic volume warrant is given in Table 2.39. It should be noted that the word "heavy vehicles" includes buses, rigid-chassis trucks and articulated vehicles.

A further warrant is based on matching Levels of Service (LOS) along the route. Alternatively, a form of partial economic analysis developed by Wolhuter (1990) could be used. Software that compares the cost of construction of the climbing lane to the costs of the delay incurred by not providing it can be used.

Table 2.39: Traffic Volume Warrant for Gradients on Major Roads

Gradient (%)	Traffic Volume in Design Hour (veh/h)	
	5% Heavy vehicles in Stream	10% heavy vehicles in Stream
4	632	486
6	468	316
8	383	257
10	324	198

Location of terminals

A slow-moving vehicle should be completely clear of the through-lane by the time its speed has dropped by 20 km/h, and remain clear of the through-lane until it has accelerated again to a speed which is 20 km/h less than its normal speed. The recommended taper length is 100 m so that the start taper begins 100 m in advance of the point where the full climbing lane width is required, and the end taper ends 100 m beyond the end of the climbing lane.

If there is a barrier line, owing to restricted sight distance, at the point where the speed reduction warrant falls away, the full lane should be extended to where the marking ends, with the taper ending 100 m beyond this point.

Climbing lane width

The climbing lane should preferably have the same width as the adjacent through-lanes. On major routes, through-lanes may have widths of 3.7 m, 3.4 m, or 3.1 m. It is unlikely that climbing lanes will be provided on roads where the traffic volumes are so low that a lane width of 3.1 m is adequate. Climbing lanes therefore tend to be either 3.7 m or 3.4 m wide. Even if the through-lanes are 3.7 m wide, a climbing lane 3.4 m or perhaps even 3.1 m wide may, however, be considered on the grounds of low lane occupancy and speed or some other constraining topographic circumstance. Climbing lanes on bus routes should, however, have a width of 3.7 m.

2.4.2 CROSS SECTION ELEMENTS

The cross-section of a road provides accommodation for moving and parked vehicles, drainage, public utilities, non-motorized vehicles and pedestrians. It is also required to serve more than just movement related activities.
Residential roads, for example, offer a neutral territory on which neighbours can meet informally. They can also serve as playgrounds for children in developments where plot sizes are too small for this purpose.

Abutting trading or light industrial activities in activity corridors may require sidewalks wider than those required purely for moving pedestrians. Pedestrians also "park", in the sense of browsing through goods on offer (either in shop windows or by roadside vendors) or relaxing in a sidewalk café. In short, the road reserve is required to address a wide spectrum of activities. For this reason, it was suggested previously that reference should be to "hard open space" with only a portion of this comprising the right of way (road reserve) as previously understood.

Movement, as an activity served by the cross-section, comprises a spectrum of needs. One end of the spectrum of the movement function relates to pure mobility, as typified by the freeway and urban arterial. Vehicle movement is the sole concern and pedestrians are totally excluded from these roads. The other end of the spectrum is concerned with accessibility and the needs of the pedestrian. Vehicular movement may be necessary on these roads, but it is tolerated rather than encouraged and is subject to significant restrictions. Between these two extremes, mixed usage is found with vehicular and non-vehicular activities sharing the available space. If these uses have to compete for their share of space, it can reasonably be stated that the design has failed to meet its objective.

The flexibility of the road reserve in accommodating such widely disparate needs derive from the disaggregated nature of the cross-section, as illustrated in Figure 2.68

The cross-section may comprise all or some of the following components:

- Lanes
  - o Basic
  - o High Occupancy Vehicle (HOV) lanes
  - o Auxiliary (turning or climbing)
  - o Parking
  - o Cycle
- Medians
  - o Shoulders
  - o Central island
- Shoulders
  - o Verges
  - o Sidewalks.

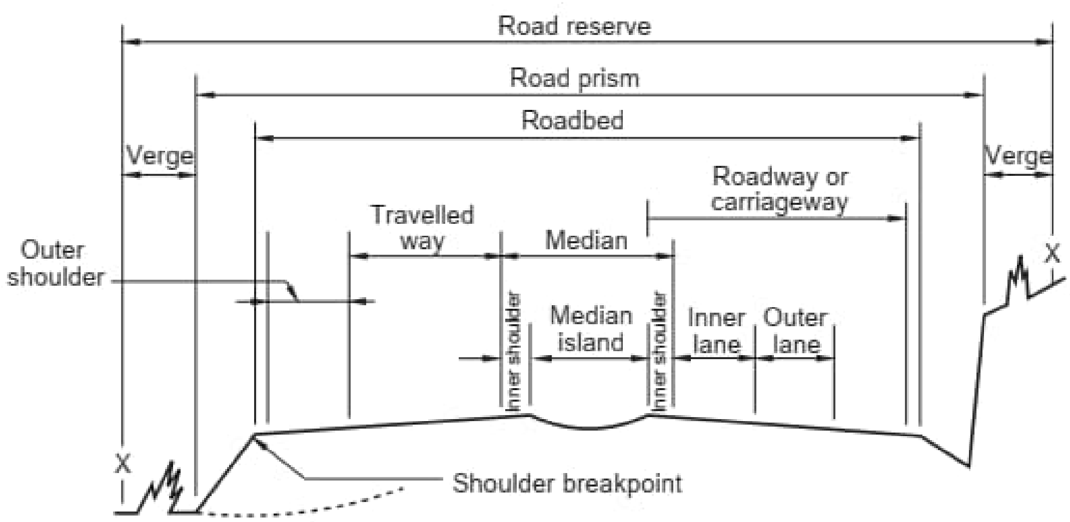


Figure 2.68: Elements of the Cross Section

Lanes

Basic / Through Lanes

Undivided roads may have either one lane in each direction (two-lane two-way roads) or more than one lane in each direction (multilane roads). Dual carriageway roads have two or more lanes in each direction separated by a median. Customarily, there is symmetry of through-lanes, and asymmetry on a particular section of road should arise only from the addition of an auxiliary lane that is clearly allocated to one direction of travel.

Road width should be minimized so as to reduce the costs of construction and maintenance whilst being sufficient to carry the traffic efficiently and safely. Please refer to section xxx for the recommended lane widths for each category of road.

Auxiliary Lanes

Auxiliary lanes are lanes added to the normal cross section to address a specific purpose and are normally applied only to vehicle-only or higher order mixed-usage roads.

Typically, auxiliary lanes are added at intersections to support left and right turns so that these man oeuvres can take place at relatively low speeds without impeding the movement of the through traffic. If a road has signalized intersections, it may be necessary to add auxiliary lanes to match the intersection capacity to that of the approach legs. These lanes are discussed in more detail below under the heading “Intersections”.

Parking Lanes

Parking lanes are normally 2.5m wide with a minimum width of 2.1m, and are usually embayed. In this configuration, the parking lane is actually located in the verge area. Individual parking bays are may typically be 6.0m long with each pair of parking bays being provided with an additional clear space of 1.5m between them to allow for manoeuvring into or out of the bays. In areas where very high tidal flows are expected, it is useful to be able to use the parking lanes as moving lanes during periods of peak flow. Under these circumstances, the parking lane should have a minimum width of 3.1m.

Cycle Lanes

Ideally, cycle lanes should be located in the verge area, as the speed differential between bicycles and pedestrians is likely to be less than that between bicycles and motorised vehicles. Where this is not possible and either there is significant cycle traffic or it is desired to encourage bicycles as a mode of travel, a cycle lane can be added outside those intended for motorised vehicles.
Such lanes should be of the order of 1,5 m wide and clearly demarcated as cycle lanes. If these lanes are wider than 2,0 m, passenger cars are likely to use them, possibly even for overtaking on the left, which is a manoeuvre to be actively discouraged.

Shoulders

The road shoulder is an extension of the carriageway by a minimum of 0.5m to provide structural support to the sealed road. Shoulders are recommended for all Design Classes and may be paved when the carriageway is paved. This has a number of advantages.

- It will prevent and protect the carriageway pavement from edge failure and ravelling.
- It will accommodate pedestrians (where pedestrian traffic is not specifically catered for) and other non-motorized traffic that would otherwise use the roadway and interrupt vehicular traffic.
- It will provide a better surface for vehicles parking and vehicles requiring immediate repair.

The width of shoulder varies from 0.5m for low volume roads up to 2.5 m for high speed / high volume roads. Table 2.40 outlines the acceptable widths in different situations.

Table 2.40: Acceptable Shoulder Widths

Shoulder Width	Situation for Recommended Use
0.5 – 1.0m	Only to be used on low-volume low order roads
1.0m	The minimum width next to a safety barrier and the recommended minimum for most situations
1.5m	The preferred width for a sealed shoulder
2.0 – 2.5m	For use on higher speed and/or higher volume roads, particularly where vehicles have to be able to stop outside of the running lanes.

Medians

The median is the total area between the inner edges of the inside traffic lanes of a divided road, and includes the inner shoulders and central island. The purpose of the median is to separate opposing streams of traffic and hence reduce the possibility of vehicles crossing into the path of opposing traffic. This is accomplished by the selection of an appropriate median width or by the use of a physical barrier such as a guardrail.

Median width depends not only on traffic volume but also on the function of the road and traffic composition. A median functioning as a pedestrian refuge could be narrower than one protecting a turning vehicle which could be anything up to a combination vehicle (i.e., semitrailer plus trailer). A median narrower than 3.0 m does not offer pedestrians any sense of security, particularly when buses or trucks are travelling in the immediately adjacent lanes.

A median of less than 1.5 m in width is physically dangerous to pedestrians and should not be considered wherever pedestrian traffic is likely to be encountered. However, with severe spatial limitations, it is possible to use medians this narrow. They would serve only to accommodate back-to-back guardrails to ensure vehicular separation. A median that is 5.0 m wide would be able to accommodate a right-turn lane with provision for a pedestrian refuge, but would also require guardrail protection to separate the opposing flows of traffic.

Medians are totally inappropriate in residential roads. These roads are principally directed to the function of accessibility, including vehicles turning right from the road to enter individual properties. Medians, particularly when raised and kerbed, preclude this movement. If medians are depressed, it is possible for vehicles to traverse them but, for oncoming vehicles, this is an unexpected and correspondingly dangerous manoeuvre.

<u>Verges</u>

The verge is defined as the area between the roadway edge and the road reserve boundary.

All facilities not directly connected with the road, e.g., telephone or power lines, are normally located in the verge. In the case of the freeway, the verge is simply the clear space between the shoulder breakpoint and the reserve boundary. On the other hand, in the urban, specifically the residential, environment it is the verge that gives the road its richness and unique character.

As in the case of the cross-section as a whole, where the total width is built up as the sum of various disaggregated elements, the verge width is also the sum of the various elements it is required to contain. In general, the verge should have a width of the order of about 5 metres, but, as implied by the preceding statement, this can only be regarded as a very rough rule of thumb.

Even where High Occupancy Vehicle (HOV) lanes are provided, it is desirable to locate bus stops in the verge. Typical layouts for bus stops are shown in Figure 2.69.

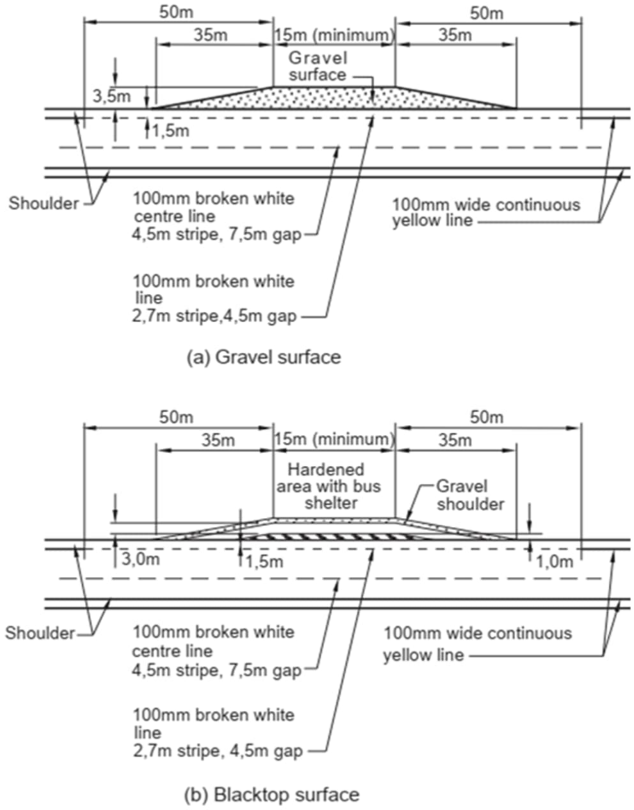


Figure 2.69: Typical Bus Stop Layouts

Table 2.41: Typical Width of Verge Elements

Elements	Width (m)
Bicycle paths	1.5 - 3.0
Bus stop embayment	3.0
Bus stop passenger queue	0.7 - 1.4
Clear strip (including kerb and drainage inlet)	2.0
Drainage inlet or manhole	1.5
Driveway approach	5.0
Electric light poles	0.3 - 0.5
Footway (sidewalk)	1.5 - 2.0
Guardrails or barriers	0.5
Kerbs (barrier)	0.15
Kerbs (mountable)	0.3
Kerbs (semi-mountable)	0.15
Landscape strip	3.0
Parking (parallel)	2.5
Traffic signals	0.6 - 1.5
Traffic signs	0.6 - 2.0
Trench width for underground service	1.0 m minimum

Footways / Sidewalks

Wherever there is significant usage by pedestrians, a sidewalk should be provided. The width of the sidewalk is dictated by the anticipated volume of pedestrian traffic, with an additional allowance being made for any other application intended as part of the function of the road reserve.

The footway should be separated from the carriageway by a grass strip or similar, at least 2.0m wide. Gradients should be gentle, preferably less than 4%. On embankments the footway/cycleway can be benched into the fore slope. The planting of shade trees can help encourage people to use the facility. This may be more applicable in rural setting. Raised, kerbed footways should be provided in the larger built-up areas.

Cut and Fill Batters

Grade lines that require cuts or fills so high that their batters require specific attention are alien to mixed-usage roads. The intention with these roads is that the grade line should be as close as possible to the natural ground level and, preferably, slightly below it. This is necessary to ensure ease of access to adjacent properties and also to support the drainage of the surrounding area.

On vehicle-only roads, the slopes of the sides of the road prism are, like those of medians, dictated by two different conditions. Shallow slopes are required for safety, and a slope of 1:4 is the steepest acceptable for this purpose. The alternative is to accept a steeper slope and provide for safety by some other means, such as guardrails. In this case the steepest slope that can be used is dictated by the natural angle of repose and erodibility of the construction material.

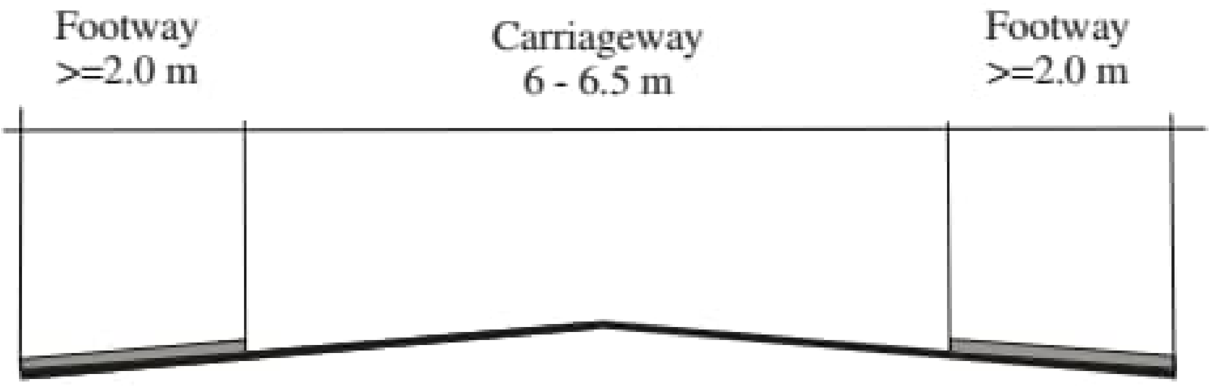


Figure 2.70: Raised, Kerbed Footway

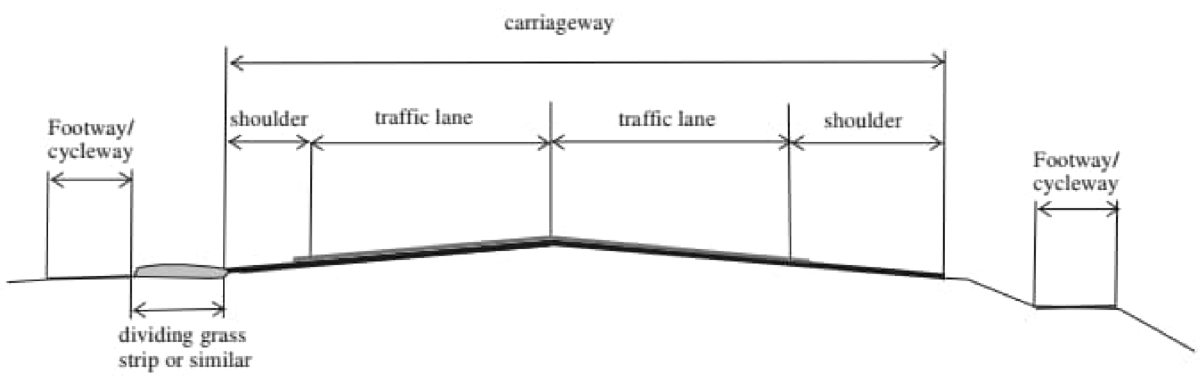


Figure 2.71: Separate Foot and Cycleway

CAMBER AND CROSSFALL

Because of rainfall, minimum transverse gradients of 3% towards the outer edge of the road should normally be used on all sealed roads. However, where existing features prevent this, the camber or cross-fall may vary between 2% and 4%. On unsealed roads, minimum transverse gradients of 4% towards the outer edge of the road should normally be used.

Transverse gradient steeper than 3% (up to 5%) is preferred on steep roads to encourage drainage towards the road channel.

Where longitudinal gradient is less than 1%, crossfall must not be less than 3%, to encourage sheet flow to road edge.

At intersections, the camber of the major road should take priority and the minor road should be designed so that it grades into the channel line of the major road. If this cannot be achieved, the crown of the minor road should not extend into the traffic lane of an arterial or collector road.

Adverse cross-fall (fall towards the outside of a bend) will not be permitted on roads with design speed greater than 50 km/h.

SUPER-ELEVATION

The superelevation to be adopted is chosen primarily on the basis of safety, but other factors are comfort and appearance. The superelevation applied to a road should take into account:

- operating (design) speed of the curve,
- tendency of very slow-moving vehicles to track towards the centre
- stability of high laden trucks where adverse crossfall is considered, and the need to increase superelevation on downgrades
- difference between inner and outer formation levels. This is especially important in urban areas
- length available to introduce the necessary superelevation

In the specific case of urban areas, the following guideline shall generally apply when providing superelevation.

- Super-elevation may not be permitted on local or collector roads and is unlikely to be required on arterial roads within urban areas.
- The maximum super-elevation should be limited to 5% in areas where pedestrian movements are prevalent.

It is also important to note that, in order to achieve the design speed for the road, super-elevation on curves is required where the longitudinal gradient is steeper than 8%.

There are a number of methods to determine the superelevation (and hence resultant side friction) for curves with a radius larger than the minimum radius for a given design speed.

Linear Method

The ‘linear method’ distribution to be used in this guide is for the superelevation and side friction to be varied linearly from zero for R = infinity to e_{max} and f_{max} for R_{min}. This then results in the proportions of the required centripetal acceleration due to superelevation and side friction being the same for larger radii as they are at R_{min}, considering the following practical considerations:

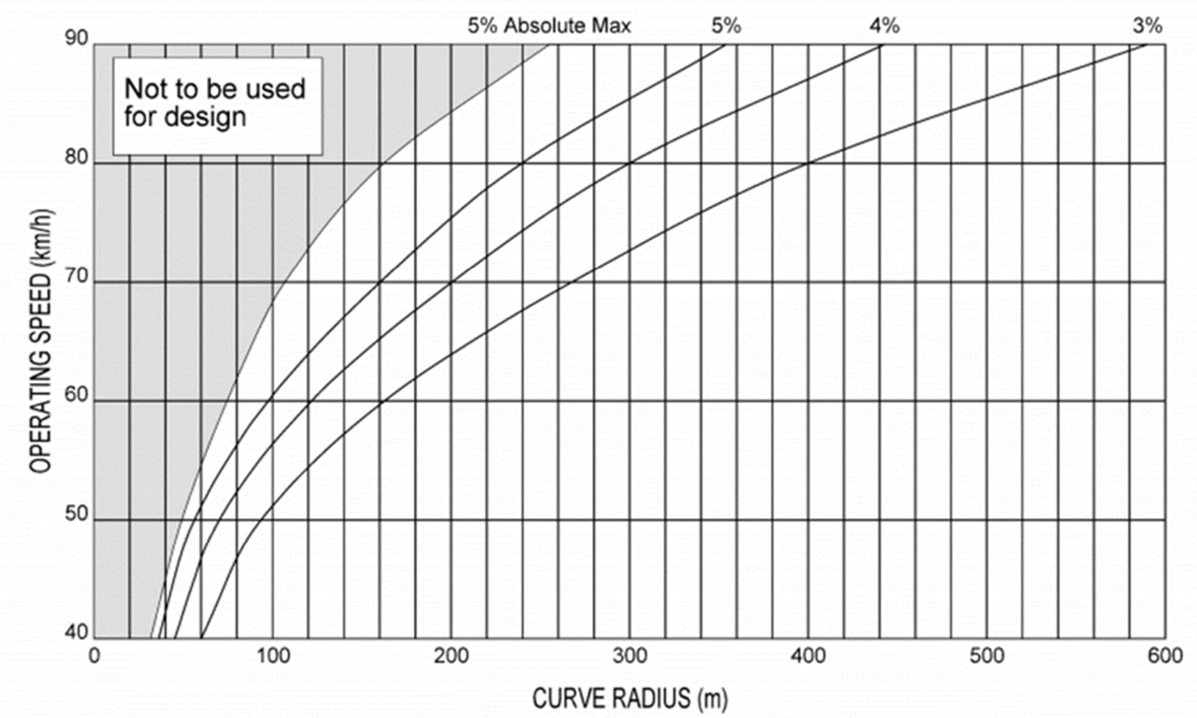
- For construction expediency, superelevation values are normally rounded (upwards) to a multiple of 0.5% and there is a corresponding adjustment of side friction.
- Other methods have been used in the past so there are likely to be many cases where the reuse of existing pavement will dictate a different superelevation. This is acceptable if the resultant side friction is suitable for the curve design speed and consistent with that for any adjacent curves.

With the ‘linear distribution method’, the superelevation (e_1) for a curve of radius R, which is greater than R_{min} is given by:

$$e_1 = \frac{V^2 e_{max}}{127R(e_{max} + f_{max})}$$

Note that f_{max} may be either the absolute maximum value or the desirable maximum value for the design speed V. Refer to Figure 2.72 for the relationship between speed, radius and superelevation.

The value of e_1 is usually rounded upwards (e.g., 4.0% but 4.1% becomes 4.5%) and the corresponding coefficient of side friction is calculated from the following formula:



Note: Based on a desirable maximum side friction for e ≤ 5%, absolute maximum side friction for e = 5%, and a linear distribution of side friction for e ≤ 5%.

Figure 2.72: Urban Roads Relationship Between Speed, Radius and Superelevation (V < 90km/h)

$$f_1 = \frac{V^2}{127R} - e_{1\,rounded}$$

However, if specific controls cannot be met, then actual e values may be used. With different possibilities for e_{max} and f_{max} (absolute maximum vs. desirable maximum), different values of superelevation may be attributed to a given combination of radius and design speed. The subjective basis of the 'linear distribution method' (and indeed most other methods) and the practice of rounding the superelevation value, allows a practical rationalization to be made.

The maximum values of superelevation (e_{max}) for the different road categories roads are listed in Table 2.42.

- For urban roads, the maximum super-elevation should be limited to 5% (e_{max} = 5%) in areas where pedestrian movements are prevalent with an adopted, rationalization of the desirable maximum side friction (f) values have been derived between zero and 5%

Table 2.42: Maximum Super Elevation per Class of Road

Class of Road	Maximum Superelevation (%)
Vehicle-only (freeway)	10
Vehicle-only (other)	6 – 8
Mixed-usage (higher-order)	4 – 6
Mixed-Usage (middle-order)	2 – 4
Mixed-usage (lower-order)	2 – 4

Application of Superelevation

Super-elevation shall not be applied on local or collector roads and is unlikely to be required on arterial roads within urban areas. For other higher-order roads including freeways maximum superelevation up to 10% may be applied.

On straights, the pavement has normal crossfall to shed water. This crossfall is provided both ways from the centre on undivided roads. On a divided road each carriageway usually has one-way crossfall away from the median on straight alignments.

A change from normal crossfall to full superelevation occurs as the road changes from a straight to a curved alignment (except where adverse crossfall is adopted), or from a very large curve with adverse crossfall to a lower radius curve.

The adopted position of the axis of rotation, the point about which the crossfall is rotated to develop superelevation, depends upon the type of road facility, total road cross-section adopted, terrain and the location of the road. On a two-lane two-way road, the superelevation is developed by rotating each half of the cross-section (including shoulders) about the carriageway centreline or crown (axis of rotation).

On divided roads where the median is relatively narrow (less than 5 m), the two carriageways may be rotated about the centreline of the median. Where the median is wide, the axis of rotation is usually along the median edge of each carriageway (particularly in flat country).

Length of Superelevation

The length required to develop superelevation should be adequate to ensure a good appearance and give satisfactory riding qualities.

The higher the speed or wider the carriageway, the longer the superelevation development will need to be to meet the requirements of appearance and comfort.

The length of superelevation development is the transition of crossfall from a normal roadway on straight alignment to that of a fully superelevated crossfall on a circular curve (refer to Figure 2.73)

The total length required to develop superelevation is called the overall length of superelevation development (L_e). It consists of two main elements:

- superelevation runoff (S_{ro}) the length of roadway needed to accomplish a change in crossfall from flat crossfall to a fully superelevated crossfall
- tangent runout (T_{ro}) is the length of roadway required to accomplish the change in crossfall from a normal crown section to a flat crossfall.

Lengths of superelevation development are determined from the two design criteria of:

- rate of rotation of the pavement crossfall
- relative grade of the axis of rotation to the edges of carriageway grades being rotated.

Superelevation runoff and tangent runout lengths are calculated by proportioning the normal crossfall to full superelevation using design values for superelevation development shown in Table 2.42.

$$S_{ro} = L_e - L_e \left[\frac{e_1}{e_1 + e_2}\right]$$

$$T_{ro} = L_e - S_{ro}$$

Where: L_e = superelevation development length (m)
S_{ro} = superelevation runoff (m)
T_{ro} = tangent runout (m)
e_1= normal crossfall (%)
e_2 = full superelevation crossfall (%)

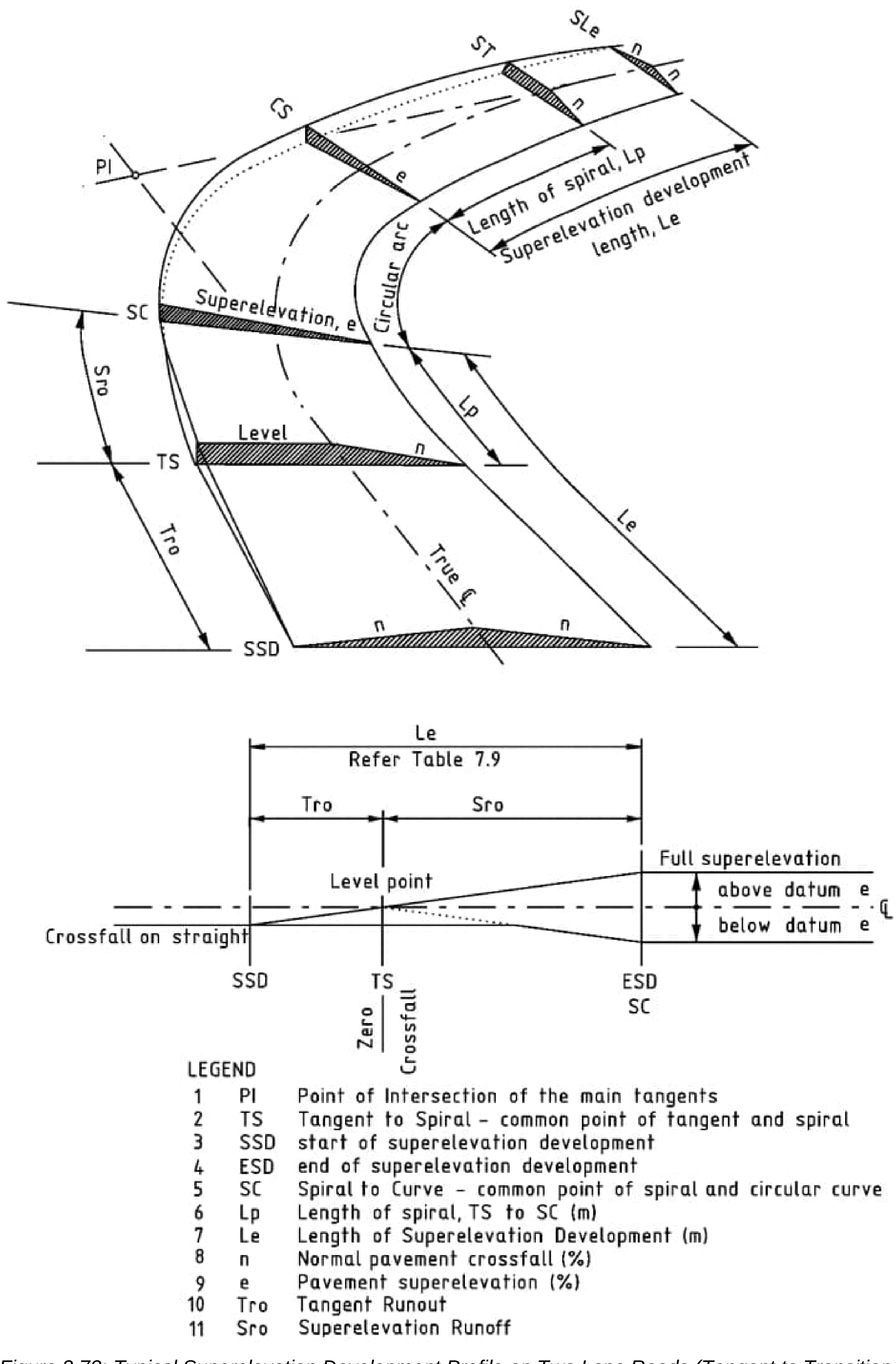


Figure 2.73: Typical Superelevation Development Profile on Two Lane Roads (Tangent to Transition Curve to Circular Curve)

Rate of Rotation

The rate of rotation of the pavement desirably should not exceed 2.5% per second of travel time at the operating speed.

The minimum superelevation development length to satisfy the appropriate rate of rotation criterion can be derived from the following expression.

The rate of rotation of 3.5% (0.035 radians/sec) per second is appropriate for operating speeds < 80 km/h.

The rate of rotation of 2.5% (0.025 radians/sec) per second is appropriate for operating speeds ≥ 80 km/h.

$$L_{rr} = \frac{0.278(e_1 - e_2)V}{r}$$

Where L_{rr} = superelevation development length (m) based on the rate of rotation criterion
e_1 = normal crossfall (%)
e_2 = full superelevation crossfall (%)
V = operating speed (km/h)
R = rate of rotation (%)

Table 2.43 shows values of superelevation development length satisfying the rate of rotation criterion.

Where there is a need to increase the rate of rotation in order to manage flow paths of storm water, consideration can be given to increasing the rates of rotation, to reduce the flow path lengths and mitigate the chance of vehicles aquaplaning. A rate of 3% per second is acceptable for higher speed roads and 4% for roads constructed in mountainous terrain.

Relative Grade

The relative grade is the percentage difference between the grade at the edge of the carriageway and the grade of the axis of rotation. This difference should be kept below the values shown in Table 2.40 to achieve a reasonably smooth appearance.

The expressions relating to the relative grade criterion are as follows (Roads and Traffic Authority 1989).

For a rate of rotation of 3.5% per second, which is appropriate for operating speeds < 80 km/h

$$G_R = \frac{12.6W_R}{V}$$

For a rate of rotation of 2.5% per second, which is appropriate for operating speeds ≥ 80 km/h.

$$G_R = \frac{9.0W_R}{V}$$

Where G_R = relative grade (%)
W_R = width from axis of rotation to outside edge of running lanes (m)
V = design speed (km/h)

Table 2.43: Maximum Relative Grade Between Edge of Carriageway and Axis of Rotation in Superelevation Development

Operating speed (km/h)	Relative grade %		
	One lane[1] (W_R=3.5)	Two lanes[2] (W_R=7.0)	More than two lanes[3] (W_R=10.5)
40 or under	0.9	1.3	1.7
50	0.75	1.15	1.5
60	0.6	1.0	1.3
70	0.55	0.9	1.15
80	0.5	0.8	1.0
90	0.45	0.75	0.95
100	0.4	0.7	0.9
110	0.4	0.65	0.85
120	0.4	0.6	0.8
130	0.4	0.6	0.8

1 *Applies to normal two-lane two-way road with the axis of rotation on the centreline.*
2 *Applies to two lane two way road with control along one edge; four lane roadway with control on centreline and two lane two way road with climbing lane and control on centreline of the two lane two way road.*
3 *Applies to multilane roadway with more than two lanes between the axis of rotation and the edge of running lanes.*

The relative grade calculated for the relevant rate of rotation is satisfactory when it is less than relevant maximum relative grade given in Table 2.40.
The length of superelevation development to satisfy the relative grade criterion is derived from the following formula.

$$L_{rg} = \frac{W_R(e_1 - e_2)V}{G_R}$$

Where Lrg = superelevation development length (m) based on the relative grade criterion
e_1 = normal crossfall (%)
e_2 = full superelevation crossfall (%)
G_R = relative grade (%), from Table 2.43
WR = width from axis of rotation to outside edge of running lanes (m)

These lengths have been calculated using G_R values from able 2.41. The designer may consider using the calculated values of G_R where they are less than the tabulated values.

Table 2.44: Design Superelevation Development Lengths (Le) Satisfying Both Rate of Rotation and Relative Grade Criteria

Operating speed (km/h)	Length (m) of superelevation development from normal crossfall to required superelevation											
	–ve 3% to + ve 3%			–ve 3% to +ve 5%			–ve 3% to +ve 7%			–ve 3% to +ve 10%		
No. lanes	1	2	3	1	2	3	1	2	3	1	2	3
40	**23**	**32**	**37**	**31**	**43**	**49**	**39**	**54**	**62**	**51**	**70**	**80**
50	**28**	**37**	**42**	**37**	**49**	**56**	**47**	**61**	**70**	**61**	**79**	**91**
60	**35**	**42**	**48**	**47**	**56**	**65**	**58**	**70**	**81**	**76**	**91**	**105**
70	**38**	**47**	**55**	**51**	**62**	**73**	**64**	**78**	**91**	**83**	**101**	**119**
80	53	53	**63**	71	71	**84**	89	89	**105**	116	116	**137**
90	60	60	**66**	80	80	**88**	100	100	**111**	130	130	144
100	67	67	**70**	89	89	**93**	111	111	**117**	–	–	–
110	73	73	**74**	98	98	**99**	122	122	**124**	–	–	–
120	80	80	80	107	107	107	–	–	–	–	–	–
130	87	87	87	116	116	116	–	–	–	–	–	–

Notes:
Final numbers should be rounded up to the nearest 5 m.
Bold numbers relate to the relative grade criterion.
Traffic lanes assumed to be 3.5 m wide.
For carriageways wider than 3 lanes, designers shall calculate the appropriate superelevation development length using both the rate of rotation and relative grade criteria and adopt the larger value.

Design Superelevation Development Lengths

Designers should adopt superelevation development lengths (Le) that satisfy both the rate of rotation and relative grade criteria. Accordingly, the greater value of the lengths calculated using the rate of rotation criteria and the relative grade criteria is then adopted for Le and these values are shown in Table 2.44.

Positioning of Superelevation Runoff

The positioning of the superelevation runoff for circular radius curves without transitions should desirably have about 70 to 90% (depending on operating speed) of the superelevation run-off on the tangent.

For circular curves with transition curves, it is good practice to make the lengths of superelevation runoff equal to the length of the transition curve. The superelevation runoff is then contained solely within the transition curve length.

Reverse Curves

Reverse curves are horizontal curves turning in opposite directions. Where there are no transitions, it is Desirable that reverse curves should have sufficient distance between them to introduce the full superelevation development for each of the curves without exceeding the standard rate of change of superelevation for the particular operating speed.

When this length cannot be achieved, superelevation development may extend into the circular curves. The operating speed will have to be managed to suit the curve geometry.

On reverse transitioned curves, the reversal of superelevation is implemented uniformly and linearly. However, in the case of long transition curves and small superelevation, it is necessary to increase the rotation rate in the vicinity of the point of zero superelevation to promote improved pavement surface drainage and minimize flow path lengths.

Compound Curves:
Compound curves are horizontal curves of different radii turning in the same direction with a common tangent point. Where compound curves are provided, the full superelevation on the smaller curve should be developed on the larger radius curve prior to the common tangent point.

Superelevation Development on Shoulders

Where the shoulders are fully sealed or partially sealed, it is convenient to construct the shoulders with the same crossfall as the abutting pavement. In this case, the superelevation development is similar to that of the pavement with the width rotated, increased by the full width of the shoulder.

On paved road with unsealed shoulders, the shoulders should drain away from the paved area to avoid loose material being washed across the road.

VEHICLE CROSSING

Vehicle crossings provide a way for vehicles to enter and exit land next to the road boundary. They are located between the edge of the roadway and the road corridor boundary, across footpaths or berms.

Vehicle crossings must not compromise the design criteria for existing or future bus facilities, footpaths or cycleways. Refer to Figure 2.74 for the main elements

A driveway crossing must be no wider at the boundary than it needs to be:

- A two-way driveway in a residential zone that is 5.5m wide will require the crossing to be 5.5m at the boundary or may be narrowed to 2.75m if there are passing places with clear sight lines.
- One way access in a centres/mixed use zone may only need to be 3m wide.
- Access to car parks or petrol stations that provides truck delivery access should restrict the width available for car access with over-run paving to manage turning speed, vehicle path and safety of footpath users.

Design Vehicles should be selected according to land use. The standard design vehicle for residential vehicle crossings is the 85-percentile car.

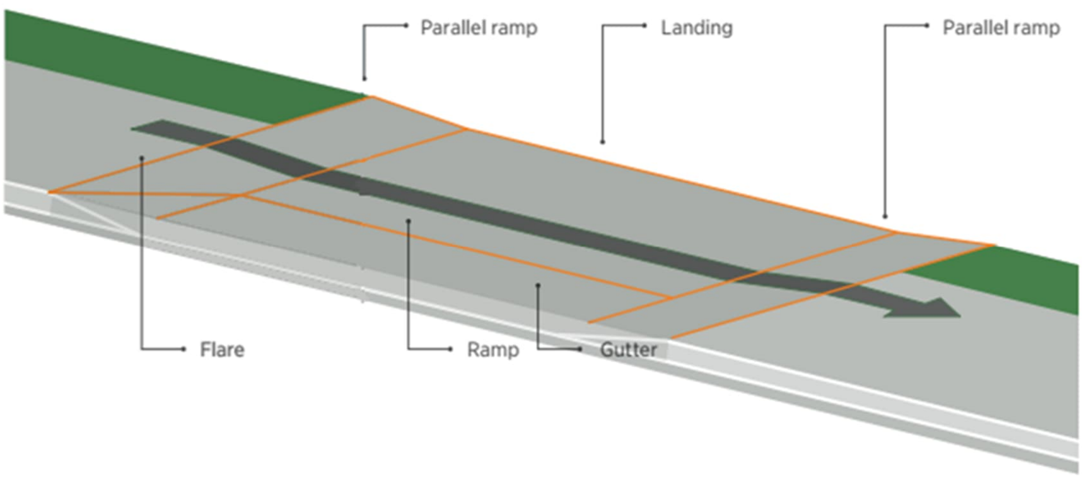


Figure 2.74: Vehicle Crossing Elements

Note that a larger vehicle may be desirable, depending on land-user specific requirements.

Crossing flare should be optimized to produce the minimum turning speeds and swept paths for the road environment.

The pedestrian path through route should be continuous in grade, cross-fall, colour and texture across the driveway, with no tactile warning indicators; the vehicle crossing and driveway must be considered subservient to the pedestrian through route.

For steep driveways requiring a change in the level of the footpath through the crossing, footpath ramps either side of the crossing should not exceed a grade of 8%. If this is not possible, the grade should not exceed 12% and the level difference at this grade should not exceed 75 mm. Check surface water flow depth to avoid flood nuisance

Vehicle crossings should be located so that drivers entering and leaving have adequate sight distances along the adjacent footpath, cycleway and road. Consideration shall also be given to the grade of the driveway to help prevent vehicles scraping and storm water entering the driveway.

2.4.3 AT-GRADE INTERSECTIONS

GENERAL PRINCIPLES

Good intersection design is based on sound geometric design and user criteria where safety is a primary consideration.

Intersection principles are:

- As compact as possible
- Part of a multi-modal network
- Integrate time and space
- Intersections are shared spaces
- Design for context

The designer must provide evidence that the design will meet capacity, safety and turning movements of intended vehicles and all other road users.
Traffic modelling must show that the design can mitigate the effects of existing traffic and that generated by new developments unless directed otherwise by the local authority. Where applicable, consideration should be given for future network traffic change, with an appropriate design year to be approved by the local authority. The assessment could include intersection modelling, using appropriate software.

Where the local authority set target capacities for a route, or intersections on a route, new intersection design should provide capacity appropriate for the network locally. Generally, capacity should be consistent with that of adjoining intersections except where improvements to these are planned through a network plan, structure plan or project.

In an urban location, left turn slip lanes should only be provided where there is clear traffic and/or safety justification. They should be avoided where there are high pedestrian volumes. If provided, a left-turn slip lane must be designed considering pedestrian safety and convenience and appropriate sight distances must be achieved. A zebra crossing should usually be provided to give priority to pedestrians. A one-way table must be used to emphasize the crossing and manage vehicle speeds.

SELECTION OF INTERSECTION CONTROL & GEOMETRIC DESIGN

Each new or upgraded intersection should be evaluated to determine the most appropriate form of intersection control. A robust assessment of all options is necessary, giving due consideration to effects on the wider road network. Level of service for all road users must be considered, and performance in traffic conditions on different days and times of day.

Designers are referred to the Road Design Manual Volume 1: Geometric Design Section 8 – At Grade Intersections, which provides guidance on selecting the type of intersection and their functional design.

2.5 CHAPTER 5: PAVEMENT DESIGN GUIDELINES

2.5.1 INTRODUCTION

The urban road practitioner is required to meet the standards and guidelines in the latest versions of the Uganda pavement design manuals. Where there is a conflict, then the URDM takes precedence only with reference to urban areas.

This pavement design section is adapted from Section I of 'The Neighbourhood Planning and Design Guide' also known as the 'Red Book' (South African Department of Human Settlements (DHS), 2019). The aim of this section is not to provide a detailed pavement engineering design manual for urban roads, but rather to summarise and reference known pavement engineering concepts from existing manuals for an urban road context. As such, the currently used Uganda national and district manuals for pavement design (including those for low-volume roads) supersede the information provided in this section and should be used as the primary source of reference for pavement design.

All new information provided herewith, for example the information on design considerations and alternative road construction materials should be seen as supplementary resources to the existing pavement design manuals used at national and district levels. Overall, this design standard is meant to provide a broader picture of pavement engineering to effectively design pavements for urban environments. For this section, a 'road pavement structure' refers to the materials and designs associated with a road, including all its underlying layers.

2.5.2 DESIGN CONSIDERATIONS FOR URBAN PAVEMENT STRUCTURES

Pavement design is undertaken with the following objectives:

- A road pavement structure will be economically feasible and structurally balanced
- The pavement will carry the desired traffic load over the specified design life
- The pavement will perform adequately under the prevailing environmental conditions
- The pavement will deliver functional performance at an acceptable level of service
- Available materials will be utilised for construction, taking into account the properties and strength of the in-situ materials

A road pavement structure is considered to be structurally balanced when no single layer is subjected to excessive stresses or strains. The overall aim of pavement design is to protect the subgrade and other underlying layers from pavement distresses over its design life. These distresses are usually caused by traffic loading, environmental conditions, material properties, poor construction and/or inadequate maintenance.

Pavement design does not typically differ for urban and rural environments, except for the type of road surfacing selected and for the provision of drainage. The following are some examples of general design considerations that need to be considered for an urban road pavement structure:

- What are the prevailing environmental conditions (e.g., geology, topography, climate, etc.)?
- What are the current and future traffic loading conditions?
- What are the structural and operational conditions applicable to the pavement structure (e.g., overloading, etc.)?
- What kinds of distresses could occur over the pavement design life (e.g., potholes, etc.)?
- What are the available types of materials that can be used (e.g., in-situ, cemented, etc.)?
- What geotechnical studies and laboratory tests have been conducted?
- Is there adequate protection for the subgrade?
- What are the expected noise pollution levels?
- Is there an acceptably smooth, safe and adequately waterproofed surfacing?
- What new technologies can be used for the road pavement structure (e.g., nanotechnology)?
- What are the impacts of future advancements in technology (e.g., automated vehicles) on the performance of the road pavement structure?
- Utility services that need to be accommodated & protected within the pavement structure.
- Channelised traffic, especially for BRT type lanes.
- Special pavement treatments for areas of high stresses, like intersections, bus stops, stations, and areas where fuel spillage is prevalent.

2.5.3 THE IMPORTANCE OF GEOTECHNICAL STUDIES FOR PAVEMENT DESIGN

Geotechnical studies are critical in order to prevent complete and partial failures to road pavement structures. The lack of geotechnical studies, undertaken before pavement design, could pose serious risk to premature pavement failure. This can lead to a risk to human life due to issues such as traffic disruptions and accidents, resulting in legal action with severe financial implications. Additionally, the in-situ ground condition of a site can sometimes necessitate the use of specialised construction methods or materials, or it can mean that certain areas of the site might not be suitable for construction. A proper preliminary soil survey should be conducted as the characteristics of the underlying subgrade will have implications for the structural design of the road".

The following are some examples of geotechnical design considerations listed and should be considered before designing a road pavement structure:

- What are the soil characteristics and quality of materials? A classification of the subgrade material should be done.
- Are there any aggressive chemicals or minerals present?
- Is the site part of or close to a dolomitic area?
- Was the site used for mining and exploration in the past?
- Are there large rock outcrops on the site?
- Are there gullies or other ditches on the site?
- Is ground water present on or near the site?
- What is the height of the water table?
- Did dumping ever occur on the site?
- Is the site subject to seasonal flooding?

For further information on the importance of geotechnical investigations and other design considerations, refer to Chapter 2 of the Ugandan Road Design and Construction Manual Volume V: Low Volume Sealed Roads (MOWT, 2018).

Other relevant secondary sources include Section 2 of the Malawian Low Volumes Road Manual: Volume 1 (MTPW, 2020) and Chapter 7 of the South African Pavement Engineering Manual (SAPEM) (South African National Roads Agency (SANRAL), 2014)

2.5.4 TYPES OF PAVEMENTS FOR URBAN ROADS

The URDM practitioner may select from the various materials and methodologies to apply in the design of urban roads.

The theory in this section has been extracted and adapted from the Red Book (DHS, 2019).

Refer to Figure 2.75 for a schematic of the pavement types.

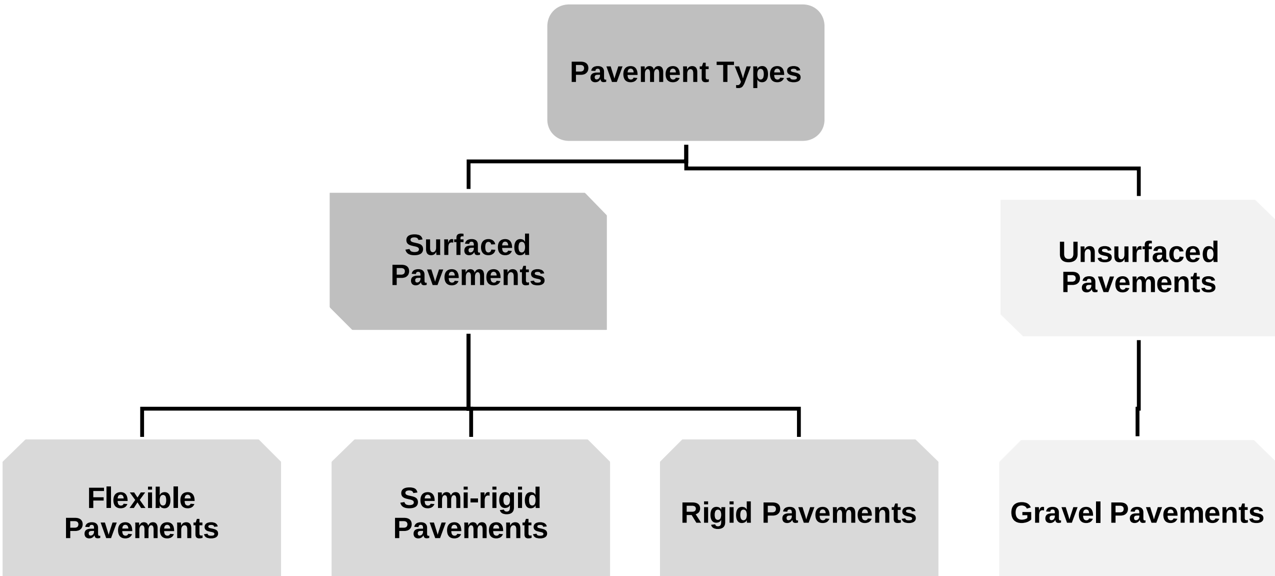


Figure 2.75: Pavement Types Based on Materials and Surfacing

FLEXIBLE PAVEMENTS

Flexible pavements typically have negligible flexural strength and therefore deform under induced traffic loading. They are based on effective stiffnesses within a road pavement structure and are therefore designed in such a way that the material quality gradually increases from the subgrade towards the upper layers, to form a well-balanced road pavement structure. Sometimes, a granular base may be constructed on top of a stronger subbase to form an 'inverted' road pavement structure

Differentiation is also made between deep and shallow pavements:

- In shallow pavements, the strength of the pavement is concentrated in the upper layers of the road pavement structure.
- In deep pavements, the strength of the pavement is distributed throughout the road pavement structure.

There are four types of flexible pavements commonly used, namely unbound granular materials, hot mix asphalt materials, bitumen stabilised materials and/or cementitious materials. These flexible pavement types are defined based on the material used to construct the base layer.

Refer to Figure 2.76 for examples of typical layers found in flexible pavements.

SEMI-RIGID PAVEMENTS

Semi-rigid pavements consist of concrete block paving or segmented concrete paving such as those typically used for walkways. These pavements are usually hand-packed or laid on a sand bedding-layer. Sand is then placed between the blocks to enhance interlocking and strength. Overall, the concrete block system provides a durable wearing course that is typically supported by a subbase and selected layer.

Refer to Figure 2.77 for examples of typical layers found in rigid pavements.

RIGID PAVEMENTS

Rigid pavements usually consist of concrete. These pavements are designed to have a very high modulus of elasticity and offer high flexural rigidity. This results in load spreading mostly within the top layer of the road pavement structure with lower stresses in the underlying layers. Concrete pavements can be constructed on poor subgrades, and generally have fewer pavement layers than flexible pavements.

GRAVEL ROADS

Gravel or unpaved roads need a designed layer of imported material to carry specified loads in all weather conditions. The wearing course should also protect the subgrade below. The material requirements for these types of roads are less stringent in terms of strength but have to be erosion resistant. Typical challenges associated with gravel roads include dust, potholes, ruts, cracks, erosion and slipperiness.

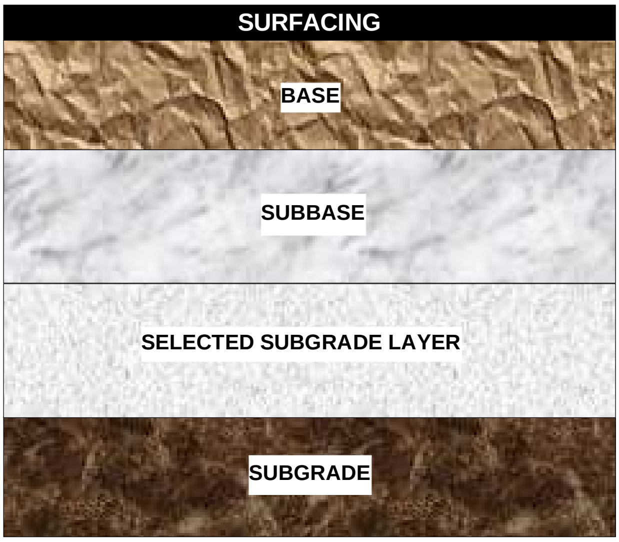


Figure 2.76: Typical Pavement Layers in Flexible Pavements

Figure 2.77: Typical Pavement Layers in Rigid Pavements

PAVEMENT TERMS

SAPEM Chapter 2 (SANRAL, 2014) describes the purpose of various layers found within a road pavement structure as follows:

- **Surfacing:** This is a functional wearing course that provides waterproofing, skid resistance, noise-damping, durability against the elements, visibility and drainage. For surfaced roads, the upper layer is bound, consisting of spray seals. Surface layers are usually very strong, durable, impermeable and expensive.

- **Base:** This is a load spreading layer and is the most important structural component of the pavement. The layer must provide the required support for the surfacing and distribute the very high tyre pressures and wheel loads uniformly over the underlying layers and subgrade. This layer is typically strong, free-draining and less expensive.

- **Subbase:** This layer provides support for the base as well as a platform upon which to construct a structural base layer of high integrity. It also protects the underlying selected subgrade layer by further spreading the load. This layer is typically moderately strong, free-draining and inexpensive.

- **Selected subgrade:** These layers are primarily capping for the subgrade to provide a workable platform on which to construct the imported pavement layers. At the same time, these layers provide depth of cover over the subgrade to reduce the stresses in the subgrade to acceptable levels. This layer is typically moderately weak and inexpensive.

- **Subgrade:** This is the existing material upon which the pavement must be constructed. It can be modified with stabilisers to reduce plasticity, ripped and recompacted to achieve uniform support, or undercut and replaced, depending on its quality. This layer is typically weak, moisture sensitive and typically consists of in-situ soil.

2.5.5 PAVEMENT MATERIALS FOR URBAN ROADS

Refer to Chapter 5 of the Ugandan Road Design and Construction Manual Volume V: Low Volume Sealed Roads (MOWT,2018) for detailed information on pavement materials available in Uganda.

The following types of naturally occurring materials are commonly available in Uganda (MOWT, 2018), refer to Table 2.45: .

Table 2.45: Common types of natural materials found in Uganda

Type of Material	General Engineering Properties
Laterite gravel	The behaviour of laterite gravel is largely dependent on the parent soil in which it is formed. Laterites that form in clayey soils tend to be plastic and this is very common. This is the major reason why laterites have not been widely recommended for road construction as the high plasticity leads to lower CBRs and most therefore do not meet the minimum standard specifications of road base of not less than 80% CBR.
Calcrete gravel	Mature calcrete can give an ACV of about 25 which is good enough for use as surfacing aggregate. The properties of calcrete are dependent on the host material in which it is deposited. If it is deposited in clay plasticity is usually high and that which is deposited in sand soils tends to have low plasticity. The maturity of the calcrete determines the strength and how and where it can be used in the road structure.
Quartzitic gravel	Quartzite gravel is a very important material in road construction. Quartzite is a very hard material, and it is usually angular. This is what gives quartzitic gravel an edge over the other forms of gravel in terms of its performance in service. Quartz gravel is usually well graded, but it depends on the composition of the parent rock. Quartz gravel may have a high content of silt which increases the plasticity of the whole gravel matrix. Most quartz gravels have low plasticity if not non-plastic. The CBR is usually high, and this makes quartzitic gravel suitable natural material for construction of bases usually without the need for stabilisation.
Decomposed granite	Decomposed granite gravels tend to have low plasticity and regardless of the low particle strength the material can be used for the construction of bases on low volume roads or sub-bases on high volume roads without treatment. However, it may be necessary to consider stabilisation with cement for use on road base for higher volume roads.
Basaltic gravel	The engineering properties of basalt gravels tend to show high variability and need close examination and monitoring. High coarseness usually leads to high bearing capacity but when plasticity is high the bearing capacity becomes highly compromised. Basalt gravels also have a tendency to degenerate in service depending on a number of factors including the moisture regime and traffic loading. Such degeneration can lead to sharp increases in plasticity of the gravel layer in-service leading to significant reduction in strength which in turn may lead to premature failures.
Ryolite gravel	Ryolite gravels can be found in many different forms but with the appropriate work norms it is possible to build good natural road bases with it. High content of volcanic ash makes construction difficult as a result of the powdery nature of the ash. Screening is usually necessary due to high contents of reject material which may include large boulders up to 300mm in diameter.
Cinders/red ash	The plasticity of cinder gravels is usually low, and most gravels are non-plastic. The grading is also variable, and the gravel may be coarse with large boulders or fi ne grained. The most important parameters are the aggregate strength, the density (the maximum dry density) which can be very low and the plasticity. Cinder gravels which a high content of basaltic material tend to be plastic and other forms tend to have low plasticity. Cinder gravels with low particle strength tend to degenerate during construction and care should be taken to prevent excessive degeneration as these compromises the overall bearing capacity of the base layer. Modification of the material may be necessary to enhance performance of the road base in-service.

GRANULAR MATERIALS

Unbound granular materials include graded crushed stone, natural and crushed gravels, sand and soils. Granular materials are typically used in the construction of the base, subbase and selected subgrade pavement layers. Certain types of gravel are also used for the wearing course of unpaved roads. The selection of a type of gravel is informed by issues ranging from traffic loading, availability of material, climate and labour intensity of construction.
Source: Red Book (DHS, 2019)

According to the MOWT (2018), naturally occurring materials of varying properties may be found locally close to the project areas. These materials may in many cases not meet conventional standard specifications for heavily trafficked roads. Such materials may however be used within a framework of standards and specifications which have been developed. However, their use demands careful attention to three factors:

- There must be good internal and external drainage of the pavement.
- The construction quality control must be rigorous with serious attention paid to compaction; and
- There must be a realistic commitment to appropriate maintenance strategies.

According to the MOWT (2018), materials prospecting is both an art and a science which involves searching for clues for the occurrence of useful materials and then excavating to see whether they exist. Materials prospecting can be very complicated and often takes several months or sometimes years. However, for most roads, local residents and the road maintenance department often have information relating to the occurrence of road building materials. Identifying features that indicate the presence of gravel from interpretation of maps, vegetation, outcrops, burrows and other information is a key activity in prospecting. Prospecting involves a desk study followed by field surveys and trial pitting. Information about gravels in the landscape typically comes from five main sources:

- Geological information from geological maps and reports.
- Soils information from agricultural soils maps and reports.
- Botanical indicators (such as certain weed types are often synonymous with the occurrence of certain gravels).
- Landscape information from topographical maps, aerial photos and satellite imagery.
- Other local information (e.g., existing borrow pits).

The aggregated analysis of all this information allows for the prospective areas of occurrence to be significantly narrowed down.

MACADAMS

Macadams are traditional, high quality, labour-intensive pavement materials which can be used as a replacement for good-quality granular materials. They are regarded as comparable in performance with a graded crushed stone, that has been used successfully in the tropics. Two nominal types are used: dry-bound and wet-bound. However, specific knowledge of construction techniques is required. Macadams are less water-susceptible than the usual granular materials and using them should be considered, especially in wet regions.
Source: Ugandan Road Design Manual Volume 3: Pavement Design Part I (MOWHC, 2005).

CEMENTED MATERIALS

Available local natural gravel materials are often found to be of inadequate quality to provide the required pavement structural strength. Cemented materials are formed when the materials with inadequate quality are treated or stabilised to improve their properties for use in selected subbase or base layers. The material can be treated using conventional stabilisers such as cement, lime, slagment, lime/fly-ash mixtures or various combinations of pozzolanic binders, depending on the properties of the natural materials.
Source: Red Book (DHS, 2019)

BITUMEN STABILISED MATERIALS

Bitumen stabilised materials (BSMs) are pavement materials that are treated with either bitumen emulsion or foamed bitumen to improve their strength, as well as to reduce the moisture susceptibility of the material. The materials to be treated may be granular materials, previously cement-treated materials, or reclaimed asphalt (RA) layers. BSMs may be used on new construction projects to treat the locally available material, and to enable the use of this material in the pavement base layer or on rehabilitation projects by treating the existing base material.
Source: Red Book (DHS, 2019)

HOT MIX ASPHALT MATERIALS

Hot mix asphalt (HMA) materials may be used for the construction of surfacing and base pavement layers. HMA is composed of virgin aggregates or RA, filler and bituminous binders. The use of RA in HMA is considered to be economical and have environmental benefits, as it enables a reduction in consumption of non-renewable resources and aggregates, as well as in the use of landfill space for discarding asphalt removed from existing roads.
Source: Red Book (DHS, 2019)

Spray seals and slurry seals or micro-surfacing
A spray seal comprises of a coat of bituminous binder sprayed onto the road surface, followed by a layer of aggregate. The layer is then rolled to ensure good adhesion between the aggregate and the binder film. The primary function of a spray seal or slurry seal layer is to provide waterproof cover to the underlying pavement structure, provide a safe all-weather, dust-free riding surface with adequate skid resistance, and to protect the underlying layer from the abrasive forces of traffic and the environment.
Source: Red Book (DHS, 2019)

PRIMES, TACK COATS AND PRE-COATING FLUIDS

Primes, tack coats and stone pre-coating fluids are essential materials in the construction and maintenance of roads. A prime consists of a bituminous binder and is used as a preliminary treatment on a granular layer prior to application of an asphalt layer to promote adhesion between the two layers.

A tack coat is also a bituminous product that is applied either on top of a primed granular base or between layers of asphalt to promote adhesion and enhance adhesion along transverse and longitudinal joints in asphalt layers. Pre-coating fluid is low viscosity bitumen and is used to pre-coat surfacing aggregates to improve the adhesion of the aggregate to the bituminous binder, as well as to reduce the possibility of early chip loss and stripping.
Source: Red Book (DHS, 2019)

PORTLAND CEMENT CONCRETE

The use of concrete as a surface layer offers significant compression and flexural strength, resulting in a very durable structural surface layer that needs very little maintenance during its design life. Concrete is completely resistant to petrol and diesel spillages, which makes this surface ideal for bus depots, fuelling stations, parking lots and overnight rest areas where oil and fuel leaks/spillages can be problematic. The most popular types of rigid concrete pavements include the following:

- Conventional concrete pavements: plain jointed concrete pavement (JCP) and continuously reinforced concrete pavements (CRCP)
- Precast concrete slab pavements
- Roller-compacted concrete pavements (RCC)
- Ultra-thin concrete pavements (UTCP)
- Pervious or porous concrete pavements (PCP)

Source: Red Book (DHS, 2019)

PAVING BLOCKS

Concrete block paving, also referred to as segmented concrete paving, comprises of singular shaped blocks interlocking with each other to create a durable wearing course, supported by a subbase and selected layer. Precast paving blocks have been successfully used for non-trafficked areas, such as walkways, as well as heavily trafficked roads.
Source: Red Book (DHS, 2019)

For further details on appropriate materials for walkways and cycle lanes using paving blocks, please refer to the Malawi Low Volume Roads Manual Volume 1: Pavement Design (MTPW, 2020).

PROPRIETARY PRODUCTS

Proprietary construction products or systems are manufactured and distributed under exclusive rights, but these products are not usually covered by national standards. However, they may be standard products in the sense that they meet the requirements of local or foreign standards, or they may be non-standard or innovative, in that there are currently no applicable standards.

Due diligence is required when using proprietary products to ensure that they have been adequately proof-tested and are considered feasible for use before implementation. It is advised that proprietary products be comprehensively proof tested using laboratory testing, accelerated pavement testing (APT) and/or long-term pavement performance (LTPP).
Source: Red Book (DHS, 2019)

ALTERNATIVE CONSTRUCTION MATERIALS

Due to scarcity of good quality material in many countries, marginal materials that contain minerology compositions that render them inadequate for road construction are sometimes considered for modification. In particular, recent developments in nanotechnology mainly in the form of nano-stabilising agents allow for the chemical modification of these marginal materials at low application rates, thus removing the need for expensive imported materials.

This enables road agencies to construct roads quicker and at lower costs, whilst at the same time maintaining adequate base/subbase layer bearing capacity at an acceptable risk. Nano-products such as nano-modified emulsions (NMEs) claim to offer hydrophobic properties and improve marginal materials at a nanoscale, making them directly suitable for road construction whilst simultaneously providing better performance to good quality materials (Jordaan et al., 2017). NMEs are made by adding nano-additives such as nano-organosilanes and/or nano-polymers to a standard anionic or cationic bitumen-emulsion (Akhalwaya and Rust, 2018).

These nano-organosilanes and/or nano-polymers then attach to any silica-based road material whilst making it hydrophobic. The nano-silane also provides increased adhesion of the bitumen with the aggregate during stabilisation and actively repels water from the layer. The implementation of NMEs therefore has the potential to improve the long-term quality and cost efficiency of road infrastructure through the enhancement of in-situ material properties at affordable cost.
Source: Rust et al. (2020)

For further information on the different types of pavement materials available for urban roads, and their standard specifications, refer to the following guideline documents (NB: this list is non-exhaustive and non-exclusive (some of these guidelines have been developed for other African countries and may not factor in local Ugandan context, hence caution is advised):

- Ministry of Works and Transport (MOWT)., 2018. General Specifications for Low Volume Roads - Series 3000LVR: Earthworks and Pavement Layers, Uganda.
- Ministry of Works and Transport (MOWT)., 2018. General Specifications for Low Volume Sealed Roads - Series 4000LVR: Bituminous Surfacing, Uganda.
- Ministry of Works, Housing and Communications (MOWHC)., 2005. Ugandan Road Design Manual Volume 3: Pavement Design Part I, Uganda.
- Ministry of Works and Transport (MOWT)., 2010. Ugandan Road Design Manual Volume 3: Pavement Design Part II, Uganda.
- Ministry of Works and Transport (MOWT)., 2010. Ugandan Road Design Manual Volume 3: Pavement Design Part III, Uganda.
- Ministry of Works, Housing and Communications (MOWHC)., 2004. Ugandan District Road Works Manual Volume 1A – Technical Manuals Manual A, Uganda.
- The South African Bitumen Association (SABITA) manuals
- The Technical Methods for Highways (TMH) Manuals
- Technical Recommendations for Highways (TRH) Manuals
- Committee of State Road Authorities., 1985. TRH 14: Guidelines for Road Construction Materials, Pretoria, South Africa.
- Concrete Manufacturers Association., 2004. Concrete Block Paving Book 2 and Book 3, South Africa.
- Jordaan, GJ. and Steyn, WJVDM. 2020. Cost-Effective Upgrading of Gravel Roads Using Naturally Available Materials with Anionic New-Age Modified Emulsion (NME) Stabilisation, Pretoria, South Africa.
- South African National Roads Agency (SANRAL)., 2014. The South African Pavement Engineering Manual (SAPEM), South Africa.
- South African Bitumen Association (SABITA)., 2020. Technical Guideline (TG) 2: Bitumen Stabilised Materials, South Africa.
- Transport Research Laboratory (TRL)., 1993. Overseas Road Note 31 (RN 31) – A guide to the structural design of bitumen-surfaced roads in tropical and sub-tropical countries, Crowthorne, United Kingdom.

2.5.6 PROCEDURE FOR PAVEMENT DESIGN

The procedure for pavement design is listed below, as extracted and adapted from the Red Book (DHS, 2019) and from the Ugandan Road Design Manual Volume 3: Pavement Design Part I (MOWHC, 2005).

Step 1 - Determine the class of road

This is done by using the road class matrix as shown in Table 2.46.

Step 2 - Select the structural design period and analysis period

The structural design period and analysis period are important parameters required during the selection of the life-cycle strategy of a road pavement structure. Typically, a design life-cycle strategy would only be applicable to road classes 1 to 4. The analysis period is a convenient planning period during which complete reconstruction of the pavement is undesirable. It is defined as the useful life over which the total present worth cost of the pavement is determined so that life-cycle cost comparisons can be made between alternative pavement design options.

The structural design period is defined as the period for which it is predicted with a reasonable degree of confidence that no structural rehabilitation or maintenance will be required. A maximum design life of 20 years is recommended for all urban roads.

Subsequently, a minimum design life of 10 years is recommended as a practical limit for economic justification or in cases where geometric design life is uncertain, or when substantial changes in the traffic loading is expected.

Three typical pavement lifecycle strategies are usually considered, depending on the availability of materials, the structural capacity demand of the actual traffic spectrum and the service level of the facility. The final selection of a particular design depends on an economic analysis and requires an understanding of the behaviour of different pavement types, and the type and timing of maintenance and rehabilitation during the life cycle.

Table 2.46: Definition of Class of Road for Structural Pavement Design Purposes

Class of Road	**1**	**2**	**3**	**4**	**5-7**
Description	Trunk Route	Major Arterial	Minor Arterial	Collector Street	Access Street, NMT Access Way, Informal Settlement Access Ways
Level of Service	High	High	High to Moderate	Moderate	Moderate to Low
Equivalent 80 kN standard axle load (ESAs) (million ESAs/lane)	10 to 30 depending on the design strategy	0.3 to 10 depending on the design strategy	0.3 to 10 depending on the design strategy	< 3 depending on the design strategy	< 1.5 depending on the design strategy
Traffic Class (million ESAs)	T7-T8	T2-T6	T2-T6	T1-T4	T1-T3

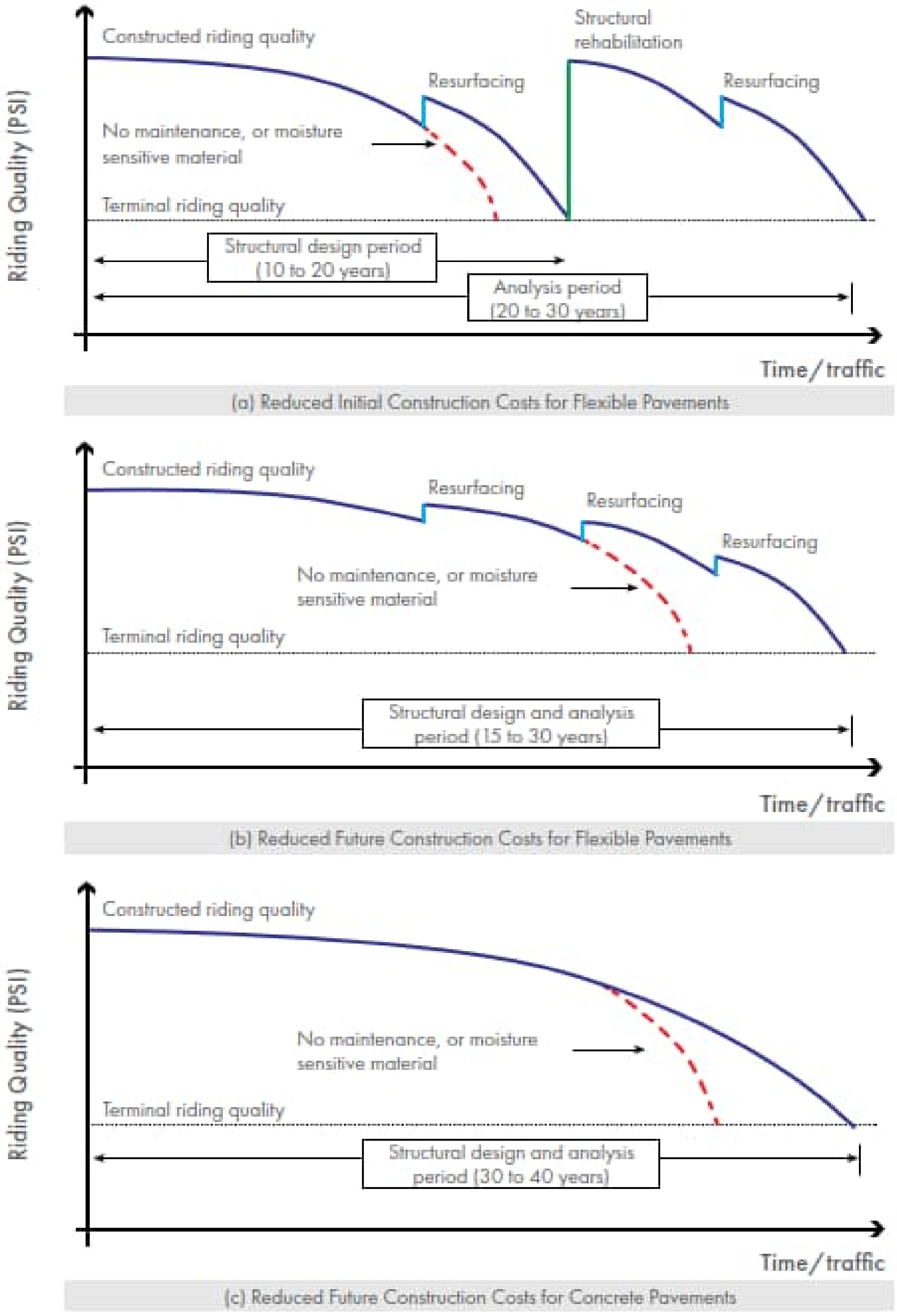


Figure 2.78: Typical Design Periods and Design Strategies Used for Pavement Design

Step 3 - Estimate the design traffic

Refer to Section 2 of the Ugandan Road Design Manual Volume 3: Pavement Design Part I (MOWHC, 2005) for guidance on how to estimate the design traffic. This is usually done by obtaining the Annual Average Daily Traffic (AADT) and the percentage of trucks in order to determine the Equivalent Standard Axles (ESAs). The composition of vehicle traffic on urban roads varies considerably. As such, the composition of the traffic on one urban road will differ from that on another because of the differences in class. Typical traffic classes for Uganda are shown in Table 2.47

Table 2.47: Uganda traffic classes

Source: MOWHC, 2005

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

Step 4 - Determine the type of pavement and material types available for a road class

According to the Red Book (DHS, 2019), certain types of pavements may not be suitable for some classes of urban roads.

Table 2.48 lists the recommended pavement types per urban road class and their subsequent traffic class. The availability of materials and costs will also influence the selection of the type of pavement.

Table 2.48: Recommended Pavement Types per Road and Traffic Class

Pavement Type		Road Class and Traffic Class					Reasons for Exclusion
Base	Subbase	1	2	3	4	5, 6, 7	
		T7-T8	T2-T6	T2-T6	T1-T4	T1-T3	
Concrete	Granular	Yes	Yes	Yes	Yes	Yes	Granular subbases are prone to erosion at joints and cracks
	Cemented	Yes	Yes	Yes	Yes	Yes	
Granular	Granular	Yes	Yes	Yes	Yes	Yes	Uncertain behaviour for high traffic demand
	Cemented	Yes	Yes	Yes	Yes	Yes	
Hot mix asphalt	Granular	Yes	Yes	Yes	Yes	No	Cost effectiveness
	Cemented	Yes	Yes	Yes	Yes	No	
Cemented	Granular	No	No	No	No	Yes	Cracking, crushing, rocking, blocks and pumping
	Cemented	No	No	No	Yes	Yes	
Bitumen Stabilised	Granular	Yes	Yes	Yes	Yes	Yes	Cost effectiveness, permanent deformation, minerology
	Bitumen Stabilised	Yes	Yes	Yes	Yes	Yes	
Nano-modified emulsion stabilised	Granular	Yes	Yes	Yes	Yes	Yes	Cost effectiveness, permanent deformation, minerology
	Nano-modified emulsion stabilised	Yes	Yes	Yes	Yes	Yes	

It is worthwhile to note that when deciding on the type of pavement to select (e.g., flexible or rigid), one should question issues such as:

- What type of materials are available?
- What capacity is available to design and construct the proposed urban road?
- What is the maintenance strategy for the urban road?
- What is the cost of the urban road?

Additionally, when deciding on whether to surface an urban road or not, one should consider factors such as the:

- Typical range of surfacing life (years) per urban road class
- Geometric conditions (e.g., whether realignment would be required if the existing urban road is surfaced)
- Would the surfaced urban road attract more traffic and impact the bearing capacity of the original pavement design?
- What will be the implications to safety for the urban road (e.g., high speeding cars)?
- What would be the effect on maintenance (e.g., potholes and skid resistance)?

During the selection of material types, maximum effort should be made to utilise the full capability of the in-situ material on the alignment in its natural or, if necessary, modified status.
Adequate geotechnical studies should be conducted as well, keeping in mind the design considerations previously mentioned.

Figure 2.79 details the design criteria that are applicable for the selection of appropriate material codes.

Material Code	Material Type	Material Specifications
G80	Natural Gravel / Crushed Stone	Min. CBR: 80% @ 98% AASHTO T180 and 4 days soaking Max. Swell: 0.5% Max. Size and grading: Max size 37.5mm, grading as specified PI: < 6 or as otherwise specified (material specific)
G65	Natural Gravel	Min. CBR: 65% @ 98% AASHTO T180 and 4 days soaking Max. Swell: 1% Max. Size and grading: Max size 37.5mm, grading as specified PI: < 10 or as otherwise specified (material specific)
G55	Natural Gravel	Min. CBR: 55% @ 98% AASHTO T180 and 4 days soaking Max. Swell: 0.2% Max. Size and grading: Max size 37.5mm, grading as specified PI: < 12or as otherwise specified (material specific)
G45	Natural Gravel	Min. CBR: 45% @ 95% AASHTO T180 and 4 days soaking Max. Swell: 0.5 % Max. Size and grading: Max size 37.5mm, grading as specified PI: < 14 or as otherwise specified (material specific)
G30	Natural Gravel / soil	Min. CBR: 30% @ 95% AASHTO T180 & highest anticipated moisture content Max. Swell: 1.0% 1.5% @ 100% AASHTO T180 Max. Size and grading: Max size 63mm or 2/3 layer thickness PI: < 16 or as otherwise specified (material specific)
G25	Natural Gravel / soil	Min. CBR: 25% @ 95% AASHTO T180 & highest anticipated moisture content Max. Swell: 1.0% 1.5% @ 100% AASHTO T180 Max. Size and grading: Max sixe 63mm or 2/3 layer thickness PI: <16 or as otherwise specified (material specific)
G15	Natural Gravel / soil	Min. CBR: 15% @ 95% AASHTO T180 & highest anticipated moisture content Max. Swell: 1.5% 1.5% @ 100% AASHTO T180 Max. Size: 2/3 of layer thickness PI: < 16 or 3GM + 10 or as otherwise specified (material specific)

Figure 2.79: Design criteria for material classes and specifications (MOWT, 2018)

Step 5 - Determine the sub-grade class and strength properties

Refer to Section 3 of the Ugandan Road Design Manual Volume 3: Pavement Design Part I (MOWHC, 2005) for guidance on how to estimate the sub-grade class and strength properties.

According to the Red Book (DHS, 2019), “a key pavement design principle is that the subgrade should provide an adequate foundation for the pavement layers. The classification of the subgrade material is based on the soaked California Bearing Ratio (CBR) at representative density”. A CBR of 15% is generally recommended for flexible and concrete block pavements. As such, a minimum recommendation is made to ensure a subgrade consists of a natural or modified S3 class for all urban roads with an appropriate selected layer where applicable. An S3 subgrade class is defined as a material with a CBR strength of between 5-8% (MOWT, 2018).

Details on the available subgrade classes used in Uganda are shown in Table 2.50.

Table 2.49*:* Subgrade Class Designations based on CBR ranges (MOWCH, 2005)

Subgrade Class Designation						
Subgrade CBR ranges (%)	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
	2	3 - 4	5 - 7	8 - 14	15 - 29	30+

Step 6 - Consider and implement all design considerations

Refer to the previous sections on design considerations for an urban road pavement structure, including the section on available types of pavements and applicable pavement materials for urban roads.

Step 7 - Determine the economic validity of the pavement design

The economic validity of a pavement design is determined by several factors such as:

- Ensuring the pavement has an adequate functional service level (e.g., good riding quality and skid resistance)
- Ensuring the pavement has an adequate structural service level (e.g., sufficient bearing capacity)
- Determining the rate at which service levels deteriorate for a road pavement structure
- Comparing the cost analyses for alternative pavement design options. This includes selecting a pavement design that is economic when the whole life-cycle cost is considered. Whole life-cycle cost comprises material construction costs, future upgrading costs, maintenance costs and road user costs, etc.

Step 8 - Determining the pavement structural design and thicknesses of pavement layers using an appropriate design method

According to the Red Book (DHS, 2019), “the purpose of structural pavement design methods is to provide a method for the unbiased estimate of the structural capacity of alternative design options, to select the most economical option that ensures the traffic demand will be met”. Although a number of pavement structural design methods are globally available, it is important to note that not all of these methods are applicable for a local urban roads’ context in Uganda.

The URDM practitioner may select a single method or any combination of design methodologies for the pavement structural design. Note that the URDM practitioner must be competent and experienced in the use of these methodologies before use. Once an appropriate method is selected, it is the practitioner’s responsibility to select the appropriate design manual for pavement design.

THE DESIGN OF FLEXIBLE PAVEMENTS

THE CATALOGUE METHOD

According to the Ministry of Works and Transport (MOWT) (2018), the catalogue method is the most convenient and most common method of pavement design.

For each type of road pavement structure, designs have been produced based on the range of subgrade strengths and the range of traffic loading. The pavement design engineer then has to estimate or measure the subgrade strength and traffic loading, choose the preferred pavement structure type and look up the design in an appropriate catalogue". Catalogue methods usually consist of a combination of empirical design systems and mechanistic design systems (i.e., they are mechanistic-empirical design systems).

Please refer to Appendix C of the Ugandan Road Design Manual Volume 3: Pavement Design Part I (MOWHC, 2005) for appropriate pavement design options using the catalogue method. For further details on catalogues for walkways and cycle lanes using paving blocks, please refer to the Malawi Low Volume Roads Manual Volume 1: Pavement Design (MTPW, 2020).

THE DYNAMIC CONE PENETROMETER (DCP) METHOD

According to the Red Book (DHS, 2019), "the Dynamic Cone Penetrometer (DCP) method incorporates the concept of a structurally balanced pavement structure in the design procedure. If used properly, designs generated by this method should have a well-balanced strength profile with depth, meaning that there will be a smooth decrease in material strength with depth. Such balanced pavements are normally not very sensitive to overloading. Some knowledge of typical DCP penetration rates for road-building material is required to apply this method. The DCP method is suitable for the design of light pavement structures with mostly unbound granular or lightly cemented layers, for new and rehabilitation pavement design. DCP design may be done by hand, but if DCP data needs to be analysed, appropriate software has to be used". The DCP method is considered to be an empirical design system.

Source: Extracted and adapted from the Red Book (DHS, 2019)

THE CALIFORNIA BEARING RATIO (CBR) DESIGN METHOD

According to the Red Book (DHS, 2019), "the California Bearing Ratio (CBR) method is based on the principle that the subgrade should be protected from the traffic loading by providing enough cover of sufficient strength. The applicability of this method should be evaluated critically before it is applied to local environmental and traffic conditions." The CBR method is considered to be an empirical design system.

Source: Extracted and adapted from the Red Book (DHS, 2019)

THE AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES

(not commonly used in Uganda)

According to the Red Book (DHS, 2019), "the 'AASHTO Guide for Design of Pavement Structures' provides the road design engineer with a comprehensive set of procedures for new and rehabilitation design and provides a good background to pavement design. This method must be applied with caution for a number of reasons, including the following:

- The method is an empirical method, based on performance data collected almost 50 years ago
- The subgrade and pavement materials, as well as the pavement structures, used in the AASHTO road test are foreign to African countries (including Uganda)
- The method is in imperial units and conversion to metric units must be done correctly. Although some software based on the procedures in the AASHTO design guide is commercially available, the procedure may also be applied manually".

Source: Extracted and adapted from the Red Book (DHS, 2019)

MECHANISTIC DESIGN METHODS

(not commonly used in Uganda)

According to the Red Book (DHS, 2019), "mechanistic design methods such as the South African Mechanistic Design Method (SAMDM) use the mechanical properties of pavement materials and their ability to resist stresses and strains. These methods usually contain ranges of typical resilient moduli and material strength input values. In South Africa, damage models were calibrated for each of the main material groups used in road construction. Mechanistic design methods may be used very effectively for new and rehabilitation design. However, extensive knowledge of the elastic properties of materials as used by the method is required, and experience in this regard is recommended. In the case of rehabilitation design or upgrading, field tests such as the DCP and Falling Weight Deflectometer (FWD) may be used to determine the input parameters for the existing structure. Access to appropriate computer software

is essential for effective use of this method, as well as for analysing DCP and FWD data".
Source: Extracted and adapted from the Red Book (DHS, 2019)

THE DESIGN OF RIGID PAVEMENTS

According to the Red Book (DHS, 2019), "the principle of pavement balance does not apply to rigid pavements. The concrete layer thus carries the majority of the applied load, and the distribution of stresses to the lower layers is low. For rigid concrete pavements, slab support influences the performance. It is therefore considered more important to have a uniform slab support than a strong, but variable, support. A strong foundation support is not necessarily required, because of the high stiffness and therefore the good load-spreading ability of concrete".

Although less than 1% of pavements in Uganda consist of rigid pavements, these pavements are especially useful in instances whereby road maintenance is deemed to be problematic or where surfacing is required on roads with gradients >10%. In a country like Uganda, the use of rigid pavements may also create economic benefits in that it facilitates the use of additional local materials for construction. Such materials include cement, gravels and steel for concrete, all of which are readily found. Furthermore, the production of concrete is considered to be more environmentally friendly than bituminous pavements, even though initial constructions costs may be slightly more expensive.

As such, the use of rigid pavements is recommended as a design option for consideration on urban roads. However, extensive knowledge on the behavioural and durability properties of concrete is required before designing rigid pavements. Additionally, specific knowledge of mechanistic-empirical design methods and/or software is frequently required for rigid pavement design, however an empirical approach is available for Uganda i.e., Ugandan Road Design Manual Volume 3: Pavement Design Part II (MOWT, 2010).

THE DESIGN OF SEMI-RIGID PAVEMENTS (BLOCK PAVING)

According to the Red Book (DHS, 2019), "the methods for the design of block pavements can be grouped into four categories:

- the catalogue design method
- equivalent thickness concept
- research-based design methods
- mechanistic design methods."

The design method most applicable to Uganda is the catalogue method, and minimal level of experience and competence is required for using this method. Several applicable catalogues for semi-rigid pavements have been developed by the Republic of Malawi Ministry of Transport and Public Works (MTPW, 2020) and these may be adopted for urban roads in Uganda where applicable.

THE DESIGN OF GRAVEL PAVEMENTS

According to the Red Book (DHS, 2019), "the main objectives when designing unsealed gravel roads are to prevent excessive subgrade strain, and to provide an all-weather, dust-free surface with acceptable riding quality. These two objectives are achieved by providing an adequate thickness of suitable material, constructed to a suitable quality".

According to the MTPW (2020), "gravel roads consist of a wearing course and a structural layer (base), which covers the in-situ material. In many cases, the same material could be used for both the structural layer and the wearing course. The minimum thickness of the structural layer is maintained in service by providing a wearing course throughout the design life of the road, which should under no circumstances be allowed to become thinner than 50 mm".

According to the Ugandan Road Design Manual Volume 3: Pavement Design Part III (MOWT, 2010), gravel road pavements are generally utilized for roads where design traffic flow Annual Average Daily Traffic (AADT) is less than 300 at the time of construction. This guide for design of gravel road sets out the standards for pavement design, and specifies the materials which may be used for gravel roads in accordance with the catalogue method. Consequently, a general consensus of 300 vehicles per day is also used as a guideline for the design of low volume roads. It is worthwhile to note that low-volume roads constitute over 90% of Uganda's road network.

