TEN STEP PLAN
TANZANIA
SAFER ROAD INFRASTRUCTURE

The Ministry of Works and Transport, Tanzania

FINAL REPORT

Review of Tanzania Road Geometric Design Manual

JANUARY 2023

UN ROAD SAFETY FUND
GRSF Global Road Safety Facility
UKaid from the British people
ECA
International Road Federation
Fédération Routière Internationale
Federación Internacional de Carreteras
iRAP
PIARC

DISCLAIMER

Lead Author: Elhanan Lema, GrandConsult Engineers & Planners LTF

Other resources about the Ten Step Project in Tanzania are available on:

https://www.gtkp.com/themepage/road-safety/ten-step-plan-for-safer-road-infrastructure/ten-step-project-tanzania/

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Acronyms

CBD	Central Business District
CH	Chainage
DHV	Design Hourly Volume
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ERA	Ethiopian Road Authority
ILO	International Labour Organization
IRF	International Road Federation
km	Kilometres
L.H.S	Left hand side
LoS	Level of Service
m^3	Cubic Meters
NEMC	National Environment Management Council
NEP	National Environment Policy
NGOs	Non-Government Organization
RoW	Right of Way
RGDM	Road Geometric Design Manual
RTDA	Rwanda Transport Development Agency
SANDRAL	South African National Roads Agency Limited
SATCC	Southern Africa Transport and Communication Commission
TANESCO	Tanzania National Electrical Supply Company
TANROADS	Tanzania National Roads Authority
TSH	Tanzanian Shillings
TARA	Tanzania Road Association
TARURA	Tanzania Rural and Urban Roads Agency
TAC	Technical Advisory Committee
ToR	Terms of Reference
UNRA	Uganda National Roads Authority
WB	World Bank

1 Introduction

1.1. Project Background

The 'Ten Step Plan for Safer Road Infrastructure' framework was developed in 2019 by the United Nations Road Safety Collaboration 'Safer Roads and Mobility' group. It was designed to provide countries with a proven step by step process to build national capacity for safer road infrastructure, and to help them achieve Targets 3 and 4 of the United Nations (UN) Global Road Safety Performance Targets.

The specific objectives of the Ten Steps project in Tanzania are:

- Provide support to review and update road design standards and infrastructure safety strategy and action plan.
- Provide training on road assessments via iRAP methodology, Road Safety Audits, and Road Safety Engineering.
- Support establishment of a Tanzania Road Assessment Program (TanRAP).
- Support establishment of a national training, accreditation and certification scheme.
- Support iRAP assessments of existing roads, designs and upgraded roads Start Rating.
- Support Road Safety Audits on new or existing roads, or proposed road designs.
- Perform evaluations of the effectiveness of project activities.

1.2. Purpose of the study

The purpose of this study is to review and make recommendations for updating the Tanzania Road Geometric Design Manual (RGDM) 2011; and for the associated documents being used in Tanzania, in conjunction with it (the manual) during road design, construction/upgrading and maintenance. The aim of this amendment is to align the RGDM to the UN Global Road Safety Performance Targets which in target 3, indicate that by 2030, all new roads ought to achieve a 3-star rating or better standard for all road users; and in target 4, that 75% of travel on existing roads achieve a 3-Stars or better technical safety standards.

1.3. Scope of the study

The scope of the study is to support the work of Working Group 2, in the Tanzania Ten Step Project by

- Providing a comprehensive list of standards, guidelines and manuals (other than the RGDM) which can be a good reference point for the review of the Tanzania Manuals.
- Perform an in-depth review of the latest Tanzania Road Geometric Design Manual (RGDM), 2011, in order to assess its suitability at addressing safety needs for all road users and achieve the United Nations Global Road Safety Performance Targets 3 and 4 in order to align to the Sustainable Development Goals (SDG).
- Identify (through the in-depth review) the gaps, and draft in detail, text and technical revisions (tables, figures, other) that are needed to update the manual.
- Identify training needs for the revised standards/manuals/guidelines to be used effectively in project development.
- Suggest a process to ensure standards/manuals/guidelines are maintained and updated regularly.

1.4. Justification and Purpose

In the WHO published, Global Status Report on Road Safety,2018, it is reported that 16,252 people were killed in road crashes in Tanzania in 2016. Of these, 30% were vehicle occupants, 23% were motorcyclists, 30% were pedestrians, and 8% bicyclists. Road infrastructure in one of the key components of the Safe system that plays a significant role in influencing the likelihood and severity of the road crashes. It is therefore critical that stakeholders and players in the development and maintenance of road infrastructure play their part in ensuring safer and forgiving road infrastructure is in place.

To address the scourge resulting from road crashes, in August 2020 the United Nations (UN) General Assembly adopted a resolution, proclaiming the Decade of Action for Road Safety 2021-2030. The ambitious target set requires countries and stakeholders to implement actions that contribute to the reduction of road Fatalities and Serious Injuries (FSI) resulting in the halving (50%) of FSIs by 2030.

As part of the Safe System, road safety engineering makes a direct contribution to the reduction of road death and injury. Looking specifically at the contribution that infrastructure can have on safety, countries should be able to assess the safety capacity of the road network for all road users and implement infrastructure improvements through targeted investment programs. The UN Global Road Safety Performance Targets indicate in target 3 that by 2030 all new roads are to achieve a 3-star rating or better standard for all road users; and target 4 that 75% of travel on existing roads is to achieve a 3-Stars or better technical safety standards. Through the International Road Assessment Program (iRAP) Methodology, locations which do not meet the minimum 3-star rating Target can be identified and interventions implemented to improve safety for all road users.

To achieve these targets, road design manuals – being the basis of all road designs - have a major role to play. These manuals should incorporate a strong link to safety because road safety is a fundamental aspect of transportation infrastructure. By incorporating safety considerations into road design manuals, designers can create roads that are safer, more accessible, and more efficient, reducing the risk of accidents and injuries for all road users including vehicle occupants, pedestrians, cyclists, and motorcyclists. The inclusion of safety considerations in road design manuals helps to ensure that roads are designed with safety in mind from the outset. This means that designers are considering factors such as traffic volume, speed limits, road conditions, and the needs of different types of road users when planning new roads or upgrading existing ones. Furthermore, considering safety in road design manuals helps to reduce the risk of crashes and injuries on the roads. This is especially important as the number of vehicles on the roads increases, and as urbanization continues to change the way that people move around cities. A well-designed road network can help to prevent crashes, improve traffic flow, and reduce congestion, all of which contribute to safer roads for everyone.

A policy to support road safety is essential to reduce the number of road crashes, injuries, and fatalities, promote economic development, and ensure that everyone has access to safe and reliable transportation. This policy should align with global standards and aim to promote the UN Global Road Safety Targets in their entirety in support of the Sustainable Development Goals (SDG). Governments, road authorities, and other stakeholders should work together to develop and implement comprehensive policies that prioritize road safety and create safer roads for all road users.

2 Reference and Document Usage

2.1. How to use the Document

This main chapters of this report have included the names of all the main Chapters in RGDM2011 for easy reference. Below are examples of the headings used in the report and explanation of the meaning of the content of the heading.

3. Chapter 2: Road Classification

3: is the Chapter number in this document reviewing the Road Geometric Design Manual.

Chapter 2: Road Classification: is the chapter number and heading in the RGDM2011.

4. Chapter 3: Road Planning & Survey Requirements

4: is the Chapter number in this document reviewing the Road Geometric Design Manual.

Chapter 3: Road Planning & Survey Requirements: is the chapter number and heading in the RGDM2011.

For each chapter of the RGDM the following areas are discussed.

- **Current Practices**, which highlights current standards in RGDM2011 and how they have been used or normalized as a practice.
- **Identified Issues**, which discusses safety issues identified.
- **Recommendations**, details the measures and possible interventions to improve safety to all road users and the eventual improvement of iRAP Star Rating on the road infrastructure.
- **Amendment**, which details the specific modification/addition/deletion and where it should occur in the current RGDM2011.

The chapters in the RGDM which have no content have been left out.

2.2. Reference Manuals

After undergoing a consultative process with Consulting firms and other institution on the 2010 draft, the 2011 Tanzania Geometric Design Manual (RGDM 2011) was released in May 2011. During this 2022/23review being undertaken as part of the Tanzania Ten Step project, wider consultation of other design manuals from around the world was conducted for reference and with a view to determine the best practices pertaining globally.

Table 2.2-1: Reference Manuals

Design Manual	Country
Road Design Manual, Volume 1: Geometric Design, Ministry of Works and Transport, 2011	Republic of Uganda
Road Geometric Design Manual, 2014, Rwanda Transport Development Agency, (RTDA)	Republic of Rwanda
Geometric Design Manual, 2013, Ethiopian Roads Authority (ERA)	Federal Democratic Republic of Ethiopia
Draft Code of Practice for the Geometric Design of Trunk Roads, September 1998 (Reprinted July 2001)	SATCC, Southern African Transport and Communications Commission
The Highway Code, Ministry of Infrastructure Development, United Republic of Tanzania, October 2008	Tanzania
A Policy on Geometric Design of Highways and Streets, AASHTO 2011.	United States of America
Guide to Road Design Part 3, Geometric Design, Austroads, 2016	Australia
Guide to Road Design Part 4, Intersection and Crossings -General, Austroads, 2016	Australia
Guide to Road Design Part 4A, Unsignalised and Signalised Intersections, Austroads, 2016	Australia
Guide to Road Design Part 4B, Roundabouts, Austroads, 2016	Australia
Guide to Road Design Part 4C, Interchanges, Austroads, 2016	Australia
Guide to Road Design Part 6, Road Side Safety and Barriers, Austroads 2016	Australia
Guide to Road Design Part 6A, Path for Walking and cycling, Austroads, 2016	Australia
Guide to Road Design Part 6B, RoadSide Environment, Austroads, 2016	Australia

In the development of the Tanzania National Road Design Manuals and associated documents it is recommended that other resources be consulted to support the incorporation of best practices in industry. The iRAP Road Safety Toolkit[1] is an important online resource that provides free, practical and up-to date information on the causes and prevention of road crashes that result in death and injury as well as knowledge on how treatments can be implemented. Building on decades of road safety research, the Toolkit provides a one-stop road safety resource for all stakeholders to help develop safety interventions for all road users.

/[1] https://toolkit.irap.org

3 Chapter 2: Road Classification

3.1. Divided Highways

Current Practices

RGDM 2011, Chapter 2.4, Table 2-2, recommended that Road Design Class1 (DC1) cross section should be used when AADT exceeds 8000 vpd. Table 2-2 from RGDM 2011 is presented below as Table 3.1-1in this report.

Table 3.1-1: Road Design Class and Functional Class

Road design class	AADT* [veh/day] in the design year	Functional Class				
		A	B	C	D	E
DC 1	>8000	■	■			
DC 2	4000 - 8000	■	■			
DC 3	1000 - 4000	■	■			
DC 4	400 - 1000	■ M	■	■		
DC 5	200 - 400		■ M	■		
DC 6	50 - 200			■	■	
DC 7	20 - 50			■	■	■
DC 8	<20				■	■

■ Applies to roads in flat to rolling terrain

M: Minimum standard for the appropriate functional class

Source, RGDM2011, Table 2-2

RGDM 2011, Chapter 2.5, Table 2-3 provides basic dimension of DC1 Cross Section which includes a minimum of 4 traffic lanes (2 on each direction), 2x2.5m outer shoulders and 2*0.9m inner shoulders. The details are presented in Table 3.1-2 below.

Table 3.1-2: Cross Section dimensions of the Road Design Classes

Design class	Surface	Road reserve width [m]	Roadway width [m]	Carriage way			Shoulder width [m]	Median width [m]
				Width [m]	Lane width [m]	No. of lanes		
DC 1	Paved	60	28-31	2 x 7.0	3.5	≥4	2 x 2.5 *	9 – 12
DC 2		60	11.5	7.5	3.75	2	2 x 2.0	-
DC 3		60	11.0	7.0	3.5	2	2 x 2.0	-
DC 4		60	9.5	6.5	3.25	2	2 x 1.5	-
DC 5		60	8.5	6.5	3.25	2	2 x 1.0	-
DC 6	Gravel or paved	40	8.0	6.0	3.0	2	2 x 1.0	
DC 7	Gravel	30	7.5	5.5	2.75	2	2 x 1.0	
DC 8	Earth or gravel	20	6.0	4.0	4.0	1	2 x 1.0	

* Inner shoulders of 2x0.9 metres are included in the median width

Source, RGDM2011, Table 2-3

Currently, major trunk roads are experiencing much higher traffic volumes than 8000 vpd. As an example, for Morogoro - Dodoma, the traffic volume is between 22,000-34,000 vpd and Dar es Salaam - Chalinze experiences more than 100,000 vpd. Other major trunk roads which are still single carriageways and connecting regions, also have traffic volumes higher than 8000.

Identified Issues

Major trunk roads with high traffic volumes have in recent years experienced fatal crashes mostly due to;

- Reckless and irresponsible overtaking of slower moving vehicle by fast moving ones leading to head on collisions especially on steep grades.
- Lack of road visibility at night causing drivers to use high-beam headlights resulting in blinding for drivers in approaching vehicles
- Vehicles parked poorly in traffic lanes without adequate visibility causing oncoming vehicles to either suddenly change lanes resulting in collisions with vehicles in opposing directions or hitting the parked vehicle.

Amendment

The following amendments/additions/deletions are recommended

1. Add the following paragraph after the 1st Paragraph below Table 2-3, Page 2.4 of RGDM 2011.

   The cross section for Rural Highways especially with traffic volume greater than 8000 vpd must the same as that of Road Design Class 1 (DC1). The DC1 cross section is likely to significantly reduce crashes related to reckless and irresponsible overtaking, blinding of drivers due to headlights in night times and improperly parked vehicles.

4 Chapter 3: Road Planning & Survey Requirements

4.1. Route Selection

Current Practice

It is not unusual for Terms of Reference (ToR) for upgrading of existing rural highways, especially from unpaved to paved status, to require the existing alignment to follow the previous alignment - with some improvement as necessary. For example, a Rural Highway passing through a town or built-up area will continue to pass along the same route. The upgrade will often result in increased vehicle speeds. This will exponentially increase risks for all road users, with the highest risk being imposed on the Vulnerable Road Users (VRU).

Inversely, it is quite unusual for bypasses to existing towns to be an important consideration. This is most often because land acquisition issues will potentially arise.