The MOWT (2010) further states that gravel pavements are to be designed to a minimum thickness required to avoid excessive strain at the subgrade level. This in turn ensures that the subgrade is not subject to significant deformations.

At the same time, the gravel materials themselves should not deteriorate to such an extent as to affect the riding quality and functionality of the pavement. These goals must be achieved throughout a specific design period. Gravel wearing courses must also be designed for an additional thickness to compensate for gravel loss under traffic during the period between regravelling operations. Such thicknesses are dependent on the subgrade strength class and the traffic class as per the design criteria.

GRAVEL WEARING COURSE MATERIAL DESIGN CRITERIA

According to the Ugandan Road Design Manual Volume 3: Pavement Design Part III (MOWT, 2010), selected material shall consist of hard durable angular particles of fragments of stone or gravel. The material shall be free from vegetable matter and lumps or balls of clay.

Type 1 Wearing Course

The grading of the gravel after placing and compaction shall be a smooth curve within and approximately parallel to the envelopes detailed in the Ugandan Road Design Manual Volume 3: Pavement Design Part III (MOWT, 2010). The material shall have a percentage of wear of not more than 50 at 500 revolutions. The material shall be compacted to a minimum in-situ density of 95% of the maximum dry density. The plasticity index should be not greater than 15 and not less than 8 for wet climatic zones and should be not greater than 20 and not less than 10 for dry climatic zones.

The linear shrinkage should be in a range of 3-10%.

Type 2 Wearing Course

This material gradation allows for larger size material and corresponds to the gradation of a base course material. The use of this gradation of materials is subject to the local experience and shall be used with PIs in a range of 10-20 as per the Ugandan Road Design Manual Volume 3: Pavement Design Part III (MOWT, 2010).

SELECTION OF APPROPRIATE PAVEMENT DESIGN STANDARDS

A range of appropriate pavement design standards (both local and international) are readily available to assist with following the pavement design methodology recommended for urban roads. Each of these pavement design standards has various limitations and benefits. It is therefore recommended that before a particular pavement design standard is adopted, it is preferable to consider and/or apply several appropriate pavement design standards to ensure optimal design of a suitable urban road pavement structure. NB: this list is non-exhaustive and non-exclusive (some of these guidelines have been developed for other African/international countries and may not factor in local context, hence caution is advised).

The following pavement design standards have been recommended as per pavement type and/or material type:

The design of flexible pavements

- Ugandan Road Design Manual Volume 3: Pavement Design Part I (Ministry of Works, Housing and Communications (MOWHC), 2005)
- Ugandan Road Design and Construction Manual Volume V: Low Volume Sealed Roads (MOWT, 2018)
- General Specifications for Low Volume Roads - Series 3000LVR: Earthworks and Pavement Layers (MOWT, 2018)
- General Specifications for Low Volume Sealed Roads - Series 4000LVR: Bituminous Surfacing (MOWT, 2018)
- Ugandan District Road Works Manual Volume 1A – Technical Manuals Manual A (MOWHC, 2004)
- The Neighbourhood Planning and Design Guide also known as the Red Book (DHS, 2019).
- The South African Pavement Engineering Manual (SAPEM) (SANRAL, 2014).
- Draft Urban Transport Guidelines (UTG) 3: Structural Design of Urban Roads (Committee
- The Technical Methods for Highways (TMH) Manuals
- The Technical Recommendations for Highways (TRH) Manuals
- The South African Bitumen Association (SABITA) Manuals
- Technical Guideline (TG) 2: Bitumen Stabilised Materials (SABITA, 2020)
- Overseas Road Note 31 (RN 31) (Transport Research Laboratory (TRL), 1993)
- Draft TRH 4: Structural Design of Flexible Pavements for Inter-urban and Rural Roads (COLTO, 1996)
- TRH 14: Guidelines for Road Construction Materials (Committee of State Road Authorities, 1985)
- Cost-Effective Upgrading of Gravel Roads Using Naturally Available Materials with Anionic New-

Age Modified Emulsion (NME) Stabilisation (Jordaan & Steyn, 2020)

The design of rigid pavements

- Ugandan Road Design Manual Volume 3: Pavement Design Part II (MOWT, 2010)
- Ugandan Road Design and Construction Manual Volume V: Low Volume Sealed Roads (MOWT, 2018)
- General Specifications for Low Volume Roads - Series 3000LVR: Earthworks and Pavement Layers (MOWT, 2018)
- General Specifications for Low Volume Sealed Roads - Series 4000LVR: Bituminous Surfacing (MOWT, 2018)
- Ugandan District Road Works Manual Volume 1A – Technical Manuals Manual A (MOWHC, 2004)
- The Neighbourhood Planning and Design Guide also known as the Red Book (DHS, 2019).
- SAPEM (SANRAL, 2014).
- Draft UTG 3: Structural Design of Urban Roads (Committee of Urban Transport Officials,1988)
- The TMH Manuals
- The TRH Manuals
- TRH 14: Guidelines for Road Construction Materials (Committee of State Road Authorities, 1985)

The design of semi-rigid pavements

- Ugandan District Road Works Manual Volume 1A – Technical Manuals Manual A (MOWHC, 2004)
- Republic of Malawi Ministry of Transport and Public Works (MTPW)., 2020. Low Volume Roads Manual Volume 1: Pavement Design, Malawi.
- Concrete Block Paving Books 2 and 3 (Concrete Manufacturers Association, 2004)
- Draft UTG 2: Structural Design of Segmental Block Pavements for Southern Africa (Committee of Urban Transport Officials,1987)
- Draft UTG 3: Structural Design of Urban Roads (Committee of Urban Transport Officials,1988)
- SAPEM (SANRAL, 2014)
- The Neighbourhood Planning and Design Guide also known as the Red Book (DHS, 2019).
- The TMH Manuals
- The TRH Manuals
- TRH 14: Guidelines for Road Construction Materials (Committee of State Road Authorities, 1985)

The design of gravel pavements

- Ugandan Road Design Manual Volume 3: Pavement Design Part III (MOWT, 2010)
- Ugandan Road Design and Construction Manual Volume V: Low Volume Sealed Roads (MOWT, 2018)
- General Specifications for Low Volume Roads - Series 3000LVR: Earthworks and Pavement Layers (MOWT, 2018)
- General Specifications for Low Volume Sealed Roads - Series 4000LVR: Bituminous Surfacing (MOWT, 2018)
- The Neighbourhood Planning and Design Guide also known as the Red Book (DHS, 2019).
- SAPEM (SANRAL, 2014).
- Draft UTG 3: Structural Design of Urban Roads (Committee of Urban Transport Officials,1988)
- The TMH Manuals
- The TRH Manuals
- TG 2: Bitumen Stabilised Materials (SABITA, 2020)
- Overseas Road Note 31 (RN 31) (TRL, 1993)
- Ugandan District Road Works Manual Volume 1A – Technical Manuals Manual A (MOWHC, 2004)
- Draft TRH 4: Structural Design of Flexible Pavements for Inter-urban and Rural Roads (COLTO, 1996)
- TRH 14: Guidelines for Road Construction Materials (Committee of State Road Authorities, 1985)
- Cost-Effective Upgrading of Gravel Roads Using Naturally Available Materials with Anionic New-Age Modified Emulsion (NME) Stabilisation (Jordaan & Steyn, 2020)
- Draft TRH 20: The Structural Design, Construction and Maintenance of Unpaved roads (Committee of State Road Authorities, 1990)

Other guidelines and resources relevant to pavement design issues found in Uganda

- Potholes – This manual does not specify minimum thicknesses for surfacing layers in order to prevent potholes. However, reference is made to the 'Pothole Technical Guide' (CSIR, 2010) which is a technical guideline that discusses the causes, identification and repair of potholes.
- Labour Intensive Construction Methods - The Neighbourhood Planning and Design Guide also known as the Red Book (DHS, 2019) provides further guidelines on the potential of pavement layers for labour intensive construction methods. The guide also includes a further breakdown of

possible activities that are labour intensive during road pavement construction.

- Climate change and adaptation - The Africa Community Access Partnership (AfCAP) developed several handbooks and guidelines on risk management and resilience optimisation for vulnerable road access in Africa. These guidelines can be accessed at: https://www.research4cap.org/index.php/regional-and-cross-regional-projects/climate-adaption

2.6 CHAPTER 6: DRAINAGE DESIGN STANDARDS

2.6.1 BACKGROUND

INTRODUCTION

This manual contains design theories, concepts, guidelines, and procedures in a condensed format for use by the urban road drainage designer. The manual has been developed to provide a basic understanding of hydrology and hydraulics. It includes example problems and all basic design elements so that the designer can design highway drainage elements with minimal assistance. However, this manual is not intended to be a complete guide to all hydrologic or hydraulic problems encountered and it does not provide guidance on complex issues regarding those problems. Each design project is unique, and this chapter should not be used as a substitute for experience and sound engineering judgment that comes with experience. The manual provides procedures for analysing and designing effective urban road drainage facilities.

The Ministry of Works and Transport Road Design Manual (2010), Volume 2 – Drainage Design Manual already presents, in considerable detail, the basic principles and concepts (Section 1) as well as approaches to be used in stormwater design (Section 2). The starting point in developing the Urban Drainage Design Manual was to review manual and identify the sections to update. The aim is not to repeat the general design sections verbatim but rather to details the requirements that apply uniquely to urban drainage design. Therefore, the current MOWT Drainage Design manual and any future updates will continue apply to urban drains and the two should be read and interpreted in tandem.

Adequate drainage is essential in the design of especially urban roads because of the intimate

- health and hygienic reasons
- prevention of flooding
- improvement of living conditions and human well-being
- rehabilitation of urban areas
- protection of the environment
- aesthetic reasons

connection of poor road drainage with the serviceability and usable life as well as the risk of increased flooding of communities and impact on lives and livelihoods. Drainage design involves providing facilities that collect, transport, and remove storm water from the roadway. The design must also consider the storm water reaching the roadway embankment through the urban stormwater drainage system or the natural streams/rivers.

DESIGN OBJECTIVES

The objective of an urban road drainage design is to provide for safe passage of vehicles during the design storm event. The drainage system is designed to collect stormwater runoff from the roadway surface and right-of-way, convey it along and through the right-of-way, and discharge it to an adequate receiving body without causing adverse on- or off-site impacts.

Stormwater collection systems must be designed to provide adequate surface drainage. Traffic safety is intimately related to surface drainage. Rapid removal of stormwater from the pavement minimizes the conditions which can result in the hazards of hydroplaning. Surface drainage is a function of transverse and longitudinal pavement slope, pavement roughness, inlet spacing, and inlet capacity.

The objective of stormwater conveyance systems (storm drain piping, ditches and channels, pumps, etc.) is to provide an efficient mechanism for conveying design flows from inlet locations to the discharge point without surcharging inlets or otherwise causing surface flooding. Erosion potential must also be considered in the design of open channels or ditches used for stormwater conveyance.

The design of appropriate discharge facilities for stormwater collection and conveyance systems includes consideration of stormwater quantity and quality. Local and national regulations often control the allowable quantity and quality of stormwater discharges. To meet these regulatory requirements, storm drainage systems should incorporate detention or retention basins, and/or other best management practices for the control of discharge quantity and quality.

Planning and design of drainage systems for urbanized areas may be done for a number of other objectives, such as:

THE NEED FOR URBAN DRAINAGE

Urban areas in Uganda, as in many developing countries, are characterized as areas with large densely populated areas with characteristic infrastructure including public and office buildings, commercial and industrial zones. Urban areas may also include playgrounds, parks, and cemeteries. Drainage serves for removal of excess water from an area by surface or subsurface means. Excess water in urban areas may be domestic and industrial wastewater or storm runoff. The need for urban drainage systems seems to be obvious considering the number of people living in urban areas and the effects of wastewaters on health or the threat of stormwater flooding. Appropriate disposal of wastewater and storm runoff contributes to human well-being and to the proper functioning of urban communities.

ROAD DRAINAGE WITHIN OVERALL CONTEXT OF URBAN DRAINAGE SYSTEM

Urban drainage design is an integral component in the design of the entire urban road network, and must seamlessly fit within the of the overall urban drainage networks. Urban drainage design for facilities must strive to maintain compatibility and minimize interference with existing drainage patterns, control flooding of the roadway surface for design flood events and minimize potential environmental impacts from highway related storm water runoff. To meet these goals, the planning and coordination of storm drainage systems must begin in the early planning phases of transportation projects.

There are two basic types of urban drainage system:

- Separate systems conveying separately domestic/industrial wastewaters and stormwater, thus allowing for good handling of domestic wastewaters with low-cost sanitation schemes, and
- Combined systems conveying domestic and industrial wastewaters and stormwater together in a single system of pipes and channels.

ISSUES OF CONCERN IN URBAN ROAD DRAINAGE

The planning and design of drainage systems in urban areas is strongly affected by climatic, physiographic, and socio-economic conditions, and institutional arrangements. Consequently, the planning of drainage systems in urbanized areas varies considerably among countries, or even regions. Nevertheless, a common technically sound and cost-effective approach to drainage planning and design should be identified together within the many appropriate existing design methods.

Urban drainage features that are of concern include, but are not limited, to the following

- Urban catchments are usually modified with impermeable built-up area or bare soils that are susceptible to erosion. Runoff coefficients have to be modified accordingly
- Choice of the drainage type must consider aspects that are not traditionally accounted for but may greatly influence the operation of the facility. The high volumes of solid waste carried by urban drains requires careful consideration when sizing structures and considering free boards otherwise blockages may result in flooding of the road and surrounding area.
- Urban drains exist in an interconnected network and the stormwater receiving area at the outlet may be a built-up area. Therefore, the design should extend beyond the project limits and ensure safe disposal of the flow
- In selecting whether to use open or closed drains, it is important to consider factors like safety of road users (especially pedestrians), ease of cleaning/ maintenance, etc. Benefits related to the above usually outweigh the additional cost related to constructing closed drains in an urban setting
- Experience has shown that drainage designs carried out especially in Kampala concentrate on proper sizing of especially cross culverts and the longitudinal/side drains. The design of other drainage system components like drain inlets for closed systems (e.g., kerb inlets and gutters) is sometimes not considered a priority. Rules of thumb approaches that are not based on flow dynamics are used instead. This may result in under-sizing causing a situation where stormwater is unable to enter into the main stormwater system resulting in water accumulation on the road and flooding surrounding areas.

DESIGN APPROACH

GENERAL APPROACH

General

A storm water management plan is prepared to consider what storm water management practices and measures are to be provided for large public works project, an urban estate, and other developments. These plans will have a local focus that is responsive to specific functions (drainage provision, open space provision, etc.). They prescribe individual area management techniques and practices. If a storm water strategy plan is available for a catchment, each local area storm water management plan will be required to accommodate the principles and directions identified in the broader strategic plan.

Ideally, a storm water management plan should be prepared for a local area prior to implementing structural and non-structural management measures identified in the strategy plan for the catchment. That is, detailed planning should precede the design, construction, and operation phases of a development project.

Preparing Concept Plans

The following tasks should be carried out for the preparation of a storm water management plan.

Step 1: Establishing Objectives and Standards - Objectives and standards should be established to guide the planning process. These may be obtained from the strategy plan for the catchment (if available). The objectives and standards should provide the basis for and give direction to the planning process and should be used to determine the expected outputs of the recommended plan.

Step 2: Data Collection - Data collected for the planning process provides the factual basis for the plan and allows an appreciation of past and an understanding of present conditions within the catchment. The extent of data collection would be the reflection of the objective/s and standard/s set. The data collected for the development of the strategy plan for the catchment should be used if available. This data may need to be supplemented with additional data necessary to further define the characteristics of the area under investigation.

Step 2.1: Base Map - The base map should identify the watershed areas and sub areas, land use and cover types, soil types, existing drainage patterns, and other topographic features. This base information is then supplemented with underground utility locations (and elevations if available), a preliminary roadway plan and profile, and locations of existing and proposed structures.

Step 2.2: Hydro meteorological Data - Hydro meteorological data gives information mainly on the rainfall, and for gauged areas, the runoff.

Step 3: Analysing Existing Conditions - The main purpose of this phase is to use the data and information collected under the data collection phase to understand the present state of storm water management related conditions in the catchment.

The water quantity and/or quality characteristics for the existing catchment conditions must be determined.

For existing developments, models are required to:

- determine the capacity of existing major and minor conveyance systems
- determine the location and extent of any flooding under major and minor system
- determine the pollutant loads for existing land uses within the catchment
- determine the performance of any existing water quality control structures

For proposed developments, models are required to determine natural flows within the catchment which may be used as flow limits for development proposals determine natural pollutant loadings within the catchment which may be used as pollutant load limits for development proposals

Step 4: Formulating Alternatives - Formulation of alternatives is the most important part of the storm water management planning process because the substance of the recommended plan originates from this step. Formulation of alternatives is creative and systematic effort where alternatives are conceptualised, screened, and if promising, further developed and consolidated. The essential conceptual, technical, economic, environmental, financial, legal, administrative, political, and other features of each alternative should be examined before finalization. In formulating alternative proposals, the water quantity and quality characteristics must be determined.

Step 5: Comparing Alternatives and Selecting the most Viable One/s - Having formulated a set of possible alternative solutions for managing storm water, the alternatives should be compared. The essential features of each alternative such as size, costs, benefits, and positive and negative attributes should be compared in summary form for presentation to decision-makers and the community when required. Alternatives should be compared on the basis of how well they achieve the established objectives.

As the positive and negative features of each alternative are considered and compared with features of other alternatives, the possibility of hybrid alternatives may arise. Hybrid alternatives might achieve a technically improved solution or might be a means of obtaining support among decision-makers.

Step 6: Preliminary Concept Development - Layout and design of a storm drainage system begins with the development of sketches identifying the basic components of the intended design. This section provides an overview of the concepts involved in the development of a preliminary concept plan.

Concept plan is usually done on a base map that shows the roadway, location of bridge points, land use and land cover conditions of the catchment. Other utility locations and situations should also be identified and shown, including surface and underground ones and any other storm drain systems.

Storm drain alignment within the road right-of-way is usually influenced, if not dictated, by the location of other utilities. These other utilities, which may be public or private, may cause interference with the alignment or elevation of the proposed storm drain.

Generally, a storm drain should be kept as close to the surface as minimum to minimize excavation costs. Another location control is the demand of traffic and the need to provide for traffic flow during construction including the possible use of detours.

SYSTEM PLANNING AND DESIGN

For this chosen mode of study through the aforementioned steps, system planning and design is the next phase to go into. Planning and design of an integrated urban storm water management development requires data base on the following area:

- boundary and natural drainage directions of a catchment and sub catchments
- runoff outlet or “disposal” points
- locations where flows, flood levels, and water quality are to be assessed
- the layout (network) of surface channels which convey runoff

System planning and design is to follow the following procedure.

- Catchment definition and discretization: Catchment definition and discretization is generally based on drainage patterns, surface slopes and land use patterns. It is usually preferable if sub-catchments are chosen in such a way that they have homogenous physical characteristics.
    - o Defining flow paths - Identify watershed from base maps. Classify existing and future developments in accordance with their effect on hydrology, hydraulics, and storm water quality. Identify locations of discharge points along with their capacity and downstream effects.
    - o Formulating conceptual alternatives - The storm water drainage system is to be developed in conjunction with overall development plans.

Flow estimation and check: Flow estimation could be done by establishing a hydrologic model by using design rainfall data and the estimation of hydrologic parameters such as runoff coefficient.

Initial assessment of minor systems: Existing drainage alignments, clearly defined channels or suitable swales should normally be set aside as major drainage lines. Starting from extreme upstream of the catchment, an initial assessment calculation is carried out.

Checking flows in the Major system: After the initial minor system is developed, flows in the major design system is checked.

Preliminary design: Using the initial analyses, preliminary design is made for the major and minor systems. Consideration is also to be given to alternatives which may result in a more economic design.

In the investigation of an individual scheme, the full range of design alternatives should be considered to determine the best alternative.

Each alternative in the preliminary design involves:

- Defining alignments and grades for storm water drainage channels. Factors that will influence alignment and grades include utility lines, embankments, buildings, etc. Other factors that influence channel grade include existing slope, erodibility, available right-of-way, and channel lining. Open drains (covered as required) or engineered waterways will be required when pipe sizes become so large as to become uneconomical. In existing built-up urban areas, the available land for open drain may be insufficient in which case larger pipe diameters, multiple pipes or box culverts will be required.

- The major system should use open space reserves to convey surface flows and land for this purpose is to be set aside as perpetual reserve. In the upper most area of a drainage catchment, major drainage ways may not consist of readily distinguishable channels. The designer should determine the path that the major system design runoff event will consider.

- Locating and sizing inlets with possibility of pipe inlets for open drains in mind.

- Computation of water surface profile and energy grade line based on storm water drainage system alignment, grades, and inflows so that the alignments and grades are adjusted to comply with freeboard criteria.

- Evaluating how topography must be adjusted to ensure that the flows are conveyed safely down gradient without threatening lives, safety, or property.

- Evaluating behaviour of detention facilities during the major system design condition and assuring that detention dams, which could pose a threat to human safety or property if they fail, are designed to handle extreme flows.

- Evaluating culverts and bridges to assure that applicable criteria are not violated, and the size and characteristics of conveyances are adjusted till the level of backwater during the major system design runoff event meets target levels. The backwater computation is also used to define the area affected by backwater flooding during the major events and to affect the necessary measures.

REVIEW OF SYSTEM PLAN AND DESIGN

- Prepare preliminary level capital and operation/maintenance cost for the alternatives. If feasible and appropriate, use life cycle cost theory for economic evaluation. The design cost objective should be to minimize the total annual costs of the drainage facilities and flood-related damage/s.
- Evaluate the alternatives with important qualitative criteria such as preservation of open space, water quality benefits.
- Prepare a preliminary design report that contrasts the alternatives quantitatively and qualitatively in a form suitable for submission to the regulators.

RE-EVALUATION

The preliminary drainage network developed in previous sections and adjusted, as a result of review, should be re-evaluated. This involves repeating the preliminary calculation for the adopted design to verify that it meets the designed targets.

Hydrologic assumptions, catchment boundaries, sub-catchment delineation, road classification, pollutant load estimates, assumed removal efficiencies and many other preliminary design values that will be used subsequently in final design should be reviewed for accuracy and applicability to final design.

FINAL DESIGN DETAILING

The following steps will complete the process.

1. Obtain final road grades, geometry, elevations, etc - Often it will be necessary to revise road construction details to facilitate drainage. This may include adjusting cross fall on roads, rising required ground elevation at buildings adjacent to roads to accommodate major drainage, or increasing road gradient to achieve sufficient capacity within the road. It is important to assure that floor elevations of buildings are well above road crown elevations to prevent repeated flooding.

2. Hydraulic Design of the Open Channels and Pipe Drainage Systems - A realistic Manning roughness value for final design should be determined and applied, treating the conduits as either open channels or pipes flowing full, as appropriate. For open channel flow, the energy

grade line should be used. For pipe storm water drains, the hydraulic grade lines must be reviewed for various runoff conditions to ensure that the hydraulic grade line is consistent with desired system performance.

IMPLEMENTATION

1. Preparing Plan Implementation Program: - The questions of when the plan elements are to be implemented, who has the primary responsibility for implementing them, and how the implementation is to be carried out should be addressed. The number of implementers can vary widely depending on the size and complexity of the storm water management plan. The elements of the recommended plan should be prioritised and scheduled. The following factors may be used to set the prioritisation.
   - The operation of certain components of the storm water management system may be dependent on the existence of other components.
   - Higher priority should be given to those elements of the recommended plan that are likely to provide the greatest benefit in relation to the stated objectives.
   - Some elements may not be implemented if action is not taken immediately or at some other appropriate time to capitalise on special circumstances or opportunities.

   Special opportunities that could have a bearing on the implementation of a plan, such as possible sources of financing, should be identified. Other aspects of implementation programme include clear identification of desired endorsements, agreements, and required approvals and permits

2. Plan Implementation - Of all the steps in the planning process, plan implementation is the most unpredictable. The extent to which a comprehensive storm water management plan is accepted and the enthusiasm with which the public and private sectors will push for its implementation will depend, among others, on the following factors:
   - the credibility of the plan as determined by the quality of the technical work and the thoroughness of the community involvement carried out during the planning process; and,
   - the frequency and severity of storm water-related problems and the level of concern that past problems will occur again.

The ultimate test of a storm water management plan is the degree to which storm water problems have been mitigated and the degree to which potential storm water problems have been prevented from occurring.

PLAN COMPONENTS

Storm water management plans should consist of two major components: a technical report and supporting plans.

1. Technical Report - This report should provide a comprehensive analysis of existing and proposed storm water quantity and quality conditions for the catchment. The report should provide narrative descriptions of existing conditions and how the proposed system will meet objectives of the plan and contain all necessary technical data for both existing and proposed conditions.
2. Supporting Plans - A conceptual or preliminary plan of the proposed storm water conveyance, runoff quantity control, and water quality control systems, based upon accurate field topographic mapping should be provided along with sufficient details to identify systems elements. Plans should be of adequate scale and detail for accurate definition and location of all system elements.

SPECIFIC FACTORS CONSIDERED

In addition to the above general factors, the following specific considerations were undertaken in development of this Uganda Urban Road Drainage Design Manual

1. Review of the current Road Design Manual (2010), Volume 2 – Drainage Design Manual to identify the areas that need to be improved especially in reference to urban roads. Urban drainage manuals for neighbouring countries (e.g., Kenya, Ethiopia, Tanzania) or other tropical countries were reviewed and used for guiding the relevant choices.
2. Consultations with stakeholders (urban planning authorities, drainage specialists, roads engineers) were carried out to identify the challenges that they face and the solutions that they proposed.
3. Based on the road classification from the Geometric Design Manual (Set A), recommendations were made for the relevant

peak flow return periods for different components of the drainage system

4. Storm water analysis methods for estimating rainfall intensities were reviewed and recommendations made for urban areas. Relevant approaches for estimating peak flows were recommended
5. Methods for sizing the drains that are applicable in Uganda were reviewed and recommendations made. The approaches build on recommendations in the Drainage Design Manual (2010) concerning drain types, alignments, materials, etc. The control of scour/ erosion is critical as it is a weakness in the drainage current design manual
6. Existing tools and software for urban drainage design were reviewed and recommendations made for their utility in urban areas in Uganda.
7. Maintenance of urban drainage systems has proved to be a major shortcoming for their functionality. Recommendations of the factors to consider in preparing urban O&M plans were made to ensure a functional system that protects motorists, pedestrians, and communities.

2.6.2 BASIC APPROACH TO URBAN DRAINAGE ASSESSMENTS

STEPS IN PLANNING OF STORM WATER MANAGEMENT STUDIES

Adequate planning is crucial to the success of the project as a whole. This section endeavours to sketch out the areas where relevant information should be assembled and how this information may be integrated into the development of key aspects of the road drainage in urban areas. This section looks at the principles which will assist the design process. For every road a comprehensive management plan is prepared to ensure what storm water management practices and measures are to be provided for large road works project all the way to urban estate roads for both paved and unpaved roads

A stormwater drainage system should be designed to collect and convey run-off generated within a catchment area during and after rainfall events, for safe discharge into a receiving watercourse or swamps. The magnitude of peak flows that have to be accommodated will depend primarily on the intensity of rainfall and the size, topography, soil type, configuration, and land use of the catchment.

Plans will have a local focus responsive to specific functions (drainage provision, open space provision, etc.). They prescribe individual area management techniques and practices. If a storm water strategy plan is available for a catchment area, each local area storm water management plan will follow the same guidelines.

Each of the key steps in developing a proper storm water management is aimed at merging natural processes with the built environment. This involves laying out at step-by-step process of how run off is managed all the way from generation, conveyance, and disposal. The proposed steps include:

ASSEMBLING OF THE RIGHT TEAM

The steps will require a multi-disciplinary team and different technical expertise. The team should compromise but not limited to.

City Planners

The main role of the planner is to ensure that the storm water management plan, blends with the overall city plan and there will not be immediate of future hindrances accruing from poor planning. The town planner should plan the development layout to locate the storm water system – attenuation dams, channels, and overland escape routes – to functionally blend with the development.

Civil/Drainage Engineers

The role of the civil/drainage engineer is mainly the technical input in the planning. An engineer skilled in the design of stormwater systems should determine runoff flows for the required recurrence intervals and proposed land uses and design appropriate measures to attenuate peak flows and safely convey the runoff. The Engineer should be able to identify the proposed channel alignment and offer feasible alternatives.

Environment specialists

The environmental consultant should alert the engineer and town planner at the conceptual stage of the development to crucial aspects of the environment, which are fulfilling an important role with respect to stormwater and should be taken into consideration, as well as opportunities for enhancement or rehabilitation of existing natural features. The consultant should also assess the proposed system and its effect on the environment and climate.

Sociologists

The major role of the sociologist is to assess the effect of the project on the community members and psychologically prepare the community for the project. He/she should encompass the views of the community into the project plan and propose ways how the community can be involved in the implementation and operation of the project.

CLEAR STAKEHOLDER ENGAGEMENT

At the planning stage, there is need to understand the key stake holders for every project. This is key to avoid project conflicts. For example, the proposed drainage corridor can share the same right of way with utilities. This means involving the utility companies at planning stage will prevent future conflict and prevent unnecessary costs under for relocation of utilities as projects are implemented

Key stake holders include the municipal authorities, UNRA, NWSC, NEMA, NBRB, Academic and Research Institutions, Political heads for the Project area among others.

ESTABLISH THE LEGAL AND POLICY FRAME WORKS

This is a key step in the planning stage, the main reason is to ensure that designs and any step to be involved in the project does not conflict any law or policy. It is also essential that the designer ensure that he is aware of any amendments to the relevant acts as these can have substantial impact on a development project. The frameworks should be established from National level, district level, municipal/city level, and any international conventions.

ESTABLISHING OBJECTIVES AND STANDARDS

Objectives and standards should be established to guide the planning process. These may be obtained from the strategy plan for the catchment (if available). The objectives and standards should provide the basis for and give direction to the planning process and should be used to determine the expected outputs of the recommended plan.

DATA COLLECTION

Data collected for the planning process provides the factual basis for the plan and allows an appreciation of past and an understanding of present conditions within the catchment. The extent of data collection would be the reflection of the objective/s and standard/s set. The data collected for the development of the strategy plan for the catchment should be used if available. This data may need to be supplemented with additional data necessary to further define the characteristics of the area under investigation. The following information should be collated for each site, during the planning stage and used to feed into the more detailed site assessment:

- Catchment area in which site is located
- Catchment or main drainage systems management plans
- The overall management objectives and recommend key management actions with respect to runoff quantity, quality, and other associated environmental and social issues, where such plans exist for the catchment in question, must be met in the design stage.
- Storm water management master plan - This Plan Identifies bulk infrastructure, including storm water flow routes, required within developing areas and may identify particular issues such as pollution which must be addressed at a local level. The existence of a stormwater management master plan, which covers the area, to be developed should be established and its recommendations applied to the design.
- Existing reports relating to the sensitivity of known wetlands / rivers / other natural ecosystems on or associated with the design areas
- Hydro meteorological Data- Hydro meteorological data gives information mainly on the rainfall, and for gauged areas, the runoff.

ANALYSIS OF EXISTING CONDITIONS

The physical characteristics of the site reflect the existing course of runoff and stormwater. Working with the natural environment and processes has been found to be safer, more sustainable, and easier to maintain in the long term than more traditional engineering approaches aimed at controlling these processes. On sites that have been substantially disturbed, consideration should be made of what the natural drainage and runoff conditions would have been, as well as the existing situation. This will enable potential problems, and opportunities, to be identified. The following are some of the main features that should be considered and collated in the form of a site analysis plan that should be used to inform the design process.

- Determine the capacity of existing major and minor conveyance systems

- Determine the location and extent of any flooding under major and minor system
- Determine the pollutant loads for existing land uses within the catchment
- Determine the performance of any existing water quality control structures

In locations of especially new alignments, consider picking up the following additional data:

Topography - The following topographical factors should be considered:

- o Gradients dictate the direction of flow and runoff/drainage routes can be plotted overland, identifying areas of ponding and concentration of loads.
- o In some areas which are very flat, earthworks may be required to provide sufficient grade for drainage.
- o Topography influences the potential for erosion to occur.
- o Topography informs the feasibility of different locations for stormwater routes, outlets, and treatment areas. The main stormwater routes should be located along natural drainage routes.
- o In ecological terms, different habitats, some of higher conservation value than others, are frequently associated with changes in topography.
- o From an environmental and stormwater management perspective, as the slope increases, culverts sizes should also increase to prevent excessive run-off and potential erosion. Road and planning layouts should also reflect the topography of an area, to enable integrated stormwater design and management.
- o The commercial (and aesthetic) value of different sections of a development area is also frequently derived from different topographical characteristics.

Geology, Soils and Groundwater - A good understanding of the geology, soil and groundwater conditions is an important factor in assessing the infiltration potential of the site. The following factors should be considered:

- o Soil types affect surface permeability and hence rate of runoff.
- o The mapping of geology and soils will indicate areas of potential groundwater recharge.
- o Geology and soils influence the potential for erosion to occur.
- o Soil types should be identified, along with the characteristics of the different soils, such as levels of infiltration, permeability, and their water-bearing capacity.
- o The presence of contaminated soils, which may pose a threat to surface and groundwater quality should be identified and plotted.
- o Areas of high groundwater levels can limit the possibilities and/or desirability of groundwater recharge and filtration methods. It should be noted that large-scale removal of certain vegetation types, such as Port Jackson (Acacia saligna) and Bluegums (Eucalyptus sp.), that consume large volumes of water, might significantly raise groundwater levels.
- o Need to determine seasonal and longer-term trends in groundwater level fluctuation
- o Groundwater information available in the CMA Soil types indicate the likely occurrence of particular plant communities, some of which may play a role in the stormwater management plan.
- o Assessing soils can also indicate the presence of both existing and even historic wetlands.
- o Seasonal variation of groundwater levels should be taken into account.
- o The geology and soils of a site will inform the feasibility of different locations for stormwater treatment areas and the potential for groundwater recharge.
- o Different habitats (some with high conservation value) are associated with specific geological features and soils

In the absence of sufficient documented groundwater information, the seasonal and long-term ground water fluctuations should be projected based on the hydrological, geological, and climatic information available.

Climate - The following climatic data should be considered to inform the design stage:

- o Storm rainfall parameters are major design factors and must be carefully determined and these should be projected using the rainfall, patterns and projected climate change should be considered.
- o The general climatic characteristics of an area will also impact on the site and stormwater systems implemented, i.e., whether the site is generally waterlogged or dry and if evaporation levels are high or low.

- Microclimate conditions can inform the spatial layout of water treatment and attenuation, particularly those associated with specific planting and multifunctional uses.

Hydrology - It is essential, for successful, sustainable, and integrated stormwater management, that the existing and/or natural hydrological response and functions of the site are understood. The following factors should be considered:

- The natural drainage that was characteristic of the development area, to the extent that this is possible, should be determined and both the irreversible as well as less permanent changes that have taken place should be identified.
- The hydrology of the development area is a function of much of the other data, which includes Rainfall patterns, catchment characteristics and land use.
- A compressive and accurate hydrological analysis should be carried out before this design stage so as to estimate the discharges and make logical conclusion

Natural Ecosystems, Flora and Fauna - The site should be assessed in terms of the natural ecosystems and habitat types that it supports. The following factors should be considered:

- Conservation (or improvement) of biodiversity and ecosystem function must be one of the objectives of a management plan, as required by policies that govern a given city and country
- Some habitats are afforded protection by existing legislation and guideline (e.g., wetlands, buffers around rivers and wetlands)
- Where the site intercepts natural corridors of movement between ecologically important areas, stormwater management should seek to retain or recreate such corridors.
- Endangered or threatened vegetation, animals and/or habitats should be identified and their opportunities and constraints for stormwater management assessed.
- Vegetation and animals that have roles or functions that can improve water quality, integrity amelioration and/or infiltration should be identified, and their natural status and determined.
- Healthy, diverse and/or relatively undisturbed natural systems should be identified and assessed in terms of their habitat integrity and importance (environmentally, socially, and culturally), and, wherever possible, be accommodated within the future planning and development of the site.
- The presence of invasive alien animals (e.g., fish, birds) or plants should be discouraged from any developments. Alien flora or fauna associated with habitats created or maintained for the management of stormwater from a site should not be allowed to pass into any downstream or associated water bodies.

Ecological Characteristics of Freshwater Ecosystems - The occurrence of rivers, streams or other watercourses on the site should be identified and the habitat integrity of each should be determined. The following ecological and ecosystem factors should be considered:

- The floodplains and ecological buffers that relate to the site should be determined at an early stage in order to establish the broad development planning and specific stormwater, implications they have for the site.
- The presence of wetlands within the development site should be red flagged, due to their global and nationally threatened status. Protection is accorded by certain policies and legislation. They also may play a useful role in natural hydrological functioning, with potential for integration in an integrated stormwater management plan
- The stormwater discharge and receiving capacity of rivers, channels and drainage courses should be determined to establish the levels of integration of the natural and proposed stormwater management systems.
- The use of these linear elements should form part of an integrated public open space and stormwater system and promote the multifunctional use of space.
- Floodplains and ecological buffers provide open space systems within which the more space-consuming “soft technologies” of stormwater management can be accommodated, without posing a conflict with development pressures on land.
- Development sites that do not have floodplains and ecological buffers within the area should consider integrating a public open space system with an overland escape

route for an extreme storm event, to maximize the opportunity for habitat corridors.

- Where ecologically important wetlands or rivers are recipients of stormwater discharge, the quality and quantity of stormwater discharges into such systems should be regulated to minimize downstream impacts.

Cultural and Historical Landscapes and Archaeological Sites - Areas, routes, vegetation, and landmarks that have a cultural and/or historical use or significance should be identified. Development and stormwater planning should avoid disturbing these areas where possible. Where possible they should generally be incorporated within the public open space of a development. This contributes a further function to the public open space system and should be integrated into a network of public open space.

Development Requirements - The public open space and pedestrian access requirements of a development should be incorporated into the stormwater management planning of the site. The integration of public open space and access requirements with the spatial requirements of stormwater management not only reduces the conflict of pressure on land, but also enables the amalgamation of maintenance requirements, and maximizes the use of resources.

The following factors should be considered:

- Land use planning should be done in relation to the natural context and ecological characteristics of the site. The land uses should take into account system that can not affect the overall on and off-site drainage.
- Innovative opportunities exist for future the stormwater management system to link-up and add value to educational initiatives (outdoor classroom), ownership (friends groups adopting the system), and water saving (re-use of stormwater/treated effluent for irrigation). These opportunities are also area specific need to be identified upfront, rather than as nice to have afterthought
- The need for a safe environment must be taken into account (e.g., avoid of potential hiding places for criminal elements; do not create unnecessary hazards in the selection of stormwater management options).
- The cost of stormwater implementation, management, and maintenance, as well as flood risk, can be greatly reduced by identifying, retaining, and enhancing the natural areas along which runoff and natural habitat retain ecological integrity. The advantages of this approach are not limited to stormwater, but can increase the visual, amenity and ecological value of a development.

Ownership Opportunities and Constraints - A clear distinction should be made between public and privately owned land. The following factors should be considered:

- As a principle, stormwater should as far as possible be accommodated within public open areas or spaces under common ownership.
- Servitudes should always be registered in the favour of the controlling authority to ensure effective management and access at all times.
- Public open space used in the stormwater systems should be clearly demarcated to ensure that the stormwater functions are apparent and to enable monitoring and policing.
- Early identification of land ownership in potential stormwater treatment or conveyance areas outside of the development area will assist in identifying constraints, in some cases, as well as opportunities to provide additional space for stormwater management, through inter alia land swaps, use of public open space and local authority land.
- Servitudes and public rights of way can also be incorporated into the stormwater systems, for example use of road reserves for conveyance and/or infiltration, but these elements be critical to performance as they may be relinquished later

Spatial Opportunities and Constraints - The amount of appropriate public space that is available for stormwater management should be identified at an early stage in project planning, since this will largely dictate the extent to which different stormwater design elements are feasible in a development. Where site analyses show that spatial constraints are likely to dictate stormwater design, attention should focus on identification of spatial opportunities outside of the development area (e.g., areas of public open space, local authority land; schools and other areas of open space), that might lend themselves, through negotiation, to more ecologically desirable stormwater design options

Surrounding Developments - Stormwater management design options should take cognisance of developments in the upstream catchment that are likely to impact on the timing, quality or quantity of stormwater generated upstream of the development area. Identification of these issue swill highlight potential problem areas in stormwater management. The following factors should be considered:

- It is important that site planning be done in context with the adjacent properties to ensure effective stormwater systems and integrated stormwater corridors. Sufficient retention facilities should therefore be planned and provided on site as part of an integrated open space system.
- Clarity on the stormwater management principles employed in upstream developments should also be obtained so that anticipated stormwater runoff from these areas can be quantified.
- The rate of growth and anticipated land-use of surrounding developments and areas that discharge onto the development site should also be considered to determine the future pressures on the stormwater systems.
- The general capacity of the stormwater systems of surrounding developments that lie downstream of the site and the current rate of growth and pressure on these systems should be considered during site planning and design. Failure of systems downstream can cause failure and flooding upstream. As a principle, the post development runoff should not exceed the predevelopment runoff.

Maintenance Capacity - Before stormwater design options are considered in any detail, it is vital that the developer has a clear indication of the practical maintenance capacity, in terms of time, personnel and finance, of the final managing authority for the stormwater system. Aesthetically or ecologically complex designs that owe their sustainability to regular maintenance inputs on a permanent basis will fail in the medium to long term if there is no capacity for ongoing and adequate maintenance. Similarly, where public expectations centre on aesthetically pleasing design, adequate allowance must be made for basic maintenance activities, such as removal of litter or alien clearing. If this is neglected, the project as a whole may be deemed a failure in the eyes of the public. This may have ramifications for the rest of the project in question, as well as future projects requiring public buy-in and support.

FORMULATING ALTERNATIVES

Formulation of alternatives is the most important part of the storm water management planning process because the substance of the recommended plan originates from this step. Formulation of alternatives is creative and systematic effort where alternatives are conceptualised, screened, and if promising, further developed and consolidated. The essential conceptual, technical, economic, environmental, financial, legal, administrative, political, and other features of each alternative should be examined before finalization. In formulating alternative proposals, the water quantity and quality characteristics must be determined.

COMPARING ALTERNATIVES AND SELECTING THE MOST VIABLE ONE(S)

Having formulated a set of possible alternative solutions for managing storm water, the alternatives should be compared. The essential features of each alternative such as size, costs, benefits, and positive and negative attributes should be compared in summary form for presentation to decision-makers and the community when required.

Alternatives should be compared on the basis of how well they achieve the established objectives. As the positive and negative features of each alternative are considered and compared with features of other alternatives, the possibility of hybrid alternatives may arise. Hybrid alternatives might achieve a technically improved solution or might be a means of obtaining support among decision-makers.

Step 6: Preliminary Concept Development – At this stage general concept plan for the site layout should be developed, taking into account the legal and physical aspects of the site as developed through the site analysis process. This plan should indicate the location of different land-uses. This will influence the storm water management conditions and reflect some of the spatial requirements of the system.

In addition, permutation of the proposed the layout and design of a storm drainage system begins with the development of sketches identifying the basic components of the intended design. This section provides an overview of the concepts involved in the development of a preliminary concept plan. A concept plan is usually done on a base map that shows the roadway, location of bridge points, land use and land cover conditions of the catchment. Other utility locations and situations should also be identified and shown, including surface and underground ones and any other storm drain systems. Storm drain alignment within the road right-of-way is usually influenced, if not dictated, by the location of other utilities.

These other utilities, which may be public or private, may cause interference with the alignment or elevation of the proposed storm drain. Generally, a storm drain should be kept as close to the surface as minimum to minimize excavation costs. Another location control is the demand of traffic and the need to provide for traffic flow during construction including the possible use of detours. The proposed drainage design should follow natural courses as much as possible and avoid diversions or alterations he development of a Conceptual Stormwater Layout should be an iterative process, informing and informed by the site analysis and conceptual layout of the development. The development of a Conceptual Storm water Layout should be an iterative process, informing and informed by the site analysis and conceptual layout of the development.

DESIGN APPROACHES

An urban drainage system is generally defined as a runoff collection and transportation system, which is responsible for quickly removing storm water runoff only from urban areas to prevent any flooding. Conventional drainage systems are designed to collect and transport water runoff from urban areas as quickly as possible via drainage networks until their final discharge points in lakes, rivers and swamps

Design approaches refer to the methods used to complete a full design from data collection, hydrological analysis, hydraulic and sizing computations all the way to the production of working drawings and setting of construction guidelines

Once the planning phase process has developed a conceptual storm water plan for the road, there is need for a design phase that develops site and context specific design of the storm water management parameters. This section provides design guidelines to inform appropriate storm water design for a development

RUNOFF ESTIMATION

To determine the volume of storm water runoff from precipitation, hydrologic calculations are used to quantify precipitation losses which occur as part of the hydrologic cycle. Typically, stormwater management calculations only consider infiltration, interception, and surface storage losses since short time scales will render losses from evaporation and transpiration insignificant. A wide variety of procedures have been developed to estimate runoff volume and peak discharge rate; and to route the runoff from the road and through to a storm water management system.

This section discusses only a few methods. Details of the analysis will be discussed in detail in section 3 of the design guidelines. The hydrological data available for Uganda is generally limited so the procedures that can be applied to estimate run off are consequently imprecise. No specific standards or definitive criteria for hydrological analysis are suitable for recommendation at this time. For standard procedures to be adopted confidently, storm water runoff coefficients, design parameters and procedures may be calibrated. However, in this manual we shall general steps that can be followed to estimate runoff.

Establish the water shed properties in which the road lies

Watershed Area Information: Most runoff estimation techniques use the size of the contributing watershed as a principal factor. Generally, runoff rates and volumes increase with increasing drainage area. The size of a watershed will not usually change over the service life of the road drainage facility. However, agricultural activity and land development may cause the watershed area to change over time. Flow diversions and catchment area changes due to urbanization and other development inevitably will also occur at some point in the future.

The drainage designer should try to identify or otherwise anticipate such changes. Urbanization, deforestation, infrastructure, development including roads, railways, and water resources projects (dams and reservoirs) will be anticipated to occur in the future in Uganda. This should be taken into consideration and consultation with the Central and local government offices is required in order to establish and identify areas allocated for future development. On the other hand, the watershed shape will also affect rainfall runoff rates. For example, a long, narrow watershed is likely to experience lower runoff rates than a short, wide watershed of the same size and other characteristics. Some hydrologic methods accommodate watershed shape explicitly or implicitly; others may not. If a drainage area is unusually irregular extremely narrow, the designer should consider using a hydrologic method that explicitly accommodates this watershed shape. Refer to Figure 2.80 for an example of a watershed shape.

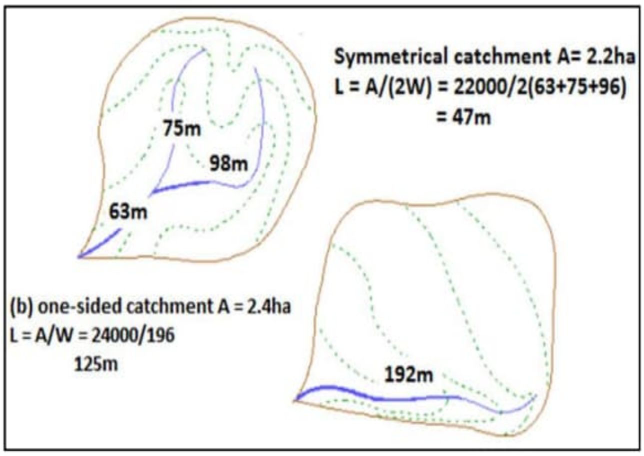


Figure 2.80: Example of Water Shed Shape

The response of a watershed to rainfall runoff may vary with respect to the direction in which a storm event passes. Generally, for design purposes, the orientation of the watershed may be ignored because it is common to assume uniform rainfall distribution over the watershed.

Geographic Location

The geographic location of the watershed within Uganda is a significant factor for the drainage designer. Rainfall intensities and distributions, empirical hydrologic relations, and hydrologic method applications vary because of geographic location. In Uganda, the rainfall distribution is mainly affected by topography and nearby massive water bodies. The designer should use hydrologic methods and parameters that are appropriate for the specific location in the country and locality.

Land Use

Land use significantly affects the parameters of a runoff event. Land use and human activity within most watersheds vary with respect to time. For example, an undeveloped watershed can be developed into a commercial area in a short period. Factors subject to change with general variations in land use include Permeable and impermeable areas, Vegetation, Minor topographic features, and Drainage systems. All of these factors usually affect the rate and volume of runoff that may be expected from a watershed. Therefore, it is important to consider current land use and future potential land use change in the development of the parameters of any runoff hydrograph

Soil Type

Soil type can have considerable effect on the discharge rates of the runoff hydrograph; the soil type directly affects the permeability of the soil and thus the rate of rainfall infiltration. The Natural Resources Conservation Service (NRCS) is a good repository for information about soils, but the soil parameters specified in NRCS should be calibrated and validated with site-specific local data within Uganda before it can be used in hydrological analysis.

Topography

Topography mostly affects the rate at which runoff occurs. The rate of runoff increases with increasing slope. Furthermore, rates of runoff decrease with increasing depression storage and detention storage volumes. Many methods incorporate a watershed slope factor, but fewer methods allow the designer to consider the effects of storage on runoff. The drainage designer should take this limitation of the chosen method into consideration.

Vegetation

In general, runoff decreases with increasing density of vegetation; vegetation helps to reduce antecedent soil moisture conditions and increases interception such as to increase initial rainfall abstractions. Vegetative characteristics can vary significantly with the land use; therefore, consider this in the assessment of potential future land use changes of the watershed.

Detention Storage Systems

Detention storage systems are common in urban areas mostly aimed at controlling increased runoff from developed areas. The drainage designer should identify any detention storage systems that might exist within the subject watershed. A detention storage facility can attenuate the runoff hydrograph, thus reducing the peak discharge. The drainage engineer may design facilities that involve detained storage to conform to established environmental regulations, to cooperate with local regulations, or where flood attenuation is deemed necessary.

Flow Diversions

Flow diversions within a watershed can change the runoff travel times and subsequent peak discharge rates. They can decrease discharge at some locations and increase discharge elsewhere. Flow diversions may redirect flow away from a location. For example, way form a crossing without clear right of way downs stream, diversions created by economic activities such as fishing, brick laying, among others during light rainfall but overflow during heavy rainfall. Assess the likely effect of diversions that exist within the watershed. Also, ensure that the potential impact of necessary diversions resulting from the highway project is minimized.

Channelization

Channelization in an urban area includes improved open channels, curb and gutter road sections, Inverted crown road sections and storm drain systems. Any of these channelization types serve to make drainage more efficient. This means that flows in areas with urban channelization can be greater, and peak discharges occur much more quickly than where no significant channelization exists.

Future Conditions

Changes in watershed characteristics and climate directly affect runoff rates. A reasonable service life of a designed system is expected. Therefore, base the estimate of design flood upon runoff influences within the time of the anticipated service life of the facility

In conclusion when estimating runoff, consider estimates for future land use and watershed character within some future range. It is difficult to predict the future, but the designer should make an effort at such a prediction, especially with regard to watershed characteristics. Local and central government officials and planners can often provide information on potential future characteristics of the watershed. In estimating future characteristics of the watershed, consider changes in vegetative cover, surface permeability, and controlled drainage systems. Climatic changes usually occur over extremely long periods of time; however, it is reasonable to consider potential climatic changes during the anticipated life span of the facility.

STORM WATER COLLECTION, CONVEYANCE AND DISPOSAL

The rapid collection of storm water from the pavement minimizes the conditions that can result in the hazardous phenomenon of hydroplaning. The strength of substructures and hence the service period of roads is highly influenced by intrusion of water. In these regards, provision of well-planned and designed storm water management facilities is a basic requirement in almost all road projects especially in urban areas.

Storm water collection is a function of the minor storm drainage system which is accommodated through the use of roadside and median ditches, gutters, and drainage inlets. Roadside and Median Ditches are used to intercept runoff and carry it to an adequate storm drain. These ditches should have adequate capacity for the design runoff and should be located and shaped in a manner that does not present a traffic hazard. If necessary, channel linings should be provided to control erosion in ditches. Where design velocities will permit, vegetative linings should be used. Gutters are used to intercept pavement runoff and carry it along the roadway shoulder to an adequate storm drain inlet.

Kerbs is typically installed in combination with gutters where runoff from the pavement surface would erode fill slopes and/or where right-of-way requirements or topographic conditions will not permit the development of roadside ditches.

Pavement sections are typically curbed in urban settings. Parabolic gutters without kerbs are used in some areas. Drainage Inlets are the receptors for surface water collected in ditches and gutters and serve as the mechanism whereby surface water enters storm drains. When located along the shoulder of the roadway, storm drain inlets are sized and located to limit the spread of surface water onto travel lanes. The term "inlets," as used here, refers to all types of inlets such as grate inlets, curb inlets, slotted inlets, etc.

An overall consideration of optimum design of stormwater collection, storage and treatment facilities indicates that at least a balance should be struck among the capital costs, operation and maintenance costs, public convenience, environmental enhancement, and other design objectives. Such an optimum balance is dynamic, changing over time with changing physical conditions and value perceptions

The objective of storm water conveyance systems (storm drain piping, ditches, and channels, etc.) is to provide an efficient mechanism for conveying design flows from inlet locations to the discharge point without surcharging inlets or otherwise causing surface flooding. Erosion potential must also be considered in the design of open channels or ditches used for stormwater conveyance.

Upon reaching the main storm drainage system, storm water should be conveyed along and through the right-of-way to its discharge point via storm drains connected by access holes or other access structures. Conveyance systems are defined as that portion of the storm drainage system that receives runoff from inlets and conveys the runoff to some point where it is discharged into a channel, waterbody, or other piped system. Storm drains can be closed conduit or open channel; they consist of one or more pipes or conveyance channels connecting two or more inlets.

Access holes, junction boxes, and inlets serve as access structures and alignment control points in storm drainage systems. Critical design parameters related to these structures include access structure spacing and storm drain deflection. Spacing limits are often dictated by maintenance activities. In addition, these structures should be located at the intersections of two or more storm drains, when there is a change in the pipe size, and at changes in alignment (horizontal or vertical). Combined and Separate Drainage Systems.

Disposal refers to the final discharge point of the storm water collected and conveyed. This can be a natural receiving body such as river, lake swamp or an artificial channel such as primary channel, retention pond or a treatment plant. The designers should be keen to ensure that the proposed discharge point can take both the quality and quantity generated from the proposed.

OPEN CHANNELS AND CLOSED CONDUITS

An open channel is a conduit in which water is conveyed with a free surface. Although closed conduits such as culverts and storm drains are open channels when flowing partially full, the term is generally applied to natural and improved watercourses, gutters, ditches, and channels. The discussions of open channels in this manual are valid for all drainage structures, the primary consideration is given to channels along, across, approaching and leaving the highway.

In addition to performing its hydraulic function, the drainage channel should be economical to construct and maintain. Open channels should be reasonably safe for vehicles accidentally leaving the travelled way, pleasing in appearance, convey collected water without damage to the highway or adjacent property and minimize the environmental impacts. These considerations are usually so interrelated that optimum conditions cannot be met for one without compromising one or more of the others. The objective is to achieve a reasonable balance, but the importance of traffic safety must not be underrated. There are various types of open channels encountered by the road drainage designer of road facilities including: natural sections, trapezoidal channels, rectangular and V- shaped road channels. The principles of open channel flow hydraulics are applicable to any of the selected open section. The details of the principal of open channels are discussed further in Chapter 5 of this design manual.

Closed are basically those without a free space exposed to the atmosphere. They convey runoff in a subsurface manner. Closed channels can be used in a longitudinal drains and as cross culverts. Both with different design approaches. Most common closed system culvert which is a structure that is designed hydraulically to take advantage of submergence to increase hydraulic capacity. It is also a structure used to convey surface runoff through embankments. A culvert is usually covered with fill and is composed of structural material around the entire perimeter. These include steel and concrete pipe culverts and concrete box culverts.

However, a culvert can also be a structure supported on spread footings with the streambed serving as the bottom of the culvert. These include some multi-plate steel structures and concrete slab culverts. In addition, a culvert can be a structure that is 6 meters or less in centreline span length, or between the extreme ends of openings for multiple boxes.

2.6.3 HYDROLOGICAL ANALYSIS

INTRODUCTION

Hydrology is the study of the properties, distribution, and effects of water on the earth's surface, and in the soils, underlying rocks, and atmosphere. For the purpose of this manual, hydrology will deal with estimating flood magnitudes as the result of precipitation. In the design of road drainage structures, floods are usually considered in terms of peak runoff or discharge in cubic meters per second ($m3$ /s) and hydrographs as discharge per time. For structures that are designed to control volume of runoff, like detention storage facilities, or where flood routing through culverts is used, then the entire discharge hydrograph will be of interest.

The planning, design, and construction of road facilities are based on the determination of one or more aspects of storm runoff. Continuous long-term records of rainfall and resulting storm runoff in an area provide the best data source from which to base the design of flow that affects the Project area. However, it is not possible to obtain such records in sufficient quantities for some locations requiring storm runoff computations. Therefore, the accepted practice is to relate storm runoff to rainfall, thereby providing a means of estimating the rates, timing and volume of runoff expected within local watersheds at various recurrence intervals.

It is generally accepted that urban development has a pronounced effect on the rate and volume of runoff from a given rainfall. Urbanization generally alters the hydrology of a watershed by improving its hydraulic efficiency, reducing its surface infiltration, and reducing its storage capacity. For certain small drainage areas (generally less than 100 acres in size), the widely used NRCS (formerly SCS) graphical peak discharge (TR55) provides a useful means of determining peak discharges. However other methods can be employed as the designer engineer deems fit.

It is essential, for successful, sustainable, and integrated road drainage design, that the existing and/or natural hydrological response and functions of the site must be understood. The following factors should be considered:

- The natural drainage that was characteristic of the development area, to the extent that this is possible, should be determined and both the irreversible as well as less permanent changes that have taken place should be identified.

- The hydrology of the development area as function of much of the other data collected at the site data collection stage, this includes existing culverts, streams, swamps, outlet conditions and general terrain as physically observed.

The purpose of the hydrological computation is related rainfall data and records to net peak flows and assess catchment performance under different hydrological conditions.

If case flow records are not available, it is necessary to implement a rainfall-runoff process that allow obtaining the flow of a delineated watershed starting from the rainfall felt within the natural boundaries of the catchment. In literature several methods allow calculating the peak flow (Rational Method, Modified Rational Method, Time Area Method, SCS Rainfall Runoff Relation) starting from the precipitation depth and the definition of some hydrological parameters (time of concentration, runoff coefficient). Alternatively, the use of a hydrological software, using as input the design hyetographs and the hydrological parameters, allows calculating the runoff curves, providing information on the peak flow, on the runoff volume and on the flooding duration.

Such a hydrological process starts with the elaboration of the raw data of the precipitation and the subsequent steps as per the hydrological model selected.

DESIGN RECURRENCE INTERVAL

This refers to the number of times a flood of a given magnitude can be expected to occur on average over a long period of time. Frequency analysis is the estimation of peak discharges for various recurrence intervals. Another way to express frequency is with probability. Probability analysis seeks to define the flood flow with a probability of being equalled or exceeded in any year.

The urban road designer’s main interest in hydrology rests in estimating run-off and peak discharges for the design of highway drainage facilities after establishing and agreed flood risk probability kwon as the recurrence interval.

The designer is particularly interested in the development of a flood versus frequency relation, a tabulation of peak discharges versus the probability of occurrence or exceedance.

Storm drain systems in urban areas have two separate drainage systems. One of the systems is the minor system to handle the frequently recurring storms. The minor system consists of underground piping, natural waterways and required appurtenances to protect against the average storms.

The second system is the major system to handle the large infrequent flows. The major system includes road flow and other overflow provisions to pass the infrequent, large flows and protect against excessive property damage and ponding depth.

Figure 2.81 describes the relationship between major and minor systems.

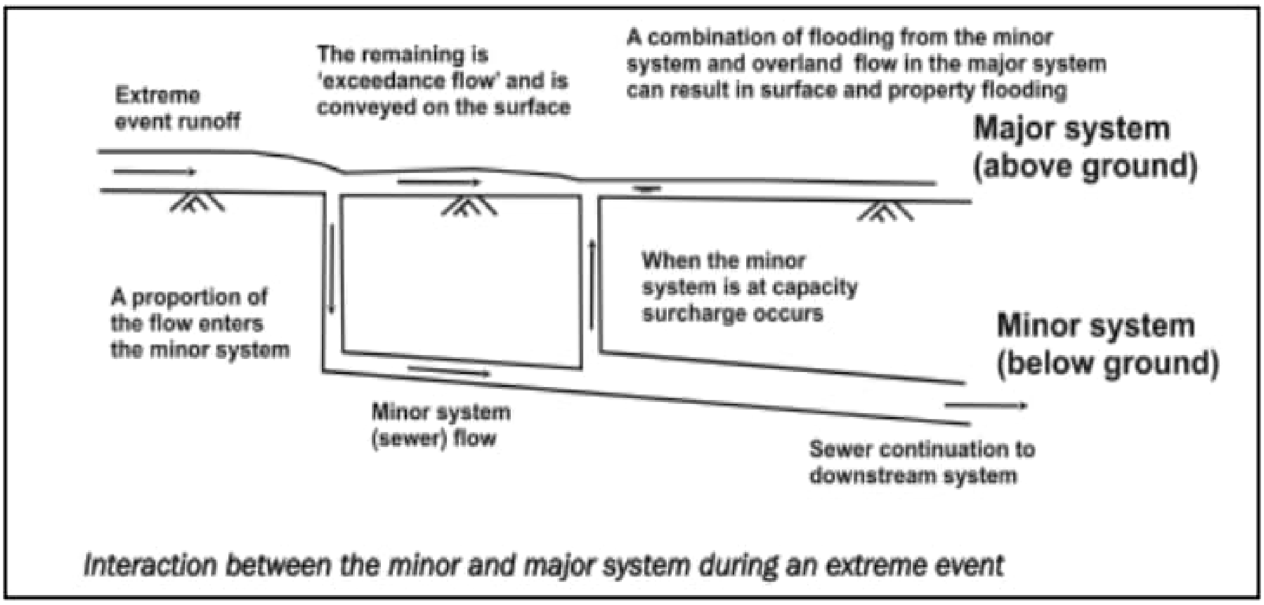


Figure 2.81: Relationship Between Minor and Major System
(Source: Designing for exceedance in urban drainage-good practice guide, CIRIA C635, 2006)

According to the Drainage Design Manual, Minor systems (span < 6.0 meters) are normally designed to carry runoff from up to 10-year frequency storm events. Major systems are designed for floods of average recurrence intervals 25, 50, and 100-years for each road class.

The selection of design flood frequencies/return periods is based on many factors as discussed in the MoWT Drainage Design Manual (2010). The MoWT Drainage Design Manual (2010) presents return periods to be considered for different classes of highways in Uganda. This Urban Road Drainage Manual takes considers the road classifications of Urbans roads and their equivalencies from the MoWT Road Design Manual (2010), to derive the return periods that are applicable for urban roads.
as specified in Table 2.50 for each road class.

Table 2.50: Urban Road classifications in comparison with national road classifications

Class	URDM Class	Function	Description
1	A	Mobility	Trunk Route (with dedicated BRT trunk or Public Transport lanes)
2	B		Major Arterial (with dedicated BRT trunk or Public Transport lanes)
3	C		Minor Arterial (with shared BRT feeder or Public Transport lanes)
4	D	Access	Collector Street (Commercial, Residential & Industrial)
5	E		Access Street (Commercial, Residential & Industrial)
6	-		NMT Access Way
7			Informal settlement access lanes

The choice of return periods is also informed by standards of the Kampala Drainage Master Plan (2016): Report T2 - Design Standard for Stormwater Facilities which set out design standards water bodies that receive stormwater. Based on the above, the proposed recurrence intervals for different urban road classes are shown in Table 2.51.

Table 2.51: Return periods for different urban road classes

Structure type	Urban Geometric Design Standard			
	Class 1 and Class 2	Class 3 and Class 4	Class 5	Class 6
Gutters and inlets	10	10	5	-
Side drains	10	10	5	5
Ford/ low water bridge	-	-	-	5
Minor culvert: span < 2m span	25	25	10	10
Major culvert: 2m < span < 6m	50	25	25	25
Short span bridge: 6m < span < 15m	100	100	50	25
Long span bridge: span > 15m	100	100	100	50
Check/ Review Flood	200	200	100	100

RAINFALL ASSESSMENT

The hydrological analysis is functional to the definition of the rainfall depth values that occur for extreme events (corresponding to different Average Recurrence Interval, ARI) for different rainfall duration; specifically, the maximum annual rainfall (MAR) values for the defined duration, need to be calculated starting from the raw data. It is important that the hydrological elaboration should be done on the basis of daily rainfall records available for the possible maximum duration (depending on availability). Data can be sourced by the Department of Meteorology for the stations of interests or the local urban municipal councils.

RAINFALL DATA

The daily highest rainfall data obtained from the National Meteorological Authority can be statistically analysed using three methods of distribution analysis namely Generalized Extreme Value, Log Pearson-3, and Gumbel's Methods. Commercially available statistical analysis software, Easy Fit 5.5 Professional can also be utilised. The reliability of the distributions can be checked by the goodness of fit tests. The goodness of fit (GOF) tests measures the compatibility of a random sample with a theoretical probability distribution

function. In other words, these tests show how well the distribution you selected fits to your data. The

Anderson-Darling (AD), the Kolmogorov-Smirnov (KS), and the Chi-Squared tests are used for the goodness of fit test. The selection of the best fit method is based on the ranks is given by the three fitness methods.

The most commonly accepted and popular distribution used for model of urban centre drainages is the maximum values (or the minimum values) of a number of samples is the Gumbel distribution, also known as Extreme Values Type 1 distribution (EV1); this statistical distribution analysis is widely used to statistically assess and calculate extreme values. For this reason, this manual recommends Gumbel distribution to be used to calculate the maximum rainfall values of each return period.

FREQUENCY ANALYSIS OF RAINFALL DATA

The Gumbel distribution can be used to model the distribution of the maximum (or minimum) of a number of samples. Specifically, for urban road drainage, Generalized Extreme Value Distribution (GEV). The frequency analysis of the Gumbel distribution should be based on 25-30 years long time series records (in order from the major to the minor) and it is carried out on the following equations.

$(ARI)i = Xm - SX\ SN\ YNm + SX\ SN\ Y(ARI)i = Xm - \alpha YNm + \alpha\ Y(ARI)$……..Eqn 3.4.2-1

Where: N = Number of samples.

ARI = Average recurrence interval of a "i" sample calculated in this way: $ARI = N+1$

X(ARI)i = The value of the "i" sample with a particular ARI

Xm = The mean value of the X variable

Sx = The mean-root-square deviation of the X variable = $Sx = \sqrt{1}\ N{-}1 \sum (Xi - Xm)\ N\ 2$ i=1
$(ARI)i$ = −ln (−ln ARI−1 ARI) = ln (−ln N+1−i N+1)
YNm = The mean value of the Y variable
SN = The mean-root-square deviation of the Y variable

The designer can adopt other methods discussed in section 6 of the MOWT Road Design Manual Vol. 2: Drainage Design to execute frequency analysis of the rainfall data.

INTENSITY-DURATION-FREQUENCY (IDF) CURVES

IDF curves provide a summary of a site's rainfall characteristics by relating storm duration and exceedance probability (frequency) to rainfall intensity (assumed constant over the duration). Intensity-Duration-Frequency (IDF) curves are useful in storm water drainage design since allows

the design hyetographs to be used as input for the rainfall-runoff model. The three variables, intensity/duration/frequency are related to each other, and data are normally presented as curves displaying two of the variables, intensity, and duration, for a range of frequencies.

Three methods studied to elaborate sub-daily and sub-hourly rainfall intensity have been implemented and compared:

- Transport and Road Research Laboratory method (presented in the Road Design Manual – Volume 2: Drainage Design, 2010 by Ministry of Works and Transport)
- Bell's equation (methodology presented in the KDMP2003)
- 24-hour rainfall ratios (methodology presented in the KDMP2003)

If the IDF curves are not available, the designer needs to develop them on a project-by-project basis using any of the above suggested methods.

Figure 2.82 shows and example of IDF curve developed for Kampala.

RAINFALL HYETOGRAPHS

This is a plot of rainfall intensity vs. time for a specific rainfall event. It is typically plotted in the form of a bar graph. For any given storm, the instantaneous intensity is the slope of the mass rainfall curve at a particular time. The mass rainfall curve is simply the cumulative precipitation which has fallen up to a specific time. For hydrologic analysis, it is desirable to divide the storm into convenient time increments and to determine the average intensity over each of the selected periods.

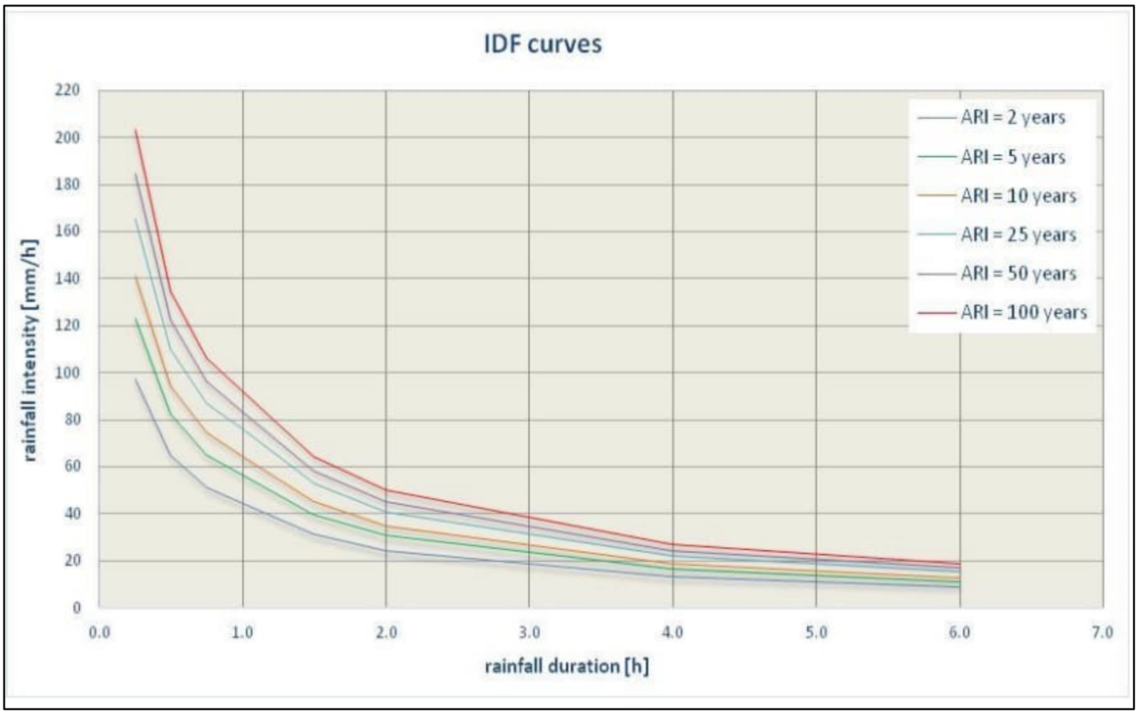


Figure 2.82: Example of IDF Developed for *Kampala*

These results are then plotted as rainfall hyetographs.

Hyetographs provide greater precision than a constant rainfall intensity by specifying the precipitation variability over time and are used in conjunction with hydrographic (rather than peak flow) methods.

Hyetographs allow for simulation of actual rainfall events which can provide valuable information on the relative flood risks of different events and, perhaps, calibration of hydrographic models.

The shape and timing of the runoff hydrograph primarily is driven by the magnitude and temporal distribution of rainfall, the hyetograph is an important component of the modelling. For example, the designer can generate a hyetograph by dividing the total rainfall volume for a 24-hour event into consecutive temporal steps of 5 minutes. The maximum peak of intensity is obtained dividing 5 minutes of rainfall by the duration and the others intensity are calculated for different durations and number of increments.

According to the Fiddes studies, the design hyetographs are symmetric, and the maximum peak is located exactly in the centre of the rainfall event; for each basin to preserve a rainfall volume related by the time of concentration the number of increments for the high values of duration are reduced. An example of hydrograph developed for a 24-hour event is shown in Figure 2.83.

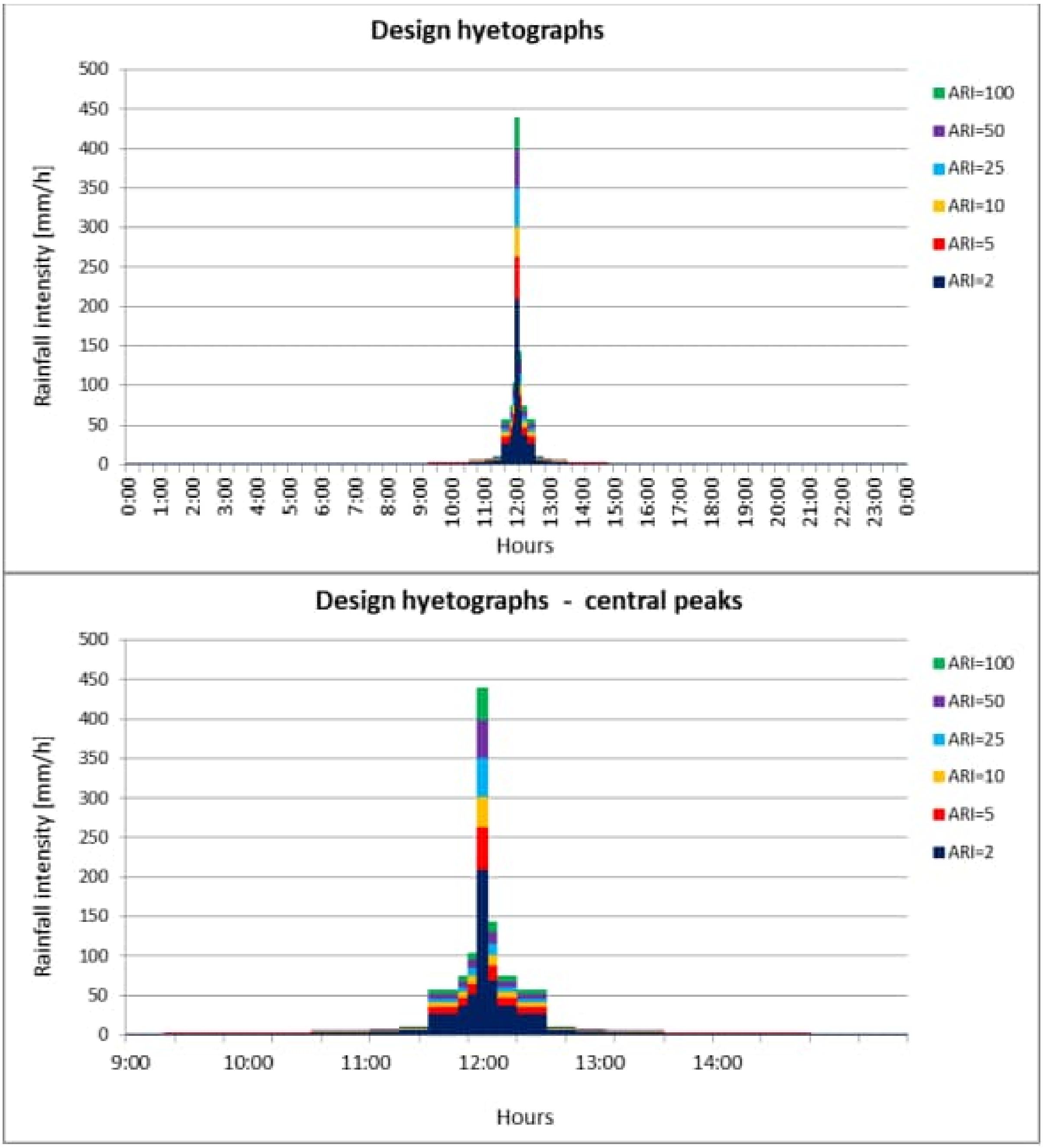


Figure 2.83: Design Hydrograph for 24-hour Event

DETERMINATION OF PEAK FLOW

Peak flow is the maximum rate of flow of water passing a given point during or after a rainfall event.

INTRODUCTION

Estimating peak discharges for various recurrence intervals is one of the most common engineering challenges faced by drainage structure designers.

This is the main challenge in Uganda where there is no adequate primary data to base the analysis. During the manual revision work and the site visit, it was noted that many of the road drainages are either are overtopped or filled with silt and solid waste making them unable to accommodate the flow generated by the catchment upstream of the crossing or source.

Therefore, flow estimation methods should be calibrated with locally collected data (if available). Discharge determination can be divided into two general categories:

- Gauged sites – where the road is at or near a gauging station and the stream flow record is of sufficient length, then statistical analysis should be used to estimate peak flows.
- Ungauged sites - the road not near a gauging station and no stream flow record is available.

Hydrologic procedures that can be used for both categories stated above will be discussed in the next sections.

In literature several methods allow calculating the peak flow (Rational Method, Modified Rational Method, Time Area Method, SCS Rainfall Runoff Relation) starting from the precipitation depth and the definition of some hydrological parameters (time of concentration, runoff coefficient). Alternatively, the use of a hydrological software, using as input the design hyetographs and the hydrological parameters, allows calculating the runoff curves, providing information on the peak flow, on the runoff volume and on the flooding duration. Such hydrological process starts with the elaboration of the raw data of the precipitation and the subsequent steps in line with the selected method.

Details of the different approaches will be discussed in subsequent chapters. The table below shows the limitations of each of the methods.

Table 2.52: Limitation of Different Peak Flow Estimation Methods

Method	Input data	Recommended maximum area(km ^{2})	Return period of flood that could be determined (years)
Rational Method	Catchment area, watercourse length, average slope, catchment characteristics, rainfall intensity	<0.5	2 – 200, PMF
SCS Method	Catchment area, watercourse length, length to catchment centroid (centre), mean annual rainfall, veg. type,soil coverand synthetic regional unit hydrograph	0.5 to 65	2 – 200, PMF
Synthetic Hydrograph Method	Catchment area, watercourse length, length to catchment centroid (centre), mean annual rainfall, veg. type and synthetic regional unit hydrograph	0.5 to 5000	2 -200
Empirical Methods	Catchment area, watercourse length, distance to catchment centroid (centre), mean annual rainfall	No limitation large areas	2 – 200, PMF
Statistical Method	Historical flood peak records	No limitation, large areas	2 – 200 (depending on the record length)

STOCHASTIC METHODS

This refers to the frequency analysis used to evaluate peak flows where adequate gaged stream flow data exist. Frequency distributions are used in the analysis of hydrologic data and include the normal distribution, the log-normal distribution, the Gumbel extreme value distribution, and the log-Pearson Type III distribution. It is important to note that Stochastic methods are not commonly used in urban drainage design due to the lack of adequate streamflow data.

RATIONAL METHOD

The Rational Method is most accurate for estimating design storm peak runoff for areas up to 50 hectares (0.5 square km). This method, while first introduced in 1889, is still widely used. Even though it has come under frequent criticism for its simplistic approach, no other drainage design method has achieved such widespread use.

Some precautions shall be considered when applying the Rational Method:

- The first step in applying the Rational Method is to obtain a good topographic map and define the boundaries of the catchment area in question. A field inspection of the area should also be made to determine if the natural drainage divides have been altered.

- In determining the runoff coefficient C value for the catchment area, thought shall be given to future changes in land use that might occur during the service life of the proposed road that could result in an inadequate drainage system. Also, the effects of upstream detention structures must be taken into account.
- Restrictions to the natural flow such as highway crossings and dams that exist in the catchment area shall be investigated to see how they affect the design flows.

The method is intensively discussed in section 4.4 of the MOWT roads drainage design Manual Vol 2: Drainage Design.

Rational coefficient

The runoff coefficient (C) is the variable of the Rational Method least susceptible to precise determination and requires judgment and understanding on the part of the designer. A typical coefficient represents the integrated effects of many drainage basin parameters. Coefficient is a function of soil groups, land use, and average land slope.
For example, a small relatively impervious area within a larger drainage area may have an independent discharge higher than that of the total area. This anomaly may occur because of the high runoff coefficient (C value) and high intensity resulting from a short time of concentration. If an exception does exist, it can generally be classified as one of two exception scenarios. The first exception occurs when a highly impervious section exists at the most downstream area of a watershed and the total upstream area flows through the lower impervious area. When this situation occurs, two separate calculations should be made.

- First, calculate the runoff from the total drainage area with its weighted C value and the intensity associated with the longest time of concentration.
- Secondly, calculate the runoff using only the smaller less pervious area.
- The typical procedure would be followed using the C value for the small less pervious area and the intensity associated with the shorter time of concentration. The results of these two calculations should be compared and the largest value of discharge should be used for design.
- The second exception exists when a smaller less pervious area is tributary to the larger primary watershed. When this scenario occurs, two sets of calculations should also be made.
- First, calculate the runoff from the total drainage area with its weighted C value and the intensity associated with the longest time of concentration.
- Secondly, calculate the runoff to consider how much discharge from the larger primary area is contributing at the same time the peak from the smaller less pervious tributary area is occurring. When the small area is discharging, some discharge from the larger primary area is also contributing to the total discharge. In this calculation, the intensity associated with the time of concentration from the small less pervious area is used.
- Details can be sourced from Section 4.3.3 of the MOWT Roads Drainage Design Manual Vol 2: Drainage Design.

Time of concentration

This refers to the time for runoff to travel from the hydraulically most distant point in concentration the watershed to a point of interest within the watershed. This time is calculated by summing the individual travel times for consecutive components of the drainage system

It is recommended in this manual that for the design of most drainage structures, the minimum time of concentration is taken as 15 minutes. The design of gutters and inlets may be based on shorter rainfall durations, but this isn't serious conservatism.

Three common errors should be avoided when calculating Tc. First, application of simplified general equations such as Kirpich for determining Tc can result in too short a time of concentration, particularly when the average basin slope varies significantly from the mean channel slope as in steep mountainous areas. Neglecting the overland flow time can also dramatically shorten the time of concentration thus increasing the design peak

Details can be sourced from Section 4.2.1 of the MOWT Roads Drainage Design Manual Vol 2: Drainage Design.

MODIFIED RATIONAL METHOD

Details can be sourced from Section 4.3.4 of the MOWT Roads Drainage Design Manual Vol 2: Drainage Design.

SCS RAINFALL-RUNOFF METHOD

The SCS 24- hour rainfall distributions are the most widely used synthetic hyetographs. These rainfall distributions were developed by the U.S. Department of Agriculture, Soil Conservation Service (SCS)(13) which is now known as the Natural Resources Conservation Service (NRCS). The SCS 24-hour distributions incorporate the intensity-duration relationship for the design return period. This approach assumes that the maximum rainfall for any duration within the 24-hour duration should have the same return period. For example, a 10-year, 24- hour design storm would contain the 10-year rainfall depths for all durations up to 24 hours as derived from IDF curves

Details can be sourced from Section 4.4.4 of the MOWT Roads Drainage Design Manual Vol 2: Drainage Design.

TRRL EAST AFRICAN FLOOD MODEL

Details can be sourced from Section 5.3 of the MOWT Roads Drainage Design Manual Vol 2: Drainage Design.

DESIGN AND USE OF DETENTION BASINS

To achieve the attenuation of runoff it is sometimes necessary to design and implement stormwater retention basins and detention ponds. These systems are very effective in the control of stormwater and flooding. In Urban areas, lots of basins are very urbanized and high values of runoff discharge occur. Placing some storage areas where is possible may be a useful solution for not oversize the drainage system especially if an outlet control is designed.

Where storage area can be used, the land of the retention pond is only utilized during storm events which predominantly occur during the wet season periods. During dry periods of the year, it is possible to use the basin for temporary community facilities such as pedestrian footpaths, soccer fields and children’s play areas

Storage areas can also improve water quality with a detention action if properly sized. Detention basins built with real-time control of the outflow from the basin are significantly more effective at retaining total suspended solids and associated contaminants, such as heavy metals, when compared to basins without control.

Therefore, as far as the design for retention and detention facilities as components of the urban road’s drainage, the Design Standards for Stormwater Drainage Facilities volume of the Kampala Drainage Master plan 2016 will be consulted.

2.6.4 PAVEMENT DRAINAGE

GENERAL

A storm drainage system for an urban road is a collection of structures to collect and convey storm water runoff from built up areas to a discharge location in a manner that adequately drains the roadway and minimizes the potential for flooding, hydroplaning and erosion to adjacent properties along pavements.

Effective drainage of urban roads and pavements is essential to maintain the levels of service and to traffic safety of pedestrians and other road users. Water on the urban roads can interrupt traffic, reduce skid resistance, increase potential for hydroplaning, limit visibility due to splash and spray, and cause difficulty in steering a vehicle when the front wheels encounter puddles. The substructures of an urban roadway are also highly influenced by intrusion of water from roadside catchments and properties.

Urban road drainage requires consideration of surface drainage, gutter flow, and inlet capacity.

PAVEMENT DRAINAGE SYSTEM

The system begins with a concentration system such as gutters and channels, a system of inlets that pass the collected flows into a conveyance system of pipes or channels that have structures to allow the connection or access to them. The collected flows are eventually conveyed to a major municipal storm water drainage system which later drains into an outfall around the urban area. The outfall may be a natural or artificial drainage system at the periphery of the municipal boundaries. The cost of drainage facilities is neither incidental nor minor on most roads. The quality of the final system usually reflects the attention given to every aspect of the design. The design of a drainage system must address the needs of the traveling public as well as those impacted by the project.

SURFACE AND SUB-SURFACE SYSTEMS

The urban roadside storm drain system may be categorized as a surface system and a subsurface system. The surface road drainage commences with the consolidation of local precipitation that runs off across a road surface in a thin stream. It ends where each accumulated stream, impacted upon by roadworks, may be released into an outfall.

SURFACE DRAINAGE SYSTEM

The surface urban drainage system usually involves gutter flow and inlet interception. Several elements can be used to intercept or capture this runoff and facilitate its safe discharge to an appropriate receiving Location. These elements include kerb and channel, edge and median drainage, table drains and blocks, diversion drains and blocks, batter drains, catch drains and banks, drainage pits and pipe networks. The design of these elements is dependent on storm frequency and the allowable spread of storm water on the pavement surface in an urban setting. This system is used to control the location and amount of water flowing along the gutters or ponding at sags to quantities that will minimize interference with the passage of traffic at the design storm event. This is accomplished by placing inlets at such points and at such intervals to intercept and capture flows as necessary to satisfy the spread and depth criteria for the specified storm frequency. The surface drainage system can be either open or closed. The urban roads drainage system shall be either a closed network with kerbs, gutters and slotted as inlets or a subsurface drainage system. slabs adequately designed as coverage.

SUB-SURFACE DRAINAGE SYSTEM

The subsurface system includes the pipes that convey the flow and the structures that connect the inlets to the pipes. There may be additional structures that allow access to the subsurface system while not being intended for capturing of flows into the subsurface system. The subsurface system allows for the entry of water at each inlet and conveys the collected flows to the discharge location in a manner that contains the flows for the design event. This is accomplished by sizing the pipes and evaluating the energy losses so that the hydraulic grade line is just near the top of the pipes for the design storm event.

CHOICE OF DRAINAGE SYSTEM

For urban drainage systems, the closed and subsurface drainage systems have been preferred compared to open systems. This is because of public safety for both the residential and transient populations and the high costs of land acquisition in Ugandan urban areas restricting the potential of land availability for all road drainage accessories.