Safety and economic and technical viability of a proposed road begins at the route location process.

Identified Issue

In the RGDM, Chapter 3.3 provides guidelines on route selection procedures and processes. However, there is insufficient guidance on route selection based on different road uses, and this can affect the legal speeds and/or the road features.

Recommendations

More guidance must be provided to ensure that designers consider all critical factors which if ignored at route selection process, may lead to unsafe designs which in turn would be more costly to mitigate. The Ethiopian Roads Authority (ERA) Design Manual 2013 Route Selection Manual provides more insight on the route location process. It is recommended that the following Tables or information from ERA 2013 Route Selection Manual be added into RGDM 2011 for purposes of guiding designers to adequately evaluate the impact of various terrain types, in order to avoid risk areas, and to prepare to mitigate risks if taken.

Amendment

The following amendments/additions/deletions are recommended:

1. Add the following after end of Section 3.3.1 of RGDM2011

   The following tables provide guidelines on evaluating the impact of various terrain types to avoid risk areas or prepare to mitigate risks if taken.

Table 4.1-1: Flat Terrain

Geographic feature	Facet	Typical problems encountered	Likelihood of existing instability
Plateau top	Flat ground	Deeply weathered soils likely; some erosion potential in stream and river courses. Possibility of expansive soils*	None
	Wide, gently sloping valleys	Deeply weathered soils likely; some erosion potential in stream and river courses. Possibility of expansive soils*	Possible shallow ground movements in expansive soils
Lowland	Flat ground	Probable alluvium with some deeply weathered soils; possibility of expansive or dispersive soils*	Possible soft ground
	Shallow depression	Deeply weathered soils; possibility of expansive or dispersive soils; possibility of saline soils in semi-arid areas.* High water tables, flooding hazards	Possible soft ground

Source, Extract, Table 5-1, ERA Geometric Design Manual 2013

Table 4.1-2: Rolling Terrain

Geographic feature	Facet	Typical problems encountered	Likelihood of existing instability
Low hill	Rounded relief	Deeply weathered soils likely; some erosion potential	Unlikely
Shallow valley	Rounded relief	Deeply weathered soils likely; some erosion potential; possibility of expansive soils	Unlikely
	Streams and minor rivers	Possible compressive alluvial soils. High water tables, flooding hazards	Unlikely

Source, Extract, Table 5-2, ERA Geometric Design Manual 2013

Table 4.1-3: Mountainous and Escarpment

Geographic feature	Facet	Typical problems encountered	Likelihood of existing instability
Ridge top	Rounded relief	Deeply weathered soils likely; some erosion potential	Unlikely
	Sharp relief	Rock at surface; costly and difficult rock excavation possible	Unlikely
	Irregular relief	Difficult alignment along ridge top between high points and low points	Possibly
	Asymmetric relief	Joint-controlled slopes will influence stability of alignments and cut slopes	Possibly - check for evidence of back scarps and failed material
	Ridge lines generally	May be subject to greater rainfall than valley sides	Possibly

Source, Extract, Table 5-3, ERA Geometric Design Manual 2013

Table 4.1-4: Mountainous and Escarpment (Continued)

Geographic feature	Facet	Typical problems encountered	Likelihood of existing instability
	Ridge lines generally	May be more affected by seismicity (topographic amplification)	Possibly
Stepped escarpment	Steep slopes with intermediate benches	Deep tension cracks behind cliff faces, very difficult topography for alignment design, seepage zones and highly variable rocks within cut slopes, potential for slope instability	Possibly – check for debris mass on intermediate benches and rock fall hazards from cliff faces
Failed escarpment	As above but masked by failed material, including failed cliffs	Deep tension cracks behind cliff faces, very difficult topography for alignment design, seepage zones and highly variable rocks and chaotic boulder/debris deposits within cut slopes, failed/failing slopes and materials, poor founding conditions (Fig 5-5)	Definitely – check for widespread instability, including failed cliffs
Valley side	Slopes are steeper than 40°	Probably underlain by rock; therefore likely to be more costly to construct but less costly to maintain	Unlikely
	Slopes 35° to 40°	Potential to be shallow taluvium on rock	Possibly
	Slopes 20° to 35°	Potential to be deep taluvium, colluvium or failed slope	Possibly
	Continuous rock slopes with persistent jointing approximately parallel to slope	Likely to be formed in dominant joint set controlling long-term stability of the slope. Depending on strength of rock this joint set could be problematic in excavations and foundations	Possibly - check for back scarps and failed debris downslope
	Embayments	Either erosional in origin or formed by landslide(s)	Probably
	Areas of irrigated farmland	Drainage problems likely; soils possibly taluvial/colluvial in origin and potentially unstable locally, depending on slope	Possibly, but mass as a whole may be stable
	Forested areas on otherwise cultivated hillside	Possibly areas of wet ground, steep slopes, instability that cannot be cultivated	Possibly
	Rounded spurs	Probably formed in residual soils and stable	Unlikely
	Elongated mid-slope benches	Either ancient river terraces or rock benches; both stable and 'easy' for road construction, though may contain expansive soils	Unlikely
	Local mid-slope benches	Could be as above, or part of deep seated landslide	Possibly

Source, Extract, Table 5-3, ERA Geometric Design Manual 2013

Table 4.1-5: Mountainous and Escarpment (Continued)

Geographic feature	Facet	Typical problems encountered	Likelihood of existing instability
Valley floor	Steep slopes forming margins of river channel (i.e. no river terrace)	Possibly unstable; difficult for road alignments, especially on meander bends; possible flood risk and high water table	Likely
	Steep slopes forming valley side margins to river terrace	Possible ancient landslides and high water table	Possibly
	River terrace	Possible flood risk, soft/loose soils and terrace edge scour; high water table	Unlikely, except at terrace edges
	Tributary streams	Possibly active debris flows and debris fan deposition causing scour and blockage/damage to road structures; possible flood risk and high water table	Debris flows only

Source, Extract, Table 5-3, ERA Geometric Design Manual 2013

2. Add the following after end of Section 3.3.2 of RGDM 2011

Below is an example on Planning and Route location with the objective of minimizing risk on crashes. It is an extract from the Guide to Traffic Planners and Engineers - "Towards Safer Roads in Developing countries" - by TRL, ODA.

Fig 3.12
Existing interurban road results in considerable conflict between through traffic and local traffic in a Korean village (Ross Silcock Partnership)

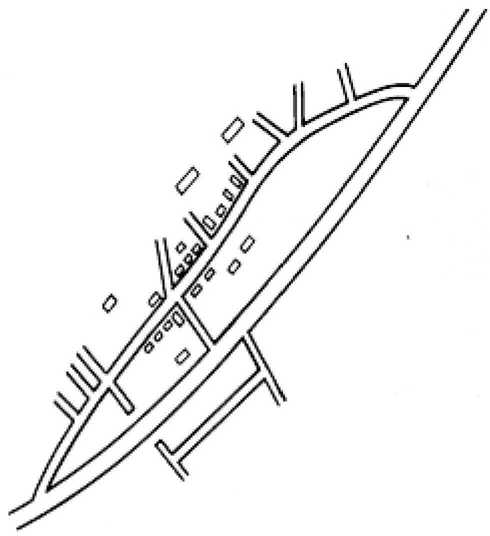


Fig 3.14
A bypass removes through traffic from the village in Fig 3.12. Note limited access points onto new road (Ross Silcock Partnership).

Source, Towards Safer Roads in Developing Countries, TRL ODA

5 Chapter 4: Design Controls and Criteria

5.1. Design Hourly Volume

Current Practice

RGDM2011 page 4.11 second paragraph, discusses and recommends the use of Design Hourly Volume (DHV) but does not give guidance on how to estimate it. DHV is used in an assessment of the performance of a road. Performance of a road has an impact on the overall safety of road users. DHV is required as an input to the design of various geometric components of roads such as junctions, and also for operational analyses.

Designers will determine traffic flow in vehicles per hour by converting daily traffic into hourly traffic, by dividing measured traffic by numbers of hours recorded, and/or by some valid assumptions. This often leads to unrealistic hourly volumes.

Identified Issue

Unrealistic hourly volumes will result in a design which will not perform effectively, leading to congestion and safety issues.

The first paragraph of the RGDM 2011 page 4.9 and second paragraph of RGDM 2011 page 4.13 discuss and recommend use of Design Hourly Volume (DHV) but does not give guidance on how to estimate DHV.

Performance of a road has an impact on the overall safety. It is therefore, important to use appropriate parameters in conducting performance predictions and one key input is the DHV.

Recommendations

The Uganda Geometric Design Manual 2010 and the Ethiopian Geometric Design Manual 2013 have provided recommendation on how to estimate DHV. Guidelines included in Section 5.4.1.4 from the Uganda Geometric Design Manual may be included/supplemented in RGDM 2011 after second paragraph Page 6.13.

Amendment

1. Add the following after second paragraph, Page 4.13

DHV is expressed as
DHV = AADT x K or ADT x K.
Where
DHV=Design Hourly Volume
AADT=Annual Average Daily Traffic
ADT=Average Daily Traffic
K = Estimated ratio of the 30th HV to AADT from similar site. K can be estimated from the following Table.

The 30th HV expressed as a fraction of ADT can vary as indicated in the following Table

Traffic Condition	30th HV as a fraction of ADT
Rural Arterial (average value)	0.15
Rural Arterial (maximum value)	0.25
Heavily trafficked road under congested urban conditions	0.08 – 0.12
Normal urban conditions	0.10 – 0.15
Road catering for recreational or Other traffic of seasonal nature	0.20 – 0.30

Source, Uganda Geometric Design Manual 2010, Table 5-2

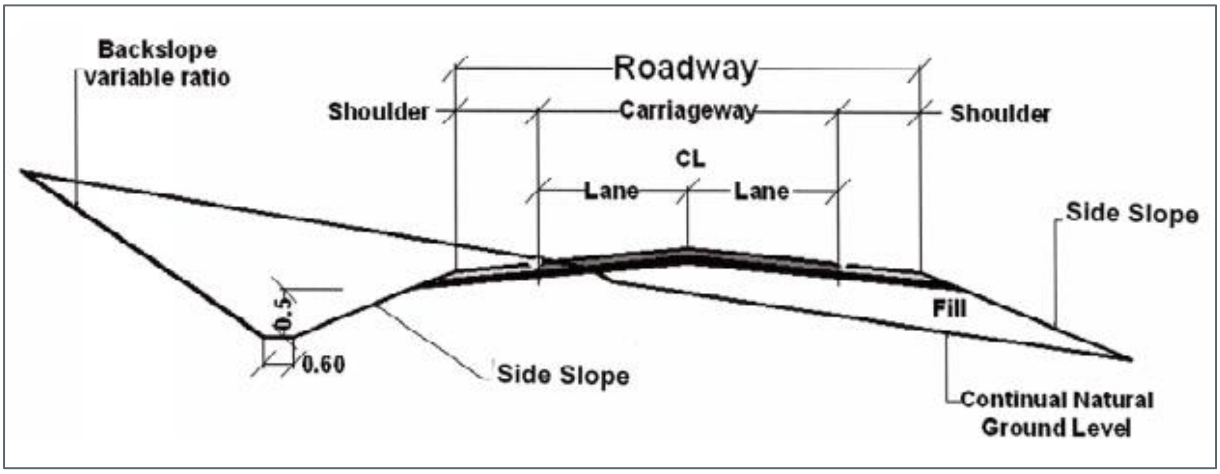
Higher percentages in the table refer to roads with relatively high concentration of traffic during rush-hours or large seasonal changes. For rural roads the 30th HV is often used as the Design Hourly Volume (DHV). The general approach to operational analysis is to compute the service volumes (SV), for a given road section for each level of service, and to compare these values with the existing or forecast design hourly volume, DHV

6 Chapter 5: Cross Section Elements

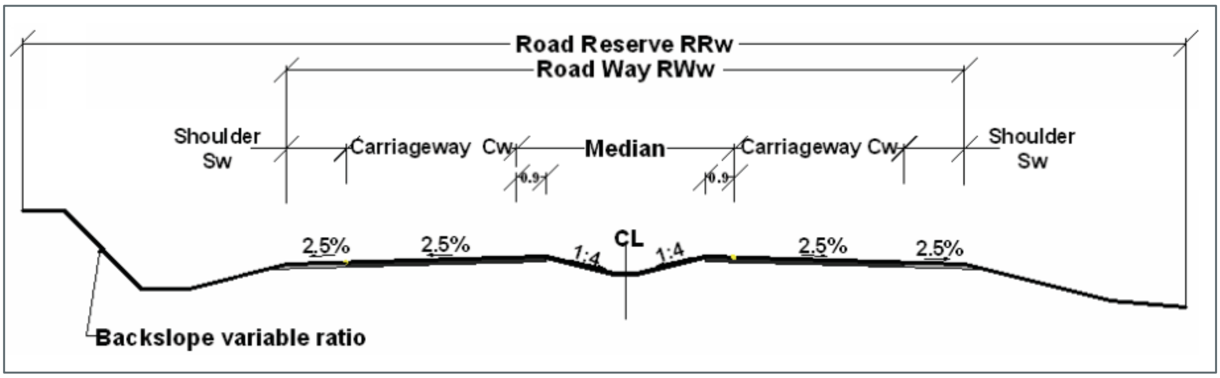
6.1. Cross Section Elements

Current Practice

RGDM2011 Section 5.1 provides the details of cross sections elements for two-lane and four-lane roads as shown below.



Source, RGDM2011, Section 5.1, Figure 5-1



Source, RGDM2011, Section 5.1, Figure 5-2

The cross section in Figure 5-1 is commonly applied on rural highways and where four lanes are required, cross section presented in Figure 5-2 have been used. There have been variations to the above cross sections depending on the various environmental conditions along the road.

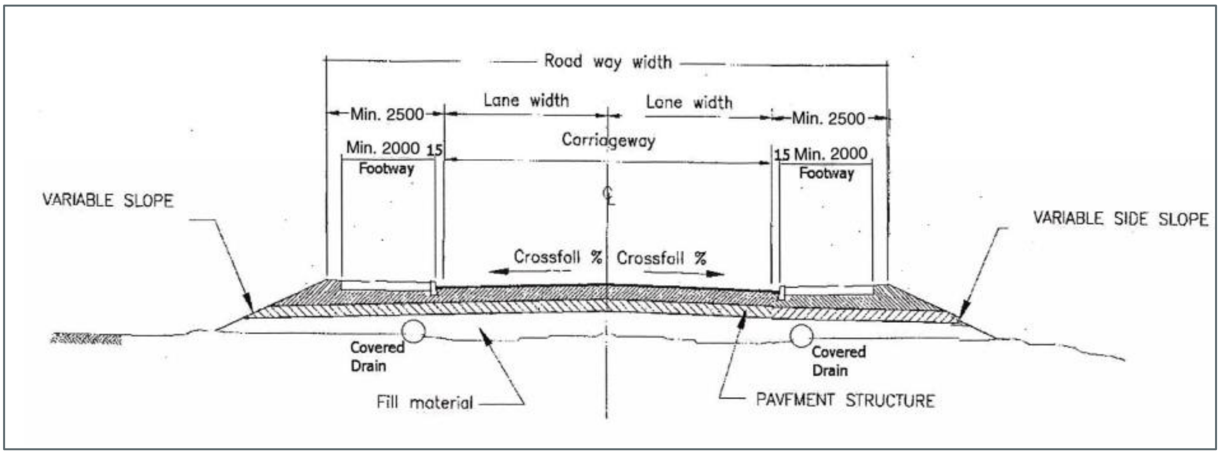
One area where modifications have been done is in urban areas where footways of different types have been integrated into the cross section by the designers.

Section 9.3 of RGDM 2011 provides information on Pedestrian facilities. Subsection 9.3.1 discusses provision of footways.

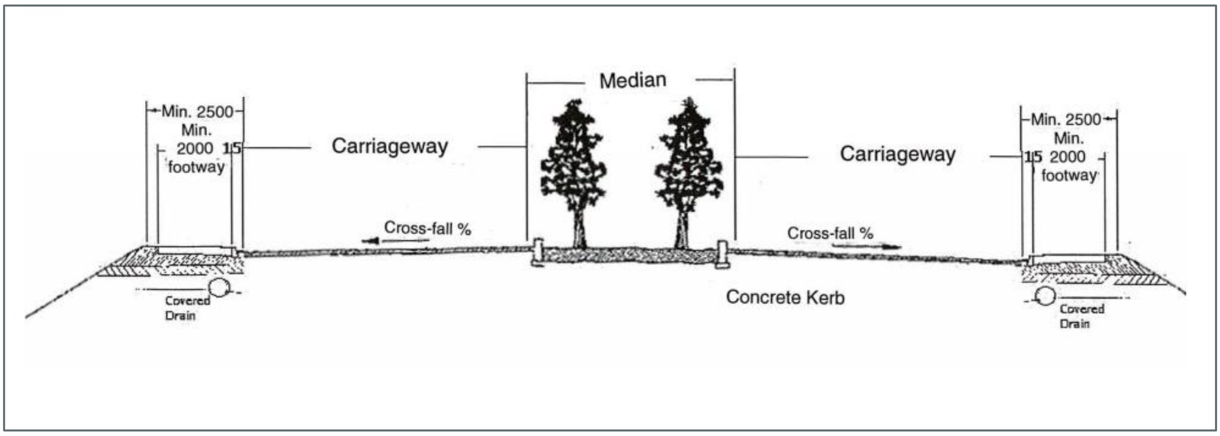
Section 9.6 of RGDM 2011 provides information on cycle facilities and criteria for determining the cycle lane width, and the combined cycle lane and footway width.

Section 5.1 does not give guidelines on how the cycle lane and footway are integrated into cross section when required. This omission has resulted in designers proposing different arrangements which have turned out to be unsafe especially for Vulnerable Road users.

RGDM 2011 however, under Terminology Section, Figure (b) Page XIX and Figure (c) Page XX, provides definitions for Cross Section elements for Single Carriageway and Dual Carriageway in Urban area.



Source, RGDM2011, Terminology Section, Figure (b)



Source, RGDM 2011, Terminology Section, Figure (c)

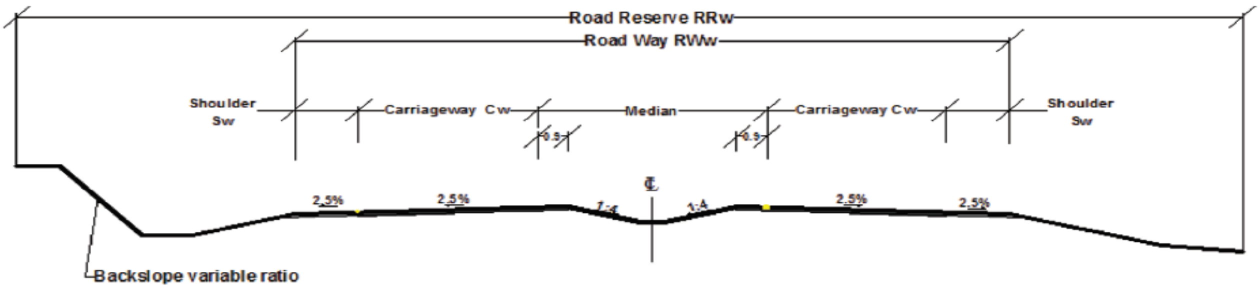
Identified Issue

Section 5.1 lacks Typical cross Sections for Urban or Peri-Urban where there are complex traffic mixes and high traffic volumes which put vulnerable road users at risk. A cross section should consider safe passage for all road users.

In 2019-2020, the International Road Assessment Programme (iRAP) through Bloomberg Initiative for Global Road Safety, Tanzania, prepared the iRAP Design Assessment on Typical Cross Sections in the Tanzania Road Geometric Design Manual 2011

The following subchapters present the outcomes of the iRAP assessments conducted.

6.1.1.4 Lane Paved freeway with median, Class 1 Rural Road



Road design class	Dimension (m)						Slope (%)		Median* width (m)
	RRw	RWw	Cw	No. of Lanes	Lw	Sw	Csl	Ssl	
1	60	28.0 to 31.0	2x7.0	4	3.5	2.5	2.5	2.5	9.0 to 12.0

* Note that the width of the inner shoulder is included in the width of the median. Recommended width is 0.9 m, minimum requirement is 0.75 metre.

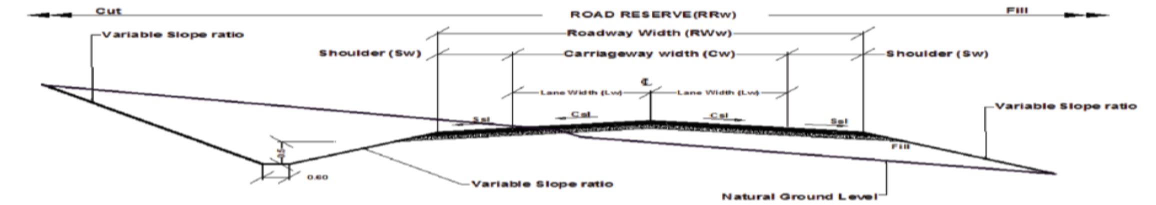
Table 6.1.1-1: Key Design Manual Road Attributes and resulting Star Ratings

MID-BLOCK		VRU FACILITIES AND LAND USE	
Carriageway label	Divided	Land use	Undeveloped
Median type	Physical Median 5-10m	Area type	Rural
Number of lanes	2	Pedestrian crossing facilities	No facility
Lane width	Wide (>3.25m)	Pedestrian crossing quality	N/A
Street lighting	Not Present	Pedestrian fencing	Not present
Vehicle parking	None	Sidewalk - Driver side	None
Service road	Not present	Sidewalk - Passenger side	None
ROADSIDE		Facilities for Bicycles	None
Rdside severity - Driver distance	>10m	**FLOW**	
Rdside severity - Driver object	None	Vehicle flow (AADT)	20000
Rdside severity - Passenger distance	1 to 5m	Motorcyclist %	1% - 5%
Rdside severity - Passenger object	Upward slope – no rollover	Ped. peak hr flow across the road	0
SPEEDS		Ped. peak hr flow along - Driver side	0
Speed	100 kph	Ped. peak hr flow along - Passenger side	101-200
Speed management / traffic calming	Not present	Bicyclist peak hr flow	26 - 50

Recommendations to achieve 3-Stars or better

- Providing any form of formal pedestrian footpath would reduce risks to a minimum 4-Star Rating for Pedestrians.
- Providing an off-road cycleway would reduce risks to cyclists improving the star rating to 5-Stars for Cyclists

6.1.2. Single Carriageway, Design Class 2-5, Rural Road



Road design class	Dimension (m)						Slope (%)	
	RRw	RWw	Cw	No. of Lanes	Lw	Sw	Csl	Ssl
2	60	11.5	7.5	2	3.75*	2.0	2.5	2.5
3	60	11.0	7.5	2	3.50	2.0	2.5	2.5
4	60	9.5	6.5	2	3.25	1.5	2.5	2.5
5	60	8.5	6.5	2	3.25	1.0	2.5	2.5

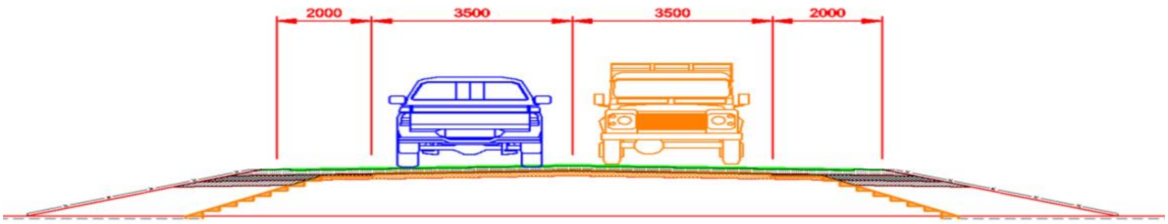


Table 6.1.2-1: Key Design Manual Road Attributes and resulting Star Ratings

MID-BLOCK		VRU FACILITIES AND LAND USE	
Carriageway label	Undivided	Land use	Undeveloped
Median type	Centre line	Area type	Rural
Number of lanes	1	Pedestrian crossing facilities	No facility
Lane width	Wide (2.75m - 3.25m)	Pedestrian crossing quality	N/A
Street lighting	Not Present	Pedestrian fencing	Not present
Vehicle parking	None	Sidewalk - Driver side	None
Service road	Not present	Sidewalk - Passenger side	None
ROADSIDE		Facilities for Bicycles	None
Rdside severity - Driver distance	1 to 5m	**FLOW**	
Rdside severity - Driver object	Tree	Vehicle flow (AADT)	8000
Rdside severity - Passenger distance	1 to 5m	Motorcyclist %	1% - 5%
Rdside severity - Passenger object	Upward slope – no rollover	Ped. peak hr flow across the road	0
SPEEDS		Ped. peak hr flow along - Driver side	26 - 50
Speed	80 kph	Ped. peak hr flow along - Passenger side	26 - 50
Speed management / traffic calming	Not present	Bicyclist peak hr flow	6 - 25

Recommendations to achieve 3-Stars or better

In order to have a minimum 3-Star Rating, the following interventions need to be incorporated as a minimum, to this standard cross section:

- Providing a formal pedestrian footpath, even on just one side of the road as a minimum and having an informal footpath on the other would reduce risks to a minimum 3-Star Rating for Pedestrians.
- Providing a dedicated on-road cycle lane as a minimum would reduce risks to cyclists improving the star rating to 3-Stars for cyclists.

6.1.3. Single Carriageway, Design Class 2-5, Rural Road

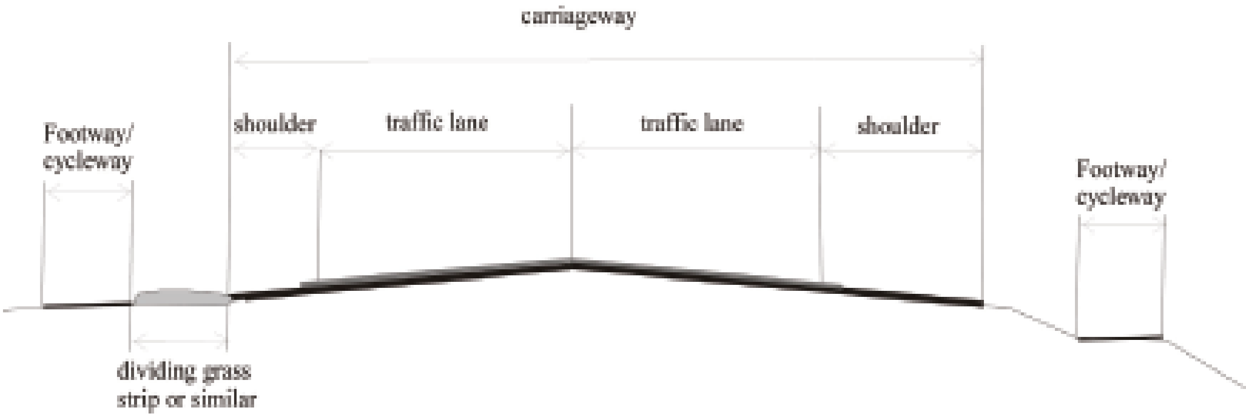


Table 6.1.3-1: Key Design Manual Road Attributes and resulting Star Ratings

MID-BLOCK		VRU FACILITIES AND LAND USE	
Carriageway label	Undivided	Land use	Residential
Median type	Centre line	Area type	Rural
Number of lanes	1	Pedestrian crossing facilities - inspected rd	No facility
Lane width	Wide (>3.25m)	Pedestrian crossing quality	N/A
Street lighting	Not Present	Pedestrian fencing	Not present
Vehicle parking	Two sides	Sidewalk - Driver side	Non-Physical 1-3m
Service road	Not present	Sidewalk - Passenger side	Non-Physical 1-3m
ROADSIDE		Facilities for Bicycles	Shared use facility
Rdside severity - Driver distance	5 - 10m	**FLOW**	
Rdside severity - Driver object	Sign / post	Vehicle flow (AADT)	20000
Rdside severity - Passenger distance	5 - 10m	Motorcyclist %	1% - 5%
Rdside severity - Passenger object	Sign / post	Ped. peak hr flow across the road	6 - 25
SPEEDS		Ped. peak hr flow along - Driver side	51 - 100
Speed	50 kph	Ped. peak hr flow along - Passenger side	51 - 100
Speed management / traffic calming	Not present	Bicyclist peak hr flow	26 - 50

This cross section achieves a minimum 3-Star rating for all road users. However, as we have modelled some pedestrian crossing flows, installing a refuge Island or a marked pedestrian crossing facility further reduces the risk in spite of remaining within the 3-Star Range. Signalizing the pedestrian crossing or installing guardrails to minimize pedestrian crossing movements increases the Star Rating to a 5-Star rating.