The closed surface systems can provide a readily available space for pedestrians, cyclists and the vision impaired lanes at the top of the urban roadside drainage. It should be put in mind however that the design and construction of closed and sub-surface systems requires more considerations than in the case of open channel system. In particular, the closed and sub-surface drains involve the use of numerous special appurtenances which may include manholes, junctions, inlets, catch basins, drop structures and siphons. Such structures can be built using in-situ poured concrete or by partial or full prefabrication / precast using various materials.

However, experience has shown that in peri-urban areas where the community stormwater drainage network is not well developed, closed drains are not very effective as their inlets are unable to tap all the stormwater on the road and from the terrain / roadside. As a result, stormwater from the terrain which carries eroded material and garbage ends up on the road blocking the inlets. The situation is further complicated by inadequate maintenance practices of urban authorities and yet closed drains have more stringent requirements for cleaning to remain effective. In these cases, a combination of open and closed drains shall be considered to meet safety, and stormwater management efficiency objectives. In cases where open drains are used, physical barriers are recommended to enhance safety of users.

The available ROW, utilities, budget, alignment, and regulations are some of the constraints in meeting the hydraulic goals. The successful design achieves the stated hydraulic goals while incurring the lowest total economic costs in terms of construction, maintenance, right-of-way, and environmental impact.

DESIGN FREQUENCY AND SPREAD

Two of the more significant variables considered in the design of urban road drainage are the frequency of the design runoff event and the allowable spread of water on the pavement. A related consideration is the use of an event of lesser frequency to check the drainage design.
Spread and design frequency are not independent.

The implications of the use of a criterion for spread of one-half of a traffic lane is considerably different for one design frequency than for a lesser frequency. It also has different implications for a low-traffic, low-speed urban road vs. a higher classed road. These subjects are central to the issue of highway pavement drainage and important to highway safety.

SELECTION OF DESIGN FREQUENCY AND DESIGN SPREAD

The objective of urban road stormwater drainage design is to provide for safe passage of vehicles during the design storm event. The design of a drainage system for a kerbed urban road / pavement section is to collect runoff in the gutter and convey it to pavement inlets in a manner that provides reasonable safety for traffic and pedestrians at a reasonable cost. As spread from the kerb increases, the risks of traffic accidents and delays, and the nuisance and possible hazard to pedestrian traffic increase.

The process of selecting the recurrence interval and spread for design involves decisions regarding acceptable risks of accidents and traffic delays and acceptable costs for the drainage system. Risks associated with water on traffic lanes are greater with high traffic volumes, high speeds, and higher urban road classifications than with lower volumes, speeds and road classifications. A summary of the major considerations that enter into the selection of design frequency and design spread has been well documented in the URDM-V2, 2010 (MoWT, 2010) and must be consulted. However, the speed limitation shall be as set out in the Urban Geometric Design Manual, Chapter 3.

In the road drainage manual, the maximum allowable speed is stated to be 70 km/hr but in an urban setting its not advised to have such a high speed on urban roads due to the high population, congestion, regulated traffic lights within the urban centres and high risk of road accidents. Only Class 1 road has a higher speed limit of 80 km/h. Therefore, a design spread that equals to the height of the shoulder + 1m shall be adopted for all urban roads and no hydroplaning shall be expected, since it’s expected at speeds greater than 70 km /hr.

Major importance shall also be put on inconvenience, hazards, and nuisances to pedestrian traffic in all urban road drainage designs. Local design practice may also be a major consideration since it can affect the feasibility of designing to higher standards, and it influences the public’s perception of acceptable practice.
The relative elevation of the urban road and surrounding terrain is an additional consideration where water can be drained only through a storm drainage system, as in underpasses.

SELECTION OF CHECK STORM AND SPREAD

A check storm should be used to assess the impact of flooding during less frequent events. Also, inlets should always be evaluated for a check storm when a series of inlets terminate at a sag vertical curve where ponding to hazardous depths could occur. The frequency chosen for the check storm should be based on the same considerations that were used to select the design storm, namely the consequences of spread exceeding the design spread and the potential for ponding. Check storms are usually unnecessary where no significant ponding can occur. Criteria for spread during the check event are well documented and should be consulted from the URDM-V2.

SURFACE DRAINAGE

A chief objective in the design of urban drainage system is to move any accumulated water off the carriageway as quickly and efficiently as possible. Where the flow is concentrated, the design objective should be to minimize the depth and horizontal extent of that flow. Appropriate longitudinal and transverse slopes can serve to move water off the carriageway to minimize the depth of sheet flow and thus minimize the potential for hydroplaning. An objective of the design should be to establish efficient drainage in conjunction with the geometric and pavement design. When rain falls on a sloped urban road pavement surface, it forms a thin film of water that increases in thickness as it flows to the edge of the pavement. Factors which influence the depth of water on the pavement are the length of flow path, surface texture, surface slope, and rainfall intensity.

The design guidance for the following surface drainage elements is presented:

- Longitudinal pavement slope
- Cross or transverse pavement slope
- Kerb and gutter
- Bridge decks

HYDROPLANING

The accumulation of runoff on roadways and shoulders constitutes the most common hydraulic road surface risk. When a rolling tire encounters a film of water on the roadway, the water is channelled through the tire tread pattern and through the surface roughness of the pavement. Hydroplaning occurs when the drainage capacity of the tire tread pattern and the pavement surface is exceeded, and the water begins to build up in front of the tire. As the water builds up, a water wedge is created, and this wedge produces a hydrodynamic force which can lift the tire off the pavement surface. This is considered as full dynamic hydroplaning and, since water offers little shear resistance, the tire loses its tractive ability, and the driver has a loss of control of the vehicle.
Hydroplaning is a function of the water depth, roadway geometry, vehicle speed, tread depth, tire inflation pressure, and conditions of the pavement surface. It has been shown that hydroplaning can occur at speeds of 87 km/hr with a water depth of 2 mm. All urban roads are expected to have an allowable speed of 50 km/hr. As a result, hydroplaning is unlikely to occur in well-designed urban road systems.

Longitudinal Slope

Experience has shown that the recommended minimum values of roadway longitudinal slope given in the AASHTO Policy on Geometric Design will provide safe, acceptable pavement drainage. In addition, the following general guidelines are presented.

- To achieve self-cleaning in the gutter, the slope should be greater than 1%. The desirable gutter grades should not be less than 0.5 percent for kerbed pavements with an absolute minimum of 0.3 percent. The minimum gutter profile grade is 0.2%.
- The minimum pavement cross slope should not be less than 2% except during the occurrence of superelevation transition. The coincident occurrence of superelevation transitions and sag points or zero grades should be avoided in urban road drainage designs.
- To provide adequate drainage in sag vertical curves, a minimum slope of 0.3 percent should be maintained within 15 meters of the low point of the curve. This is accomplished where the length of the curve in meters divided by the algebraic difference in grades in percent (%) is less than or equal to 50. This is represented as:

$$K = \frac{L}{G_2 - G_1}$$

Eqn 8.1

Where:
K = Vertical curve constant m/percent
L = horizontal length of curve, m
G_i = Grade of roadway, percent

Cross (transverse) Slope

Table 4-2 indicates an acceptable range of cross slopes as specified in AASHTO's policy on geometric design of urban roads. These cross slopes are a compromise between the need for reasonably steep cross slopes for drainage and relatively flat cross slopes for driver comfort and safety. These cross slopes represent standard practice.

Cross slopes of 2% have little effect on driver effort in steering or friction demand for vehicle stability, according to Pavement and Geometric Design Criteria for Minimizing Hydroplaning. It is not recommended to use a cross slope steeper than 2% on pavements with a central crown line. To aid drainage in areas of heavy rainfall, a maximum steeper cross slope (2.5 percent) may be used.

On multi-lane highways where three lanes or more are sloped in the same direction, it is desirable to counter the resulting increase in flow depth by increasing the cross slope of the outermost lanes. The two lanes adjacent to the crown line should be pitched at the normal slope, and successive lane pairs, or portions thereof outward, should be increased by about 0.5 to 1 percent. Additional guidelines related to cross slope are:

- Although not widely encouraged, inside lanes can be sloped toward the median if conditions warrant.
- Median areas should not be drained across travel lanes.

- The number and length of flat pavement sections in cross slope transition areas should be minimized. Consideration should be given to increasing cross slopes in sag vertical curves, crest vertical curves, and in sections of flat longitudinal grades.
- Shoulders should be sloped to drain away from the pavement, except with raised, narrow medians and super elevations.

Kerb and Gutter

Kerbs is normally used at the outside edge of pavements for urban roads drainage. They serve the following purposes:

- Contain the surface runoff within the roadway and away from adjacent.
- Prevent erosion on fill slopes.
- Provide pavement delineation; and,
- Enable the orderly development of property adjacent to the roadway.

Gutters formed in combination with kerbs are available in 0.3 through 1.0-meter widths. Gutter cross slopes may be the same as that of the pavement or may be designed with a steeper cross slope, usually 80 mm per meter steeper than the shoulder or parking lane (if used). AASHTO geometric guidelines state that an 8 percent slope is a common maximum cross slope or in steeper slopes, the road longitudinal slope shall be adopted.

A kerb and gutter combination form a triangular channel that can convey runoff equal to or less than the design flow without interruption of the traffic. When a design flow occurs, there is a spread or widening of the conveyed water surface. The design of the kerb-gutter combination is well discussed in the URDM-V2. Therefore, this will be adopted for urban road drainage.

FLOW IN GUTTERS

A pavement gutter is defined as a section of pavement adjacent to the roadway which conveys water during a storm runoff event. It may include a portion or all of a travel lane. Gutter sections can be categorized as conventional or shallow swale type. Conventional kerb and gutter sections usually have a triangular shape with the kerb forming the near-vertical leg of the triangle. Conventional gutters may usually have a straight cross slope, or a composite cross slope where the gutter slope varies from the pavement cross slope. This concept has been thoroughly discussed in the URDM-V2, therefore it will be adopted for urban road drainage design.

Capacity Relationship

Gutter flow calculations are necessary to establish the spread of water on the shoulder, parking lane, or pavement section. A modification of the Manning equation can be used for computing flow in triangular channels. The modification is necessary because the hydraulic radius in the equation does not adequately describe the gutter cross section, particularly where the top width of the water surface may be more than 40 times the depth at the kerb. To compute gutter flow, the Manning equation is integrated for an increment of width across the section.

The resulting equation is:
Eqn 8.3

$$Q = \frac{K_c}{n} S_x^{1.67} S_L^{0.5} T^{2.67}$$

Where:
Kc = 0.377
n = Manning's coefficient (Table 2.53)
Q = flow rate, m3/sec
T = width of flow (spread), m
Sx = cross slope, m/m
SL = longitudinal slope, m/m

Equation 8.3 neglects the resistance of the kerb face since this resistance is negligible.

Table 2.53: Manning's Roughness (n) for Road and Pavement Gutters

Type of Gutter or Pavement	Manning's n
Concrete gutter, troweled finish	0.012
Asphalt Pavement: Smooth texture Rough	 0.013 0.017
Concrete gutter – asphalt pavement: Smooth Rough	0.013 0.015
Concrete Pavement: Float finish	 0.014
Broom finish	0.017

Spread on the pavement and flow depth at the kerb are often used as criteria for spacing pavement drainage inlets.

Relative Flow Capacities

Equation 8.6-8 in the URDM-V2 shall be adopted for this section in order to examine the relative effects of changing the values of spread, cross slope, and longitudinal slope on the capacity of a section with a straight cross slope.

The effects of cross slope are also relatively great as illustrated by a comparison of gutter capacities with different cross slopes. At a cross slope of 4 percent, a gutter has 10 times the capacity of a gutter of 1 percent cross slope. A gutter at 4 percent cross slope has 3.2 times the capacity of a gutter at 2 percent cross slope.

Little latitude is generally available to vary longitudinal slope in order to increase gutter capacity, but slope changes which change gutter capacity are frequent. Figure 4-3 (URDM-V2) shows that a change from = 0.04 to 0.02 will reduce gutter capacity to 71 percent of the capacity at = 0.04.

INLETS

Storm drain inlets are used to collect runoff and discharge it to an underground storm drainage system. Inlets are typically located in gutter sections, paved medians, and roadside and median ditches. Inlets used for the drainage of urban road surfaces can be divided into the following four classes:

- grate inlets
- slotted inlets
- kerb-opening inlets
- combination inlets

The efficiency and basis of choice of which inlets has been exhaustively discussed in Chapter 8 of the URDM-V2. It will be consulted during design of urban road drainage design.

DRAINAGE INLET DESIGN

Drainage inlets should be sized and located to limit the spread of water on travel lanes in accordance with the design criteria specified in this manual. The hydraulic capacity of a storm drain inlet depends upon its geometry as well as the characteristics of the gutter flow. Inlet capacity governs both the rate of water removal from the gutter and the amount of water that can enter the storm drainage system. Inadequate inlet capacity or poor inlet location may cause flooding on the roadway resulting in a hazard to the traveling public. As they are highly efficient and their interference with carriageways is rather limited, the design of kerb opening inlets is further discussed in the Uganda Road Design Manual Volume 2 (URDM-V2), Chapter 8 and will be consulted during the use of this manual by the designer.

Grate inlets and local depression at curb opening inlets should be located outside the through travel lanes to minimize the shifting of vehicles attempting to avoid these areas. All inlet grates should be bicycle safe when used at locations where bicycle travel is anticipated.

Kerb-Opening Inlets

Kerb-opening inlets are effective in the drainage of urban roads where flow depth at the kerb is sufficient for the inlet to perform efficiently. Kerb openings are less prone to clogging, making them preferable to grate inlets due to their debris handling capabilities and minimal interference with traffic operation. They are viable alternative to grates on flatter grades where grates would be in traffic lanes or would be hazardous for pedestrians or bicyclists. Kerb opening heights vary in dimension.

The location and spacing of kerb inlets depend on the following factors:

- Amount of runoff
- Grade profile
- Geometry of intersection
- Width of flow limitation
- Inlet capacity

SUBSURFACE DRAINAGE

The aim of subsurface drainage is the removal of detrimental quantities of ground water to ensure stable roadbed and side slope conditions. Effective subsurface drainage for urban roads must ensure groundwater control, stabilized slopes, and lowered water tables in the vicinity of the designed road. The examination of the proposed subsurface drainage system should include the horizontal and vertical location of all of the conduit systems to assure that they will in fact carry water away from the pavement structure (and not serve as a source of supply) and, if desired, to enable conduit used for drainage of the pavement structure to connect with existing piping for the ultimate removal of water from the roadway system.

A satisfactory solution to subsurface drainage problems requires a knowledge of geology and an insight into soil mechanics. Many variables and uncertainties exist regarding the actual subsurface conditions. In most cases the need for the installation of subsurface drainage can only be established on site during the construction stage'.

The subsurface drain types, design criteria, materials to be used have been exhaustively explained in the URDM-V2. Therefore, for the urban road drainage, the URDM-V2 shall be consulted.

2.6.5 LONGITUDINAL AND MEDIAN DRAINS

INTRODUCTION

Large amounts of runoff should be intercepted before reaching the roadway in order to minimize the deposit of sediment and other debris on the roadway and to reduce the amount of water that must be carried in the gutter section. Slope median areas and inside shoulders to a centre depression to prevent runoff from the median area from running across the pavement. Surface channels should have adequate capacity for the design runoff and should be located and shaped in a manner that does not present a traffic hazard.

Roadside channels and median channels are part of the storm drain system and are commonly used with uncurbed roadway sections to convey runoff from the roadway pavement and from areas which drain toward the roadway. Due to right-of-way limitations, roadside channels cannot be used on most urban arterials. They can be used in cut sections, depressed sections, and other locations where sufficient right-of-way is available and driveways or intersections are infrequent. Where practical, the flow from major areas draining toward curbed highway pavements should be intercepted in the ditch as appropriate.

OPEN CHANNEL FLOW

Where land use permits, open channels should be the preferred option when compared with underground pipelines and culverts since the latter are more expensive to construct and maintain than open channels.

In general, open trapezoidal channels provide the most economical cross-section for the conveyance of stormwater, both in terms of construction and maintenance costs. Rectangular open channels are usually most costly to construct and have limited scope for improving the aesthetics when compared with trapezoidal channels. An analysis of land availability, acquisition and the channel appearance should be carried out before a rectangular section is adopted. Whichever section is adopted, the design should make due allowance for the appearance of the channel, the selection of suitable lining materials and the provision of landscaping.

Design analysis of both natural and artificial channels proceeds according to the basic principles of open channel flow. The basic principles of fluid mechanics continuity, momentum, and energy can be applied to open channel flow with the additional complication that the position of the free surface is usually one of the unknown variables. The determination of this unknown is one of the principal problems of open channel flow analysis and it depends on quantification of the flow resistance. The drainage designer is expected to possess the knowledge of theoretical principles of open channel flow; hence most of the theoretical equation are not included in this manual. The designer should refer to open channel flow textbooks for theoretical background information. This must include the theoretic knowledge on hydraulic jump, flow classifications, energy, specific energy and momentum conservation equations and their applications in hydraulic design.

FLOW RESISTANCE

The depth of flow in a channel of given geometry and longitudinal slope is primarily a function of the channel's resistance to flow or roughness. This depth is called the normal depth and is computed from Manning's equation for "V" combined with the continuity equation, Q = VA. The combined equation, often referred to as Manning's equation One of the major factors in design of roadside and median drains is the flow resistance. The channel roughness varies from one channel lining to another.

Table 2.54 shows the various channel linings that can be adopted for roadside and median channel designs: Hydraulics designers should analyse drainage locations throughout the project with potential erosion problems to evaluate the suitability and stability of the channel lining.

Examples of locations to consider are:

- Flow velocity in the channel is greater than the permissible velocity.
- Existing erosion areas,
- Ditches with grades steeper than 3%,
- Drainage areas greater than 10 acres,

- Roadway embankments that transition from a ditch cut to a fill,
- Toe of fills that result in a V-ditch, and
- Narrow channel sections (steep-sided V-ditches).

In addition, the hydraulics designer should consider that occasionally even small, concentrated flows in a channel may merit evaluation, depending on the channel grade and configuration. The following identify typical lining types as adopted by HEC-15.

Table 2.54: Manning's Roughness Coefficient (HEC-15)

Lining Category	Lining Type	n – value : Depth Ranges		
		0-0.15m	0.15–0.06m	> 0.6m
Rigid	Concrete Grouted Riprap Stone Masonry Soil Cement Asphalt	0.015 0.040 0.042 0.025 0.018	0.013 0.030 0.032 0.022 0.016	0.013 0.028 0.030 0.020 0.016
Unlined	Bare Soil Rock Cut	0.023 0.045	0.020 0.035	0.020 0.025
Temporary*	Woven Paper Net Jute Net Fiberglass Roving Straw with Net Curled Wood Mat Synthetic Mat	0.016 0.028 0.028 0.065 0.066 0.036	0.015 0.022 0.022 0.033 0.035 0.025	0.015 0.019 0.019 0.025 0.028 0.021
Gravel Riprap	25 mm D_{50} 50 mm D_{50}	0.044 0.066	0.033 0.041	0.030 0.034
Rock Riprap	150 mm D_{50} 300 mm D_{50}	0.104 --	0.069 0.078	0.035 0.040

TEMPORARY LININGS

- Vegetative mulch (provides no value, just erosion control)
- Asphalt mulch
- Excelsior mat
- Excelsior mulch
- Wood cellulose fibre
- Nylon erosion control mat

PERMANENT LININGS:

Note: The longitudinal channel slopes noted here provide a starting point for the selection of a trial lining. Permanent linings may require environmental permits and other mitigation requirements if designed within the OHW.

- Vegetation (see Figure 8.5-B for Classes) for S < 3%,
- Turf reinforcement mats for 3% < S < 15%,
- Riprap for 3% < S < 10%,
- Concrete for S > 3%, or
- Gabions (see Chapter 11 “Energy Dissipators” in HEC-15) for S > 3%.

SPECIAL LININGS

These include composite linings that have a low-flow channel with one type of lining and upper side slopes with a different lining.

CONCRETE LININGS

Concrete linings for the proposed channel should be a continuously reinforced concrete design or reinforced using wire mesh. The following will apply:

Joints. Only construction joints will be used, except at channel lining/concrete structure junctions where expansion joints are required.

Weepholes. These will be provided where the channel exceeds 30m in length. On less than 30m long channels, granular backfill will vent the pressure.

Bottom Slab Thickness. Bottom slab thicknesses will be a minimum of 100mm. A minimum slab thickness of 150mm is required if the channel is intended to accommodate maintenance vehicles.

Side Slope Lining Thickness. Side slope lining thicknesses (for slopes 1:1½ or flatter) will be 100mm. For side slopes steeper than 1:1½, channel linings will be designed as retaining walls.

Cut-off Walls. Cut-off walls are not generally required to prevent progressive failure in reinforced concrete channels. However, there may be some concern for the stability of lining slope walls at transitions where the cross-section shape changes or at locations where the channel slope changes. To prevent local buckling at these locations, cut-off walls rigidly attached to the paving should be installed to stiffen the linings. Cut-off walls will also be required at the start and end of channels where there is a change to other types of lining and at existing structures where the new linings cannot realistically be made continuous with the existing lining.

FLOW IN BENDS

Flow around a bend in an open channel induces centrifugal forces because of the change in flow direction. This results in a superelevation of the water surface. The water surface is higher at the outside of the bend than at the inside of the bend.

This superelevation can be estimated by the equation:

$\Delta d = \frac{V^2 T}{g R_c}$ = superelevation of the water surface.

Where:
V = mean velocity, m/s
T = surface width of the channel, m
g = gravitational acceleration, 9.8 m/s2.
Rc = mean radius of the bend, m

STABLE CHANNEL DESIGN

HEC-15 provides a detailed presentation of stable channel design concepts related to the design of roadside and median channels. This section provides a brief summary of significant concepts:

- Stable channel design concepts provide a means of evaluating and defining channel configurations that will perform within acceptable limits of stability. For urban road drainage channels, bank instability and lateral migration cannot be tolerated. Stability is achieved when the material forming the channel boundary effectively resists the erosive forces of the flow. Principles of rigid boundary hydraulics can be applied to evaluate this type of system.

- Both velocity and tractive force methods have been applied to the determination of channel stability. Permissible velocity procedures are empirical in nature, and have been used to design numerous channels throughout the world. However, tractive force methods consider actual physical processes occurring at the channel boundary and represent a more realistic model of the detachment and erosion processes.

- The hydrodynamic force created by water flowing in a channel causes a shear stress on the channel bottom. The bed material, in turn, resists this shear stress by developing a tractive force. Tractive force theory states that the flow-induced shear stress should not produce a force greater than the tractive resisting force of the bed material. This tractive resisting force of the bed material creates the permissible or critical shear stress of the bed material. In a uniform flow, the shear stress is equal to the effective component of the gravitational force acting on the body of water parallel to the channel bottom.

DESIGN PARAMETERS

Parameters required for the design of roadside and median channels include discharge frequency, channel geometry, channel slope, vegetation type, freeboard, and shear stress. This section provides criteria relative to the selection or computation of these design elements

DISCHARGE FREQUENCY

Roadside and median drainage channels are typically designed to carry 5- to 10-yr design flows; however, when designing temporary channel linings, a lower return period can be used. Usually a 2-yr return period is appropriate for the design of temporary linings

CHANNEL GEOMETRY

Several typical shapes with equations for determining channel properties. The channel depth, bottom width, and top width must be selected to provide the necessary flow area. Channel side slopes for triangular or trapezoidal channels should not exceed the angle of repose of the soil and/or lining material, and should generally be 1V:3H or flatter. In areas where traffic safety may be of concern, channel side slopes should be 1V:4H or flatter. Design of roadside and median channels should be integrated with the geometric and pavement design to ensure proper consideration of safety and pavement. As per this manual, concrete lining shall always be preferred. The following shapes and sections shall be adapted as shown in Table 2.55, Figure 2.84 and Figure 2.85.

These example channel configurations are for guidance only. The design engineer shall compare them with the design flows and hydraulic requirements and make the necessary adjustments. Closed channels should be considered wherever open drains may pose a safety risk for pedestrians and vehicles.

Table 2.55: Proposed Channel Sections

Section Type	Top width (mm)	Depth / Height (mm)	Side slopes
V-shaped	600		At 45°
	800		At 45°
Trapezoidal	600		At 45°
	800		At 45°
Rectangular	450	450	
	600	600	
	800	800	
	800	1000	
	1000	1200	

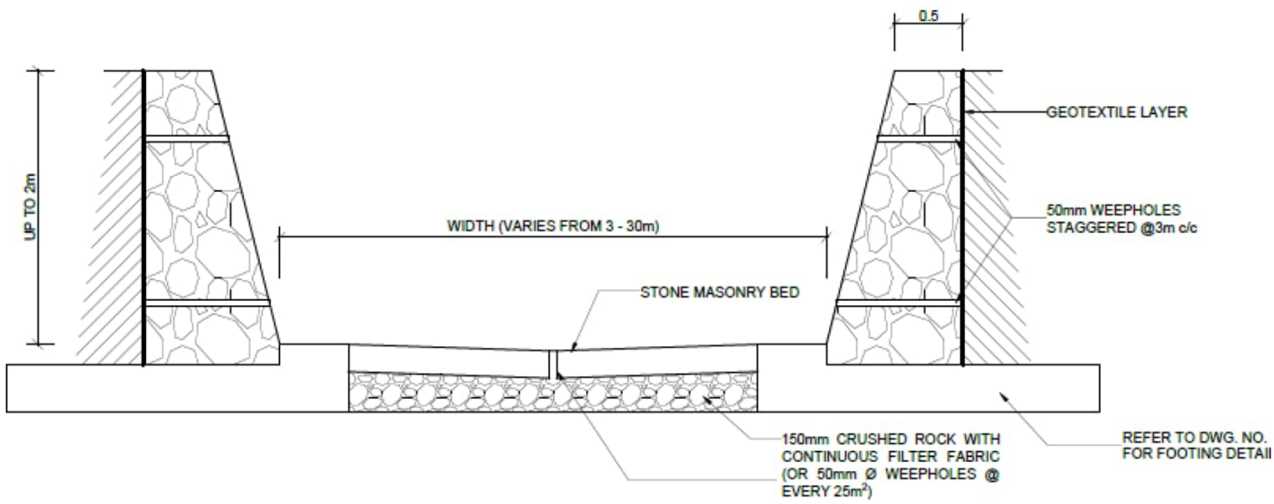


Figure 2.84: Trapezoidal Channel Section

Source: Kampala Drainage Masterplan 2016

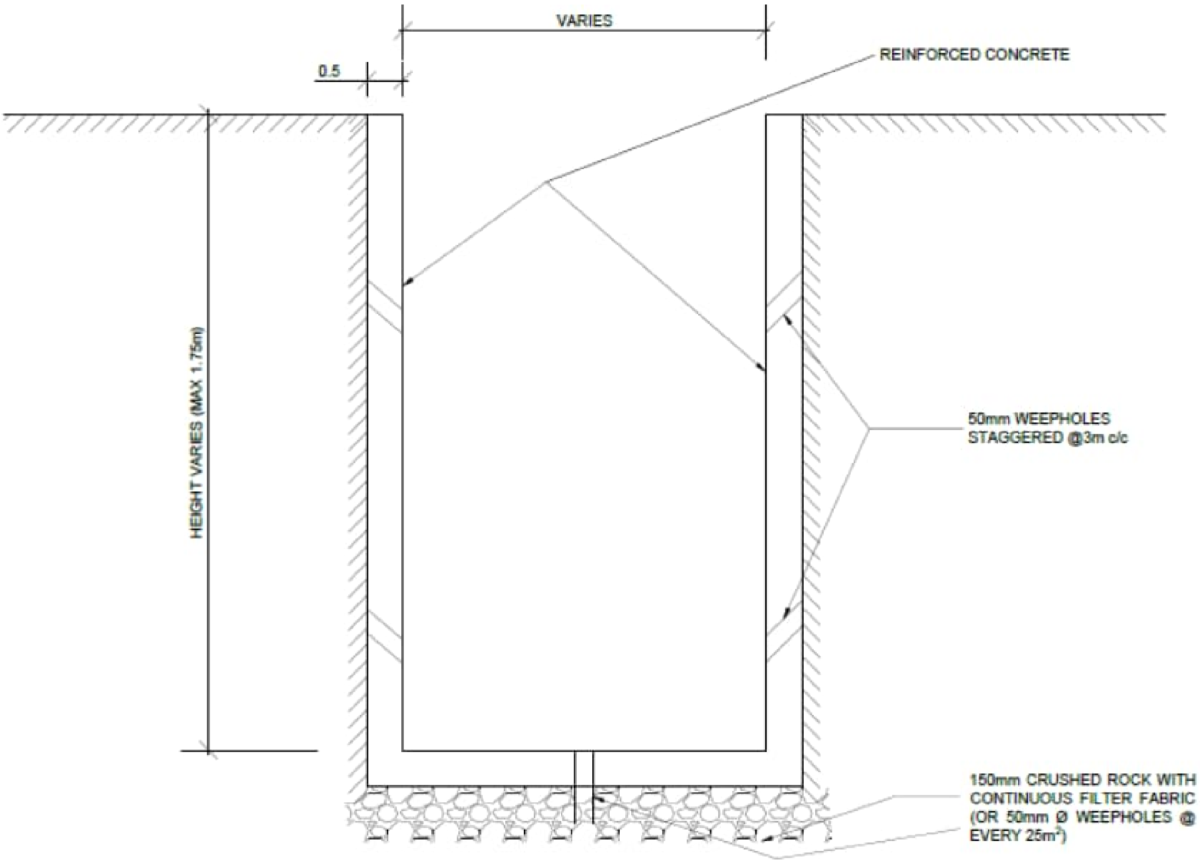


Figure 2.85: Rectangular Channel Section
Source: Kampala Drainage Masterplan 2016

CHANNEL SLOPE

Channel bottom slopes are generally dictated by the road profile or other constraints. However, if channel stability conditions warrant, it may be feasible to adjust the channel gradient slightly to achieve a more stable condition. Channel gradients greater than 2 percent may require the use of flexible linings to maintain stability. Most flexible lining materials are suitable for protecting channel gradients of up to 10 percent, with the exception of some grasses. Linings such as riprap and wire-enclosed riprap are more suitable for protecting very steep channels with gradients in excess of 10 percent. Rigid linings, such as concrete paving, are highly susceptible to failure from structural instability due to such occurrences as overtopping, freeze thaw cycles, swelling, and excessive soil pore water pressure.

FREEBOARD

The freeboard of a channel is the vertical distance from the water surface to the top of the channel.
The importance of this factor depends on the consequence of overflow of the channel bank. At a minimum the freeboard should be sufficient to prevent waves, superelevation changes, or fluctuations in water surface from overflowing the sides. However, a steep gradient channel should have a freeboard height equal to the flow depth to compensate for the large variations in flow caused by waves, splashing, and surging. The freeboard will vary according to the importance of the road but is usually set at 250 mm for major roads and 150 mm for minor roads.

SHEAR STRESS AND PERMISSIBLE VELOCITY

By comparing the maximum applied shear stress imparted by the flow to the permissible shear stress of the lining, determines the acceptability of a given lining type. If the permissible shear stress is greater than or equal to the computed shear stress, including consideration of a safety factor, the lining is acceptable. If a lining is unacceptable, a lining with a higher permissible shear stress is selected, the discharge is reduced, or the channel geometry is modified. The general equation for maximum applied shear stress in open-channel flow is:

$$\tau_d = \gamma d S_o$$

Where:
τ_d = Shear stress in channel at max. depth, N/m^2
γ = unit weight of water, N/m^2
d = depth of flow in channel, m
S_o channel bottom slope, m/m

The equation for permissible shear stress is different for each lining material. Further details about the equations used in the channel lining design calculator are located in the following reference: Kilgore, R.T., and Cotton, G.K., September 2005, Design of Roadside Channels with Flexible Linings, Hydraulic Engineering Circular No. 15, Third Edition, FHWA-NHI-05-114, HEC 15

The minimum permissible velocity is the lowest velocity that will not cause sedimentation or siltation that usually occurs on the inside of bends. This velocity is uncertain because the sedimentation process depends largely on the particle size of the materials being transported during flood flows. For lined surfaces a mean velocity of 0.6 to 0.9 m/s on straight sections may be used when the percentage of silt is low.

DESIGN PROCEDURE

Each project is unique, but the following six basic design steps are normally applicable to the hydraulics design of roadside channels if the channel reach is assessed as stable. To obtain the optimum roadside channel system design, it may be necessary to make several trials with various linings before a final design is achieved.

STEP 1: ESTABLISH A ROADSIDE PLAN

- Collect available site data.
- Document the existing and proposed plan-profile layout including highway, culverts, and bridges.
- Plot the locations of natural basin divides and roadside channel outlets.
- Lay out the proposed roadside channels to minimize diversion flow lengths.

STEP 2: ESTABLISH CROSS SECTION DATA

- Identify features that may restrict the cross-section design:
  - o right-of-way limits,
  - o trees or environmentally sensitive areas,
  - o utilities, and/or
  - o existing drainage facilities.
- Provide a channel depth adequate to drain the sub-base.
- Choose channel side slopes and bottom width based on the ODOT design criteria, including the consideration of safety, economics, soils, aesthetics, and access.

STEP 3. DETERMINE CHANNEL GRADE

- Plot initial longitudinal grades on plan-profile layout, including inlet and outlet considerations.
- Consider the influence of grade on type of lining.
- Where practical, avoid features that may influence or restrict grade (e.g., utility locations).
- Select final channel grade to minimize ponding and sediment accumulation.

STEP 4. CHECK FLOW CAPACITIES AND ADJUST AS NECESSARY

- Compute the design discharge at the downstream end of a channel segment
- Set preliminary values of channel size, roughness coefficient and slope.
- Determine maximum allowable depth of channel including freeboard.
- Determine Manning's Roughness Coefficient.
- If capacity is inadequate, possible adjustments are as follows:
- increase bottom width,
- make channel side slopes flatter,
- make channel slope steeper,
- provide smoother channel lining, and/or
- install drop inlets and a parallel storm drainpipe beneath the channel to supplement channel capacity.
- Provide smooth transitions at changes in channel cross section.
- Provide extra channel storage where needed to replace floodplain storage and/or to reduce peak discharge.

STEP 5. DETERMINE CHANNEL LINING/PROTECTION NEEDED

The hydraulics designer has two options for assessing the lining material:

- Option 1 - Considers only the shear stress on the lining or channel protection. This method was introduced in the mid-1970s, has substantial lining tests, and has the advantage of being easy to use.
- Option 2 - Considers both the shear stress on the liner and the shear stress on the soil being protected.

Option 1

The following procedure is based on HEC-15 (9) procedure, which considers the shear stress on the liner.

- Select a trial lining and determine the permissible shear stress τp.
- Estimate the flow depth and choose an initial Manning's n from.
- Calculate normal flow depth, yn (m), at design discharge using Manning's equation and compare with the estimated depth. If they do not agree, repeat Steps 5b and 5c.
- Compute maximum shear stress at normal depth as:

$\tau d = 62.4ynS$, where S = channel slope.

- If $\tau d < \tau p$, then lining is acceptable. Otherwise, consider the following options:
  - o choose a more resistant lining.
  - o decrease channel slope.
  - o decrease slope in combination with drop structures; and/or
  - o increase channel width and/or flatten side slopes.

Option 2

The following procedure is based on HEC-15 (2005) (10) procedure, which considers both the shear stress on the liner and the shear stress on the soil being protected.

- Determine the permissible shear stress for TRM.
- Determine n value.
- Calculate y using Manning's equation.

STEP 6. ANALYSE OUTLET POINTS AND DOWNSTREAM EFFECTS

- Identify any adverse impacts (e.g., increased flooding or erosion to downstream properties) that may result from one of the following at the channel outlet:
  - o increase or decrease in discharge,
  - o increase in velocity of flow,
  - o concentration of sheet flow,
  - o change in outlet water quality, or
  - o diversion of flow from another watershed.
- Mitigate any adverse impacts identified in Step 6(1). Possibilities include:
  - o increase capacity and/or improve lining of downstream channel.
  - o install velocity-control structures.
  - o install sedimentation/infiltration basins or control structures to provide detention of increased runoff and/or sediment; and/or
  - o install weirs or other outlet devices to redistribute concentrated channel flow; see HEC 22 (13).

2.6.6 DESIGN OF CROSS DRAINAGE STRUCTURES

GENERAL

When a pipe or other type of conduit carries stream flow under a road or railroad structure, that pipe or conduit is in a culvert situation. The location of a roadway crossing is usually governed by the location of an existing road reserve, but when circumstances allow, waterway crossings should ideally be located:

- On a straight section of the waterway
- Well downstream of sharp channel bends
- On a stable channel section

This section considers the hydraulics of conventional culverts and the requirements for selecting a culvert size for a given set of conditions. Guidelines are provided to enable the designer to make use of standard design charts adopted from AASHTO-Model Drainage Manual, as well as other relevant documents. However, the designer retains the right to deviate from the standard on the basis of well-proven and applicable state-of-the-art knowledge on the subject and with the approval of the concerned authority (MoWT). Roads passing through urban areas should generally be constructed high enough not to act as collector channels for surrounding runoff during a storm. The designer should at the same time take into account the damage that might occur as a result of a major storm. The type of drainage required should be interactive with the type of urban road.

CULVERT TYPE AND CLASS

Hydraulic performance is one of several factors which influence the selection of type of culvert for a particular Location. However, the shape and type of culvert to be used should not be determined by hydraulic performance alone. The economics and availability of different culvert types in the various regions should also be considered. The guidelines in this manual indicate the common types of culverts in use. Whenever the designer feels that other appropriate culvert types are applicable to specific local conditions, he can use his professional experience to select the appropriate type after getting the permission of the concerned urban authority.

CULVERT TYPES

Different shapes of culverts and a description of their applicability is given in the form of a table. Land use requirements can dictate a larger or different barrel geometry than required for hydraulic consideration. Arch or oval shapes are used only if required by hydraulic limitations, site characteristics, structural criteria, or environmental criteria. Refer to Figure 2.86 for the culvert shapes.

Transport and purchase costs play a major role in selecting the culvert type for a particular urban area. In evaluating the suitability of alternate materials, the selection process shall be based on a comparison of the total cost of alternate materials over the design life of the structure that is dependent upon the following:

- Durability (service life)
- Cost
- Availability
- Construction and maintenance ease
- Structural strength
- Traffic delays
- Abrasion and corrosion resistance
- Water tightness requirements

If aggregate materials are available locally, concrete is the preferred material for culvert construction.
Other materials, however, may be more appropriate for a specific location, hydraulic roughness, bedding condition, and so on. A pipe material other than concrete may be accepted as an alternate if evidence is provided that the hydraulic capacity, strength, durability, abrasion resistance, and corrosion resistance of the concrete pipe specified are equalled or exceeded. Furthermore, any substitution must be cost effective, and availability analysed.

The advantages of corrugated metal pipe sections should be considered for small to medium sized culverts and the corrugated metal multi-plated arch for larger culverts. Such culverts usually require protection from corrosion. They shall be protected at the ends by headwalls. Use of corrugated metal pipes with projecting ends is not permitted under any circumstances.

Prefabricated concrete pipe and portal units are encouraged, wherever they can be economically and practically justified. A newly developed plastic pipe with radial ribs may also be considered for the smaller range of culvert sizes.

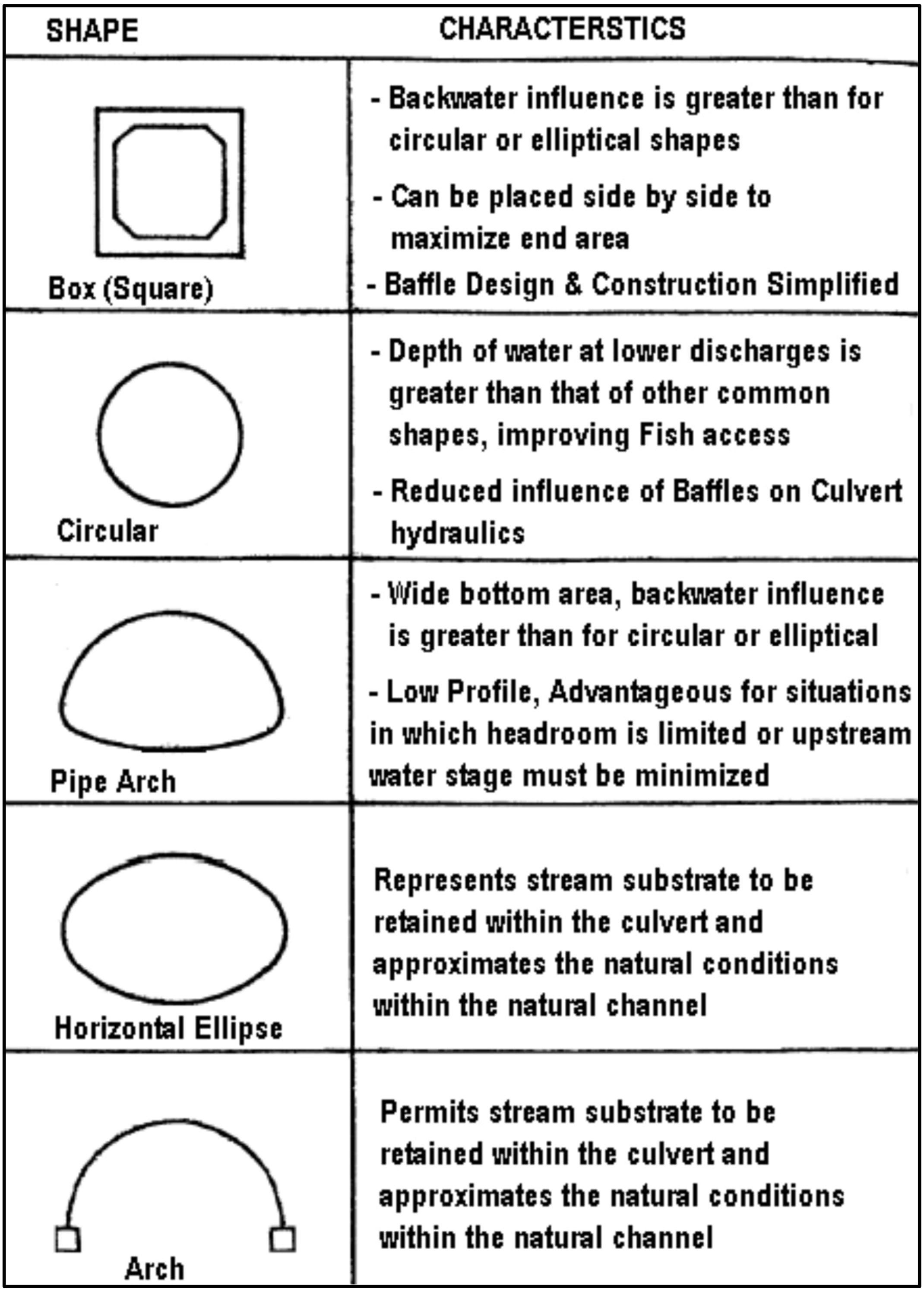


Figure 2.86: Different Shapes of Culverts
Source: Drainage Design Manual 2010

CULVERT LOADING

Culvert of whatever type will be subjected to loads. The primary loads which should be considered are as follows: self-mass, water mass, mass of backfill, traffic loads, temporary handling, and construction. These factors, individually or collectively, influence the class of culvert to be installed.

HEADWATER-DEPTH RELATIONSHIP

All culverts should be designed to carry the design frequency flood with a headwater depth that does not materially increase the size of the flooded upstream area. Allowable headwater depth is determined by the maximum permissible elevation of the headwater pool at the culvert for the design discharge. It is limited by one of the following factors:

- non-damaging to upstream property.

- below the traffic lines of interest or no higher than the shoulder or 0.5 m below the edge of the shoulder.
- equal to an Hw/D no greater than 1.2; for urban culvert.
- no greater than the low point in the road grade; and,
- equal to the elevation where flow diverts around the culvert.
- A headwater - culvert depth ratio (Hw/D) equal to 1.2 is recommended for cases where insufficient data is available to predict the flooding effect from headwater depth.

INLET AND OUTLET CONTROL

There are two types of control that can have an effect on the capacity of a culvert: inlet and outlet control. Both of these types of control must be considered in the design of culverts. It will be the designer's responsibility to verify that the backwater effect of the new culvert does not negatively affect the upstream culvert.

A culvert may flow with either inlet or outlet control over its full design discharge range. Alternatively flow through the culvert may vary with discharge from inlet to outlet control. The designer should check both inlet and outlet control to determine the governing headwater depth. The following sections are aimed to guide the designer on these issues. Control Section—the location where there is a unique relationship between the flow rate and the upstream water surface elevation. Inlet control is governed by the inlet geometry. Outlet control is governed by a combination of the culvert inlet geometry, the barrel characteristics, and the tailwater.

INLET CONTROL

Culverts flowing with inlet control usually lie on relatively steep gradients and flow only partly full. Guidance for the sizing of culverts for inlet control are adapted from publications by the U.S. Bureau of Public Roads, and from AASHTO model drainage manual.

For inlet control, the control section is at the upstream end of the barrel (the inlet). The flow passes through critical depth near the inlet and becomes shallow, high velocity (supercritical) flow in the culvert barrel. Depending on the tailwater, a hydraulic jump may occur downstream of the inlet.

Headwater depth is measured from the inlet invert of the inlet control section to the surface of the upstream pool. The inlet area is the cross-sectional area of the face of the culvert.

Generally, the inlet face area is the same as the barrel area. Inlet edge configuration describes the entrance type. Some typical inlet edge configurations include thin edge projecting, mitred edges, square edges in a headwall, and bevelled edges. Inlet shape is usually the same as the shape of the culvert barrel. Typical shapes are rectangular, circular, elliptical, and arch. It is necessary to check for additional control section if the shape of inlet is different from that of the barrel.

Flow with inlet control can be further subdivided into different flow regions depending on whether inlet is submerged or unsubmerged. Hydraulically, three regions of flow are known: unsubmerged, transition, and submerged types of flow regions.

<u>Unsubmerged</u>
For headwater below the inlet crown, the entrance operates as a weir, Figure 2.87. A weir is a flow control section where the upstream water surface elevation can be predicted for a given flow rate. The relationship between flow and water surface elevation can be determined by model tests of the weir geometry or by measuring prototype discharges.

<u>Submerged Zone</u>
For headwaters above the inlet, the culvert operates as an orifice, Figure 2.88. An orifice is an opening, submerged on the upstream side and flowing freely on the downstream side, which functions as a control section.

<u>Transition Zone</u>
The transition zone is located between the unsubmerged and the submerged flow conditions where the flow is poorly defined. This zone is approximated by plotting the unsubmerged and submerged flow equations and connecting them with a line tangential to both curves.

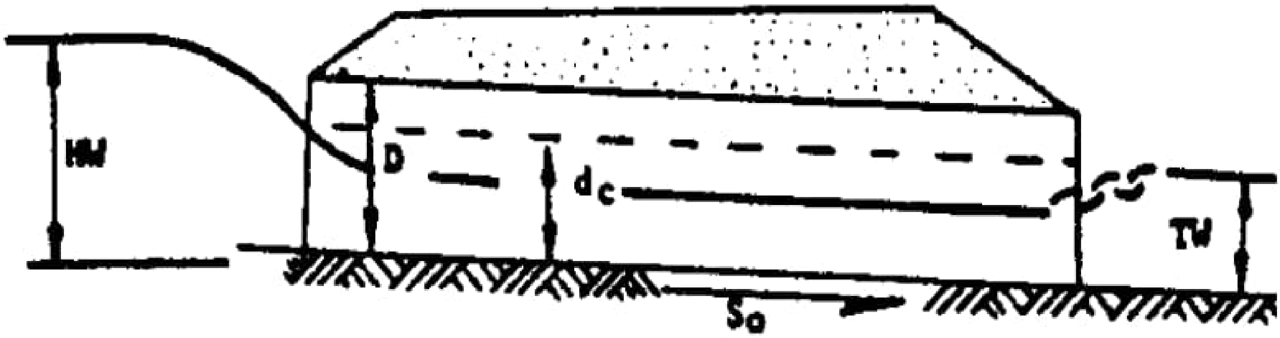


Figure 2.87: Unsubmerged Flow Inlet Control

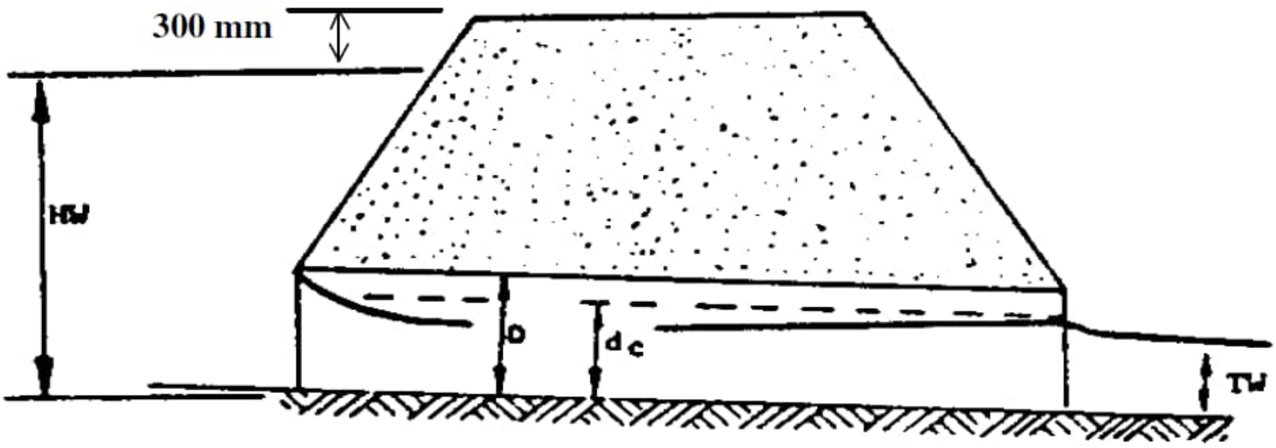


Figure 2.88: Submerged Flow Inlet Control

OUTLET CONTROL

Outlet control has depths and velocity that are subcritical. The control of the flow is at the downstream end of the culvert (the outlet). The tailwater depth is assumed to be critical depth near the culvert outlet or in the downstream channel, whichever is higher. Detailed analysis of the outlet control has been discussed in Chapter 9 of the URDM-V2 and shall be consulted during culvert design.

HYDRAULIC DESIGN PROCEDURES

The hydraulic design of culverts encompasses the different types of flow conditions discussed in the previous section. In addition, the design should satisfy the constraints given in the next sections. In general, a standard approach can be laid to guide the designer in the procedures to be followed. In cases where rigorous methods are considered unnecessary, alternative approximating methods are given.

HY-8 SOFTWARE

HY-8 is a computerized implementation of FHWA-endorsed culvert hydraulic analysis approaches and protocols. The HY-8 program is available free of charge. The FHWA has been sponsoring development of computerized culvert hydraulic software since the early 1960's (beginning with the HY-1 program).

The HY-8 culvert hydraulic analysis program has been used by engineers for decades to design new culvert crossings and analyse existing culvert crossings. HY-8 uses the methods described in FHWA's HDS-5 manual, last updated in January 2012. HY-8 performs 1-D Hydraulic analysis on culvert crossings with multiple culvert barrels. HY-8 determines if a hydraulic jump occurs and if it does, the location of the jump. HY-8 can analyse broken back culverts as well as horizontal and adversely sloped culverts. It is also used to design energy dissipation structures using methods described in FHWA's HEC-14 manual.

HEC-RAS

HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking environment. The system is comprised of a graphical user interface (GUI), separate analysis components, data storage and management capabilities, graphics, mapping and reporting facilities. The HEC-RAS system contains the following river analysis components for: (1) one dimensional steady flow water surface profile computations; (2) one-dimensional and/or two-dimensional unsteady flow simulation; (3) Quasi un-steady or fully unsteady flow movable boundary sediment transport computations (1D and 2D); and (4) one dimensional water quality analysis. A key element is that all four components use a common geometric data representation and common geometric and hydraulic computation routines. In addition to the four river analysis components, the system contains several hydraulic design features that can be invoked once the water surface profiles are computed. HEC-RAS also has an extensive spatial data integration and mapping system (HEC-RAS Mapper).

The HEC-RAS program has the ability to model multiple culverts at a single Location. The culverts can have different shapes, sizes, elevations, and loss coefficients. The user can also specify the number of identical barrels for each culvert type. Culverts can also be buried into the ground and have different roughness coefficients for the bottom, versus the top and sides.

HEC-RAS computes energy losses, caused by structures such as culverts, in three parts. The first part consists of losses that occur in the reach immediately downstream from the structure, where an expansion of flow takes place. The second part consists of losses that occur as flow travels into, through, and out of the culvert. The last part consists of losses that occur in the reach immediately upstream from the structure, where the flow is contracting towards the opening of the culvert. HEC-RAS has the ability to model single culverts; multiple identical culverts; and multiple non-identical culverts. This chapter discusses how culverts are modelled within HEC-RAS. Discussions include general modelling guidelines; how the hydraulic computations through the culvert are performed; and what data are required and how to select the various coefficients.

The culvert routines in HEC-RAS are similar to the bridge routines, except that the Federal Highway Administration's (FHWA, 1985) standard equations for culvert hydraulics are used to compute inlet control losses at the structure. The walls and roof of the culvert correspond to the abutments and low chord of the bridge, respectively. Because of the similarities between culverts and other types of bridges, culverts are modelled in a similar manner to bridges. The layout of cross sections, the use of the ineffective areas, the selection of loss coefficients, and most other aspects of bridge analysis apply to culverts as well.

PCSWMM

PCSWMM is a GIS-based decision support version of the EPA Stormwater Management Model (SWMM) developed by Computational Hydraulics International (CHI). SWMM is a dynamic rainfall-runoff (hydrologic-hydraulic) simulation model, developed by the US EPA, used for single-event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. SWMM tracks the quantity of runoff generated within each sub - catchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps (James, et al., 2010).

The SWMM5 engine is based on the 1-D Saint-Venant equations as follows:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = 0$$

$$\frac{\partial Q}{\partial t} + \frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right) + gA\frac{\partial H}{\partial x} + gAS_f + gAh_L = 0$$

where Q, H, and A denote the flow rate, hydraulic head, and cross-sectional area, respectively; g is the gravitational acceleration; S_f is the friction slope; and h_L is the local energy loss per unit length. The continuity and momentum equations (as shown in Equations (1) and (2), respectively) are solved by the finite difference method with successive approximations (James, Rossman, & James, 2010).

Various modules in PCSWMM: rainfall-runoff and flow routing process models, can be selected for hydrological and hydraulic modelling, respectively. Figure 2.89 shows the parameters required for a

PCSWMM model. Four input layers, including the sub-catchments, junctions, conduits, and outfalls, play an essential role in the flood simulations. The model area is first divided into sub-catchments using the catchment delineation tool in ArcGIS and the imported into PCSWMM. For hydrologic analysis, each sub-catchment is assigned with the hydrology input parameters, such as area, flow length, slope, and imperviousness.

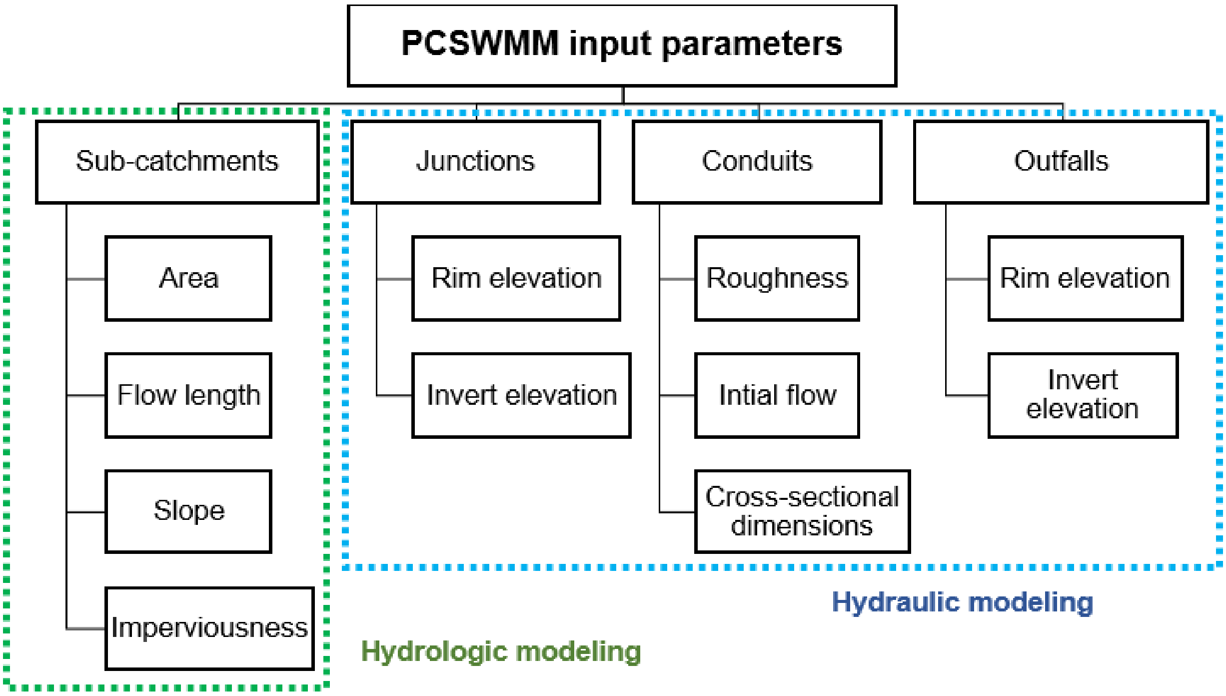


Figure 2.89: Input parameters used in PCSWMM for Stormwater Drainage

The particular loss calculation method is adopted in the development of the hydrological model. Its related parameters are inferred from the land use DEM of the particular project area following the guidance of the Kampala drainage master plan (KCCA, 2016) and the Road Drainage Design Manual (MOWT, 2010).

The runoff generated from each sub-catchment subsequently enters a junction, usually a manhole structure, exits through a single conduit, representing any water conveyance channel, and finally flows into an outfall point. This process is referred to as hydraulic simulations, in which a flood routing model can be chosen. The required parameters of the rim (surface) and invert elevations for each junction and outfall can be assigned based on the survey data obtained from the field.

FREEBOARD REQUIREMENTS

Drainage structure should be sized such that the headwater elevation resulting from the design discharge is somewhat lower than the road shoulder break point at the low point in the road. This difference in level is referred to as the freeboard. The freeboard will vary according to the importance of the road but is usually set at 250 mm for major roads and 100 mm for minor roads.

The design flood could be permitted to discharge over the road up to a depth of 200 mm but only if approved by the Engineer-in-Chief. Low points should be localised and the road graded level over them so as to minimize scour damage caused by overtopping. Wherever possible dips in the road grading on low class roads should be located at watercourse crossings where the deck slabs of concrete box culverts could be used as the riding surface of the roadway. Scour damage would then be localised and minimised.

LIMITATIONS ON OUTLET VELOCITY

A culvert, because of its hydraulic characteristics, generally increases the velocity of flow above that in the natural channel. High velocities are critical immediately downstream of the culvert outlet and the scour potential from the resulting energy is a factor to be considered in culvert design.

Culverts should be laid to grades that produce a non-silting or a non-erosive velocity, ideally between 1.00 m/s and 3.5m/s. This is particularly important in the sandy, Semi-Arid regions which experience sporadic high intensity cloudbursts. Maximum permissible velocities in erodible ditches and corresponding roughness coefficients are given in Table 2.56.

Table 2.56: Manning's value for culverts
Source: FHWA Hydraulic design of highway culverts, 2012

Type of Culvert	Roughness or Corrugation	Manning's n	Reference
Concrete Pipe	Smooth	0.010-0.011	Straub et al. 1960 May et al. 1986 Tullis 1986 & 1991a
Concrete Boxes	Smooth	0.012-0.015	FHWA 1961
Spiral Rib Metal Pipe	Smooth	0.012-0.013	Tullis 1983 & 1991b
Corrugated Metal Pipe[2] (Helical Corrugations)	2-2/3 by 1/2 in 68 by 13 mm	0.011-0.023	FHWA 1980 Tullis 1991c
Corrugated Metal Pipe[2] (Helical Corrugations)	6 by 1 in 150 by 25 mm	0.022-0.025	FHWA 1980
Corrugated Metal Pipe[2], Pipe-Arch and Box (Annular Corrugations)	2-2/3 by 1/2 in 68 by 13 mm	0.022-0.027	FHWA 1980
Corrugated Metal Pipe[2], Pipe-Arch and Box (Annular Corrugations)	5 by 1 in 125 by 25 mm	0.025-0.026	FHWA 1980
Corrugated Metal Pipe[2], Pipe-Arch and Box (Annular Corrugations)	3 by 1 in 75 by 25 mm	0.027-0.028	FHWA 1980
Corrugated Metal Structural Plate[2] (Annular Corrugations)	6 by 2 in 150 by 50 mm	0.033-0.035	FHWA 1980
Corrugated Metal Structural Plate[2] (Annular Corrugations)	9 by 2-1/2 in 230 by 64 mm	0.033-0.037	FHWA 1980
Corrugated Polyethylene	Smooth	0.009-0.015	Barfuss & Tullis 1988 Tullis et al. 1990
Corrugated Polyethylene	Corrugated	0.018-0.025	Clyde 1980 USBR 1985
Polyvinyl chloride (PVC)	Smooth	0.009-0.011	Neale and Price 1964 Bishop and Jeppson 1975

CULVERT ALIGNMENT

In general, a culvert should be installed parallel to the natural watercourse. The culvert, on the other hand, should be straight between the inlet and outlet. This may necessitate some changes to the natural environment. Where natural conditions necessitate skewed alignments, a lower degree of skew angle should be investigated in order to shorten the culvert and save money. Without the approval of the local urban authority, the culvert skew shall not exceed 45° as measured from a line perpendicular to the roadway centreline. Any associated channel relocations should be done with caution, as they may have an adverse effect on the culvert's hydraulic performance. Unless downstream scour poses a serious problem, the culvert's inlet should be placed in the natural watercourse.

Culvert outlet velocity is one of the primary indicators of erosion potential. Outlet velocities are seldom less than 3.05 m/s and range up to 9 m/s for culverts on small or mild slopes and can exceed this for culverts on steep slopes. Under these conditions, it is reasonable to investigate measures to modify or reduce velocity within the culvert before considering an energy dissipator. Several possibilities exist, but the degree of velocity reduction is, in most cases limited and must always be weighed against the increased costs which are generally involved.

The continuity equation Q =AV can be utilized in all situations to compute culvert velocities, either within the barrel or at the outlet. Since discharge will generally be known from culvert design, determining the flow area will define the velocity.

Minimum gradient:
Gradients less than 0.5 percent should never be considered for culvert installation.
Steep gradient:
Culverts must be installed with a maximum of 10%. For any grade above 10%, strapping must be considered.

Minimum culvert size:

Minimum sizes of culverts shall be 450 for minor roads, 900 mm for major roads for cross culverts.

END STRUCTURES

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.

In the higher-class roads, the design and type of inlet and outlet structures should be aimed at providing a balance between hydraulic performance and cost. In the lower-class roads, the emphasis should be on the cost saving aspect. Unless hydraulic or other considerations require special end structures, the least expensive type of end structure should be adopted throughout the project for continuity. The type, purpose and choice of the end structure of culverts as described in the URDM, 2010 chapter 9 shall be adopted for use in the urban road drainage designs.

SCOURING PROTECTION

Effects on Culverts
Unchecked erosion is a prime cause of culvert failure. The greatest scour potential is at the culvert outlet where high velocities may necessitate scour protection or energy dissipation. Road embankments that are designed to be overtopped in a flood should also be protected against scour, if this is deemed desirable.

Effects at Bridge Sites
The need for scour protection can be minimized by locating bridges on stable tangential reaches of rivers and by placing foundations on non-erodible materials. However, such a solution is not always practicable, economic or desirable from the road alignment standpoint.

In such cases the designer is reminded to check for local scour at bridge sites, which is caused by macro-turbulence resulting from the concentration of energy. Potential scour around piers and abutments should also be checked and allowed for if necessary. Where scour around the abutments of major bridges is likely to be a serious problem, particularly where the bridge is sited in a wide flood plain, consideration should be given to the allowance of guide banks or spur dykes. Before finally fixing the level of the pier and abutment foundation footings, consideration should be given to the possible shifting of the river channel during a flood.

Protection of Culverts Against Scour

Scour can be eliminated by the effective use of:
- gabion mattresses.

- hand placed or dumped rip-rap.
- stone pitching (plain or grouted).
- concrete (in-situ or interlocking blocks).
- cut-off walls at the culvert exit.

Embankments and training works should always be protected against undermining. The choice of protection to be used should be determined by materials availability and cost at the site.

TOPOGRAPHIC SURVEY REQUIREMENTS

The hydraulic design of culverts or bridge openings should be carried out using the procedure described in this and the next section respectively, calling to organize the topographic surveys as the first step of coherent data collection. Topographic survey activity consists of performing detailed ground survey along the entire established alignment of the roadway opening. Surveys information should be collected for river profile at the culvert or bridge site and also for the cross-section of the opening. It is recommendable to conduct detailed survey operations including cross sections, stream alignment centre line on different sections to be determined by the designer.

Wherever available the coordinates should be recorded automatically using total station theodolites. Total stations enable to carry out the whole topographic survey by recording all data directly into electronic data recording books, which will be retrieved by a computer system for drainage design. Modern total stations are also programmed for construction stakeout and for road infrastructure surveys. Total stations have made trigonometric levels as accurate as many of the differential level techniques in areas possessing large relief landforms.

If the RTK -GPS machine is not available, a total station or any other non-digital theodolites may be used. The question of field notes is an important issue. Based on availability of facilities, field notes can be kept, or data collector may be used to replace field notes with an electronic field book.

2.7 CHAPTER 7: DESIGN OF ROAD BRIDGES

2.7.1 INTRODUCTION

Bridges are defined as structures that transport traffic over waterways or other obstructions; and part of a stream crossing system that includes the approach roadway over the flood plain, relief openings, and the bridge structure. Proper hydraulic analysis and design is as vital as the structural design. Stream crossing systems shall be designed for minimum cost, to the desired level of hydraulic performance up to an acceptable risk level, and to mitigate impacts on stream environment.

The goal is to provide guidance on the hydraulic design of a stream crossing system through appropriate policy, design, and technical criteria. The design principles, design criteria, investigation, and design procedures, scour and aggradation for bridges on urban roads as well as the natural armouring, river training and stabilization shall be adopted as stipulated in the URDM, 2010 Chapter 10 for bridge design.

The MOWT Road Design Manual Volume IV: Bridge Design, dated January 2010, is part of the series of Engineering Specifications, Standards, Manuals and Guidelines issued by the Engineer-in-Chief of the MOWT. These must be referenced for all urban road bridge designs.

2.7.2 GENERAL NOTES

The specifications for loads in Bridge Design Manual (Vol. IV) should be is read in conjunction with the other part of British Standard BS 5400, which covers the design, material and workmanship of steel, concrete and composite bridges.

It should be noted that although the Bridge Design Manual (Vol. IV) refers to highways and highway bridges in the context of the United Kingdom naming of roads, the road classes of the URDM are subject to the same design standards.

Wind and temperature effects in the Bridge Design Manual relates to conditions prevailing in the United Kingdom and Eire.

When bridge designs are undertaken, the requirements of BS 5400 state that the relevant Uganda data must be adopted.

The Manual includes the following local data of Uganda:

- Wind intensity per region
- Seismic map of Uganda

2.8 CHAPTER 8: ENVIRONMENTAL AND SOCIAL STANDARDS

2.8.1 INTRODUCTION

The quality of the urban environment is to a large extent influenced by the design, construction, and maintenance of roads. A well-developed road network will not only promote faster and safe mobility, seamless economic activity and social interaction but will further serve to promote ecosystem health and social integration and cohesion.

2.8.2 ENVIRONMENTAL AND SOCIAL DESIGN PRINCIPLES

Environment and social design principles are the basic tenets that will anchor the development of roads in urban areas. These basic tenets are intended to guide Urban Authorities, design teams and contractors on urban roads to operate within the National Environment regulatory regime and Good International Industry Practices (GIIP), with the aim of promoting urban sustainability.

2.8.3 COMPLIANCE WITH NATIONAL ENVIRONMENT POLICIES, LAWS AND REGULATIONS

Urban road development and maintenance shall be undertaken in close reference to existing Environmental and associated policies, laws, regulations, and guidelines. Specific reference shall be made to the National Environment Policy (1994), The National Environment Health Policy (2010), The National Policy on Conservation and Management of Wetland Resources (1995), Uganda Forestry Policy (2001) among other policies. Observation of the following key pieces of legislation shall also be made: The Constitution of the Republic of Uganda, 1995, The National Environment Act No 5 of 2019, The Physical Planning Act, 2010, The Uganda Wildlife Act, Cap 200, 2000 and The Historical Monuments Act, 1968 among other relevant laws.

DESIGN GUIDELINES

- Review applicable National Development Plans and other planning document as applicable to road design and construction activity
- Review National Environment Act N0 5 of 2019 and apply to road design and/or construction activity
- Apply National Environment (Environment and Social Assessment) Regulations 2020.

2.8.4 THE ESHS MANAGEMENT STRATEGIES AND IMPLEMENTATION PLAN (ESHS – MSIP)

These are strategies and plans that describe in detail the actions to manage key ESHS risks that may arise from mobilization or construction phases, and they relate to workers, materials, equipment, management processes etc. These risks may include traffic impacts on the community, pollution of drinking water, dumping waste on private land, impacts on rare species etc. The key ESHS risks to be addressed by the Bidders should be identified in ESIA reports, Resettlement Action Plan (RAP), Environment and Social Management Plans/ project Briefs, (ESMP/PB), Regulatory Authority conditions attached to any permits or approvals of the project.

The Bidder shall submit at least four (4) Management Strategies and Implementation Plans (MSIP) to manage the key Environmental, Social, Health and Safety (ESHS) risks identified. The ESHS-MSIP may differ according to the project and the location. The ESHS –MSIP may include but not limited to the following:

- Regulatory Compliance Plan to ensure that all regulatory requirements – both pre-construction and during construction are met;
- Campsite management plan to ensure that all ESHS risks in the campsite are met;
- On-site works management plan to ensure that all on-site risks are addressed;
- Borrow area management plan to ensure that risks associated with opening, operating and closing the borrow areas are addressed;
- Quarry management plan that includes the operating licenses of the quarry from where the material is sourced;

- Traffic management plan to ensure community safety from construction traffic; and
- Labour recruitment and management plan.

Note: the Contractor shall be required to submit for approval, and subsequently implement, the Contractor's Environment and Social Management Plan (C-ESMP), in accordance with the Particular Conditions of Contract, that includes the agreed Management Strategies and Implementation Plans described here.

2.8.5 ENVIRONMENT, SOCIAL, HEALTH AND SAFETY (ESHS) CODE OF CONDUCT

A satisfactory code of conduct will contain obligations on all project staff (including sub-contractors and casual laborers) that are suitable to address the following issues, as a minimum. Additional obligations may be added to respond to concerns of the region, the location and the project sector or to specific project requirements. The issues to be addressed include:

- Compliance with applicable laws, rules, and regulations of the jurisdiction
- Compliance with applicable health and safety requirements (including wearing prescribed personal protective equipment, preventing avoidable accidents and a duty to report conditions or practices that pose a safety hazard or threaten the environment)
- The use of illegal substances (for example smoking in public, use of illegal drugs)
- Non-Discrimination (for example on the basis of family status, ethnicity, race, gender, religion, language, marital status, birth, age, disability, or political conviction)
- Interactions with community members (for example to convey an attitude of respect and non-discrimination)
- Sexual harassment (for example to prohibit use of language or behaviour, in particular towards women or children, that is inappropriate, harassing, abusive, sexually provocative, demeaning or culturally inappropriate)
- Violence or exploitation (for example the prohibition of the exchange of money, employment, goods, or services for sex, including sexual favours or other forms of humiliating, degrading or exploitative behaviour)
- Protection of children (including prohibitions against abuse, defilement, or otherwise unacceptable behavior with children, limiting interactions with children, and ensuring their safety in project areas)
- Sanitation requirements (for example, to ensure workers use specified sanitary facilities provided by their employer and not open areas)
- Avoidance of conflicts of interest (such that benefits, contracts, or employment, or any sort of preferential treatment or favours, are not provided to any person with whom there is a financial, family, or personal connection)
- Respecting reasonable work instructions (including regarding environmental and social norms)
- Protection and proper use of property (for example, to prohibit theft, carelessness or waste)
- Duty to report violations of this Code
- Non retaliation against workers who report violations of the Code, if that report is made in good faith.

The Code of Conduct should be written in plain language and signed by each worker to indicate that they have:

- received a copy of the code.
- had the code explained to them.
- acknowledged that adherence to this Code of Conduct is a condition of employment; and
- understood that violations of the Code can result in serious consequences, up to and including dismissal, or referral to legal authorities.

2.8.6 ENVIRONMENT AND SOCIAL IMPACT ASSESSMENTS

OVERVIEW

The decision to develop and operate urban road infrastructure shall be guided by a comprehensive environment and social assessment process as prescribed in the National Environment Act No 5 of 2019 and The National (Environment and Social Assessment) Regulations, 2020. The responsible authority or agency shall be required to undertake an appropriate level of assessment in accordance with the Act and in consultation with the National Environment Management Authority (NEMA) and all relevant LEAD agencies. Environment and social assessments play a critical role in informing stakeholders and decision makers of the many benefits and risks/impacts of developing given road infrastructure as well as mitigation measures being proposed to promote road infrastructure sustainability. Maintenance will also the subject to appropriate levels of Environment and Social Assessment especially for material source areas.

DESIGN GUIDELINES

The agency responsible for urban road development shall undertake appropriate level of assessment as prescribed in the following legal provisions:

- National Environment Act No 5 of 2019. Relevant schedules of the act are schedule 5 and Schedule 10. Other provisions of the Act shall be observed as guided by the National Environment Authority
- The National Environment (Environment and Social Assessment) Regulations 2020. The regulations guide the conduct of assessment as prescribed in the Act.
- The National Environment (Strategic Environment Assessment) Regulations 2020

While observing the specifications and procedures elaborated in the above regulations, the agency responsible for urban road development shall by way of emphasis:

- Undertake a comprehensive Stakeholder Engagement following a well-designed Stakeholder Engagement Plan (SEP)
- Review all relevant urban development planning documents that may have a bearing on the said road development project
- Document all existing biophysical and Socioeconomic baselines including cultural heritage of the project area
- Undertake a climate change vulnerability analysis of the project area
- Identify and review urban infrastructure maps and designs
- Undertake to identify and analyse potential impacts that may accrue to the proposed road development
- Provide mitigation measures for identified negative impacts.

Refer to Volume 2, Chapter 9 for more guidance on conducting Environment and Social Impact Assessments.

2.8.7 CLIMATE PROOFING ROADS/CLIMATE SMART ROADS

OVERVIEW

Most road infrastructure is expected to have a long lifespan or service life. However, climate change will continue to increase the frequency and severity of a range of climate and weather extremes, impacting urban roads. Unpredicted excessive rainfall received over much of the country leading to higher-than-normal flash floods will continue to affect urban road construction and maintenance. Urban Authorities and other agencies with mandates/interests in urban road development should pursue climate-neutral and climate–resilient road development. This will result in “Climate Smart” roads that will be better able to resist changing weather patterns that impact the service life of the road and may experience increased flooding. Climate Smart roads are also better at providing accessibility for emergency services and an escape route for the inhabitants of an urban centre during extreme weather events.

Climate impact mitigation and adaptation shall be the basis for all road development operations.

Urban road development (design and construction) and operation shall be guided by climate risk and vulnerability analysis. Climate proofing is a cross-cutting concern that has to be mainstreamed in all spheres including pavement material choices, alignment specifications and drainage, among others.

DESIGN GUIDELINES

- Depending on the nature of urban road to be developed, the agency shall as appropriate undertake to quantify GHG emissions (Scope I, Scope II and Scope III)
- Carry out sensitivity, exposure, and vulnerability analysis on the project areas. Where appropriate national guidelines exist, they must be followed, however in the absence of appropriate guidelines, Good International Industry Practices shall be adopted (GIIPs).
- Identify significant climate change risks within the project impact area
- Assess the likelihood of occurrence and magnitude of identified climate change risks
- Undertake impact analysis to determine level of significance of impacts
- Carry out a risk assessment

- Identify adaptation options
- Appraise adaptation options
- Undertake adaptation planning
- Develop an implementation and monitoring plan for future scenarios

2.8.8 CONSERVING SENSITIVE ECOSYSTEMS AND MAINTAINING ECOLOGICAL CONNECTIVITY

OVERVIEW

Urban road development and operationalization shall take special cognizance of sensitive ecosystems (wetlands, forests, rich biodiversity sites and other areas legally protected). Road development traversing such sensitive ecosystems shall be subject to follow Environment Management Plans (EMP) drafted to guide project operations. Statutory approvals where required shall be a prerequisite as specified in The National Environment Act No 5 of 2019, The Uganda Wildlife Act, 2019 and related laws and regulations. Urban Road design should maintain and promote ecological connectivity and the conservation of biodiversity identified at such sites. For purposes of clarity, Environment Management plans and site-specific biodiversity management plans among others shall be based on exhaustive Environment and Social Impact Assessment.

DESIGN GUIDELINES

- Undertake detailed biodiversity assessment and ecological connectivity studies during the Environment and Social Impact Assessment.
- Design appropriate structures to facilitate wildlife crossing and further offer safety to humans.
- Monitor wildlife patterns to ascertain effectiveness of location and design of structures

2.8.9 WASTE MANAGEMENT

OVERVIEW

Urban roads are central in the generation and management of solid waste. Construction processes generate large amounts of spoil and construction debris among others. The main receptors of such wastes are ecologically sensitive areas especially wetlands. Planning for the management of such high-density bulky wastes is central to scheduling urban road construction. Contractors must deliberately designate waste stockpiling and reception sites and subject them to appropriate levels of Environment and Social Impact Assessment.

Operational roads are the cornerstone for an effective community waste management system. Most waste storage facilities (fixed masonry structures and movable bins) are designed to be fixed along urban roads on permanent pads or provide stations for mobile wheeled containers. Road design should ultimately make provision for such facilities to avoid bottlenecks caused by loading operations involving urban solid waste.

GUIDELINES

Management of Construction Waste

- Management of construction waste shall be guided by a comprehensive Construction Waste Management Plan (CWMP). The CWMP shall detail management objectives, scope, waste categorization (Hazardous & general waste), legal requirements, management approaches and any other procedures and actions required for the safe disposal of all wastes generated by road construction
- Identify all categories and sources of construction waste to be generated by the project and where possible compute tonnage of each category.
- Specifically identify all hazardous waste and their sources, indicating possible volumes anticipated where possible
- Design a waste minimization strategy (procurement, reuse, recycling, etc.)
- Ensure that correct handling of construction waste materials by containment, separation and storage are adhered to
- Present a NEMA licensed Waste Management firm to handle hazardous wastes
- Develop a chain of custody for handling hazardous wastes
- Identify bulk waste (Waste concrete, waste rock, spoil, topsoil, demolition rubble) receptors and undertake an appropriate level of Environment and Social Impact Assessment.
- Design and implement training program on waste management for all categories of employees

Domestic waste generated by Workers Camps and Offices

- Minimization of materials ordered to reduce the amount of waste produced.
- Correct handling and storage of materials to prevent damage and wastage
- Co-ordinate with the site team the reuse or recycling of materials for alternative usage where possible.
- Promote minimization of energy usage on site.
- Ensure that all employees under their supervision act responsibly.
- Ensure that correct handling of waste materials by containment, separation and storage are adhered to.
- Ascertain that labelling of waste storage containers to show where to deposit specific materials has been done and appropriately.
- Ensure containers are stored safely and securely
- Ensure that disposal of waste to appropriate site with correct documentation completed.
- Ensure waste is address in method statements and risk assessments.
- Ensure that all waste storage containers are accurately labelled to show all site workers where to deposit specific materials.
- Liaise with the procurement team and input into the procurement procedure to ensure appropriate management of incoming materials and establishing of waste management contracts, and the provision of receptacles.

2.8.10 VEGETATION AND LANDSCAPE MANAGEMENT

OVERVIEW

Vegetation and landscape management are fundamental components of the urban environment serving to maintain and enhance both aesthetics and ecological processes. Urban road vegetation shall be taken to include all vegetation associated with the right of way thus roadside vegetation, decorative plantings (planter boxes and potted plants) and vegetation contained in storm water facilities. Urban Road design shall consider appropriate specifications for the establishment of vegetation to enhance liveability of urban areas while promoting road safety. Establishment of vegetation shall accord preference to indigenous and non-invasive species. A landscaping and vegetation plan shall be the basis for guiding the procedures.

GUIDELINES

- A landscaping and vegetation plan shall be the basis for guiding the process. The plan shall detail among others site description/conditions, objectives, scope, vegetation species location and procedures to be followed
- Landscaping and vegetation processes shall be subject to safety considerations at all stages.
- Plant species selection shall as much as possible follow national guidelines, preference for indigenous plant species shall be prioritized
- Invasive exotic plant species shall not be planted (consultations with local experts to identify invasive species is required).
- Plant species selection shall consider among others appropriate location and purpose for trees, shrubs, grasses etc.
- Plant species characteristics (tree height, crown size, height of branching and spread, nature of rooting (trees with buttressed should not be near pavements) shall be considered during vegetation species selection.
- Planting distances for trees and shrubs shall be determined onsite guided by a competent florist ecologist
- An assessment of site soil, drainage and slope conditions shall be used to guide species selection, planting seasons and dates, spacing, shading characteristics among other conditions.
- Application of fertilizers and any other soil improvements including compost manure shall be applied under supervision to check surface water pollution.
- All planted vegetation shall be supported until establishment by professional personnel (watering)
- All vegetative planting materials shall be procured from certified or approved (National level approval) local nursery beds.
- Planted vegetation species should not require watering after establishment
- Fruit trees and shrubs should be discouraged on busy urban roads due to safety considerations. Where they are to be established, a safety assessment shall be a requirement.

During construction, protection of trees and shrubs considered of values (either by law or scientific considerations) shall be the responsibility of the contractor and the developer (agency).

The following measures shall apply during site Preparations:

- Landscaping of sites through shaping and trimming
- Ripping of hard soil pans where they exist
- Top soiling sites where unsuitable substrate materials exist. Topsoil shall consist of fertile loamy soil, obtained from areas with good soil coverage of natural vegetation within the same ecological zone.
- Planting using the most appropriate approved planting material from an approved nursery bed.

The management of all vegetation established shall be in accordance with the General Specifications for Roads and bridges of the Ministry of works. Consultations with local professionals will be undertaken to provide contextual management advice.

2.8.11 HABITAT RESTORATION

OVERVIEW

Construction site restoration is a good practice that mitigates road construction environmental footprint and promotes eco-sustainability. Where roads traverse sensitive ecosystems, a biodiversity assessment shall be a prerequisite during the Environment and Social Impact Assessment procedure. Restoration shall be guided by a restoration plan drafted prior of construction commissioning and updated throughout the active construction phase. Material source areas shall also be considered for restoration as they may not be in the vicinity of the project. They still constitute an impact area.

DESIGN GUIDELINES

- Draft a site Restoration Plan to guide site restoration process
- All sites disturbed during construction shall be mapped
- Soil restoration shall follow the following:
  - o The contractor should undertake to removal all construction facilities and materials from site, cleaning up of any remaining oil or other spills and removal of all construction waste from site.
  - o Steep cut surfaces 1h:1.5v will be properly stabilized to prevent erosion.
  - o Disturbed areas will be shaped to blend with the surrounding landscape.
  - o Topsoil shall be placed on all disturbed areas (minimum depth 150 mm).
  - o All slopes shall be protected to reduce soil erosion that could potentially block storm water channels.

LANDSCAPING AND PREPARATION FOR RESTORATION OF VEGETATION

Construction sites will require landscaping on completion. The following will be done:

- A site landscaping and vegetation restoration plan shall be drafted and approved by the Consulting Team
- The entire site shall be reshaped by cutting and refilling and compacted so as to follow the contours of the surrounding landscape.
- Topsoil initially removed will be spread on the subsoil during shaping operations.
- In areas where a crust has formed on the soil before re-vegetation is commenced, the crust will be loosened by scarifying to an appropriate depth
- Topsoil will be replaced at a minimum uniform depth of 100 mm.
- Appropriate planting material for a recommended indigenous species will be planted an appropriate spacing to be determined on site. Guidance from an ecologist will be sought
- Suitable mulch should be applied to protect the planted area from erosion. Material used for mulching should not be dry and not in advanced state of decomposition.
- Mulch should be anchored and applied to a depth and density that will prevent erosion by wind and water.
- Re-vegetated areas will be screened off with an appropriate erected safety barrier to prevent trampling and any other factors that might cause erosion or compaction. No road building equipment, trucks or other heavy equipment will be permitted onto re-vegetated areas.
- Temporary and permanent drainage protection will be installed prior to the institution of the re-vegetation process
- Appropriate temporary and/or permanent drainage protection will be installed prior to the institution of the re-vegetation process.
- Replanting shall as much as possible use plant species that were present on site before clearing. These should be replaced in soil and

slope conditions similar to those from which they were originally removed.

- All replanted sites shall be monitored and maintained following a plan that shall be drafted prior to commencement of restoration. The maintenance program will include monitoring of the success of plant germination, growth, removal of invasive weeds, replanting of areas where re-vegetation has not been successful. Further maintenance will involve repair of any runnels or erosion channels.

Restoration of Stockpile areas

- All remnant stockpiles of aggregate, fines, sand etc. shall be removed from site
- The site shall be inspected to assess the level of compaction
- Where compaction has occurred, ripping will be undertaken
- Re-vegetation shall be carried out following the process described above

Restoration of Camp and Equipment yard areas

Camp and equipment yard restoration shall be guided by an approved Decommissioning and Restoration Plan. The following procedures shall be followed:

- Concrete and compacted earth platforms.
- Removal of fuel storage tanks.
- Removal of temporary ablutions; and
- Access roads running into and through the camps.
- Concrete platforms will be broken up and rubble taken to an appropriate waste disposal site.
- The exposed surface will be checked for contaminants and if any is found, the contaminated soil will be removed along with the concrete to the waste disposal site.
- Contaminated soil in the compacted earth platforms will be removed according to the method described above.
- All temporary ablutions will be removed from site on dismantling of the construction camp.
- Compacted and un-compacted earth platforms, as well as temporary access roads required during construction, will be rehabilitated according to the prescribed rehabilitation and re-vegetation method.
- Re-vegetation will then be undertaken

2.8.12 AMBIENT AIR QUALITY, NOISE AND COMMUNITY HEALTH

OVERVIEW

Urban road transport modernization is the goal of many urban authorities in developing countries as residents move towards acquisition of private automobiles. Numerous road construction, upgrade, rehabilitation, or maintenance projects characterize cities all the time. These ever-present activities together with urban traffic are responsible for much of the reduced urban air quality. The most common air pollutants resulting from vehicular traffic (PM10, PM2.5, O3, NOx, CO and SO2) are known to have detrimental health impacts and can cause damage to assets.

Design strategies that reduce emissions and noise are considered more sustainable as they not only reduce direct impacts on community health but moderate ecological processes. Reference to the National Environment Act No5 of 2019, the Draft National Air Quality Standards, 2006, The National Environment (Noise Standards and Control) regulations 2003 shall guide the development of ambient air quality and noise management strategy.