6.1.4. Single Carriageway with kerbed footway in Urban Areas

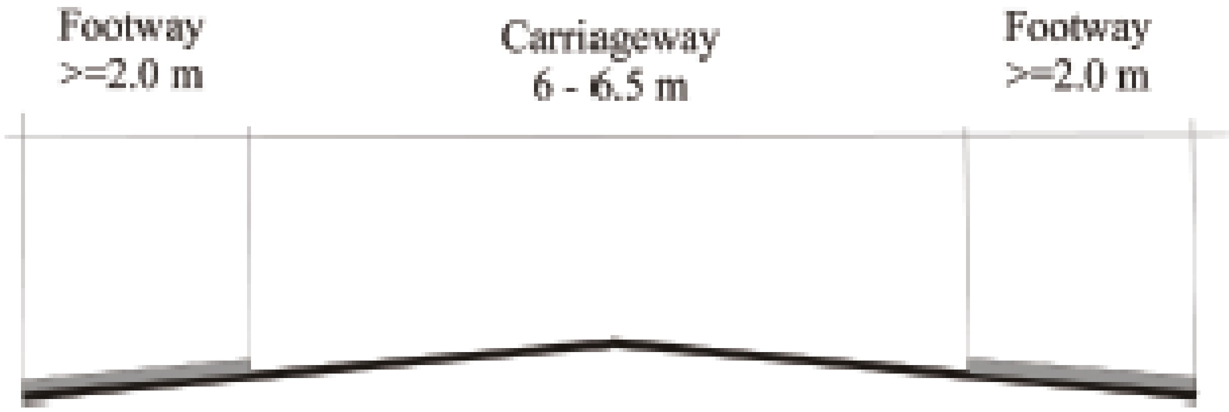


Table 6.1.4-1: Key Design Manual Road Attributes and resulting Star Ratings

MID-BLOCK		**VRU FACILITIES AND LAND USE**	
Carriageway label	Undivided	Land use	Commercial
Median type	Centre line	Area type	Urban
Number of lanes	1	Pedestrian crossing facilities	No facility
Lane width	Med(>2.75-<3.25m)	Pedestrian crossing quality	N/A
Street lighting	Not Present	Pedestrian fencing	Not present
Vehicle parking	None	Sidewalk - Driver side	Non-Physical 0-1m
Service road	Not present	Sidewalk - Passenger side	Non-Physical 0-1m
ROADSIDE		Facilities for Bicycles	None
Rdside severity - Driver distance	0 - 1m	**FLOW**	
Rdside severity - Driver object	Sign / post	Vehicle flow (AADT)	20000
Rdside severity - Passenger distance	0 - 1m	Motorcyclist %	1% - 5%
Rdside severity - Passenger object	Sign / post	Ped. peak hr flow across the road	26 - 50
SPEEDS		Ped. peak hr flow along - Driver side	201 – 300
Speed	50 kph	Ped. peak hr flow along - Passenger side	201 - 300
Speed management / traffic calming	Not present	Bicyclist peak hr flow	6 - 25

As the speeds are relatively low (@50kph) The risk rating in urban areas is relatively low. However, we would recommend that where you have high pedestrian crossing flows, marked crossings with pedestrian refuge and associated signage be installed.

General Recommendations on Cross Section Elements

From the above it is clear that the typical cross sections included in RGDM 2011 need improvement to safely accommodate all road users. The proposed improvement is achievable.

A key consideration in determining the appropriate cross-section of a road is to understand the type and mix of traffic expected to use the road.

With a growing public awareness of sustainability and the impact that congestion and pollution have on the environment, and considering the well-being of people including safety to all road users, road designers need to be conscious of the effort that various road agencies are expending to provide road space for all types of transport, including:

- bicycles
- motorcycles
- road based public transport (buses and trams), e.g., BRT
- cars
- trucks (including high productivity freight vehicles).

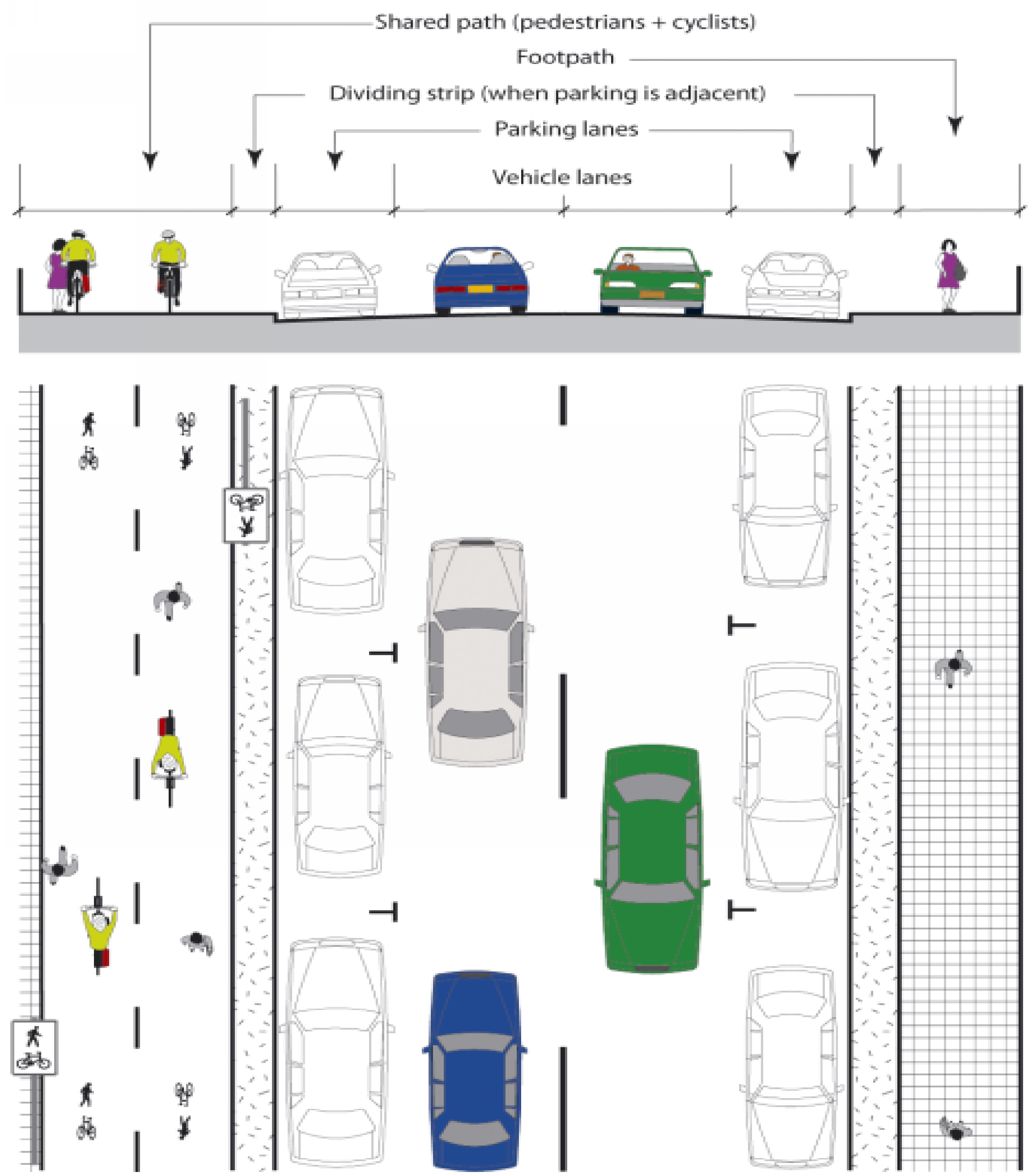
In most urban areas, there is limited space to provide for all of the above-mentioned types of transport facilities thus careful consideration by a designer is needed.

Figure (b) Page XIX and Figure (c) Page XX under Terminology Section of RGDM 2011 should be placed under Section 5.1.

However, some modifications are needed to accommodate pedestrians and cyclist sections especially in Urban areas.

Figure 6.1.4-1 below presents an example a single carriageway cross section with parallel parking, and shared pedestrian and cyclist path. The shared path is separated from parking area by a dividing strip.

Figure 6.1.4-1: Example of Shared path in a road related area

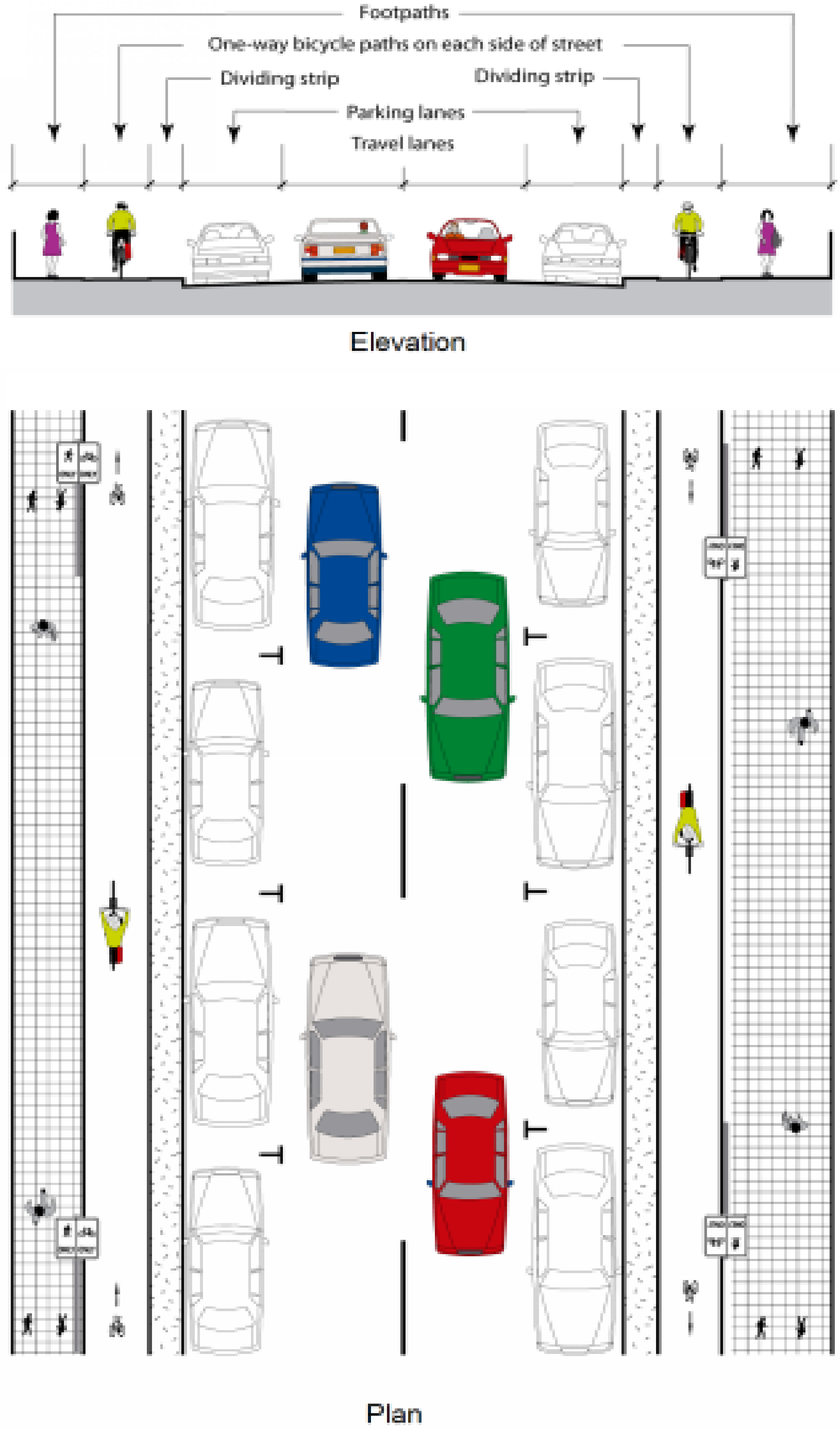


Source, Guide to Road Design Part 6A, Figure 2.3, Austroads, 2017

Figure 6.1.4-2 below present an example a single carriageway cross section with parallel parking and separated pedestrian and cyclist paths.

The separation between pedestrian and cyclist is done by having two paths at different elevation, cycle path being lower than pedestrian path. Pedestrian and Cycle path are separated from parking area by a dividing strip.

Figure 6.1.4-2: Example of a separated one-way bicycle path in a road related area



Source, Guide to Road Design Part 6A, Figure 2.5, Austroads, 2017

The drainage system and other utilities can be accommodated under footpath and cycle lane if there is no sufficient space between edge of footway and property line.