DESIGN GUIDELINES

- Air quality and noise assessment shall be undertaken as part of the ESIA following prescribed procedures as contained in the National Environment Act No5 of 2019 and The National Environment (Environment and Social Assessment) regulations and Draft Ambient Air quality guidelines.
- Air quality assessment shall consider national guidelines and Good International Industry Practices during calculations and field measurements for air quality.
- Determine the area of assessment following conventional methodologies for air quality assessment. Professional judgment should be exercised. On a new road proposal, for example, the initial approach might be to constrain the assessment area to the road corridor plus, say, two or three rows of houses on either side of that corridor. However, community interests and future complaints may require expanding the area beyond the road corridor.
- Assessment should Identify all sensitive receptors (dwellings, settlements, education facilities, health facilities, future settlement areas

etc) along the proposed road and determine duration and form of exposure. Distance from the last lane should guide planning and design

- Assessment of exposure duration of identified sensitive receptors including humans shall be undertaken
- Air quality assessment on any road or road section shall consider key variables including (traffic composition and volumes, vehicle speeds, road gradients, congestion, air movement and dispersion conditions, predicted air quality, receptors relative to each road and development approval conditions.
- Site selection for measurements shall follow appropriate sampling procedure to select representative sites in each category of land use. Cluster sampling procedures may be used or any other that improves the probability of obtaining realistic sampled sites. Overall, the guiding principle of site selection is to ensure that there is full spatial coverage of all potential air quality sensitive receptors along the road.
- Weather conditions shall be monitored and measured locally in conjunction with the traffic air quality measurements. Particular attention shall be given to wind speed and direction, atmospheric stability, solar radiation, and rain periods. In addition, the location of the weather station shall be documented.
- Identification of air pollution from sources other than road traffic (e.g., industry, agriculture, rail, and aircraft) shall be undertaken during air quality assessments
- Construction emissions shall be estimated using appropriate methods which shall be explained before application
- Where deemed necessary, the assessor shall be required to acquire road and traffic data for each sensitive receiver for the proposed road. The information required here includes information on factors such as traffic volumes (hourly and daily), traffic compositions (usually expressed as the percentage of heavy vehicles in the traffic), traffic speeds, speed limits, traffic growth rates and road type.
- Where deemed necessary the assessor may acquire the road geometry and terrain data where necessary.
- Design air quality management measures to avoid situations that will lead to breaching air quality standards as set in the National Guidelines and Good International Industry Practices
- Draft an Air Quality Management and Monitoring Plan for the project

2.8.13 GREENHOUSE GAS EMISSIONS

OVERVIEW

Carbon emissions are a critical element of urban pollution raising multiple concerns most especially global warming and subsequent climate change. Much as this can be treated as generalized air pollution, the global nature of impacts associated with increased carbon emissions demands that particular attention is directed to crafting design strategies for carbon management in accordance with the National Environment (Management of Ozone Depleting Substances & Products) Regulations S.I. No. 48 of 2020.

DESIGN GUIDELINES

- Management of products associated with Greenhouse Gas Emissions (GHG) shall be in accordance with the National Environment (Management of Ozone Depleting Substances & Products) Regulations S.I No. 48 of 2020
- Greenhouse Gas Emissions assessment shall be undertaken as part of the Environment and Social Impact Assessment process during design of all urban roads.
- Assessment of GHG shall include direct and indirect emissions (Scope 1 direct emissions from production, scope 2 indirect emissions from consumption and scope 3 other indirect emissions).
- Where possible urban road designs shall include designated cycle lanes and pedestrian sidewalks to reduce motorised traffic and encourage cycling and walking.
- The contractor shall provide a manifest of all road construction equipment indicating their model, year of manufacture, operating hours anticipated for each equipment
- Ensure all equipment is services on schedule and service tags displayed on the said equipment
- Design measures to reduce traffic congestion and improve flows including synchronised signalled junctions and electronic tolling where appropriate.
- Design roads for public transport and discourage private cars.

2.8.14 RUNOFF MANAGEMENT, STORM WATER QUALITY AND POLLUTION OF SURFACE WATER

OVERVIEW

Development and maintenance of urban road networks is closely related to runoff generation, storm water quality and pollution levels in nearby surface water courses. Urban roads serve as effective trapping surfaces, delivering high volumes of runoff to surface streams and lakes. Runoff is either directly discharged by road drains into surface water or via a network of drains and gullies designed to channel runoff to streams transporting high quantities of sediments and other pollutants. Non-point source pollution in urban environment is therefore highly associated with roads which serve to deliver increased volumes of contaminated runoff and do it faster helping to modify stream channel characteristics. Urban Road design has to consider hydro-modification with the following key concerns:

- Pollutant generation and transportation
- Habitat degradation and loss
- Species loss
- Streambank slope stability
- Erosion of channels or changes in flow path of streams
- Flooding

Design projects are required to apply Low Impact Development flow control methods (infiltration, evaporation, transpiration, dispersion, interception, storage, and release).

In terms of storm water quality, the most common type of pollutants contained in road runoff are Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), Heavy metals, hydrocarbons, and pathogens. Runoff management strategies will also serve to mitigate non-point source pollution.

DESIGN GUIDELINES

- The design team shall develop a Storm Water Management Plan based on Good International Industry Practices for flow control
- Design storm water road drainage infrastructure of specifications to hold high peak volume discharge generated by the road surface and adjacent trapping surfaces
- Preserve as much natural vegetation within the ROW as possible to check erosion and improve infiltration. Consider introducing grassed medians where possible.
- Compact soils to a level which allows infiltration to reduce runoff and subsequent erosion
- Protect drainage channel embankments using appropriate methods
- Design and specify drainage structure de-siltation program indicating periods for mandatory de-siltation
- Where deemed necessary, the hydrological assessment shall recommend construction of infiltration structures as appropriate
- Encourage water harvesting within the road watershed to reduce discharge reaching the ROW.
- Methods Statements shall be drafted for approval before commencement of any works to ensure that work methods have minimum interference with water courses and further that accidental spills are properly managed.
- Excavations will be preceded by identification of a stockpile area suitable for generated spoil which will be used in recovery processes after construction works have ceased. Stockpiles will be designed to conform to regulations as contained in the National Environment Act No 5 of 2109, the National Environment (Environment and Social Assessment) regulations 2020 among others.
- To reduce the footprint area in wetlands, work platforms will be created for heavy earth moving equipment.
- Work in wetlands will be restricted to the drier months of the year wherever possible
- All surface run-off from both approach sides of main drainage infrastructure will be diverted diagonally across the road at 30-60m intervals and discharged down slope from a distance appropriate to the size of the channel.
- Down-slope discharge will be protected by stone pitching until a point where the velocity of the run-off has been dissipated to such an extent that no erosion will occur.
- Diversion will be protected using a combination of rocks and sandbags. These will be of appropriate specifications such that they cannot be transported during peak flow.
- Care shall be taken during excavation; to minimize the amount of material spilt into the watercourses should such a water course be flowing. Material that is spilt into water shall be recovered to the satisfaction of the RE

- Cofferdams shall be constructed to avoid spillage of construction materials into the surface water courses.
- Material stockpiles and staging areas will be located at least 100m from surface water and commercial areas.
- All materials used for construction will be prepared off –site where contamination risk is high especially involving hazardous materials.
- Created slopes along the embankments will be stabilized and grassed or stone pitched. This will entail construction of proper erosion control measures such as gabions, stepped energy dissipaters, rip-rap among others, whichever will be deemed appropriate.
- During backfilling, temporary buffers will be erected to limit the amount of material spilt into the any water course.
- Any runnels or erosion channels developing during the construction period will be backfilled and consolidated immediately and the area restored to the proper condition.
- All erosion damage will be repaired as soon as possible. Displaced topsoil shall be replaced.
- A site spillage control plan will be drafted to aid emergence operations.

2.8.15 ENVIRONMENT MANAGEMENT SYSTEM

Firms or agencies awarded contracts or sub-contracted on road construction, maintenance or any form of management action shall be required to have a documented Environment Management System (EMS). The EMS must be designed to reflect all requirements as contained in the National Environment Act No 5 of 2019 and other laws and regulations of Uganda. As a minimum, the EMS shall meet ISO 14001 requirements and shall be subject to reviews as stipulated in ISO 14001 in any case every 3 years or whenever a statutory audit is demanded by the National Environment Authority or any other mandated agency.

2.8.16 SOCIAL PRINCIPLES

Road design and development should be guided by social principles that promote social integration, easy mobility, and community resilience. Urban road development projects ought to be flexible addressing local community realities and contexts.

2.8.17 UNIVERSAL ACCESS

All people have a right to access urban road transport infrastructure irrespective of their circumstances. Universal access requires that as many people as possible can use urban roads regardless of age or ability. Urban roads and roads should be designed facilitate access by mobility enhancement devices for particular groups of persons with disabilities. The Constitution of the Republic of Uganda, 1995 recognizes the right of access for all people and the National Policy on Disability 2006 guides on enhancement of facilities to enforce a barrier free and disability friendly environment.

2.8.18 GENDER SENSITIVE DESIGNS

Urban road design must improve safety, security and overall user experience by women and girls. The network and its design ought to make it easy for females to walk, cycle or use public transport at any time of the day. Women and girls have their own gender skewed expectations and requirements on a road for example lighting greatly enhances their safety as do the location and management of toileting facilities.

The assumption that men and women benefit equally from urban road improvements is misguided. Failure to provide gender sensitive design may render new urban road developments a risk to women and girls. Dark subways and poorly designed pedestrian bridges may increase the risk of gender-based violence.

2.8.19 STAKEHOLDER INVOLVEMENT

Planning and design of urban roads requires an inclusive approach that considers the views concerns and needs of different actors. Participatory planning aimed at empowering stakeholders during decision making is of essence for urban road development. Consultations using appropriate approaches that recognize and respect people and groups at different power scales, lifestyles and those responsible for upholding institutional mandates should be treated as key.

A well designated Stakeholder Engagement Plan will be the basis for stakeholder involvement bringing on board sectoral regulatory agencies, local government authorities, non-state advocacy actors and the local communities who are the ultimate beneficiaries.

2.8.20 SUPPORT INFORMAL LIVELIHOODS PURSUED BY URBAN VULNERABLE GROUPS

Urban roads support livelihoods of the very vulnerable urban groups. Road vending is common throughout cities of the developing world, providing essential goods and services to urban dwellers. Urban unemployed youth and women normally begin their entrepreneurial careers on roads before venturing into formal commercial businesses. Roads are incubation centres where skills are gained, and enduring support networks built. Where organized, the physical presence of road vendor serves to provide an extra layer of security as they strive to attract and retain clients. Urban road design should strive to accommodate vendors and not castigate them as an urban scourge interfering with road use.

2.8.21 ROAD SAFETY AND POSITIVE USER EXPERIENCE

Urban roads designs should strive to offer maximum safety and a positive user experience to all categories of city commuters. The designs should strive to achieve a balance between safety for pedestrians and cyclists and offer a positive experience for mass public transport and private vehicles. While pedestrians require designated walkways, free from traffic interference, road crossing will offer maximum usability when they are designed at grade and where vehicular traffic volume is low and vehicle speed is low.

Frequent unguided interface between pedestrians, cyclists and motor vehicles will generate high accident rates. Motorcycles (Boda-bodas) complicates urban road design. Much as they are recognized as automobiles, they must follow all traffic regulations. Motorcycle drivers may use the road in an unsafe manner such as travelling on NMT walkways. Urban Road designs should serve to deter such tendencies.

2.8.22 CULTURAL HERITAGE SITES

Cultural Heritage is a reflection and expression of a peoples constantly evolving values, beliefs, knowledge, and traditions. Cultural heritage encompasses both tangible and intangible cultural heritage. Tangible cultural heritage includes movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance.

Intangible cultural heritage includes practices, representations, expressions, knowledge, skills as well as the instruments, objects, artefacts, and cultural spaces associated with what communities and groups recognize as part of their cultural heritage, as transmitted from generation to generation and constantly recreated by them in response to their environment, their interaction with nature and their history.

Roads that service heritage sites should be designed to recognize the central role they play in shaping beliefs and community life. Heritage sites are areas of either permanent or occasional crowding depending on their functions. Design features should be commensurate with the level of functionality of the site. While frequently visited sites may require ample parking space, sites that occasionally receive visitors may not demand permanent parking slots.

2.9 CHAPTER 9: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENTS

2.9.1 INTRODUCTION

Environment and Social Impact Assessments is a tool for achieving sustainable urban development. The desire to develop ecologically resilient and socially liveable towns and cities demands that elaborate and comprehensive Environment and Social Impact Assessment is undertaken prior to any development project whether located in urban or rural areas. Environment and Social Assessment (ESIA or SEA) are now integral to any planning and development process, urban road networks included.

The Fourth and Fifth Schedules of the Act lists projects to be considered for ESIA. Schedule 4 listed projects that require Project Briefs (ESMPs) to be prepared whereas Schedule 5 lists projects for Mandatory detailed ESIA including Scoping and detailed studies. Guidelines on conducting Environment and Social Impact Assessment is provided by the National (Environment and Social Assessment) Regulations, 2020. Urban road design and construction shall without any deviations follow procedures and standards contained in the NEA No 5 of 2019 and the above regulation together with any relevant legal provisions as will be determined by the NEMA Registered Environment Practitioner. Below is a summary of procedure to be followed.

2.9.2 SCOPING

The Responsible Urban Authority shall contract the services of a competent Registers Environment Practitioner at the level of Team Leader with experience commensurate with the type of development under consideration. The TL will constitute a team of relevant consultants to undertake scoping for the ESIA. When constituting the team, the following shall be key consideration.

- A multidisciplinary team composition reflecting the principles for urban road development
- Individual experience in the field of Environment and Social Impact Assessment
- Certification of Key team members

Scoping shall be undertaken following the National (Environment and Social Assessment) Regulations, 2020. Some of the key procedures are listed below. However, the contracted consulting team shall at all times be required to follow the legal provisions as specified in legislation above. The scoping exercise has been exhaustively explained in the regulations.

- Appraisal of the proposed tentative road project design to gain insight into specification to be applied for.
- Field reconnaissance study undertaken by TL, key team members, representation of the urban Authority (Environment Officer/Natural Resource Officers etc), Engineering Design team representation and any person relevant and co-opted on the reconnaissance.
- Identification and consultation with key stakeholders (Lead Agencies, Local Governments, the Authority, Selected local opinion drivers, local residents among others
- Identification and mapping of key sensitive environment and social receptors within the project area
- Make a rapid assessment of land requirements for the proposed road development
- Undertake a preliminary risk and impact identification
- Identify possible alternatives to the project (locational, Design, scheduling etc)
- Identify a team of experts to undertake the study and develop work plans
- Draft a scoping report as per the law and appended Terms of Reference (TOR)
- Submit the scoping report to the Authority (NEMA) for review

2.9.3 ENVIRONMENT AND SOCIAL IMPACT STUDIES

The impact study is the most critical stage of the ESIA process, it entails undertaking detailed baseline studies and wider consultations to be able to identify impact both positive and negative that will accrue to the proposed road development project. The ESIA team shall undertake a series of progressive activities that will culminate in the drafting of the Environment Impact Statement to be submitted to the Authority following laid down procedures as contained the Act and regulations.

The EIA should be conducted to achieve the following:

- To identify all impacts arising from the development of urban roads
- To identify a range of mitigation measures this could reduce and mitigate the potential adverse impacts to minimal or insignificant levels
- Identify feasible project alternatives
- To identify measures that could optimise beneficial impacts
- To establish a method of monitoring and auditing environmental management practices during all phases of the improvement
- To be included in the Contractual Clauses in the construction contracts
- Financial obligations
- Party responsible for carrying out management recommendations
- Timing and duration of management actions
- Guidelines for monitoring and auditing of compliance

The ESIA team shall at all times be subject to provisions on the National Environment Act No 5 of 2019 and the National (Environment and Social Assessment) Regulations, 2020 during the ESIA study. The following are key procedures to be followed:

- Undertake extensive review the regulatory regime to guide on scope of studies
- Develop comprehensive methodologies for carrying out baselines
- Undertake detailed baseline studies following designated disciplinary methods
- Carry out extensive stakeholder consultation with all affected individuals and groups
- Identify all risks and impacts associated with the development of a given road using appropriate methods
- Evaluate significance of all identified impacts using recognised methods
- Propose mitigation measures following the mitigation hierarchy
- To analyse all possible alternatives and carry out comparative analysis of determine the most suitable choice.
- Draft an Environment and Social Management and Monitoring Plan
- Develop Environment Management Plans for selected sensitive/key impacts (Noise, air quality, OHS, Gender, erosion, storm water etc)
- Submit the Environment Impact Statement to the Authority following laid down legal procedures as contained in the National (Environment and Social Assessment) Regulations 2020

2.10 CHAPTER 10: PREPARATION OF DRAWINGS AND DESIGN REPORTS

2.10.1 DRAWING STANDARDS

The drawings listed in Table 2.57, the drawing checklist, is a standard requirement for urban road projects and should be furnished to the relevant local and national authorities for approval prior to construction.

Design changes may occur during construction, these changes must be captured on the drawings. A full set of final As-built drawings must be submitted to the relevant authorities subsequent to the completion of the works.

Table 2.57: Design drawing checklist

SN	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
1.1	**Book of Drawings**				
	Location Map				
	List of Survey controls (Primary & Secondary Benchmarks)				
	Setting Out data (centreline)				
	Stakeout Data				
	Typical Cross-sections				
	Plan and Profile drawings				
	Detailed Cross-sections – preferably at 20m intervals and alignment geometry points				
	Drainage Details				
	¾ Side drains and wing walls				
	¾ Pipe Culvert Layouts				
	¾ Culvert schedule				
	Standard Ancillary drawings:				
	¾ Road Signs				
	¾ Humps / Rumble Strips				
	¾ Road Markings				
	¾ Junction layout details				
a)	**Details to be included on Plan layout**				
i)	Plan at original scale of 1:1000 (full size drawing)				
ii)	Graphic bar scale for drawing reduction				
iii)	North Point and Gridlines with coordinates				
iv)	Position and coordinates of Primary Setting out Beacons				
v)	Position and coordinates of Secondary Setting out Beacons / Benchmarks				
vi)	Right of Way Markers				
vii)	Contours at 1.0m intervals (05m intervals in flat lands)				
viii)	Proposed centreline with Chainage numbers at 100m centres along centreline				

SN	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
ix)	Chainage mark at 20m intervals along proposed centreline				
x)	Existing road edge outline and junctions				
xi)	Proposed road edge outline and junctions				
xii)	Note guiding user to drawings showing existing and diverted Utility services				
xiii)	Markers for extent of cut and fill (tadpoles)				
xiv)	Plan shape of all buildings within the ROW and any likely to be affected by proposals				
xv)	Data boxes containing curve data for each curve including Curve number, chainage, radius, length, deflection angle, coordinates of PI, Transition lengths in and out				
xvi)	Names of Village/Settlements along route				
xvii)	Water courses crossing and adjacent to alignment if any				
b)	**Details to be included on Profile**				
i)	Line illustrating existing ground level along proposed centreline				
ii)	Line illustrating proposed finished road level along proposed centreline				
iii)	Background grid lines for levels and chainages with indicative levels at LHS				
iv)	Illustrative positions and levels of all cross culverts				
v)	Data boxes with all type, size and level details for each culvert				
vi)	Illustrative positions and levels and all bridges				
vii)	Data boxes with names and details of each bridge and reference to bridge drawings				
c)	**Details to be contained in Data boxes below Profile**				
i)	Chainage with existing ground levels on centreline at 20m intervals (min)				
ii)	Proposed finished road levels on centreline at 20m intervals				
iii)	Level difference on centreline through proposed construction works				
iv)	Lengths of all horizontal transition curves (where relevant)				
v)	Lengths and radii of all circular curves including chainages of start and finish				
vi)	Illustrative details of straight gradients and details of points of vertical intersection				
vii)	Details of start points, finish points and lengths of vertical, K values				
viii)	Details of proposed superelevation percentage including run off lengths				

SN	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
ix)	Indicator marker posts and plates for culverts and bridges				
d)	**Additional Options (alternatively on separate schedules or drawings)**				
	Roadside drainage channel details including access culverts				
	Road widening on curves and embankments				

2.10.2 THE DESIGN REPORT

A design report containing the following information should accompany the drawings:

- Details of design criteria and standards adopted in the design of the various project components.
- Details of investigations carried out, such as material investigations, etc.
- Findings of the road safety review and the environmental audit.
- Requirements for future maintenance arrangements.

2.10.3 APPROVAL OF DRAWINGS & DESIGN REPORTS

The drawings and design report for each project must be reviewed by the local authority, their Ministerial oversight (such as MOWT, USMID) and if required the funder of the Project. A record must be kept of the delegated engineers and other professionals such as environmental practitioners, and a responsibility matrix of these persons should be kept on file from the start to end of a project.

2.11 CHAPTER 11: SUMMARY

The Design Guideline assists the decision-making process of which design should be adopted in order to prepare the final design of the road features. The design standards must be used by the urban councils to plan their network, prepare estimates for the maintenance and improvements and be able to supervise the maintenance and improvement works.

The designer should have the necessary competence in terms of skills, knowledge, and experience in order to participate in the preparation of the designs. Essentially, the designer has to be in position to understand key issues involved in the preparation of the design by asking the questions provided in Table 2.58, which helps to summarise the outcomes of the design process.

Table 2.58: Summary of Questions for the Urban Roads Planner

What information does a road designer need for the standard design?	Where do I get this information from?	What are the standards used?	What is the outcome?
1. Data collection and field surveys	Data from the field and other Departments such as Mapping and Meteorological.	-	Field data
2. Design Standard Review	MoWT Design Standards MoWT URDM Standard Drawings	Urban Roads Manual Vol 2.	Draft Standard Design and Drawings
3. Selection of the designs	MoWT Design Standards, Urban Road Design Standard Drawings	Urban Road Design Manual Standard Drawings	Standard Designs
4. Environmental Impact Assessment	EIA Guidelines	EIA Standards	EIA Report
5 Schedule of Drawings and Report	MoWT Design Standards, Urban Road Design Standard Drawings	Urban Road Design Manual Standard Drawings	Standard Drawings and Report

This Chapter has provided the answers to the key design issues:

- Information source for the design process.
- Standards to be used and complied with in the design process.
- The factors to be considered when preparing road designs for Urban Road maintenance, improvements, and new road construction.
- Typical Design Standards for Urban Roads.

2.11.1 ROAD DESIGN GUIDANCE

Table 2.59 summarised the typical items required in the design of an urban road and have spaces allocated to keep track of the basic assumptions made in the design (i.e., road class, road reserve width, lane width, etc). It can be used as a guideline and should be read in conjunction with the latest version of the relevant design manuals.

Note, this table should not be seen as comprehensive, as additional items may be required depending on the complexity and extent of the road project.

Table 2.59: Typical road design items

	Item	Sub Item	Design Values	Reference
1	**Data Collection**			
1.1	Planning Information	Road Class	1 / 2 / 3 / 4 / 5 / 6 / 7	Table 2.2, Table 2.4
		Public Transport allowed?	Y / N	
		Road Reserve Width	…………. m	
		Operating Speed	……….. km/h	
1.2	Topographical Survey	Required?	Y / N	Section 2.2.2
1.4	Geotechnical Study	Required?	Y / N	Section 2.3.11
2	**Traffic Data & Analysis** *(Traffic data to be used to determine intersection geometry, number of road lanes and pavement design)*	Collect Traffic Data	Y / N	Appendix 5
		Analysis/Assessment	Y / N	Section 1.3.4
3.	**Alignment**	Design Speed	……….km/h	
		Horizontal Alignment (Curves & Straight Sections)	Design alignment to connect the start and end points, taking obstacles in item 1 into account	ROAD DESIGN MANUAL Volume 1: Geometric Design
		Vertical Alignment (Vertical Curves, Grades)		
		Climbing lanes – Warranted?	Y / N	Table 2.37
		Check Sight Lines – Acceptable?	Y / N	Table 2.26, Figure 2.51, Figure 2.52, Table 2.27, Table 2.28, Table 2.29
4.	**Cross-section design**	Verge	Y / N Width: ……….m	Section 2.3.4 & 2.3.5
		Trade	Y / N Width: ……….m	
		Walkway, planters, street furniture, street lighting	Y / N Width: ……….m	
		Public transport (bus shelters)	Y / N Width: ……….m Type:	
		Lanes	Number: ………. Width: ……….	
		Median required? BRT stations (kerb or median)?	Y / N Y / N Width: ……….m	

		Lanes	Number: ………. Width: ……….m	
		Public transport (bus shelters)	Y / N Width: ……….m Type:	
		Walkway, planters, street furniture, street lighting	Y / N Width: ……….m	
		Trade	Y / N Width: ……….m	
		Verge	Y / N Width: ……….m	
		Confirm cross section width fits within Road Reserve. (If No, revise until Yes)	Y / N	
5.	**Pavement Design**	Class of Road	1 / 2 / 3 / 4 / 5 / 6 / 7	Item 1.a
		Structural Design Period (10 -20 years)	……….. years	Section 2.2.2 / Section 2 of the Ugandan Road Design Manual Volume 3: Pavement Design Part I (MOWHC, 2005)
		Design Traffic	ESA: ……….	
		Check Material Availability	Y / N	Geotech report
		Type of Pavement		Section 2.5.5
		Subgrade Class & Strength		Section 5.1 – 5.6
		Cost benefit Analysis (Economic Validity)		Section 2.2.2
		Pavement Structural Design (choose design method)		Section 2.2.2
6.	**Road Signs & Markings**	Road Signs	Design as per manuals	Ministry of Works and Transport, The Highway Code and Traffic Signs Manual Volume 1, published by the Ministry of Works, Housing and Communication
		Road Markings	Design as per manuals	
7.	**Drainage Networks**	Confirm Legal and policy frameworks	List relevant documents:	
		Confirm Standard/s to be used	From URDM and national standards	
		Data collection: Catchment Area Existing Drainage Systems Management Objectives Storm Water masterplan Ecological Information Hydro Meteorological Data		Vol 2, Chapter 6
8.	**Services & Utilities** *(determine services to be replaced, relocated or provision made for future services*	List each current & future service and specify requirements: Electrical Potable water Sewer Traffic signals ICT/Communication/CCTV	Present: Y / N Location: ……… (retain, relocate, replace, make provision for future service such as ducts)	Vol 1, Chapter 1.1.5

9.	**Road Furniture** *(determine appropriate requirements based on class of road, need, budget)*	Pedestrian Railings Type (material), location, design (length, height, etc.)	Y / N	Vol 1, Chapter 1.1.5
		Pedestrian Crossings No. and location	Y / N	
		Guard Rails Type (material), location, design (length, height, etc.)	Y / N	
		Street Lighting Type (solar/conventional), location, design (length, height, etc.)	Y / N	
		Seating Type (material), location, design	Y / N	
		Public Transport Shelters Type (material), location, design (length, height, etc.)	Y / N	
10.	**Urban Greening** *(determine appropriate requirements based on class of road, available space, need, budget)*	Urban Greening	Required? Y / N Location: ……… Type: ……………	Vol 1, Chapter 1.1.5

2.11.2 ROAD DESIGN EXAMPLE

Table 2.60 summarised the typical process to undertake the design of a road.

Table 2.60: Typical road design example

1. Road Section Identification & Description
The first step in the process of an urban road construction project is the identification of the road section. The road section can either be the upgrade of an existing road or the implementation of a new road link. In order to illustrate the design process, a road section upgrade is described herewith. - *Please note that this road section is for illustrative purposes only and some features will be assumed to describe elements of the design process and may not be representative of the road section described below.* The road section is typically shown on a locality plan and accompanied by a description of the route, including the start point, end point and any specific inclusions/exclusions to be considered in the design.
Location: Old Port Bell Road/Spring Road from the intersection of the A109 to the intersection with Fifth Street. Suburb: Wabigalo City: Kampala Length: 2.0 km Current road type: Single carriageway with 1 lane per direction, surfaced and unsurfaced sidewalks, no street lighting and sub-surface drainage with kerb-inlets. Upgrade inclusions: Road upgrade (resurfacing), new median island of average 1.0 m wide with median opening at designated intersection and mid-block locations, replace sub-surface drains and kerbs, surface all sidewalks and implement dropped kerbs for improved pedestrian accessibility at all side road intersections, implement street lighting on one side. Upgrade exclusions: The start and end intersections are excluded from the project; they will be retained unchanged. Locality Map: 

2. Road Classification

A large number of design elements are dependent on the road class. The second step is to determine the road class and the associated design elements.

The Road Class for the road should be determined:

- Refer to Table 1.6 for the Road Classification Hierarchy

The design elements specific to each road class should be obtained from the following references:

- Road Classification Matrix, Tables 2.2 to 2.11
- Public transport provision (stops, shelter, etc), Chapter 2.3.6
- Intersection controls, Chapter 2.3.7 & 2.3.8

There are different approaches for road upgrades and new roads:

Road Upgrade:

- The existing road function will inform the road classification.
- Determine the existing Road Reserve width from cadastral information, if the available road reserve width is less than the minimum width for the specific road class, there are two options:
  1. Reduce the required road reserve by removing optional features such as trees, space for on-street vendors etc.
  2. Land expropriation to widen the road reserve.
- The new rad design elements must be tied into existing features (intersections) at either end.

New Road:

- The envisioned function of the road will inform the road classification
- Determine the required road reserve width as well as required features (i.e., public transport provision, trees, on0pstreet vending, etc.)
- It is recommended that a road reserve for a new road allow for future expansion where possible.
- Road design elements should be tied into existing features where the road ties into existing roads.

Example:

Old Port Bell Road has a Class 3 Road – Minor Arterial classification.

Existing Road Reserve width: Varies between 21.0m and 28.0m

The design elements for a Class 3 Road are as follows (From Table 2.3):

- *Class 3B (2)*
- *Ideal Road Reserve: ideal 28m, minimum 20.1m.*
  The existing road reserve meets the minimum requirements.
- *Intersection Spacing: 600m*
- *Intersection Controls allowed: Stop, Signal, Roundabout*
- *Max Speed: 50km/h*
- *Lane Width: 3.5m*
- *Public Transport: Allowed, kerb stops.*
- *NMT Facilities: Crossings at intersections, Walkways segregated from road, Bike lane segregated from road.*
- *Urban Greening: allowed, determine space available/required.*

<table>
<tr><th colspan="2">3. Data Collection</th></tr>
<tr><td colspan="2">Before the design process can start, data must be collected to inform the design.
<u>Existing Data to obtain:</u>
All available mapping
All available photography
Geological maps and reports of the areas
Rainfall records
Hydrological records
Existing traffic data including all available intersection, link and pedestrian counts
Recent contract rates for road construction
Any previous reports from earlier relevant studies
Details of all Urban and sub-Urban development plans (town and spatial planning)
<u>New data to be collected:</u>
Traffic Volumes: Traffic counts are required for two purposes, to design intersections to accommodate the traffic volumes as well as for the determination of the ADT required for the design of the pavement structure. Traffic counts should be conducted using the Traffic Count Form in Appendix 5. This data should be used to conduct a traffic study in order to design intersection layouts and lane width recommendations for the geometric design.

Topographical survey: A topographical survey of at least the full road reserve width is required. All existing features should be noted, including but not limited to pipes and cabling (including invert levels and diameters) trees and plants, all road furniture, top and bottom levels of existing kerbs, road levels on the edge and centre of the road, including contour mapping etc.</td></tr>
<tr><td>Road Upgrade:
The features of the existing road is important to note, the upgraded road should be designed to tie into the existing start and end points.
The survey should be used to check the alignment of the existing road to see if it meets the requirements in Volume 2, Chapter 4
The existing services in the area should be noted in case it is required to relocate the services.</td><td>New Road:
The survey information will be used to determine the alignment of the new road.
Features such as large trees, abandoned buildings, fences, and drainage elements should be noted for inclusion in the site clearance items of the Bill of Quantities.
The features of the tie-in points on any existing rods are important.</td></tr>
<tr><th colspan="2">4. Geometric Design</th></tr>
<tr><td colspan="2">For the geometric design, the following should be determined:
Design elements from Step 2
Design Vehicles, refer Table 2.25
Horizontal Alignment:
Sight Distance
Minimum Radii, refer Table 2.32
Refer to full geometric design guidelines in the Ministry of Works and Transport Road Design Manual: Vol. I Geometric Design, January 2010.
Vertical Alignment:
Refer to full geometric design guidelines in the Ministry of Works and Transport Road Design Manual: Vol. I Geometric Design, January 2010.</td></tr>
<tr><td>Road Upgrade:
Check new design values to existing road design elements and update</td><td>New Road:
Follow all design parameters as determined above</td></tr>
</table>

5. Intersection Design (incl. traffic control such as signalisation)
• Refer to Vol 2, Chapter 2.4.3 • For this example, the existing intersections are excluded and will be retained unchanged. Therefore, no additional design work is required.
6. Drainage Design

• Refer to Vol 2, Chapter 6 for the design considerations:
  o Data collection and surveys
  o Hydrological analysis
  o Pavement drainage design
  o Design of longitudinal and median drains
  o Design of cross-drainage structures

7. Pavement Design

• Refer to Vol 2, Chapter 2.5.2 for the design considerations.
• Undertake a Geotechnical study as noted in Chapter 2.5.3. This is critical to prevent complete and partial failures to road pavement structures. The lack of geotechnical studies, undertaken before pavement design, could pose serious risk to premature pavement failure.
• Determine type of pavement – in this example a flexible surfaced pavement is required to replace the existing flexible surfaced pavement.
• Refer to Chapter 5 - Ugandan Road Design and Construction Manual Volume V: Low Volume Sealed Roads (MOWT,2018) for detailed information on pavement materials available in Uganda.
• Pavement designs step – refer to Vol 2 Chapter 2.5.6:
  o Step 1 - Determine the class of road.
  o Step 2 - Select the structural design period and analysis period.
  o Step 3 - Estimate the design traffic.
  o Step 4 - Determine the type of pavement and material types available for the road class.
  o Step 5 - Determine the sub-grade class and strength properties.
  o Step 6 - Consider and implement all design considerations.
  o Step 7 - Determine the economic validity of the pavement design.
Step 8 - Determining the pavement structural design and thicknesses of pavement layers using an appropriate design method.

8. Street furniture consideration & design

Street lighting
• *Refer to Vol 2 Chapter 2.3.12 for the design guidelines.*
• *Lighting is required as it should be provided on at least all Class 1 to Class 4 roads in urban areas.*
• *Refer to table 2.23 for the recommended Lighting Values for Class 1 – 4 Roads (SANS 10098-1)*
 	
Street furniture
• *Refer to Vol 2 Chapter 2.3.10 for the design guidelines.*
• *In terms of the class, urban location and alignment of this road section, the following is required:*
  o Road signage & markings
  o Parking bays where required near commercial land-uses.
  o Kerbs with dropped kerbs at intersections with all side roads for universal accessibility.
  o Litter bins and seating is required.
  o Determine if the route is a public transport route, if so, consider public transport shelters on each side of the road.
 	
Urban Greening
• *Desirability of Tree Belts, Table 1.9: Desirable*
• *Tree size and right of way guidance, Figure 1.20: 19-25m Reserve = Medium Trees*
• *Tree Species, Table 1.13: Plumeria spp (Frangipani) (8m height, 8m spacing, 12m open space)*

• *Tree guard size, Table 1.10: 0.6m X 0.6m (vase shaped)* • *Minimum Clearance of Roadside Elements for Tree Planting, Table 1.11: Required for the positioning of trees only.*
9. Road Safety review
All road safety considerations should be reviewed to envisage the completed road from point of view of all road users' safety, e.g., drivers of all vehicles, cyclists and pedestrians. The review should assess the horizontal, vertical, and cross-sectional geometry, traffic signs, road marking, road lighting, other road furniture and other objects within the road corridor.
10. Environmental & Socials aspects
Refer to Vol. 2 Chapter 8: Environmental and Social Standards & Vol. 2 Chapter 9: Environmental and Social Impact assessments to determine if an ESIA is required for the project. If required, the assessment must be undertaken by a qualified environmental practitioner and the findings and recommendations of the study should be incorporated in the design, where applicable.
11. Standard Drawings & Design Report
• Refer to Vol 2 Chapter 10 for the guidelines to develop the formalise the standard drawings of all the road design elements as developed in the preceding sections. • Refer to Table 2.57 for the Design drawing checklist that must be adhered to. • The engineer must submit and obtain approval of the Design drawings and Design Report. They must be reviewed by the local authority, their Ministerial oversight (such as MOWT, USMID) and if required the funder of the Project. • A record must be kept of the delegated engineers and other professionals such as environmental practitioners, and a responsibility matrix of these persons should be kept on file from the start to end of a project.
12. BOQ, Tender documents & Procurement Process
• Refer to Vol 4 Chapter 2 for the requirements to develop the BOQ for the road project. • Refer to Vol 4 Chapter 3 for the requirements to draft the tender documentation. • Refer to Vol 4 Chapter 4 for the requirements of the procurement process.
13. Construction & Maintenance
• Refer to Vol 5 for the requirements of the construction and later maintenance phase of the road upgrade project.

2.12 CHAPTER 12: STANDARD DRAWINGS

Refer to Table 2.61 for the list of Standard Drawings that should be read in conjunction with Volume 2. Also refer to Volume 2, Chapter 10: Preparation of Drawings and Design Reports for further details.

The Standard Drawings are found in Part 3 of the URDM, a separate document.

Table 2.61: List of Standard Drawings

Drawing No.	Description
	LIST OF STANDRD DRAWINGS
General	
G -1	DRAWING CHECKLIST & STANDARDS
G -2	EXAMPLE DRAWING TITLE BLOCK
Typical Cross Sections	
CS 1A	1A (1 to 3) - TRUNK ROUTES (with BRT lanes)
CS 1B	1B (1 to 3) - TRUNK ROUTES (with PT lanes)
CS 2A	2A (1 to 3) - MAJOR ARTERIALS (with median BRT trunk lanes)
CS 2B	2B (1 to 2) - MAJOR ARTERIALS (with kerbside PT lanes)
CS 3A	3A (1 to 3) - MINOR ARTERIALS (with BRT feeder route)
CS 3B	3B (1 to 3) - MINOR ARTERIALS (with PT route)
CS 4A-1	4A (1 to 2) - COLLECTORS (Commercial & mixed-use, parking both sides) - PAVED
CS 4A-2	4A (1 to 3) - COLLECTORS (Commercial & mixed-use, parking both sides) - GRAVEL
CS 4B-1	4B (1 to 2) - COLLECTORS (Residential, parking both sides) - PAVED
CS 4B-2	4B (1 to 3) - COLLECTORS (Residential, parking both sides) - GRAVEL
CS 4C	4C (1 to 2) - COLLECTORS (Industrial, parking both sides) - PAVED
CS 5A-1	5A (1 to 2) - ACCESS ROADS (Commercial, mixed-use, residential - parking both sides) – PAVED
CS 5A-2	5A (1 to 2) - ACCESS ROADS (Commercial, mixed-use, residential - parking 1 side) - GRAVEL
CS 5B	5B (1 to 2) - ACCESS ROADS (Industrial - no parking) - PAVED
CS 6	6 - ACCESS WAYS: INFORMAL SETTLEMENTS - PAVED & GRAVEL
CS 7	7 - ACCESS WAYS: NMT ONLY - PAVED & GRAVEL
Road Drainage	
CUL-1	GENERAL CULVERT INSTALLATION DETAILS
CUL-2A	SINGLE CONCRETE PIPE CULVERT DETAILS
CUL-2B	DOUBLE CONCRETE PIPE CULVERT DETAILS
CUL-3	GENERAL CULVERT CROSSING DETAILS
CUL-4	SINGLE METAL PIPE CULVERT CROSSING
CUL-5	CULVERT HEAD AND WING WALLS
CUL-6	BOX CULVERT TYPICAL DRAINAGE DETAILS
CUL-7	TYPICAL CULVERT HEADWALL DETAILS
CUL-8	PRE-CAST BOX CULVERT DETAILS

CUL-9	DOUBLE RCC CULVERT CROSSINGS
CUL-10	DOUBLE RCC CULVERT DETAILS
CUL-11	CULVERT BEND DETAILS
GU-1	GULLY POT DETAILS
GU-2	GULLY FRAMES AND PIT DETAILS
CP-1	DROP INLET DETAILS
CP-2	CATCH PITS AND DROP INLETS DETAILS
CP-3	CATCH PITS AND KERB INLET DETAILS
D-1	OPEN SIDE DRAIN DETAILS
D-2	INVERT BLOCK POSITIONING AND DETAILS
D-3	OPEN SIDE DRAINS
SD-1	DRAINAGE CHANNEL PEDESTRIAN CROSSINGS 0-2m
SD-2	DRAINAGE CHANNEL PEDESTRIAN CROSSINGS 2-3m
SD-3	DRAINAGE CHANNEL VEHICULAR CROSSINGS 0-2m
SD-4	DRAINAGE CHANNEL VEHICULAR CROSSINGS 2-3m
SWD-1	STORMWATER DRAINS
SWD-2	SLEEVE ARRANGEMENTS FOR DEEP AND SHALLOW CUTTINGS
MH-01	MANHOLES: SHALLOW & DEEP
MH-02	MANHOLES: SHALLOW & DEEP
MH-03	MANHOLES: SHALLOW & DEEP
Road Features	
KB-01	TYPICAL KERB TYPES
KB-02	TYPICAL KERB TYPES
KB-03	STANDARD DETAILS FOR KERBS AND CHANNELS
KB-04	BEDS AND HAUNCHES FOR KERBS AND CHANNELS
GR-01	TYPICAL GUARDRAIL INSTALLATION
GR-02	TYPICAL GUARDRAIL FASTENING
GR-03	TYPICAL GUARDRAIL MOUNTING DETAILS
GR-04	TYPICAL GUARDRAIL END TREATMENT - FISHTAIL
GR-05	GENERAL GUARDRAIL INSTALLATION NOTES
GR-06	TYPICAL GUARDRAIL END TREATMENT - BUILT INTO GROUND
GR-07	TYPICAL GUARDRAIL ON HIGH FILLS
GR-08	TYPICAL GUARDRAIL INSTALLATION AT STRUCTURES
SH-01	TYPICAL SPEED HUMPS
SH-02	TYPICAL RAISED PEDESTRIAN CROSSING
PA-01	TYPICAL BUSBAY
PA-02	TYPICAL MINIBUS TAXI BAY
PA-03	STANDARD DISABLED PARKING BAYS
PA-04	STANDARD PARKING DETAILS

PA-05	STANDARD PARKING DETAILS
PA-06	STANDARD PARKING DETAILS
VT-01	TYPICAL VEHICLE TURNING FACILITIES
VT-02	TYPICAL VEHICLE TURNING FACILITIES
VT-03	TYPICAL VEHICLE TURNING FACILITIES
EM-01	TYPICAL EMERGENCY MEDIAN CROSSING DETAILS
CS-01	CONCRETE STAIRCASE FOR ROAD ACCESS
KM-01	KILOMETER MARK POSTS
SL-01	TYPICAL SERVICES LAYOUT 15m & 20m ROAD RESERVES
SL-02	TYPICAL SERVICES LAYOUT 28m & 40m ROAD RESERVES

3 VOLUME 3: MAINTENANCE & IMPROVEMENT - TECHNICAL SPECIFICATIONS

Volume 3 Table of Contents

3.1 CHAPTER 1: INTRODUCTION

3.1.1 INTRODUCTION & OBJECTIVE

This Volume provides a set of typical specifications for urban road works and acts as a complementary guideline to the MOWT's General Specifications for Roads and Bridge Works.

This Volume aims to:

- Stipulate the general requirements during construction
- Stipulate the materials specifications
- Specify the limits and tolerances required during the execution of urban road works
- To detail the units and procedures that will be used for the payment of certified works identified in relation to the Bills of Quantities

The structure of this Volume includes maintenance specifications for a selection of the most important routine maintenance activities and some periodic maintenance measures. Periodic maintenance is carried out according to the construction type of standard, and supervision procedures includes proper testing. These are discussed in Chapter 2. Methods to be used in road paving works (overlay and other surface treatment) and road rehabilitation and reconstruction are discussed in Chapter 3.

The objective of the Volume is an understanding of:

- The types of Standard Technical Specifications for maintenance and improvement Works.
- Use of Technical Specifications in the planning of urban road works
- Use of Technical Specifications in the supervision of urban road works

3.2 CHAPTER 2: ROAD MAINTENANCE SPECIFICATIONS

3.2.1 INTRODUCTION

The purpose of road maintenance is to provide continuous acceptable conditions that allow for uninterrupted, safe, and economical travel and goods transport on the road network. Properly planned and timely maintenance interventions ensure the least long-term costs for the urban councils by avoiding premature deterioration that may lead to higher rehabilitation costs.

3.2.2 ROAD CONDITION INSPECTIONS

Road condition inspections are required in order to regularly update AURICS and prioritise maintenance and improvement works, as described in Volume 1, Chapters 4 and 5. This section expands on the requirements for road inspections for more efficient maintenance management.

This section is adapted from the SANRAL Routine Road Maintenance Manual unless specified. Routine inspections should be carried out to ensure that any problems can be identified, investigated and corrected timeously.

The three major objectives of routine maintenance are to:

- provide a safe and acceptable level of service for the travelling public
- maintain the condition of the road such that maximum life is obtained from the road (asset preservation).
- ensure that the road environment is attractive (aesthetically pleasing)

The recommended intervals for inspecting and maintaining road elements are provided in Table 3.1; however, it should be noted that several external factors can influence the degradation of the road elements, including:

- **Traffic loading:** The volume and type of vehicles using the road may have a significant impact on the maintenance cycle, where a larger proportion of heavy vehicles (trucks, busses, etc.) use the road, maintenance may be required at increased intervals.
- **Climate:** Variations in the climate across the country may influence the durability of the road elements.
- **Construction Quality:** The quality of work and materials used in construction will influence the durability of the road elements.

Table 3.1: Routine Road Inspection Typical Frequency

Road Elements	Frequency	Additional Notes
Road Signs	Yearly	
Road Marking	Yearly	
Traffic Signals	Yearly	
Guardrails	Weekly	
Structures	Yearly	
Road Condition	Yearly	
Drainage	Monthly	As well as before/after large storms
Litter	Weekly to Quarterly	The frequency of cleaning operations depends on factors listed in Section 5.4.2
Vegetation Control	Varies	The frequency of cleaning operations depends on factors listed in Section 5.4.2

3.2.3 ROAD MAINTENANCE GUIDELINES

The determinants for routine road maintenance required for AURICS are listed in Appendices 6 and 7 for unpaved and paved roads respectively. Appendices 8 and 9 are tables of the determinants for periodic maintenance requirements for un-paved and paved roads respectively. This section expands on the aspects to be inspected and on the possible defects that may be.

Basic descriptions of maintenance actions are provided, but all maintenance works should be carried out in accordance with the specifications provided in Volume 3.

ROAD SIGNS AND MARKINGS

Road signs and markings play a significant role in road safety. A formal inspection should be made at least once a year, both during the day and at night, and during wet and dry conditions. Typically, road signs can have a life of 7 years, while road markings could have a life of 2 to 4 years depending on traffic loading and climate.

Typical Maintenance actions include:

- Cleaning dirty road signs
- Repairing or replacing damaged road signs. Damage may include the signs being faded/, bent, corroded or vandalised etc.
- Straightening or replacing damaged or bent poles.
- Road Marking should be re-painted at intervals as per the periodic maintenance schedule

TRAFFIC SIGNALS

Routine road maintenance for traffic signals should include inspection of the traffic signal equipment and the identification of faulty components. Maintenance teams can then be dispatched to undertake the maintenance actions as and when required. Different manufacturers of traffic signal equipment may have different maintenance requirements, and these should be taken not account when developing a maintenance plan.

Figure 3.1: Signalised Intersection in Kampala (Source: Uganda Road Fund)

The following list should be used as a guide to conduct inspections at a traffic signal installation. The list should be adjusted based on the requirements received from the supplier.

1. **Controller Cabinet (including pedestal)**
   - Door, hinges and locks
   - Weatherproof seal
   - Damage, rust, dirt, insect infestation, etc

2. **Signal Heads**
   - Clean signal heads (particularly lenses)
   - Signal head alignment
   - Damage to signal heads and lamps (broken lenses, faded colours etc.)

3. **Signal Posts (including anchor bolts)**
   - Repainting of posts
   - Damage and rust
   - Post support and anchors

4. **Pushbuttons**
   - Push button operation
   - Damage and rust

5. **Loop Detectors**
   - Visual inspection of loops
   - Verify detector operation

6. **Draw-boxes and Manholes**
   - Damage to covers and installations
   - Excessive water, dirt, insect infestation

7. **Cables and Other Electrical**
   - Cabe joints (those that are visible
   - Circuit breakers
   - Earthing

8. Controllers
- o Electromechanical assemblies
- o Relays, flashers, Switches, connectors
- o Lamp and fault monitor
- o Conflict monitor
- o Communication devices
- o Lightning protection unit (if installed/if testable)
- o Backup batteries (if installed)
- o Solar Panels (if installed)

9. Other items as per Manufacturer Requirements

Traffic signal timing plans should be checked regularly and adjusted if required, typically when one or more of the following occurs:
- Significant changes in land use in close vicinity to the intersection under consideration
- Significant changes in the road network
- When complaints have been received with regards to the operation of a signal
- If none of the above occurs, every 3 years.

(Adapted from the South African Road Traffic Signs Manual, Volume 3)

GUARDRAILS

Guardrails are generally robust and have a relatively long life. However, guardrails damaged in accidents should be repaired/replaced as soon as possible, and a general inspection should be carried out on an annual basis.

When the guardrails are inspected/repaired, the following should be checked:
- Eye height and alignment of the full length of the guardrail
- Missing and damaged reflectors should be replaced
- Guardrail plates should be overlapped in the correct direction
- Missing splice bolts should be replaced
- Posts should not be shortened
- Where guardrails are painted and not galvanised, damage and blemishes should be touched up with paint regularly to prevent corrosion.

Where guardrails are damaged regularly, the road geometry should be checked.

STRUCTURES

Structures described in this section exclude the evaluation of the drainage systems covered separately. Most repairs to structures require specialist input and are outside the scope of routine road maintenance, this section therefore describes the items that require inspection on a routine basis.

The items that require inspection include the following:

1. Watercourses
- o Waterway clear of obstructions (vegetative growth, silt, rubble, flood debris)
- o Signs of erosion, scour, and watercourse rerouting

2. Foundations
- o Condition of footings for the piers, abutments, and wing walls
- o Signs of subsidence, cracking

3. Substructure
- o Signs of cracking (horizontal or vertical displacement)
- o Condition of bearing pads and seatings as far as can be determined
- o Weep holes are working

4. Superstructure
- o Damage to balustrades, handrails, and guardrails
- o Scuppers cleaned
- o Joint material in place and cleaned out, cracking at joint edges/noses
- o Signs of cracking and distress of bridge deck
- o Road approach signage and traffic aids are appropriate and in place

5. Retaining Structures
- o Retaining structures includes structures such as gabion walls, reinforced or mass concrete walls, concrete block retaining walls and reinforced earth walls
- o Catchwater drains spilling water behind the structures, eroding and/or undermining the structure
- o Permanently wet areas (identifiable by plant growth or water seepage
- o Displacement, movement or cracking of structures

ROAD SURFACE

Road surfaces are typically described in 3 sub-categories:

1. Surfaced Roads – Flexible Pavements
2. Surfaced Roads – Rigid Pavements
3. Unsurfaced Roads

The extent of the damage should be considered in the decision to include corrective works in the routine roadworks contract or in a separate/rehabilitation contract. Localised or Intermittent occurrences can be repaired under the routine road maintenance contract, but extensive repairs should be excluded.

SURFACED ROADS – FLEXIBLE PAVEMENTS

The typical failures that may be experienced on flexible pavements are described below:

Surfacing Failures: Surfacing failure is the breaking up of the surfacing layer (seal or asphalt) exposing but not affecting the under-lying layer.

Figure 3.2: Surface Failure Example

Potholes: Potholes are surface failures extending into the base layer, forming a hole.

Pavement Failures: Consist of a combination of rutting, cracking and displacement of the road surface.

Figure 3.3: Cracking and Rutting (Pavement Failure Example)

Cracks: Cracks can broadly be classified into two categories, active and passive cracks. Active cracks generally originate from below the surfacing while passive cracks apply to the surface.

Before any crack treatment is applied, it is recommended that the crack mechanisms and factors affecting the crack behaviour are understood.

Figure 3.4: Volcano Crack (Active Crack Example)

Figure 3.5: Open Surface Crack (Passive Crack Example)

Pumping: Pumping is easily identified by the distinctive stains on the road surface.

Figure 3.6: Pumping in Wheel Track

Deformation: Ruts (rutting) is longitudinal depressions in the surface of the road.

Settlement: Settlement is evidenced by depressions in the road surface and is most easily identified in wet weather when the surface water cannot drain away.

Figure 3.7: Settlement on Fill

Undulations: A non-localised wavy form of deformation often associated with heaving clay.

Bleeding: Bleeding is the movement of binder (bitumen) upwards relative to the aggregate until there is a layer of free binder on the road surface.

Figure 3.8: Severe Bleeding

Ravelling: Ravelling is the loss of surface stone, normally from seals or lean asphalts.

Figure 3.9: General Ravelling

Edge break: Edge break is the failure of the edge of the surfacing usually accompanied by a loss of gravel on the shoulder. If allowed to progress edge break can also result in loss of the underlying base layer.

Figure 3.10: Edge break

Gravel Loss/Steep Shoulder Drop-offs: The gravel on the shoulder is lower than the adjacent surfacing causing a step from surfacing to gravel or falls away too steeply from the surfacing.

SURFACED ROADS – RIGID PAVEMENTS

Most repairs to rigid pavements require specialist input and are outside the scope of routine road maintenance. It is recommended that a condition assessment/ inspection should be carried out annually on rigid pavements, noting the following for specialised repair:

- Stepping
- Faulting
- Excessive problems with joints (loss of seal or spalling)
- Badly cracked panels
- Distress due to alkali/aggregate reaction
- Severe surface abrasion
- Poor ride quality
- Poor drainage

Some temporary maintenance actions using asphalt can be carried out on rigid pavements:
Loose/Spalled Concrete is usually located at joints but can occur in the centre of a slab when the cause is related to an alkali/aggregate reaction or localised poor-quality concrete.

Joints/open cracks occurs where the seal has failed or where cracks are sufficiently large to allow grit and water to penetrate. Only isolate instances should be repaired under routine road maintenance, extensive issues should be addressed in a specialised contract.

Weeds can grow in the pavement joints, especially close to the shoulder.

Figure 3.11: Joint Cracks with Weeds

UNPAVED ROADS

Maintenance of gravel roads are based around good road drainage, both from the surface (shape of the road) as well as maintaining the side drains to a good standard. Maintenance actions on gravel roads are typically divided into three categories:

1. Roadside Maintenance
2. Drainage Maintenance
3. Surface maintenance

Keeping the roadside clear of vegetation is for the purpose of safety, i.e., keeping sight lines clear as well as to avoid damage to vehicles from vegetation overhanging the road. Roadside maintenance includes actions such as clearing the verge of obstructions, removal of litter, vegetation Clearing and grass cutting.

Maintaining all drainage elements and structures to a good condition is important for gravel roads where poor maintenance can cause erosion of and damage to the road surface. Drainage maintenance includes actions such as clearing and maintaining side and mitre drains, clearing and maintaining drainage structures such as culverts as well as repairing damage caused by erosion.

The road surface should be kept smooth for safety reasons as well as to insure the quick run-off of water from the surface. Typical problems that can be experienced is potholes, corrugation and erosion ditches. Potholes can be patched but grading at regular intervals is recommended.

Figure 3.12: Corrugation
Source: Gravel Roads Maintenance and Design Manual, SD LTAP

Figure 3.13: Potholes
Source: Gravel Roads Maintenance and Design Manual, SD LTAP

DRAINAGE

The purpose of the drainage network is to keep the road and its surround free from standing water and should have sufficient capacity to prevent the road from being overtopped. The best time to inspect the drainage network is during/immediately after a rain event to observe where flooding occurred.

The following should be noted during inspections:

1. **Kerbs and chutes**
   - o damaged kerbs/chutes
   - o debris blocking water flow

To correct: Replace damaged kerbs and repair damaged chutes. Report road surface issues to the roads team for repairs. If problems persist, check the spacing of structures with the designer.

2. **Side drains (open and pipework)**
   - o standing water
   - o blockage due to loose material
   - o silting and vegetation
   - o cracked/damaged liners.

To correct: clean drains of loose debris, silting and vegetation, and re-shape earth drains where applicable. If problems persist, check the drain slope and size with the designer.

Figure 3.14: Blocked Pipe Culverts

3. **Bridges and Culverts**
   - o blockage caused by transported debris
   - o vegetation and silting (upstream and downstream of structures)
   - o flooding/overtopping of structures
   - o collapsed/damaged culverts.

To correct: clear out debris, vegetation and silting (cart away debris to prevent it from washing back into the culvert). If problems persist, check the slope and culvert size with the designer.

4. **Berms**
   - o erosion and breeching
   - o condition of perm protection (vegetation or stone pitching, etc.)
   - o check for damming of water.

To correct: repair the berm and place protection if none exists, re-shape to deflect water instead of damming it.

5. **Standing water on the road surface**
   - o Check for blocked drainage structures (inlets, outlets, pipes and channels)
   - o wheel rutting, flat or high shoulders and flat grades

LITTER

The amount of litter next to the road depends on a number of factors, including:
- The availability of litter bins
- The number of pedestrians along the route
- The proximity to cities and towns

Each town/city should determine its own cleaning frequency, which can range from weekly to quarterly.

Litter clearing should typically include the sweeping of roads and sidewalks, removal of rocks and other debris, and the emptying of litterbins.

VEGETATION CONTROL

The frequency of vegetation control varies based on a number of factors:
- The season
- The climate
- Type of vegetation in the road reserve

Each town/city should determine its own vegetation control programme, based on the local climate and season.

Vegetation control should typically include the following actions:
- Grass cutting,
- Pruning of trees and shrubs
- Checking for and removing intolerable weeds and invasive species
- Protecting protected plants

All debris created by the actions listed above should be carted away and disposed of, leaving plant material in the verge can encourage fires and may be swept into drainage systems during storm events.

Figure 3.15: Trees to be pruned/maintained in the median (Road in Kampala)

3.2.4 ROUTINE MAINTENANCE SPECIFICATIONS

Routine maintenance activities are conducted on the roads, usually on an annual basis, sometimes several times a year, and even weekly or daily, if conditions so require. Routine maintenance activities may be divided into cyclic and reactive work types. Cyclic works like vegetation control and drainage cleaning are dependent on environmental effects rather than traffic volumes and modes. Reactive works like pothole and edge repair are carried out in response to the combination of traffic and environmental effects. In this Volume, Specifications for Routine Maintenance Activities have been sub-divided under the following headings:
- Paved Roads Maintenance
- Gravel Roads Maintenance
- Drainage Maintenance
- Vegetation Control
- Litter Removal
- Road Furniture Maintenance
- Erosion Control

The full maintenance specifications are included herewith in Appendix 15.

PAVED ROADS MAINTENANCE SPECIFICATIONS

This comprises specifications for the following activities:
- Pothole patching using premix
- Shoulder repair of paved roads
- Crack sealing using hot Bitumen
- Edge Step backfill using gravel

A list of routine maintenance interventions for paved roads are included in Appendix 6,

GRAVEL ROAD MAINTENANCE SPECIFICATIONS

This comprises specifications for the following activities:
- Filling Potholes and Minor gullies
- Grubbing
- Light Grading
- Medium Grading
- Heavy Grading
- Weeding
- Shoulder/slope erosion repair

A list of routine maintenance interventions for gravel (un-paved) roads are included in Appendix 7.

DRAINAGE MAINTENANCE SPECIFICATIONS

This comprises specifications for the following activities:
- Drainage Cleaning
- Drainage Repair

A list of routine maintenance interventions for paved and un-paved roads are included in Appendix 6 and Appendix 7.

VEGETATION CONTROL SPECIFICATIONS

These are specifications for the following activities:
- Vegetation Clearing (grass cutting)

A list of routine maintenance interventions for paved and un-paved roads are included in Appendix 6 and Appendix 7.

LITTER REMOVAL SPECIFICATIONS

This shall comprise specifications for the following activities:
- Cleaning or sidewalks and road verges of litter
- Emptying waste bins along the road

ROAD FURNITURE MAINTENANCE

This includes specifications for routine maintenance of the following:
- Traffic signs maintenance
- Guard rails maintenance

REMOVAL OF OBSTRUCTIONS ON CARRIAGEWAYS

This is the specification for the removal of deposits and obstructions on the carriageway and shoulders.

3.2.5 PERIODIC MAINTENANCE SPECIFICATIONS

Periodic maintenance activities are carried out periodically, with intervals of the number of years as required. Typical periodic maintenance works include overlay works on paved roads and re-gravelling on unpaved roads.

Periodic Maintenance Specifications are grouped as follows:
- Paved Roads
- Unpaved Roads

PAVED ROADS PERIODIC MAINTENANCE SPECIFICATIONS

This shall comprise specifications for the following:
- Overlay works

A list of periodic maintenance interventions for paved roads are included in Appendix 9

UNPAVED ROADS PERIODIC MAINTENANCE SPECIFICATIONS

This shall comprise specifications for the following activity:
- Heavy Grading

- Re-gravelling

A list of periodic maintenance interventions for gravel (un-paved) roads are included in Appendix 8

3.3 CHAPTER 3: IMPROVEMENT WORKS SPECIFICATIONS

3.3.1 INTRODUCTION

Improvement works which comprise rehabilitation and/or upgrading a gravel road to bituminous standard shall comprise the following selected or all of the under listed activities:

- Preliminaries and General
- Drainage works
- Site Clearance, Earthworks and Pavement Layers of Gravel and Crushed Stone Base
- Wearing Course and Shoulders comprising Bituminous Layers and Seals
- Ancillary Road Works

The Selected Works items for Rehabilitation, Up-grading to Bituminous Standards and New Construction are listed below.

REHABILITATION WORKS FOR GRAVEL ROADS

The specifications for Work Items relevant to the Urban Road Rehabilitation Works are:

- Preliminaries and General
- Drainage Works
- Site Clearance, Earthworks and Pavement Layers of Gravel
- Ancillary works

UP-GRADING WORKS FROM GRAVEL TO BITUMINOUS SURFACE

The Specifications for Work Items relevant to the Urban Road Up-grading Works are:

- Preliminaries and General
- Drainage works
- Wearing Course and Shoulders comprising Bituminous Layers and Seals
- Ancillary Road Works

NEW CONSTRUCTION

New Construction works require all Work Items, and therefore the Specifications to use are:

- Preliminaries and General
- Drainage works
- Site Clearance, Earthworks and Pavement Layers of Gravel and Crushed Stone Base
- Wearing Course and Shoulders comprising Bituminous Layers and Seals
- Ancillary Road Works

3.3.2 GENERAL SPECIFICATIONS

The General Specifications shall comprise the following Works Items:

- The Scope of Works
- The General Requirements
- Construction Method (if any)
- Measurement and Payments Methods

PRELIMINARIES AND GENERAL ITEMS

The General Specifications for this Item shall be the scope of works, general requirements, measurements, and payment methods for the following items:

- Provide, erect, and remove after use temporary information boards
- Management of daily traffic movement; handling utility services (power cables, water pipes, telephone wires etc.)
- Testing of materials and/or Works that may be ordered by the Engineer
- Surveys and drawings of actual layout, profile, and cross-sections before and after the Works, Site Meetings and Supervision of the Project by the Employer

The general specifications are contained in Sections 1000, 1200, 1500 and 7000 of the Ministry of Works and Transport General Specifications for Roads and Bridges, October 2004.

SITE CLEARANCE AND EARTHWORKS

The General Specifications for site clearance and Earthworks shall be the scope of works, materials, general requirements, measurements, and payment methods for the following items:

- Clear all shoulders and side drains of grass and reeds as instructed by the Engineer, load, and cart to spoil excess material.
- Load and cart to spoil all debris and excess material which cannot be spread within the road reserve to a distance not exceeding 500m,

spread all excess material as directed by the Engineer.

- Fell down tress of a minimum diameter of 300mm within road reserve, load and cut to spoil as directed by the Engineer.
- Remove tree stumps, fill hole appropriately and cut to spoil debris as directed by the Engineer.
- Excavate to spoil surplus and unsuitable material obtained from preparation of carriageway and footway (not exceeding 150mm deep, exceeding 300mm deep), excavations into embankments/widening, completion of formation of Carriageway and shoulders.
- Provide, spread, shape, water, and compact granular fill material to at least 95% Mod. AASHTO, compaction layers not exceeding 125mm thick, for sub-grade improvement.
- Provide, spread, shape, water, and compact granular fill material to at least 95% Mod. AASHTO, compaction layers not exceeding 125mm thick, for sub-base, Provide, spread, shape, water and compact to at least 98% Mod AASHTO approved gravel, in layers not exceeding 125mm thick, for base layer.
- Provide approved road lime for chemical stabilisation of gravel sub-base & base layers mixed at a rate of 4-5%. Provide approved crushed stone (GCS) and construct base layer, not exceeding 150mm thick

The general specifications are contained in Section 3000 of the Ministry of Works and Transport General Specifications for Roads and Bridges, October 2004.

DRAINAGE WORKS

The General Specifications for drainage works shall be the scope of works, general requirements, materials, measurements, and payment methods for the following items:

- Excavation for side drains, catch-water drains, toe drains, offshoots including disposal of material as directed by the Engineer.
- Excavate for drainage structures: culverts, headwalls, wing walls, aprons, toe walls and drop inlet chambers.
- Provide, lay, and join concrete culverts on granular bedding and surround including backfilling, watering, and compacting
- Remove existing culvert pipes, clean and re-use or install elsewhere as directed by the Engineer
- Clean/unblock existing pipe culverts manually
- Construct culvert end structures
- Additional concrete Grade 25 as haunching to culverts
- Construct lined drains using stones stone pitching, cast-in-situ concrete, IBDs.
- Construct standard manholes complete with heavy duty covers as specified or directed by the Engineer
- Construct standard gulley pots complete with heavy duty gratings as specified or directed by the Engineer
- Construct standard catchpits as specified or directed by the Engineer
- Masonry repairs to stone pitched side drains, including resetting of stone pitching with cement-sand mortar.
- Clear and reshape existing unlined side drains, toe drains, mitre drains or any other water channels. All spoil to be disposed of, as instructed by the Engineer
- Remove silt, soil, debris, and any other material from lined roadside drains and dispose to designated sites.
- Provide and place RCC precast concrete slabs as foot bridges over open drain, 100mm thick at appropriate pedestrian crossing points.
- Excavations for foundation gabions
- Supply gabion boxes place and fill
- Supply gabion mattresses place and fill

The general specifications are contained in Sections 2100, 2200, 2500 and 2600 of the Ministry of Works and Transport General Specifications for Roads and Bridges, October 2004.

WEARING COURSE AND SHOULDERS

The General Specifications for wearing course and shoulders shall be the scope of works, general requirements, materials, measurements, and payment methods for the following items:

- Shape road surface by heavy grading to camber and cross fall including side drains, all inlets, and outlets of the drainage with a grader and compact to 95% Mod. AASHTO.
- Shape road surface by medium grading to camber and cross fall including side drains, all inlets, and outlets of the drainage with a grader and compact to 95% Mod. AASHTO.
- Provide and transport up to 10km, spread water and compact to at least 95% MOD.AASHTO. Natural base material to a thickness instructed by the Engineer
- Overhaul of base material

- Remove vegetation and all deleterious materials, scarify, shape and compact existing pavement/shoulder to at least 95% MOD AASTHO density.
- Scarify and cart to spoil unwanted materials
- Trim and clean potholes and edges and fill with approved granular material and compact to 95% MOD AASTHO density
- Seal potholes and edges with a premix layer of 50m thickness and of approved materials composition by the Engineer.
- Provide and apply MC 70 cutback bitumen as prime coat at a nominal rate of 0.8 - 0.9 l/m^2 to cleaned, dust-free and dry surface
- Provide and spread blinding material on primed surfaces at a rate of $1m^3/200m^2$
- Provide and apply 85/100 penetration bitumen at a rate of 1.3 - $1.5kg/m^2$ for application of first coat
- Provide and spread 20mm nominal size chippings at a rate of $1m^3/65m^2$.
- Heat and spray 85/100 penetration bitumen at a rate of 1.1 - $1.3kg/m^2$ for application of second coat
- Provide and spread 14mm nominal size chippings at a rate of $1m^3/150m^2$.
- Provide and spread Type I asphalt concrete designation 0/10, 50mm thick on primed surface, to form wearing course.
- Provide and lay a 50mm thick sand bed

The general specifications are contained in Sections 4000 of the Ministry of Works and Transport General Specifications for Roads and Bridges, October 2004.

ANCILLARY WORKS

The General Specifications for Ancillary Works shall be the scope of works, general requirements, materials, measurements, and payment methods for the following items:

- Remove, transport, and store existing road signs. Make necessary repairs, repaint, and re-erect
- Provide and erect standard regulator type signs of size 600mm.
- Provide and erect standard warning type signs of size 900mm.
- Provide and erect standard information signs of size 500x600m
- Provide and erect non-standard information signs of area under $1m^2$
- Provide and erect non-standard information signs of area between 1 and $2m^2$
- Provide and erect guardrails as specified or directed by the Engineer
- Prepare road surface, spray tack coat, paint white road marking lines 100mm wide.
- Prepare road surface, spray tack coat, paint yellow marking lines 100 mm wide
- Provide, prepare, and paint kerb stones
- Provide, prepare, and paint pedestrian crossings (zebra crossings), to details
- Provide and install reflective cat eyes
- Precast concrete kerbing laid in dropped crossings
- Precast concrete kerbing laid complete in straights and bends, complete with channels
- Precast concrete drainage inlets at intervals as specified or directed by the Engineer
- Additional concrete grade 25 as bed and backing for kerbing (Provisional Item)
- Speed breakers (humps) as per drawings and specifications (Provisional Item)
- Provide, lay, and fix in position heavy duty UPVC pipes for future utility crossings, of 150mm internal diameter with proper joint in required slope as directed by the Engineer
- Provide and install standard lighting complete with fittings ready to connect to mains
- Plant grass as directed by the Engineer
- Plant trees as directed by the Engineer
- Tend to flower beds as directed by the Engineer
- Provide and erect standard litter bins as specified or as directed by the Engineer

The general specifications are contained in Sections 5000 of the Ministry of Works and Transport General Specifications for Roads and Bridges, October 2004.

3.4 CHAPTER 4: SUMMARY

The Technical Specification Volume stipulates the general requirements of the material specifications, the limits and tolerances required and details of the units and procedure that will be used for the measurement and payment of certified works identified in relation to the Bills of Quantities.

The user should have the necessary competence in terms of skills, knowledge, and experience in order to prepare the standard specifications for use in road works by asking the questions provided in Table 3.2 which helps to summarise the outcomes of the preparation of the specifications.

The Volume provides key information for the preparation of the urban road's technical specifications:

- Information source for the preparation of Technical Specifications
- Standards to be used and complied with in the preparation of the technical specifications.
- The factors to consider when preparing the technical specifications for urban road works.

Table 3.2: Summary of Questions for the Preparation of Technical Specifications

What information does a road designer need to for the preparation of Standard Tech. Specs.?	**Where do I get this information from?**	**What are the standards used?**	**What are the outcomes?**
1. Data	Data from the field and other Departments.	-	Field data
2. Design Drawings	MoWT Design Standards.	MoWT Design Standards and Urban Roads Design Guidelines	Standard Designs
3. Bills of Quantities	Urban Roads Manual Volume 4.	Urban Roads Manual Volume 4.	Standard BoQ
4. MoWT General Specifications	MoWT Standard Specifications	MoWT Standard Specifications	Technical Specifications for urban road works

4 VOLUME 4: BILL OF QUANTITIES & TENDER DOCUMENTS

Volume 4 Table of Contents

4.1 CHAPTER 1: INTRODUCTION

4.1.1 BACKGROUND & OBJECTIVES

This Volume describes the preparation of Bills of Quantity (BOQ) and the preparation of tender documents for road works.

The objective of the volume is an understanding of:

- **Preparation of Bills of Quantities.** This involves what BOQ's are, their relevance, composition and their preparation, types, and pricing in order to develop the Engineer's estimate.
- **Preparation of Tender Documents.** This involves what tender documents are, their relevance, components, their preparation, and types.

4.1.2 BILLS OF QUANTITIES AND TENDER DOCUMENTS IN PROCUREMENT

Preparation of Bills of Quantities and Tender Documents are key inputs in procurements for road civil works since they form basis for future contractual agreements between the Urban Council and Contractors. The process of preparing contract documentation for road works shall first involve preparing the BOQ's and Tender Documents as illustrated in Figure 4.1. As a minimum, all procurement for road works should be commenced after the preparation of BOQ's and Tender Documents following adequate scoping of the work as informed by a detailed design.

4.1.3 WHAT ARE BILLS OF QUANTITIES?

A bill of quantities is a schedule of items of works required under the contract, with quantities against each item. The quantities are estimates and are measured basing on a standard as stipulated in the contract documents. A BOQ is a planning document that itemises and prices how much material, equipment, labour, and any other work is required to complete a maintenance, rehabilitation, upgrade or new construction project. A BOQ itemise, describe, quantify, and cost all different work and material components of the works. Therefore, the items in a BOQ should cover the entire scope of works because BOQs form basis for all payments under admeasured work contracts.

Item descriptions in a BOQ should clearly indicate the nature and scope of work covered with reference being made to a particular drawing defined and/or specifications. The unit rates against items must reflect the full cost of executing the item covering both direct and indirect components.

Where lump sum contracts are used for civil works, as is in Design and Build Contracts, the BOQ will be replaced with a Schedule of Payments/Prices which indicate and describe the different project activities or work components and their lumpsum payments after completion.

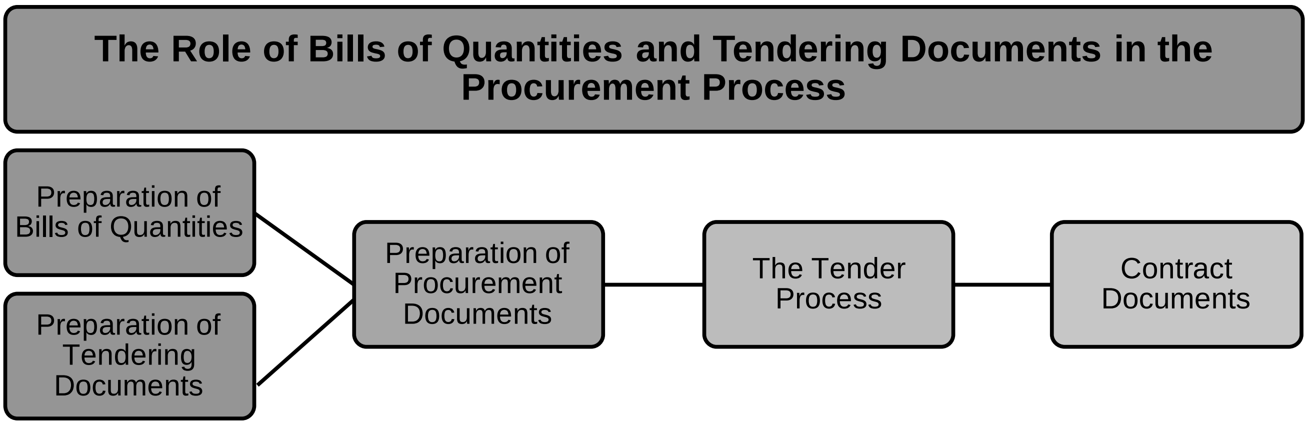


Figure 4.1: Bills of Quantities and Tendering Documents in the Procurement Process

4.1.4 PREPARATION OF TENDER DOCUMENTS

Tender documents are documents used to procure goods or services at an agreed price. Usually for road works, the suppliers (contractors) are obtained through a formal tender process.

A pre-requisite of choosing a contractor is the need to obtain a tender or a bid, which can be defined as an offer by a tenderer or a bidder to enter a contract for a price on stated terms, following an invitation from a prospective employer. Public bodies deal with public funds and must be seen to be spending that fund both wisely and honestly. Consequently, the letting of their contracts follows some form of competitive bidding/tendering. To facilitate a transparent and equitable procurement process, tendering or bidding is based on tender or bid documents prepared by the prospective employer.

Such tender or bid documents include the following:

- Forms of Tender with Appendices
- Form of Agreement
- Conditions of Contract
- Drawings
- Specifications
- Bills of Quantities/Schedule of Prices
- Terms of Reference/Employer's Requirements

The duly completed tender documents by the prospective contractors is the tender which is addressed to the employer and is the contractor's formal offer to design, construct, complete and maintain the permanent works in conformity with the conditions of contract within the time stated.

4.2 CHAPTER 2: PREPARATION OF BILLS OF QUANTITIES FOR ROAD WORKS

4.2.1 INTRODUCTION

This chapter outlines the contents of the Bills of Quantities.

The Standard Bill of Quantities guides the urban councils in estimating the quantity and cost of execution of road works for maintenance and improvement and are included in this volume.

For consistency and clarity during management of contract works, it is recommended that bill items in a BOQ are consistent with the general outline of the latest MOWT General Specifications for Road and Bridge works. For this chapter, the presented bill items have followed the 2005 MOWT General Specifications. BOQ consistency with the MOWT General Specifications ensures clarity in interpreting bill item descriptions, measurements, and acceptability during project implementation.

4.2.2 OBJECTIVES OF A BOQ

The objectives of the Bill of Quantities are:

- To provide sufficient, clear information on the description and quantities of work to be performed to enable bids to be prepared efficiently and accurately
- When a Contract has been entered into, to provide a priced Bill of Quantities for use in the periodic valuation of works executed.
- Similarly, a Schedule of Payments and Schedule of Prices will be used to describe the various work components of a lumpsum contract and their respective lumpsum payments

4.2.3 COMPONENTS OF A BOQ

- Bills of Quantities generally has 11 components:
- Bill 1: GENERAL
- Bill 2: DRAINAGE
- Bill 3: EARTHWORKS & PAVEMENT LAYERS
- Bill 4: ASPHALT PAVEMENT & SEALS
- Bill 5: ANCILLARY ROADWORKS
- Bill6: STRUCTURES
- Bill 7: TOLERANCES, TESTING & QUALITY CONTROL
- Bill 8: SCHEDULE OF DAYWORKS RATES (LABOUR)
- Bill 9: SCHEDULE OF DAYWORKS RATES (MATERIALS)
- Bill 10: SCHEDULE OF DAYWORKS RATES (PLANT)
- Summary bill

Where MOWT General Specification items do not include work items required for Urban Road works, such as road lighting, litter bins and traffic signal installation, it is incumbent on the designer or Urban Council to ensure that such unique work items are clearly detailed in the project BOQ.

When adding these unique work items, the added bill item should specifically:

- Clearly describe the work item
- Provide clear quality/material specifications
- Provide measurement units
- Describe installation method
- Be referenced to a clear acceptance and payment criteria in the contract documents

Refer to the following appendices:

- Appendix 16: Preamble to Bills of Quantities
- Appendix 17: A sample BOQ for urban road works
- Appendix 20: Sample measurement sheet and payment certificate of the BOQ

4.2.4 PROCEDURE FOR PREPARATION OF A BOQ

BOQ's must be prepared after the field assessment and finalisation of the design and the technical specifications in order to obtain the necessary quantities of the various items of the works. Preparation of Bills of Quantities shall therefore consist of the following steps:

- Field Assessment
- Measurement of the Quantities (Taking Off)
- Estimation of the costs of works
- Preparation of the Engineer's Estimates

FIELD ASSESSMENT

All BOQ's should be informed by detailed and up-to-date field assessments. Field Assessment data gathered during AURICS and preparation of AURWP should be updated in order to prepare project Bill of Quantities, Engineers Cost Estimate, and corresponding work programme. Field assessments are of critical importance when preparing BOQ's if the contracted works are to be fully performed in accordance with the Technical Specifications and completed within schedule and cost. Field assessments may be undertaken by Urban Council staff in order to adequately scope a project or by a consultant as part of a feasibility study/detailed design.

Accurate identification of all the work items for inclusion in the Bills of Quantities and determination of the quantities thereof can only be achieved by undertaking a detailed and comprehensive site visit. Appropriately trained and experienced staffs from the urban council's Works Department are responsible for carrying out this important work. The field observation involves the following processes:

- The data obtained from the field assessment are compared with the design data and technical specifications in order to determine the adequacy of estimated quantities of the works item.

- Checklists and other standard field assessment forms should be utilised during field assessments to ensure that field assessments capture all necessary details needed to develop a 'practical' BOQ that is less susceptible to foreseeable changes.

- Detailed sketches and notes should be taken during field assessments, using standard formats where available, to facilitate documentation of measurements that will form basis of the various quantities in the BOQ.

MEASUREMENT OF QUANTITIES

There are three methods of estimating the quantities of works to be executed. The methods consist of the following:

- Quantities that are measured before construction (MBC), using the field assessment data and design.
- Quantities that are measured after the actual work has been done (AWD), whereby estimates are obtained using the field assessment data.
- Quantities that are measured as planned (MAP), using the field assessment data and designs.

These three methods for estimating the quantities of works items should therefore be used when measuring quantities for BOQ items. It is envisaged that most often than not, quantities for BOQ's will be estimated before construction. In this case, bill quantities will be taken off from approved drawings or appropriate field sketches. Double counting and omission of work items should be continuously checked for when developing BOQ quantities.
Measurement methods and units should be consistent with the MOWT General Specifications and other relevant work measurement guidelines.

PRICING OF ITEMS

In the Bill of Quantities, items are priced in four ways namely:

- Quantified items
- Provisional Sum items
- Day-works items
- Contingencies

QUANTIFIED ITEMS

Construction quantities for the main items of work are determined from field assessment data, plans, drawings, and related specifications. The costs of materials, equipment and labour required to construct, maintain, or repair the works are then estimated. In addition, the cost shall include overheads, cost of supervising the works, risk allowance and profit margin.

The rate for executing a unit of this work item known as unit rates should be built from unit rate analysis by referencing on-going and previously completed similar works. Unit rate analysis can be a qualitative or quantitative study that identifies the basic elements of a work item in order to build a rate for performing the work item. The resources required to achieve a work item are identified and costed in order to build up a rate for each work item. The basic resources costed for each work item are labour, material, equipment, overheads, and profit.

Other documents such as the District Roads Manual, Volume 2, Manual A4 provides additional unit rate analysis details.

The use of rates from on-going and previous works is recommended when pricing bill items. It is recommended that unit rate analysis is undertaken for each project BOQ as part of developing the Engineer's Estimate. These rates should be updated annually by the Urban Councils to reflect the current market rates in the country or various regions of the country.

PROVISIONAL SUMS

Specialized work to be carried out by a contractor are estimated and indicated in the relevant part of the Bill of Quantities as a particular provisional sum with an appropriate description. Provisional sums are only spent with approval of the Employer.

DAY-WORK SCHEDULE

Day-Work Schedules should normally only be included if the probability of unforeseen work (labour, materials and plant), outside the items included in the Bill of Quantities, is high. Given the complexity of urban road work sites, it is likely that unforeseen work will be required on urban road construction or maintenance projects. It is thus recommended that day work schedules are included in BOQs for Urban Roads. The Day Work Schedule should normally comprise the following:

- A list of the various classes of labour, materials, and construction plant for which basic day-work rates or prices are to be inserted by the bidder, together with a statement of the conditions under which the Contractor will be paid for work executed on a day-work basis.
- Nominal quantities for each item of day-work, to be priced by each Bidder at day work rates as Bid. The rate to be entered by the Bidder against each basic day work item should include the Contractor's profit, overheads, supervision, and other charges.

CONTINGENCIES

A contingency sum is an item which refers to unforeseeable cost likely to be incurred during the contract. These can be expressed a physical contingencies or financial contingencies.

There are two types of contingency sums.

- The first refers to a specific item i.e., where an item for alterations to existing works is not contained within the BOQ but some work is envisaged. This is usually approximated by the contractor.
- The second type of sum is where money can be allocated to any item, within the BOQ, in the same way as the above example or used as additional work to be undertaken by the contractor, at the request of the contract administrator. This is usually approximated by the client/urban council.

4.2.5 ENGINEER'S ESTIMATES

Engineer's Estimate is the amount required to execute a given Bill Item or the total amount required to execute the maintenance or improvement works as costed by the council technical personnel. The Engineers' estimates are usually required for evaluation of the tenders.

Following the entering of work item and quantity information in the Bills of Quantities, it is then necessary to apply appropriate Unit Rates for each of the work Items.

The simple multiplication of each work Item quantity by the corresponding Item Unit Rate results in a series of sub-totals which, when added all together including the Preliminaries Items, provides a grand total or estimated Contract Price for the works; otherwise referred to as the Engineers Estimate.

Realistic Unit Rates is the key to success and for the avoidance of variations. Unit Rates that are too low will not allow the Contractor(s) to perform the works to the quality standards required by the Technical Specifications, resulting in delays, cost overruns and sub-standard work. In addition, Unit Rates that are too high only result in uneconomical use of public resources.

In this Volume, the Engineer's Estimate is costed using estimates from on-going or previous works and unit rate analysis. Appendix 18 has been provided to guide the Urban Councils on the rates as determined by MOWT as of 2021. However, the Urban Councils are encouraged to update these rates taking into consideration the materials, fuel, and labour cost changes. It is recommended that each Urban Council maintains updated rates for use in developing work cost estimates.

4.2.6 BOQ FOR ROUTINE MAINTENANCE

In the case of Minor (routine) Maintenance and Repair Works Contracts, the Maintenance Activity Schedule defines the work Items to be undertaken and the Monthly Site Inspection Report / Measurement Sheet identifies those work Items and locations thereof that are to be undertaken each and every month. Volume 5 gives details of the management of routine maintenance activities.

The Engineers Cost Estimate for routine maintenance Contracts is the total cost per kilometre per year for unpaved roads based on the current maintainable condition of road section(s) determined during the most recent AURICS, and for paved roads the Engineer's Cost Estimate are similarly determined for Minor Works above.

The Contract documentation states this cost and assigns a monthly payment to the Contractor(s) for works satisfactorily performed in accordance with the Monthly Site Inspection Report / Measurement Sheet.

4.3 CHAPTER 3: PREPARATION OF TENDER DOCUMENTS FOR ROAD WORKS

4.3.1 INTRODUCTION

Tendering for urban road works aims at acquisition of the best works in the right quantity and quality, at the right time and within the appropriate cost. The PPDA Act and Regulations 2003, detail the full procurement processes, rules and procedures and the procurement methods that must be complied with. Urban Councils should always ensure compliance with the latest and appropriate PPDA Procurement Regulations and Guidelines when preparing tender documents and procuring contractors.

The relevant parts of the bidding process involve the following:

- Shortlisting/Selection of Bidders
- Preparation and Issue of Bidding Documents
- Bidding Period and Bid Receipt
- Bid Opening
- Bid Evaluation
- Bid Acceptance
- Contract Award and Commencement

Tender Documents comprise the following documents: Invitation and Instructions to Bidders; Bid Data Sheet (BDS); Evaluation Methodology and Criteria; Standard Bidding Forms; Eligible Countries; General Conditions of Contract (GCC); Special Conditions of Contract (SCC) and Contract Forms. In addition, Special Specifications, Drawings, Statement of Requirements and Bill of Quantities should be provided as relevant. PPDA Guidelines provide Standard Bidding Documents and tendering processes to be used for all public procurements.

Therefore, PPDA Guidelines should be followed at all times during tender documents preparation and procurement.

Figure 4.2 shows the components of tender documents.

INVITATION AND INSTRUCTIONS TO TENDER

1 - INVITATION TO BID

These are designed to invite specific bidders who are assessed to have the prerequisite skills, capacity, or qualifications to fulfil a requirement. Invitations to bid are issued for:

- Restricted Bidding (Domestic or International) methods or where bidders have been pre-qualified through issuing of Invitation to bid letters
- Open Bidding where no pre-qualification has been done through advertisement.
- Shortlisting after receipt of Expressions of Interest

2 - INSTRUCTIONS TO BIDDERS

The Instructions to Bidders (ITB) inform Bidders of the procedures that regulate the bidding process. The ITB contain standard provisions that have been designed to remain unchanged and to be used without modifying their text. The ITB clearly identify the provisions that may normally need to be specified for a particular bidding process and require that such details be introduced through the Bid Data Sheet.

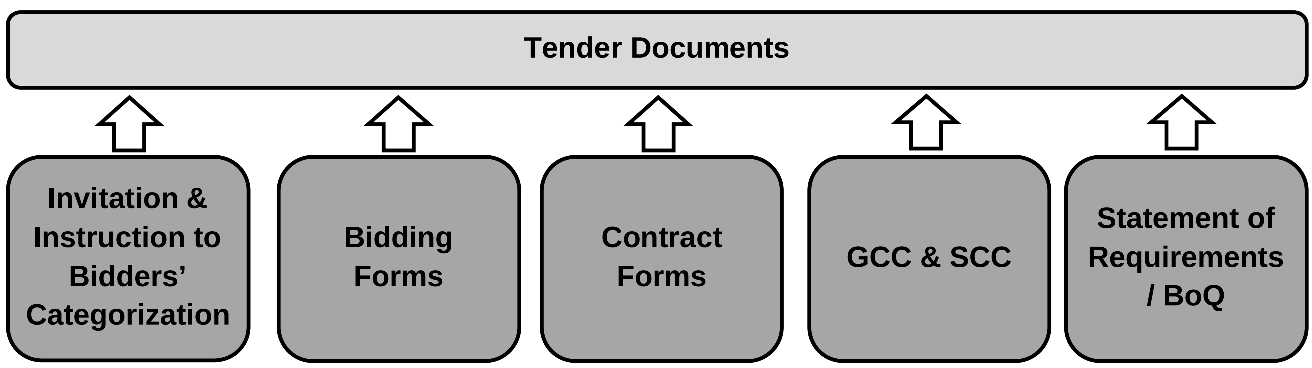


Figure 4.2: Components of Tender Documents

3 - Bid Data Sheet

The Bid Data Sheet (BDS) supplements the ITB by specifying details relevant to an individual bidding document such as its closing date, the value of bid security required, site inspection dates, etc.

To facilitate the preparation of the BDS, its clauses are numbered with the same numbers as the corresponding ITB clause.

Bidding Forms

Bidding Documents include all bidding forms that the Bidder must fill out and include in its bid. These forms include:

- Bid Submission Sheet
- Code of Ethical Conduct
- Bid Securing Declaration
- Activity Schedule/Bills of Quantities
- Bid Security
- Qualification Form

Contract Forms

Contract Forms comprise the following:

- Form of Agreement
- Security Forms: Performance Security and Advance Payment Guarantee, etc.

1. Agreement

The Form of Agreement is the agreement for the contract; it spells out the offer of the Employer in terms of payments and acceptance by the contractor. The details to be completed on the Agreement are specific to the successful Bidder and therefore should be left blank for inclusion in the Bidding Document.

2. Performance Security and Advance Payment Security

A Performance Security is guarantee from a financier on behalf of the Contractor to pay to the Employer a certain amount of money in an event of a default by the Contractor in executing the Contract. The details to be completed are specific to the successful Bidder and shall be completed by the financial institution and submitted by the Contractor to the Employer and therefore should be left blank for inclusion in the Bidding Document.

Similarly, an Advance Payment Security is a guarantee from a financial institution on behalf of the Contractor to enable the Contractor receives advance money from the Employer under the Contract. The details to be completed are specific to the Bidder and should be completed by the financial institution and submitted by the Contractor to the Employer with an invoice. The form should therefore be left blank for inclusion in the Bidding Document.

General And Special Conditions of Contract

1. The General Conditions of Contract (GCC) contain standard provisions that have been designed to remain unchanged and to be used without modifying their text. The GCC clearly identify the provisions that may normally need to be specified for a particular bidding process and require that such provisions be introduced through the SCC.

   The GCC will form part of any resulting Contract.

2. Special Conditions of Contract (SCC) supplement the GCC by modifying conditions applicable to an individual contract, such as payment terms or the name of the project manager. The SCC prevails over the GCC. To facilitate the preparation of the SCC, its clauses are numbered with same numbers as the corresponding GCC clauses.

   The SCC will form part of any resulting Contract.

Statements Of Requirements/BoQ

The Statement of Requirements (SOR) informs Bidders of precisely what the Employer wishes to procure. The Statement of Requirements (SOR) should provide sufficient information to enable bidders to efficiently and accurately prepare bids that are realistic and competitive and to ensure that bids meet the Employer’s needs. The SOR must be prepared by suitably qualified and experienced staff. The completed Statement of Requirements will form part of the Contract.

The Employer must prepare the SOR and include it as a part of the Bidding Documents. Depending on the size of the contract and the number of pages in each section, it is usual to package each part in a separate volume. For example, for a large contract, the Technical Specifications, Activity Schedule, and Drawings may all need to be issued in separate volumes. Where separate volumes are issued:

- each volume should be appropriately titled and include the procurement reference number; and
- The relevant page should be included in the Bidding Document for completeness, with a reference to the appropriate volume.

The Statement of Requirements consists of five parts:

- Scope of Works
- Technical Specifications
- Drawings
- Activity Schedule/Bills of Quantities
- Completion Schedule

4.3.2 THRESHOLDS FOR PROCUREMENT

The procurement of works, services and supplies can be undertaken by one of the following methods:

- Open Bidding
- Restricted Bidding
- Quotations
- Micro Procurement

The choice of the method above is determined by the expected value of the works, service or supplies. The thresholds value range (in UGX) for each is determined by the Public Procurement and Disposal of Public Assets Authority (PPDA) and the PPDA Act.

4.3.3 PREPARATION OF TENDER DOCUMENTS

The Urban Council is responsible for the preparation and issuance of the Bidding Document and must use the appropriate Standard Bidding Documents (SBD) currently in use as issued by the Public Procurement and Disposal of Public Assets Authority (PPDA), as this is a mandatory requirement for contracts to be publicly funded.

In the preparation of the Bidding Documents, the urban councils shall refer to the PPDA Act and Regulations, 2003 (or the latest version) for guidance.

Notes:
The current Standard Bidding Document (SBD), dated March 2014, has been prepared by the PPDA for use by Procuring and Disposing Entities (PDEs) for the procurement of Works. The procedures and practices presented in the SBD have been developed to reflect the requirements of the Public Procurement and Disposal of Assets Act, 2003, the Public Procurement and Disposal of Assets Regulations, 2014 and best international procurement practices including enhancement of Environmental, Social, Health and Safety (ESHS) requirements.

This SBD for the Procurement of Works is suitable for use under the Open (International or Domestic) Bidding procurement method without following pre-qualification. Pre-qualification is not envisaged for small and medium works. It is also suitable for the Restricted (International or Domestic) Bidding procurement method. The SBD may also be used for procurement under the Direct Procurement method with appropriate modifications to the document.

For procurements under the Quotation Method, a simpler SBD has been developed which is generally more appropriate for this method.

This SBD is suitable for ad measurement and lump-sum works contracts. This SBD can also be used for framework contracts with appropriate modifications to the documents. The User Guide to this SBD indicates the circumstances in which its use is most appropriate.

This SBD includes wording for Technical Compliance Selection (TCS) as the required evaluation methodology for works (except for design and build contracts for which this SBD would not be suitable).

Before using this SBD, the user should be familiar with the PPDA Act and Regulations and should read the User Guide to this SBD which has been prepared to provide guidance on the correct use of the Standard Bidding Document (SBD) for Works as a model for preparing an individual Bidding Document.

In the preparation of the Bidding Documents, the urban councils shall refer to the PPDA Act and Regulations, 2003 (or latest) for guidance.

These standards bidding documents has not been included in this Manual, as they may be amended or adapted in future.

4.4 CHAPTER 4: TENDERING FOR ROAD WORKS

4.4.1 INTRODUCTION

This chapter introduces the user to the process of tendering and Figure 4.3 illustrates the key steps in the tendering process.

4.4.2 SELECTION OF BIDDERS

The method for selection of Bidders depends on the procurement method used and whether or not a pre-qualification has been conducted. Refer to the PPDA Act and Guidelines of 2003.

OPEN (DOMESTIC OR INTERNATIONAL) BIDDING WITHOUT PRE-QUALIFICATION

Where Open (Domestic or International) Bidding without pre-qualification is used, the Urban Councils must publish a bid notice, so that bidding is open to all interested bidders. This process uses the standard format provided in the Regulations. Guidance notes on completing the bid notice. The Bid Notice must be approved by the Contracts Committee before publication.

The notice must be published in at least one widely read national newspaper or a publication of wide international circulation, depending on whether bidding is domestic or international. It must also be displayed on the Authority's website and on the urban council's notice board.

The Urban Council must comply with the minimum advertising period given in the Regulations before the issue of bidding documents. They should also ensure that bidding documents are finalised and approved before publishing the bid notice, to avoid any delays in the process.

OPEN (DOMESTIC OR INTERNATIONAL) BIDDING WITH PRE-QUALIFICATION

Where Open (Domestic or International) Bidding with pre-qualification is used, the bidders invited will be those selected during the pre-qualification process. There is therefore no need to publish a bid notice, but the bidding document should be accompanied by an invitation to bid letter. The letter should be approved by the Contracts Committee, at the same time as the bidding document.

In exceptional circumstances, where this document is used under Restricted (Domestic or International) Bidding, the bidders invited will be those included on the shortlist. There is therefore no need to publish a bid notice, but the bidding document should be accompanied by an invitation to bid letter. A sample letter and guidance notes on completing it are included later in this manual.

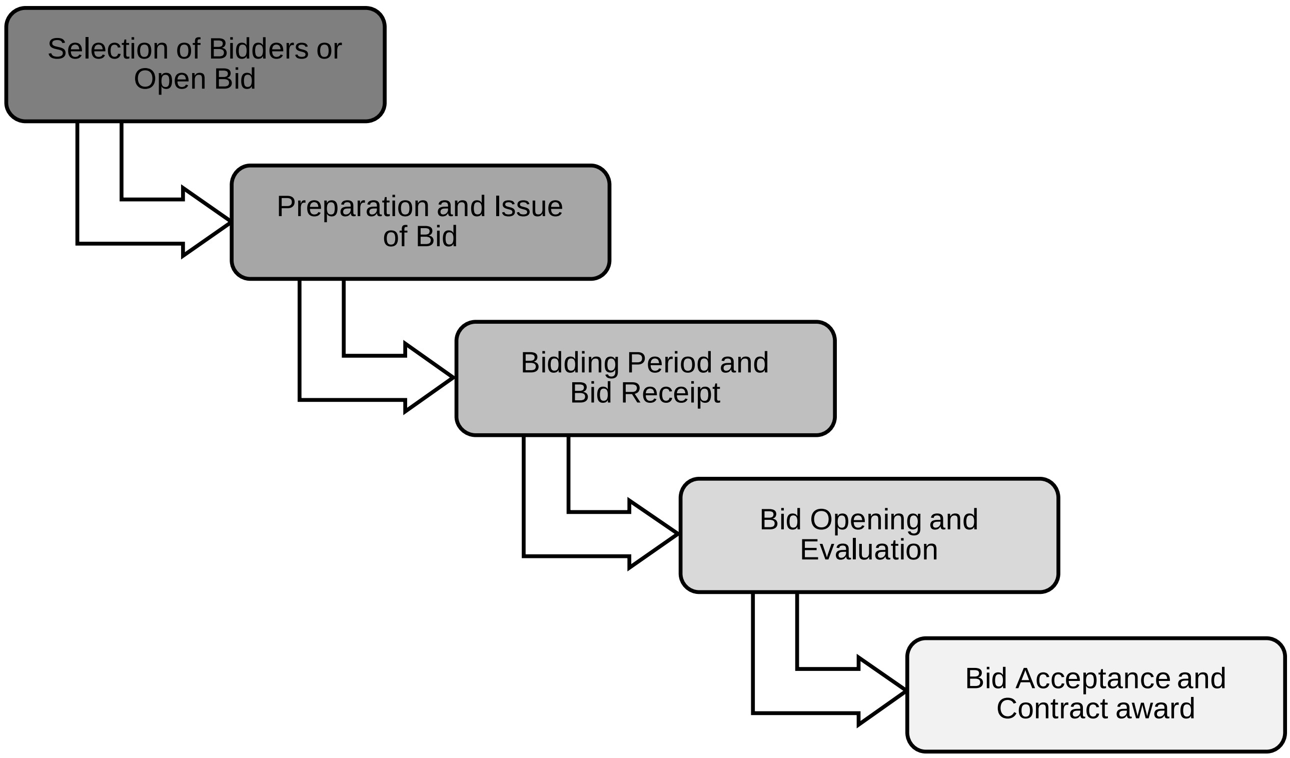


Figure 4.3: Key steps in the tendering process

The letter should be approved by the Contracts Committee, at the same time as the bidding document.

The shortlist must be developed in accordance with the Regulations and include sufficient bidders to ensure effective competition. The shortlist must be approved by the Contracts Committee before issue of the bidding documents.

4.4.3 BIDDING PERIOD AND BID RECEIPT

The Bidder is responsible for Bid preparation and the submission of its Bid. During the bidding period, the Urban Council shall:

- Hold any pre bid meeting and issue minutes promptly
- Promptly respond to requests for clarifications from Bidders
- Amend the Bidding Documents if necessary (only with the Contracts Committee's prior approval)
- Receive and record sealed bids from Bidders or make a Bid Box available up to the deadline for bid submission as required by the Regulations
- Close bidding at the precise date and time of the deadline and ensure that no late bids are received
- Keep all bids received secure until the time for bid opening

AMENDMENT OF THE BIDDING DOCUMENTS

Where the Bidding Document is amended with less than one third of the bidding period remaining, the Urban Council must extend the deadline for submission of bids. The deadline may also be extended where more than a third of the bidding period remains. The period of the extension will depend on the nature of the changes. As a guide only, 5 to 10 days should be allowed for minor changes and 10 to 20 days for major changes.

4.4.4 BID OPENING

The Urban Council is responsible for the Bid Opening, which is a critical event in the bidding process. The Council shall appoint experienced Procurement and Disposal Unit staff (accompanied by a Contracts Committee member to witness proceedings) to conduct the Bid Opening who must be aware that inappropriate procedures at Bid Opening are usually irreversible and may require cancellation of the Bidding Process with the consequent delays and waste of time and resources. The Bid Opening must follow the rules and procedures given in the Regulations.

BEST BID-OPENING PRACTICES TO OBSERVE

The Urban Council in observance of the Regulations and best practices should:

- Conduct the Bid Opening strictly following the procedures specified in the ITB Sub-Clause 25 for all bids received on or prior to the date and time of the bid submission deadline. The term "Bid Opening" can be misleading because a bid for which a Bid Withdrawal or Replacement notice was received in time shall not be opened but returned unopened to the Bidder. The sequence in which bids are handled and opened is crucial.
- Ensure that all bids that were received on time are accounted for, before starting the Bid Opening, as bids that are not opened and read out at Bid Opening shall not be further considered.
- Do not reject any bid at Bid Opening, except for late bids received after the date and time of bid submission deadline. Technically, late bids should not reach the Bid Opening, but in certain cases a Bidder may attempt to submit its bid at the Bid Opening place after the deadline.
- Examine the bids at Bid Opening in accordance with the provisions of ITB Sub-Clause 21. The Council shall, verify at the Bid Opening the existence of the documentation (Power of Attorney or other acceptable equivalent document), confirming the validity of a bid withdrawal, or bid replacement (as specified in ITB Sub-Clause 24). A withdrawn bid shall not be opened and in consequence not read out and, therefore, they shall not be further considered by the Council. Similarly, a bid replacement shall be opened and read out to replace a bid that was received on time.

4.4.5 BID EVALUATION

The Evaluation Committee is responsible for the evaluation of all bids received. In appointing an Evaluation Committee, the Urban Council must remember that mistakes committed at bid evaluation may later prompt complaints from Bidders, requiring re-evaluation of the bids, with the consequent delays and waste of time and resources, hence the need for observance of the Regulations and best practices.

BID EVALUATION

- Maintain the bid evaluation process strictly confidential
- Reject any attempts or pressures to distort the outcome of the evaluation, including fraud and corruption
- Strictly apply only and all of the evaluation and qualification criteria specified in the Bidding Documents to determine the Best Evaluated Bidder and to make a recommendation for award of contract to the Contracts Committee. (The Evaluation Report may recommend also that post qualification and/ or negotiations be held with the recommended Bidder).
- Conduct any post qualification or negotiations recommended in the Evaluation Report.
- Upon completion of the Bid Evaluation, and any post-qualification or negotiations the Contracts Committee shall be requested to make a Contract Award decision. It is important to note that a Contract Award decision is not a contract; it is a decision to award a contract to the Best Evaluated Bidder.

4.4.6 BID ACCEPTANCE, CONTRACT AWARD AND PLACEMENT

Bid acceptance, award and placement of a contract can be confusing for both parties if there is not a precise and specified procedure for award of contracts. The procedure specified in the Regulations provides a sequence of events based on the need to recognize Bidders; rights to appeal against the conduct of the evaluation and the need for a contract to be in place as soon as is practical after a decision to award has been approved. The following procedure is required under the Regulations.

BID ACCEPTANCE AND CONTRACT AWARD

- The Contracts Committee approves an Evaluation Report (and the result of any post-qualification and/or negotiations) and in doing so makes a contract award decision.
- The Council drafts a Notice of Best Evaluated Bidder and displays this in accordance with the Regulations for the prescribed period of time.
- Upon the expiry of the period of time for the Notice of Best Evaluated Bidder, if no appeal has been received by the Accounting Officer, a contract may be placed by:
    1. Issuing a Letter of Bid Acceptance followed (and confirmed by a Contract Document), or
    2. Issuing a Contract Document without a Letter of Bid Acceptance having been issued first.

Contract formation occurs either at the issue of a Letter of Bid Acceptance described in sub paragraph (i) above, or the issue of a Contract Document described in sub paragraph (ii) above.

The Urban Council should note:

- The Letter of Bid Acceptance or the Contract Document should not contain any provisions or conditions which vary from those in the Bidding Document, or the Bidder's bid, or any subsequent clarifications or negotiations. Any such modifications should be agreed by the Bidder in writing before a contract award decision is made.
- There is no provision for a Letter of Intent or a Letter of Intention to Place a Contract as there is much legal ambiguity surrounding the use of such documents.

The Contract Document comprises those papers contained at Section 9 of the Bidding Document (Contract Forms), and it is at the stage of contract award that these can be completed with details as agreed with the Bidder.

4.5 CHAPTER 5: SUMMARY

This Volume provided an outline of the preparation of documents required to carry out the tendering process. In order to have a realistic document, the Bills of Quantities must be accurately prepared, and it is therefore essential that data and information required is collected and analysed so that realistic cost estimates can be obtained from the bidders. Documents comprising the Tender Documents are prepared for the purposes of acquiring the services of contractors for the works.

The technical personnel in the Works Departments should have the necessary competence in terms of skills, knowledge, and experience in order to prepare proper Engineer's Estimates and procure the right service provider to execute the maintenance or improvement works within the time and budget limits.

The Volume provides the following key BOQ and tender documentation information:

- Information source for the preparation of tender and contract documents
- The factors to consider when preparing a BOQ to be incorporated in the tender documents
- The factors to consider when preparing Engineer's Estimates for Tender Evaluation
- The tendering processes for Urban roads maintenance and improvements works
- Standards to be used and complied with in preparation of tender documents, tendering and evaluation, preparation of contract documents.

Table 4.1 Summary of Questions for the Preparation of Bills of Quantities and Tender Documents

What information is required for the preparation of Urban Roads Tender and Contract Documents?	Where do I get the data required from?	What are the standards Specifications used?	What is the outcome?
1. Bill of Quantities	• Field Assessments • Designs	Standard Format Appendix 17	Tender Document
2. Other Procurement Documents, such as • Invitation to Bid • Instructions to Bidders	PPDA Guidelines	PPDA Standard Formats	
3. Engineer's Estimates	MOWT Unit Rates in Appendix 18	Standard Format Appendix 17	Estimates for Evaluation of Tenders
4. Evaluated Tenders	Evaluated Tenders and Contract Forms	PPDA Guidelines	Contract Documents

5 VOLUME 5: CONSTRUCTION AND MAINTENANCE MANAGEMENT GUIDELINES

Volume 5 Table of Contents

5.1 CHAPTER 1: INTRODUCTION

5.1.1 BACKGROUND & OBJECTIVE

This volume contains guidelines on how to effectively manage the construction and maintenance of urban road works. The volume assumes that the urban road works falling under the "Major" category shall be executed by contracts, while the "Minor" works may be executed by either contract or by use of force account. For major road works, this volume outlines how to manage and administer the process during the pre-construction, construction, and the defects liability periods. For Minor works, it outlines the procedure on how to manage the process.

The objective of the volume is an understanding of:

- The main steps in the Construction Management Process for Major Works
- The main steps in Roads (Routine) Maintenance management for Minor Works
- The role of Urban Councils as a "Client" in Construction and Maintenance
- The role of contractors in urban road works.

5.1.2 BASIS FOR MANAGEMENT OF CONSTRUCTION AND MAINTENANCE FOR MAJOR WORKS

Following the planning, designing and procurement of contractor services for roads works, the next process is the construction process. After construction, the road asset must be preserved through maintenance (defects liability period). It is during the construction and maintenance periods, that management plays a key role in achieving the required standard and timely delivery of the works.

5.1.3 KEY FEATURES IN THE MANAGEMENT OF CONSTRUCTION AND MAINTENANCE OF MAJOR ROAD WORKS BY CONTRACT

KEY FEATURES

The key features in the construction and maintenance management for major works are:

- The pre-construction period management
- The construction period management
- The defects liability period management

The main stages of the construction process are Planning, Designing, Procurement, Construction and Maintenance. Figure 5.1 outlines the construction and maintenance process for Major road works.

PRE-CONSTRUCTION PERIOD MANAGEMENT

During this period, the contracting authority carries out the following:

- Planning of road works
- Detailed design and costing of road works (usually done by external consultant)
- Procurement of contractor, engineer/supervisor
- Preparation of the contract documents
- Signing of the Contracts
- Issuing instructions to the contractors to commence works.

It is important at this stage to understand the following general terms:

1. What is a Contract?

A contract may be defined as an agreement between two or more parties creating mutual obligations enforceable by law. The basic elements of a contract that can be legally enforced are:

- mutual assent by all contract parties,
- valid offer and acceptance,
- agreed consideration and capacity documentation.

In road works, a contract document defines the offer as described below, and similarly the parties involved together with additional details of contractual undertaking such as quality of work, schedule of work, quantity of work, etc.

2. Types of Contracts

While there are many types of contracts, public authorities such as the urban councils often use admeasured (Bill of Quantities) Contracts. This comprises of a completed design, drawings, specifications, and Bill of Quantities. This type of contract offers the following:

- A common basis for competitive bidding,
- An estimate of the cost of the job,

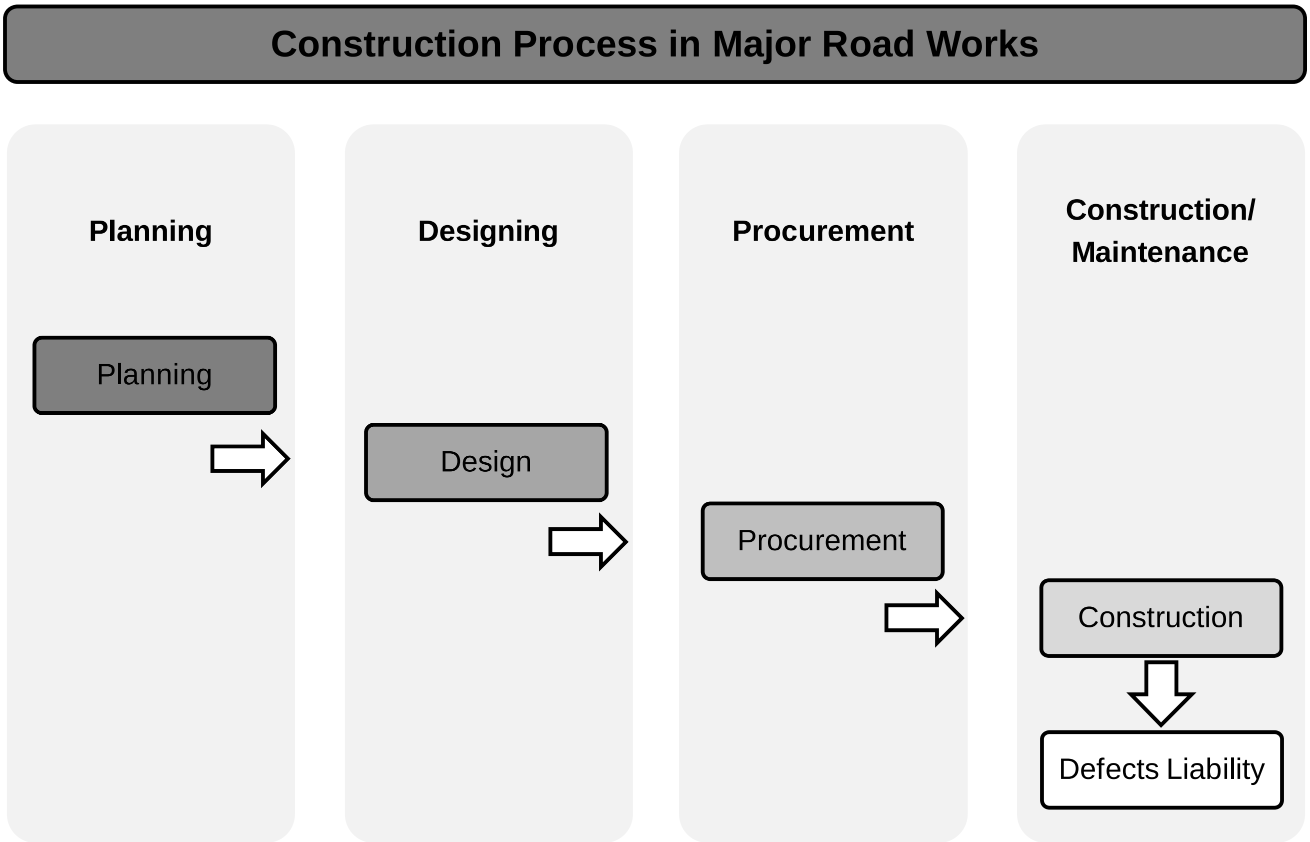


Figure 5.1: The Road Works Construction Process in Major Road Works

- Provides a basis for paying the interim certificates and final accounts,
- Provide a basis for valuating variations.

Depending on project complexity, conditions of contract may be drawn from National Public Procurement and Disposal of Public Assets (PPDA) guidelines or other international conditions of contract such as International Federation of Consulting Engineers (FIDIC).

In some other instances, especially where the road works scope is somewhat complex and with a pressing schedule, the Urban Authority may opt for Design and Build type of contract. In this type of contract, the Urban authority will procure a Design and Build contractor to prepare detailed project designs and then construct the approved designs. Procurement of Design and Build contractors will be based on 'Employer's Requirements' so it is imperative that the Urban Authority has competent staff to prepare detailed and clear 'Employer's Requirements' when opting for this type of contract. Design and Build contracts are often lumpsum contracts with periodic or interim lumpsum payments based on a schedule of prices.

3. Contract Documents

The user is specifically referred to the latest guidelines and publications issued by the PPDA as relevant. Contract documents should be drawn with the latest PPDA documents or latest documents of any other conditions of contract being used. Nevertheless, contracts are compiled to a standard format as follows:

- Form of Tender and Appendix to Form of Tender
- Form of Agreement
- Conditions of Contract
- Special Conditions of Contract
- Drawings
- Specifications
- Bill of Quantities or Schedule of Prices

The description of the above documents is included in Volume 4.

4. Parties involved in construction contracts

The parties involved in the construction and maintenance contract management include:

- The "Employer", at times referred to as the "Client" is the owner of the Project. In this case it is the urban council.

- The Supervisor, at times referred to as the “Engineer” or “Project Manager”, can be the Employer (urban Council Engineer) or a consultant appointed by the Employer to supervise the contract on its behalf.
- The Contractor is the person who has been selected by the Employer to execute the contract.

CONSTRUCTION PERIOD MANAGEMENT

After issuance of commencement instructions to the contractor by the Employer or Engineer, the Contractor will commence mobilization and construction works as per contract requirements. Some of the key activities to be undertaken by the Contractor after receipt of commencement instructions include:

- Mobilization of staff and equipment, and submission of mobilization plan
- Submission of works program
- Acquiring municipal and other statutory licenses to undertake works (e.g., environmental certificates, etc)
- Commencement of construction works

During the initial period of construction, the Urban council should diligently supervise mobilization activities are undertaken by the contractor as required by contract to avoid delays in executing the contract.

The Urban Council through its staff or appointed representative such as the ‘Engineer’ will then supervise works to ensure that all construction work is undertaken on schedule, to cost and to the required quality. Some of the tools used during this period will include project quality management plan/manual that outlines work testing methods and approval processes, interim payment certificates for cost management and regular review and update of work programs to ensure practicality.

Progress reporting is a key tool to tracking overall performance of the project during construction. Through progress reports, urban councils can monitor cost, quality and physical performance of the contract and undertake any necessary correction/management measures.

During the construction period, it is also vital for open and regular communication channels to exist amongst all contract parties such that all project issues and risks are proactively discussed and managed thereby reducing uncertainties and threats to successful project completion. This may be achieved through monthly progress meeting and brief weekly technical meetings during the construction period.

DEFECTS LIABILITY PERIOD MANAGEMENT

This period is commenced after practical completion of construction works for a period specified in the contract, normally 6 – 24 months. During this period, the Contractor will correct any work snagged at practical completion under the supervision of the Urban Council and/or Supervisor. During this period, the Urban Council and/or Supervisor should routinely carryout out inspections to identify any defects on the completed work, and then instruct the Contractor to correct any defects satisfactorily within the Defects Liability Period (DLP) before issuance of the Defects Liability Period Certificate and Certification of the Contractor’s Final Accounts.

Urban road projects present unique circumstances for the defects liability period in that there might be significantly increased usage of roads soon after practical completion, especially for areas with a relatively under-developed road network. This increased usage of newer roads in urban roads may result in ‘contentious defects’ during DLP. Therefore, management of DLP should be proactively discussed pre-contract by the Contractor and Urban Council, with clear defects identification criteria and correction methods included in the contract documents. Urban Councils also ought to critically analyse and adopt practical DLP durations taking in consideration work scope, complexity, location, etc.

ROLES OF VARIOUS PARTIES

As mentioned above, there are three main parties involved in a works contract, the roles, responsibilities, and obligations of the parties may be summarized as follows:

1. **Role of Urban Council as the Employer/Client includes:**

- Supervise and monitor the project using the guidelines provided in PAF Monitoring or other available guidelines.
- Make payments on the recommendation of the Urban Council Engineer and or a Consultant appointed by the Urban Council to supervise the works on its behalf.

- Provide necessary support to the Supervisor or Contractor to engage relevant stakeholder such as local communities, other public bodies, etc.

2. The Role of the Supervisor or the Engineer

The “Engineer” or “Consultant” is employed by the Client to supervise the works as an agent of the Client to ensure that the contractor complies with the contract. In doing so, the Engineer/Supervisor shall:

- Issue instructions to the contractor
- Supervise the work on a day-to-day basis
- Issue variations
- Check valuations, final accounts, and claims
- Approve certificates for payments
- Evaluation of Claims
- Coordinate between the various parties both within the contract and outside
- The supervisor/engineer is expected to act impartially, honestly and with professional integrity towards both parties to the contract.

3. The Role of the Contractor

The “Contractor” is a person, persons or company whose tender has been accepted by the client. Under the contract the Contractor undertakes the following:

- Receive instruction on the assignment
- Execute the works as per the contract
- Undertaking the maintenance works
- Correct any defects identified by the Employer or Supervisor
- Hand over works upon completion.

5.1.4 BASIS FOR MANAGEMENT OF MINOR MAINTENANCE WORKS

Maintenance works activities are routinely determined during the Field Assessment, and during this period the degree of difficulty of each of the work items are determined to decide on the best technology for implementation in order to meet the requirements of the Technical Specifications. In other words, whether the Contract be labour-based, equipment-based or a combination of the two or by force account. Figure 5.2 illustrates these options.

However, in order to maintain a sustainable and sound road network, maintenance works need to be undertaken under a well-planned road maintenance program. Hence, Planning is the first step to any road maintenance. Urban councils should develop and follow road maintenance programs to realize better performing road networks in a cost-effective way resulting from well planned, resourced, and timely maintenance interventions. The maintenance program should among other things include schedule of road condition surveys, road condition assessment guidelines/references, road condition rating criteria, guidelines on selection of appropriate road maintenance interventions, description of possible road maintenance interventions (including labour based or mechanized interventions), budget estimates for planned maintenance, etc.

There should also be regular reviews, preferably yearly at minimum, of the performance of road maintenance by the Urban Council. This review of maintenance activities will assess performance of maintenance programs and interventions and highlight critical areas for improvement.

As much as practically and technically possible, Urban Councils should utilize labour-based road maintenance interventions. Labour based road maintenance interventions provide cost-effective road maintenance options, directly reduces urban unemployment, and may also increase ‘ownership’ of road assets in a community.

Figure 5.2 summarizes a typical road maintenance process as managed by an Urban Council.

Chapter 2 details the process of supervision during the execution of the contract for major works (Construction, Maintenance and other improvement works).

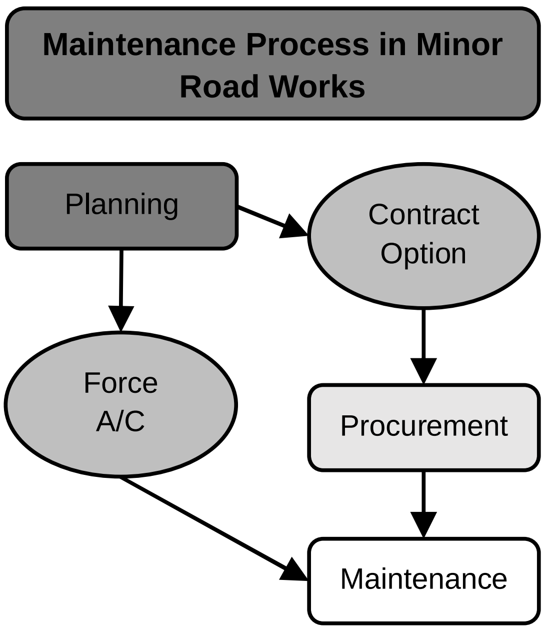


Figure 5.2: Minor (Routine) Works Execution Options

5.2 CHAPTER 2: MANAGEMENT OF CONSTRUCTION FOR MAJOR ROAD WORKS

5.2.1 INTRODUCTION

The management of construction for major road works under contract is the obligation of the Supervisor/Engineer/Project Manager where one has been appointed by the Urban Council. If no Supervisor/Engineer has been appointed by the Urban Council, the Urban Council will through the appointment of competent technical staff, supervise major road works.

Where a supervisor is to be procured by the Urban Council to oversee construction works, the Urban Council should schedule procurement activities to ensure that the Supervisor is appointed in-time to supervise the Contractor at commencement of works. This will ensure that there are no supervision gaps at commencement which may threaten project success.

The management of construction process is divided into six different and complementary groups of activities as follows:

1. Project Start up activities
2. Design review
3. Contract administration
4. Construction Management
5. Defect Liability period
6. Reporting

5.2.2 START UP ACTIVITIES

- **Start-up meeting with Employer and Contractor** to introduce the client, contractor, and supervision team, review all technical, administrative, and contractual documents and the supervisor prepares the minutes of the meeting.
- **Start-up meeting with Supervision Team Personnel** to define each other's roles and responsibilities, timetable, and budget for the work. The minutes of the meeting should be prepared by the supervisor and distributed to everyone.

DESIGN REVIEW

This is to be conducted by the supervisor/engineer who will prepare a design review report. The review should include the following:

- **Review Organisation and Mobilisation procedures** of the supervisory team, review of contract document and drawings to ensure that the contractor has the necessary documents to commence work.
- **Review of Materials Survey Information** to verify the information provided in the design documents and carryout additional field investigations to identify or confirm material borrow sources if necessary.
- **Survey Data Checking** of the centreline, structures and earthworks setting out information, checking the coordinates, condition of the installed control benchmarks and topographical survey data to ensure complete compatibility with the construction drawings. Where required, traffic surveys will also be reviewed and additional traffic surveys (MCCs, Axle Load, etc) carried out to verify traffic data used for design.
- **Detailed Design Confirmation** which should focus on confirming geometric design, pavement design, structural design, and drainage design to ensure that they are in accordance with current standards, manuals and published guidelines and existing ground conditions at project implementation. Update detailed designs, drawings, BOQs, etc as necessary for approval by the Employer.
- **Review of Road Safety Audit** by assessing the effectiveness of the road safety features, and where necessary recommend additional safety measures that may become necessary after the completion of the designs.
- **Relocation of Services** which includes a survey of existing utility services and liaise closely with authorities concerned on the proposed relocation of such services.
- **Review of ESIA** which includes review of ESIA report to check completeness of the report and adequacy of recommended mitigation measures, proposing improvements where necessary to ensure that project works are safe, gender and social sensitive and environmentally friendly.
- **Risk Analysis** of key uncertainties the project faces and how these uncertainties are to be managed so that the project is completed to schedule, to specification and within budget.

Where practically possible, design reviews for major road works should commence 3 to 6 months prior to commencement of construction works. This will enable incorporation of any proposed design amendments with minimal disruption to the construction schedule/program and budget if the design review is undertaken simultaneously with construction works.

5.2.3 CONTRACT ADMINISTRATION

This activity should be carried out in parallel with the works supervision and quality control activities. It deals with the management of the contract especially with tasks that are routine and periodical (quantity, records, monthly certificates etc.) This is the responsibility of the supervisor/engineer.

1. Preparatory Tasks

- **Preparation of Quantity Records** to ensure accurate records of the contract advancement in terms of quantities. This is done monthly with joint measurements with the contractor's team of contractual quantities. All quantities should declare that work has been done in the last period are measured and evaluated.

- **Sureties**, all sureties, bank guarantees, performance bonds required for the contract are received by the client, stored in safe custody, and released after completion of the contract.

- **Review of Contractor's Resources (Plant, Personnel, Facilities)** to ensure that the plant and equipment are in suitable condition, are as required per contract and are compatible with the nature and quantities of the work to be performed, that the contractor's key personnel are adequate to the task and that the staff are suitable experienced to undertake the tasks. Contractor's resources should be monitored regularly (daily, weekly, and monthly) throughout the contract duration and the Contractor should be notified whenever mobilization is below the required threshold.

- **Insurances** required by the contract should be provided by the contractor. The renewal dates of all policies should be recorded in the project programme to ensure that no policy is allowed to lapse during the course of the contract.

2. Implementation Tasks

- **Measurement and Financial Management** this include; keeping a record of statements of work done and materials used; reviewing the Contractor's monthly quantity reports and claims for payment for work executed; preparing interim payment certificates for forwarding to the client; verifying and correcting repayment of advance if required; responding to the queries or discrepancies; preparing Variation Orders; ensuring that variation of price provisions are implemented in accordance with the contract and that valid substantiating documentation is produced.

- **Management of Contractors Claims:** The supervisor/engineer should ensure continuous communication framework with the Contractor and Employer in order to avoid, as much as possible, any claims. If the contractor or Employer declares a claim, the supervisor/engineer should use all the expertise available to analyse the Claim and recommend settlements to Employer and Contractor. There should be an attempt to settle claims through open discussion to minimise escalation to disputes; this may be achieved by organizing meetings with the Contractor/Employer and presenting alternatives and cost analysis.

- **Organisation of Periodic Site Meetings and visits** involves organizing and setting agenda for weekly and monthly site meetings with the contractors' and employer's representatives; arranging the participation of representatives from other entities as the need may arise; issue brief minutes of meetings to all participants in the 5 days following each meeting and conducting periodic site visits to assess progress generally and the works conformity with the construction documents.

- **Coordination with the contractor's design team** involves receiving reports from the contractor's design; conducting regular exchanges with the contractor's design to ensure that construction work meets the intent of the project's design; monitoring and reviewing the record drawings kept by contractor; review and coordinate the reviews by the contractor's design and during the post construction warranty period, management of the performance of the works and verification of the completion of the remedial work by the contractor and his design.

- **Work Programme/Schedule Analysis and Approval** involves maintaining an up-to date schedule/work programme at all times so that potential delays may be recognized well in advance and remedial action taken. The Contractor prepares and submits Schedules/programme to the details specified in Clause 14.1 of the FIDIC General Conditions of contract or Clause 27 PPDA General Conditions of Contract showing the sequence in which he proposes to carry out the Works. In developing, reviewing, analysis and approval of the work schedule, the supervisor/engineer should work closely with the Contractor to arrive at realistic task start, duration, and completion times, bearing in mind local conditions and seasons, particularly the potential effect of heavy rain and flooding to disrupt certain activities, such as surfacing works. If delays occur in the course of the project, the supervisor/engineer should bring this to the Contractor's attention and should assist the Contractor, as required, to develop measures to accelerate the progress of the works to ensure timely completion.

- **Administrative/Variation Orders to a Contract** if required, the supervisor/engineer prepares a detailed report on the description, justification, and cost for each change. The supervisor/engineer should then make his recommendations to client on the cost required to complete the Contract. When a cost increase is approved by the Client, the supervisor/engineer will prepare the official Variation Order in an approved format for the Contract.

- **Management of Risks and Elimination of Constraints** involves identification of risks well in advance and proposes mitigation measures. Problems in road works may arise due to inability to obtain the local resources and support needed for the timely completion of the project and unforeseen delays to key events in the programme caused by factors outside the control of the Contractor and the supervisor/engineer. The factors most important to guard against or cater for include adequate materials in sufficient quantities; unseasonable weather and high river flows and or floods; equipment breakdown; inability to meet quality standards or programme deadlines and risk or any emergency affecting the safety of life or of adjoining property; epidemics/pandemics.

- **Organising of a provisional taking over of completed works**. This is done jointly with the Contractor to the provisional taking-over of completed portions of the works. It requires the inspection of the works and observation/snagging of deficiencies and is the start of the defects liability period for the portion of the works taken over. Both the supervisor/engineer and the Contractor should record all observations in a document that should be signed by all concerned. The document should include pertinent recommendations as to the receivability of the works, retention of certain monetary amounts until deficiencies are repaired, etc. and forwarded to the client. The client may attend these inspections.

5.2.4 CONSTRUCTION MANAGEMENT

This is the responsibility of the supervisor/engineer and shall consist of the following:

PRE-CONSTRUCTION ACTIVITIES

- **Review Organisation and Mobilisation** of the Contractor's team and contract documentation and the drawings to ensure that the Contactor has the necessary documents to enable him to commence work.

- **Review and approve contractor's work program and methods**, design criteria, delivery schedule and construction methods before the beginning of work and to review work scheduling in order to ensure that the project's schedule is respected.

- **Contractor's site installations and camps** should be in agreement with the conditions of the contract. Additionally, the list of equipment incorporated into the project should be in agreement with that submitted in the contractors' tender; and the installations should be in accordance with the client's, municipal/city, and national regulations. The contractor's site installations (camps, casting yards, laboratories, etc) are the heart of construction supervision operations and must therefore be efficiently planned and well positioned within the contract limits. The acceptance of the contractor's site installations and equipment forms the basis for the payment of the mobilisation item.

- **Establish Procedures for Contract Management**. This is done to ensure that the contractor understands and applies the procedures needed in order to establish sound contract management practices and respect of time frames, quality and budgets which forms basis of good contract management. The supervisor should establish and communicate the standard forms to be filled out by the Contractor periodically (daily, weekly, monthly, quarterly, annually, etc) including measurement sheets, weather records, site dairies, the bill of quantities, the updated schedule, the cash flow, and the required planning for the next period. These documents should be prepared by the contractor and approved by the supervisor per relevant period.

- **Standardise Forms and Procedures**. A representative list of forms and procedures to be reviewed in preparing these guidelines is shown below.
  a. Work Orders, Change Orders (Format for Variation Orders).
  b. Format for Certificate of Substantial Completion.
  c. Formats for Monthly and Quarterly Progress Report.
  d. Procedures for quality control (Earthworks, Subbase and Base, Bituminous Surfacing).
  e. Guidelines and forms for soils/materials testing.
  f. Guidelines for evaluating Contractor's work schedule.
  g. Checklists for inspection.
  h. Written interpretation of any of the specifications and other contract documents which are ambiguous or open to misunderstanding.
  i. Forms for construction records relating to labour and materials.
  j. Format for the Site Diaries and Weekly/Daily Project Diaries.
  k. Format for official correspondence and communications.
  l. Format for minutes of meetings.
  m. Guidelines for project record keeping and filing.
  n. Guidelines and forms for conducting preliminary hand over and final hand over inspections.
  o. Requests form (Request for Inspection, etc) and orders/instruction forms given to the Contractor.
  p. Measurement Sheets

CONSTRUCTION QUANTITY MANAGEMENT/CONTROL

- **Review Survey and Material Information** is to verify that the contractors' survey control points, staked out alignments, beacons and benchmarks are exact and ensure that the site construction is properly started with the right localization in plan and elevation. The supervisor/engineer should focus on the following aspects: verification of the staked-out alignments and all traverse points, control points, benchmarks as set out by the contractors; verification of the adequacy of borrow pits and quarries; seek information from the contractor on the planned material sources, supply and testing of construction materials and components inter alia and; request the contractor to submit mix design proposals, and provide comments and approvals before the commencement of work.

- **Review Methods for Quantity Measurement** requires establishing with the contractor a workable method which allows fast accurate and reliable quantity measurement. The supervisor/engineer uses compatible quantity measurement techniques in order to facilitate joint measurement and quantity calculations. Based on the conditions of contract and the latest MoWT General Specifications for Road and Bridge Works guidelines, derive a method of quantity measurement that is acceptable to all parties.

QUALITY MANAGEMENT & CONTROL

Establish Quality Control Procedures. Quality Assurance System should include:

a. Procedure for selection and approval of material sources, quarry and borrow area operations, bituminous products, stabilizing agents, reinforcement, etc.
b. Procedure for storing of materials to be used in pavement and other permanent works
c. Type, frequency, and procedure of tests for different kinds of materials and related pavement works
d. Norms and procedures for control of alignment, surface regularity for pavement layers and concrete structures
e. Works and workmanship regarding temporary works of various types
f. Organization of materials testing laboratory (personnel and equipment)

g. Equipment and organization for field tests and sampling for laboratory tests
h. Norms for sampling of materials from stock-yards during laying and finished works
i. Procedures for monitoring of compaction equipment and field compaction
j. Procedures for monitoring asphalt plants during production, laying and compaction
k. Procedures for monitoring concrete production, laying, and compacting concrete
l. Tests of concrete for strength including its ingredients and mix designs
m. Formats for recording and compilation of test data
n. Reporting system for test results and for actions to be taken in respect of quality

Review and Approve construction material sources to ensure that sufficient and adequate material sources are available within the quality standards specified in the contract documents before the start of works. The supervisor/engineer should review the proposed material sources, review the necessary tests to be performed for quality assessment, should ensure the conformity of the results of these tests with the technical specifications and assess the availability of each material in terms of quantity. Appendix 19 shows the necessary Quality Assurance measures at the disposal of the supervising Engineer.

ENVIRONMENTAL/SOCIAL MANAGEMENT

- **Review Contractor's Safety Program** to ensure that the contractor possesses and enforces a Safety Program adapted to the specific work he/she is requested to do and safety in the workplace for the contractors' workers. The supervisor should review the contractors' Safety Program, propose changes if necessary and ensure that the program is implemented throughout the contracts' duration. For this purpose, a Safety Committee in which all parties are represented should be established. Any safety deficiencies encountered on the construction site should be immediately pointed out to the contractor and corrections should become the first priority at all times. Safety equipment should be maintained on the site for the whole duration of the project.

- **Gender Mainstreaming, VAC and HIV/AIDS;** Supervisor should ensure that work is undertaken in compliance with the latest national and local policies on gender, HIV/AIDS and protection of minors (limiting violence against children, VAC)

- **Review Contractors Traffic Management Programme:** This is done to optimise the Contractor's Traffic Management Plan in order to minimize the impacts of work on the flow of traffic while respecting special event requirements and ensuring safety for all concerned. Given the relatively high volumes of traffic on urban roads, it is critical that the Contractor develops and implements a holistic traffic management program.

  Development of a traffic management program requires close and continued communications between the clients, the contractor and supervisor. Where necessary, traffic simulation may be required to validate route re-assignments/road closures in the traffic management program if road construction is taking place in congested urban areas. Necessary communications should be made to all affected travelling public well ahead of work in order to permit transit adaptation. Public notices as well as a communications program (radio, newspaper, social media, etc) should be utilised.

  The activities to be undertaken should include: review of the Contractor's drawings illustrating the detour requirements including pavement markings, regulatory warning and detour signing; allowances for pedestrian and cycling movements; attendance at site meetings; review of the Contractor's progress claims and review of progress of current work; assistance in the implementation/coordination of the traffic management; assistance in the warranty review activities and; assistance in the verification of the project record documents. It is recommended that electronic signals and warning signage such as LED signs are part of traffic management systems on urban roads.

TECHNICAL CONTROL AND CONSTRUCTION SUPERVISION

This activity is the core of the Supervisor's mandate. It involves all the daily activities that ensure that works are executed correctly and in accordance with the drawings, specifications and best construction practices. It also involves the quality control of the materials and of the finished work.

Schedule/Time and Cost Management

Issue Work Orders/Instructions as to indicate in writing to the Contractor instructions related to specific work to be conducted following regular inspections and observed non-conformities or related to safety issues. Work orders resulting in additional work with financial impact are directed to the Supervisor/Engineer to review and to the Client for approval with all relevant explanations and recommendations.

Economic and Financial Control

The supervisor/engineer should establish complete control of the development of the project from an economic point of view. Where allowed for in the contract conditions, price adjustment should be applied as appropriate. At the end of each month the Contractor should submit his statements (in a format agreeable to the client) detailing the work executed up to the end of the month. Together with the statement, all relevant measurement sheets and quantity schedules should be submitted.

The supervisor/engineer should inform the Contractor in advance and then check this report for payment making measurements jointly with the Contractor as required. After checking and making any revisions, the supervisor/engineer should sign the Certificates and transmit them to the client for processing and payment. A sample format for Measurement Sheet and Payment Certificate is appended as Appendix 20.

In the course of the project, the supervisor/engineer should ensure that all the Contractor's interim certificates (and payments) are fully justified on the basis of work satisfactorily completed and approved. All work measurements should be reviewed, certified and recommendations made monthly for payment of the Contractor's invoices.

The overall financial management of the project should include the following services:

- keeping a record of statements of work done and materials used
- reviewing the Contractor's monthly quantity reports regarding payments and claims
- preparing interim payment certificates for forwarding
- preparing Variation Orders including rate analysis, if any
- ensuring that variation of price provisions is implemented in accordance with the contract and that valid substantiating documentation is produced; costing and making recommendations for any design change orders by the client and evaluating their impact on overall project budget
- general assistance to the client with administrative and financial matters relating to the project.

Quantity Management & Control

Quantity measurements verification and procedures

- Monthly measurements of quantities are required in order to verify the Contractor's payment certificates and to assess progress of work vs. planning. This information should be shared with the Contractor and agree on final payment quantities. Particular care should be ensured for the measurement and recording of the more sensitive units, or units of work likely to be the subject of claims, or work performed under protest from the Contractor.

Completion of Daily work logs and Photographs

- This is undertaken to keep a daily accurate account of all activities and conditions taking place on the construction site. Work logs and relevant photographs are especially useful in case of disputes resulting in possible claims or when important delays occur in the course of the contract. Data consigned includes among others number of personnel on site, equipment, material delivered, accidents, type and extent of work carried out, weather conditions, detailed activities, work hours, visitors, work orders delivered, tests carried out and their results, and any other incident encountered that could eventually impact on the project in any way.

Quality Management & Control

Inspect works for compliance with drawings and specifications

- This is carried out in order to ensure that works carried out by the Contractor are in accordance with the agreement, approved drawings and technical specifications. The Supervisor's mandate is to make sure these conditions are respected and to timely request corrections each time undue or unapproved differences are observed. Day to day inspections and observations are compiled on site and compared with the construction drawings.

Quality of Materials and Workmanship Control

- This is undertaken to ensure that all materials that are incorporated into the works comply with the quality standards set forth in the contract documents; and confirm that workmanship meets quality standards specified in the contract documents.

The characteristics of materials should relate among others to:

- For the road and infrastructures sub-base and base materials (sand, gravel): grain size, percentage of fines, presence of organic matter, strength of grains etc.
- For concrete works: mix design, quality of aggregate, quality of cement, quality of water, reinforcing agents (polymers), etc.
- For asphalt concrete mixes: mix design, quality of aggregates, quality of bitumen etc.

Workmanship verification will relate among others to:

- For the roads and infrastructure; degree of compaction of sub-base and base materials (sand, gravel), and thickness of different specified layers
- For concrete works: extent of demolition, surface preparation and rehabilitation
- For asphalt pavement density, thickness, transverse and longitudinal slopes etc.

Environmental & Social Management

<u>Traffic Maintenance and Local Access</u>

- It is critical that traffic flow is maintained throughout the construction period with minimum disruption. To attain this, the Contractor is required to submit traffic control plans for the sections of the works where interaction with existing traffic may occur. These plans should be discussed with the Contractor before approval, and modified, if so required.

<u>Traffic safety</u>

Items to be considered in these plans are:

- Planned detours and their maintenance
- Traffic control plans – detour and caution signs or lights, guards, watchmen, fencing etc.
- Maintenance of access to properties along the road
- Methods for keeping traffic off newly constructed pavement
- Diversion plans for drainage structures
- Temporary structures to carry traffic during construction must be structurally and hydraulically adequate
- Dust containment measures, particularly in built-up areas

<u>Environmental Control & Monitoring</u>

- The Supervisor should be responsible for an effective monitoring programme to ensure that the Contractor complies closely with required environmental impact mitigation measures. All environmental monitoring activities should be fully documented and submitted as part of the supervisor’s monthly and quarterly Progress Reports, as well as summarized in the Project Completion Report.

<u>Environmental safety</u>

Issues requiring special attention include:

- Provision for road safety, including traffic regulations and warning signs during construction such as temporary road signs and markings
- Deviations and haul routes (length of routes, warning signs, measures to keep dust levels down, use of material)
- Dust emissions and effluent discharge from construction activities
- Protection of water sources (including prevention of runoff into streams/rivers and water sources that are used for construction activities, and for workmen’s camps)
- Disposal of construction debris
- Occupational health and safety of workforce (including conditions of work, and conditions in the workmen’s camps)
- Excavation methodology and rehabilitation of quarries and gravel pits (landscaping and re-vegetating).
- Prevention of soil erosion during and after construction works
- Adequacy (in environmental terms) of special parking areas for heavy vehicles at main centres.
- The Supervisor shall recommend to the Client to issue a Certificate of Environmental Restoration. A sample format is appended as Appendix 22.

<u>Social Impact Monitoring</u>

- The Supervisor should closely monitor the procedure applied and the subsequent progress of any possible reallocation/resettlement of the local population in relation to the Road Project and should ensure that adequate and suitable communication with the local councils and the local population is established thus ensuring a high level of understanding of the purpose of the road and subsequent reallocation is achieved. The progress of possible resettlement should be included in the month progress report.

Works Safety

- The Supervisor should closely monitor the Contractor's arrangements for safeguarding his workforce and if found required, direct the Contractor to immediately take any necessary, additional safety measures to effectively protect his workforce and the supervisor at all work sites. These should include such measures as additional protective clothing, reflectors on clothing, lights, guards, fencing, watchmen, signs, and/or a change to less dangerous work methods.

Note: Overall, management of quality, quantity and cost aspects of construction work should always be done in accordance with the latest MoWT General Specifications for Bridge and Road Works.

5.2.5 DEFECTS LIABILITY PERIOD

Works inspection during defects liability period and final acceptance is to ensure that all deficiencies noted during the taking over of completed works inspections are repaired and that the behaviour of the finished works is in accordance with the contract requirements. The warranty and defects liability period allows the contractor to repair all deficiencies observed to the satisfaction of the supervisor/engineer and the client. This is communicated to the contractor by the issuance of a Defects Liability Certificate by the client upon a recommendation from the supervisor/engineer. A sample format of this Certificate is appended as Appendix 21.

Final Certificate and Final Account; The Contractor is scheduled to submit the Final Payment certificate on completion of the work. The supervisor/engineer should discuss with the Contractor and client on any unresolved claims/accounts of the Interim Bills and a format to be evolved to prepare the Final Certificate. The supervisor/engineer should scrutinize and certify all bills and should assist the client with settlement of claims, bills and account on satisfactory completion of the project. In the end the supervisor/engineer will recommend to the Client for the issuance to the contractor a Certificate of Completion. A sample format is appended as Appendix 23.

5.2.6 REPORTING

The following reports are required by the client and other stakeholders and the supervisor/engineer shall be responsible for the preparations:

- **Design Review Report** should provide a record of the method of review and the conclusions reached on each component of the design. All changes in design or documentation found to be necessary should be listed and described, with reasons given. If any additional investigations work is undertaken, a full description of this should be included.
- **Daily Reports** shall record all events pertaining to the administration of the contract, requests from and orders given to the contractor, weather, equipment, workforce, work fronts, and any other information which may at a later date be of assistance in resolving queries which may arise concerning the execution of the works.
- **Monthly Report** should be submitted to the client within the first week of the succeeding month and should provide a brief, but comprehensive end of month progress assessment for each contract. It should include schedules of claims and variation orders, tabulated and graphical representations of physical and financial progress compared with the work programme and cash flow forecasts, relevant photographs and details of impediments to the works and proposals for overcoming them. The reports should also include information on contractors' plant, equipment and staffing, weather conditions, accidents on site and any other relevant details.
- **Quarterly Progress Report** is a summary of the monthly report over a period of three months.
- **Special Reports** are required whenever particular events take place and/or are requested by the Client. These should include among other Section Completion Report and Substantial Completion Reports
- **Interim Defects Reports** are issued following the defects liability period and the joint inspections by the contractor and the supervisor/engineer.
- **Final Completion Report** address all aspects of the Project Implementation, including financial summaries, suggestions and recommendations for future design and construction methods,

technical specifications, changes in Special Conditions of Contract and in road maintenance practices.

5.3 CHAPTER 3: MANAGEMENT OF MINOR MAINTENANCE WORKS

5.3.1 INTRODUCTION

Minor (Routine) works are usually executed either by contract or by force account. When a decision has been made by the urban council to execute the maintenance works by contract, the parties involved are much similar to that for Major works. However, if the works are to be executed by force account, then execution and supervision are the responsibility of the urban council.

5.3.2 PARTIES AND THEIR ROLES IN THE EXECUTION OF MINOR CONTRACTED WORKS

The parties involved in the execution of minor contracted works are similar to that for major works and are described below.

PARTIES INVOLVED

The parties involved in the maintenance contract management include:
- The Employer, at times referred to as the Client, is the owner of the Project. In this case it is the urban council.
- The Supervisor, at times referred to as the Engineer or Project Manager; can be the Urban Council Engineer or a consultant appointed by the urban council to supervise the contract on its behalf.
- The Contractor is the person who has been selected by the Employer to execute the contract.

THE ROLES OF URBAN COUNCILS

- Monitor the project using the guidelines provided in PAF Monitoring or other available guidelines.
- Make payments on the recommendation of the urban Council Engineer.

THE ROLES OF THE SUPERVISOR

- Issue instructions to the contractor
- Supervise the work on a day-to-day basis, control quantity, quality and costs of the project
- Approve certificates for payments
- Coordinate between the various parties both within the contract and outside.

THE ROLES OF THE CONTRACTORS

The Contractor on the award of the contract is supposed to:
- Receive instruction on the assignment
- Execute the works as per contract
- Undertaking the maintenance works
- Hand over work upon completion.

5.3.3 MANAGEMENT PROCEDURE FOR MINOR (ROUTINE) WORKS BY CONTRACT

The management procedure for Minor (routine) works by contract is similar to that for major works. It comprises the following:
- Selection of contractors
- Maintenance contract management

SELECTION OF CONTRACTORS

The tendering process, the selection and preparation of the contracts for Minor (Routine) works are similar to that for Major Works. The urban councils are advised to use the latest PPDA Act and Guidelines to acquire the services of the contractors.

MANAGEMENT OF MAINTENANCE CONTRACTS

Maintenance contract management consists of the following:
- Instructions to contractors
- Supervision, measurement, and approval of payments

INSTRUCTIONS TO CONTRACTORS

This consist of carrying out a detailed inspection of the project road in order to measure and prepare a Monthly Site Inspection Report/Measurement Sheet by listing those maintenance activities to be performed and specifying the road sections on which they are to be performed during the month immediately following this site inspection.
The Monthly Site Inspection Report / Measurement Sheet are then provided to the Contractor for his/her

records and use for planning and implementation of the listed maintenance activities.

SUPERVISION AND CERTIFICATION OF WORKS

1. Supervision of Works

Supervision of minor (routine) maintenance works are the responsibility of the supervisors of the urban councils. Some of the maintenance activities identified require a day-to-day supervision, while others are inspected monthly. It is therefore important for the urban councils to determine during the preparation of the monthly measurement sheet which activities are to be inspected daily and which one to be inspected monthly.

2. Certification of Works

Certification and payment for works performed under a Contract for routine maintenance operations include the following:

- Monthly Site Inspection Report/Measurement Sheet
- Payment Certificate

5.3.4 MANAGEMENT OF MINOR (ROUTINE) WORKS BY FORCE-ACCOUNT

Management of Minor (Routine) Works by Force-account requires that the urban councils are responsible for both execution and supervision of the works.

The procedure involves the following:

- Preparation of monthly inspection sheets
- Recruitment of labourers
- Day-to-day supervision and maintaining timesheets
- Payment of labourers.

Management of Minor (Routine) Works by force-account is not discussed in detail in this Manual. The user can refer to other available publications where required.

5.4 CHAPTER 4: SUMMARY

This Volume enables the Urban Councils to know the roles and functions of the key players in the management of the construction and maintenance of different categories of road works.

It describes the key road construction and maintenance issues in terms of:

- Information source for the Urban Road works construction and supervision
- The role of the Urban Engineer, Contractor and Consultant in the Urban Road works construction and maintenance.
- The role of Urban Councils in the urban road works process.
- Standards to be used and complied with in Construction process

Table 5.1 summarises the outcomes of the various process in construction and maintenance management.

Table 5.1: Summary of Questions for the Urban planner

What information does a manager need for the Road Construction and maintenance?	Where do I get this from?	What are the standards for Specifications used in Urban Roads Construction and Maintenance?	What is the outcome?
1. Tendering process	PPDA regulations	Latest PPDA Act	Transparent tendering process
2. Urban Road Works Supervision	The Consultant or the Urban Engineer	Standard guidelines of MOWT Works Supervision	Effective works supervision
3.Minor Maintenance Works	The Consultant or the Urban Engineer	Standard guidelines of MOWT Works Supervision	Quality road works
4. Road Construction and Maintenance	Records of the Urban Engineer	Standard guidelines on road construction and Maintenance	Quality road works

6 VOLUME 6: REPORTING GUIDELINES

Volume 6 Table of Contents

6.1 CHAPTER 1: INTRODUCTION

6.1.1 BACKGROUND & OBJECTIVE

This Volume contains guidelines on how to prepare reports for submission to the MOWT and Transport and other stakeholders such as the Urban Council Executives, with regards to urban road works.

Specifically, this Volume outlines the preparation for reporting on the quarterly planning/budgeting; procurement; works progress and post construction activities.

The objective of the volume is an understanding of:
- The main steps in the Reporting on the quarterly planning/budgeting
- The reporting on procurement
- The reporting on the works progress
- The reporting procedures on the post construction activities
- The role of Urban Councils in the supervision of the reporting preparation

6.1.2 KEY REPORTING FEATURES

A reporting system is a communication tool that presents salient project information to stakeholders and thus provide informed basis for decision making pertaining to the project. An appropriate report should:
- Provide information to stakeholders on the status of the project.
- Provide information regarding where the project stands relative to cost, scheduled and technical performance objectives.
- Facilitate informed communication among the project stakeholders about the project.
- Provide information on the use of project resources and predict likely future needs for resources and the future outcomes of the use of resources on the project.
- Help recognize project successes and failures
- Identify and isolate significant variables between planned and actual performances and possibly the reasons why a project deviated from the plan.
- Emphasize, the quantitative and the specific qualitative factors that impact and are likely to impact the project.
- Provide insights into the specific corrective actions that can be planned and executed.
- Give insight into what revisions are needed, when and why.

6.1.3 THE NEED FOR REPORTING IN URBAN ROADS MANAGEMENT

In view of the reporting features, reporting on Urban Roads Works is necessary for all Urban Authorities for the following reasons:
- In order to secure funding for the current financial year, the urban council must report on work progress verses the planned programme of work.
- The urban council similarly must report on all aspects of the work such as funds received or not received, any shortfall in order for the funding authorities to improve on the method or address any shortcoming in the process of releasing funds.

6.1.4 MAIN REPORTING DOCUMENTS

The main reporting documents involve the following:
- Quarterly planning/ budgeting
- The procurement processes
- Work Progress reporting
- Monitoring reporting/contract tracking
- Post Construction activities reporting

It must be emphasised that when using this manual, it is important to have a thorough knowledge of information provided in the five volumes. It is important that you have read the volumes on planning, design, bills of quantities, construction and maintenance management before reading this volume.

PAF REPORTING GUIDELINES

In addition, it is important and advisable to use the following guidelines in addition to this with regards to reporting. They involve the PAF guidelines for planning and operation of Urban Road Maintenance and Rehabilitation Programmes. These guidelines provide for preparation of the Progress Report for the following operations:
- Rehabilitation of Urban Roads
- Periodic Maintenance of Urban Roads
- Improvement to Bituminous Standards of Urban Road.

PAF Guidelines requires that a monthly report be prepared and submitted to the MOWT on a monthly basis; however, in this Manual a Quarterly Progress Reporting System (QPRS) has been adopted. This is essentially due to the fact that within a period of one month no substantial progress will have been recorded in any road works, and secondly, according to the Sector Guideline, funds are released on a quarterly basis and lastly, due to capacity in the urban councils, reporting on quarterly basis reduces the workload and expenditures associated with submissions.

6.2 CHAPTER 2: QUARTERLY PROGRESS REPORT

6.2.1 INTRODUCTION

This chapter outlines the key issues involved in the preparation of the quarterly progress report.

6.2.2 OVERVIEW OF QUARTERLY PROGRESS REPORT

COMPLETION OF THE QUARTERLY PROGRESS REPORT

The Quarterly Progress Report (QPR) is prepared by the Urban Council Engineer (UCE), prior to transmission to the MoWT-DUCAR Desk and copied to the Director Budget, MoFED, the QPR shall be approved and signed by the UCE and the Town Clerk (TC).

CONTENTS OF THE QUARTERLY PROGRESS REPORT

The basic reference for the QPR is the AURWP which provides a description of all the works/operations planned to be undertaken on the urban road network during the financial year (FY). In addition, it shows the timing of works implementation, their estimated costs including support or operational expenditures, sources of funding, and works implementation and associated expenditure schedules and budget summary.
The AURWP and QPRS documentation, when used together, act as a management information system (MIS) enabling rational planning, programming, implementation and reporting of urban road works/operations. The formats used for both the AURWP and QPRS are similar and allow continuous updating on a day-to-day basis.

THE QUARTERLY PROGRESS REPORT PROCESS

The QPR has been designed to act as a continuous/rolling report and plan allowing for:

- Reporting on progress during the last quarter
- Reporting on cumulative progress to date during the FY
- Readjusting the work plan to include those activities planned, but not completed, to be brought forward into subsequent quarters and included in future budget requests

When preparing the QPR, a number of standard formats shall be adopted to ensure that all essential and relevant information is included. Appendices 24 and 26 to this Manual are further described herewith.

6.2.3 SOURCES OF FUNDING

Different funding sources require different kinds of reporting procedures. Road maintenance, rehabilitation and improvement works are funded from a variety of sources including the Road Fund/PAF Grants, Local Government Development Program, JICA funds and local revenue. In most cases, funding sources have pre-conditions attached and may only be used for clearly defined or dedicated purpose; these are generally referred to as tied funding sources.
It should be noted here that these funding sources are the current funding sources available for urban road works. In future there may be a need to add or delete from the forms as funding source/s may change.

6.2.4 EXPENDITURE SCHEDULE

When preparing the Expenditure Schedule of the QPR, the UCE needs to take into account the following: priority works/operations planned during the quarter under report; funds spent during the quarter under report including their sources; funds available for the remaining quarters of the FY including their sources; timing for subsequent works/operations implementation including those not completed during the quarter under report.

6.2.5 WORK IMPLEMENTATION SCHEDULE

In preparing the Works Implementation Schedule of the QPR, the UCE needs to take into account the following: priority works/operations planned during the quarter under report; priority works/operations actually performed during the quarter under report; the timing for subsequent works/operations implementation including those works not completed during the quarter under report; funding needs for implementation of the works/operations planned in subsequent quarters; funding needs for the procurement process and supervision of the works / operations (operational expenses) planned in subsequent quarters

The Expenditure Schedule (Form F1) and the Works Implementation Schedule (Form F2) together comprise the base line data for the QPR detailing what works/operations have been and are to be implemented, at what cost and when. It is therefore important that these two forms are prepared together and updated together on a regular basis.

The Summary of Actual Expenditure / Fund Request provide seven important pieces of information:

- Identification of all actual expenditures by funding source, for the quarter reported
- Identification of all actual expenditures for each individual works/operation for the quarter reported
- An historical overview of all actual expenditures to date by source and for each individual works/operation together with their percentage achievements
- Estimates of the total funding requirements from each funding source for each of the individual works/operations planned for the next quarter
- Estimates of the total funding needs for meeting operational expenses associated with implementation of the works/operations for the next quarter
- Identification of fund balances available at the end of the quarter reported
- Determination of the Total Fund Request for the next quarter for each works/operation and from each funding source.
- The importance of this Summary of Actual Expenditure / Fund Request cannot be ignored as it allows those agencies responsible for the release of funds to be aware of.
- The total amounts spent in the quarter under report and to date
- The total amounts required for each of the planned activities in the subsequent quarter
- The total amounts required from each funding source

This information is of particular importance to both the MoWT-DUCAR Desk and the MoFED when undertaking quarterly releases of funds. Finally, the Summary of Actual Expenditure / Fund Request is a tool enabling the UCE to properly monitor and report on expenditures (and physical progress) not only for each planned activity, but also from each funding source.

6.2.6 CONTRACT TRACKING FORMAT

The Contract Tracking Format provides a tool for the UCE to record all transactions related to the implementation of all urban road works/operations funded from all sources. It provides for these transactions to be recorded immediately they occur, thereby ensuring that all relevant information is readily available and up-to-date for inclusion in the QPRs. It also provides vital information regarding the progress of each and every work/operation, whether undertaken under a formal contract or by Force Account.

It further allows the day-to-day tracking of performance for each and every work/operation in terms of time worked and physical and financial progress. Finally, it is used as a basis for monitoring of urban road works/operations by urban council staff, the MoWT and other concerned parties. Form F4, indicate the Contract Tracking Format.

6.2.7 MONTHLY PROGRESS REPORTS

To accompany the Contract Tracking Format, it is essential to attach the Monthly Progress Reports for that Quarter of all the on-going contracts within the urban council. The Monthly Progress Reports are obtained from the Project Manager as described in Manual 5, Chapter 2.7.

6.2.8 PROCUREMENT REPORTING

In the submission of the QPR, it is important to include a report on all procurement done during the period and to-date for all the maintenance and improvement works. This is best recorded in a tabular form and is known as the Procurement register. Appendix 25 shows such a register.

STANDARD COVERING LETTER FORMAT

The standard covering letter shall, together with its attachments (Forms F1, F2, F3 and F4, Procurement Register), be the QPR document that provides information required by the Agency responsible for recommending further releases of funds to the urban council.

The standard covering letter is a tool enabling the UCE to provide all essential data necessary for the MoWT-DURCAR Desk to report in a comprehensive and timely manner to the MoFED. The standard covering letter includes three tables for the entry of summarised data extracted from Forms F1, F2 and F3. These three tables include:

- Table A - Summary of Quarterly Progress Report
- Table B - Cumulative Summary of Quarterly Progress Report(s)
- Table C - Quarterly Budget Request

In addition to these three tables, provision is made in the standard covering letter to list all those urban roads on which works/operations were performed during the quarter reported.

Finally, the standard covering letter provides a checklist of all attachments that shall accompany and comprise the whole of what is a QPR.

6.3 CHAPTER 3: GUIDANCE ON PREPARATION OF QUARTERLY PROGRESS REPORTS

6.3.1 INTRODUCTION

This chapter expands on Chapter 2 to prepare a QPR. It is necessary to note that as a basic procedure, QPR has to anchor into the AURICS and AURWP in addition to the Local Government Budgetary Framework Plan (LGBFP).

6.3.2 UPDATING OF AURWP

The AURWP details those works and operations together with their timing and estimated costs that comprise the annual work plan for the forthcoming FY. The QPR reports on actual performance, compared to the AURWP, during the four quarters of the FY.

In the first quarter, the QPR reports progress compared to those specific works/operations and expenditures planned for implementation in the first quarter of the FY as detailed in the AURWP.

However, in the second and subsequent quarters, the QPR is used to readjust the work plan to accommodate those works/operations not undertaken during the quarter(s) reported. Therefore, by the end of the first quarter, the AURWP may be outdated.

- The work plans for the second, third and fourth quarters has adjusted timetables for implementation of works/operations and their associated expenditures included in Forms F1 (Expenditure Schedule) and F2 (Works Implementation Schedule) of the QPR.
- The work plan for the second quarter is not that shown in the AURWP, but is that shown in the adjusted figures for the second quarter as detailed in the first quarter's QPR.
- The work plan for the third quarter is, again, not that shown in the AURWP, but is that shown in the adjusted figures for the third quarter as detailed in the second quarter's QPR.
- Finally, the work plan for the fourth quarter is not that shown in the AURWP, but is that shown in the adjusted figures for the fourth quarter as detailed in the third quarter's QPR.
- It is only when preparing the final QPR (end of FY), that reference is again made to the AURWP in order to compare the actual annual achievement, in terms of total works/operations implementation and total expenditures, with that planned in the AURWP for the FY.

6.3.3 THE PROCEDURE OF THE PREPARATION OF THE QPR

FORM F1: EXPENDITURE SCHEDULE

It is strongly recommended to complete together and at the same time, Form F1 (Expenditure Schedule) and Form F2 (Works Implementation Schedule). Appendix 24 are samples of the forms,

FORM F1 – EXPENDITURE SCHEDULE

Enter the name of the Urban Council, the number of the quarter under report and the FY.

For each type of intervention, namely Rehabilitation, Periodic Maintenance, Improvement to Bituminous Standards and Road Survey and Design enter the following details of each road.

Column (i) – Works Reference Code: enter the contract reference number.

Column (ii) - Road Code; enter the road code in accordance with the Urban Council's official list.

Column (iii) – Road Name; enter the road name in accordance with the Urban Council's official list.

Column (iv) - Total Road Length in kilometres (km); enter those road lengths as determined during AURICS.

Column (v) - Road Section Length in km; enter the actual road section lengths on which specific works/ operations are planned to be undertaken.

These four columns shall contain exactly the same information and in its order of presentation as in the AURWP.

Column (vi) - Total Planned Expenditure this Quarter; enter the total planned expenditures for each of the works/operations planned for implementation in the quarter reported.

Columns (vii) to (xviii) are filled as follows for each reporting quarter.

- For the first QPR of the FY, Columns (vii), (viii) and (ix), will use the planning data for the first quarter found in Columns (vii), (viii) and (ix) of Form E1 of the AURWP.
- For the second QPR of the FY, Columns (x), (xi) and (xii) will use the adjusted planning data from Columns (vii), (viii) and (ix) found in Form F1 of the first quarter QPR.
- For the third QPR of the FY, Columns (xiii), (xiv) and (xv) will use the adjusted planning data from Columns (x), (xi) and (xii) found in Form F1 of the second quarter QPR.
- For the fourth QPR of the FY, Columns (xvi), (xvii) and (xviii) will use the adjusted planning data from Columns (xiii), (xiv) and (xv) found in Form F1 of the third quarter QPR.
- When preparing the fourth (end of FY) QPR, reference is also made to the AURWP in order to compare the actual annual achievement, in terms of total works/operations implementation and total expenditures, with that planned in the AURWP for the FY.

FORM F2: WORKS IMPLEMENTATION SCHEDULE

Step 1

Enter the name of the Urban Council, the number of the quarter under report and the FY.

Columns (i), (ii), (iii) and (iv) - Enter the same information as for these same Columns in Form F1.

Column (vi) - Total Planned Works this Quarter; enter the percentages for each of the works/operations planned for implementation in the quarter under report.

Columns (vii) to (xviii) are filled as follows for each reporting quarter.

- For the first QPR of the FY, Columns (vii), (viii) and (ix) will use the planning data for the first quarter found in Columns (vii), (viii) and (ix) of Form E2 of the AURWP.
- For the second QPR of the FY, Columns (x), (xi) and (xii) will use the adjusted planning data from Columns (vii), (viii) and (ix) found in Form F2 of the first quarter QPR.
- For the third QPR of the FY, Columns (xiii), (xiv) and (xv) will use the adjusted planning data from Columns (x), (xi) and (xii) found in Form F2 of the second quarter QPR.
- For the fourth QPR of the FY, Columns (xvi), (xvii) and (xviii) will use the adjusted planning data from Columns (xiii), (xiv) and (xv) found in Form E2 of the third quarter QPR.
- When preparing the fourth (end of FY) QPR, reference is also made to the AURWP in order to compare the actual annual achievement, in terms of total works/operations implementation and total expenditures, with that planned in the AURWP for the FY.

Continue to complete Form F1 and Form F2 together and at the same time.

Step 2

Form F1 - Actual Expenditure (UGX 000) to Date and Planned Next Quarter(s)

Columns (vii) to (xviii) - For the quarter under report, enter the actual monthly expenditures for each of the actual works/operations performed during the quarter under report and readjust the estimated costs for implementation of each of the planned works/operations over each month of the remaining period of the FY taking into account works/operations not performed during the quarter under report, time restraints related to releases of funds, the procurement process, wet season, etc.

Column (xix) - Total Actual Expenditure to Date; enter the sum of the total actual expenditure to date for each of the actual works/operations performed being the sum of Form F1, Column (iv) in the previous QPR and column (iv) of the current QPR.
In the second last row below the activities of each type of interventions Quarterly Works Expenditure, sum the expenditures for the plan period, for each month of the quarter under report and those for planned subsequent months of the FY in which expenditures may have been adjusted to take account of works/operations not performed during the quarter under report.

In the last row below the activities of each type of interventions, Cumulative Actual Quarterly Expenditure (UGX 000) to Date, enter the sums of actual quarterly cumulative expenditure to date, i.e., the quarter under reporting.

In the fifth last row, Operational Expenditure, enter the total operation expenses for the plan period, for each month of the quarter under report and subsequent months of the FY.

In the fourth last row, Total Quarterly Expenditure, enter the total expenditures (works plus operational) for the plan period, for each month of the quarter under report and those planned for subsequent months of the FY in which expenditures may have been adjusted to take account of works/operations not performed during the quarter under report.

In the third last row, Actual Funds Received by Quarter to Date (UGX 000), enter the actual funds received during each quarter to date.

In the second last row, Cumulative Actual Funds Received by Quarter to Date (UGX 000), enter the sums of actual quarterly cumulative fund receipts to date.

In the last row, Balance of Funds Available at end this Quarter, enter the balance of the funds remaining being the difference between Cumulative Actual Funds Received by Quarter to Date (UGX 000) and the Cumulative Actual Quarterly Expenditure (UGX 000) to date.

Form F2 - Works Implementation Schedule

Columns (vii) to (xviii) - For the quarter under report, enter the actual monthly percentages for each of the actual works/operations performed during the quarter under report and readjust the estimated percentages for implementation of each of the planned works/operations over each month of the remaining period of the FY taking into account works/operations not performed during the quarter under report, time restraints related to releases of funds, the procurement process, wet season, etc.

Column (xix) - Actual Works Done to Date; enter the sum of the total actual percentages to date for each of the actual works/operations performed being the sum of Form F2, Column (vi) in the previous QPR and column (vi) of the current QPR.

When completing QPRs for the second, third and fourth quarters, the information regarding actual percentages in previous quarters remains unchanged and shall be included in subsequent QPRs thereby providing an historical overview of physical progress to date.

Step 3

On completion of Forms F1 and F2, finalise completion of Form F3 in the following manner.

Form F3 - Summary of Actual Expenditure / Fund Request

Enter the name of the Urban Council, the number of the quarter under report and the FY.

Form F3 comprises two Tables; the top Table entitled Summary of Actual Expenditure (UGX 000) to End Quarter x of FY x and the bottom Table entitled Fund Request (UGX 000) for Quarter of FY x.

Form F3 - Top Table

The purpose of this Table is to report on actual expenditure for each works/operation and from each funding source during the quarter under report.

For the quarter under report, relevant data is entered in columns (i) to (ix) of this Table as follows.

Column (i) - Actual Interventions/Works Done This Quarter, lists the main works/operations included in the AURWP.

Column (ii) – Road Fund/PAF, enter the actual expenditure for this item during the quarter under report.

Column (iii) - LGDP, enter the actual expenditure for this item during the quarter under report.

Column (iv) - JICA, enter the actual expenditure for this item during the quarter under report.

Column (v) – Local Revenue, enter the actual expenditure for this item during the quarter under report.

Column (vi) - TOTAL EXPENDITURE - THIS QUARTER, enter the sum of expenditures for each works/operation from each funding source for the quarter under report.

Column (L) - TOTAL EXPENDITURE - TO DATE, enter the sum to date of expenditures for each works/operation from each funding source; the sum of Form F3, Column (vi) of the previous QPR plus Column (vi) of the current QPR.

Column (viii) - TOTAL PLANNED ANNUAL EXPENDITURE, already complete following the Local Government Budgetary Framework Plan (LGBFP).

Column (ix) - PROGRESS TO DATE %, Column (vii) divided by Column (viii) x 100.

The bottom part of this top Table provides a QUARTERLY SUMMARY listing actual expenditures during each quarter under report by their funding sources, together with quarterly and cumulative totals of all expenditures and the overall percentage progress to date.

Form F3 - Bottom Table

The purpose of this Table is to provide details of the Fund Request for the next quarter for each works/operation and from each funding source.

Column (x) - PLANNED INTERVENTIONS/WORKS - NEXT QUARTER, lists the works/operations included in the AURWP.

Column (xi) – Road Fund/PAF I, enter the planned expenditure for the next quarter.

Column (xii) - LGDP, enter the planned expenditure for the next quarter.

Column (xiii) - JICA, enter the planned expenditure for the next quarter.

Column (xiv) – Local Revenue, enter the planned expenditure for the next quarter.

Column (xv) - TOTAL PLANNED EXPENDITURE, enter the sum of the planned expenditures for each of the works/operations from each funding source for the next quarter.

The third last row, Sub Totals, sums the columns of each funding source.

The second last row, Balance Available, details the balances available for each funding source at the end of the quarter under report.

The last row, TOTAL FUND REQUEST NEXT QUARTER by SOURCE, sums the columns of each funding source less the balances available.

The last row of this Table details the Total Fund Request for the Next Quarter by Source, the amounts of which will ensure achievement of the planned works/operations for the next quarter.

This information is essential for a number of reasons including –

- Transparency thereby ensuring the urban authorities is fully informed regarding the sources of the funds and the amounts available.
- Management of the funds taking into account their sources and pre-conditionality of use.
- Accountability of the funds taking into account their sources and amounts.
- Timeliness of reporting.
- Accuracy to ensure the timely release of further funds.

Step 4

Complete the QPR Covering Letter (Appendix 26), ensure all attachments are included, and submit the entire document to the MoWT-DURCAR Desk. This standard format of the QPR Covering Letter is self-explanatory.

It cannot be stressed enough that all data required for inclusion in the three summary Tables and the list of roads be included and accurately presented. All the information necessary for completion of the three Tables is simply extracted from Forms F1, F2 and F3 for the quarter under report.

6.3.4 UGANDA ROAD FUNDING PROGRAMMING TABLES

An example of the tables required for quarterly reporting to the Uganda Road Fund is included in Appendix 27. The tables include the following:

- Table 1: Summary of Quarterly Progress – This table is completed separately for each district, town council and sub-country roads and excludes maintenance.
- Table 2a: QPR Routine Manual Maintenance
- Table 2b: QPR Routine Mechanical Maintenance
- Table 2c: QPR Periodic Maintenance
- Table 2d: QPR Operational Expenses
- Table 4: Financial Accountability Report
- Table 5: Transfers to Sub-Counties and Town Councils
- Table 6: Cumulative Financial Accountability Report for FY

The tables are completed with example values for ease of use.

6.4 CHAPTER 4: SUMMARY

This Volume enables the Urban Councils to understand the main steps in the reporting on maintenance and improvement works on a quarterly basis and the role of Urban Councils in the supervision of the reporting preparation.

The volume specifies the key items needed for reporting on progress during the implementation of road maintenance and improvements.

- Information source for the Urban Road works Quarterly Progress Reports
- Format for the preparation of the Quarterly Progress Reports
- Format for submission of Quarterly Progress Reports

Table 6.1 summarises the outcomes of the various processes in reporting on road improvement and maintenance works.