It is recommended that RGDM 2011 provides more options of expected typical cross section with different traffic type and mix. For example;

- Single Carriageway, Rural Section with shoulders
- Single Carriageway, Urban Section with shoulders, footways and cycle lane
- Multilane Carriageway, Urban Section, with shoulders, footways and cycle lane
- Multilane Carriageway, Urban Section, with shoulders, footways, cycle lane and bus lanes

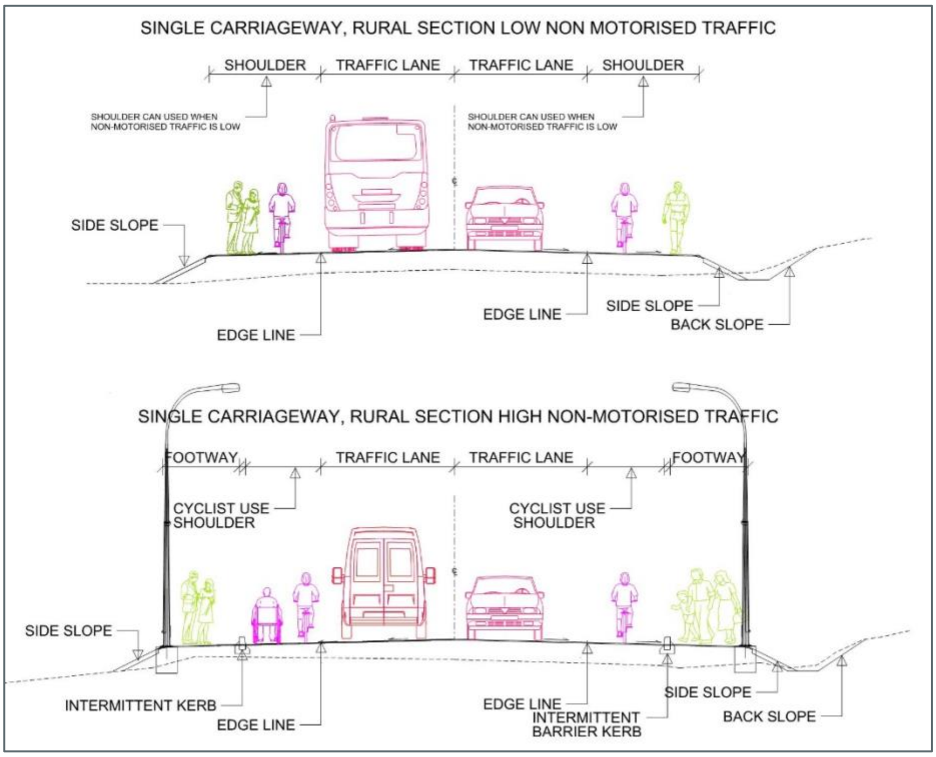
Amendments

1. Amend the following Second Paragraph of Chapter 5.1, Page 5.1 to read as follows:

   The roadway is the portion of the road, consisting of the shoulders and carriageway. Roadway may also include median, footways, cycle lanes and special lanes such as bus lanes. The carriageway is the portion of the road used for the movement of vehicles. Footway is exclusively used by pedestrians while cycle lane is for exclusive use of non-motorized cyclist.

   Figure 6.1.4-3 illustrates various components of the cross section for a two-lane (Single Carriageway) road in Rural Areas.

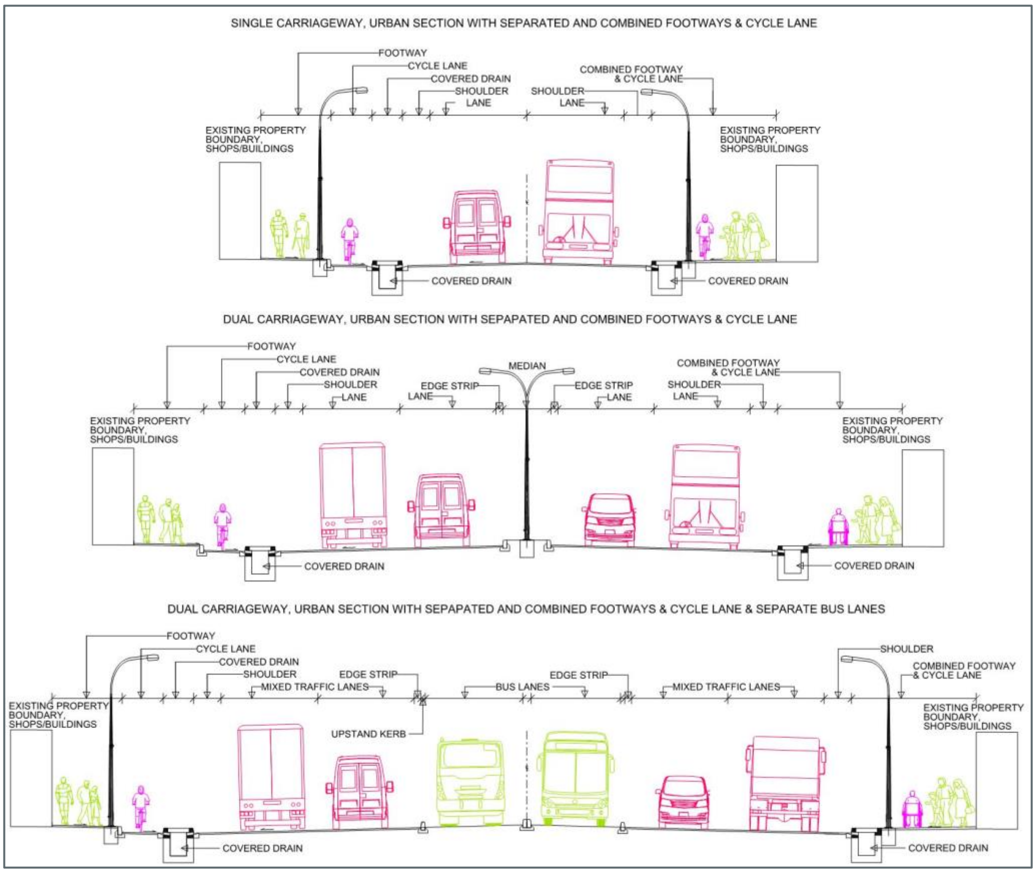
Figure 6.1.4-3: Typical Cross Section Single Carriageway, Rural Areas



Source, Grandconsult Proposal

Figure 6.1.4-4 illustrates various components of the cross section for a two-lane (Single Carriageway) and four-lane (Dual Carriageway) road in Urban Areas.

Figure 6.1.4-4: Typical Cross Section Single and Dual Carriageway, Urban Areas



Source, Grandconsult Proposal

The designer shall ensure that the proposed cross section caters for the traffic demand, and with the expectation of conveying the intended traffic with acceptable capacity and safety to all road users.

A key consideration in determining the appropriate cross-section of a road is to understand the type and mix of traffic expected to use the road.

With a growing public awareness of sustainability and the impact that congestion and pollution have on the environment and well-being of people including safety to all road users, road designers need to be conscious of the effort that various road agencies are expending to provide road space for all types of transport, including:

- *bicycles*
- *motorcycles*
- *road based public transport (buses and trams), e.g., BRT*
- *cars*
- *trucks (including high productivity freight vehicles).*

In most urban areas, there is limited space to provide for all of the above-mentioned types of transport thus careful consideration by the designer is needed.

Guidelines on Dimensioning of the cross-section elements is provided in the various Chapters of RGDM 2011 as described below:

- *Chapter 2, Road Design Class, where number of lanes, lane width and shoulder requirements are defined for various Road Class.*
- *Chapter 4, Design Control and Criteria, where the selected cross sections may be varied in number depending on road capacity needs in the design year*
- *Chapter 5, Cross Section Elements, where more details on how the cross-section elements are fitted and refined to roadway, i.e., Lateral Clearance, Shoulders, Normal cross fall, Side and back slopes, Drainage, clear zone, Multilane Road, Section over bridge and culverts, Footways and Cycleway*
- *Chapter 9, Road Furniture and Other Facilities, where criteria for sizing shoulders and Footway, Pedestrians Facilities, Bus bays, Vehicle Parking Facilities and Cycle Facilities are provided.*

7 Chapter 6: Alignment Design

7.1. Superelevation Run off Length

Current Practice

Section 6.3.5 Superelevation of the RGDM 2011 provides for superelevation with maximum values of 4%, 6% and 8%. Related superelevation runoff length is calculated by using rates of change of superelevation provided in Table 6-9 of RGDM2011.

Identified Issue

There is no clear guidance in the RGDM 2011 regarding the adoption of maximum, minimum or mean rates of change of superelevation when calculating superelevation run off length. Therefore, designers are at liberty to adopt values of the rate of change of superelevation, which gives different superelevation run off lengths. Rates of change of Superelevation included in RGDM 2011 are shown in Table 7.1-1 below.

Table 7.1-1: Maximum and Minimum rate of Change of Superelevation

Design Speed Km/h	30	40	50	60	70	80	90	100	110	120
Max. Δs (%)	0.75	0.7	0.65	0.6	0.55	0.5	0.47	0.44	0.41	0.38
Min. Δs (%)		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Source: RGDM2011, Table 6-9

Superelevation Run off lengths computed based on maximum, minimum and mean rate of change of superelevation are shown in Table 7.1-2 below.

Table 7.1-2: Superelevation Runoff Length

Design speed [km/hr]	Max Run off Length	Mean Run off Length	Min Run off Length
50	32.0000	44.0000	70.0000
60	35.0000	47.0000	70.0000
70	38.0000	49.0000	70.0000
80	42.0000	53.0000	70.0000
90	45.0000	55.0000	70.0000
100	48.0000	57.0000	70.0000
110	51.0000	59.0000	70.0000

As it can be seen above, there are significant differences in lengths of superelevation run off i.e. lengths between the maximum and minimum rates of change of superelevation runoff length.

Very lengthy superelevation can cause a vehicle to take longer to change from full superelevation to adverse camber. This causes the vehicle to tilt to the opposite side, but while already outside the curve. A driver can therefore, loose control and move into the opposing lane. Furthermore, very lengthy superelevation lengths often result in flatter pavement surfaces which can cause drainage issues.

Recommendations

Superelevation lengths in the AASHTO guidelines are based on the rate of change of superelevation or relative slopes. These are included in Table 7.1-3 below. Also, figures in Table 7.1-3 have been adopted in RGDM 2011. Table 6-9 presents as the max rate of change of superelevation.

Table 7.1-3:Maximum Relative Gradients

Metric			U.S. Customary		
Design Speed (km/h)	Maximum Relative Gradient (%)	Equivalent Maximum Relative Slope	Design Speed (mph)	Maximum Relative Gradient (%)	Equivalent Maximum Relative Slope
20	0.80	1:125	15	0.78	1:128
30	0.75	1:133	20	0.74	1:135
40	0.70	1:143	25	0.70	1:143
50	0.65	1:154	30	0.66	1:152
60	0.60	1:167	35	0.62	1:161
70	0.55	1:182	40	0.58	1:172
80	0.50	1:200	45	0.54	1:185
90	0.47	1:213	50	0.50	1:200
100	0.44	1:227	55	0.47	1:213
110	0.41	1:244	60	0.45	1:222
120	0.38	1:263	65	0.43	1:233
130	0.35	1:286	70	0.40	1:250
			75	0.38	1:263
			80	0.35	1:286

Source: AASHTO Geometric Design of Highways and Streets, 2011, Table 3-15

Uganda Geometric Design Manual 2010, Section 6, page 92 states that,

> *"The superelevation runoff length obtained by the above relationship should not be less than the minimum length of runoff which is approximately the distance traveled in 2 seconds at the design speed. This minimum length should be provided from the point of view of general appearance and to avoid undesirably abrupt edge-of-pavement profiles".*

AASHTO Geometric Design of Highways and Streets, 2018 section 3.3.8.21 mentions that the relative slopes are based on approximately the distance travelled in 2 seconds at the design speed and further, pronounces that values have considered optimal comfort and avoidance of abrupt appearance.

Amendment

1. Replace Table 6-9 of RGDM2011 with the following Table.

Table 7.1-4: Relative Gradients

Design Speed km/h	30	40	50	60	70	80	90	100	110	120
Relative Gradient (%)	0.75	0.7	0.65	0.6	0.55	0.5	0.47	0.44	0.41	0.38

2. Insert the following after Table 6-7 of RGDM2011

The superelevation runoff length obtained by the above relationship should not be less than the minimum length of runoff which is approximately the distance traveled in 2 seconds at the design speed.

This minimum length should be provided from the point of view of general appearance and to avoid undesirably abrupt edge-of-pavement profiles.

7.2. Superelevation on Gravel Road

Current Practice

RGDM 2011, Page 6.14 provides guidelines for calculating superelevation for a given radius and design speed for Gravel roads. The text and formula as extracted from Page 6.14 of RGDM2011 are shown below.

B. Guidelines for application of Superelevation on Gravel Roads

The maximum rates for super elevation to be applied on gravel roads shall be calculated using the following relationship:-

$$e = \frac{V_D^2}{260R}$$

Where:

e = super elevation rate (decimals)

V_D = design speed (km/h)

R = radius of curve (m)

- The values of superelevation to be applied shall be rounded – off to the nearest 0.001 or 0.1%.
- The maximum rate of superelevation for gravel roads shall be 0.06 (6%) irrespective of terrain classification.

Below is guidance for application of superelevation where the value of e computed by the formula above is less than 0.03;

- For $0.03 \geq e > 0.002$ remove adverse crown only
- For $e < 0.002$ use normal camber

Source, Extract RGDM 2011, Page 6.14

Identified Issue

A vehicle driven on a gravel road curve will experience less friction and is likely to lose control compared to a similar vehicle driven on a paved road with same radius and speed.

The gravel road is using different methods of determining superelevation without considering the effects of side friction. For example, when the superelevation guidelines for Gravel Roads is applied on a Curve Radius of 400m and Design Speed of 60kph, the superelevation is calculated 4.0%. However, the AASHTO method included in the same manual (RGDM 2011), gives superelevation of 6.0% for the same curve radius and design speed. The comparison of superelevation determined by two methods is included in Appendix 7.1.

Recommendation

Gravel roads tend to have less side friction especially when the gravel is wet. To enhance safety, it is advised that geometry for gravel road follow the same principle as paved road and adjust the friction factor according to surface type.

The Ethiopia Geometric Design Manual 2013 (ERGDM 2013) uses AASHTO Method to calculate superelevation rates and recommends side frictions to be used for unpaved roads.

Further, ERGDM 2013 restrict superelevation to maximum of 4%. RGDM 2011 allows superelevation for gravel road to maximum of 6%. Ethiopia Geometric Design Manual assumes that friction factors for unpaved road is about 80% of the paved roads. Table 7.2-1 below which is an extract from ERGDM 2013, presents recommended friction factors for unpaved roads.

Table 7.2-1: Side Friction Factor for Gravel Road

Design speed (km/h)	20	25	30	40	50	60	70	80	85	90	100
Side Friction Factor	0.19	0.17	0.16 5	0.15	0.14	0.12	0.11	0.10	0.10	0.10	0.09

Source: Table 8-2, ERGDM 2023, Page 8-11

Amendment

1. Remove the paragraphs and associated formula below from page 6-14, RGDM2011

> The maximum rates for super elevation to be applied on gravel roads shall be calculated using the following relationship:-
>
> $$e = \frac{V_D^2}{260R}$$
>
> Where:
>
> e = super elevation rate (decimals)
>
> V_D = design speed (km/h)
>
> R = radius of curve (m)
>
> - The values of superelevation to be applied shall be rounded – off to the nearest 0.001 or 0.1%.
> - The maximum rate of superelevation for gravel roads shall be 0.06 (6%) irrespective of terrain classification.
>
> Below is guidance for application of superelevation where the value of e computed by the formula above is less than 0.03;
>
> - For $0.03 \geq e > 0.002$ remove adverse crown only
> - For $e < 0.002$ use normal camber

2. Insert under Section 6.3.5 B

The minimum radius for Gravel Road shall be determined with the same principles as for paved road and as described in Section 6.3.4 of RGDM 2011. However, the following Side Friction shall be used in calculating minimum radius on the Gravel Roads.