Table 6.1: Summary of Questions for the Urban Road Manager

What information does a manager need for the reporting on road improvement & maintenance works?	**Where do I get this from?**	**What are the standards for Specifications used in reporting?**	**What is the outcome?**
1. Works Implementation reports	Field data	Site Dairy	Realistic progress report
2. Expenditure reports	Books of Accounts	Books of Accounts	Actual Expenditure incurred
3. Planned Interventions	Field data and AURWP	AURWP	Works planned for the next quarters
4. Fund Request	AURWP and Books of Accounts	AURWP	Actual amount of funds required in the next quarters

7 BIBLIOGRAPHY

1. LED Global (February 2018) Uganda's National Master Plan – potential for low carbon development; WRI Ross Centre for Sustainable Cities.
2. Salt Lake City: Department of City & Metropolitan Planning, University of Utah; School of Public Health and Community Development, Maseno University: 2012). "Pedestrian Safety Review: Risk Factors and Countermeasures
3. Thierry Ngoga Hoza (January 2018) Land tenure considerations for neighbourhood planning reference number: C-43418-UGA-1
4. UGANDA POLICE ANNUAL CRIME REPORT: https://www.upf.go.ug/wp-content/uploads/2021/04/ANNUAL-CRIME-REPORT-2020-1.pdf?x74136
5. Lall, Somik (INCLUSIVE GROWTH POLICY NOTE 4 Planning for Uganda's Urbanization1
6. UNHS: World Bank https://openknowledge.worldbank.org/bitstream/handle/10986/27439/695230WP0ugand0604020120Box369278B0.pdf?sequence=1&isAllowed=y
7. https://www.urbanet.info/kampalas-inspiring-journey-towards-a-cycling-friendly-city/
8. Queensland Government: Road Landscape Manual Second Edition Engineering & Technology Branch 2013 (Australia)
9. (PDF) Kampala Bus Rapid Transit: Understanding Kampala's Paratransit Market Structure. Available from: https://www.researchgate.net/publication/342233740_Kampala_Bus_Rapid_Transit_Understanding_Kampala's_Paratransit_Market_Structure [accessed Dec 13, 2021].
10. Global Designing Cities: https://globaldesigningcities.org/publication/global-street-design-guide/utilities-and-infrastructure/lighting-and-technology/lighting-design-guidance/#:~:text=Taller%20poles%20between%2010%20m,be%20installed%20at%20closer%20intervals.
11. Practices, knowledge and risk factors of street food vendors in Uganda: Charles Muyanja a,*, Leontina Nayiga a, Namugumya Brenda a, George Nasinyama a Makerere University, School of Food Technology, Nutrition and Bio-engineering, Department of Food Technology and Nutrition, Kampala, Uganda. Makerere University, Faculty of Veterinary Medicine, Department of Veterinary, Public Health and Preventive Medicine, Kampala, Uganda: http://dx.doi.org/10.1016/j.foodcont.2011.01.016
12. Civil and Environmental Research www.iiste.org ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) Vol.8, No.10, 2016
13. Solid Waste Management Practices in the Street Food Sector in Thu Duc District, Ho Chi Minh City Angeli Doliente Cabaltica, Hung Dinh Nguyen, Hoa Nhan Pham Department of Civil Engineering, International University - VNU HCMC, Quarter 6, Linh Trung Ward, Thu Duc District, Ho Chi Minh City, Vietnam
14. De-Democratisation and the Rights of Street Vendors in Kampala, Uganda Article in The International Journal of Human Rights, July 2018. DOI: 10.1080/13642987.2018.1492915
15. Risk factors in street food practices in developing countries: A review https://doi.org/10.1016/j.fshw.2016.05.001
16. https://smartnet.niua.org/sites/default/files/resources/Inclusive-Design-for-Street-CUE-02-12-14.pdf

17. Kampala Capital City Authority Public Health and Environment Directorate Minimum Standards For Onsite Sanitation Technology Options In Kampala Second Edition, 2020.
18. Ministry of Works, Housing and Communications, Road Development Program Phase 2, Traffic Signs Manual, Volume 1, July 2004
19. Akhalwaya, I. and Rust, FC., 2018. Laboratory evaluation of road construction materials enhanced with Nano-Modified Emulsions (NMEs). Southern African Transport Conference, CSIR, Pretoria, South Africa.
20. Committee of Land Transport Officials (COLTO)., 1996. Draft TRH 4: Structural Design of Flexible Pavements for Inter-urban and Rural Roads, Pretoria, South Africa.
21. Committee of State Road Authorities., 1990. Draft TRH 20: The Structural Design, Construction and Maintenance of Unpaved roads, Pretoria, South Africa.
22. Committee of State Road Authorities., 1985. TRH 14: Guidelines for Road Construction Materials, Pretoria, South Africa.
23. Committee of Urban Transport Officials.,1987. Draft Urban Transport Guidelines (UTG) 2: Structural Design of Segmental Block Pavements for Southern Africa, Pretoria, South Africa.
24. Committee of Urban Transport Officials.,1988. Draft Urban Transport Guidelines (UTG) 3: Structural Design of Urban Roads, Pretoria, South Africa
25. Concrete Manufacturers Association., 2004. Concrete Block Paving Book 2 and Book 3, South Africa.
26. Council for Scientific and Industrial Research (CSIR)., 2010. Potholes: Technical guide to their causes, identification and repair, Pretoria, South Africa.
27. Department of Human Settlements (DHS)., 2019. The Neighbourhood Planning and Design Guide also known as the Red Book, South Africa.
28. Jordaan, GJ., Kilian, A., Du Plessis, L. and Murphy, M., 2017. The Development of Cost-Effective Pavement Design Approaches Using Minerology Tests with New Nano-Technology Modifications of Materials, Southern African Transport Conference, CSIR, Pretoria, South Africa.
29. Jordaan, GJ. and Steyn, WJVDM. 2020. Cost-Effective Upgrading of Gravel Roads Using Naturally Available Materials with Anionic New-Age Modified Emulsion (NME) Stabilisation, Pretoria, South Africa.
30. Ministry of Works and Transport (MOWT)., 2018. Ugandan Road Design and Construction Manual Volume V: Low Volume Sealed Roads, Uganda.
31. Ministry of Works and Transport (MOWT)., 2018. General Specifications for Low Volume Roads - Series 3000LVR: Earthworks and Pavement Layers, Uganda.
32. Ministry of Works and Transport (MOWT)., 2018. General Specifications for Low Volume Sealed Roads - Series 4000LVR: Bituminous Surfacing, Uganda.
33. Ministry of Works, Housing and Communications (MOWHC)., 2005. Ugandan Road Design Manual Volume 3: Pavement Design Part I, Uganda.
34. Ministry of Works and Transport (MOWT)., 2010. Ugandan Road Design Manual Volume 3: Pavement Design Part II, Uganda.
35. Ministry of Works and Transport (MOWT)., 2010. Ugandan Road Design Manual Volume 3: Pavement Design Part III, Uganda.
36. Ministry of Works, Housing and Communications (MOWHC)., 2004. Ugandan District Road Works Manual Volume 1A – Technical Manuals Manual A, Uganda.

37. Rust, FC., Smit, M.A., Akhalwaya, I., Jordaan, GJ. and du Plessis, L., 2020. Evaluation of two nano-silane-modified emulsion stabilised pavements using accelerated pavement testing, International Journal of Pavement Engineering, 23:5, 1339-1352.
38. South African National Roads Agency (SANRAL)., 2014. *The South African Pavement Engineering Manual (SAPEM)*, South Africa.
39. South African Bitumen Association (SABITA)., 2020. Technical Guideline (TG) 2: Bitumen Stabilised Materials, South Africa.
40. Transport Research Laboratory (TRL)., 1993. Overseas Road Note 31 (RN 31) – A guide to the structural design of bitumen-surfaced roads in tropical and sub-tropical countries, Crowthorne, United Kingdom.
41. Kasese Municipal Council Five Year Solid Waste Management Strategy and Plan 2022/23-2026/27
42. Developing municipal solid waste management strategy for the municipal local governments of Apac, Busia, Kamuli, Kasese, Kitgum, Lugazi, Mubende and Ntungamo, 2021 (JBN)
43. Draft Information, Education And Communication Strategy For Solid Waste Management 2021-2026 (JBN Consultants).
44. Ministry of Works and Transport, Non-Motorised Transport Manual, June 2020
45. Ministry of Works, Housing and Communications, National Physical Planning Standards and Zoning Guidelines, 2022 (Draft)
46. Ministry of Lands, Housing and Urban Development, National Physical Planning Standards and Guidelines, 2011.
47. Urban Street Design Guide, National Association of City Transportation Officials https://nacto.org/publication/urban-street-design-guide/

APPENDICES

FINAL

July 2023

TABLE OF CONTENTS

1. General Road Terms

General Road Design Terms

General Road Terms

1 Earth Roads
Earth roads are formed from the in-situ soil material.

2 Gravel Road
Gravel roads have a gravel layer as a surfacing material.

3 Paved Roads
Paved roads have a homogenous and strengthened carriageway surface, which consists of bitumen, concrete, or other pavement materials such as stones and bricks.

4 Constructions
The process by which a road is built according to established design standards and work methods.

5 Rehabilitation
Activities which restore a road's geometric characteristics to the original recommended design standards.

6 Upgrading
The process by which the standard of an existing road is improved to allow safe use by a greater volume of traffic than originally designed for.

7 Maintenance
The work required to keep the road, its structures and property within the road margins as near as possible to their as constructed or rehabilitated condition.

Road Elements and Geometric Terms

1 Plan
Plan is what you see if you are looking from above toward the ground.

2 Elevation
Elevation is a view of the object as seen from the side.

3 Cross-Section
Cross-section is the drawing of an object as it is seen if it has been cut across.

4 Road Centreline
A longitudinal axis along the middle of the road.

5 Horizontal Alignment
Arrangement of a road on the plan view showing a series of straight lines connected by curves.

6 Vertical Alignment
Longitudinal section of a road referring to the surface level of the completed road along the carriageway centreline

Road Cross Section Terms

1 Road Reserve
Strip of land legally awarded to the Road Authority in which the road is or will be situated and where no other work or construction may take place without permission from the Road Authority. The width of the road reserved is measured at right angles to the centreline of the road and varies according to the classification of the road.

2 Formation Width
Full width of the road, including side drains, side cuts and embankments.

3 Roadway
Full width of the road, including shoulders and carriageway for use by traffic.

4 Carriageway
Paved or unpaved width of the road, excluding the shoulders, normally used by traffic.

5 Shoulders
Paved or unpaved width of the road between the edge of the carriageway and the shoulder break point. The shoulder provides side support for the pavement or gravel surface and allows vehicles to stop or pass in an emergency.

6 Shoulder Break Point
The point where the roadway and the ditch inside slope or embankment slope meet along the sides of the road.

7 Camber
The lateral slope(s) of the cross-section of the carriageway and shoulder, constructed to drain the rainwater from the carriageway to the side drains.

8 Cross-fall
The difference in level measured transversely across the surface of the carriageway expressed as a percentage (%).

9 Crown
Peak or highest point of the cross-section of a cambered carriageway.

10 Road Surface
The top layer of the pavement on a paved road. It consists of wearing course and sometimes a base course or binder course. On the gravel road, it is the gravel surface.

11 Pavement
The part of a road designed to withstand the weight or loading by traffic.

12 Sub grade Surface
Constructed upper layer of the natural or imported soil (free from unsuitable material) which supports the pavement layer or gravel surface?

13 Road base
The pavement courses/layers between surfacing and sub-base.

14 Sub-base
The course between the road base course and the sub grade.

15 Original Ground Level
The natural ground level prior to construction of the road.

16 Embankment
Constructed fill material below the pavement or gravel surface raising the road above the surrounding natural ground level.

17 Embankment Slope
The constructed, inclined soil surface on the side of the embankment.

18 Cut
Excavation in the natural ground with graded slope to accommodate the road.

19 Cut Slope
The constructed inclined soil surface in a cut.

20 Superelevation
Inward tilt or transverse inclination given to the cross-section of a carriageway throughout the length of a horizontal curve to reduce the effects of centrifugal forces on a moving vehicle. Super-elevation is expressed as a percentage.

Drainage Terms

1 Side Drain

Long flat-bottomed excavation running along the road side, designed to collect and drain surface runoff water from the carriageway and adjoining land, away from the roadway to a suitable point of disposal. It can be of natural earth or lined with stones (stone pitching) or concrete.

2 Mitre Drain

Mitre drain leads the water out of the side drains and safely disperses it onto adjoining land.

3 Catch Water Drain

Catch water drain is a ditch constructed on the uphill side designed to intercept or collect and drain away surface runoff water flowing towards the road from the uphill side, and lead it to a suitable point of disposal.

4 Scour Check

Scour check is a small structure placed across the drain on steep gradients and is designed to slow down the flow of water to prevent erosion of drain invert and slopes.

5 Headwalls

Retaining wall at the entry or exit of the culvert to retain and protect the embankment or retained soil/gravel.

6 Wing walls

Retaining wall at the side of the culvert or large structures to retain and protect the embankment or retained soil.

7 Apron

The flat paved area at the culvert inlet or outlet to prevent erosion.

8 Cut-off Wall

A vertical wall under the headwall to prevent water seeping under the structure and undermining it.

9 Invert

The lowest point on the cross section through the culvert opening. This usually varies through the length of the culvert.

10 Gradient

This is the longitudinal slope of the culvert invert, typically between 2% and 5%.

11 Culvert

The culvert is a structure constructed under the road and is designed to allow water from the drains and/or natural water course to safely cross under the roadway.

12 Bridge

A structure providing a means of crossing safely above water, railway, or other obstruction whether natural or artificial.
The lowest surface of the internal cross section of a drain.

13 Drain Invert

The lowest surface of the internal cross section of a drain.

14 Drain Inside Slope

The slope from the shoulder break point to the inside edge of the side drain invert.

15 Drain Back Slope (Drain Outside Slope)

The outer slope of a side drain with an appropriate angle to prevent soil from sliding into the ditch.

2. List of Urban Council Codes

List of Urban Council Codes

Urban Council	Code	Urban Council	Code
Abim	1	Kihihi	58
Adjuman	2	Kira	59
Amolator	3	Kiruhura	60
Amudat.T.C*	4	Kisoro	61
Amuria	5	Kitgum	62
Amuru	6	Koboko	63
Apac	7	Kotido	64
Arua	8	Kumi	65
Bombo	9	Kyenjonjo	66
Budaka	10	Kyotera	67
Bududa	11	Lira	68
Bugembe- Jinja	12	Lugazi	69
Bugir	13	Lukaya	70
Bukedea	14	Luweero	71
Bukwo	15	Lwakhakha (Manafa)	72
Buliisa	16	Lyantonde	73
Bundibugyo	17	Malaba	74
Busembatya	18	Manafwa	75
Bushenyi/Ishaka	19	Maracha	76
Busia	20	Masaka	77
Busolwe	21	Masindi	78
Butaleja	22	Mayuge	79
Buwenge	23	Mbale	80
Bwera-Mpondwe(Kasese)	24	Mbarara	81
Dokolo	25	Mityana	82
Entebbe	26	Mororto	83
Fort Portal	27	Moyo	84
Gulu	28	Mpigi	85
Hima	29	Mubende	86
Hoima	30	Mukono	87
Ibanda	31	Nagongera	88
Iganga	32	Nakapiripiti	89
Ishongorero (Ibanda)	33	Nakaseske	90
Isingiro	34	Nakasongola	91
Jinja	35	Namutumba	92
Kaabong	36	Nansana	93
Kabale	37	Nebbi	94
Kaberamaido	38	Njeru	95
Kabwohe- Itendero	39	Nkokonjeru	96
Kagadi	40	Ntungamo	97
Kakiira- Jinja	41	Nyahuka (Bundibugyo)	98
Kakiri	42	Otuke.T.C*	99
Kalangala	43	Oyam	100
Kaliro	44	Pader	101
Kalisizo	45	Padibe.T.C*	102
Kalongo	46	Paidha	103
Kamuli	47	Pakwach	104
Kamwenge	**48**	Pallisa	105
Kanungu	49	Rakai	106
Kapchorwa	50	Rukungiri	107

Kasese	51	Sembabule	108
Katakwi	52	Sironko	109
Katwe/Kabatoro	53	Soroti	110
Kayunga	54	Tororo	111
Kibaale	55	Wakiso	112
Kiboga	56	Wobulenzi	113
Kigorobya	57	Yumbe	114
		Zombo. T.C* (estimate)	115

3. Road Register

Roads Register

Urban Council: ……………………..   **Date:** ………………………………..

Road Code	Road Name	Start	End	Approx. Length (km)	Average width (m)	Surface Type	Planning Area	Average Road Condition
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)

4. Road Condition Assessment Forms (AURICS)

ROAD SECTION INVENTORY AND CONDITION SURVEY FORM **Form A UNPAVED ROADS**

Urban Council Name: ________________________________ **Road Name:** ________________________________

Assessed by: ________________________________ **Road Length:** ___________ **km**

Road Sect. No.	Section					Carriageway												Traffic Condition Factor	Comments
	Start	End	Length of Section	Road Type	Road width (m)	Left Side Drains/Shoulder			Surface Material Factor	Year surfaced	Potholes	Rutting	Erosion and gullies	Surface Condition Factor	Right Side drain/shoulder				
						Shoulder Condition Factor	Side Drains Type	Drainage Condition Factor							Drainage Condition Factor	Side Drain type	Shoulder Condition Factor		
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)	(xix)	(xx)

Notes: Refer to "Look-Up" Tables in Form A1 for Coding and Definitions.

Soil Type: ______________________ **Rainfall:**________________**mm** **Topography:**___________________ **Land Use:**____________________

Page___of _______

ROAD SECTION CONDITION ASSESSMENT - LOOK-UP TABLES UNPAVED ROADS

Form A1

(v) ROAD SURFACE TYPE

E	Earth	Not gravelled in last 5 years
G	Gravel	Gravelled in last 5 years

(xi) SURFACE MATERIAL FACTOR

1	Good	Surface wears steadily
2	Fair	Surface wears quickly
3	Poor	Surface damages quickly

(viii) & (xvii) SIDE DRAIN TYPE

L	Lined Drains	stones or concrete
C	Closed Drains	pipes or slabs
E	Earth Drains	open

(ix) & (xiv) DRAINAGE CONDITION FACTOR

1	Good	No water on the road during rain No erosion or silt deposits good roadside drainage
2	Fair	Some water on the road during rain some erosion/scouring in roadside drains or drains half silted
3	Poor	Much water on the road during rain severe erosion/scouring in roadside drains or drains fully silted
4	Bad	Non existing/non functioning drainage system

(vii) & (xviii) SHOULDER CONDITION FACTOR

1	Good	Good shape, allowing easy runoff from the road surface into the roadside drains; shoulder not eroded.
2	Fair	Uneven shape, but allowing most water to run off the road surface into the roadside drains; some erosion of shoulder.
3	Poor	Poor shape and seriously restricts water to run off the road surface into the roadside drains; severe erosion of the shoulder.
4	Bad	Non functioning or non existing

(xv) SURFACE CONDITION FACTOR

		Roughness
1	Good	<8 m/km: good shape, smooth running surface
2	Fair	9-14 m/km: reasonable shape, corrugations and potholes up to 10cm deep
3	Poor	15-18 m/km: poor shape, frequent depressions rutting and potholes >10 cm deep
4	Bad	>18 m/km: bad shape, deep depressions and potholes, serious rutting, 4WD-dry weather only

Column	**OTHER PARAMETERS**
(ii) & (iii)	chainage in metres
(iv)	Section length (km) = (iii) - (ii)
(x)	Year last surfaced
(xx)	Comments

(xix) TRAFFIC GROUP FACTOR

1	Very Light	< 20 vehicles/day
2	Light	20 -30 vehicles/day
3	Medium	30-40 vehicles/day
4	Heavy	>40 vehicles/day

To be used with Form A (Road Section Condition Assessment Form)

ROAD SECTION INVENTORY AND CONDITION SURVEY FORM

Form B PAVED ROADS

Urban Council Name: ______________________________ **Road Name:** ___________________________________

Assessed by: ____ **Road Length** ____________ **km** ***Page__of*** _____

Road Sect. No.	Section				Left Footway		Carriageway									Right Footway		Traffic	Comments
							Left Side Drains							Right Side Drains					
	Start	End	Length of Section	Road width (m)	Left Footway Condition	Left Footway Width (m)	Side Drains Type	Drainage Condition	Year surfaced	Potholes	Rutting	Large Cracks	Width Loss	Drainage Condition	Side Drain Type	Right Footway Condition	Right Footway Width (m)		
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)	(xix)	(xx)

Soil Type:_______________ **Rainfall:**__________________ **mm** **Topography:**____________________ **Landuse:**______________________

ROAD SECTION CONDITION ASSESSMENT - LOOK-UP TABLES - PAVED ROADS

FORM B1

(ix) & (xv) DRAINAGE CONDITION FACTOR		
1	Good	No water on the road during rain
		No erosion or silt deposits
		Good roadside drainage
2	Fair	Some water on the road during rain
		Some erosion/scouring in roadside drains or drains half silted
3	Poor	Much water on the road during rain
		Severe erosion/scouring in roadside drains or drains fully silted
4	Bad	Non existing/non functioning drainage system

(vi) & (xvii) SHOULDER CONDITION FACTOR		
1	Good	Good shape, allowing easy runoff from the road surface into the side drains
		Shoulders not eroded
2	Fair	Uneven shape, but allowing most water to run off the road surface into the roadside drains
		Some erosion of shoulders
3	Poor	Poor shape and seriously restricts water to run off the road surface into the roadside drains
		Severe erosion of the shoulders
4	Bad	Non functioning or non existing

(viii) & (xvi) SIDE DRAIN TYPE		
L	Lined Drains	stones or concrete
C	Closed Drains	pipes or slabs
E	Earth Drains	open

Column	**OTHER PARAMETERS**
(ii) & (iii)	chainage in metres
(iv)	Section length (km) = (iii) - (ii)
(x)	Year last surfaced
(xx)	Comments

(xix) TRAFFIC GROUP FACTOR		
1	Very Light	< 20 vehicles/day
2	Light	20 -30 vehicles/day
3	Medium	30-40 vehicles/day
4	Heavy	>40 vehicles/day

To be used with Form B (Road Section Condition Assessment Form)

ROAD FEATURE INVENTORY AND CONDITION DATA **FORM C**

Urban Council ______________________ **Date:** ______________________

Road Name: ______________________ **Inspector:** ______________________

Road Code: ______________________

Chainage (km)	Feature Description	Type	Size/Width (m)	Location (P/S/E)	Side (LHS/RHS/Both/C)	Condition	Comments

NOTES:

Location: P - Point, S - Start, E - End

Side: LHS - Left Hand Side, RHS - Right Hand Side, Both - Both Sides, C - Center

Condition: G -Good, D - Damaged, M - Missing

CULVERT INVENTORY AND CONDITION DATA **FORM D**

Urban Council ______________________ **Date:** ______________________

Road Name: ______________________ **Inspector:** ______________________

Road Code: ______________________

No.	Chainage (km)	Culvert Type [C/A]	Alignment A/S/C	Barrels	Dia./Span (m)	Width (m)	Condition	Comments
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(via)	(ix)

PAGE____OF_____

Culvert Type: C - Concrete; A - Armco

Alignment: A - Access; S - Skew; C - Cross

5. Traffic Count Forms

LINK TRAFFIC VOLUME SURVEY FORM

Road No.: ____________________ Date: ____________________ Weather conditions: ____________________ Counter name: ____________________

Site location: ____________________ Day: ____________________ General remarks: ____________________ Checked by: ____________________

Vehicle Class	Hrs to	Hrs to	Hrs to	Hrs to	Hrs to	Hrs to	Hrs to	Hrs to	Hrs to	Hrs to	Hrs to	Hrs to	Count	Factor	Total	
Boda-boda													Count	Factor	Total	
														x 0.2		a
Carts Animal/hand drawn													Count	Factor	Total	
														x 0.2		b
Passenger cars													Count	Factor	Total	
														x 0.5		c
LGV Pick-ups 4WD Small trucks													Count	Factor	Total	
														x 1.0		d
Tractors													Count	Factor	Total	
														x 1.0		e
Medium & heavy trucks													Count	Factor	Total	
														x 2.0		f
Buses													Count	Factor	Total	
														x 1.5		g
Total																

Manual traffic counts must last 12 continuous daytime hours, example 6:00 to 18:00

Counts must be undertaken at a single point between intersections - in both directions

Average Daily Traffic (ADT) to be calculated from average of 7 consecutive days

Total (G) = a+b+c+d+e+f+g ______ G

Daily Traffic (DT) = G x 1.33 =

ADT = Average DT over 7 days =

Dates:

6. Routine Maintenance Interventions for Paved Roads

Routine Maintenance intervention for Paved Roads

Feature	Defects	Extent (% of sub-section length)	Intervention/Activities
Roadway	Obstacles, stones, trees	Visual assessment	Inspection and removal of obstruction from the carriageway
Roadway	Litter	Visual assessment	Road Sweeping
Road Verges	Litter	Visual assessment	Collect and remove
Road Verges	Grass more than 150 mm height	Interference with line of sight	Grass cutting
Side Drains	Silt deposit	Ditch depth reduced to < 1.0 m	Cleaning of side drains
Line Drains	Silt deposit	Ditch depth reduced to < 0.5 m	Cleaning of lined drains
Culverts	Silt deposit	Blocked to the extent that the free flow of water is impeded	De-silting of culverts and clearing of culverts inlets and outlets
Bridge/Channel	Vegetation/Silts	Blocked to the extent that the free flow of water is impeded	Clearing of bridge channels
Road Signs	Dirty	Unreadable	Clean road signs
Road Signs	Damaged/corroded	Visual assessment	Repair or replace
Road Signs	Poles damaged or not vertical	Visual assessment	Repair or replace
Road markings	Illegible	Visual assessment	Repaint road markings
Traffic Signals	Lights not working	Visual assessment	Replace lights
Traffic Signals	Signal heads missing	Visual assessment	Replace signal heads
Traffic Signals	Posts damaged or not vertical	Visual assessment	Repair or replace
Traffic Signals	Timing plan	Review when: - Land use, road network changes or background traffic growth causes poor intersection performance - Public complaints received	Review traffic signal timing plan

Litter Bins	Full	Scheduled visual assessment	Litter removal
Line Drains	Damaged	Visual assessment	Lined drains repair
Culverts	Scoured/Damaged	Visual assessment	Culvert repair
Bridge	Scoured/Damaged	Visual assessment	Minor bridge repair
Retaining Wall	Damaged	Hazard to traffic, or the structure is in danger of collapse	Retaining wall repair
Roadway	Potholes	Visual assessment	Pothole patching
Roadway	Trench/Utility opening	Visual assessment	Trench/Utility Opening
Kerbs	Missing or Damaged	Visual assessment	Kerb repair or replacement
Shoulder/Foot way	Cracking or settlement >25mm	Visual assessment Pedestrian trip hazard	Shoulder repair/Footway repair

7. Routine Maintenance Interventions for Un-paved Roads

Routine Maintenance Intervention for Unpaved Roads

Feature	Defects	Extent	Intervention/Activities
Roadway	Obstacles, stones, fallen trees	Visual assessment	Inspection and removal of obstruction from the carriageway
Roadway	Litter	Visual assessment	Road Sweeping
Road Verges	Grass more than 150 mm height	Interference with line of sight and pedestrian accessibility	Grass cutting
Side Drains	Silts deposits	Ditch depth reduced to < 1.0 m	Cleaning of side drains
Line Drains	Silts Deposits	Ditch depth reduced to < 0.5 m	Cleaning of lined drains
Culverts	Silts Deposits	Blocked to the extent that the free flow of water is impeded	De-silting of culverts and clearing of culverts inlets and outlets
Bridge/Channels	Vegetation, Silt	Blocked to the extent that the free flow of water is impeded	Clearing of bridge channels
Road Signs	Dirty	Unreadable	Clean road signs
Road Signs	Damaged/corroded	Visual assessment	Repair or replace
Road Signs	Poles damaged or not vertical	Visual assessment	Repair or replace
Litter Bins	Full	Visual assessment	Litter removal
Line Drains	Damaged	Visual assessment	Lined drains repair
Culverts	Scoured or damaged	Visual assessment	Culvert repair
Bridge	Deck or column support damage	Visual assessment	Minor bridge repair
Retaining Wall	Damaged	Hazard to traffic or the structure is in danger of collapse	Retaining wall repair
Roadway	Corrugated	Visual assessment	Regrade roadway
Roadway	Excessive dust generation	Visual assessment	Regrade or reblade roadway
Roadway	Potholes	Visual assessment	Fill potholes on carriageway
Roadway	Ruts	Visual assessment	Fill ruts on carriageway
Roadway	Loose aggregate	Visual assessment	Regrade or reblade roadway

8. Periodic Maintenance Interventions for Un-paved Roads

A: Periodic Maintenance intervention for Unpaved Roads

Defects	Level	Extent (% of sub-section length)	Climatic/ traffic category	Intervention/ Activities
Potholes, ruts, corrugations, erosions, and gullies	-	-	All	Light Grading and reshaping of the road surface
Gravel loss	<25 mm	>10	All	Spot/Full re-gravelling
Missing culverts, side drains and other drainage	-	-	-	Drainage Works
Road Sign Missing/Damaged/ Illegible	-	-	-	Installation/replacement of road signs

Note: Overseas Road Note 1, Road Maintenance management for district engineers

B: Matrix of Periodic Maintenance Interval

Interval Code	Surface Material Type	Traffic Group	PM Interval (years)
01	Good	Very Light	7
04	Good	Light	6
07	Good	Medium	5
10	Good	Heavy	4
02	Fair	Very Light	6
05	Fair	Light	5
08	Fair	Medium	4
11	Fair	Heavy	3
03	Poor	Very Light	5
06	Poor	Light	4
09	Poor	Medium	3
12	Poor	Heavy	2

Note: RAMPS Table

9. Periodic Maintenance Interventions for Paved Roads

Periodic Maintenance intervention for Paved Roads

Defects	Level	Extent (% of sub-section length)	Climatic/traffic category	Intervention/Activities
Potholes and Large cracks	<5mm	-	Rainfall: >1500mm or Traffic: >1000vpd	Surface Dressing
Missing culverts, side drains and other drainage	-	-	-	Drainage Works
Road marking illegible	-	-	-	Renewal of Road Markings
Road Sign Missing	-	-	-	Renewal of Road Signs
Traffic Signals				Review traffic signal after 3 years

Note Overseas Road Note 1, Road Maintenance management for district engineers

10. Determining Rehabilitation Requirements From AURICS

Determining Rehabilitation requirements from AURICS

The first step in determining the requirement for rehabilitation is to determine the **Maintainable Condition Index (MCI)** of every road section in the road link.

Maintainable Condition index is defined in RAMPS (Rehabilitation and Maintenance Planning System) as an index based on the surface condition, shoulder condition and drainage condition factors of a road section.

The maintainability of every section of the road is determined by these three conditions, each contributing a percentage as shown in the table below.

Factors to calculate Maintainable Condition Index (MCI)

Factor	%
Road Drainage Condition Factor	40.00
Road Shoulder Condition Factor	20.00
Road Surface Condition Factor	40.00
Total	100.00

Cut-off value of Maintainable Condition Index for road maintenance = 2.5; up to which the road section is maintainable.

From the lookup tables, default values of these three factors (Surface, Drainage and Shoulder) vary from 1 to 4 and as such, value of MCI also varies from 1 to 4.

- If the value of MCI of a road section is between 1 and 2.5 then the road section will be termed maintainable and will be earmarked for maintenance.
- If the value of MCI is above 2.5 then the road section will be termed as non-maintainable (i.e., the condition is too poor/bad to do regular maintenance) and it must be earmarked for rehabilitation.

For example, if a road section has the following factors in the look-up tables:

- Drainage Condition Factor = 2
- Shoulder Condition Factor = 3
- Surface Condition Factor = 4

The MCI = (40÷100) x 2 + (20÷100) x 3 + (40÷100) x 4 = 3

This factor is > 2.5 and therefore it means that the section is not maintainable and therefore rehabilitation is recommended.

The average drainage, shoulder, and surface condition factors for all the sections of a road link are calculated, and the MCI of the road link is determined. The link can then be selected for either rehabilitation or maintenance.

11. Indicative Cost Breakdown of Maintenance & Improvement of Urban Road Works

Indicative Cost Breakdown for Maintenance & Improvement Works
(Costs to be determined from latest relevant projects)

A: Approximate breakdown of cost of intervention per Bill Item for Periodic Maintenance

No	Bill Item	Approx. % cost of Total Works
1.0	Preliminaries	2
2.0	Site Clearance and Earthworks	11
3.0	Drainage Works	30
4.0	Surfacing/Wearing Course	50
5.0	Ancillary	7
	Total	**100**

B: Approximate breakdown of cost of intervention per Bill Item for Rehabilitation

No	Bill Item	Approx. % cost of Total Works
1.0	Preliminaries	2
2.0	Site Clearance and Earthworks	11
3.0	Drainage Works	50
4.0	Surfacing/Wearing Course	30
5.0	Ancillary	7
	Total	**100**

C: Approximate breakdown of cost of intervention per Bill Item for Upgrades

No	Bill Item	Approx. % cost of Total Works
1.0	Preliminaries	2
2.0	Site Clearance and Earthworks	11
3.0	Drainage Works	30
4.0	Surfacing/Wearing Course	50
5.0	Ancillary	7
	Total	**100**

12. Database for Road Works Planning

ROAD PLANNING DATABASE

FY:
Urban Council:

Page __of__
Date: __________

Road Code	Road Name	Road Length (km)	Surface Type	Average Width (m)	Planning Area	Traffic Condition	Maintainable Condition Status	Year Last Maintained/ Improved	Maintenance/Improvement Costs (UGX)				Cost/km (UGX)
									Routine Maintenance	Periodic Maintenance	Rehabilitation	Upgrade to Bituminous	
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)

13. Standard Forms for Submission of AURWP

AURWP - EXPENDITURE SCHEDULE

FY :

Urban Council:

AURWP Form E1

Road Information						Planned Monthly Expenditure Schedule ('000 UGX)												Total Annual Budget
						Q1			Q2			Q3			Q4			
Work Ref:	Road Code	Road Name	Road Length (km)	Section Length (km)	Spent in Last Year	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)	(xix)

A: REHABILITATION

1. Preliminaries													
2. Site Clearance and Earthworks													
3. Drainage Works													
4. Wearing Course and Shoulders													
5. Ancillary Works													
Total Quarterly Expenditure of Rehabilitation Works Implementation:													

B: PERIODIC MAINTENANCE

1. Preliminaries													
2. Site Clearance and Earthworks													
3. Drainage Works													
4. Wearing Course and Shoulders													
5. Ancillary Works													
Total Quarterly Expenditure of Periodic Maintenance Works Implementation:													

C: INPROVEMENT TO BITUMINOUS STANDARD

1. Preliminaries													
2. Site Clearance and Earthworks													
3. Drainage Works													
4. Wearing Course and Shoulders													
5. Ancillary Works													
Total Quarterly Expenditure of Improvement Works Implementation:													

D: ROUTINE MAINTENANCE

Activities (Appendix 6 & 7)																		
Total Quarterly Expenditure Routine Maintenance:																		

Signed: UCE **Signed: TC** **Date:**

AURWP - WORKS IMPLEMENTATION SCHEDULE

Page __of __

FY :

Urban Council:

AURWP Form E2

Road Information					Done Last Year	Planned Monthly Works Implementation Schedule											
						Q1			Q2			Q3			Q4		
Work Ref:	Road Code	Road Name	Road Length	Section Length		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)
A: REHABILITATION																	
1. Preliminaries																	
2. Site Clearance																	
3. Drainage Works																	
4. Wearing Course and Shoulders																	
5. Ancillary Works																	
B: PERIODIC MAINTENANCE																	
1. Preliminaries																	
2. Site Clearance																	
3. Drainage Works																	
4. Wearing Course and Shoulders																	
5. Ancillary Works																	
C: INPROVEMENT TO BITUMINOUS STANDARD																	
1. Preliminaries																	
2. Site Clearance																	
3. Drainage Works																	
4. Wearing Course and Shoulders																	
5. Ancillary Works																	
D: ROUTINE MAINTENANCE																	
Activities (Appendix 6 & 7)																	

Signed: UCE **Signed: TC** **Date:**

ANNUAL URBAN ROAD WORK PLAN - BUDGET SUMMARY

FY :

Urban Council:

AURWP Form E3

Table A: Funding Ceilings (LGBFP)

Planned Intervention	Planned Sources of Funding				Annual Total Intervention Costs (UGX. 000)	Average Cost per Km (UGX/km 000)
	Road Fund/PAF	LGDP	JICA	Local Revenue		
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
A: REHABILITATION						
B: PERIODIC MAINTENANCE						
C: IMPROVEMENT TO BITUMINOUS STANDARDS						
D: Routine Maintenance						
Grand Total:						

Table B: Planned Sources of Funding

Planned Interventions	Planned Sources of Funding												Annual Total
	Road Fund/PAF				LGDP				JICA				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	
A: REHABILITATION													
Total Quarterly Expenditure of Rehab Works:													
Operational Expenses													
B: PERIODIC MAINTENANCE													
Total Annual Expenditure of PM Works:													
Operational Expenses													
C: INPROVEMENT TO BITUMINOUS STANDARD													
Total Quarterly Expenditure of Impt Works:													
Operational Expenses													
D: ROUTINE MAINTENANCE													
Totals Quarterly Expenditure for Routine Maintenance													
Totals of Funds per quarter:													

Signed: (UCE) **Signed: Town Clerk** **Date:**

ANNUAL URBAN ROAD WORK PLAN - ESTIMATE FOR OFFICE SUPPLIES

Form E4

Urban Council: **FY:** Ref; Volume 1

Item	Qty	Unit Price (UGX)	Total Cost (UGX 000)	Planned Monthly Expenditure (UGX 000)											
				July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June

Note: 1. Office Supplies shall include adequate quantities of stationery for Contract Documentation, AURICS, Quarterly Progress Reports, other reports and day-to-day needs
2. Adequate provision shall be made for computer printer cartridges, photocopier toner and replacement drums, filling cabinets and other essential furniture items.

Signed: UCE ………………….. Signed: TC …………………… Date:

ANNUAL URBAN ROAD WORK PLAN - MAJOR SCHEDULE PROCUREMENT

Form E5

Urban Council: **FY:** Ref; Volume 1

Item	Qty	Unit Price (UGX)	Total Cost (UGX 000)	Planned Monthly Expenditures (UGX 000)											
				July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June

Note: 1. Where urban road works of an emergency nature are required to be performed under Force Account, this Form provides for the procurement of essential materials the minimum quantities of which shall be determined by the UCE, and following delivery, taken on charge and stored in the Council Stores.

Signed: UCE …………………… Signed: TC ………………….. Date:

ANNUAL URBAN ROAD WORK PLAN - GENERAL ADMINISTRATIVE EXPENSES

Form E6

Urban Council: **FY:** Ref; Volume 1

Item	Qty	Unit Price (UGX)	Total Cost (UGX 000)	Planned Monthly Expenditures (UGX 000)											
				July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June

Notes:

1. General Admin. Expenses provide for the supervision of urban road works including: fuel for supervision transport, minor repairs and servicing of supervision transport, allowances, maintenance, and repairs of office equipment including computers/printers/photocopiers etc.

2. Where the UCE incurs expenses associated with maintenance and payments for utilities of the office, these expenses shall also be taken into account herein.

Signed: UCE ………………….. Signed: TC ………………. Date:

ANNUAL URBAN ROAD WORK PLAN - TOTAL UNDISTRIBUTED EXPENSES

Form E7

Urban Council: **FY:** Ref; Volume 1

Line	Reference	Expenditure Item	Total Cost (UGX 000)	Planned Monthly Expenditures (UGX 000)											
				July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1	Form E4	Office Supplies													
2	Form E5	Major Schedule Procurement													
3	Form E6	General Admin. Expenses													
4															
5															
	Total Undistributed Expenses														

Note: 1.
1. Lines 4 and 5 are provided for other funding requests as may be permitted under revisions as may be made from time to time by the MoFED to the PAF Guidelines and following advise/approval of MOWT

Signed: UCE …………………… Signed: TC ………….. Date:

14. Covering Letter for Submission of AURWP

OFFICE OF THE TOWN CLERK
MUNICIPAL/TOWN COUNCIL: ___________________
P.O. BOX _____________
Date:

The Permanent Secretary
Ministry of Works and Transport
P O Box 7174
Kampala

ATTN: _______________________

Dear Sir/Madam

RE: Submission of Annual Urban Road Work Plan for Urban Road Works in
______________ Municipal/Town Council Planned for Implementation during Financial Year: _________

Please find herewith the Annual Urban Road Work Plan (AURWP) for urban road works in _____________ Municipal/Town Council for financial year (FY): ______

1. Introduction

The total length of urban roads in ______________ Municipality/Town is _______km:

- Good condition: _________km
- Fair condition: __________km
- Poor condition: __________km
- Bad condition: ___________km

The AURWP for this FY includes the following:

- Routine Maintenance: ________km
- Periodic Maintenance: ________km
- Rehabilitation: ________km
- Improvement to Bituminous Standard: _________km

This AURWP also includes the Surveying and Design of ___________ road sections.

The overall funding requirements including the planned quarterly disbursements for implementation of the above listed road works are detailed in Forms E1 to E3 attached hereto. The following Table provides a summary of the planned works and budget requirements included in the AURWP for the forthcoming FY.

Funding Sources & Ceilings (LGBFP)

Planned Interventions	PAF/ ROAD FUND	LGDP	JICA	Equalization Grant	Local Revenue	Annual Total Intervention Costs (UGX 000)	Average Cost (UGX/km)
Routine Maint (RM) - km							
Periodic Maint (PM) - km							
Rehabilitation (RH) - km							
Routine Maintenance							
Sub – Totals							
Operational Expenditures - max. 15%							
Grand Totals (Ush 000)							

2.0 Overview

2.1 The development objectives/priorities of ________________Urban Council for this FY include the following: _______________

2.2 Performance during the current FY: _______________

3.0 Attachments

The following Attachments form a part of and are included with this Annual Urban Road Work Plan:

- Urban Road Register, detailing the road Inventory, and its current Condition.
- Prioritised Lists for all interventions/activities including a) those roads in maintainable condition and requiring routine maintenance, b) those roads requiring periodic maintenance, c) those roads needing rehabilitation and d) details of road to be improved to bituminous standards.
- Expenditure Schedule detailing cost estimates of all planned interventions/activities **(Form E1).**
- Works Implementation Schedule detailing when the planned interventions/activities are to be undertaken:**(Form E2).**
- Annual Road Works / Source of Funds Summary detailing the total expenditures planned for each of the interventions/activities, their sources of the funds and the schedule for their quarterly release: **(Form E3).**
- Estimate of Operational/Supervision Expenses necessary to undertake planning, procurement, supervision and monitoring and reporting of all of the works: **(Forms E4, E5, E6 & E7).**

Yours sincerely,

Town Clerk
_____________________ Municipal/Town Council

cc:
The Permanent Secretary/Secretary to Treasury, MoFEP
The Permanent Secretary, Ministry of Local Government
The Chairperson: _________________District Public Accounts Committee
The Mayor/Chairman LC III: ________________ Municipal/Town Council
The Chief Administrative Officer: ___________________ District
The Senior Internal Auditor: ________________ Municipal/Town Council
RDC, ... District
Director Budget, MFPED, Kampala

15. Maintenance Specifications

Maintenance Specifications

Table of Contents

1 Road Verge Maintenance

1.1 Removal of Obstructions

WORK ACTIVITY DESCRIPTION

Identification and disposal of obstructions (e.g. rocks and stones, dead animals, minor ant hill, earth slips, fallen trees etc.) located on the verge and/or roadway surface.

PERFORMANCE CRITERIA

All excess deposits and obstacles shall be removed from the roadway within the Inspection Interval after the deposits and obstacles have been observed. The original as-built formation level shall be reinstated to its original level, solidity and cross fall. Deposits shall be suitably disposed to at least 25 m distant from the road centreline.

All obstacles such as fallen rocks, woods etc. shall be removed immediately they after having been observed. Disposal shall be as described above in this Section unless the obstructions harm the environment visually or otherwise. Harmful materials shall be transported away for proper treatment.

PERSONNEL

Work Supervisor... 1
Foreman 1
Workmen 6-10

MACHINERY AND TOOLS

Claw Bars 4-10
Shovels.. 4-10
Hoes 4-10
Rakes 4-10
Pick axes 4-10
Axes 4-10
Wheel Barrows.. 2-4
Ropes
Timber Planks
Matches

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
"Men working" sign..2
Go Slow...2
Red/green flags... 2-4
Diversion

Site protection equipment
Traffic cones 10

Safety Equipment
Yellow/orange safety coats/vests 8-12

QUALITY REQUIREMENTS

If the obstruction is a dead animal, 1 m deep pit or cart away.

In case of anthills special treatment should be given.

If it is any other fallen material on the road, it should be disposed off the road reserve.

WORK EXECUTION

A. Determine scope of work

B. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

Place flagmen and go-slow signs between “men working” signs and work area.

Place diversion signs if required

C. Dispose of the obstruction

Remove all obstructions from the road surface, median and verge. Collect debris and cart away or dispose as per *Performance Criteria.*

D. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

To be added, if up-to-date data exist.

1.2 Litter Removal

WORK ACTIVITY DESCRIPTION

Litter control on roadside and median areas using hand tools and labour to maintain a condition that contributes to neat, clean and attractive road surroundings.

PERFORMANCE CRITERIA

Within urban area collect and remove all rubbish whenever roadside or median areas become untidy. To avoid rubbish blocking road drainage system it has to be removed regularly. In rural areas collect and remove rubbish from roadside as necessary.

PERSONNEL

Foreman 1
Workmen 4

MACHINERY AND TOOLS

Brooms 4
Rakes 4
Spiked rods... 4
Plastic sacks

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
"Men working" sign..2
"End of restriction" signs..................................2

Site protection equipment
Traffic cones 10
Reversible "stop/go" signs................................2

Safety Equipment
Yellow/orange safety coats/vests 5

QUALITY REQUIREMENTS

Bigger particles of rubbish from the carriageway and slopes have to be removed and collected into plastic sack. Smaller particles from the carriageway have to be removed using brooms. All collected rubbish has to be transported to a dumping area.

WORK EXECUTION

A. Determine scope of work

B. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

Place flagmen and go-slow signs between “men working” signs and work area.

Place diversion signs if required

C. Dispose of the obstruction

Pick up bigger particles of rubbish from the carriageway and slopes using spiked rods and collect them into plastic sacks. Remove smaller particles from the carriageway using brooms. Remove all collected rubbish to dumping area.

D. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

To be added, if up-to-date data exist.

1.3 Vegetation Clearing

WORK ACTIVITY DESCRIPTION

Cut trees and bushes on road site using labour with hand tools to maintain a condition that contributes to safety for road users, maintains proper sight distance requirements and allows for proper drainage.

PERFORMANCE CRITERIA

Perform bush clearing on the road side when the trees and bushes are over dimensions described in *Quality Requirements*

PERSONNEL

Foreman 1
Workmen ....6 – 10

MACHINERY AND TOOLS

Cutting knives .... 6 - 10
Axes ....6 – 10

SIGNS AND SAFETY EQUIPMENT

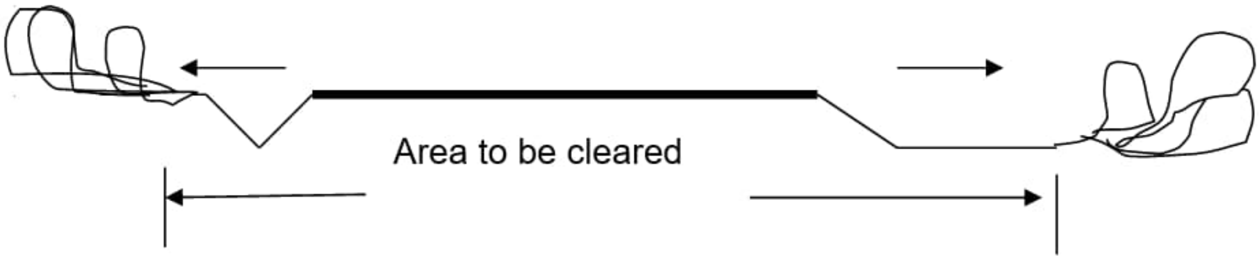
Advance warning signs
"Men working" sign..2
"End of restriction" signs..................................2

Site protection equipment
Traffic cones 10
Reversible "stop/go" signs 2

Safety Equipment
Yellow/orange safety coats/vests 7-11

QUALITY REQUIREMENTS

Generally trees and bushes higher than 50 cm on the road area have to be cut and removed out from the back slope or up to 3m from the inner slope.



WORK EXECUTION

A. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

Place “end of restriction” signs or other suitable signs on the shoulder at the end of the site.

B. Removal of vegetation

Cut and remove vegetation in order to maintain proper sight distance requirements and allows for proper drainage. Collect all removed vegetation and transport to dumping area.

C. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

Grass cutting 1000 m2/day/person
Bush/shrub clearing 150 m2/day/person

1.4 Weeding

PERFORMANCE CRITERIA

Weed shoulders and median along the road edge in order to stop grass from encroaching to the carriageway.

PERSONNEL

Foreman 1
Workmen ....6 – 10

MACHINERY AND TOOLS

Spades/shovels....................................... 6 - 10
Hoes ....6 – 10
Rakes ....6 – 10

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign..2
“End of restriction” signs..................................2

Site protection equipment
Traffic cones 10
Reversible “stop/go” signs 2

Safety Equipment
Yellow/orange safety coats/vests 7-11

QUALITY REQUIREMENTS

Shoulder and median edges and carriageway to be free of weeds.

WORK EXECUTION

D. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

Place “end of restriction” signs or other suitable signs on the shoulder at the end of the site.

E. Removal of weeds

Use pegs and strings to clearly mark the shoulder edge on gravel and earth roads to guide the labourers.

Remove grass and root from shoulder and deposit on road reserve.

Collect all removed vegetation and transport to dumping area.

F. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

70m^2/day/person

1.5 Grass Cutting

PERFORMANCE CRITERIA

Cut grass on road verges and medians to prevent interference with line of sight and pedestrian access.

PERSONNEL

Foreman 1
Workmen 4

MACHINERY AND TOOLS

Weed Wacker/String Trimmer.......................... 4
Rakes... 4
Appropriate fuel (ie diesel)

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign...2
“End of restriction” signs...................................2

Site protection equipment
Traffic cones 10
Reversible “stop/go” signs 2

Safety Equipment
Yellow/orange safety coats/vests 5

QUALITY REQUIREMENTS

Grass should have a length of less that 100mm.

WORK EXECUTION

A. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

Place “end of restriction” signs or other suitable signs on the shoulder at the end of the site.

B. Grass cutting

Cut grass on verges and medians to length of less than 100mm.

Collect all cut grass and transport to dumping area.

C. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

To be added, if up-to-date data exist.

2 Road Furniture Maintenance

2.1 Traffic Sign Maintenance

WORK ACTIVITY DESCRIPTION

Repair and/or clean damaged or dirty traffic signs using hand tools and labour to maintain an acceptable condition. Damages include damaged signs and/or supports, poor visibility of signs impaired by dirt or vandalism or by the growth of vegetation

PERFORMANCE CRITERIA

Perform cleaning when dirt hampers visibility of signs. Replace signs when they have lost 50 % of the original reflection or it has faded remarkably. Replace signs when they are bent or letters are missing. Straighten/replace tilted poles or supports.

PERSONNEL

Foreman 1
Workmen 4

MACHINERY AND TOOLS

Screwdriver 2
Adjustable wrench.. 2
Hammer... 2
Ladder 1
Water container.. 1
Cleaning clothes... 4
Billhooks 2

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” signs...2
“End of restriction” signs..................................2

Site protection equipment
Traffic cones 10
Reversible “stop/go” signs................................2

Safety Equipment
Yellow/orange safety coats/vests 5

QUALITY REQUIREMENTS

Dirty signs have to be cleaned using water and cleaning cloth. Avoid damaging painting or reflective film.

Damaged signs have to be replaced with new or rehabilitated ones if they have lost 50 % of the original reflection or they have faded considerably.

Tilted poles and supports have to be straightened into vertical position and severely bent poles have to be replaced.

WORK EXECUTION

A. Place safety devices

Place the safety devices only if working near to carriageway.

Place “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the roadworks.

Place “end of restriction” signs or other suitable signs on the shoulder at each end of the site.

B. Clean signs

Clean dirty signs using water and cleaning cloth. Avoid damaging the painting or the reflective film.

C. Replace damaged signs

Remove damaged signs and replace them with new or rehabilitated ones.

D. Straighten tilted poles or supports

Straighten tilted poles and supports into vertical position and replace bent poles.

E. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

Rate of production is dependant on the number and type of corrections to be made.

To be added, if up-to-date data exist.

2.2 Guardrails

WORK ACTIVITY DESCRIPTION

Repair damaged or missing safety rails using hand tools and labour in order to restore good condition of safety rails (guard rails).

ROUTINE VS PERIODIC MAINTENANCE

The countermeasures described below in *Performance Criteria* must be carried out within the Inspection Interval. In case of lack of spare parts the work is allowed to be postponed until the spares delivery has taken place. Warning signs must be placed at the site immediately for the damaged rail system.

Small painting works and minor repair works should be carried out as routine maintenance, large painting works and systematic renewal of railings should be undertaken during periodic maintenance.

PERFORMANCE CRITERIA

Perform vegetation removal when visibility of safety rails is limited. Replace damaged or missing rails when there is a hazard for road safety. Replace damaged or missing supports to prevent more severe damages.

PERSONNEL

Foreman 1
Workmen 4

MACHINERY AND TOOLS

Screwdriver 2
Adjustable wrench.. 2
Hammer... 2
Ladder 1
Shovels.. 2
Pickaxes 2
Axes 2
Billhooks 2

SIGNS AND SAFETY EQUIPMENT

Materials:
Bolts and nuts
Rails

Advance warning signs
“Men working” sign..2
“End of restriction” signs..................................2

Site protection equipment
Traffic cones 10
Reversible “stop/go” signs 2

Safety Equipment
Yellow/orange safety coats/vests 5

QUALITY REQUIREMENTS

Safety rails have to be free of vegetation.

Damaged rails or supports have to be replaced with new ones similar to the original ones.

Tilted supports have to be straightened into vertical position

WORK EXECUTION

A. Place safety devices

Place “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

Place “end of restriction” signs or other suitable signs on the road shoulder at the end of the site.

B. Vegetation control

Cut and remove vegetation hiding the rails using axes or billhook.

C. Replace damaged rails or supports

Remove damaged rails or supports and replace them with new ones similar to the original ones.

D. Straighten tilted supports

Straighten tilted supports into vertical position.

E. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

Rate of production is dependant on the number and type of corrections to be made.

To be added, if up-to-date data exist.

2.3 Traffic Signals

WORK ACTIVITY DESCRIPTION

Repair or replace all damaged elements of the traffic signal, including lights, signal heads, bent or damaged poles and electrical equipment. It s recommended that routine maintenance of a traffic signal be pre-ceded by an inspection in order to determine the required activities and equipment required to carry out the maintenance action. Electrical work should only be carried out by a licenced person.

PERFORMANCE CRITERIA

All elements should be in good working order:

1. The controller cabinet should be clean and weatherproof
2. Signal heads should not be dirty or damaged such that the visibility of the lights to oncoming traffic is hampered.
3. Signal post should not be bent and should be painted where damaged to prevent rust.
4. Push-buttons/Loop detectors should be in working order
5. Drawboxes/manholes should be cleaned and damaged covers should be replaced
6. All electrical elements should be confirmed to be in working order
7. Other as per manufacturer requirements

PERSONNEL

Foreman 1
Workmen 4
Electrician ....(as required)

MACHINERY AND TOOLS

Screwdriver 2
Adjustable wrench.. 2
Hammer... 2
Ladder 1
Water container... 1
Cleaning clothes... 4
Shovels.. 2

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
"Men working" sign..2
"End of restriction" signs..................................2

Site protection equipment
Traffic cones 10
Reversible "stop/go" signs................................2

Safety Equipment
Yellow/orange safety coats/vests 5

Other equipment based on inspection of traffic signal equipment.

QUALITY REQUIREMENTS

Dirty signal heads have to be cleaned using water and cleaning cloth. Avoid damage to lenses

Faulty lights should be replaced.

Damaged signal heads have to be replaced with new or rehabilitated ones if they impede visibility of the lights for oncoming traffic

Tilted poles have to be straightened into vertical position and severely bent poles have to be replaced.

WORK EXECUTION

E. Place safety devices

Place the safety devices only if working near to carriageway.

Place “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the roadworks.

Place “end of restriction” signs or other suitable signs on the shoulder at each end of the site.

B. Clean traffic signal heads

Clean dirty traffic signal heads using water and cleaning cloth. Avoid damaging the lenses.

C. Replace damaged signal heads

Remove damaged signs and replace them with new or rehabilitated ones.

D. Straighten or replace tilted poles

Straighten tilted poles and supports into vertical position and replace bent poles.

E. Check electrical equipment

All electrical equipment should be confirmed to be in working order by qualified person/electrician. Elements not in working order should be repaired or replaced. (check Push-buttons, Loop detectors, all cabling, controller box etc.)

F. Update traffic signal timing plan

Update traffic signal timing plan if required.

G. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

Rate of production is dependant on the number and type of corrections to be made.

To be added, if up-to-date data exist.

2.4 Kerbs and Footways

WORK ACTIVITY DESCRIPTION

Damaged and missing kerbs should be replaced, cracking and settling in footways should be repaired.

PERSONNEL

Foreman 1
Workmen 4

MACHINERY AND TOOLS

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign...2
“End of restriction” signs..................................2

Site protection equipment
Traffic cones 10
Reversible “stop/go” signs 2

Safety Equipment
Yellow/orange safety coats/vests 5

QUALITY REQUIREMENTS

Cracks and settlement of footways of more than 25mm pose a tripping hazard and should be repaired.

WORK EXECUTION

AVERAGE PRODUCTION

2.5 Utilities

WORK ACTIVITY DESCRIPTION

Clean utility manholes from litter and debris. Repair damaged utility manholes and covers. Replace missing utility covers

PERSONNEL

Foreman 1
Workmen 4

MACHINERY AND TOOLS

Shovels.. 2
Handtools

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
"Men working" sign...2
"End of restriction" signs..................................2

Site protection equipment
Traffic cones 10
Reversible "stop/go" signs 2

Safety Equipment
Yellow/orange safety coats/vests 5

WORK EXECUTION

A. Place safety devices

Place the safety devices only if working near to carriageway.

Place "men working" signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the roadworks.

Place "end of restriction" signs or other suitable signs on the shoulder at each end of the site.

B. Conduct cleaning and repairs

Clean utility manholes of litter and debris

Repair damaged utility manholes

Relace utility manhole covers.

C. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

To be determined

3 Paved Roads

3.1 Pothole Patching Using Premix

WORK ACTIVITY DESCRIPTION

Patch potholes and hollows on the road pavement to maintain a smooth, safe riding surface, by using pre-prepared hot or cold mix, hand tools and manual labour.

PERFORMANCE CRITERIA

Carry out patching to meet the Level of Service requirements.

The work should be done when the surface is dry.

Open potholes and cracks may cause danger to road users, have to be patched within two working days on priority class 1 – 2 roads and holes and cracks within the inspection period.

PERSONNEL

foreman 1
driver.. 1
vibrating roller operator................................... 1
traffic controllers... 2
workmen 4

MATERIALS

premix
aggregates
quarry dust 0-4 mm
crushed stone 4-10 mm
bituminous binder
Bitumen 60/70

MACHINERY AND TOOLS

tipper or tractor with trailer............................... 1
small vibrating roller or plate................ 1
wheelbarrows... 2
pickaxes.. 4
hand rammers.. 2
brooms.. 4
watering cans... 2
emulsion sprayer.. 1
two-meter straight edge.................................. 1
chalk for marking

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign...2
“End of restriction” signs..................................2

Site protection equipment
Traffic cones 10
Reversible “stop/go” signs 2

Safety Equipment
Yellow/orange safety coats/vests 9

QUALITY REQUIREMENTS

The defective/damaged area has to be repaired to at least 100 mm outside of the damaged area.

The depth of the pothole has to be increased until firm, dry material is found.

The bottom of the pothole has to be trimmed flat, horizontal and free from loose material.

The walls of the pothole have to be made flat and vertical.

Compact the bottom of the hole.

A thin coat of bitumen has to be applied evenly on the sides and bottom of the hole.

Premix has to be placed in layers of no more than 50mm each prior to each compaction.

The final compacted top layer has to smoothly blend with the surrounding surfacing.

Loose material must be brushed from the carriageway.

WORK EXECUTION

A. Place safety devices

Place “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

Place “end of restriction” signs or other suitable signs on the road shoulder at the end of the site.

B. Mark the area to be repaired

Mark out areas to be repaired to at least 100 mm outside of damaged areas with chalk, by drawing a rectangle around the defects.

C. Excavate the hole

Remove all loose material from the potholes within the marked area and increase the depth of the hole until firm, dry material is found. Trim the pothole “walls” so that they are vertical. Flatten the bottom of the hole and compact it.

D. Fill the hole and compact

Spread a light coat of bitumen evenly on the sides and bottom of the hole.

Place premix in layers of not more than 50mm prior to compaction.

Use hand rammer or small compaction plate to compact each layer.

Check the final layer with the straight edge.

Brush away any loose material.

E. Remove safety devices

Remove all the safety signage and devices from the site.

F. Isolate zone, if not yet patched

All potholes prepared, but not yet patched must be isolated and protected overnight with warning signs and delineators (cones).

AVERAGE PRODUCTION

15 m^2/day for concentrated repair work. Production will be reduced for scattered pothole patching over a larger road section.

3.2 Crack Sealing Using Hot Bitumen

WORK ACTIVITY DESCRIPTION

Seal cracked surface using hand tools, labour and hot bitumen to prevent water infiltration through cracks into the road structure. The work may be carried out as routine maintenance measure (small scale) or as periodic measure (large scale).

PERFORMANCE CRITERIA

Carry out crack sealing to meet the Level of Service requirements. The work should be done when the surface is dry.

PERSONNEL

Foreman 1
Driver 1
Traffic controllers.. 2
Workmen 4

MACHINERY AND TOOLS

Tipper or tractor with trailer.............................. 1
Wheelbarrows 2
Bitumen heater.. 1
Brooms 4
Watering cans 4

MATERIALS

Bitumen
Fine sand

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign...2
“End of restriction” signs..................................2

Site protection equipment
Traffic cones 10
Reversible “stop/go” signs 2

Safety Equipment
Yellow/orange safety coats/vests 8

QUALITY REQUIREMENTS

Crack sealing can be carried out only when the surface is dry. Fine sand has to be spread on sealed cracks to avoid bitumen to stick on the tyres of vehicles.

WORK EXECUTION

A. Place safety devices

Place “men working” or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the roadworks.

Place “end of restriction” sign on the shoulder on the side of the departing traffic, at each end of the site.

B. Heat the bitumen

Bitumen must be heated in the heater until it reaches liquid form. Special attention must be paid to avoid overheating because bitumen will start burning if overheated.

C. Seal the cracks

Pour hot bitumen from the heater to the watering cans. Fill cracks by pouring hot bitumen into the cracks until bitumen layer is about 2 cm wider than the crack.

D. Sand the sealed cracks

Spread fine sand over the sealed area to avoid bitumen to stick on the tyres of passing vehicles. Excess sand must be removed.

D. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

To be determined

3.3 Edge Step Backfill using Gravel

WORK ACTIVITY DESCRIPTION

Repair high edge steps using hand tools, labour and gravel to maintain a smooth, safe edge.

PERFORMANCE CRITERIA

Perform when edge steps become a traffic safety risk to road users. Failing areas should be repaired before severe deformation occurs.

PERSONNEL

Foreman 1
Driver 1
Traffic controllers.. 2
Workmen 4

MACHINERY AND TOOLS

Tipper or tractor with trailer.............................. 1
Self propelled or pedestrian roller 1
Wheelbarrows 2
Brooms 4
Shovels 4
Camber board 1

MATERIALS

Gravel
Crushed aggregates

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign...2
“End of restriction” signs...................................2

Site protection equipment
Traffic cones 10
Reversible “stop/go” signs................................2

Safety Equipment
Yellow/orange safety coats/vests 8

QUALITY REQUIREMENTS

The existing surface of the shoulder has to be scarified with tines of a motor grader to loosen the surface.

Excess material has to be removed to the embankment side slope. In cuttings excess material have to be removed by wheelbarrow.

The compacted surface is to be adjusted smoothly onto the road pavement, with correct crossfall.

All loose material and debris have to be brushed from the carriageway.

WORK EXECUTION

A. Place safety devices

Place “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead the road works.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the roadworks.

Place “end of restriction” sign on the shoulder on the side of the departing traffic, at each end of the site.

B. Haulage of backfill material

New shoulder material is off-loaded or tipped onto the shoulder, allowing a small surplus to requirements.

C. Backfill

The existing surface of the shoulder should be scarified with tines of a motor grader to loosen the surface and add the backfill material.

Shape the added material slightly above the final level and correct the crossfall.

Excess material has to be removed to the embankment side slope. In cuttings excess material has to be removed by wheelbarrow.

D. Compaction

The shoulder has to be compacted using a self-propelled or pedestrian roller. If the material is dry it has to be sprinkled with water to optimum moisture content.

The compacted surface is to be adjusted smoothly onto the road pavement.

Check the finished crossfall with a camber board and repeat the reshaping if necessary

Brush all loose material and debris from the carriageway.

E. Remove safety devices

Remove all safety devices from the site.

AVERAGE PRODUCTION

To be determined

3.4 Shoulder Repair of Paved Roads

WORK ACTIVITY DESCRIPTION

The addition of selected gravel to isolated areas of shoulders where low spots have developed/grading of shoulders

PERFORMANCE CRITERIA

Perform when shoulder low spots become a traffic and pedestrian safety risk.

PERSONNEL

Foreman Civil.. 1
Headmen 1
Operator Heavy... 3
Operator Light 1
Driver Heavy 2
Driver Light 1
Site Clerk 1
Mechanic 2
Labourers.. 5

MATERIALS

Selected gravel ....$135m^3$

SIGNS AND SAFETY EQUIPMENT

Advance warning signs

"Men working" sign..2
"Red flag 2

MACHINERY AND TOOLS

Pick up 1
Tippers.. 2
Water Bowser.. 1
Motorcycle... 1
Traxcavator 1
Grader... 1
Roller PTR or Vib. Drum 1
Water Pump
Shovels 6
Hard Brooms.. 4
Camber boards level 1

QUALITY REQUIREMENTS

Special care has to be taken (i) to avoid damaging the pavement edge and (ii) to avoid grading off the shoulder at too great across fall, so it is important to use a camber board to maintain a cross fall of 4-6% (but not on superelevated sections of curve where the superelevation cross fall will govern). 2. When cleaning the ditch, it is important to ensure the spoil is disposed of well clear of the edge of ditch so that (i) the spoil does not get washed back into the ditch with rainwater run-off and (ii) it does not form a berm, which will obstruct rainwater run-off entering the ditch.

WORK EXECUTION

1. Define work area and set up safety signs, flags etc.
2. Grade shoulder to restore even cross-section, lightly scarify and water.
3. Haul and place selected gravel.
4. Spread and shape gravel to approximate level and cross fall.
5. Water and compact, rolling from outer edge inwards.
6. Skim shoulder to edge of pavement level and correct 4-65 cross fall, by grader.
7. Lightly water and complete compaction, rolling from the outer edge inwards.
8. Brush/clean pavement edge.
9. Clear drainage from side drain and jettison well clear of ditch.
10. Remove safety signs and devices.

AVERAGE PRODUCTION

1,000 linear meter of shoulder spot

4 Unpaved Roads

4.1 Filling Potholes and Minor Gullies

WORK ACTIVITY DESCRIPTION

Filling of potholes and gullies that have developed on the carriageway using approved material.

PERFORMANCE CRITERIA

Material used should be in accordance will the existing road materials. Filling should be done in layers of 150mm and compacted well.

PERSONNEL

Work Supervisor... 1
Foreman 1
Workmen 4-6

MACHINERY AND TOOLS

Wheel barrows 2-4
Spades/shovels... 2-4
Hoes 2-4
Rakes 2.4
Rammers 2-4

MATERIALS

Gravel material to match gravel road.

MOWTC to provided; 1: Approved material to a distance not more than 100m where necessary.

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign 2
“End of restriction” signs 2

Site protection equipment
Traffic cones... 10
Reversible “stop/go” signs 2

Safety Equipment
Yellow/orange safety coats/vests 6-8

QUALITY REQUIREMENTS
Special care has to be taken (i) to avoid damaging the surrounding pavement, and (ii) that the repaired surface is uniform

WORK EXECUTION

A. Identify area

B. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

C. Fill pothole

Remove weak material from pothole and dig out until firm ground/material is reached.

Fill in new material in layers not more than 15cm.

Compact each layer adequately.

D. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

$3m^3$/day/person

4.2 Grubbing

WORK ACTIVITY DESCRIPTION

Grubbing to reinstate road camber and shoulder crossfall.

PERFORMANCE CRITERIA

Material used should be in accordance will the existing road materials. Filling should be done in layers of 150mm and compacted well.

PERSONNEL

Foreman 1
Workmen 4-6

MACHINERY AND TOOLS

Hoes 2-4
Rakes 2.4
Shovels... 2-4

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign 2
“End of restriction” signs 2

Site protection equipment
Traffic cones... 10
Reversible “stop/go” signs 2

Safety Equipment
Yellow/orange safety coats/vests 5-7

QUALITY REQUIREMENTS

Item only to be instructed if the lump sum is sufficient to cover the required work.

The Contractor shall inform and seek authority to carry out the activity.

Only to be covered out as and if directed in writing by the Engineer-in-chief.

WORK EXECUTION

A. Identify area

B. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

C. Grub area

Rake existing material to original level and tamp

D. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

70m^2/day

4.3 Light Grading

WORK ACTIVITY DESCRIPTION

Light grading is pure blading of the carriageway and/or shoulders by motor grader to restore a smooth driving surface and camber by grading off the highpoints of surface irregularities and evenly spreading the arisings to low points, drawing the arisings inwards towards the centre of the road while travelling longitudinally. The aforesaid grading operation being repeated as necessary until the full width and extent of the designated area has been graded as specified.

The existing cross-section and longitudinal profiles shall be graded to a surface tolerance of plus minus 12 mm of the mean existing level, gradient and crossfall at the respective off-set from the centre-line of the road and shall not at any point be so formed as not to shed surface water.

AVERAGE PRODUCTION

More than 2000 linear metres per day.

4.4 Medium Grading

WORK ACTIVITY DESCRIPTION

Repair damaged gravel or earth surface using motor grader without deep cutting and mechanical compaction to maintain a smooth and safe riding surface. Damages are usually potholes, ruts and corrugation. Slight loss of camber may also occur

PERFORMANCE CRITERIA

Carry out grading to meet the Level of Service requirements. Damaged areas should be graded before severe defects occur. The surface should be moist when grading. If it does not have moisture naturally, watering should be applied.

The required frequency of grading depends on the damaging effects of traffic and climate, and the LOS requirements. Maintaining smooth carriageway surface with a proper camber will enable efficient road surface drainage and minimize the eroding effects of rain water.

PERSONNEL

Grader operator... 1
Workman 1

SIGNS AND SAFETY EQUIPMENT

Safety Equipment
Yellow/orange safety coats/vests 2

MACHINERY AND TOOLS

Motor Grader... 1
Rake 1

QUALITY REQUIREMENTS

After medium grading, the carriageway has to be smooth with a camber of about 5 per cent (4-6%). All over-sized stones have to be removed from the carriageway

WORK EXECUTION

A. Identify area

B. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

C. Grading

Adjust the cutting blade to a 30 degree angle (see Figure 1) in order to minimize the cutting force needed. Adjust the cutting angle to 75 degrees (see Figure 2).

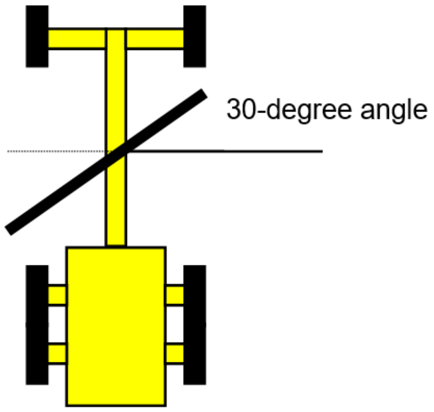


Figure 1

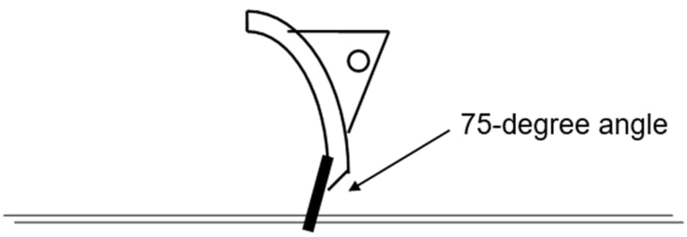
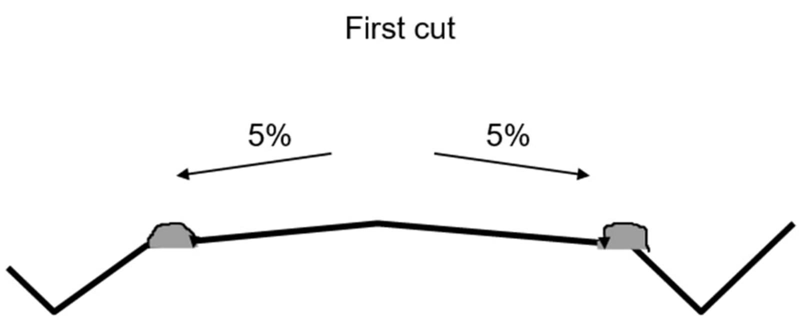


Figure 2

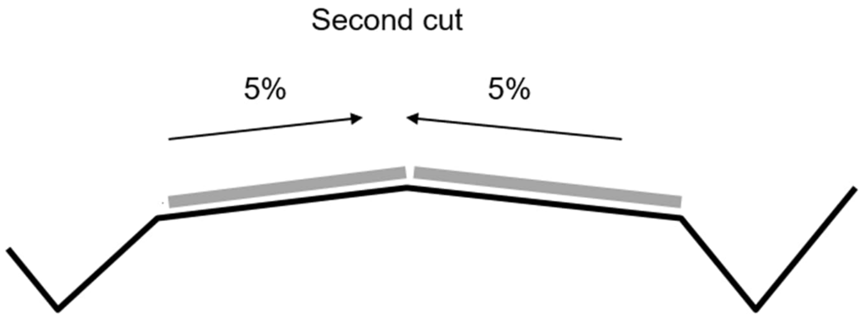
Start grading by cutting from the centre and move loose material by grader blade to the edge of the carriageway. Cut deep enough to reach the bottom of the potholes.

Adjust the cutting blade to form 5% camber in order to correct the cross-section of the carriageway.



By the second cut loose material is spread back to the carriageway as an even layer, maintaining 5% camber.

Oversized boulders must be removed from the carriageway using a rake in order to avoid damages to vehicles.



D. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION 2000 linear metre per day.

4.5 Heavy Grading

WORK ACTIVITY DESCRIPTION

Repair damaged gravel or earth surface using motor grader to restore smooth and safe riding surface and to reshape the cross-section. Damaged areas usually comprise deep potholes and ruts. Heavy corrugation and loss of camber usually also appear.

PERFORMANCE CRITERIA

Perform heavy grading whenever the gravel road surface shows significant damage, and light grading will not be sufficient. Failing road sections have to be graded before severe deformation occurs. If there is not enough moisture in the wearing course of the road, watering has to be applied.

PERSONNEL

Grader operator... 1
Workman 1

SIGNS AND SAFETY EQUIPMENT

Safety Equipment
Yellow/orange safety coats/vests 2

MACHINERY AND TOOLS

Motor Grader... 1
Rake 1

QUALITY REQUIREMENTS

After the completion of the heavy grading, the carriageway has to be smooth with a 5% camber (4-6%). All oversized stones have to be removed from the carriageway after the grading.

WORK EXECUTION

A. Identify area

B. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

C. Grading

Adjust the cutting blade to a 30 degree angle (see Figure 1) in order to minimize the cutting force needed. Adjust the cutting angle to 75 degrees (see Figure 2).

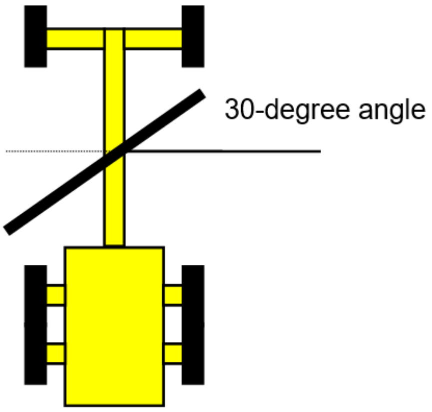


Figure 1

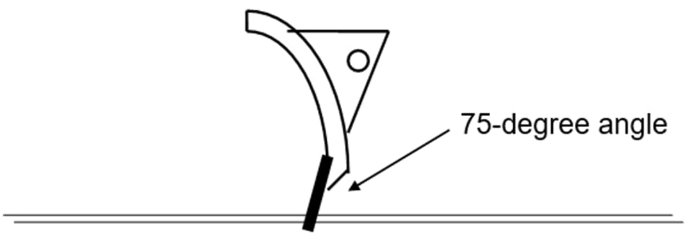
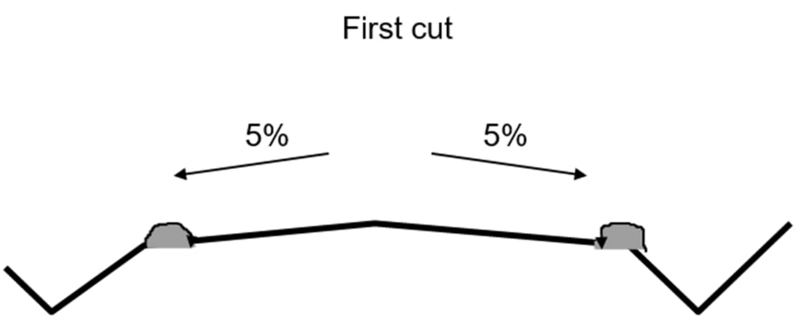


Figure 2

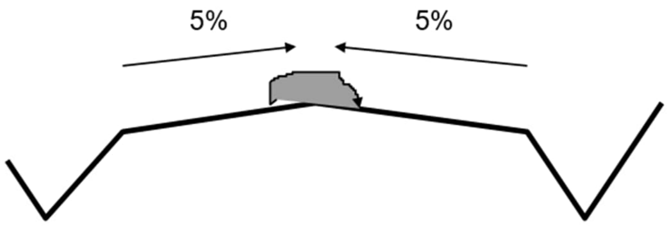
Start grading by cutting from the centre and move loose material by grader blade to the edge of the carriageway. Cut deep enough to reach the bottom of the potholes.

Adjust the cutting blade to form 5% camber in order to correct the cross-section of the carriageway.



With the second cut loose material is taken to the centre of the carriageway.

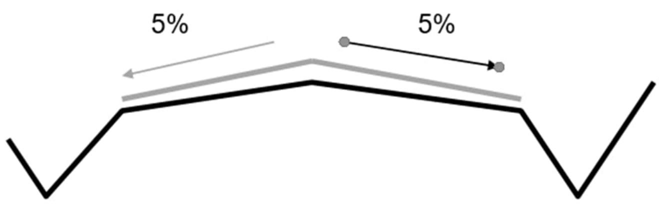
Second cut



By the third cut loose material is spread as an even layer back to the carriageway, maintaining the 5% camber.

Oversized boulders must be removed from the carriageway using a rake in order to avoid damages to vehicles.

Third cut



AVERAGE PRODUCTION 500 linear metres

4.6 Heavy Grading and Regravelling

WORK ACTIVITY DESCRIPTION

Repair damaged gravel or earth road surface to reshape the cross-section material by using motor grader and roller. Add wearing course material by regravelling. The material has to be selected material meeting the wearing course requirements. Damaged areas usually comprise deep potholes and ruts, and the wearing course thickness has been reduced. On many occasions the carriageway is unnecessarily wide, the road has heavy corrugation and the original camber has been lost.

PERSONNEL

Foreman 1
Operator..11
Helper 4

MACHINERY AND TOOLS

Grader 2
Dump Truck 6
Water Tanker 1
Loader 1
Roller 1
Hand tools..Several

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign 2
Speed limit 30km/h signs................................. 2

Safety Equipment
Yellow/orange safety coats/vests
(as required for working team)

WORK EXECUTION

A. Identify area

B. Place safety devices

Place the safety devices only if working near to carriageway.

Locate the "men working" signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area. Place reduced speed signs.

C. Grading

Adjust the cutting blade to a 30 degree angle (see Figure 1) in order to minimize the cutting force needed. Adjust the cutting angle to 75 degrees (see Figure 2).

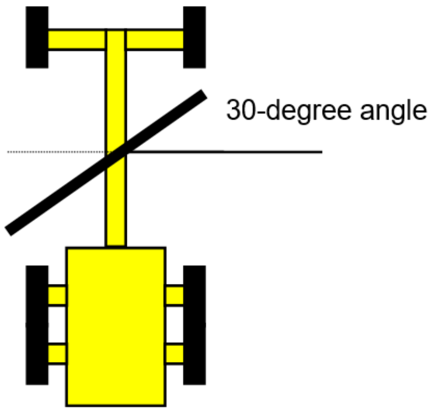


Figure 1

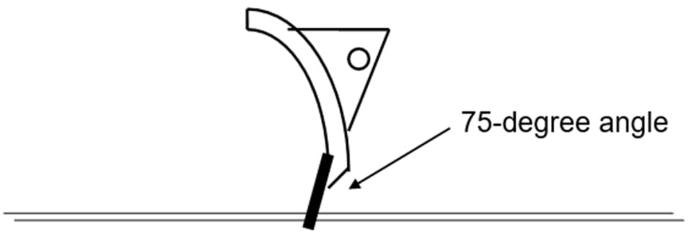
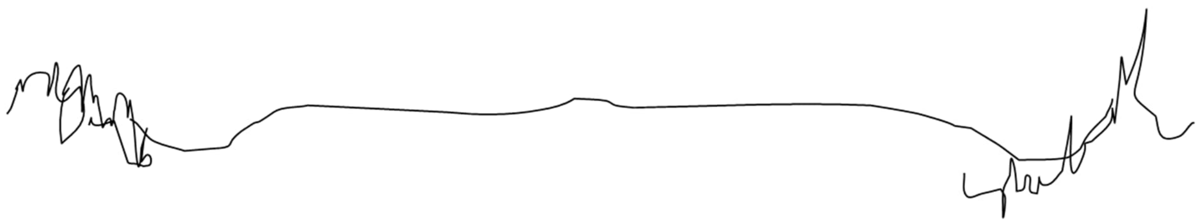


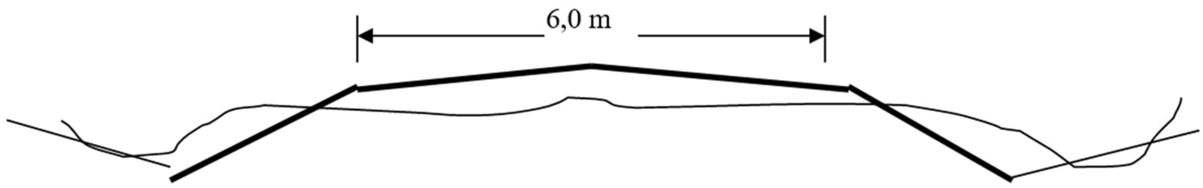
Figure 2

The camber of the road is lost and the road is too wide (8–12 m).

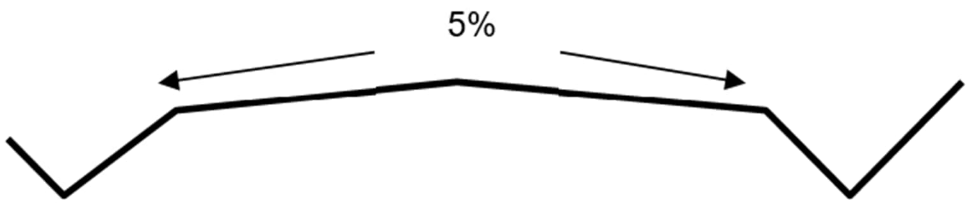


First the trees and bushes within back slopes are cleared by grader.

The second step is to move the material from both sides of the road to the middle of the road and to shape the surface. The surface has to be compacted by roller before regravelling



Adjust the cutting blade to form 5% camber to correct cross-section of the carriageway.



D. Regravelling

Gravel has to be moved by dump trucks and sprayed by dozer and levelled by grader on top of the surface. The thickness of the wearing course has to be from 10 cm to 15 cm

The gravel has to be compacted by roller using watering.

E. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION
To be added, if up-to-date data exist.

4.7 Shoulder Slope Erosion Repair

WORK ACTIVITY DESCRIPTION

Re-instatement of eroded shoulders and ditch slopes with appropriate material.

PERFORMANCE CRITERIA

Shoulders to be repaired to the gradient. Material used should be in accordance with the existing shoulder material.

PERSONNEL

Foreman 1
Workmen 4-6

MACHINERY AND TOOLS

Wheel barrows 2-4
Spades/shovels.. 2-4
Hoes 2-4
Rakes 2-4
Rammers 2-4

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
"Men working" sign...2
"End of restriction" signs...................................2

Site protection equipment
Traffic cones 10
Reversible "stop/go" signs 2

Safety Equipment
Yellow/orange safety coats/vests 9

QUALITY REQUIREMENTS

MOWHC to provide all safety signs.

Where grass exists on the shoulder, it should be kept low to assist in preventing shoulder erosion.

WORK EXECUTION

E. **Identify eroded shoulders**

F. **Place safety devices**

Place the safety devices only if working near to carriageway.

Locate the “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead of the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

G. **Correct shoulder slopes**

Place material on damaged shoulders and slopes.

Rake the material to original level.

H. **Remove safety devices**

Remove all the safety devices from the site.

AVERAGE PRODUCTION

$90m^2$/day/person

5 Drainage

5.1 Manual Drainage Cleaning

WORK ACTIVITY DESCRIPTION

Cut trees and bushes and open the ditch area using labour and hand tools. Repair roadside ditches using hand tools and gravel, if necessary. Usually vegetation, debris and soil silted up may obstruct the water flow. Clean the blocked culverts and their outlets to the minimum distance of 20 m, offshoot (mitre) drains and other water courses. Clean stream channels of debris and vegetation at all times 10 m both upstream and downstream. Clean catch-water drains. The purpose is to maintain proper shape and condition of ditches and culverts in order to allow for functioning drainage system of the road. If possible the side ditch bottom must be 0.5 m below the adjacent shoulder level. Application: Paved and Gravel Roads.

PERSONNEL

Foreman 1
Operator.. 1
Workmen 6

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
“Men working” sign 2

Safety Equipment
Yellow/orange safety coats/vests 6

MACHINERY AND TOOLS

Light truck 1
Shovels.. 6
Axes 6
Bush knives 6

QUALITY REQUIREMENTS

All trees and bushes higher than 50 cm on the ditch area have to be cut and removed out from back slope. The drainage structures (culverts, bridges, fords, ditches, outlets) have to be cleaned from debris, silted sand etc. The cleaning result has to allow for uninterrupted flow of water out from the road area. Harmless soil material can be disposed in the near surrounding. Other material removed should be disposed at least 10 m from the centreline of the road or as directed by the Engineer. Section with cliffs, urban centres to be given consideration for disposal.

WORK EXECUTION

A. Place safety devices

Place the “men working” signs on the shoulder on the site of the approaching traffic, 100m meters ahead of the road works area.

B. Remove vegetation and debris

Cut and remove all vegetation blocking free water flow at least one meter wide on the ditch slopes using axes and bush knives. Remove all debris blocking the ditch or hindering water flow. Remove all debris and vegetation from both culvert inlets and outlets.

C. Remove soil

Remove carefully soil blocking free water flow from ditches by shovels to maintain original alignment and cross section of ditches and outlets. In culverts, remove carefully the soil covering aprons and also inside the culvert by using shovels (with long culverts, shovels with extension handle may be required).

Soil removed from culverts and ditches must be placed far enough from the drainage structures in order to prevent it from running back down to block the drainage system again.

D. Remove safety devices

Remove all the safety devices from the site.

AVERAGE PRODUCTION

Side/mitre drains:
Fully silted 30-40 m/day/person, measurement linear metre
Half silted 50-60 m/day/person
Stream channels:
15 m/day/person, measurement linear metre
Culverts:
Completely blocked 4 m/day/person, measurement linear metre
Half blocked 8 m/day/person
Catch water drain: 25 to 40 m/day/person.

Note: the average daily production depends heavily on the severity of the damages

5.2 Drainage Repair

WORK ACTIVITY DESCRIPTION

This is usually a periodic maintenance measure.

Clear vegetation and open ditch areas using a grader in order to restore good condition of roadside drainage.

Repair any damages to culverts.

PERSONNEL

Foreman 1
Operator.. 1
Workmen 2
(more, if culvert repair is needed)

SIGNS AND SAFETY EQUIPMENT

Advance warning signs
"Men working" sign 2

Safety Equipment
Yellow/orange safety coats/vests 4
(more if additional workmen are required)

MACHINERY AND TOOLS

Light truck 1
Grader 1
Shovels.. 2
Axes 2
Bush knives 2

QUALITY REQUIREMENTS

The ditch area has to be restored to its original shape, alignment and cross-section. Also outlets have to be repaired in order to allow for free drainage water flow. Any culvert damages have to be repaired.

WORK EXECUTION

A. Place safety devices

Use safety devices only if working near to the carriageway.

Place “men working” signs or other suitable warning signs on the road shoulder for the approaching traffic, 100-200 meters ahead the road works area.

Place 4 to 10 traffic cones, as required, to clearly separate the traffic from the road works area.

Place “end of restriction” signs or other suitable signs on the road shoulder at the end of the site.

B. Carry out ditch clearing by grader

C. Carry out Culvert repair

D. Remove safety devices

AVERAGE PRODUCTION

Culvert replacement: 5 linear metres per day

16. Preambles to Bills of Quantities

Relevant Information on Bills of Quantity (BoQ)

- The Bills of Quantity (BoQ) must be read in conjunction with the Conditions of Contract, Technical Specifications and the Conditions of Tender and Instructions to Tenderers and any other documents comprising the Contract.

- The Contractor is assumed to have acquainted him/herself with the specific requirements and standards of the Works and working methods by which they are to be carried out.

- The prices and Unit Rates entered in the **BoQ** are required to be the full inclusive value of the cost of the whole of the Works and all expenses which cover supervision of the Works, hand tools, materials, overheads, risks, profit, liabilities, and other obligations such as insurance, labour regulations, indemnity, etc., are included in the **BoQ** Item Unit Rates. There shall be no exceptions to this requirement.

- The quantities set down against the **BoQ** Items are estimated quantities and are not to be taken as a guarantee that the quantities will be carried out in their entirety or that they will not be exceeded.

- Under no circumstances are the indicated quantities to be exceeded without authorization from the Employer: refer **Clause 38** of the Conditions of Contract.

- The quantities shown in the **BoQ** shall not be considered as representing the final amounts of Works unless otherwise stated. It being the intention of the Contract that all Works shall be measured to determine quantities of actual Works performed and paid for at the Unit Rates given in the **BoQ**.

- The sum allowed under Bill Item 1: Preliminaries is to cover all costs of traffic accommodation, billboards, handling of utility services, materials testing, surveys and drawings and supervision of the project by the employer and site meetings.

- Company overhead costs including supervision of the Works, risk allowance and profit shall be included in the Item Unit Rates.

- All materials required to perform the Works, including their sources of supply, shall be approved by the Engineer. Stockpiling of such materials shall be made at locations approved by the Engineer. Under no circumstances shall additional payments be made for the stockpiling or double handling of these materials.

- Where materials supplied to Site are found to contain other material than those from approved sources, the Engineer shall cause them to be removed from the site by the Contractor and at the full expense of the Contractor.

- When authorized in writing by the Engineer, **Dayworks** will be undertaken and paid for in accordance with the Item Unit Rates given in the **BoQ**.

17. Summary of BoQ for Urban Roads

SUMMARY OF PRICED BILL OF QUANTITIES

Rehabilitaion/Upgrading of Urban Roads

Project: ______________________________

Bill No.	Description	Amount Brought Forward (UGX)
Bill No.01	General	-
Bill No.02	Drainage	-
Bill No.03	Earthworks and Pavement Layers of Gravel or Crushed Stone	-
Bill No.04	Asphalt Pavements and Seals	-
Bill No.05	Ancillary Roadworks	-
Bill No.06	Structures	-
Bill No.07	Tolerances, Testing and Quality Control	-
Bill No.08	Schedule of Daywork Rates (Labour)	-
Bill No.09	Schedule of Daywork Rates (Materials)	-
Bill No.10	Schedule of Daywork Rates (Plant)	-
A	**SUBTOTAL 1**	**-**
B	ADD 10% OF (A) AS CONTINGENCY FOR PHYSICAL VARIATION (PROVISIONAL)	**-**
C	**SUBTOTAL 2**	**-**
D	ADD 18% VAT (OF SUB-TOTAL 2)	**-**
	BID PRICE (C+D) CARRIED FORWARD TO "FORM OF BID"	**-**

Rehabilitation / Upgrading of Urban Roads

Project :____________________________________

Bill No. 1 - General

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
		GENERAL REQUIREMENTS AND PROVISIONS				
12.01		**Land Acquisition**				
	a	Arrange and pay compensation for unforeseen additional landtake and injurious affection	Provisional Sum			-
	b	Allow for Contractor's Overhead and Profits as a percentage of subitem 12.01(a)	percent (%)			-
12.02		**Relocation of Services**				
	(a)	Relocation of services	Provisional Sum			
	(b)	Allow for Contractor's overheads and profits as a percentage of Subitem 12.02(a)	percent (%)			
12.03		Maintenance of the Existing Road				
	(a)	Contractor to maintain existing road	month			
	(b)	Additional Grading of Existing Road as instructed by the Engineer	Km			
	(c)	Provisonal Sum for Upgrading of Existing Town Roads	PS			
12.04		Dispute Review Board (DRB)				
	(a)	Payment for Employer's share of the cost of the Dispute Review Board	P.S.			
	(b)	Contractor's Mark-Up/ Overheads as a Percent (%) of Subitem 12.04 (a)	%			
		CONTRACTOR'S ESTABLISHMENT ON SITE AND GENERAL OBLIGATIONS				
13.01		Contractor's Preliminary and General Obligations				
	(a)	Fixed obligations	L.S.			
	(b)	Time-related obligations	month			
		ENGINEER'S ACCOMMODATION AND ATTENDANCE UPON THE ENGINEER				
14.01		House for the Engineer				
	(f)	Supply, Maintain and pay all rents and municipal services for Type I house fully furnished and equipped for the Engineer (2 No.)	House Unit x month			
	(g)	Supply, Maintain and pay all rents and municipal services for Type II house fully furnished and equipped for the Engineer (6 No.)	House Unit x month			
	(i)	Supply, Maintain and pay all rents and municipal services for multiple accommodation units fully furnished and equipped for the Engineer (4 No.)	House Unit x month			
	(j)	Maintain and pay all rents and municipal services for fully furnished and equipped temporary accommodation and offices for the Engineer (after three months from start of Contract, the Contractor is liable for rental costs)	month			
14.02		Offices for the Engineer				
	(b)	Supply, maintain and pay all rents and municipal services for fully furnished and equipped offices for the Engineer	Office Unit x month			
14.03		Wash house for the Engineer				
	(b)	Supply, maintain and pay all rents and municipal services for fully furnished and equipped wash house for the Engineer (2 No.)	Wash House Unit x month			
14.04		Site cabin / office for the Engineer				
	(b)	Supply, maintain and pay all rents and municipal services for fully furnished and equipped site cabin / office for the Engineer	Site Cabin Unit x month			

Rehabilitation / Upgrading of Urban Roads

Project :___________________________________

Bill No. 1 - General

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
		Vehicles for the Engineer				
14.05		Four wheel drive station wagon for the Engineer				
	(a)	Supply, operate and maintain vehicle (min. 3000cc) for an average of 3,000 km per month (1 No.)	vehicle x month			
	(b)	Operate and maintain vehicles for travel distance in excess of average 3,000 km per month per vehicle	km			
	(C)	Provide Labourers for Survey	Months			
14.06		Four wheel drive Double Cab Pick-up for the Engineer				
	(b)	Supply, operate and maintain vehicle (min. 3000cc) for an average of 3,000 km per month (3 No.)	vehicle x month			
	(c)	Operate and Maintain vehicles for travel distance in excess of average 3,000 km per month	km			
14.07		Survey equipment for the Engineer				
	(b)	Supply, maintain specified survey equipment for the Engineer	month			
14.08		Laboratory for the Engineer				
	(a)	Provide laboratory fully furnished for the Engineer	L.S.			
	(b)	Supply, maintain laboratory fully furnished for the Engineer	month			
14.09		Laboratory equipment for the Engineer				
	(a)	Provide specified laboratory equipment for the Engineer	L.S.			
	(b)	Maintain specified laboratory equipment for the Engineer	month			
14.12		Communication Facilities For the Engineer and His/her Staff				
	(c)	Monthly Subscription for AIRTIME for Mobile phones and Internet for Engineer's Office	month			
		Accommodation Of Traffic				
15.01		Accomodation of traffic on existing road, diversions and detours				
		Accommodating traffic and maintainng diversion and detours and Constructing in half width	Km			
15.02		Temporary traffic control signs Provision of full set of signs as detailed on drawings for:-				
	(a)	Type 1 Control - half width working	Number			
	(b)	Type 2 Control - Temporary Road Surface	Number			
	(c)	Type 3 Control - 2 Lane diversion	Number			
	(d)	Type 4 Control - 2 Single Lane diversion	Number			
	(e)	Type 5 Control - Detours	Number			
15.03		Priovision of barricades and delineational devices				
	(a)	New Jersey Barrier	Number			
	(b)	Drums	Number			
	(c)	Delineators	Number			
	(d)	Cones	Number			

Rehabilitation / Upgrading of Urban Roads

Project :________________________________

Bill No. 1 - General

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
		ENVIRONMENTAL PROTECTION AND WASTE DISPOSAL				
17.01	(a)	Environmental action plan, decommissioning plans and reporting	L.S.			
17.02	(a)	induction, training and environmental awareness, contingencies, motoring and auditing	P.S.			
	(b)	Allow for Contractor’s overheads and profits as a percentage of Sub-item (a)	percent (%)			
		OCCUPATIONAL HEALTH AND SAFETY, HIV/AIDS AND GENDER				
18.01	(a)	Provide qualified safety officer to deal with OHS, HIV/AIDS and gender management, including transport	month			
18.02		HIV/AIDS and STD prevention and counselling				
	(a)	Payment of Employer’s Nominated Service Provider for provision of HIV/AIDS Programme (including all associated expenses)	Provisional Sum			
	(b)	Management Fee for handling payment of the Employer’s Sub Contractor (NSP)	Percentage			
	(b)	Provide and maintain sexual health (STI and HIV/AIDS) and first aid Clinic on main site compound	P.S.			
	(C)	Allow for Contractor’s overheads and profits as a percentage of Sub-item (b)	percent (%)			
18.03		Gender				
	(a)	Gender sensitisation and awareness raising meeting/workshops	no.			
	(b)	Gender sensitive monitoring and reporting	month			
18.04		**Safety Clothing and Medical Equipments**				
	(a)	Provision of safety clothing and equipment for the workforce.	month			
	(b)	Provision of medical supplies and equipment for site clinical facility	P.S.			
	(c)	Allow for Contractor’s overheads and profits as a percentage of Sub-item (b)	percent (%)			
		TOTAL OF BILL NO 1 CARRIED TO GRAND SUMMARY				-

Rehabilitation / Upgrading of Urban Roads

Project :___________________________________

Bill No. 2 - Drainage

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
	DRAINS					
21.01	Excavation for open drains					
	(a)	Excavating soft material situated within the following depth ranges below the surface level:				
		(i) 0.0 m up to 1.5 m	cu.m.			
		(i) Exceeding 1.5 m and up to 3.0 m	cu.m.			
	(b)	Extra over subitem 21.01(a) for excavation in rock as defined in Clause 3603 of the Standard Specifications, irrespective of depth	cu.m.			
21.17	**EXCAVATION FOR CLEARANCE OF EXISTING DRAINAGE SYSTEMS**					
	(a)	Manholes and inlet and outlet structures	cu.m.			
	(b)	Culvert barrels	cu.m.			
	(c)	Concrete side drains	cu.m.			
21.18	Selected backfill material under concrete-lined side drains compacted to 92% BS-Heavy density		cu.m.			
	PREFABRICATED CULVERTS					
22.01	Excavation					
	(a)	Excavating soft material situated within the following depth ranges below the surface level:				
		(i) Up to 1.5 m	cu.m.			
		(ii) Exceeding 1.5 m and up to 3.0 m	cu.m.			
	(b)	Extra over sub-Item 22.01(a) for excavation in rock as defined in Clause 3603, irrespective of depth.				
22.02	Backfilling					
	(a)	Using excavated material	cu.m.			
	(b)	Using imported selected material	cu.m.			
22.03	Concrete pipe culverts					
	(a)	On Class A bedding				
		(i) 900 mm diameter	m			
		(ii) 1200 mm diameter	m			
	(b)	Reinforced concrete pipe culverts on Class B bedding				
		(i) 600 mm diameter	m			
		(ii) 900 mm diameter	m			
		(iii) 1000 mm diameter	m			
		(iv) 1200 mm diameter	m			
		(v) 1500 mm diameter	m			

Rehabilitation / Upgrading of Urban Roads

Project :______________________________

Bill No. 2 - Drainage

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
22.04	Metal Culverts					
	(a)	Corrugated Metal Pipe Culverts				
	(i)	600 mm diameter, wall thickness tbc	m			
	(ii)	900 mm diameter wall thickness tbc	m			
	(iii)	1200 mm diameter, wall thickness tbc	m			
	(vi)	1500 mm diameter, wall thickness tbc	m			
22.07	Cast in-situ concrete and formwork					
	(a)	Concrete Class 15/40 for Class A Bedding, Screeds, Haunching and Encasing for Pipes, including Formwork to pipes,	cu.m.			
	(c)	Concrete Class 25/20 in inlet and outlet structures, excluding formwork, but including Class U2 surface finish	cu.m.			
	(d)	Formwork to concrete under sub item 22.07(c) above (class of finish indicated)				
		(i) Class F1	sq.m.			
		(ii) Class F2	sq.m.			
	(e)	Class 25/20 concrete in concrete linings for the inverts of metal culverts, including formwork and Class U2 surface finish	cu.m.			
22.10	Steel reinforcement					
	(b)	High-Tensile steel bars (Type-2)	ton			
22.14	Removing and stacking existing prefabricated pipes (all sizes)		m			
22.23	Service Ducts					
	(a)	Ordinary Pipes (PVC pipes and 200 mm diameter)	m			
	(b)	Split Pipes for existing services crossing at all surfaced intersections (PVC pipes and 200 mm diameter)	m			
22.24	Duct Marker Blocks		no.			
	CONCRETE KERBING, CONCRETE CHANNELING, OPEN CONCRETE CHUTES AND CONCRETE LININGS FOR OPEN DRAINS					
23.01	Concrete Kerbing					
	(a)(i)	Precast concrete Class 30 semi-mountable kerbs, 300 x 350 mm, including 100mm Class 15 concrete bedding and backing	m			
	(ii)	Precast concrete Class 30 barrier kerbs, 150 x 300 mm, including 100mm Class 15 concrete bedding and backing	m			
	(b)	Precast concrete strip along shoulder edges (Class 30 concrete)	cu.m.			
23.08	Concrete lining for opens drains:					
	(a)	Cast in situ concrete lining				
	(a)(i)	Concrete Class 25/20 with Class U2 surface finish	cu.m.			

Rehabilitation / Upgrading of Urban Roads

Project :______________________________________

Bill No. 2 - Drainage

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
23.09	Formwork to cast in situ concrete lining for open drains (Class F2 surface finish):					
	(a)	To sides with formwork on the internal face only	sq.m.			
23.12		Steel reinforcement:				
	(c)	Welded steel fabric, BRC A142	ton			
23.16		Precast concrete Class 30/14 slabs				
	(a)	0.9m (L) x 0.5m (W) x 0.1 (T)m side drain crossing slab	no.			
	(b)	2.25m (L) x 0.5m (W) x 0.15 (T)m side drain crossing slab	no.			
	(c)	2m (L) x 0.7m (W) x 0.15m cover slab over kerb-inlet drainage structure	no.			
	PITCHING, STONEWORK AND PROTECTION AGAINST EROSION					
25.01	Stone Pitching/ Rock Pitching					
	(b)	Grouted stone/ rock pitching, 250 mm thick	sq.m			
25.02	Riprap					
	(a)	Package Riprap	cu.m.			
	(c)(ii)	Filter sand obtained from borrow pits	cu.m.			
25.07	Prepare Foundation Trenches		cu.m.			
25.08	Concrete Class 20 walls at erosion checks		cu.m.			
SECTION 2600: GABIONS						
26.01	Foundation trench excavation and backfilling:					
(a)	In solid rock as defined in Clause 3603		cu.m.			
(b)	In all other material than rock as defined in Clause 3603		cu.m.			
26.02	Surface preparation for bedding the gabions		sq.m			
26.03	Gabions:					
(a)	Galvanised gabion boxes, 2.0 x 1.0 x 1.0 m , 5mm dia wire mesh stainless steel		cu.m.			
(c)	Galvanised gabion mattresses, 4.0 x 2.0 x 0.3 m, 5mm dia wire mesh stainless steel		cu.m.			
26.04	Filter fabric (type and grade indicated)		sq.m			
		TOTAL OF BILL NO 2 CARRIED TO GRAND SUMMARY				-

Rehabilitation / Upgrading of Urban Roads

Project :___________________________________

Bill No. 3 - Earthworks and Pavement Layers of Gravel or Crushed Stone

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
	CLEARING, GRUBBING AND REMOVAL OF TOPSOIL					
31.01	Clearing, grubbing and removal of topsoil					
	(a)	Clearing and grubbing	ha			
	(b)(i)	Removal of topsoil for Re-use.	cu.m.			
	(b)(ii)	Removal of topsoil to Spoil.	cu.m.			
31.02	Removal and grubbing of large trees and tree stumps					
	(a)	Girth exceeding 1.0m up to and including 2.0m	no.			
	(b)	Girth exceeding 2.0m up to and including 3.0m	no.			
32.01	**REMOVAL OF EXISTING STRUCTURES**					
	(a)	Removal of existing pipe culverts of any size	m			
	(b)	Removal of reinforced concrete in bridges, box culverts and slabs including wingwalls and aprons	cu m			
	(f)	Removal of existing buildings	sq.m.			
	BREAKING UP EXISTING PAVEMENT LAYERS					
33.01		Excavating or Milling materials from an existing pavement				
	(a)	Granular materials	cu.m.			
	(b)	Bituminous material	cu.m.			
33.04	Scarification and recompacting of existing pavement layers to 150mm depth and compacted to 95% BS-Heavy		cu.m.			

Rehabilitation / Upgrading of Urban Roads

Project :____________________________________

Bill No. 3 - Earthworks and Pavement Layers of Gravel or Crushed Stone

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
	EARTHWORKS					
36.01		Excavations:				
	(a)	Common excavation to spoil	cu.m.			
	(b)	Excavation in swamps or wetlands to spoil	cu.m.			
	(c)	Rock Excavation (provisional sum)	cu.m.			
36.02	Fill and Improved subgrade layers:					
	(a)	Improved subgrade layer as specified in the Drawings to required minimum G15 quality material	cu.m.			
	(b)	fill as specified in the drawings to require minimum G7 quality material	cu.m.			
	(d)	Fill or improved subgrade layer using rock fill (provisional item)	cu.m.			
	(e)	Cross fill	cu.m.			
	(f)	Side fill compacted by dozers or as specified	cu.m.			
	(h)	Pioneer layer (0.3 to 0.5 m thickness as directed)	cu.m.			
	(i)	Crusher run layer f 0.2m on top of rockfill	cu.m.			
36.03	Roadbed preperation and compaction of material:					
	(b)	Compaction to 95% of BS-heavy density	cu.m.			
	PAVEMENT LAYERS OF NATURAL GRAVEL MATERIALS					
37.02		Natural gravel for Subbase				
	(c)	Granular Subbase Class G45	cu.m.			
	STABILISATION					
38.04		Mechanical Modification				
	(a)	Extra Over the relevant pay Item for Mechanical Modifications of Existing pavement layers	cu.m.			
	(b)	Binder Materials used for Mechanical Modification				
	(b)(i)	Crushed aggregate	cu.m.			

Rehabilitation / Upgrading of Urban Roads

Project :___________________________________

Bill No. 3 - Earthworks and Pavement Layers of Gravel or Crushed Stone

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
	CRUSHED AGGREGATE FOR ROAD BASE					
39.01	Crushed aggregate for road base/ sub base					
	(a)	Crushed aggregate Class CRS	cu.m.			
	(b)	Crushed aggregate Class CRR	cu.m.			
		TOTAL OF BILL NO 3 CARRIED TO GRAND SUMMARY				

Rehabilitation / Upgrading of Urban Roads

Project :___________________________________

Bill No. 4 - Asphalt Pavements and Seals

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
	PRIME AND CURING MEMBRANES					
41.01	Prime coat					
	(a)	MC-70 cut-back bitumen 1.0 L/M2	ltr			
41.03	Aggregate for blinding: 0.004m3/m2		cu.m.			
	SECTION 4200: BITUMINOUS BASE COURSE AND ASPHALT CONCRETE SURFACING					
42.01	Asphalt concrete surfacing:					
	(a)	Asphalt concrete surfacing	cu.m.			
	(b)	Bitumen for Asphalt Concrete Surfacing 5%	ton			
42.03	Tack Coat of 30% stable grade bitumen emulsion 0.55 L/M2		ltr.			
	SECTION 4900: CONCRETE PAVING					
49.00	(a)	Concrete paving blocks 100 x 200 x 60mm thickness,25N/mm2, laid in herring bond including bedded sand in 30mm compacted thickness	sq.m			
		TOTAL OF BILL NO 4 CARRIED TO GRAND SUMMARY				

Rehabilitation / Upgrading of Urban Roads

Project :____________________________________

Bill No. 5 - Ancillary Roadworks

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
	MARKER AND KILOMETRE POSTS					
51.01	(a)	New marker posts	no.			
	(b)	Flexible cylinders	no.			
51.02	(a)	New kilometre posts	no.			
	(b)	Delineators	no.			
	(c)	Culvert marker posts	no.			
51.03	Road reserve marker post		no.			
	GUARDRAILS					
52.01	Guardrails on steel posts					
	(a)	Galvanised	m			
52.03	(a)	End sections including foundation in the ground, 3.8 m long	no			
52.05	Reflective Plates					
	(a)	Reflectors on guard rails	no.			
	ROAD SIGNS					
54.01	Road Signs					
	(a)	Danger/Warning signs	no.			
	(b)	Regulatory Signs	no.			
	(c)	Information Signs	no.			
54.03	Guidance and Information sign boards					
	(a)	Plates ares >0.25m2, but <0.5m2	no.			
		Plates ares >0.5m2, but <1.0m2	no.			
		Plates ares >1.0m2, but <2.0m2	no.			
54.05	Removal of Obsolete road signs and poles as instructed		no.			
	ROAD MARKINGS					
55.01	Road marking using road marking paint material					
	(f)	Kerb Markings	sq.m.			
55.03	Road marking using thermo-plastic road marking material					
	(a)	White edge line, 100mm wide	m			
	(b)	Yellow lines, broken or unbroken				
		(i) 100mm wide broken Centreline	m			
		(iv) Speed Humps (9.5m by11m wide circular hump)	m			
55.05	(a) Roadstuds, 100 x 100 mm ROADTEC or similar		no.			
55.06	Setting out & premarking the lines (excl. islands, lettering and symbols)		m			

Rehabilitation / Upgrading of Urban Roads

Project :___________________________________

Bill No. 5 - Ancillary Roadworks

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
55.09	Rumble strips and Speed humps					
	(a)	Rumble strip (specify type/size) - Asphalt concrete				
	(a)(iii)	0.5m wide x 4no. x 11m length	no.			
	(a)(iv)	0.5m wide x 2no. x 11m length	no.			
	(b)(ii)	Circular 9.5m wide x 100mm high x 11m length	no.			
	LANDSCAPING AND GRASSING					
56.03	Preparing the Area for Grassing					
	(c)	Topsoiling within the road reserve, where the following materials are used;				
	(c)(i)	Topsoil Obtained From Within The Road Reserve or Borrow Areas	cu.m.			
56.04		Grassing:				
	(a)	Planting of Grass Cuttings (Type of Grass as Indicated)	ha			
	(b)	Sodding by Using the Following Types of Sods:				
	(i)	Nursery Sods (Type of Grass Specified)	sq.m.			
56.09	(a)	Providing the trees and shrubs (types and age/size indicated)				
	(b)	Planting and establishing:				
	(b)(i)	Trees	number (no)			
	(b)(ii)	Shrubs	number (no)			
56.10		Extra Work For Landscaping				
	(a)	Work Ordered By Engineer	P.S.			
	(b)	Contractor's Mark-Up/ Overheads and Profits as a Percent (%) of that part of Sub item 56.10 (a) used for payment to the Forestry Department for Landscaping Work.	percent (%)			
	STREET LIGHTING					
		Complete based on specification (solar, conventional, etc.)	Provisional Sum			
		TOTAL OF BILL NO 5 CARRIED TO GRAND SUMMARY				

Rehabilitation / Upgrading of Urban Roads

Project :______________________________________

Bill 6: Structures

Item No.	Description	Unit	Quantity	Rate (UGX)	Amount (UGX)
SECTION 6100: FOUNDATIONS FOR STRUCTURES					
61.01	Additional foundation investigations:	Provisional sum			
61.02	Excavation:				
(a)	Common excavation in soft material situated within the following successive depth ranges:				
(a)(i)	0 m up to 2 m	cubic metre (m^3)			
(a)(ii)	2 m up to 4 m	cubic metre (m^3)			
(a)(iii)	Further increments of 2 m	cubic metre (m^3)			
(b)	Extra-over sub-Item 61.02(a) for excavation in rock irrespective of depth	cubic metre (m^3)			
61.03	Access and drainage:				
(a)	Access	lump sum			
61.04	Backfill to excavations utilising:				
(a)	Material from the excavations	cubic metre (m^3)			
(b)	Imported material	cubic metre (m^3)			
61.05	Foundation fill consisting of:				
(a)	Rock fill	cubic metre (m^3)			
(c)	Compacted granular material	cubic metre (m^3)			
(e)	Concrete blinding	cubic metre (m^3)			

Rehabilitation / Upgrading of Urban Roads

Project :______________________________________

Bill 6: Structures

SECTION 6200: FALSEWORK, FORMWORK AND CONCRETE FINISH					
62.01	Formwork to provide surface finish:				
(a)	Class F1 to concealed surfaces	square metre (m^2)			
(b)(i)	Class F2 to exposed surfaces	square metre (m^2)			
SECTION 6300: STEEL REINFORCEMENT FOR STRUCTURES					
63.01	Steel reinforcement for:				
(a)(ii)	High-yield-stress-steel bars	tonne (t)			
SECTION 6400: CONCRETE FOR STRUCTURES					
64.01	Cast in situ concrete [Class of concrete and part of structure or use indicated]				
(a)	Class 15/40 in blinding and other unreinforced concrete	cubic metre (m^3)			
(b)	Class 25/20 in reinforced concrete	cubic metre (m^3)			
SECTION 6600: NO-FINES CONCRETE; JOINTS; BEARINGS; PARAPETS AND DRAINAGE FOR STRUCTURES					
66.19	Drainage pipes and weep holes:				
(a)	Drainage pipes: ·				
(a)(i)	(Type and size indicated)	metre (m)			
(a)(ii)	(Type and size indicated)	number (no)			
(b)	Weep holes:				
(b)(i)	(Type and size indicated)	metre (m)			-
(b)(ii)	(25mm Conduits)	number (no)			-
	TOTAL OF BILL NO. 6 CARRIED TO GRAND SUMMARY				**0**

Rehabilitation / Upgrading of Urban Roads

Project :___________________________________

Bill No. 7 - Tolerances, Testing and Quality Control

Item No.		Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
		Testing of Materials and Workmanship				
71.01	(a)	Provisional Sum for Special Tests to be carried out at the instruction of the Engineer	Prov Sum			
	(b)	Allow for Contractor's overheads & profits as a percentage of Item 71.01(a)	percent (%)			
71.02		**INITIAL SPECIFIC GEOTECHNICAL INVESTIGATION**				
	b)	Soil investigation to deep cuts not exceeding 20m deep, requested by the Engineer				
		Deep cut trial hole by excavator				
	b)1	Excavate in trial hole to deep cut sites using excavator and take samples, depth not exceeding 3.0m	no.			
		Deep cut investigation by Penetrometer using SE equipment				
	b)3	Undertake mobile platform penetrometer tests and sampling to deep cuttings, depth not exceeding 5.0m	no.			
		Deep cut investigation by borehole				
	b)7	Set up rotary or shell and auger drilling equipment for boreholes and clear away on completion	no.			
	b)8	Construct borehole and take disturbed samples depth not exceeding 5.0m	m			
	b)12	Set up rotary or auger drill to prove integrity of rock formation to a depth of at least 1.5m rock drilling below first refusal, including recovery of sample	no.			
		Investigation in swamps				
	c)	Soil investigation to swamp areas requested by the Engineer, including provision of pontoon or other form of platform				
	c)1	Provide hand auger and take disturbed samples of materials in swamp depth not exceeding 3.0m	no.			
		Testing and Reporting				
	d)2	Complete set of Laboratory tests on disturbed deep cut samples as described in Special Specification 7128 b)	no.			
	d)3	Provide complete Factual report of all initial specific investigations	Item			
		TOTAL OF BILL NO 7 CARRIED TO GRAND SUMMARY				-

Rehabilitation / Upgrading of Urban Roads

Project :___________________________________

Bill No. 8 - Schedule of Daywork Rates (Labour)					
Item No.	**Description**	**Unit**	**Estimated Quantity**	**Rate (UGX)**	**Amount (UGX)**
	Labour				
81.01	Unskilled labour	hr			
81.02	Skilled labour	hr			
81.03	Headman	hr			
81.04	Foreman	hr			
81.06	Site Manager	hr			
81.07	Driver heavy	hr			
81.08	Driver Light	hr			
81.09	Plant Operator H/D	hr			
81.10	Plant operator LH/D	hr			
81.11	Land surveyor	hr			
81.12	Draftman	hr			
81.13	Mason	hr			
81.14	Carpenter	hr			
	Cost for Daywork: Labour				**-**
	add 25% Cost for daywork: Labour				**-**
	TOTAL OF BILL NO 8 CARRIED TO GRAND SUMMARY				**-**

Rehabilitation / Upgrading of Urban Roads

Project :_______________________________________

Bill No. 9 - Schedule of Daywork Rates (Materials)

Item No.	Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
	Materials				
91.01	Diesel (gas oil)	ltr			
91.02	Petrol	ltr			
91.03	Coarse crushed aggregate	ton			
91.04	Fine aggregate (sand)	ton			
91.05	Ordinary Portland Cement	ton			
91.06	Mild steel reinforcement	ton			
91.07	High yield stress steel bars	ton			
91.08	Timbering for trenches	sq m			
91.09	Formwork	sq m			
91.10	Road Paint	ltr			
91.11	Granular material for Subabse	cu.m			
91.12	Bitumen, PG 76-10 performance grade	ton			
91.13	Cutback bitumen MC-30	ltr			
91.14	30% bitumen emulsion	ltr			
91.15	Lubricant	kg			
91.16	Lime	ton			
	Cost for Daywork: Materials				
	add 25 % to daywork: Materials				
	TOTAL OF BILL NO 9 CARRIED TO GRAND SUMMARY				**-**

Rehabilitation / Upgrading of Urban Roads

Project :____________________________________

Bill No. 10 - Schedule of Daywork Rates (Plant)

Item No.	Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
	Equipment				
100.01	D4 Dozer or equivalent with blade and ripper	hr			
100.02	D8 Dozer or equivalent with blade and ripper	hr			
100.03	Wheeled excavator, bucket capacity under 1 m3	hr			
100.04	Track Loader, 3-4 m3 bucket capacity, (Cat 973C or equivalent)	hr			
100.05	Wheeled excavator, bucket capacity 1-2 m3	hr			
100.06	Backhoe loader	hr			
100.07	5t tipper lorry	hr			
100.08	9t tipper lorry	hr			
100.09	Dump Truck	hr			
100.10	Motorgrader, complete with scarifier (Cat. 14 or equivalent)	hr			
100.11	5-6t drawn vibrating roller and tractor	hr			
100.12	10-12t smooth wheeled roller	hr			
100.13	16-18t Smooth Wheeled Roller	hr			
100.14	Pneumatic Roller, 5,000 kg per tyre when fully ballasted	hr			
100.15	Vibrating plate compactor	hr			
100.16	Self-propelled water tanker min. 14,000 ltr. with pick-up pump	hr			
100.17	Compressor 120 l/m complete with all tools	hr			
100.18	Generator 15 kW	hr			
100.19	Generator 150 kW	hr			

Rehabilitation / Upgrading of Urban Roads

Project :___________________________________

Bill No. 10 - Schedule of Daywork Rates (Plant)

Item No.	Description	Unit	Estimated Quantity	Rate (UGX)	Amount (UGX)
100.20	Rock drill	hr			
100.21	Concrete mixer up to 400 litres	hr			
100.22	Concrete mixing plant, complete 1.0cu.m or above	hr			
100.23	Asphalt Plant 120 T/h	hr			
100.24	Concrete Vibrator	hr			
100.25	Pick-up Truck	hr			
	Cost for Daywork: Plant				
	add 25 % for Daywork: Plant				
	TOTAL OF BILL NO 10 CARRIED TO GRAND SUMMARY				

18. MoWT Unit Rates 2023

FIXED UNIT RATES FOR ROAD MAINTENANCE & BRIDGE WORKS
FINANCIAL YEAR 20??/??

Rates to be determined from latest comparative tender prices

ITEM	DESCRIPTION	UNIT	RATE (UGX)
	BILL NO.1: PRELIMINARIES		
1.1	Allow for traffic management (Safe passage of traffic, installation and removal of temporary warning signs according to Uganda traffic law.)	Month	
1.2	Provision for material testing and quality control (as determined by the Engineer depending on size and complexity of contract).	Month	
1.3	Allowance for supervision (as determined by the Engineer depending on size and complexity of contract).	Month	
1.4	Mark up on all deliverables to the client or supervisor.	%	
1.5	Provision for survey and setting out works	Lump sum	
	BILL NO.2: SITE CLEARANCE		
2.1	Clear all shoulders and side drains of grass and reeds as instructed the Engineer. Load and cart to spoil excess material. Clear all excess materials as directed by the drainage from debris.	m^2	
2.2	Load and cart to spoil all debris and excess material which cannot be spread within the road reserve to a distance not exceeding 500m. Spread all excess material as directed by the Engineer.	m^3	
2.3	Fell down trees of a minimum diameter of 300 mm within the road reserve, load and cut to spoil as directed by the Engineer	No.	
2.3	Fell down tress of a minimum diameter diameter 300 within road reserve, load and cut to spoil as directed by the Engineer	No.	
2.4	Remove tree stumps, fill hole appropriately and cut to spoil debris as directed by the Engineer	No.	
	BILL NO.3: DRAINAGE		
3.1	Clear existing fully blocked culverts, remove all debris soils and stones. Cart and/or spread all materials as directed by the Engineer (half rate for half blocked culverts)		
3.1.1	Diameter 300 - 900mm	m	
3.1.2	Diameter 1000 - 1800mm	m	
3.1.3	Diameter over 18000mm	m	
3.2	Clean manually both lined and unlined side drains, remove silt and unsuitable material and spread all debris and excess material in the road reserve as directed by the Engineer.	m	
3.3	Clear and reshape mitre drains, spread excess material within the road reserve with the approval of the Engineer.	m	
3.4	Excavate for side drains, catchwater drains, toe drains, offshoots and dispose of excavated material as directed by the Engineer.	m	
3.5	Carry out river training in river beds, remove debris and dispose it off as directed by the Engineer.	m^2	
3.6	Excavate in soft material for pipe culverts, headwalls, wingwalls, aprons, toe drains and drop inlet chambers to any depth as directed by the Engineer.	m^3	
3.7	E.O Item 3.6 for excavation in hard material	m^3	

FIXED UNIT RATES FOR ROAD MAINTENANCE & BRIDGE WORKS
FINANCIAL YEAR 20??/??

Rates to be determined from latest comparative tender prices

ITEM	DESCRIPTION	UNIT	RATE (UGX)
3.8	Deliver and install concrete pipes. Use for bedding and backfilling approved		
3.8.1	Diameter 450mm	m	
3.8.2	Diameter 600mm	m	
3.8.3	Diameter 900mm	m	
3.8.4	Diameter 1200mm	m	
3.9	Deliver and install AMCO pipe culverts . Use for bedding and backfilling approved material.		
3.9.1	Diameter 900mm	m	
3.9.2	Diameter 1200mm	m	
3.9.3	Diameter 1500mm	m	
3.9.4	Diameter 1800mm	m	
3.9.5	Diameter 2500mm	m	
3.10	Install AMCO or concrete pipe culverts . Use for bedding and backfilling approved		
3.1.0.1	Diameter 450mm	m	
3.10.2	Diameter 600mm	m	
3.10.3	Diameter 900mm	m	
3.10.4	Diameter 1200mm	m	
3.10.5	Diameter 1800mm	m	
3.10.6	Diameter 2500mm	m	
3.11	Construct culvert end structures		
3.11.1	Using clay bricks and cement sand mortal 1:3, and finish with plaster	m^3	
3.11.2	Using concrete blocks and cement sand mortal 1:3, and finish with plaster	m^3	
3.11.3	Using stone masonry and cement sand mortal 1:3, and finish with plaster	m^3	
3.11.4	Using reinforced concrete	m^3	
3.12	Line drains using:		
3.12.1	stone pitching	m^2	
3.12.2	reinforced concrete	m^3	
3.13	Demolition and removal of existing structures, spoil materials as directed by the Engineer.	m^3	

FIXED UNIT RATES FOR ROAD MAINTENANCE & BRIDGE WORKS
FINANCIAL YEAR 20??/??

Rates to be determined from latest comparative tender prices

ITEM	DESCRIPTION	UNIT	RATE (UGX)
3.14	Provide and lay pedestrian and cover slabs made out of:		
3.14.1	Mass concrete	m^3	
3.14.2	Reinforced concrete	m^3 m^3	
3.15	Provide scour checks made out of		
3.15.1	Mass concrete	m^3	
3.15.2	Reinforced concrete	m^3	
3.15.3	Stones with planted grass	m^3	
3.16	Construct sub surface drains by using		
3.16.1	Perforated pipes	m	
3.16.2	French drains	m	
	BILL NO.4: WEARING COURSE AND SHOULDERS.		
4.1	Un paved Shoulders		
4.1.1	Remove vegetation and all deleterious materials, scarify, shape and compact existing shoulder to at least 95% MOD AASTHO density.	m^2	
4.1.2	Provide approved granular materials, spread, water and compact in layers to 150 mm thickness to at least 95% MOD AASHTO on the carriageway as directed by the Engineer. Free haulage up to 10 Km.	m^3	
4.2	Paved carriageway and paved Shoulders		
4.2.1	Scarification and compaction of existing pavement and/or shoulders	m^2	
4.2.2	Scarify and cart to spoil unwanted material.	m^3	
4.2.3	Provide approved granular materials, spread, water and compact in layers to 150 mm thickness to at least 95% MOD AASHTO on the carriageway as directed by the Engineer. Free haulage up to 10 Km.	m^3	
4.2.4	Provide, lay shape and compact crushed stone base to at least 97% Mod. AASHTO density	m^3	
4.2.5	Trim and clean potholes and edges and fill with approved granular material.	m^3	
4.2.6	Provide and transport the following stabilising agent to natural base material to stabilised in ranges of percentages by weight		
4.2.6.1	Lime(at rates ranging from 2% to 6%)	Ton	
4.2.6.2	Cement(at rates ranging from 1% to 5%)	Ton	
4.2.7	Provide, transport and mix quarry dust at a rate varying from 10 to 30 percent by volume with natural base material while carrying out mechanical stabilisation	m^3	
4.2.8	Over haulage of base material in item 4.3 & 4.5 in excess of 10Km.	$m^{3/}km$	
4.2.9	E.O. Items 4.2.6 for processing and mixing stabilising agent material at a rate varying from 1 to 6percent by weight as directed by the Engineer.	m^3	

FIXED UNIT RATES FOR ROAD MAINTENANCE & BRIDGE WORKS
FINANCIAL YEAR 20??/??

Rates to be determined from latest comparative tender prices

ITEM	DESCRIPTION	UNIT	RATE (UGX)
4.2.10	Prepare base course surface, provide, heat and spray MC 30 cutback bitumen prime coat rates of 0.7L/m^2 to 1.2L/m^2 or as directed by the Engineer.	m^2	
4.2.11	Seal potholes and edges with A Premix Layer of 50m thickness and of approved materials composition by the Engineer.	m^2	
4.2.12	Provide, heat and spray first seal coat of 80/100 penetration bitumen at rates of 0.8L/m^2 to 1.3L/m^2 or as directed by the Engineer.	m^2	
4.2.13	Provide, spread and roll 14/20mm nominal sized chippings at the rates of 70m^2 /m to 110m^2/m^3 or as directed by the Engineer.	m^2	
4.2.14	Provide, heat and spray second seal coat of 80/100 penetration bitumen at rates of 1.1L/m^2 to 1.6L/m^2 or as directed by the Engineer.	m^2	
4.2.15	Provide, spread and roll 10/14mm nominal sized chippings at rates of 90m^2/m^3 to 130m^2/m^3 or as directed by the Engineer.	m^2	
4.2.16	Provide, heat, and spray 80/100 tack coat at rates 0.34L/m^2 to 0.50L/m^2	m^2	
4.2.17	Provide, heat, mix, lay and compact asphalt concrete wearing course of 50mm thickness	m^3	
4.3	Unpaved carriageway and shoulders		
4.3.1	Shape road surface by heavy grading to camber and cross fall including side drains, all inlets and outlets of the drainage with a grader and compact to 95%	m^2	
4.3.2	Shape road surface by medium grading to camber and cross fall including side drains, all inlets and outlets of the drainage with a grader and compact to 95%	m^2	
4.3.3	Provide and transport up to 10km, spread water and compact to at least 95% MOD.AASHTO. Natural base material to a thickness instructed by the Engineer	m^3	
4.3.4	Overhaul of base material	$m^{3/}$km	
4.4	EARTH WORKS		
4.4.1	Provide and transport up to 10km, spread water and compact to at least 95%	m^3	
	BILL NO. 5: Ancillary Works		
5.1	Remove, transport and store existing road sign. Make necessary repairs, repaint and re-erect.	No.	
5.2	Provide and erect standard regulator type signs of size 600mm.	No.	
5.3	Provide and erect standard warning type signs of size 900mm.	No.	
5.4	Provide and erect standard informatorily signs of size 500x600m	No.	
5.5	Provide and erect non-standard information signs of area under 1m^2	No.	
5.6	As item 5.5 but area between 1 and 2m^2	No.	
5.7	Prepare road surface, spray tack coat paint white road marking lines 100mm wide.	m	
5.8	As item 5.7 but yellow	m	

FIXED UNIT RATES FOR ROAD MAINTENANCE & BRIDGE WORKS
FINANCIAL YEAR 20??/??

Rates to be determined from latest comparative tender prices

ITEM	DESCRIPTION	UNIT	RATE (UGX)
5.9	Provide, prepare and paint kerb stones	m	
5.10	Provide and install RC Km marker posts	No.	
5.11	Provide and lay precast concrete kerbstones to sides of road	m	
5.12	Provide and install Reflective cat eyes	No.	
5.13	Build speed humps as directed by the Engineer	m^3	
5.14	Build rumble strips as directed by the Engineer	m^3	
5.15	Cut grass to height specified by the Engineer	m^2	
5.16	Plant grass as directed by the Engineer	m^2	
5.17	Plant trees as directed by the Engineer	No.	
5.18	Tend flower beds as directed by the Engineer	m^2	
5.19	Excavations for foundation gabions	m^3	
5.20	Supply gabion boxes, place and fill	m^3	
5.21	Supply gabion mattresses, place and fill	m^3	
	BILL NO. 6: DAY WORKS		
6.1	Equipment		
6.1.1	D6 Bulldozer complete a blade and ripper	hr	
6.1.2	D8 Bulldozer complete a blade and ripper	hr	
6.1.3	Traxcavator 165HP with loader attachments bucket size 1-2m3	hr	
6.1.4	Wheel loader 105HP and 1.8m3 bucket capacity	hr	
6.1.5	Motor grader 135HP complete with the blade, ripper and scarifier	hr	
6.1.6	7 ton tipper	hr	
6.1.7	10 Ton tipper	hr	
6.1.8	15 Ton tipper	hr	
6.1.9	Pedestrian Roller	hr	
6.1.10	7 Ton Vibrating roller	hr	
6.1.11	Pneumatic tyred roller	hr	
6.1.12	Water pump	hr	
6.1.13	Water bowser ,6000 litre	hr	
6.1.14	Bitumen Sprayer	hr	
6.1.15	Bitumen boiler	hr	

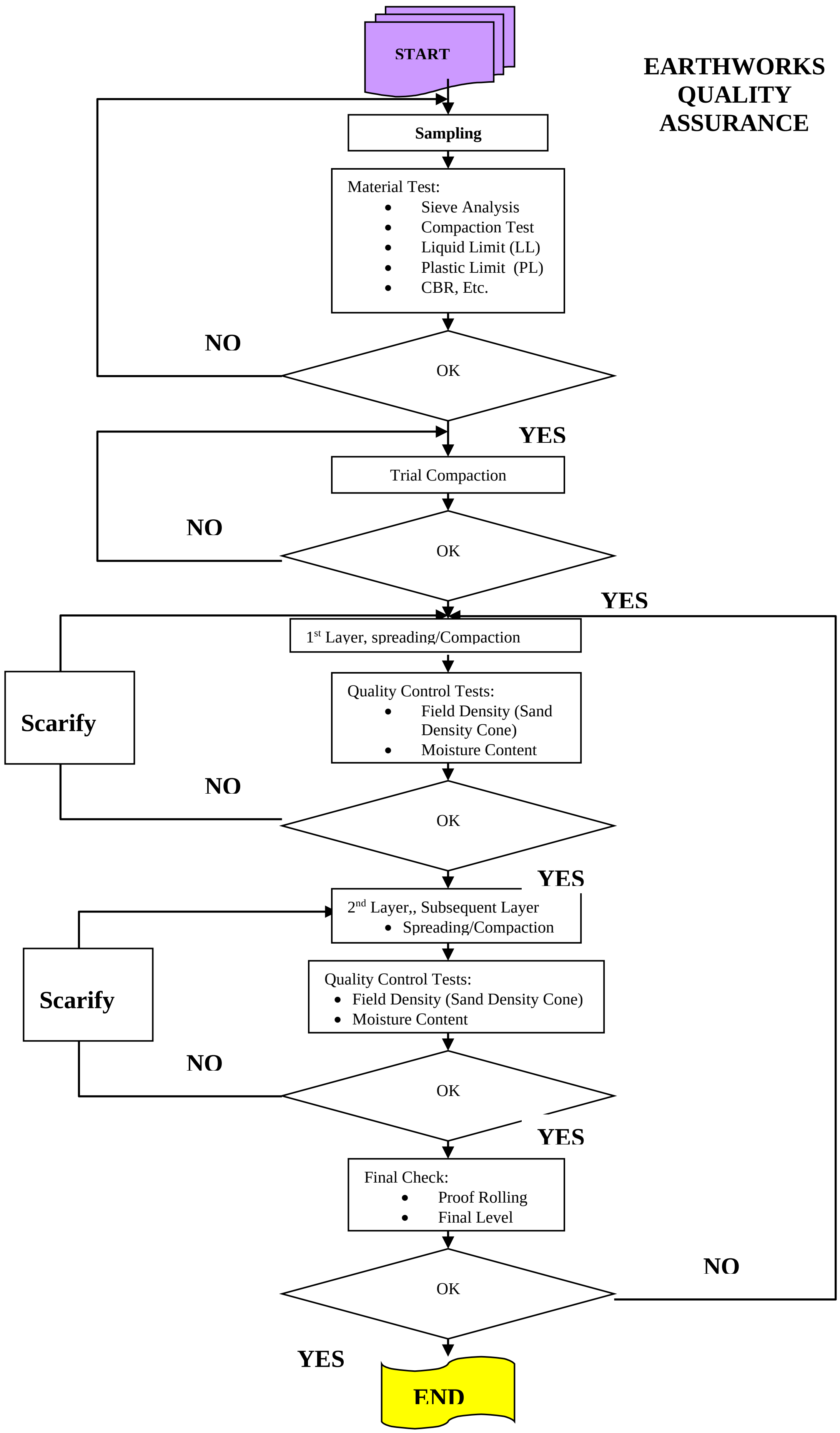
FIXED UNIT RATES FOR ROAD MAINTENANCE & BRIDGE WORKS
FINANCIAL YEAR 20??/??

Rates to be determined from latest comparative tender prices

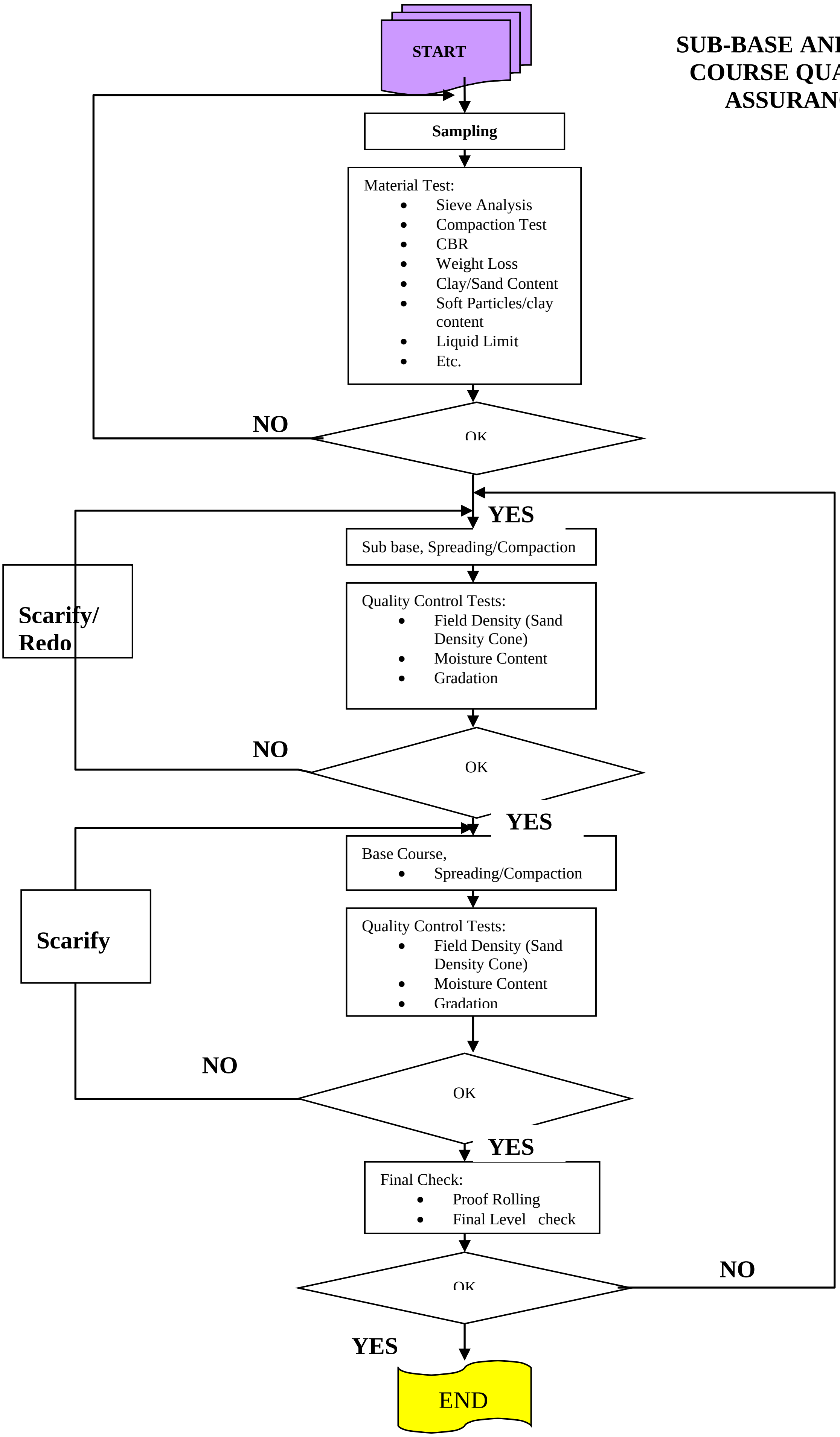
ITEM	DESCRIPTION	UNIT	RATE (UGX)
6.1.16	Asphalt plant	hr	
6.1.17	Chip spreader	hr	
6.1.18	Mechanical Broom	hr	
6.1.19	Pick up	hr	
6.1.20	Concrete mixer	hr	
6.1.21	Concrete vibrator (poker type)	hr	
6.1.22	Compressor (minimum 120 litre per min) Complete with all tools, hoses, steels	hr	
6.2	MATERIALS		
6.2.1	Ordinary Portland cement	Ton	
6.2.2	Road lime	Ton	
6.2.3	Fine aggregate for concrete up to 2mm nominal size	m^3	
6.2.4	Course aggregate of nominal size 6mm-29mm	m^3	
6.2.5	As for 6.24 but nominal size 21mm-40mm	m^3	
6.2.6	Wrought shattering timber	m^3	
6.2.7	Instant road repair materials	m^3	
6.2.8	High Density Polyethylene (HDPE) pipe culverts of diameter:		
6.2.8.1	600mm (31 mm thickness)	m	
6.2.8.2	900mm (50 mm thickness)	m	
6.2.8.3	1000mm (56 mm thickness)	m	
6.2.8.4	1200mm (62 mm thickness)	m	
6.2.8.4	1500mm (80 mm thickness)	m	
6.2.9	Hard core	m^3	
6.2.10	Reinforcement steel		
6.2.10.1	Mild	Kg	
6.2.10.2	High tensile	Kg	
6.3	LABOUR		
6.3.1	Unskilled labour	hr	
6.3.2	Semi-skilled labour	hr	
6.3.3	Skilled labour	hr	

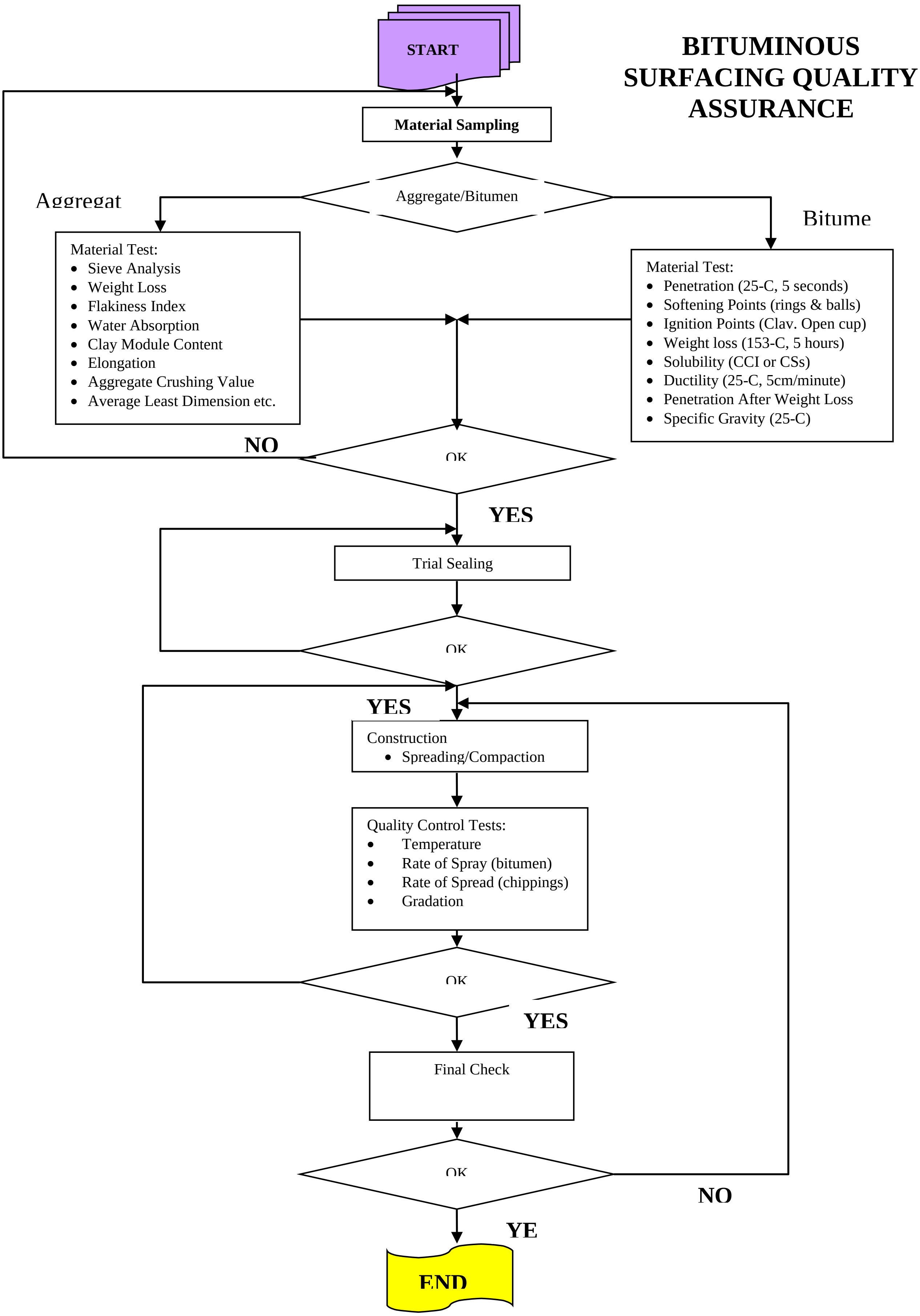
19. Materials Quality Assurance

Quality Assurances



SUB-BASE AND BASE COURSE QUALITY ASSURANCE




BITUMINOUS SURFACING QUALITY ASSURANCE
START
Material Sampling
Aggregate/Bitumen
Aggregat
Bitume
Material Test:
Sieve Analysis
Weight Loss
Flakiness Index
Water Absorption
Clay Module Content
Elongation
Aggregate Crushing Value
Average Least Dimension etc.
Material Test:
Penetration (25-C, 5 seconds)
Softening Points (rings & balls)
Ignition Points (Clav. Open cup)
Weight loss (153-C, 5 hours)
Solubility (CCI or CSs)
Ductility (25-C, 5cm/minute)
Penetration After Weight Loss
Specific Gravity (25-C)
NO
OK
YES
Trial Sealing
OK
YES
Construction
Spreading/Compaction
Quality Control Tests:
Temperature
Rate of Spray (bitumen)
Rate of Spread (chippings)
Gradation
OK
YES
Final Check
OK
NO
YE
END

20. Sample Measurement Sheet & Payment Certificate

……………………Municipal/Town Council

Measurement Sheet No._______

Contract Name:…………………………………………………………………. Contract No……………………………………… Certificate Number ……………………….. Date……………. 20…………

BoQ ITEM No.		BoQ ITEM DESCRIPTION	ITEM UNIT	BoQ ITEM QUANTITY	CUMULATIVE QUANTITIES-LAST CERTIFICATE	CUMULATIVE QUANTITIES -THIS CERTIFICATE	MEASURED QUANTITIES THIS CERTIFICATE	BoQ UNIT RATE (UGX)	TOTAL AMOUNT THIS CERTIFICATE (UGX)
(i)		(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
		BILL NO.1: GENERAL							
		GENERAL REQUIREMENTS AND PROVISIONS							
12.01		**Land Acquisition**							
	a	Arrange and pay compensation for unforeseen additional landtake and injurious affection	Provisional Sum						
	b	Allow for Contractor's Overhead and Profits as a percentage of subitem 12.01(a)	percent (%)						
12.02		**Relocation of Services**							
	(a)	p	P.S.						
	(b)	Allow for Contractor's overheads and profits as a percentage of Subitem 12.02(a)	percent (%)						
12.03		Maintenance of the Existing Road							
	(a)	Contractor to maintain existing road	month						
	(b)	Additional Grading of Existing Road as instructed by the Engineer	Km						
	(c)	Provisonal Sum for Upgrading of Existing Town Roads	PS						
12.04		Dispute Review Board (DRB)							
	(a)	Payment for Employer's share of the cost of the Dispute Review Board	P.S.						
	(b)	Contractor's Mark-Up/ Overheads as a Percent (%) of Subitem 12.04 (a)	%						
		CONTRACTOR'S ESTABLISHMENT ON SITE AND GENERAL OBLIGATIONS							
13.01		Contractor's Preliminary and General Obligations							
	(a)	Fixed obligations	L.S.						
	(b)	Time-related obligations	month						
		ENGINEER'S ACCOMMODATION AND ATTENDANCE UPON THE ENGINEER							
14.01		House for the Engineer							
	(f)	Supply, Maintain and pay all rents and municipal services for Type I house fully furnished and equipped for the Engineer (2 No.)	House Unit x month						
	(g)	Supply, Maintain and pay all rents and municipal services for Type II house fully furnished and equipped for the Engineer (6 No.)	House Unit x month						
	(i)	Supply, Maintain and pay all rents and municipal services for multiple accommodation units fully furnished and equipped for the Engineer (4 No.)	House Unit x month						
	(j)	Maintain and pay all rents and municipal services for fully furnished and equipped temporary accommodation and offices for the Engineer (after three months from start of Contract, the Contractor is liable for rental costs)	month						
14.02		Offices for the Engineer							
	(b)	Supply, maintain and pay all rents and municipal services for fully furnished and equipped offices for the Engineer	Office Unit x month						
14.03		Wash house for the Engineer							
	(b)	Supply, maintain and pay all rents and municipal services for fully furnished and equipped wash house for the Engineer (2 No.)	Wash House Unit x month						
14.04		Site cabin / office for the Engineer							
	(b)	Supply, maintain and pay all rents and municipal services for fully furnished and equipped site cabin / office for the Engineer	Site Cabin Unit x month						
		Vehicles for the Engineer							
14.05		Four wheel drive station wagon for the Engineer							
	(a)	Supply, operate and maintain vehicle (min. 3000cc) for an average of 3,000 km per month (1 No.)	vehicle x month						
	(b)	Operate and maintain vehicles for travel distance in excess of average 3,000 km per month per vehicle	km						
	(C)	Provide Labourers for Survey	Months						
14.06		Four wheel drive Double Cab Pick-up for the Engineer							
	(b)	Supply, operate and maintain vehicle (min. 3000cc) for an average of 3,000 km per month (3 No.)	vehicle x month						
	(c)	Operate and Maintain vehicles for travel distance in excess of average 3,000 km per month	km						
14.07		Survey equipment for the Engineer							
	(b)	Supply, maintain specified survey equipment for the Engineer	month						

14.08		Laboratory for the Engineer							
	(a)	Provide laboratory fully furnished for the Engineer	L.S.						
	(b)	Supply, maintain laboratory fully furnished for the Engineer	month						
14.09		Laboratory equipment for the Engineer							
	(a)	Provide specified laboratory equipment for the Engineer	L.S.						
	(b)	Maintain specified laboratory equipment for the Engineer	month						
14.11		Four wheel drive Single Cab Pick-up for the Engineer							
	(b)	Supply, Operate and Maintain vehicles (Single Cabin min. 3000cc) for an average of 5,000 km per month (2 No.)	vehicle x month						
	(c)	Operate and Maintain vehicles for travel distance in excess of average 5,000 km per month	km						
14.12		Communication Facilities For the Engineer and His/her Staff							
	(b)	Provision of Mobile Telephones	No.						
	(c)	Monthly Subscription for AIRTIME for Mobile phones and Internet for Engineer's Office	month						
		Accommodation Of Traffic							
15.01		Accomodation of traffic on existing road, diversions and detours							
		Accommodating traffic and maintainng diversion and detours and Constructing in half width	Km						
15.02		Temporary traffic control signs Provision of full set of signs as detailed on drawings for:-							
	(a)	Type 1 Control - half width working	Number						
	(b)	Type 2 Control - Temporary Road Surface	Number						
	(c)	Type 3 Control - 2 Lane diversion	Number						
	(d)	Type 4 Control - 2 Single Lane diversion	Number						
	(e)	Type 5 Control - Detours	Number						
15.03		Priovision of barricades and delineational devices							
	(a)	New Jersey Barrier	Number						
	(b)	Drums	Number						
	(c)	Delineators	Number						
	(d)	Cones	Number						
		ENVIRONMENTAL PROTECTION AND WASTE DISPOSAL							
17.01	(a)	Environmental action plan, decommissioning plans and reporting	L.S.						
17.02	(a)	induction, training and environmental awareness, contingencies, motoring and auditing	P.S.						
	(b)	Allow for Contractor's overheads and profits as a percentage of Sub-item (a)	percent (%)						
		OCCUPATIONAL HEALTH AND SAFETY, HIV/AIDS AND GENDER							
18.01	(a)	Provide qualified safety officer to deal with OHS, HIV/AIDS and gender management, including transport	month						
18.02		HIV/AIDS and STD prevention and counselling							
	(a)	Payment of Employer's Nominated Service Provider for provision of HIV/AIDS Programme (including all associated expenses)	Provisional Sum						
	(b)	Management Fee for handling payment of the Employer's Sub Contractor (NSP)	Percentage						
	(b)	Provide and maintain sexual health (STI and HIV/AIDS) and first aid Clinic on main site compound	P.S.						
	(C)	Allow for Contractor's overheads and profits as a percentage of Sub-item (b)	percent (%)						
18.03		Gender							
	(a)	Gender sensitisation and awareness raising meeting/workshops	no.						
	(b)	Gender sensitive monitoring and reporting	month						
18.04		**Safety Clothing and Medical Equipments**							
	(a)	Provision of safety clothing and equipment for the workforce.	month						
	(b)	Provision of medical supplies and equipment for site clinical facility	P.S.						
	(c)	Allow for Contractor's overheads and profits as a percentage of Sub-item (b)	percent (%)						
		Bill No. 2 - Drainage							
	DRAINS								
21.01	Excavation for open drains								
	(a)	Excavating soft material situated within the following depth ranges below the surface level:							
		(i) 0.0 m up to 1.5 m	cu.m.						
		(i) Exceeding 1.5 m and up to 3.0 m	cu.m.						
	(b)	Extra over subitem 21.01(a) for excavation in rock as defined in Clause 3603 of the Standard Specifications, irrespective of depth	cu.m.						
21.17	**EXCAVATION FOR CLEARANCE OF EXISTING DRAINAGE SYSTEMS**								
	(a)	Manholes and inlet and outlet structures	cu.m.						

	(b)	Culvert barrels	cu.m.						
	(c)	Concrete side drains	cu.m.						
21.18	Selected backfill material under concrete-lined side drains compacted to 92% BS-Heavy density		cu.m.						
	PREFABRICATED CULVERTS								
22.01	Excavation								
	(a)	Excavating soft material situated within the following depth ranges below the surface level:							
		(i) Up to 1.5 m	cu.m.						
		(ii) Exceeding 1.5 m and up to 3.0 m	cu.m.						
	(b)	Extra over sub-Item 22.01(a) for excavation in rock as defined in Clause 3603, irrespective of depth.							
22.02	Backfilling								
	(a)	Using excavated material	cu.m.						
	(b)	Using imported selected material	cu.m.						
22.03	Concrete pipe culverts								
	(a)	On Class A bedding							
		(i) 900 mm diameter	m						
		(ii) 1200 mm diameter	m						
	(b)	Reinforced concrete pipe culverts on Class B bedding							
		(i) 600 mm diameter	m						
		(ii) 900 mm diameter	m						
		(iii) 1000 mm diameter	m						
		(iv) 1200 mm diameter	m						
		(v) 1500 mm diameter	m						
22.04	Metal Culverts								
	(a)	Corrugated Metal Pipe Culverts							
	(i)	600 mm diameter, wall thickness tbc	m						
	(ii)	900 mm diameter wall thickness tbc	m						
	(iii)	1200 mm diameter, wall thickness tbc	m						
	(vi)	1500 mm diameter, wall thickness tbc	m						
22.07	Cast in-situ concrete and formwork								
	(a)	Concrete Class 15/40 for Class A Bedding, Screeds, Haunching and Encasing for Pipes, including Formwork to pipes,	cu.m.						
	(c)	Concrete Class 25/20 in inlet and outlet structures, excluding formwork, but including Class U2 surface finish	cu.m.						
	(d)	Formwork to concrete under sub item 22.07(c) above (class of finish indicated)							
		(i) Class F1	sq.m.						
		(ii) Class F2	sq.m.						
	(e)	Class 25/20 concrete in concrete linings for the inverts of metal culverts, including formwork and Class U2 surface finish	cu.m.						
22.10	Steel reinforcement								
	(b)	High-Tensile steel bars (Type-2)	ton						
22.14	Removing and stacking existing prefabricated pipes (all sizes)		m						
22.23	Service Ducts								
	(a)	Ordinary Pipes (PVC pipes and 200 mm diameter)	m						
	(b)	Split Pipes for existing services crossing at all surfaced intersections (PVC pipes and 200 mm diameter)	m						
22.24	Duct Marker Blocks		no.						
	CONCRETE KERBING, CONCRETE CHANNELING, OPEN CONCRETE CHUTES AND CONCRETE LININGS FOR OPEN DRAINS								
23.01	Concrete Kerbing								
	(a)(i)	Precast concrete Class 30 semi-mountable kerbs, 300 x 350 mm, including 100mm Class 15 concrete bedding and backing	m						
	(ii)	Precast concrete Class 30 barrier kerbs, 150 x 300 mm, including 100mm Class 15 concrete bedding and backing	m						
	(b)	Precast concrete strip along shoulder edges (Class 30 concrete)	cu.m.						
23.08	Concrete lining for opens drains:								
	(a)	Cast in situ concrete lining							
	(a)(i)	Concrete Class 25/20 with Class U2 surface finish	cu.m.						
23.09	Formwork to cast in situ concrete lining for open drains (Class F2 surface finish):								
	(a)	To sides with formwork on the internal face only	sq.m.						
23.12		Steel reinforcement:							
	(c)	Welded steel fabric, BRC A142	ton						
23.16		Precast concrete Class 30/14 slabs							

	(a)	0.9m (L) x 0.5m (W) x 0.1 (T)m side drain crossing slab	no.						
	(b)	2.25m (L) x 0.5m (W) x 0.15 (T)m side drain crossing slab	no.						
	(c)	2m (L) x 0.7m (W) x 0.15m cover slab over kerb-inlet drainage structure	no.						
	PITCHING, STONEWORK AND PROTECTION AGAINST EROSION								
25.01	Stone Pitching/ Rock Pitching								
	(b)	Grouted stone/ rock pitching, 250 mm thick	sq.m						
25.02	Riprap								
	(a)	Package Riprap	cu.m.						
	(c)(ii)	Filter sand obtained from borrow pits	cu.m.						
25.07	Prepare Foundation Trenches		cu.m.						
25.08	Concrete Class 20 walls at erosion checks		cu.m.						
N 2600: GABIONS									
26.01		Foundation trench excavation and backfilling:							
(a)		In solid rock as defined in Clause 3603	cu.m.						
(b)		In all other material than rock as defined in Clause 3603	cu.m.						
26.02		Surface preparation for bedding the gabions	sq.m						
26.03	Gabions:								
(a)	Galvanised gabion boxes, 2.0 x 1.0 x 1.0 m , 5mm dia wire mesh stainless steel		cu.m.						
(c)	Galvanised gabion mattresses, 4.0 x 2.0 x 0.3 m, 5mm dia wire mesh stainless steel		cu.m.						
26.04	Filter fabric (type and grade indicated)		sq.m						
		Bill No. 3 - Earthworks and Pavement Layers of Gravel or Crushed Stone							
	CLEARING, GRUBBING AND REMOVAL OF TOPSOIL								
31.01	Clearing, grubbing and removal of topsoil								
	(a)	Clearing and grubbing	ha						
	(b)(i)	Removal of topsoil for Re-use.	cu.m.						
	(b)(ii)	Removal of topsoil to Spoil.	cu.m.						
31.02	Removal and grubbing of large trees and tree stumps								
	(a)	Girth exceeding 1.0m up to and including 2.0m	no.						
	(b)	Girth exceeding 2.0m up to and including 3.0m	no.						
32.01	**REMOVAL OF EXISTING STRUCTURES**								
	(a)	Removal of existing pipe culverts of any size	m						
	(b)	Removal of reinforced concrete in bridges, box culverts and slabs including wingwalls and aprons	cu m						
	(f)	Removal of existing buildings	sq.m.						
	BREAKING UP EXISTING PAVEMENT LAYERS								
33.01		Excavating or Milling materials from an existing pavement							
	(a)	Granular materials	cu.m.						
	(b)	Bituminous material	cu.m.						
33.04	Scarification and recompacting of existing pavement layers to 150mm depth and compacted to 95% BS-Heavy		cu.m.						
	EARTHWORKS								
36.01		Excavations:							
	(a)	Common excavation to spoil	cu.m.						
	(b)	Excavation in swamps or wetlands to spoil	cu.m.						
	(c)	Rock Excavation (provisional sum)	cu.m.						
36.02	Fill and Improved subgrade layers:								
	(a)	Improved subgrade layer as specified in the Drawings to required minimum G15 quality material	cu.m.						
	(b)	fill as specified in the drawings to require minimum G7 quality material	cu.m.						
	(d)	Fill or improved subgrade layer using rock fill (provisional item)	cu.m.						
	(e)	Cross fill	cu.m.						
	(f)	Side fill compacted by dozers or as specified	cu.m.						
	(h)	Pioneer layer (0.3 to 0.5 m thickness as directed)	cu.m.						
	(i)	Crusher run layer f 0.2m on top of rockfill	cu.m.						
36.03	Roadbed preperation and compaction of material:								
	(b)	Compaction to 95% of BS-heavy density	cu.m.						
	PAVEMENT LAYERS OF NATURAL GRAVEL MATERIALS								
37.02		Natural gravel for Subbase							

	(c)	Granular Subbase Class G45	cu.m.						
	STABILISATION								
38.04		Mechanical Modification							
	(a)	Extra Over the relevant pay Item for Mechanical Modifications of Existing pavement layers	cu.m.						
	(b)	Binder Materials used for Mechanical Modification							
	(b)(i)	Crushed aggregate	cu.m.						
	CRUSHED AGGREGATE FOR ROAD BASE								
39.01	Crushed aggregate for road base/ sub base								
	(a)	Crushed aggregate Class CRS	cu.m.						
	(b)	Crushed aggregate Class CRR	cu.m.						
		Bill No. 4 - Asphalt Pavements and Seals							
	PRIME AND CURING MEMBRANES								
41.01	Prime coat								
	(a)	MC-70 cut-back bitumen 1.0 L/M2	ltr						
41.03	Aggregate for blinding: 0.004m3/m2		cu.m.						
	SECTION 4200: BITUMINOUS BASE COURSE AND ASPHALT CONCRETE SURFACING								
42.01	concrete surfacing:								
	(a)	Asphalt concrete surfacing	cu.m.						
	(b)	Bitumen for Asphalt Concrete Surfacing 5%	ton						
42.03	Tack Coat of 30% stable grade bitumen emulsion 0.55 L/M2		ltr.						
	SECTION 4900: CONCRETE PAVING								
49.00	(a)	Concrete paving blocks 100 x 200 x 60mm thickness,25N/mm2, laid in herring bond including bedded sand in 30mm compacted thickness	sq.m						
		Bill No. 5 - Ancillary Roadworks							
	MARKER AND KILOMETRE POSTS								
51.01	(a)	New marker posts	no.						
	(b)	Flexible cylinders	no.						
51.02	(a)	New kilometre posts	no.						
	(b)	Delineators	no.						
	(c)	Culvert marker posts	no.						
51.03	Road reserve marker post		no.						
	GUARDRAILS								
52.01	Guardrails on steel posts								
	(a)	Galvanised	m						
52.03	(a)	End sections including foundation in the ground, 3.8 m long	no						
52.05	Reflective Plates								
	(a)	Reflectors on guard rails	no.						
	ROAD SIGNS								
54.01	Road Signs								
	(a)	Danger/Warning signs	no.						
	(b)	Regulatory Signs	no.						
	(c)	Information Signs	no.						
54.03	Information sign boards								
	(a)	Plates ares >0.25m2, but <0.5m2	no.						
		Plates ares >0.5m2, but <1.0m2	no.						
		Plates ares >1.0m2, but <2.0m2	no.						
54.05	Removal of Obsolete road signs and poles as instructed		no.						
	ROAD MARKINGS								
55.01	Road marking using road marking paint material								
	(f)	Kerb Markings	sq.m.						
55.03	Road marking using thermo-plastic road marking material								
	(a)	White edge line, 100mm wide	m						
	(b)	Yellow lines, broken or unbroken							
		(i) 100mm wide broken Centreline	m						
		(ii) 400mm wide Give Way lines	m						
		(iii) 500mm wide pedestrian crossing lines	m						
		(iv) Speed Humps (9.5m by11m wide circular hump)	m						
		(v) Rumble strips (2 No. and 4No. 0.5mm thick strips)	m						
55.04	Variation in rate of application of:								
	(d)	Thermoplastic Road Marking Material	ltr.						
55.05	(a) Roadstuds, 100 x 100 mm ROADTEC or similar		no.						
55.06	Setting out & premarking the lines (excl. islands, lettering and symbols)		m						
55.09	Rumble strips and Speed humps								
	(a)	Rumble strip (specify type/size) - Asphalt concrete							
	(a)(iii)	0.5m wide x 4no. x 11m length	no.						
	(a)(iv)	0.5m wide x 2no. x 11m length	no.						
	(b)	Speed hump (specify type/size) - Asphalt concrete	no.						
	(b)(ii)	Circular 9.5m wide x 100mm high x 11m length	no.						
	LANDSCAPING AND GRASSING								
56.03	Preparing the Area for Grassing								

	(c)	Topsoiling within the road reserve, where the following materials are used;							
	(c)(i)	Topsoil Obtained From Within The Road Reserve or Borrow Areas	cu.m.						
56.04		Grassing:							
	(a)	Planting of Grass Cuttings (Type of Grass as Indicated)	ha						
	(b)	Sodding by Using the Following Types of Sods:							
	(i)	Nursery Sods (Type of Grass Specified)	sq.m.						
56.09	(a)	Providing the trees and shrubs (types and age/size indicated)							
	(b)	Planting and establishing:							
	(b)(i)	Trees	number (no)						
	(b)(ii)	Shrubs	number (no)						
		Bill 6: Structures							
	SECTION 6100: FOUNDATIONS FOR STRUCTURES								
61.01		Additional foundation investigations:	Provisional sum						
61.02		Excavation:							
(a)		Common excavation in soft material situated within the following successive depth ranges:							
(a)(i)		0 m up to 2 m	cubic metre (m^3)						
(a)(ii)		2 m up to 4 m	cubic metre (m^3)						
(a)(iii)		Further increments of 2 m	cubic metre (m^3)						
(b)		Extra-over sub-Item 61.02(a) for excavation in rock irrespective of depth	cubic metre (m^3)						
61.03		Access and drainage:							
(a)		Access	lump sum						
61.04		Backfill to excavations utilising:							
(a)		Material from the excavations	cubic metre (m^3)						
(b)		Imported material	cubic metre (m^3)						
61.05		Foundation fill consisting of:							
(a)		Rock fill	cubic metre (m^3)						
(c)		Compacted granular material	cubic metre (m^3)						
(e)		Concrete blinding	cubic metre (m^3)						
	SECTION 6200: FALSEWORK, FORMWORK AND CONCRETE FINISH								
62.01		Formwork to provide surface finish:							
(a)		Class F1 to concealed surfaces	square metre (m^2)						
(b)(i)		Class F2 to exposed surfaces	square metre (m^2)						
	SECTION 6300: STEEL REINFORCEMENT FOR STRUCTURES								
63.01		Steel reinforcement for:							
(a)(ii)		High-yield-stress-steel bars	tonne (t)						
	SECTION 6400: CONCRETE FOR STRUCTURES								
64.01		Cast in situ concrete [Class of concrete and part of structure or use indicated]							
(a)		Class 15/40 in blinding and other unreinforced concrete	cubic metre (m^3)						
(b)		Class 25/20 in reinforced concrete	cubic metre (m^3)						
	SECTION 6600: NO-FINES CONCRETE; JOINTS; BEARINGS; PARAPETS AND DRAINAGE FOR STRUCTURES								
66.19		Drainage pipes and weep holes:							
(a)		Drainage pipes: ·							
(a)(i)		(Type and size indicated)	metre (m)						
(a)(ii)		(Type and size indicated)	number (no)						
(b)		Weep holes:							
(b)(i)		(Type and size indicated)	metre (m)						
(b)(ii)		(25mm Conduits)	number (no)						
		Bill No. 7 - Tolerances, Testing and Quality Control							
		Testing of Materials and Workmanship							
71.01	(a)	Provisional Sum for Special Tests to be carried out at the instruction of the Engineer	Prov Sum						
	(b)	Allow for Contractor's overheads & profits as a percentage of Item 71.01(a)	percent (%)						
71.02		**INITIAL SPECIFIC GEOTECHNICAL INVESTIGATION**							
	b)	Soil investigation to deep cuts not exceeding 20m deep, requested by the Engineer							
		Deep cut trial hole by excavator							
	b)1	Excavate in trial hole to deep cut sites using excavator and take samples, depth not exceeding 3.0m	no.						
		Deep cut investigation by Penetrometer using SE equipment							
	b)3	Undertake mobile platform penetrometer tests and sampling to deep cuttings, depth not exceeding 5.0m	no.						
		Deep cut investigation by borehole							
	b)7	Set up rotary or shell and auger drilling equipment for boreholes and clear away on completion	no.						
	b)8	Construct borehole and take disturbed samples depth not exceeding 5.0m	m						
	b)12	Set up rotary or auger drill to prove integrity of rock formation to a depth of at least 1.5m rock drilling below first refusal, including recovery of sample	no.						
		Investigation in swamps							
	c)	Soil investigation to swamp areas requested by the Engineer, including provision of pontoon or other form of platform							
	c)1	Provide hand auger and take disturbed samples of materials in swamp depth not exceeding 3.0m	no.						
		Testing and Reporting							
	d)2	Complete set of Laboratory tests on disturbed deep cut samples as described in Special Specification 7128 b)	no.						

	d)3	Provide complete Factual report of all initial specific investigations	Item						
		Bill No. 8 - Schedule of Daywork Rates (Labour)							
		Labour							
81.01		Unskilled labour	hr						
81.02		Skilled labour	hr						
81.03		Headman	hr						
81.04		Foreman	hr						
81.06		Site Manager	hr						
81.07		Driver heavy	hr						
81.08		Driver Light	hr						
81.09		Plant Operator H/D	hr						
81.10		Plant operator LH/D	hr						
81.11		Land surveyor	hr						
81.12		Draftman	hr						
81.13		Mason	hr						
81.14		Carpenter	hr						
		Bill No. 9 - Schedule of Daywork Rates (Materials)							
		Materials							
91.01		Diesel (gas oil)	ltr						
91.02		Petrol	ltr						
91.03		Coarse crushed aggregate	ton						
91.04		Fine aggregate (sand)	ton						
91.05		Ordinary Portland Cement	ton						
91.06		Mild steel reinforcement	ton						
91.07		High yield stress steel bars	ton						
91.08		Timbering for trenches	sq m						
91.09		Formwork	sq m						
91.10		Road Paint	ltr						
91.11		Granular material for Subabse	cu.m						
91.12		Bitumen, PG 76-10 performance grade	ton						
91.13		Cutback bitumen MC-30	ltr						
91.14		30% bitumen emulsion	ltr						
91.15		Lubricant	kg						
91.16		Lime	ton						
		Bill No. 10 - Schedule of Daywork Rates (Plant)							
		Equipment							
100.01		D4 Dozer or equivalent with blade and ripper	hr						
100.02		D8 Dozer or equivalent with blade and ripper	hr						
100.03		Wheeled excavator, bucket capacity under 1 m3	hr						
100.04		Track Loader, 3-4 m3 bucket capacity, (Cat 973C or equivalent)	hr						
100.05		Wheeled excavator, bucket capacity 1-2 m3	hr						
100.06		Backhoe loader	hr						
100.07		5t tipper lorry	hr						
100.08		9t tipper lorry	hr						
100.09		Dump Truck	hr						
100.10		Motorgrader, complete with scarifier (Cat. 14 or equivalent)	hr						
100.11		5-6t drawn vibrating roller and tractor	hr						
100.12		10-12t smooth wheeled roller	hr						
100.13		16-18t Smooth Wheeled Roller	hr						
100.14		Pneumatic Roller, 5,000 kg per tyre when fully ballasted	hr						
100.15		Vibrating plate compactor	hr						
100.16		Self-propelled water tanker min. 14,000 ltr. with pick-up pump	hr						
100.17		Compressor 120 l/m complete with all tools	hr						
100.18		Generator 15 kW	hr						
100.19		Generator 150 kW	hr						
100.20		Rock drill	hr						
100.21		Concrete mixer up to 400 litres	hr						
100.22		Concrete mixing plant, complete 1.0cu.m or above	hr						
100.23		Asphalt Plant 120 T/h	hr						
100.24		Concrete Vibrator	hr						
100.25		Pick-up Truck	hr						

……………………………………..Municipal/Town Council
Payment Certificate

No……………………………….

Date………/………../ 20……….

Contract Name………………………………………………………………. Contract No………………………

Name of Contractor………

Contract Start Date……../……../ 20……. Contract End Date……../……./ 20…. Contract Period ……… weeks

Actual Start Date………./……./ 20………

Actual Completion Date……/……./ 20…..

Actual Time Completed to Date……………………%

Defects Liability Period…………………days

Original Contract Price		UGX……………………………………………..		Dated……/………./ 20…
Current Contract Price	(a)	UGX……………………………………………..		Dated……/………./ 20…
Total Value of Work This Certificate - (From Measurement Sheet)			UGX	…………………………
	Add	Variations	UGX	…………………………
Gross Total Amount This Certificate			UGX	…………………………
	Less	Advance Payment Recovery (b)	UGX	…………………………
	Less	Retention 10%	UGX	…………………………
		Sub - Total	UGX	…………………………
Total Amount This Certificate			UGX	…………………………
	Less	Withholding Tax (Current %, if applicable)	UGX	…………………………
Net Amount Payable to Contractor this Certificate			UGX	…………………………
	VAT (at current %, if applicable)		UGX	…………………………

1. TABLE 1 - PAYMENT CERTIFICATE RECORD
(refer to (a) above)

Current Contract Price incl. VAT if UGX				Current Contract Price excluding VAT UGX ……………………………….
Payment Certificate Number and Details	**Payment Amount UGX**	**Cumulative Payments To Date (UGX)**	**Percentage Payment To Date (%)**	**Balance Owing To Contractor (UGX)**
Advance Payment				
Progress Payment				
Progress Payment				
Progress Payment				
Substantial Completion				
Final Payment				

2. ADVANCE PAYMENT RECOVERY
refer to (b) above

Total Advance Payment		**UGX**	…………………………………….
Repayment Balance - Last Certificate		UGX	…………………………………….
Recovery, This Certificate	(b)	UGX	…………………………………….
Repayment Balance		**UGX**	…………………………………….

3. RETENTION PAYMENT RECORD
refer to (c) above

Total Retention to Date - Last Certificate	UGX	…………………………………….
Retention, This Certificate	UGX	…………………………………….
Total Retention to Date	UGX	…………………………………….

Notes: 1. 100% Retention Release on Final Account
2. VAT is based on Net Amount - This Certificate

Signed by: **Municipal/Town Engineer…………………………………..** **Dated: ……/……/20……..**

Town Clerk…………………………………………………… **Dated: ……/……/20……..**

21. Defects Liability Certificates

……………………Municipal/Town Council

Defects Liability Certificate

(Refer Clause 35, of the Conditions of Contract)

Name of Contractor:

Registered Address:

Contract Name:

Contract Number:

Date of Hand Over: The day of 20

This is to Certify that the above Contract has been jointly inspected, found to fully comply with the requirements of the Conditions of Contract, in particular Clause 35, and handed over and accepted for Maintenance by the Town Clerk, …………….. Municipal/Town Council.

Signed by:

Municipal/Town Engineer: .... **Dated** ..…./ …./ 20 ….

Town Clerk:.. **Dated** ..…./ …./ 20 ….

Contractor: .... **Dated** ….. /…./ 20 ....

22. Environmental Restoration Certificate

……………………Municipal/Town Council

Certificate of Environmental Restoration

(Refer Clause 63, of the Conditions of Contract)

Name of Contractor:

Registered Address:

Contract Name:

Contract Number:

Date of Hand Over: The day of 20

This is to Certify that the above Contract has been jointly inspected, found to fully comply with the requirements of the Conditions of Contract, in particular Clause 63, and handed over and accepted for Maintenance by the Town Clerk, ………………………….. Municipal/Town Council.

Signed by:

Municipal/Town Engineer:	**Dated** ..…. / …. / 20 ….
Town Clerk:	**Dated** ...… / …. / 20 ….
Contractor:	**Dated** ….. /…. / 20 ....

23. Certificate of Completion

……………………Municipal/Town Council

Certificate of Completion

(Refer Clauses 35, 55 and 56 of the Conditions of Contract)

Name of Contractor:

Registered Address:

Contract Name:

Contract Number:

Date of Hand Over: The day of 20

This is to Certify that the above Contract has been jointly inspected, found to fully comply with the requirements of the Conditions of Contract, in particular Clauses 35, 55 and 56, and handed over to the Town Clerk, Municipal/Town Council.