Design speed (km/h)	20	25	30	40	50	60	70	80	85	90	100
Side Friction Factor	0.19	0.17	0.16 5	0.15	0.14	0.12	0.11	0.10	0.10	0.10	0.09

7.3. Successive Curves

Current Practice

Section 6.3.9 of RGDM 2011 discusses and provides guidance on how to safely use different types of successive curves. Two successive curves should not be different by more than 50% in radius. For example, if the first curve is 200m radius, the successive curve should be more than 400m radius or less than 100m radius. The designer is free to choose the successive curves as long as they do not exceed the ration of 1.5.

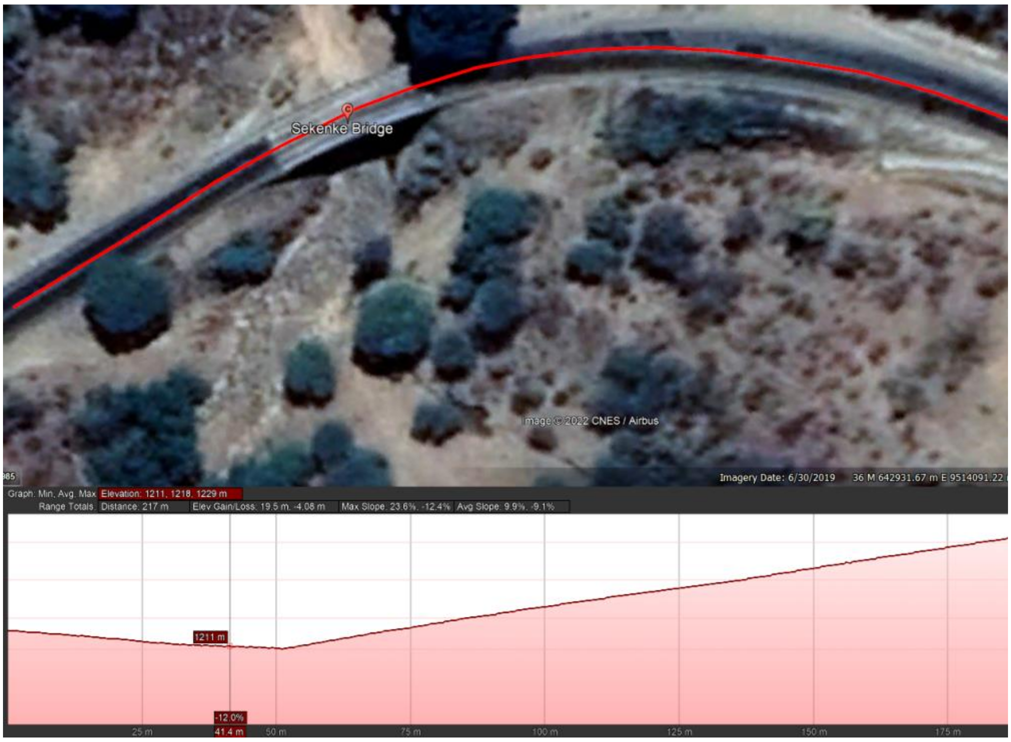
Identified Issue

Changes on curves radii along the road normally result on speed changes. Excessive speed changes along the road can easily result on drivers applying sudden brake or losing control. The change in radius between successive curve should be as smooth as possible to limit extent of speed change and possibility of overshooting especially if the curve ahead has a smaller radius. Figure 7.3-1 below is Sekenke Bridge in Shinyanga and Figure 7.3-2 is the google image and profile of the same bridge.

Figure 7.3-1: Sekenke Bridge

Source, Grandconsult

Figure 7.3-2: Google Image Plan and Profile, Sekenke Bridge



Source, Grandconsult

This bridge has a history of fatal crashes where, vehicles coming from the hill sides tend to fail to negotiate the curve on the bridge.

During a Road Safety assessment for The Central Corridor Transit Transport Facilitation Agency (CCTTFA) in 2017, it was noted that the curve on approach to the bridge is not exactly the same as the curve on the bridge.

The curve on the bridge is tighter than the approach curve. Some vehicles approaching the bridge from the south (downhill) fail to negotiate the curve on the bridge and careen (overshoot) into the river.

Recommendation

The Ethiopia Geometric Design Manual provides more guidance on how to select suitable successive curves to minimize negative impact.

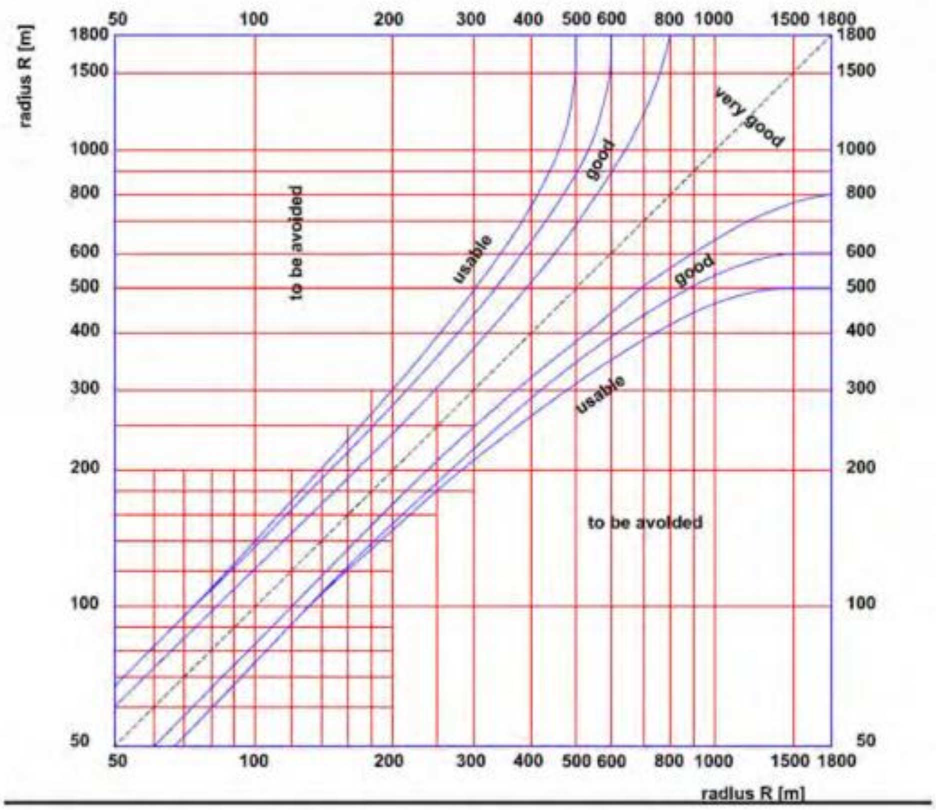
It is recommended that the guidelines are added into RGDM 2011 as explained below.

Amendment

2. Under Section 3.6.9, A, after 3rd Paragraph add the following:

   Figure 7.3-3 below is a graph that provides a suitable ratio between successive curves, to ensure speed changes are minimized.

Figure 7.3-3: Ratio of radii of consecutive horizontal curves



Source: Ethiopia Geometric Design Manual 2013. Figure 8-1.
Original Source: German Road and Transportation Research Association, Cologne, Germany (1973). Guidelines for the design of rural roads (RAL), Part II.

When the horizontal curves cannot be avoided on bridges, it is recommended to use one curve radius only i.e., not compound curves. Tight horizontal curves should be avoided on bridges.

7.4. Fill Widening

Current Practices

Embankment widening is required at high fills partly for the psychological comfort of the driver.

Since RGDM 2011 is silent about embankment widening on high fills, some designers will opt to use or not to use embankment widening because it is not a requirement in the RGDM 2011. It's inclusion mostly depends on whether it is specifically stated in the Design Terms of Reference.

This constraint becomes more apparent during implementation of Design and Build project because contractors will not want to spend more money on earthworks if is not part of the Client's Requirement.

Identified Issue

High embankments create psychological discomfort to drivers especially when opposing vehicles are passing each other. As a result of that, some drivers tend to keep close to the centerline thus creating a high risk of a crash. This type of incidence is common on sag curves on highway embankments.

This discomfort is normally reduced by widening the carriageway on such high embankment.

Recommendation

Uganda Geometric Design Manual provides Guidance on the extent of Fill widening required in relation to embankment height. See Table 7.4-1 below.

Table 7.4-1: Widening on Curves and on High Fills

Radius of Curve [m]	Curve widening		Fill widening	
	Single lane	Two lane	Height of fill [m]	Widening [m]
			0.0 – 3.0	0.3
20-40	0.6	1.5	3.0 – 6.0	0.6
41 – 60	0.6	1.2	6.0 – 9.0	0.9
61 – 120	0.0	0.9	Over 9.0	0.9
121 – 250	0.0	0.6		
>250	0.0	0.0		

Source: Uganda Geometric Design Manual 2010, Table 6-10

Rwanda Geometric Design Manual 2014, also provides Guidance on the extent of Fill widening required in relation to embankment height, see Table 7.4-2 below.

Table 7.4-2: Widening on Curves on High Fills for Class 1 and 2 Road Only

Radius of Curve (m)	Curve Widening: Single Lane (m)	Curve Widening: Two Lanes (m)	Fill Widening	
			Height of fill (m)	Amount (m)
>250	0.0	0.0	0.0-3.0	0.0
120- 250	0.0	0.6	3.0- 6.0	0.3
60-120	0.0	0.9	6.0 - 9.0	0.6
40-60	0.6	1.2	Over 9.0	0.9
20-40	0.6	1.5	Over 9.0	0.9

Source: Rwanda Geometric Design Manual 2014, Table 6-3

Ethiopia Geometric Design Manual 2013 also provides Guidance on the extent of Fill widening in relation to embankment height Table 7.4-3 below.

Table 7.4-3: Widening on curves and High Fills

Radius of Curve (m)	Curve Widening: Single Lane (m)	Curve Widening: Two Lanes (m)	Fill Widening	
			Height of fill (m)	Amount (m)
>250	0.0	0.0	0.0-3.0	0.0
120- 250	0.0	0.6	3.0- 6.0	0.3
60-120	0.0	0.9	6.0 - 9.0	0.6
40-60	0.6	1.2	Over 9.0	0.9
20-40	0.6	1.5	Over 9.0	0.9
<20	See Section 8.10: Switchbacks			

Source: Ethiopia Geometric Design Manual 2013, Table 8-3

The above three Tables are similar in terms of fill widening. To ensure that the carriageway is widened in order to reduce d driver's psychological discomfort on high embankment, we recommend that Embankment Fill widening details are included in RGDM 2011.

Amendment

1. Add the following under Section 6.3.7, after the last paragraph,

   Embankment widening is required at high fills for the psychological comfort of the driver. The widening is applied on both edges of the carriageway. The embankment widening shall be in accordance with Table 7.4-4 below. The values in Table 7.4-4 are for one side of the carriageway.

Table 7.4-4: Embankment Widening

Embankment Widening (Edgeof Carriageway	
Fill Height (m)	Fill Widening (m)
0.0 - 3.0	0.3
3.0 - 6.0	0.6
6.0 - 9.0	0.9
> 9.0	0.9

7.5. Relief Gradient

Current Practice

The length of grade is controlled by Table 6-12 and Table 6-13 of the RGDM 2011, where Limiting grades and Critical length of grades for vertical alignment are defined. See Table 7.5-1 and Table 7.5-2 below. Some Roads in Tanzania have long continuous grades where designers recommend some mitigating measures like the use of low gear on down grade, prohibition of overtaking and introduction of climbing lanes to improve safety.

Table 7.5-1: Maximum Grades (%)

Terrain	Design Speed (km/h)								
	40	50	60	70	80	90	100	110	120
Flat			5	5	4	3.5	3	3	3
Rolling	8	7	6	6	5	4.5			
Hilly/ Mountainous	10	9	8	7	7				

Source: Tanzania Geometric Design Manual 2011, Table 6-12

Table 7.5-2: Critical Length of Grades

Gradient	Length of grade at design speed of 60 km/h	Length of grade at design speed of 80 km/h	Length of grade at design speed of 100 km/h	Length of grade at design speed of 120 km/h
3%	NA	≥ 900 m	≥ 175 m	0
4%	≥ 1200 m	≥ 550 m	≥ 125 m	0
5%	≥ 800 m	≥ 400 m	≥ 110 m	0
6%	≥ 600 m	≥ 350 m	≥ 90 m	0
7%	≥ 500 m	≥ 300 m	≥ 75 m	0
8%	≥ 400 m	≥ 200 m	≥ 40 m	0

Source: Tanzania Geometric Design Manual 2011, Table 6-13

Identified Issue

When vehicles are climbing long steep grades, the engines are normally overworked and they overheat. Some heavy loaded trucks will experience mechanical failures on transmission systems. Some heavy vehicles on long upgrade loose power to continue uphill, putting them at high risk of rolling back downhill.

When heavy vehicles are on long downgrade, drivers tend to use brakes so often that sometimes the braking systems overheat and fail to stop the vehicle. This is a common cause of crashes for vehicles on steep grades.

AASHTO 2018, A Policy on Geometric Design of Highway and Streets, Page 3-136, 4th Paragraph recommends that where the length of critical grade is exceeded, an added uphill lane (Climbing Lane) should be considered to cater for slow-moving vehicles, particularly where volume is at or near capacity and the truck volume is high.

However, Climbing Lane will only increase the capacity of the lane but will not solve the problem of overheating due to long and steep grades.

Recommendation

Ethiopia Geometric Design Manual 2013, Chapter 9-11, Page 9-12 recommends that when critical length of grade is reached, it is necessary to design a relief gradient of less than 6% between steep sections. The relief gradient must have a minimum length of 100 meters.

Similarly, Rwanda Geometric Design Manual 2014, Chapter 7-8, Page 7-11, Second Paragraph recommends that when these distances are reached, consideration should be given to designing a relief gradient of less than 6 percent between steep sections, with a minimum of 100 meters.

The relief gradient will provide heavy loaded truck space to cool down the engines and breaks. The relief gradient, when provided will benefit both up grade and down grade heavy vehicle. Therefore, it is recommended that provision of relief gradients be made on long steep gradients where terrain permits.

Amendment

1. Add the following paragraph under Section 6.3.10, Page 6.25 after the last paragraph,

   When critical length of grade is exceeded, it is necessary to design a relief gradient of less than 6% between steep sections. The relief gradient must extend to a minimum of 100 meters.

7.6. Switchback Curve (Hairpin) Vertical alignments

Current Practice

Section of 6.3.10 of RGDM 2011, gives guidance on designing horizontal alignment of hairpins (switch back curves). Hairpins are used in mountains and escarpments. RGDM 2011, is silent on approach grades to hairpins. On some occasions steep vertical alignment will continue even around the corner. Figure 7.6-1 below is an example of switchback (hairpin) curve in Ethiopia.

Figure 7.6-1: Existing Switchback Curve (Hairpin), Gore-Masha-Tepi Road Ethiopia

Source, Grandconsult

Identified Issue

A steep gradient during turning poses high risk of a vehicle failing to complete turning maneuvers because of a rapid increase on gradient in edges of the road.

Recommendation

Ethiopia Geometric Design Manual 2013, Chapter 9.7, page 9-9 states that where switchback curves are unavoidable in mountainous or escarpment terrain, there is a need to reduce the maximum allowable gradient at any point through the curve. The maximum allowable gradient through switchback curve is 4% for Road Standards DC8 to DC5, and 6% for DC4 to DC1. The minimum allowable gradient is 0.5%.

Rwanda Geometric Design Manual 2014, Chapter 7.5, page 7-8 states that where switchback curves are unavoidable in mountainous or steep terrain, there is a need to reduce the maximum allowable gradient at any point through the curve. Otherwise, the combination of the superelevation and the longitudinal gradients make the combined gradient at the inner road edge too steep. The maximum allowable gradient through a switchback curve is 4% for Road Classes 1 and 2, and 6% for Classes 3-5 and Single Lane roads. The minimum allowable gradient through a switchback curve is 0.5%.

Corresponding crest and sag curves approaching the switchback curve must meet the requirements of subsections 7.3 and 7.4, and the transitions must be completed outside of the switchback curve. The sag curve above the switchback shall be made as long as possible to allow ascending vehicles to accelerate at the flatter grade when leaving the switchback, and for descending vehicles to slow down before the curve.

Subsection 7.3 in Rwanda Geometric Design Manual 2014 provides details for Sag and Crest curve parameters while subsection 7.4 provides details of maximum gradients.

It is recommended to limit longitudinal gradient at any point through the switchback curve to 4%.

Further, it is recommended to extend the maximum gradient of 4% to a minimum 150 m from the end of a switch back curve on both sides.

Amendment

2. Add the following after Figure 6-13 in RGDM 2011

   It is recommended to limit longitudinal gradient at any point through the switchback curve to 4%.

   The maximum gradient of 4% shall be extended to minimum a 150 m from the end of switch back curve on both sides

   Corresponding crest and sag curves approaching the switchback curve must meet the requirements of Table 6-14, and the transitions must be completed outside of the switchback curve.

   The sag curve on upgrade side of the switchback shall be made as long as possible to allow ascending vehicles to accelerate at the flatter grade when leaving the switchback, and for descending vehicles to slow down before the curve.

7.7. Climbing Lanes

7.7.1. Warranty for Climbing Lanes

Current Practice

Section 6.4.1 Gradients Part (c) Climbing lanes, of the RGDM 2011, provides for Warrant for Climbing Lanes. This sections states:

Once the critical lengths of gradients shown in Table 6-13 are exceeded the designer should consider the traffic, terrain and economic factors before deciding on whether to introduce a climbing lane or not. A traffic volume of ADT ≥ 1500 shall warrant the introduction of a climbing lane when the critical length of gradients is exceeded.

Identified Issue

When you have a significant number of slow-moving vehicles (normally loaded trucks) on steep long grade, they will force faster moving vehicles to queue behind them until the opportunity to overtake comes. In many cases, overtaking opportunities are limited on long and steep grades. Therefore, a long queue will build up and reduce road capacity at that location. Some drivers will become impatient and take the risk of overtaking slow-moving vehicles and put all road users at high risk of a serious crash. In this case the provision of a climbing lane will be necessary for safety and capacity reasons.

On the other hand, when there is an insignificant number of heavy trucks, there will be more gaps and opportunities to overtake thus limited reduction of capacity and less risk of serious crashes. In this case provision of climbing lanes may not be very necessary.

However, the composition of that traffic has not been mentioned in RGDM 2011 Section 6.4.1. Steep grades have significant impact on heavy trucks speed during climbing but insignificant for light vehicles thus affecting overall Level of Service and safety operation of the section.

Very low proportion of heavy vehicles in the traffic stream will have less impact on overall speed reduction. Thus, provision of climbing lane for fast moving vehicles will not be economically feasible.

Recommendation

Therefore, it is recommended that Warrant for climbing lane should not only consider traffic volumes but other criteria like the drop in truck speed, drop in Level of Service, and traffic mix (proportion of trucks in the stream). The following methods have been developed and used by different countries in the region.

SATCC Geometric Design Manual Section 4.5.1 use the following criteria to evaluate need for climbing Lane:

- Speed drop by 20 kph established from truck speed profile
- Traffic Volume in design hour (vph) as shown in Table 7.7.1-1, extracted from of SATCC Code of Practice for Geometric Design of Trunk Roads, 2011.

Table 7.7.1-1: Traffic Volume Warrants for Climbing Lanes

Gradient (%)	Traffic volume in design hour (veh/h)	
	5 % trucks in stream	10 % trucks in stream
4	632	486
6	468	316
8	383	257
10	324	198

Source, Code of Practice for the Geometric Design of trunk Roads, 2011 Table 4.5

The EAC recommends the use of the following AASHTO warrants for climbing lanes:

i. Upgrade traffic flow rate in excess of 200 vehicles per hour

ii. Upgrade truck flow rate in excess of 20 vehicles per hour

iii. One of the following conditions exists:

   a) A 15 km/h or greater speed reduction is expected for a typical heavy truck

   b) Level of service E or F exists on the grade

   c) A reduction of two or more levels of service is experienced when moving from the approach segment to the grade.

Uganda Road Geometric Design Manual 2010, Section 6.6 provides criteria to Warrant for Climbing Lane as described below

i. Climbing lanes will not be required on

   a) Roads with AADT < 2000 pcu in design Year 10

   b) On all design Class, III, A, B Roads if AADT exceeds 2000 pcu in design year 10

ii. Where passing opportunities are limited on the gradients, then climbing lanes must be considered on the design class I & II with traffic flows in design year 10 in the range of 2000 pcu < AADT < 6000 pcu.

iii. Climbing lanes will normally be required on roads with AADT >= 6000 pcu in design year 10

Climbing lanes should be considered if the truck speed decreases more than 20 km/h under the truck speed limit, normally 80 km/h in rural conditions.

In summary the following is recommended procedures on Warrant for climbing lanes.

Determine whether truck speed will drop by 20 kph from the onset speed before start climbing. If the drop is less than 20 kph, then climbing lane should not be considered.

If the speed drop is more than 20 kph then determine the 10-year design hourly traffic volume in each direction and proportion of trucks in the mix.

Then use Table 4-5 from SATCC with appropriate gradient trucks proportion to check whether 10-year design hourly volume exceeds indicated value. If that is the case then, Climbing Lane is required.

Amendment

1. Replace the whole paragraph under "Warrant for climbing lanes" in Page 6.26 of RGDM2011 with the following.

   Once the critical lengths of gradients shown in Table 6-13 are exceeded, the designer should consider the traffic volume and its composition, terrain and economic factors before deciding on whether to introduce a climbing lane or not.

   Determine whether truck speed will drop by 20 kph from the onset speed before start climbing. If the speed drop is less than 20 kph, then climbing lane should not be considered.

   If the speed drop is more than 20 kph then determine the 10-year design hourly traffic volume in each direction and the proportion of trucks in the mix.

   Then use Table 7.7.1-2 *from SATCC with appropriate gradient and trucks proportion to check whether 10-year design hourly volume exceeds indicated value.*

   If the design hourly volume at specified truck proportion and gradient exceeds values in the Table 7.7.1-2*, then Climbing Lane is required.*

Table 7.7.1-2: Traffic Volume Warrants for Climbing Lanes

Gradient (%)	Traffic volume in design hour (veh/h)	
	5 % trucks in stream	10 % trucks in stream
4	632	486
6	468	316
8	383	257
10	324	198

7.7.2. Misuse of Climbing Lanes

Current Practice

In recent years, inappropriate use of Climbing Lanes has been noticed on number of the roads, including Chalinze - Segera Section and Salanda Hill.

What was observed is, fast downhill moving Public Buses are using the middle uphill lane to overtake slow downhill moving vehicles.

Similarly, some of uphill fast-moving vehicles use opposing lane to overtake vehicle on both climbing lane and normal uphill lane.

Figure 7.7.2-1 below is the photo showing overturned trailer and truck which was trying to avoid a bus which was overtaking other vehicle in upward direction using opposing lane on Salanda Hill

Figure 7.7.2-1: Consequences of overtaking, Salanda Hill

Source, Central Corridor Road Safety & Security Audit, 2018

Identified Issue

The misuse of traffic lanes put the drivers at very high risk of head-on collision which can be fatal.

This imposes very high-risk fatal crashes to fast uphill moving vehicles. Crashes of similar nature have been reported on Salanda Hill section in Singida and other places in the country.

Recommendation

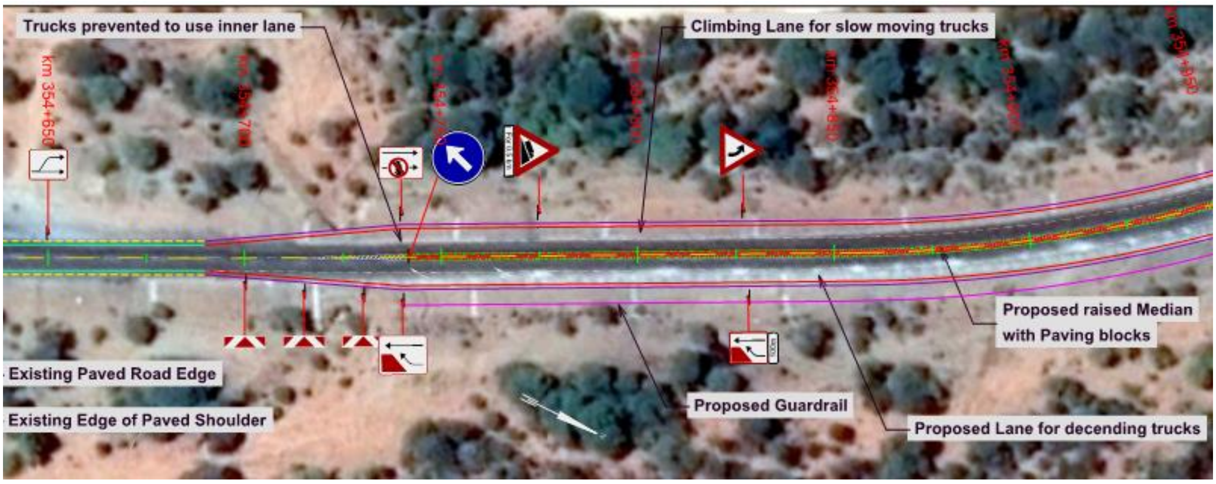
In such situation it is recommended to provide completely separated upgrade and downgrade lanes by using concrete barrier. The separation should be done well in advance with proper signage to prevent driver choosing wrong lanes.

Alternatively, upgrade and down grade lanes should be completely separated with central wide median or even separated both horizontally and vertically to omit possibility of opposing traffic meeting on steep section.

An example of separation of uphill and downhill lane is shown in Figure 7.7.2-2 and

Figure 7.7.2-3 below.

Figure 7.7.2-2: Start of Climbing Lanes



Source, Central Corridor Road Safety & Security Audit Report, 2018

Figure 7.7.2-3: End of Climbing Lane

Source, Central Corridor Road Safety & Security Audit Report, 2018

Amendment

1. It is recommended to add the following paragraph after Figure 16-6 of RGDM2011.

   When there is high risk of traffic misusing the climbing lanes, crashes are likely to be fatal. Therefore, it is recommended to provide completely separated upgrade and downgrade lanes by using concrete barrier. The separation should be done well in advance with proper signage to prevent driver choosing wrong lanes.

   Alternatively, upgrade and down grade lanes should be completely separated with central wide median or even separated both horizontally and vertically to omit possibility of opposing traffic meeting on steep section.

8 Chapter 7: At Grade Intersections

8.1. Approach Grade to Side Junction

Current Practice

When there is significant elevation difference between main road and side road, there is tendency to connect the minor road to main road at any grade which fits with level difference between the two. Some of these connections end up having very steep grades. The picture below shows a typical example of the problem. Figure 8.1-1 below was taken at Bwawani near Wazo hill Cement Factory.

Figure 8.1-1: Steep Grade connection of Minor Road to Major Road

Source, Grandconsult

Identified Issue

RGDM 2011, discusses and provides guidance on how junctions should be designed in order to ensure that the required sight visibility at the junction is achieved. Those recommendations work well when the side junctions are connected to major roads on a relatively flat vertical alignment from side road.

When the side junction or junctions are located on deep cut or deep fill, the connection to the main road ends with steep gradients. Steep gradients put drivers coming from the lower end or going down to main road at risk of either failing to break or failing to climb. RGDM 2011 is silent on the approach grade to the junction. Vehicles rolling back hill have been observed at a number of places.

The elevation difference between two roads creates visibility issues thus putting road users at high risk of crashes.

Recommendation

Section 10.3 of the Rwanda Road Geometric Design Manual provides guidance which helps in controlling the approach gradient to any intersection:

Amendment

1. Add the statement below after 5th Paragraph, Section 7.6.7 of RGDM 2011;

   Intersections should be located where sight distances both horizontally and vertically are met.

   The approach grade connecting intersections shall not exceed 4% and shall have minimum length of at least 50m before the junction to ensure sight visibility.