In accordance with the Conditions of Contract, Clause 35.2, the Defects Liability Period of ……..days shall expire on the …….day of …..…… , 20 .... , during which time the Contractor remains fully responsible for the Maintenance of the whole of the Works under the Contract.

Signed by:

Municipal/Town Engineer: **Dated** ..…./ …./ 20 ….

Town Clerk: **Dated** ...…/ …./ 20 ….

Contractor: **Dated** ….. /…./ 20 ....

24. Quarterly Progress Report Forms

QUARTERLY PROGRESS REPORT - EXPENDITURE SCHEDULE

QUARTER_________OF FY :

Urban Council:

QPR Form F1

Road Information						Actual Expenditure (UGX 000) to Date & Planned Next Quarter(s)												
						First Quarter			Second Quarter			Third Quarter			Fourth Quarter			
Work Ref:	Road Code	Road Name	Road Length (km)	Section Length (km)	Total Planned Expend. This Qr.	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total Actual Spent to date
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)	(xix)
A: REHABILITATION																		
1. Preliminaries																		
2. Site Clearance and Earthworks																		
3. Drainage Works																		
4. Wearing Course and Shoulders																		
5. Ancillary Works																		
Quarterly Works Expenditure																		
Cumulative Actual Quarterly Expenditure (UGX 000) to date																		
B: PERIODIC MAINTENANCE																		
1. Preliminaries																		
2. Site Clearance and Earthworks																		
3. Drainage Works																		
4. Wearing Course and Shoulders																		
5. Ancillary Works																		
Quarterly Works Expenditure																		
Cumulative Actual Quarterly Expenditure (UGX 000) to date																		
C: INPROVEMENT TO BITUMINOUS STANDARD																		
1. Preliminaries																		
2. Site Clearance and Earthworks																		
3. Drainage Works																		
4. Wearing Course and Shoulders																		
5. Ancillary Works																		
Quarterly Works Expenditure																		
Cumulative Actual Quarterly Expenditure (UGX 000) to date																		
D: ROUTINE MAINTENANCE																		
Activities (Appendix 6 & 7)																		
Quarterly Operational Expenditures																		-
Total Quarterly Expenditure																		-
Actual Funds Received by Quarter to Date (UGX 000)																		
Cumulative Actual Funds Received by Quarter (UGX 000) to Date																		
Balance of Funds Available at end of this Quarter (+)/(-)																		

Signed: UCE

Signed: Town Clerk

Date:

QUARTERLY PROGRESS REPORT - WORKS IMPLEMENTATION SCHEDULE

Page____of____

QUARTER_1__ OF FY :

Urban Council:

QPR Form F2

Road Information					Total Planned Works this Qtr.	Actual Intervention/Works to Date & Planned Next Quarter(s) (% only)												
Work Ref:	Road Code	Road Name	Road Length	Section Length		Quarter 1			Quarter 2			Quarter 3			Quarter 4			Actual Work Done to date
						Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	(xviii)	(xix)

A: REHABILITATION

1. Preliminaries																		
2. Site Clearance and Earthworks																		
3. Drainage Works																		
4. Wearing Course and Shoulders																		
5. Ancillary Works																		

B: PERIODIC MAINTENANCE

1. Preliminaries																		
2. Site Clearance and Earthworks																		
3. Drainage Works																		
4. Wearing Course and Shoulders																		
5. Ancillary Works																		

C: IMPROVEMENT TO BITUMINOUS STANDARD

1. Preliminaries																		
2. Site Clearance and Earthworks																		
3. Drainage Works																		
4. Wearing Course and Shoulders																		
5. Ancillary Works																		

D: ROUTINE MAINTENANCE

Activities (Appendix 6 & 7)																		

Signed: (UCE) **Signed: (TC)** **Date:**

QUARTERLY PROGRESS REPORT - SUMMARY OF ACTUAL EXP./FUND REQUEST

Page____of____

QUARTER_____OF FY :

Urban Council: **QPR Form F3**

Summary of Actual Expenditure (Ush. 000)

	Sources of Funding				Total Actual Expenditure			
Actual Interventions/Works Done this Quarter	**Road Fund/PAF**	**LGDP**	**JICA**	**Local Revenue**	**This Quarter**	**To-date**	**Total Planned Annual Expend.**	**Progress to Date (%)**
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Rehabilitation								
Periodic Maintenance								
Improvement to Bituminous Standards								
Routine Maintenance								
Operational Expenditure								
Total:								
QUARTERLY SUMMARY					Quarter	Cumm..	Quarter	%
First Quarter	-							
Second Quarter								
Third Quarter								
Fourth Quarter								

Fund Request (Ush. 000) **Quarter_____________of FY______________**

PLANNED INTERVENTIONS/WORKS - NEXT QUARTER	**Road Fund/PAF**	**LGDP**	**JICA**	**Local Revenue**	**Total Planned Expenditure**	**Comments**
(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)
Rehabilitation					-	
Periodic Maintenance						
Improvement to Bituminous Standards						
Routine Maintenance						
Operational Expenditures					-	
Sub Total					-	
Balance Available					-	
TOTAL FUND REQUEST NEXT QUARTER by SOURCE					-	

Signed: UCE Signed: Town Clerk Date:

25. Sample Contract Register

Procurement Register

Urban Roads - Contracted Works – To (date):________

Urban Council Name:
Contract No:
Road No & Type of Work:
Contract Name:
Name of Contractor:

Contract Name	Contract Amount Eng. Est. (UGX)	Date Contract Advertised	Date Tender Submission	Number of Tenders Received	Date Tenders Evaluated (CC)	Date Contract Awarded (CC)	Actual Contract Price (UGX)	Date Work Started	Contract Period (weeks)	Scheduled Completion Date	Approved Claims Amount (UGX)	Revised Contract Amount (UGX)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)

Notes: Explanations are Required for Increases in Contract Price (columns k and l) and Extensions of Time (column m).
Any significant difference between Eng. Est. (column a) and Actual Contract Price (column g) must be fully explained.

Explanation/Comments:

26. Typical Quarterly Report Covering Letter

OFFICE OF THE TOWN CLERK
________________ Municipal / Town Council
P.O. BOX ____________
Date: ____________

The Permanent Secretary
Ministry of Works and Transport
P O Box
Kampala

ATTN:

Dear Sir,

RE: Submission of __________ Quarterly Progress Report for Urban Road Works in _____________Municipal Council for Financial Year _______________ .

Please find herewith ___________________ Quarterly Progress Report for urban road works in _________________*Town/Municipal Council*.

Table A below provides a summary of achievements against planned activities for this reporting period; refer to Annual Urban Road Work Plan for FY __________ , and Forms F1, F2, F3 and F4, attached hereto, detailing planned activities and actual achievements during this reporting period.

Table A - Summary of Quarterly Progress Report

ACTIVITY	**PLANNED**		**ACHIEVED**		**VAR.**	**REASON FOR VAR.**
	Target	**Budget (a) (UGX 000)**	**Actual**	**Expend. (b) (UGX 000)**		
A. Rehabilitation						
B. Periodic Maint.						
C. Improvement to Bituminous Stand.						
D. Routine Maintenance						
E. Operational Expenditures	Procurement Activities		Procurement Activities			
F. Bank Charges						
Total	**BUDGET**		**Expend.**			
Balance at end of Previous Quarter						
Funds Received This Quarter						
Balance Remaining						

Those activities planned but not undertaken during this Quarter are included in the plan for the subsequent Quarter(s) of this FY; refer Forms F1, F2, F3 and F4, attached hereto.

The list of all those roads on which works were planned and performed during this reporting period follows; refer AURICS Inventory data for official road names, and Form F2 of this Quarterly Progress Report.

Road Cc No	**Road Name**	**Length Worked On (km)**		**Type of Works Done (km)**		
		Planned	**Actual**	**RH**	**PM**	**IMPMT.**
	Totals (km)					

Table B below provides a cumulative summary of achievements against planned activities up to and including this reporting period; refer Annual Urban Road Work Plan for FY ….. , and Forms F1, F2, F3 and F4 detailing planned activities and actual achievements during this and previous reporting periods.

Table B - Cumulative Summary of Quarterly Progress Report(s)

ACTIVITY	**PLANNED**		**ACHIEVED**		**COMMENTS**
	Target	**Budget (UGX) 000)**	**Actual**	**Expend. (UGX 000)**	
A. Rehabilitation					
B. Periodic Maintenance					
C. Improvement to Bituminous Standards					
D. Routine Maintenance					
E. Operational / Undistributed Exp.	Procurement activities		Procurement activities		
F. Bank charges	-		-		
Totals	**Budget**		**Expend.**		
	Funds Received to Date				
	Un-spent Balance Remaining				
	Un-presented Cheques				
	Balance on Bank Statement				**- Copy of Bank Statement attached**

Table C below provides justification for the Release Request for the next quarter; refer Forms F1, F2 and F3

Table C - Quarterly Budget Request - All Funding Sources

ACTIVITY	PLAN FOR QUARTER	Road Fund/PAF	LGDP	JICA	Local Rev.	TOTAL QUARTER (Ush 000)
A. Rehabilitation						
B. Periodic Maintenance						
C. Improvement to Bituminous Standards						
D. Routine Maintenance						
E. Operational Expenses	Preparation contract docs & procurement					
	Total Budget					
	Un-spent					
	Release Request					

The following Attachments are included with this Quarterly Progress Report -
Note 1. If this is the First Quarterly Progress Report, then the following need to be Attachments -

- Forms E1, E2 and E3 detailing the Annual Urban Road Work Plan for the current FY - these should have been provided with the Fourth Quarterly Progress Report of the previous FY; refer Note 3. below
- Form F1 - Expenditure Schedule detailing actual spending during this Quarter and planned spending for the remainder of this FY
- Form F2 - Works Implementation Schedule detailing actual works done this Quarter and planned for the remainder of this FY
- Form F3 - Summary of Actual Expenditure during this Quarter together with the Fund Request for the following Quarter
- Form F4 - Quarterly Progress Report detailing all urban road works undertaken during this Quarter and planned for the remainder of this FY
- Bank Statement detailing all transactions during and to the end of this quarter

Note 2. If this is the Second and Third Quarterly Progress Reports, then the following need to be Attachments -

- Form F1 - Expenditure Schedule detailing actual spending during this Quarter and planned spending for the remainder of this FY
- Form F2 - Works Implementation Schedule detailing actual works done this Quarter and planned for the remainder of this FY
- Form F3 - Summary of Actual Expenditure during this Quarter together with the Fund Request for the following Quarter
- Form F4 - Quarterly Progress Report detailing all urban road works undertaken during this Quarter and planned for the remainder of this FY
- Bank Statement detailing all transactions during and to the end of this quarter

Note 3. If this is the Fourth Quarterly Progress Report, the list of Attachments will be as follows;

- Forms F1, F2, F3 and F4 for the last Quarter of the current FY including, in Form F3, the Fund Request for the following Quarter which will be the first quarter of the next FY
- Form E1 - Annual Urban Road Work Plan for next FY, detailing the Expenditure Schedule for those works planned for implementation during the FY
- Form E2 - Annual Urban Road Work Plan for the next FY, detailing the Works Implementation Schedule or programme for all those works planned during the FY

- Form E3 - Annual Urban Road Work Plan for the next FY, detailing, for each of the works to be performed, the funding required, its source of origin, and the planned schedule for quarterly Fund Releases to ensure achievement of the works programme
- Bank Statement detailing all transactions during and to the end of this quarter

Yours sincerely,

Town Clerk
________________ ***Municipal Council***

The Permanent Secretary/Secretary to Treasury, MOFEP
The Permanent Secretary, Ministry of Local Government
The Chairperson ____________________ District Public Accounts Committee
The Mayor/Chairman LCIII ____________________ Municipal/Town Council
The Chief Administrative Officer ____________________ District
RDC ____________________ District
The Senior Internal Auditor ____________________ Municipal/Town Council
Director Budget, MFPED, Kampala

27. Uganda Road Fund Programming Tables

UGANDA ROAD FUND PROGRAMMING TABLES

Table 1: Summary Quarterly Progress

Designated Agency: Kabarole District Feeder Roads   Quarter: One   FY:........

ACTIVITY		Length (Km)	Annual Work Plan			Quarterly Physical progress (km)				Quarterly Financial progress (UGX '000)			
Category	Sub Category		Length to be treated (Km)	Planned Exp UGX '000	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4
District Roads													
Routine Maintenance of which:	Routine manual maintenance												
	Paved Roads												
	Un paved Roads	203.6	191.5	137 902	Gang System	-	-	-	-	2 700	-	-	-
	Bridges												
	Other Structures												
	Sub total	**203.6**	**191.53**	137 902		-	-	-	-	2 700	-	-	-
	Routine mechanised maintenance												
	Paved Roads												
	Un paved Roads	144.8	112.6	199 423	Force Account	32.2	0.0	0.0	0	45 000	0	0	0
	Bridges/Culvert (m)												
	Other Structures												
	Sub total	**144.8**	**112.6**	199 423		32.2	0.0	0.0		45 000	-	-	-
Periodic Maintenance of which:													
	Paved Roads												
	Un paved Roads												
	Bridges				Force Account								
	Other Structures (culverts m)	0	0	-	Force Account								
	Sub total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Road Safety works													
Other qualifying work													
	Consultancy Services and professional fees												
	Mechanical Imprest			60 000						7 984			
	Supervision/Administration costs	4.50%		18 722	Force Account					4 621	-	-	
	Sub total			78 722	Force Account					12 605			
	Total			416 047		32	-	-	-	60 305	0	0	0

Signed: ______________________ District Engineer   Signed: ______________________ Chief Administrative Officer

Date:________________________   Date:________________________

Notes:

1. Summary Quarterly progress table to be filled separately for Districts, Town council and Subcounty roads.
2. Provide substantiated evidence for buildup of unit costs; differentiate work being done by Force Account and Competitive Contract procedures.
3. Districts to collate v Total Transfers to Sub-counties
4. Routine and periodic maintenance works being funded by other agencies shall not be included in the work plan to URF.

UGANDA ROAD FUND PROGRAMMING TABLES

Table 1: Summary Workplan

Designated Agency: KIKO - TOWN COUNCILS Quarter: One FY:........

ACTIVITY		Length (Km)	Annual Work Plan			Quarterly Physical workplan (km)				Quarterly Financial request (UGX '000)			
Category	Sub Category		Length to be treated (Km)	Planned Exp UGX '000	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4
District Roads													
Routine Maintenance of which:	Routine manual maintenance												
	Paved Roads												
	Un paved Roads	21.6	21.6	20 401	Gang System	51.0	-	-		5 100	-	-	-
	Bridges												
	Other Structures												
	Sub total	**21.6**	21.6	20 401		51	-	-	-	5 100	-	-	-
	Routine mechanised maintenance												
	Paved Roads												
	Un paved Roads	1.2	0.0	8 705	Force Account	0	0	0	0	0	0	0	0
	Bridges												
	Other Structures(Culvert)		0.0			0	0	0					
	Sub total	1.2	0.0	8 705		0	0.0	0		0	0	0	0
Periodic Maintenance of which:													
	Paved Roads												
	Un paved Roads	7	5.4	67299	Force Account	0.0	0	0	0	3000	0	0	0
	Bridges/Culverts		6 lines										
	Other Structures												
	Sub total	**7**	**5.4**	**67 299**		**0**	**0**	**0**	**0**	**3000**	**0**	**0**	**0**
Road Safety works													
Other qualifying work													
	Consultancy Services												
	Mechanical Imprest			16 485	Force Account					-			
	Supervision/Administration costs	4.50%		4 909	Force Account					825	-	-	-
	Sub total			21 394	-	-	-	-	-	825	-	-	-
	Total			109 094	-	51	-	-	-	8 925	-	-	-

Signed: ______________________ District Engineer

Signed: ______________________ Chief Administrative Officer

Date:________________________

Date:________________________

Notes:

1. Summary workplan table to be filled separately for Districts, Town council and Subcounty roads.
2. Provide substantiated evidence for buildup of unit costs; differentiate work being done by Force Account and Competitive Contract procedures.
3. Districts to collate work plans for sub counties and summarise them in the consolidated district plan.
4. Routine and periodic maintenance works being funded by other agencies shall not be included in the work plan to URF.

UGANDA ROAD FUND PROGRAMMING TABLES

Table 1: Summary Workplan

Designated Agency: KIJURA - TOWN COUNCILS Quarter: One FY:........

ACTIVITY		Length (Km)	Annual Work Plan			Quarterly Physical workplan (km)				Quarterly Financial request (UGX '000)			
Category	Sub Category		Length to be treated (Km)	Planned Exp UGX '000	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4
District Roads													
Routine Maintenance of which:	Routine manual maintenance												
	Paved Roads												
	Un paved Roads	5.2	5.2	3 744	Gang System	27	-	-	-	-	-	-	-
	Bridges												
	Other Structures												
	Sub total	**5.2**	5.2	3 744		27	-	-	-	-	-	-	-
	Routine mechanised maintenance												
	Paved Roads												
	Un paved Roads												
	Bridges												
	Other Structures												
	Sub total	0.0	0.0	0		0				0	0	0	0
Periodic Maintenance of which:													
	Paved Roads												
	Un paved Roads	8.5	8.5	45277	Force Account	0	0	0	0	0	0	0	0
	Bridges												
	Other Structures												
	Sub total	**8.5**	**8.5**	**45 277**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Road Safety works													
Other qualifying work													
	Consultancy Services												
	Mechanical Imprest	15%		16 933	Force Account					1 500			
	Supervision/Administration costs	4.50%		5 078	Force Account					913	-	-	-
	Sub total			22 011	-	-	-	-	-	2 413	-	-	-
	Total			112 888	-	27	-	-	-	2 413	-	-	-

Signed: ____________________ District Engineer

Signed: ____________________ Chief Administrative Officer

Date:______________________

Date:______________________

Notes:

1. Summary workplan table to be filled separately for Districts, Town council and Subcounty roads.
2. Provide substantiated evidence for buildup of unit costs; differentiate work being done by Force Account and Competitive Contract procedures.
3. Districts to collate work plans for sub counties and summarise them in the consolidated district plan.
4. Routine and periodic maintenance works being funded by other agencies shall not be included in the work plan to URF.

UGANDA ROAD FUND PROGRAMMING TABLES

Table 1: Summary Workplan

Designated Agency: MUGUSU - TOWN COUNCILS   Quarter: One   FY:........

ACTIVITY		Length (Km)	Annual Work Plan			Quarterly Physical workplan (km)				Quarterly Financial request (UGX '000)			
Category	Sub Category		Length to be treated (Km)	Planned Exp UGX '000	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4
District Roads													
Routine Maintenance of which:	Routine manual maintenance												
	Paved Roads												
	Un paved Roads	33.0	33.0	12 150	Gang System	-		-		-	-		
	Bridges												
	Other Structures												
	Sub total	**33.0**	**32.992**	12 150		-	-	-	-	-	-	-	-
	Routine mechanised maintenance												
	Paved Roads												
	Un paved Roads	0.00	0.00	0	Force Account	0	0	0		0	0	0	0
	Bridges												
	Other Structures												
	Sub total	0.0	0.0	0		0	0	0		0	0	0	0
Periodic Maintenance of which:													
	Paved Roads												
	Un paved Roads	6.8	6.8	26290	Force Account	0				0			
	Bridges												
	Other Structures												
	Sub total	**6.8**	**6.8**	**26 290**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Road Safety works													
Other qualifying work	VAT from previous works												
	Consultancy Services												
	Mechanical Imprest			-	Force Account								
	Supervision/Administration costs	4.50%		1 560	Force Account					36	-	-	-
	Sub total			1 560	-	-	-	-	-	36	-	-	-
	Total			40 000	-	-	-	-	-	36	-	-	-

Signed: ______________________ District Engineer   Signed: ______________________ Chief Administrative Officer

Date:_________________________   Date:_________________________

Notes:

1. Summary workplan table to be filled separately for Districts, Town council and Subcounty roads.
2. Provide substantiated evidence for buildup of unit costs; differentiate work being done by Force Account and Competitive Contract procedures.
3. Districts to collate work plans for sub counties and summarise them in the consolidated district plan.
4. Routine and periodic maintenance works being funded by other agencies shall not be included in the work plan to URF.

UGANDA ROAD FUND PROGRAMMING TABLES

Table 1: Summary Workplan

Designated Agency: Community Access Roads Quarter: One FY:........

ACTIVITY		Length (Km)	Annual Work Plan			Quarterly Physical workplan (km)				Quarterly Financial request (UGX '000)			
Category	Sub Category		Length to be treated (Km)	Planned Exp UGX '000	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4
District Roads													
Routine Maintenance of which:	Routine manual maintenance												
	Paved Roads												
	Un paved Roads												
	Bridges												
	Other Structures												
	Sub total												
	Routine mechanised maintenance												
	Paved Roads												
	Un paved Roads	40.8	38.3	84 933	Force Account	0	0	0	0	0	0	0	0
	Bridges/Culvert instaallation	0.0	0.0										
	Other Structures												
	Sub total	40.8	38.3	84 933		0	0	0	0	0	0	0	0
Periodic Maintenance of which:													
	Paved Roads												
	Un paved Roads	0	0	0									
	Bridges												
	Other Structures												
	Sub total	**0**	**0**	-									
Road Safety works													
Other qualifying work													
	Consultancy Services												
	Mechanical Imprest (to be retained at the district)				Force Account						-	-	-
	Supervision/Administration costs	4.50%		4 002	Force Account								
	Sub total			4 002	-	-	-	-	-	-	-	-	-
	Total			88 935	-	-	-	-	-	-	-	-	-

Signed: ______________________ District Engineer

Date:________________________

Signed: ______________________ Chief Administrative Officer

Date:________________________

Notes:

1. Summary workplan table to be filled separately for Districts, Town council and Subcounty roads.
2. Provide substantiated evidence for buildup of unit costs; differentiate work being done by Force Account and Competitive Contract procedures.
3. Districts to collate work plans for sub counties and summarise them in the consolidated district plan.
4. Routine and periodic maintenance works being funded by other agencies shall not be included in the work plan to URF.

UGANDA ROAD FUND PROGRAMMING TABLES

Table 2a: Quarterly Progress Report - Routine Manual Maintenance
Quarterly Physical and Financial Performance - Roadworks

Designated Agency:Kabarole District Quarter: One FY:........

				Annual Work Plan			Quarterly Physical Progress (km)				Quarterly Financial progress (UGX '000)				
Item No.	Road Name	Surface Type	Road length, Km	Length to be treated (Km)	Works category/ sub-category	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4	Explanation for variances and planned measures
Routine Manual Maintenance															
DISTRICT ROADS															
1	Kicuuna Mporampora Kyembogo	U	5.0	5.0	1	Gang System	0.0				75				Works scheduled to start in Q2
2	Mitandi Kinyankende	U	1.8	1.8	1	Gang System	0				27				Works scheduled to start in Q2
3	Kisongi Munobwa	U	6.7	6.7	1	Gang System	0				101				Works scheduled to start in Q2
4	Mugusu Kinyankende	U	6.8	6.8	1	Gang System	0.0				102				Works scheduled to start in Q2
5	Kichwamba Kiburara	U	24.8	24.8	1	Gang System	0				372				Works scheduled to start in Q2
6	Kiburara Orubanza	U	9.2	9.2	1	Gang System	0.0				138				Works scheduled to start in Q2
7	Kahangi Mbagani	U	6.7	6.7	1	Gang System	0				101				Works scheduled to start in Q2
8	Ruteete Mituli Rwaihamba	U	9.5	9.5	1	Gang System	0				143				Works scheduled to start in Q2
9	Mbagani Kisongi	U	5.2	5.2	1	Gang System	0.0				78				Works scheduled to start in Q2
10	Katoma Bwabya Kyembogo	U	11.6	11.6	1	Gang System	0				174				Works scheduled to start in Q2
11	Nyabukara Harugongo	U	6.4	6.4	1	Gang System	0.0				96				Works scheduled to start in Q2
12	Isunga Rwankenzi	U	18.1	18.1	1	Gang System	0				272				Works scheduled to start in Q2
13	Kaboyo Kyezire Kazingo	U	5.7	5.7	1	Gang System	0				86				Works scheduled to start in Q2
14	Kabegira Kirere	U	4.9	4.9	1	Gang System	0.0				74				Works scheduled to start in Q2
15	Kyakaigo Kikonga Harugongo	U	6.0	6	1	Gang System	0				90				Works scheduled to start in Q2
16	Mpinga Bulyambuzi Nyantabooma	U	8.5	8.5	1	Gang System	0.0				128				Works scheduled to start in Q2
17	Kifuruka Kanyanswiga Kyanyaitemba	U	3.5	3.5	1	Gang System	0				53				Works scheduled to start in Q2
18	Kida Lyantonde	U	4.3	4.3	1	Gang System	0				65				Works scheduled to start in Q2
19	Rwaihamba Isunga	U	5.5	5.5	1	Gang System	0.0				83				Works scheduled to start in Q2
20	Rutoma Ntezi	U	2	2	1	Gang System	0				30				Works scheduled to start in Q2
21	Geme Katojo	U	2	2	1	Gang System	0.0				30				Works scheduled to start in Q2
22	Hakigere Ssaka Buhara Kyakagusa	U	6.8	6.8	1	Gang System	0				102				Works scheduled to start in Q2
23	Kyezire Kasirra	U	2.5	2.5	1	Gang System	0				38				Works scheduled to start in Q2
24	Buhara Mukonomura	U	2.3	2.3	1	Gang System	0.0				35				Works scheduled to start in Q2
25	Rwaitera Nkuruba	U	4.5	4.5	1	Gang System	0				68				Works scheduled to start in Q2
26	Rwaihamba Kyakatama Rweraza	U	6.0	6	1	Gang System	0.0				64				Works scheduled to start in Q2
27	Kagogo Kaguma Kitarasa	U	6.2	5.4	1	Gang System	0				81				Works scheduled to start in Q2
SUBTOTAL - DISTRICT			182.5	181.7			0.0				2700				
MUGUSU TOWN COUNCIL ROADS*															
1	Mugusu Kahungera	U	4.3	4.3	1	Gang System	0.0				0				
2	Mugusu Kiraro	U	1.6	1.6	1	Gang System	0.0				0				
3	Mugusu Muhora	U	4.5	4.5	1	Gang System	0.0				0				
4	Total Transfers to Sub-counties	U	2.5	2.5	1	Gang System	0.0				0				
5	Burungu Kijongo Kaboyo	U	2.5	2.5	1	Gang System	0.0				0				
6	Kibede Bwiriza	U	1.2	1.2	1	Gang System	0.0				0				
7	Burungu Kyanduru	U	1.9	1.9	1	Gang System	0.0				0				
8	Kahungera Kyakijara	U	0.9	0.9	1	Gang System	0.0				0				
9	Mweri Kyogya	U	0.6	0.6	1	Gang System	0.0				0				
SUB TOTAL -MUGUSU TOWN COUNCIL			**20.00**	**20.00**	**9.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	

Item No.	Road Name	Surface Type	Road length, Km	Annual Work Plan			Quarterly Physical Progress (km)				Quarterly Financial progress (UGX '000)				Explanation for variances and planned measures
				Length to be treated (Km)	Works category/ sub-category	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4	
KIJURA TOWN COUNCIL ROADS*															
1	Igogonya Paskali	U	4	4	1	Gang System	3.9				0				
2	Rukebuga Kihoora	U	0.3	0.3	1	Gang System	0.3				0				
3	Katusabe Kabarwini	U	0.6	0.6	1	Gang System	1.0				0				
4	Byaragasi - Full Gospel	U	0.6	0.6	1	Gang System	0.6				0				
5	Kahuna Nsorro	U	3.3	3.3	1	Gang System	3.3				0				
6	Kamusanga Miyoora Mubali	U	5.1	5.1	1	Gang System	4.9				0				
7	Kyaitamba Kyabaganda	U	1	1	1	Gang System	1.0				0				
8	Kyaitumbi	U	0.6	0.6	1	Gang System	0.5				0				
9	Kyajumba	U	0.5	0.5	1	Gang System	0.5				0				
10	Kasokero Kyabaganda	U	5.7	5.7	1	Gang System	5.7				0				
11	Karokarungi	U	0.6	0.6	1	Gang System	0.4				0				
12	Kyererezi Katego	U	3.5	3.5	1	Gang System	3.1				0				
13	Kyakamanya	U	0.6	0.6	1	Gang System	0.6				0				
14	Mubali Kahuna	U	1.7	1.7	1	Gang System	1.5				0				
15	Karangara Kyererezi	U	1.6	1.6	1	Gang System	1.5				0				
SUBTOTAL - KIJURA TOWN COUNCIL			28	28			27				0				

Item No.	Road Name	Surface Type	Road length, Km	Annual Work Plan			Quarterly Physical Progress (km)				Quarterly Financial progress (UGX '000)				Explanation for variances and planned measures
				Length to be treated (Km)	Works category/ sub-category	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4	
KIKO TOWN COUNCIL ROADS*															
1	Kanyambeho Rwamugonera	U	2.2	2.2	1	Gang System	2.2				220				
2	Nyabubale Busoro	U	4.3	4.3	1	Gang System	4.3				430				
3	Katoke Muganyirwa	U	1.5	1.5	1	Gang System	1.5				150				
4	Banura Kaihura	U	2	2	1	Gang System	2.0				200				
5	Makobyo Kyanyawara	U	5.3	5.3	1	Gang System	5.3				530				
6	Kigarama Bwenderwa	U	3.3	3.3	1	Gang System	3.3				330				
7	Kyakaija Banura	U	2.2	2.2	1	Gang System	2.2				220				
8	Kyarutotera	U	0.6	0.6	1	Gang System	0.6				60				
9	Miranga	U	1	1	1	Gang System	1.0				100				
10	Bwairora	U	1.2	1.2	1	Gang System	1.2				120				
11	Mburro	U	1.8	1.8	1	Gang System	1.8				180				
12	Kasojo Ibura	U	1.8	1.8	1	Gang System	1.8				180				
13	Kyamusunga road	U	1.8	1.8	1	Gang System	1.8				180				
14	Bwirora Kyangabukama	U	20	20	1	Gang System	20.0				2000				
15	Kamakune	U	1	1	1	Gang System	1.0				100				
16	Kitabonwa	U	1	1	1	Gang System	1.0				100				
SUB TOTAL - KIKO TOWN COUNCIL			**51**	**51**			51.0				5100				
COMMUNITY ACCESS ROADS**															
1															
2															
3															
SUBTOTAL - CARs															
SUBTOTAL 1 (RMan)			281.60	280.80	9.00	-	78.27	-	-	-	7 799.70	-	-	-	

Sn	Category	Sub-category		Category	Sub-category		Sn	Category	Sub-category	
1	Routine Manual Maintenance	1.1	Drainage Works	Periodic Maintenance	3.1	Sealing			4.4	Foot Bridges
		1.2	Culvert Cleaning		3.2	Shoulder regravelling			4.5	Realignemet
		1.3	Grass cutting		3.3	Shoulder sealing			4.6	Others (Please specify)
		1.4	Debris removal		3.4	Major Drainage Works	5	Bridges	5.1	Concrete repairs
		1.5	Others (Please specify)		3.5	Edge repairs			5.2	Steel repairs/painting
2	Routine Mechanised Maintanance	2.1	Pothole patching		3.6	Regraveling			5.3	Signage
		2.2	Grading		3.7	Grading			5.4	Element replacement
		2.3	Spot regravelling		3.8	Others (Please specify)			5.5	Embankment reconstruction
		2.4	Drainage works	Road Safety	4.1	Road Marking			5.6	Guard rail repairs
					4.2	Sign posts			5.7	River Training
		2.5	Other (Please specify)		4.3	Black spots			5.8	Others (Please specify)

Notes:

* Separately fill for all Town councils in Designated Agency.

** Separately fill for all Subcounties in Designated Agency.

UGANDA ROAD FUND PROGRAMMING TABLES

Table 2b: Quarterly Progress Report - Routine Mechanised Maintenance

Quarterly Physical and Financial Performance - Roadworks

Designated Agency:Kabarole District Quarter: One FY:........

Item No.	Road Name	Surface Type	Road length, Km	Annual Work Plan			Quarterly Physical Progress (km)				Quarterly Financial progress (UGX '000)				Explanation for variances and planned measures
				Length to be treated (km)	Works category/ sub-category	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4	
Routine Mechanised Maintenance															
DISTRICT ROADS															
1	Rutete Mituli Rwaihamba	U	9.5	9.5	2.2, 2.4	Force Account									
2	Kagogo Kichwamba	U	5.4	5.4	2.2, 2.4	Force Account	5.4				10000				
3	Kirere Kabegira	U	5.2	5.2	2.2, 2.4	Force Account	5.2				10000				
4	Geme Katojo	U	2.8	2.8	2.2, 2.4	Force Account									
5	Katoma- Bwabya -Kyembogo	U	11.6	11.6	2.2, 2.4	Force Account									
6	Isunga- Rwankezi	U	18.3	16.1	2.2, 2.4	Force Account	16.1				15000				
7	Buhara Mukonomura	U	2.0	2.0	2.2, 2.4	Force Account									
8	Emergency/ spot improvement works	U	15.0	15.0	2.2, 2.4	Force Account									
9	Kicwamba -Kiburara	U	24.8	24.8	2.2, 2.4	Force Account									
10	Mitandi Kinyankende	U	1.8	1.8	2.2, 2.4	Force Account									
11	Kyakaigo Kikonge Harugongo	U	5.5	5.5	2.2, 2.4	Force Account	5.5				10000				
12	Kiburara Orubanza	U	9.4	5.0	2.2, 2.4	Force Account									
13	Kida Lyantonde	U	3.1	3.1	2.2, 2.4	Force Account									
14	Kifuruka Kyanyaitemba Kanyanswaiga	U	4.4	4.4	2.2, 2.4	Force Account									
SUBTOTAL - DISTRICT			118.8	112.2	0		32.2				45000				
Mugusu															
1	Kirugu Kijungo	U	1.5	1.5	2.2, 2.4	Force Account									
2	Kigarama Farm	U	1.2	1.2	2.2, 2.4	Force Account	0				0				
SUBTOTAL - Mugusu T C			2.7	2.7			0	0	0	0	0	0	0	0	

Item No.	Road Name	Surface Type	Road length, Km	Annual Work Plan			Quarterly Physical Progress (km)				Quarterly Financial progress (UGX '000)				Explanation for variances and planned measures
				Length to be treated (km)	Works category/ sub-category	Implementation strategy	Q1	Q2	Q3	Q4	Q 1	Q 2	Q 3	Q 4	
COMMUNITY ACCESS ROADS**															
1	Mechanised routine maintenance of	U	1.5	1.5	2.2, 2.4	Force Accont									
2	Magunga Kyakato Kahungera (Mugusu SC)	U	1.5	1.5	2.2, 2.4	Force Accont									
3	Completion of Nyahanga Karundo Kamuka (Mugusu	U	2	2	2.2, 2.4	Force Accont									
4	Kihondo Kigarama (Kichwamba SC)	U	2	2	2.2, 2.4	Force Accont									
5	Kitumbi Kitangira (Kichwamba SC)	U	2	2	2.2, 2.4	Force Accont									
6	Nsaho Buzinda(Busoro SC)	U	1.5	1.5	2.2, 2.4	Force Accont									
7	Mugusu Kihingami(Busoro SC)	U	1.2	1.2	2.2, 2.4	Force Accont									
8	Ngombe Kasanjura(Busoro SC)	U	0.8	0.8	2.2, 2.4	Force Accont									
9	Kyogya road(Busoro SC)	U	1.2	1.2	2.2, 2.4	Force Accont									
10	Top Hill Kidubuli (Busoro SC)	U	2.5	2.5	2.2, 2.4	Force Accont									
11	Kadindo Nyakitokoli Primary School (Karangura SC)	U	3.0	3.0	2.2, 2.5	Force Accont									
12	Total Transfers to Sub-counties	U	3.0	3.0	2.2, 2.4	Force Accont									
13	Mbogo Kyabuhongoto Kyansimbi Kaitanjahi (Hakib	U	1.0	1.0	2.2, 2.4	Force Accont									
14	Isunga Bulera (Hakibale SC)	U	4.0	4.0	2.2, 2.4	Force Accont									
15	Bunyasaigi Burungu (Bukuuku SC)	U	4.3	4.3	2.2, 3.4	Force Accont									
16	Kabende Centre Biharurre (Kabende SC)	U	0.3	0.3	2.2, 2.4	Force Accont									
17	Murruming Mukumbwe Humura road(Karambi SC	U	0.5	0.5	2.2, 2.4	Force Accont									
18	Murruming Karambi H C III Road (Karambi SC)	U	2.4	2.4	2.2, 2.4	Force Accont									
19	Spot Murruming Kafunda Kanyambeho (Karambi SC)	U	2	2	2.2, 2.4	Force Accont									
20	Butebe Mbuzi Karuhinda (Karambi SC)	U	2	2	2.2, 2.4	Force Accont									
21	Bulyambuzi Kikuuta (Harugongo SC)	U	2	2	2.2, 2.4	Force Accont									
22	Mpinga Mundama (Harugongo SC)	U	4	4	2.2, 2.4	Force Accont									
23	Rusenyi Kigando KyakatemboKyarwaisengya Rutoma (Ruteete SC)	U	3.0	3.0	2.2, 2.4	Force Accont									
24	Rweraza Kinombe (Kasenda SC)	U	3.0	3.0	2.2, 2.4	Force Accont									
SUBTOTAL - CARs			50.7	50.7					0	0.0			-	-	
SUBTOTAL 2 (RMech)			172.2	165.6			32.2	-	-	-	45 000.0	-	-	-	

UGANDA ROAD FUND PROGRAMMING TABLES

Table 2c: Quarterly Progress Report - Periodic Maintenance
Quarterly Physical and Financial Performance - Roadworks

Designated Agency:Kabarole District | Quarter: One | FY:........

Item No.	Road Name	Surface Type	Road length, Km	Annual Work Plan: Length to be treated (Km)	Works category/ sub-category	Implementation strategy	Quarterly Physical Progress (km): Q1	Q2	Q3	Q4	Quarterly Financial progress (UGX '000): Q 1	Q 2	Q 3	Q 4	Explanation for variances and planned measures
Periodic Maintenance															
DISTRICT ROADS															
1	Kinyankende Mitandi	1.8	0+700	1	5.8	Force Account									
2															
SUBTOTAL - DISTRICT															
KIKO TOWN COUNCIL ROADS*															
1	Kitabonwa Kyarwaisenyi	U	2.5	2.5	3.6, 3.7	Force Account					3000				Site clearance and mobilisation
2	Nyabubale road	U	3.0	3.0	3.6, 3.7	Force Account									
SUBTOTAL -KIKO TOWN COUNCIL			**5.5**	**5.5**			0.0	0.0	0.0	0.0	3000	-	-	-	
MUGUSU TOWN COUNCIL ROADS*															
SUBTOTAL -MUGUSU TOWN COUNCIL			0.0	0.0			0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	
KIJURA TOWN COUNCIL ROADS*															
1	Katego Nyababa road	U	0.8	0.8	3.6, 3.7, 3.4	Force Account									
2	Hakiabe Igongonya road	U	2.5	2.5	3.6, 3.7, 3.4	Force Account									
3	Rwamafa Kayenje Mugyenzi	U	1.8	1.8	3.6, 3.7, 3.4	Force Account									
SUBTOTAL -KIJURA TOWN COUNCIL			5.1	5.1			0.0	0.0	0.0	0.0	0	0	0	0	
COMMUNITY ACCESS ROADS**															
1															
SUBTOTAL - CARs															
SUBTOTAL 3 (PM)			10.60	10.60	-	-	-	-	-	-	3 000	-	-	-	

Total Transfers to Sub-counties

UGANDA ROAD FUND PROGRAMMING TABLES

Table 2e: Quarterly Financial Progress Report - Operational expenses (including DRCs)
Planned and Actual Quarterly Financial Performance - Operational expenses

Designated Agency: Kabarole District | Quarter: One | FY:........

Item No.	Description	Planned Annual Exp UGX '000	Quarterly Planned Exp UGX '000				Quarterly Actual Exp UGX '000					Remarks
			Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Total	
Operational expenses (including District Road Committees)												
DISTRICT EXPENSES												
1	Supply of fuel and lubricants	5500	1375	1375	1375	1375	2006					
2	Information and Communication Technology (internet services)	500	125	125	125	125	255					
3	Supply of stationery and other office requirements	3000	750.0	750.0	750.0	750.0	600					
4	Repair and service of office equipment	2000	500	500	500	500						
5	Facilitation of DRC sitting	2700	675	675	675	675						
6	Professional training and fees	0	0	0	0	0						
7	Travel facilitation	4000	1000	1000	1000	1000	1760					
9	Bank charges	65	16	16	16	16						
	Total Administrative Costs for the District	17 765	4441	4441	4441	4441	4621	0	0	0	4621	
KIKO TOWN COUNCIL EXPENSES*												
1	Supply of fuel and lubricants	450	113	113	113	113	157				157	
2	UIPE Subscription and trainings	0	0	0	0	0					0	
3	Supply of stationery and other office requirements	750	188	188	188	188	130				130	
4	Repair and service of office equipment	877	219	219	219	219					0	
5	Monitoring / Supervision works	1500	375	375	375	375	250				250	
6	Bank Charges	798	200	200	200	200	121				121	
7	Travel facilitation	1120	280	280	280	280	167				167	
	Total Administrative Costs for the District	5495	1374	1374	1374	1374	825	0	0	0	825	
KIJURA TOWN COUNCIL EXPENSES*												
1	Supply of fuel and lubricants	1150	288	288	288	288	250				250	
2	UIPE Subscription and meetings	800	200	200	200	200					0	
3	Supply of stationery and other office requirements	800	200	200	200	200	100				100	
4	Procurement of a lap top	0	0	1600							0	
5	Monitoring works	1150	288	288	288	288	300				300	
6	Travel facilitation	800	200	200	200	200	200				200	
7	Bank Charges	370	93	93	93	93	63				63	
	Total Expenses for Kijura T C	5070	1268	2868	1268	1268	913	0	0	0	913	

MUGUSU TOWN COUNCIL EXPENSES*												
1	Supply of fuel and lubricants	594	149	149	149	149	0				0	
2	Repair and service of supervision transport	0	0	0	0	0					0	
3	Supply of stationery and other office requirements	400	100	100	100	100					0	
4	UIPE Subscription and meetings	300	75	75	75	75					0	
5	Monitoring works	400	100	100	100	100					0	
6	Total Transfers to Sub-counties	400	100	100	100	100					0	
7	Bank Charges	156	39	39	39	39	36				36	
	Total Expenses for Mugusu T C	2250	524	524	524	524	36	0	0	0	36	
SUBCOUNTIES EXPENSES**												
1	Monitoring works	4000	1000	1000	1000	1000						
2	Supply of stationery and other office requirements	1462	366	366	366	366						
	Total Expenses for Sub counties	5462	1366	1366	1366	1366			0	0		
TOTAL		33 792	8 448	10 048	8 448	8 448	6 359	-	-	-	6 359	

Signed: ______________________ District Engineer

Signed: ______________________ Chief Administrative Officer

Date:________________________

Date:________________________

Notes:

* Separately fill for all Town councils in Designated Agency.

** Separately fill for all Sub counties in Designated Agency.

UGANDA ROAD FUND PROGRAMMING TABLES

Table 4: Financial Accountability Report for 1st Quarter

Designated Agency: Kabarole District Vote No. 513

Programme: Uganda Road Fund FY 2021/22

Activity		Budget for the quarter	Funds b/f from previous quarter	Funds Received	Funds available	Funds Variance	Expenditure (Ush.)	Variance	Comments
Category	Sub-Category	(a)	(b)	(c)	d = (b +c)	e' = (a - c)	(f)	g = (d - f)	
Routine Maintenance									
(Routine Manual Maintenance or	Unpaved Roads	25 425 000		3 000 000	3 000 000	22 425 000	2 700 000	300 000	
Routine Mechanised Maintenance)	Unpaved roads	35 000 000		45 000 000	45 000 000	(10 000 000)	45 000 000	-	
	Other structures (Culverts)					-		-	
	Sub total	60 425 000		48 000 000	48 000 000	12 425 000	47 700 000	300 000	
Periodic Maintenance									
	Paved Roads	-			-	-		-	
	Unpaved roads	-			-	-		-	
	Other structures (Culverts)	40 000 000		0	-	40 000 000		-	
	Sub total	40 000 000			-	40 000 000		-	
								-	
Other qualifying Works	P'se Specify from list below								
	Equipment repair	14 750 000		9 000 000	9 000 000	5 750 000	7 983 912	1 016 088	
	DRC Meeting				-	-		(7 983 912)	
	Administrative costs	4 441 000		4 466 010	4 466 010	(25 010)	4 621 000	(154 990)	
	Sub total	19 191 000		13 466 010	13 466 010	5 724 990	12 604 912	861 098	
	Bank Charges				-	-	-	-	
	Grand Total	119 616 000		61 466 010	61 466 010	58 149 990	60 304 912	1 161 098	

Designated Agency: Kabarole Kiko Vote No. 513

Activity		Budget for the quarter	Funds b/f from previous quarter	Funds Received	Funds available	Funds Variance	Expenditure (Ush.)	Variance	Comments
Category	Sub-Category	(a)	(b)	(c)	d = (b +c)	e' = (a - c)	(f)	g = (d - f)	
Routine Maintenance									
(Routine Manual Maintenance or	Paved Roads				-	-		-	
Routine Mechanised Maintenance)	Unpaved roads	7 225 000	37 047	5 200 000	5 237 047	2 025 000	5 100 000	137 047	
	Other structures (Specify)				-	-		-	
	Sub total	7 225 000	37 047	5 200 000	5 237 047	2 025 000	5 100 000	137 047	
Periodic Maintenance					-	-		-	
	Paved Roads				-	-		-	
	Unpaved roads	-	-	6 811 000	6 811 000	(6 811 000)	3 000 000	3 811 000	
Total Transfers to Sub-counties	Other structures (Specify)	-			-	-		-	
	Sub total	-	-	6 811 000	6 811 000	(6 811 000)	3 000 000	3 811 000	
Road Safety Works								-	
	Marking of roads				-	-		-	
	Others (Specify)	-			-	-		-	
	Sub total	-			-	-		-	
								-	
Other qualifying Works	Operational expenses	852 000		832 647	832 647	19 353	825 883	6 764	
	Mechanical repairs	4 071 000	-	4 000 000	4 000 000	71 000	1 000 000	3 000 000	
	Sub total	4 923 000	-	4 832 647	4 832 647	90 353	1 825 883	3 006 764	
	Bank Charges		-		-	-	-	-	
	Grand Total	12 148 000	37 047	16 843 647	16 880 694	(4 695 647)	9 925 883	6 954 811	

Signed: ____________________ District Engineer

Signed: ____________________ Chief Administrative Officer

Date:______________________

Date:______________________

Other qualifying Works:

Culverts Installation
Surface Dressing 1st Seal
Surface Dressing 2nd Seal
4. Recycling technology/Research
5. Low Cost Surfacing/Research
6. AIDS Awareness on Road Maintenance
7. Operational Costs
8. DRC operations
9. Road Safety

Required Accounts Information:
Bank statement at end of Quarter (Should reflect funds received, Funds transfers to Works Account, Sub Counties and Town Councils)
Receipt issued to URF for funds received
Payment vouchers for Funds transfers to Works Account, Sub Counties and Town Councils
Evidence of commitment of Funds at end of Quarter
Please attach first pages for each of the certificates paid

UGANDA ROAD FUND PROGRAMMING TABLES

Table 4: Financial Accountability Report for 1st Quarter

Designated Agency: Kabarole Mugusu Vote No. 513

Programme: Uganda Road Fund FY 2021/22

Activity		Budget for the quarter	Funds b/f from previous quarter	Funds Received	Funds available	Funds Variance	Expenditure (Ush.)	Variance	Comments
Category	Sub-Category	(a)	(b)	(c)	d = (b +c)	e' = (a - c)	(f)	g = (d - f)	
Routine Maintenance									
(Routine Manual Maintenance or	Paved Roads				-	-		-	
Routine Mechanised Maintenance)	Unpaved roads	3037000		2 451 000	2 451 000	586 000		2 451 000	
	Other structures (Specify)	3587000			-	3 587 000		-	
	Sub total	6 624 000		2 451 000	2 451 000	4 173 000	-	2 451 000	
Periodic Maintenance									
	Paved Roads				-	-		-	
	Unpaved roads	7 500 000		3 311 000	3 311 000	4 189 000		3 311 000	
	Other structures (Specify)				-	-		-	
	Sub total	7 500 000		3 311 000	3 311 000	4 189 000	-	3 311 000	
								-	
Other qualifying Works	Operational expenses	524 000	88 292	441503	529 795	82 497	36 000	493 795	
	Mechanical repairs	-			-			-	
	Sub total	524 000		441 503	441 503	82 497	36 000	405 503	
	Bank Charges			0	-	-		-	
	Grand Total	14 648 000	-	6 203 503	6 203 503	8 444 497	36 000	6 167 503	

Signed: ____________________ District Engineer

Signed: ____________________ Chief Administrative Officer

Date:______________________

Date:______________________

Other qualifying Works:

Culverts Installation
Surface Dressing 1st Seal
Surface Dressing 2nd Seal

4. Recycling technology/Research
5. Low Cost Surfacing/Research
6. AIDS Awareness on Road Maintenance

7. Operational Costs
8. DRC operations
9. Road Safety

Required Accounts Information:
Bank statement at end of Quarter (Should reflect funds received, Funds transfers to Works Account, Sub Counties and Town Councils)
Receipt issued to URF for funds received
Payment vouchers for Funds transfers to Works Account, Sub Counties and Town Councils
Evidence of commitment of Funds at end of Quarter
Please attach first pages for each of the certificates paid

UGANDA ROAD FUND PROGRAMMING TABLES

Table 4: Financial Accountability Report for 1st Quarter

Designated Agency: Kabarole Kijura Vote No. 513

Activity		Budget for the quarter	Funds b/f from previous quarter	Funds Received	Funds available	Funds Variance	Expenditure (Ush.)	Variance	Comments
Category	Sub-Category	(a)	(b)	(c)	d = (b +c)	e' = (a - c)	(f)	g = (d - f)	
Routine Maintenance									
(Routine Manual Maintenance or	Unpaved Roads	11 200 000		6 278 000	6 278 000	4 922 000		6 278 000	
Routine Mechanised Maintenance)	Unpaved roads				-	-		-	
	Other structures (Specify)				-	-		-	
	Sub total	11 200 000		6 278 000	6 278 000	4 922 000		6 278 000	
Periodic Maintenance								-	
	Paved Roads					-		-	
	Unpaved roads	1 824 000		5459000	5 459 000	(3 635 000)		5 459 000	
	Other structures (Specify)				-	-		-	
	Sub total	1 824 000		5 459 000	5 459 000	(3 635 000)		5 459 000	
Road Safety Works									
	Marking of roads					-		-	
	Others (Specify)				-	-		-	
	Sub total	-		-	-	-		-	
Other qualifying Works	Mechanical repairs	4 215 000		2 159 446	2 159 446	2 055 554	1 500 000	659 446	
	Operational cost	1 268 000	2 585	3 528 000	3 530 585	(2 260 000)	913 000	2 617 585	
	Sub total	5 483 000		5 687 446	5 687 446	(204 446)	2 413 000	3 274 446	
	Bank charges					-		-	
	Grand Total	18 507 000	-	17 424 446	17 424 446	1 082 554	2 413 000	15 011 446	

Signed: ______________________ District Engineer

Signed: ______________________ Chief Administrative Officer

Date:________________________

Date:________________________

Other qualifying Works:

Culverts Installation
Surface Dressing 1st Seal
Surface Dressing 2nd Seal

4. Recycling technology/Research
5. Low Cost Surfacing/Research
6. AIDS Awareness on Road Maintenance

7. Operational Costs
8. DRC operations
9. Road Safety

Required Accounts Information:

Bank statement at end of Quarter (Should reflect funds received, Funds transfers to Works Account, Sub Counties and Town Councils)
Receipt issued to URF for funds received
Payment vouchers for Funds transfers to Works Account, Sub Counties and Town Councils
Evidence of commitment of Funds at end of Quarter
Please attach first pages for each of the certificates paid

Designated Agency: Kabarole Vote No. 513

Table 5: Transfers to Sub Counties & Town Councils

Table 5a. Sub Counties

	Sub County	Quarter 1			Quarter 2			Quarter 3			Quarter 4				
		Funds released by URF	Funds transferred by District	Variance	Funds released by URF	Funds transferred by District	Variance	Funds released by URF	Funds transferred by District	Variance	Funds released by URF	Funds transferred by District	Variance	Total Funds With held by District	Comments
		[a]	[b]	c = [a-b]	[d]	[e]	f = [d-e]	[g]	[h]	i= [g-h]	[j]	[k]	l= [j-k]	m= [c+f+i+l]	
1	Busoro	0	0	0											
2	Hakibale	0	0	0											
3	Karangura	0	0	0											
4	Kasenda	0	0	0											
5	Kicwamba	0	0	0											
6	Mugusu	0	0	0											
7	Ruteete	0	0	0											
8	Kabende	0	0	0											
9	Harugongo	0	0	0											
	Sub Total	0	0	0	0	0	0								

Table 5b. Town Councils

	Town Council	Quarter 1			Quarter 2			Quarter 3			Quarter 4				
		Funds released by URF	Funds transferred by District	Variance	Funds released by URF	Funds transferred by District	Variance	Funds released by URF	Funds transferred by District	Variance	Funds released by URF	Funds transferred by District	Variance	Total Funds With held by District	Comments
		[a]	[b]	c = [a-b]	[d]	[e]	f = [d-e]	[g]	[h]	i= [g-h]	[j]	[k]	l= [j-k]	m= [c+f+i+l]	
1	Kijura	17 427 823	17 427 823	0			0			0			0		
2	Kiko	16 833 647	16 833 647	0			0			0			0		
3	Mugusu	6 203 503	6 203 503	0			0								
	Sub Total	40 464 973	40 464 973		0	0	0	0	0	0	0	0	0		

Signed: ______________________ District Engineer

Signed: ______________________ Chief Administrative Officer

Date:________________________

Date:________________________

N.B This report is applicable only to those Districts that have received funds to be transferred to Sub Counties and/or Town Councils

UGANDA ROAD FUND PROGRAMMING TABLES

Table 6: Cumulative Financial Accountability Report for FY 2021/22

Designated Agency:	Kabarole
Vote No.	513
Programme:	Uganda Road Fund

Table 6a. Funds Reconciliation

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total Funds Received in Financial Year 2019/20
Balance brought forward from previous Quarter	0	1 161 088	0	0	
Funds Received in the Quarter	61 466 010				
Total Funds Available in the Quarter	61 466 010				
Funds carried forward to next Quarter (total funds available less Actuals for the Quarter)	1 161 088				

Table 6b. Cumulative Financial Accountability Report

Category	Sub-Category	Annual Ceiling	Actuals Quarter 1	Actuals Quarter 2	Actuals Quarter 3	Actuals Quarter 4	Cumulative Expenditure	Variance [Carry over to next Financial Year]
		(a)	(b)	(c)	(d)	(e)	f=(b+c+d+e)	g =(a-f)
District								
Total Routine Maintenance								
(Manual	Unpaved Roads	101 700 000	2 700 000				2 700 000	
and Mechanised)	Unpaved roads	147 000 000	45 000 000				45 000 000	
	Other structures (Culverts)						-	
	Sub total	248 700 000	47 700 000	-	-	-	47 700 000	
Total Periodic Maintenance								
	Paved Roads						-	
	Unpaved roads						-	
	Other structures (Bridge redecking and culverts)	60 000 000	0				-	
	Sub total	60 000 000	-	-	-	-	-	
Road Safety Works							-	
	Marking of roads						-	
	Others (Specify)	-					-	
	Sub total	-	-	-	-	-	-	
Other qualifying Works	P'se Specify						-	
	Equipment repairs	59 000 000	7 983 912				7 983 912	
	Road Condition Assessment	5 406 800	-				-	
	Road safety	2 500 000	-				-	
	Administrative costs	17 765 354	4621000				4 621 000	
	Sub total	84 672 154	12 604 912	-	-	-	12 604 912	
Total Transfers to Town councils		258 968 758	40 464 973	-	-	-	40 464 973	
Total Transfers to Sub-counties		83 161 000	-	-	-		-	
	Grand Total	735 501 912	100 769 885	-	-	-	100 769 885	

Signed: ______________________ District Engineer

Signed: ______________________ Chief Administrative Officer

Date:_______________________

Date:______________________

Other qualifying Works:

Culverts Installation	4. Recycling technology/Research	7. Operational Costs
Surface Dressing 1st Seal	5. Low Cost Surfacing/Research	8. DRC operations
Surface Dressing 2nd Seal	6. AIDS Awareness on Road Maintenance	9. Road Safety

28. Design Checklist

CHECKLIST FOR DESIGN REVIEW AND INDEPENDENT DESIGN CHECK OF ROAD UPGRADING / REHABILITATION PROJECTS

Project Name:	
Client:	
Design Consultant:	
Date of Submission:	

1.0 GEOMETRIC DESIGN PROCESS

The following checklist provides procedures/steps/design elements that should be considered by the Design Consultants (DCs) in the preparation of geometric designs for upgrading/rehabilitation of roads. The technical reference guide in use is the Uganda Roads Design Manual 2010, Vol.1 Geometric Design, herein after refereed to RDM Vol.1.

SN	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
1.1	**Road survey procedure and Requirements**				
a)	State Survey data collection method (i.e. instruments used)				
b)	Standard Bench mark establishment				
c)	Survey Methodology used (i.e. Toposurvey, photogrammetry etc)				
d)	Data collection method and transfer				
e)	Data validation method				
1.2	**Geometric Design Elements**				
a)	Establish road design class & Dimensions (as per RDM Vol.1 Table 4.2)				
b)	Geometric Design Parameters (RDM Vol.1, Tables 4.3 – 4.9 Combined: Geometric Design Parameters for all the Design Classes of Roads)				
1.3	**Design Control and Criteria**				
	State Design Vehicle with dimensions (accordance to RDM Vol 1 Table 5.1)				
	Type of Terrain (as per RDM Vol. 1 section 5.2)				
1.4	**Elements of Design: Horizontal Alignment**				
a)	Maximum Length of Straight between Consecutive Curves at design speed				
b)	Minimum Length of Straight between Consecutive Curves of Same Hand				
c)	Minimum Horizontal Curve Radius - as per RDM Vol. 1				
d)	Minimum Length of Horizontal Curve - as per RDM Vol. 1				
e)	Maximum Radius for Use of Transition Curve - for the various design speeds				
f)	Desirable Length of Transition Curve - for the various design speeds				

SN	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
g)	Maximum relative gradient (slope) ratio for profiles between edges of two lane carriageway and centerline and design speed (as per RDM Vol 1, Table 6-2)				
h)	Length of super-elevation runoff for multi-lane roads expressed in the length of two lane road] (as per RDM Vol 1, Table 6-3)				
i)	Super elevation rate and length of runoff for horizontal curves (should be in accordance to RDM Vol1 Tables 6-4 to 6-9)				
j)	Phasing of Horizontal & Vertical Alignment: should be as guided in Fig 6.28 (Basic Space Elements), of RDM Vol.1				
1.5	**Elements of Design: Vertical Alignment**				
a)	Maximum vertical gradient (desirable) dependent on topography but should be in conformity to Tables 6.14 (max gradients , desirable) & Table 6.12 (Absolute max. gradients) of RDM Vol.1				
b)	Minimum Vertical gradient to avoid standing water in road side ditches should be (0.3 – 0.5) as per Section 6.5.2 of RDM Vol.1				
c)	Critical length of gradient. Should be in conformity to Tables 6-16 (Max desirable length of gradient) of RDM Vol.1				
d)	Stopping Sight Distance (SSD) in accordance to Table 6.19 (Stopping sight distance on level ground for wet pavement condition) and Table 6.20 (Effect of grade on stopping sight distance of the RDM Vol.1				
e)	Passing Side Distances (PSD) in conformity to Table 6.22 (Minimum passing sight distance for design) of the RDM Vol.1				
f)	Desirable Minimum 'K' Values for Vertical Crest Curves as per RDM Vol.1				
g)	Desirable Minimum 'K' Values for Vertical Sag Curves as per RDM Vol.1				
h)	Minimum Vertical Clearance beneath as per RDM Vol 1 - bridges or vehicle underpasses - underpasses for pedestrians, animals & bicycles				
1.6	**Elements of Design: Cross Section**				
a)	Normal cross falls (for 2 lane undivided road max 2.5%) as guided under section 7.5, RDM Vol.1				
b)	Side slopes and back slopes (section 7.6) and Table 7.4 slope ratio table (vertical to horizontal ratio) as per RDM Vol. 1				
c)	Right of Way – as given in Tables 4.3 – 4.9 of RDM Vol.1				
d)	Cross section over bridges and culverts (as guided under section 7.1.4 RDM Vol.1)				
e)	Typical cross section for road classes – should be in conformity with figures 7.14 – 7.18, RDM Vol.1				
f)	Report should show the adopted road cross sections drawings				
1.7	**Elements of Design: At Grade Intersections:**				
a)	Junction /intersection type - should be as guided under Table 8-1 (Types of at grade intersections) of RDM Vol.1				
b)	Design Requirements for the type of intersection – (As per guidance provided by the RDM Vol.1 under sections 8.2; 8.3; 8.5; 8.6 and conformity to Fig. 8.11, 8.12 and 8.13 for visibility splays for approach or yield conditions and stop conditions respectively.				

SN	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	Conformity to Figures 8-18 & 8-19 for junction layout types required.				
c)	Show the Summary of the Geometric Design Considerations Adopted for the project road. Indicate justifications for proposed departures:				
1.8	**Road Safety Design**				
a)	List the locations of all the schools along the length of the road.				
b)	Identify areas of pedestrian concentration along the road, both for crossing points, and side walks along the road.				
c)	The completed geometric design will have been carried out in accordance with the Geometric Design Manual, and as such will include for road safety measures insofar as the described in the Manual.				
1.9	**The Geometric Design Report should indicate the Schedule of Departures for Clients consideration / Approval**				
1.10	**BOOK OF DRAWINGS**				
	Location map				
	List of Survey controls (Primary & Secondary Benchmarks)				
	Setting Out data (centerline)				
	Stakeout Data				
	Typical Cross-sections				
	Plan and Profile drawings				
	Detailed Cross-sections – preferably at 20m intervals and alignment geometry points				
	Drainage Details: - Side drains and wing walls - Pipe Culvert Layouts - Culvert schedule				
	Standard Ancillary drawings: - Road Signs - Humps / Rumble strips - Road Markings - Junction layout details				
a)	**Details to be included on Plan layout**				
i)	Plan at original scale of 1:1000 (full size drawing)				
ii)	Graphic bar scale for drawing reduction				
iii)	North Point and Gridlines with coordinates				
iv)	Position and coordinates of Primary Setting out Beacons				
v)	Position and coordinates of Secondary Setting out Beacons/Bench Marks				
vi)	Right of Way Markers				
vii)	Contours at 1.0m intervals (0.5m intervals in flat lands)				
viii)	Proposed centreline with Chainage numbers at 100m centres along centerline				
ix)	Chainage marks at 20m intervals along proposed centerline				
x)	Existing road edge outline and junctions				
xi)	Proposed road edge outline and junctions				
xii)	Note guiding user to drawings showing existing and diverted Utility services				
xiii)	Markers for extent of cut and fill (tadpoles)				

SN	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
xiv)	Plan shape of all buildings within the ROW and any likely to be affected by proposals				
xv)	Data boxes containing curve data for each curve including Curve number, chainage, radius, length, deflection angle, coordinates of PI, Transition lengths in and out				
xvi)	Names of Village/Settlements along route				
xvii)	Water courses crossing and adjacent to alignment if any				
b)	**Details to be included on Profile**				
i)	Line illustrating existing ground level along proposed centerline				
ii)	Line illustrating proposed finished road level along proposed centerline				
iii)	Background grid lines for levels and chainages with indicative levels at LHS				
iv)	Illustrative positions and levels of all cross culverts				
v)	Data boxes with all type, size and level details for each culvert				
vi)	Illustrative positions and levels of all bridges				
vii)	Data boxes with names and details of each bridge and reference to bridge drawings				
c)	**Details to be contained in Data boxes below Profile**				
i)	Chainage with existing ground levels on centreline at 20m intervals (min)				
ii)	Proposed finished road levels on centreline at 20m intervals				
iii)	Level difference on centreline through proposed construction works				
iv)	Lengths of all horizontal transition curves (where relevant)				
v)	Lengths and radii of all circular curves including chainages of start and finish				
vi)	Illustrative details of straight gradients and details of points of vertical intersection				
vii)	Details of start points, finish points and lengths of vertical curves, K values				
viii)	Details of proposed superelevation percentage including run off lengths				
Vix)	Indicator marker posts and plates for culverts and bridges				
d)	**Additional Options (alternatively on separate schedules or drawings)**				
	Roadside drainage channel details including access culverts				
	Road widening on curves and embankments				

2 Traffic Forecasting and Traffic Loading for Pavement Design

Where reliable and recent traffic data is not available from the relevant MDAs for the particular road under design, Traffic Forecasting shall include field counts of existing motorised and non motorised traffic at relevant points along the proposed route. Field surveys shall include classified vehicle counts, origin and destination surveys and axle load surveys.

The data from basic volume of traffic will determine the capacity of the road. The cumulative totals of typical axle loadings of medium and heavy vehicles will be necessary for selection of the type and depth of road pavement layers.

2.1 Traffic Forecasting

The following checklist items indicate the primary components of the traffic forecasting procedure.

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
2.1.1	**Data from previous Traffic Surveys**				
a)	Collect from MDAs all relevant historic vehicle and classified vehicle counts available for all roads in the region, both manual and automatic.				
b)	Collect all available records of Origin and Destination surveys in the region				
c)	Collect records of recent axle load surveys undertaken in the region with comparison region by region				
2.1.2	**Average Daily Traffic (ADT) and AADT**				
a)	From the seven day counts, the daily average (12 hour) counts are calculated. These are extended by the factor for 24 hour traffic to provide the current ADT. (RDM Vol.3 Part 1 Section 2.2)				
b)	The ADT should be adjusted by a factor according to the month of the year to provide the current Average Annual Daily Traffic (AADT).				
c)	For calculation of the ADT and AADT for road capacity purposes, the traffic flows in each direction should be aggregated.				
2.1.3	**Origin and Destination (O-D) Surveys**				
a)	Origin and Destination surveys are to be carried out to establish transport patterns in the region and should be conducted by means of roadside interviews with drivers. Location of survey stations should be selected such that any vehicles may be identified that are travelling on alternative routes which may, upon completion of the proposed road upgrading, subsequently divert to the project road.				
b)	O&D surveys are not necessary where the project road is the only practical route for traversing the region and no additional vehicles will divert from alternative routes				
2.1.4	**Future Traffic Growths**				
	Using ADT established in section 2.1.2 above, compare with any recently available counts of ADT for the project road. If correlation is poor, try to establish cause of differences.				
a)	Future growth rates should be based on an assessment from the following factors • current population growth rates;				

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	household employment and income; historic and current vehicle ownership and usage; new vehicle registrations non vehicular road usage (animal carts, animals, pedestrians); development proposals for regional businesses				
b)	The assumed growth rates for traffic should (may) consider private and commercial vehicles separately and the variations in growth rates during the design life of the project road should be considered.				
2.1.5	**Final Base Year Traffic Calculation**				
	From the above, the base year traffic should consider the following factors should be used:				
a)	AADT in both directions as derived from Section 2.4, increased at the selected annual growth rates up to the appropriate Base Year date;				
b)	Consider Diverted traffic in accordance to Section 2.0 of RDM Vol 3				
c)	Estimate of the likely generated traffic from that same date				

2.2. Traffic Loading for Pavement Design

Design practice will most normally include the execution of Axle load studies along and in the region of the project road. In exceptional circumstances this may be considered unnecessary where recent surveys have been undertaken in the region and reliable axle data is available to establish typical vehicle equivalency factors (VEF but sometimes referred to as Vehicle Damage Factors).

The following procedure should be carried out where Axle Load Surveys are to be undertaken as part of the design process for a particular project road

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
2.2.1	**Axle Load Surveys**				
a)	Locations for axle load surveys shall be partly those where O and D surveys have been carried out and also along the project road, one survey for each discreet section where axle load characteristics may change (e.g. near an internal container base, a commercial quarry or a cement plant).				
b)	Surveys shall be carried out ideally over a three day period with police cooperation to avoid argument with any driver reluctant to have his (possibly overloaded) vehicle weighed.				
c)	Each Axle load recorded shall be converted to ESA in accordance with the following equation. Equivalence Factor for each axle = Axle load in Kgs 4- 8160 and ESAs for all axles of each type of vehicle.				
d)	Check all cumulative axle loads per vehicle that exceed 20 to ensure no mistake in weighing has distorted the individual result				
e)	VEFs derived above should be compared with those in the region obtained under specific Nation-wide Axle Load Studies.				
f)	Adapt AADT classified data for each direction to establish average ESA for each vehicle type at base date in each direction . The classified AADT for that direction having highest				

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	ESA per day should be used. (as per RDM Vol.3 Part 1 section 2.2.4)				
2.2.2	**Traffic Classifications**				
a)	Traffic Classifications are expressed in numbers T1 to T8, based upon cumulative ESAs over the design life of the road. See in the Flexible Pavement Design Manual (volume 3, part 1). Select Traffic Classification for cumulative ESAs as derived in 2.2.1 above.				
c)	Where future traffic growth may be high, consider possible future pavement strengthening rather than full initial construction to meet the design life criteria.				
d)	The selected Traffic Classifications shall be used in the Pavement Design Process.				

3.0 SOILS AND MATERIALS INVESTIGATIONS

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
3.1	**Checklist of Contents of Factual Soils Report for General Use**				
a)	Brief description of Geological, hydro-geological, soil conditions and climate in the project area				
b)	Description of the methodology used in carrying out the soils and materials field investigations and associated laboratory testing				
c)	Locality sketch maps of all identified potential borrow and quarry sites showing offsets from main alignment, indicating relative locations of each trial and sampling pit with reference numbering.				
d)	Tabulated results of investigations in existing surfaced areas where either existing pavement to be strengthened or rehabilitated or recovered materials in existing pavement to be reused in new pavement.				
e)	Tabulated presentation of summary of DCP test results as in Figures 6.1 in Annex 6				
f)	Graphical presentation of summary of CBR test results from trial pits tested in laboratory presented as in Figures 6.3 in Annex 6				
g)	Tabulated test results on samples from borrow materials from borrow pits				
h)	Tabulated test results on samples of potential sub base materials from borrow pits				
i)	Tabulated results for potential chemical stabilisation or mechanical modification to granular materials from borrow areas for use as sub base or base materials, showing varied percentages of chemical additives (cement or other) used in the mixed samples, and varied percentages of stone used in mechanical stabilisation. For the latter, the source and grading of the stone sample used shall also be shown.				

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
j)	Tabulated summaries of test results from potential quarries. Or copies of recent test results from other commercial quarries currently in operation in the project area. Rock boring samples shall be retained by the client for inspection.				
k)	Copies of relevant tests on samples of water suitable for concrete construction				
l)	Analysis of test undertaken on fine aggregate (sand) samples to be used in concrete works				
m)	Copies of recent test certificates from manufacturers of bulk cement within reasonable haul distance of the project area.				
n)	Borehole logs (or logs of trial pits) taken at bridge sites showing all details of material layers, results of lab testing of undisturbed samples, results of STPs, depth of ground water encountered and results of chemical tests on ground water.				
o)	Brief selection of relevant photos for all the above field activities.				
p)	Discussion on options for preparation of improved subgrades, including any additional blending, removal of expansive clays, alternatives for use of geogrids, sub soil drainage, pioneer layers etc.				
q)	Measures to be adopted for dealing with high ground water tables where appropriate				
r)	Description of any special measures to be taken at swamps such as estimating settlement, providing sand blankets, surcharging embankments				
s)	Discussion on safe side slopes for embankments and cuttings with recommendations for any further investigations or shear testing. Where retaining walls are required, provide advice on bearing capacity, slope stability, overturning and sliding resistance.				
t)	Discussion on plasticity and CBR values of proposed pavement construction materials, which could be safely adopted for pavement design				
u)	The location and extent [including quantities available] of road aggregates and concrete aggregates and haulage implications				
v)	Description of bridge sites and design parameters for structures with estimates of bearing strengths and settlement in shallow foundations. Where shallow foundations are possible, advise on depth of foundations. Advise on potential for seismic activity in the region. Where piled foundations may be required, make recommendations on type, lengths, shear strengths in soils and end bearing capacities				
w)	Recommendations for protection of structures from aggressive groundwater or aggregates with high Alkali/Silica Reaction (ASR).				
x)	Soils and Materials Reports shall contain full descriptions of all trial pits and borehole logs describing the materials encountered, the presence of ground water, the sampling and testing undertaken for each set of samples. Test results shall be presented in Appendices to the Report with brief summary tables and charts within the main text of the report.				

4.0 Pavement Design

The following guidelines are aimed at reminding the Designer of the steps that should be considered during the pavement design for new/ rehabilitation/ upgrading of existing roads. This cannot be finalised until after completion of the traffic survey data collection and analysis of the Soils and Materials investigation.

4.1	**Outline Process for Undertaking Pavement Designs**				
	The Pavement Design of any sealed, non concrete road surface, shall be designed according to the Road Design Manual, Volume 3, Pavement Design, Part 1, Flexible Pavements, (2010 edition) published by the Ministry of Works, Housing and Communications.				
	The Catalogue of Pavement Structures used in this manual for design of flexible pavements should not be used for any pavement where: a) Nominal subgrade strength measured in terms of CBR over any substantial length is less than 2% b) The design life pavement loading is estimated to be in excess of 30 million equivalent standard axles (ESAs) c) The wearing course will not provide and impervious surfacing d) The road does not have a minimum 2.5% crossfall camber e) The shoulder width is less than 1.0m wide on each side of the carriageway.				
	The DC and Reviewer should check and confirm each of the possibilities described in 4.1 above.				
	The Pavement Design Manual outlines the following 6 steps. These are: (i) Estimating the cumulative traffic loading expected during the design life. (ii) Defining the strength of the subgrade (soil) over which the road will be built (iii) Defining the nominal operating climate (wet or dry) (iv) Defining the strength of the existing pavement layers where an overlay will be applied to existing sealed surface (v) Determining any practical aspects which will influence the design selection. (vi) Selecting possible pavement structures. Each step is considered separately below in Section 7.2 (i) to 7.2.(vi) - The Pavement Design Process.				
4.2	**Establishment of Traffic Loading (ESAs)**				
	For item 4.1(i) above, Section 2.2 of this Checklist entitled Traffic Loading for Pavement Design, provides guidance on the method of estimating the design life pavement loading in terms of ESAs and the equivalent Traffic Classification. Briefly the steps are as follows: Having extracted AADT flow data from Section 2.2 for each vehicle class together with estimates of diverted and generated traffic, project the increase in traffic from the various growth factors (for each period and each class of vehicle if varied growth rates are used) throughout the proposed design life of the road. The estimated total AADT should be calculated separately for any sections of road that may indicate significant differences in accumulated traffic loading. - Extract the Equivalent Standard Axle loading for each class of vehicle from the project axle load studies or from approved available data from previous studies. - Apply the ESA factor to the estimated design life total numbers for each class of vehicle to establish the estimated accumulated total ESAs that the road will be expected to carry during the design period. Individual ESA totals should be calculated for vehicles travelling in each direction. Apply the factors for variable carriageway width to establish the design total ESA for each section of road with individual traffic loading characteristics (Table 2.4 RDM Vol.3 Part 1). These totals shall be used to provide the Traffic Classification used in the catalogue of Pavement Designs. As stated in Section 4.1 above, this method of Pavement Design should not be used for design life traffic loading estimated to exceed 30 million ESA. Should the DC estimate that this figure will be exceeded during the design life, one of the following options should be followed:				

	Establishment of Traffic Loading (ESAs)	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	• DC to state report reference for Section 4.2 in submitted documentation. • Reviewer to comment on DC use of this section.				
4.3	**Assessment of Subgrade Soil Strength**				
	For Item 4.1(ii) above, data from the alignment subgrade testing, sampling and laboratory test results shall be extracted from the Soils and Materials Investigation Report. The principle indicator used in defining the strength shall be the CBR derived from the laboratory CBR tests. Other data including the soil classification, liquid limit, plasticity index, natural moisture content and swell potential should also be considered to assist in establishing the representative strength characteristics over lengths that exhibit reasonably uniform soil classifications and strengths. Separate uniform sections should be of a reasonable length to assist with ease of construction. However, economic considerations may dictate certain changes in design over short lengths where areas of extreme material variation are found (e.g. expansive clays). Isolated locations within any 'uniform' section which have strength characteristics below the overall chosen representative CBR for the section can be brought up to the required minimum design strength by one of the following: - replacing material of the upper zone of the subgrade material with material possessing better strength parameters (improved subgrade), - mixing material with better stability characteristics into the upper zone of the subgrade - stabilisation with additives such as lime, cement or other chemical treatments. Having established the minimum subgrade strength in terms of design CBR for each uniform section, the Subgrade Classification may be determined				
	Assessment of Subgrade Soil Strength	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	• DC to state report reference for Section 4.3 in submitted documentation. • Reviewer to comment on DC use of this section.				
4.4	**Define Normal Operating Climate**				
	See Volume III Pavement Design Manual Part 1: Flexible Pavement Design Guide, Section 3.3, Classifying Design Subgrade Strength and Table 3.2. Therein, may be found guidance on the appropriate use of either the soaked or unsoaked CBR Value. As a first step, the definition of 'High Rainfall Areas' would have to be determined though most regions of Uganda fall into that category. There can also be an argument for classifying subgrade on embankments differently from that in cuttings and/or on the type of surfacing to be employed, based on likelihood of saturation. The DC must justify their choice of soaked or unsoaked CBR determination.				
	Define Normal Operating Climate	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	• DC to state report reference for Section 4.4 in submitted documentation. • Reviewer to comment on DC use of this section.				
f4.5	**Identification of Overlay Criteria**				
	For existing pavement requiring strengthening by bituminous overlay, review the information on the surface condition gathered under the road inventory to assess the degree of existing deformation. If quantity of bituminous material required to regulate				

	existing surface is uneconomic, removal of bituminous layer (and possible reuse of material) and reconstruction of bituminous layers may be better option. For those sections where extent of deformation is acceptable, carry out a Falling Weight Deflectometer (FWD) or Benkelman Beam survey on each lane of the existing pavement to be strengthened. This should be used to identify the weakest locations for each lane, such as in wheel paths. The residual strength characteristics may thus be identified, and if appropriate, divided into uniform sections for design of the suitable overlay necessary for the design life loading of each section.				
	Identification of Overlay Criteria	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	• DC to state report reference for Section 4.5 in submitted documentation. • Reviewer to comment on DC use of this section.				
4.6	**Define Practical Aspects of Pavement Design**				
	Review the location, availability and characteristics of the various pavement material options identified in the Soils and Materials Investigation Report. Determine whether they are suitable for use in their 'as-dug' condition or whether it will be necessary to undertake some stabilisation or modification to improve the 'as laid' characteristics of CBR and Plasticity.				
	Define Practical Aspects of Pavement Design	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	• DC to state report reference for Section 4.6 in submitted documentation. • Reviewer to comment on DC use of this section.				
4.7	**Selection of suitable Pavement Structure**				
	By selection under Task 4.2 of the cumulative ESAs giving Traffic Classification, task 4.3 for the Soils Classification and task 4.4 for the climate criterion, the most appropriate pavement structures and layer thicknesses may be read off from the Catalogue of Pavement Designs. These must be appropriate to the materials available as identified through task 4.6. Where overlay design is required, Uganda Road Design Manual deals with pavement strengthening in Volume 3, Part I, Flexile Pavements and Part IV, Pavement Rehabilitation Guide. This provides a solution using Structural Number Method for analysis of the residual strength in the existing pavement structure for design of the required overlay to achieve the load carrying capacity arrived at under 4.2.				
	Selection of suitable Pavement Structure	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	• DC to state report reference for Section 8.2(vi) in submitted documentation. • Reviewer to comment on DC use of this section.				

5.0 Hydrological Investigations and Drainage Design

The following items provide a checklist of procedures and activities required in undertaking hydrological analysis and hydraulic design of cross and longitudinal drainage structures, drainage structures schedules and producing a hydrological /drainage report.

This report should be used for providing full identification and assessing the condition and status of existing bridge and drainage features along the road and detailing the proposed remedial works and new construction required to replace and supplement the existing facilities.

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	Hydrological Investigations & Drainage Design				
	The design of the longitudinal and cross drainage structures was carried out in accordance to the provisions in the Ministry of Works and Transport Road Design Manual, Volume 2: Drainage Design, herein denoted as the RDM Vol.2. The applied design procedure (stipulated in the RDM Vol.2 section 2.1.2) is summarized as follows: - (i) Hydrological field data collection; (ii) Determination of catchment characteristics (e.g. catchment size, catchment slope, mail stream length and stream slope) from Digital Elevation Model, using ArcGIS OR other Software; (iii) Determination of the peak floods for different return periods depending on the structure type; (iv) Determination of the appropriate road drainage structures or systems to safely convey the peak flood volumes through or away from the road structure without causing any structural or flood damage.				
5.1	**Hydrological field data collection**	**Included in Design**	**Report Reference**	**Reviewed**	**Comment / Reference (if any)**
a)	Mapping - Topographic maps to scale of 1:50,000 or larger, covering the project area and any catchment areas from which flows may cross or affect the project road - Soils and land-use/cover to the largest scale available - Aerial photographs where available - Land satellite imagery where available - DTM if available - Details of proposed area development that may increase run off				
b)	Preliminary Inventory -Initial site visit to establish types of existing structures and scope of proposed inventory investigations - Identify any major springs that will effect road and roadside drainage -Prepare a drainage map of the project area showing basic catchment areas, rivers and major streams together with urban and rural development,				
c)	Rainfall - Rainfall maps of the area - Rainfall records for the project area including locations and types of rain gauges - Listing of annual maximum daily rainfall for gauges close to the project area - Regional Rainfall intensity / Frequency /Duration studies.				
d)	River Flow Data - Record of Annual maximum floods for nearby rivers and any rivers crossing the road, if available. The frequency of river gauging and types of river gauges should be noted. -Flood study reports for the area together with any regional flood formulae.				

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	-Regionally recommended methods of estimating floods in ungauged catchments.				
e)	Detailed Inventory of Existing or Potential Culvert sites and Drainage -For all water courses crossing the alignment record location, type, material, condition, grade, direction of flow, condition of headwalls, wingwalls and aprons where appropriate, inlet and outlet details, including box culverts, fords and piped culverts. All dimensions of existing structures to be recorded. -Assess general geographical, geological, soils and land cover in each catchment -Estimate channel sizes upstream and downstream together with channel roughness. -Evidence of downstream scour and of any road overtopping should be recorded, together with anecdotal evidence of flooding. All to be presented in tabular form. -Record shapes and lengths of existing roadside drains (lined and unlined) -Assess during the field visit the stretches of road where turnouts to roadside drains are possible and provide table of chainages. Observe possible adverse effects on properties adjacent to road				
5.2	**Assessment of Design Flood Projection Methodology**				
a)	Compare Methodology/ies to be used for calculation of design floods for the bridges and culverts e.g., - Rational Method, - Probabilistic Analysis, - SCS Unit Hydrograph, - TRRL or Regional Maximum Flood, Give reasons for the selection and explain why it is most appropriate methodology/ies.				
b)	Flood Return Period Determine design flood return period for each cross drainage structure in accordance with Table 3.2, Section 3 of the RDM Vol.2. Any variation to this should be stated in the Report				
c)	Freeboard to structures The freeboard for culverts should be as set out in Section 9 of the RDM Vol.2, (250 mm for major roads and 100 mm for minor roads). - The RDM Vol.2 does not specify freeboard requirements for bridges, but the minimum freeboard should be 300 mm increasing to 1.0 m for design floods >1000 m^3/sec and 2.0 m for flows >10,000 m^3/sec. These figures should be increased if it is anticipated that there will be large flood debris.				
d)	Rainfall - Analyse rainfall data to determine the rainfall intensity/ duration/frequency if this is not already available use methods stipulated in 5.1 above. - In the absence of suitable data or previous studies, regionally derived relationships can be used depending on the flood analysis method selected.				
e)	Catchment -Catchment area and the slope of each major channel shall be measured either from topographical maps by planimeter or by computer from the DTM, tabulated for each river and stream. -In swamps and areas of flat ground where there are no discernable watercourses, the catchment and its characteristics for the swamp as a whole should be taken.				

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	-Determine catchment areas relative to the side and median drains. Characteristics such as slope, categories of the land, soil type, land use, land cover should be estimated as a percentage for each category. -All the characteristics and derived parameters to be presented in tabular form for each catchment crossing the project road.				
e)	Time of Concentration - Determine as outlined in Section 4 or 5 of the RDM Vol.2 depending on the methodology adopted and the catchment characteristics - Present for each structure in an Excel table.				
f)	Final Design Flood The estimated floods calculated by the above methods are to be set out as an Excel table where possible and the reasons given for the final selection of the design flood.				
5.3	**Hydraulics at Bridge and Culvert Sites**				
a)	Bridges -Assess the hydraulic capacity of each bridge using the HEC-RAS program or similar software. The inputs include the river cross sectional data and other topographical data together with the design flood. Indicate which bridges can be retained subject to modification and/or repair. -Provide in an appendix all the inputs used in the analysis together with all the river cross sections used. -Present longitudinal water profile under flood conditions with and without bridge to show backwater effect. -Present at least one cross section at the bridge under flood conditions to show water velocities across the section.				
b)	Culverts -Assess the hydraulic capacity of each culvert using the HY-8 program or similar software or appropriate methodology. -Present all the inputs such as the culvert size and type, length and slope together with the stream cross section downstream of the culvert and its roughness together with the design flood. -Present the individual program outputs for each culvert in an Appendix. Indicate which culverts might be retained subject to modification and/or repair.				
c)	Side and Median Drains -Provide details of side and median drains designed in accordance with Section 8 of the RDM Vol.2. Note these should cover all the stretches of the road except where turnouts are feasible. -Also provide details of gutters, kerb inlets, catchpits and manholes and other pertinent surface drainage requirements as guided under section 8.3 of the RDM Vol.2.-				
5.4	**Scour and Erosion**				
a)	Bridges Present pier and abutment scour outputs from the HEC-RES programme and describe methods to be used to alleviate/control erosion to structures				
b)	Culverts Using the velocity outputs from the HT-8 programme details of bed material, describe suitable erosion protection measures at culvert inlets and particularly outlets				
c)	Side and Sub Soil Drains - Provide details of any proposed energy dissipaters, cascades or other erosion protection measures in roadside drains with gradients and bed material liable to erosion				

	Design Element / Criteria / Description	Included in Design	Report Reference	Reviewed	Comment / Reference (if any)
	- Provide detailed drawing of subsoil and cut off drainage to embankment and pavement, showing filter media, catch pits, outlets				
5.5	**Hydrological / Drainage Report Conclusions**				
a)	General - Set out any adverse effects of food plain encroachment and measures to alleviate. - Set out any requirement for river training - Present all calculations, computer program outputs and computer files - Re-state all chainages for bridges and culverts based upon final alignment				
b)	Bridges - Present in tabular form, the location, type, and main dimensions of all the bridges, together with the return period, freeboard, maximum flood and soffit levels. - Comments should include a brief description of scour protection.				
c)	Culverts - Present in tabular form, the location, type, and size of all the culverts, together with the return period, design flood, headwater level, road centreline and shoulder levels. - Conclusions should also include brief descriptions of energy dissipaters, cascades and other downstream erosion protection measures.				

6.0 Completeness of the Design Documents Submission

SN	Document	Requirement		Reviewed	Comment / Reference (if any)
1	Engineering Design Report	Endorsed by Registered Engineer			
2	Book of Drawings				
3	Engineer's Confidential Cost Estimates				
4	Any Other Relevant Technical Documents				

<u>Reviewed By</u>:

Name: ....

Signature: ....

Date: ....