   The approach grade from side roads connecting to the main road shall not exceed 4%. Such approach grade shall be at least 30 m in length to accommodate at least 2 vehicles while at a stop, waiting to enter the main road from the junction.

   Alternatively, acceleration lane for left turning traffic should be provided to allow for seamless merging. Right turning traffic must have sufficient visibility before entering the junction.

9 Chapter 8: Road Furniture and Other Facilities

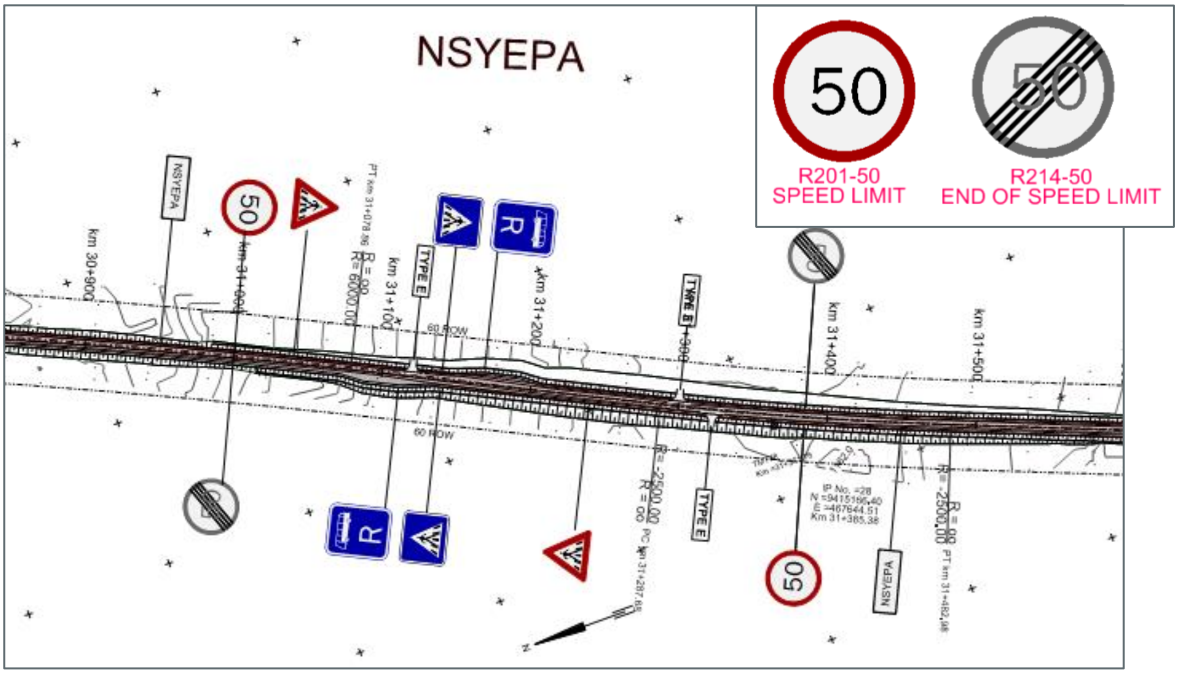
9.1. Traffic Signs and Road Marking

Current Practice

Drivers will normally regulate their vehicle speeds to comply with posted speed limit signs when approaching speed restricted sections such as built-up areas (urban area, village) and other speed restricted areas such as sharp bends. The speed limit will normally be maintained when driving through the speed restricted section. When departing built-up areas, drivers will normally face a sign which indicates end of speed limit, where thereafter they will drive with speed of their choice because there are no posted speed signs to guide them. Sometimes onwards speed limits on sharp bends are installed.

An example of arrangement of speed limit sign and end of speed limit sign commonly found in Tanzania is shown in Figure 9.1-1 below.

Figure 9.1-1: Example of End of Speed Limit Sign, Nsyepa



Source, Tabora Koga Mpanda Road Project, TANROADS

Identified Issue

The Highway Code by Ministry of Infrastructure and Development, 2008 under Section “Speed”, subsection “Obey the speed limits” states;

“You MUST NOT exceed the maximum speed limit for your vehicle. Currently the legal limits are:

50 km/h *for all vehicles in built-up areas (even if there is no traffic sign).*

80 km/h *for heavy vehicles (>3500 kgs gross vehicle weight) and public service vehicles (buses, coaches, but not taxis) outside built-up areas.*

100 kph *is the maximum speed for cars and other light vehicles outside built-up areas*

These limits may be varied by local speed limits shown by a regulatory traffic sign. You MUST NOT exceed the maximum speed indicated on the sign. ***Remember that a speed limit does not mean that it will always be safe to drive at that speed****. You must drive at a speed that* is safe for road, traffic and weather conditions.

Traffic police have been enforcing speed limits instituted for public buses and heavy good vehicles even outside built-up areas. However, maximum speed of 100 kph for cars and other light vehicles is only stated as advisory in The Highway Code and has been difficult to enforce. There are no signs to advise road users and enforcing agents on onward speed limits outside built-up areas, and other restricted areas, for cars and other light vehicles.

Speed restrictions minimize risks for road crashes that result from driver's speed choices. Safe speed reduces the severity of a crash if it happens. Traffic police, on many occasions have reported crashes being caused by high speed "Mwendo kasi".

It must be noted that all roads in Tanzania are designed to predetermined design speeds which are defined in RGDM 2011 in the "Abbreviations and Definition" Section, Page vi.

A speed is selected for purposes of design and correlation of those features of a road, such as curvature, superelevation and sight distance, upon which the safe operation of vehicles is dependent.

A guide to Traffic Signing 2009, Ministry of Infrastructure Development, Tanzania, has adopted SADC Traffic Road Sign Manuals as a guideline for Road Signing and Marking.

SADC Road Sign Manuals for example, do not provide End of Speed Limit Sign (De-restriction sign) but do for onwards speed limits that are suitable and safe for onward sections. For example, when departing 50 kph speed restriction area a driver will face another sign indicating speed limit ahead, say 70 or 100 kph.

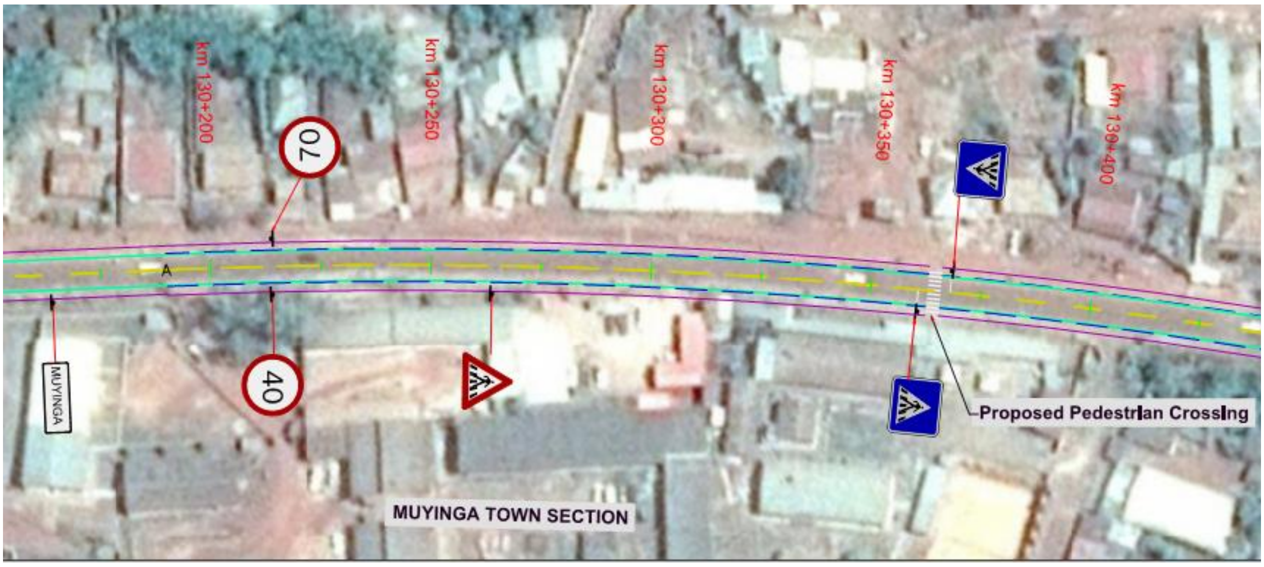
Recommendations

Introduction of upper speed limits throughout the road which are dependent on road environment and design speed will reduce risk of crashes related to over speeding and loss of vehicle control that we currently experience.

The Republic of Rwanda not only implements speed restriction including the required upper speed limit but also the gradual speed changes. Figure 9.1-2 and Figure 9.1-3 below present examples of application proposed speed restriction to 40 kph and upper speed limit of 70 kph outside restricted area at Muyinga Town in Bugarama, Rwanda. Rwanda adopted similar solutions in other areas.

Figure 9.1-2 below, shows an example of 40 kph speed limit sign on entry to Muyinga Town in Rwanda (RHS Driving) and on the opposite side is onward speed limit sign of 70 kph on exit of Muyinga Town.

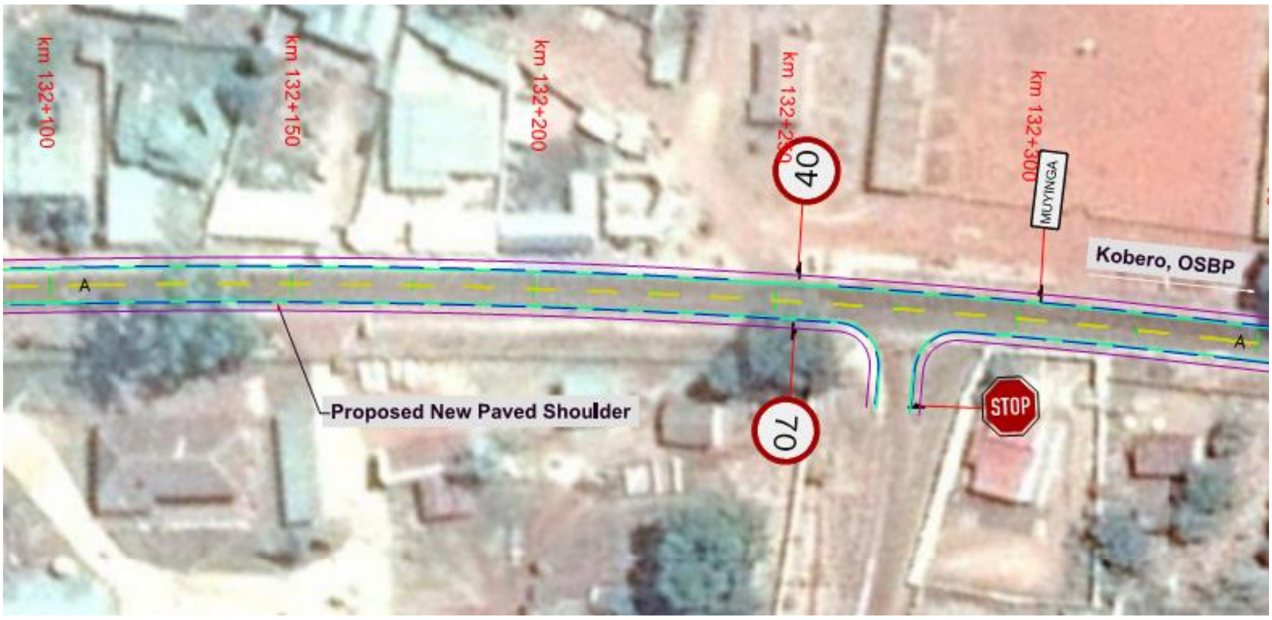
Figure 9.1-2: Entry to Restricted Area Left to Right direction, Muyinga Town



Source, Central Corridor Road Safety & Security Audit Report, 2018

Similarly, Figure 9.1-3 below shows an example of 70 kph onward speed limit on exit of Muyinga and on the opposite side is a 40 kph speed limit sign on entry to Muyinga Town.

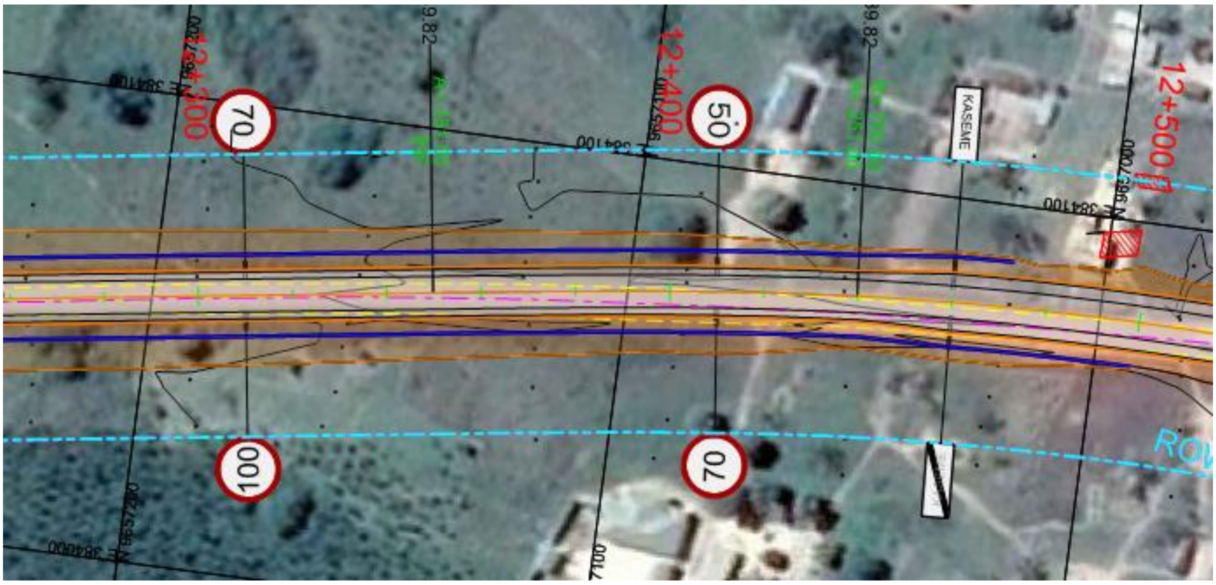
Figure 9.1-3: Exit from Restricted Area Left to Right direction, Muyinga Town



Source, Central Corridor Road Safety & Security Audit Report, 2018

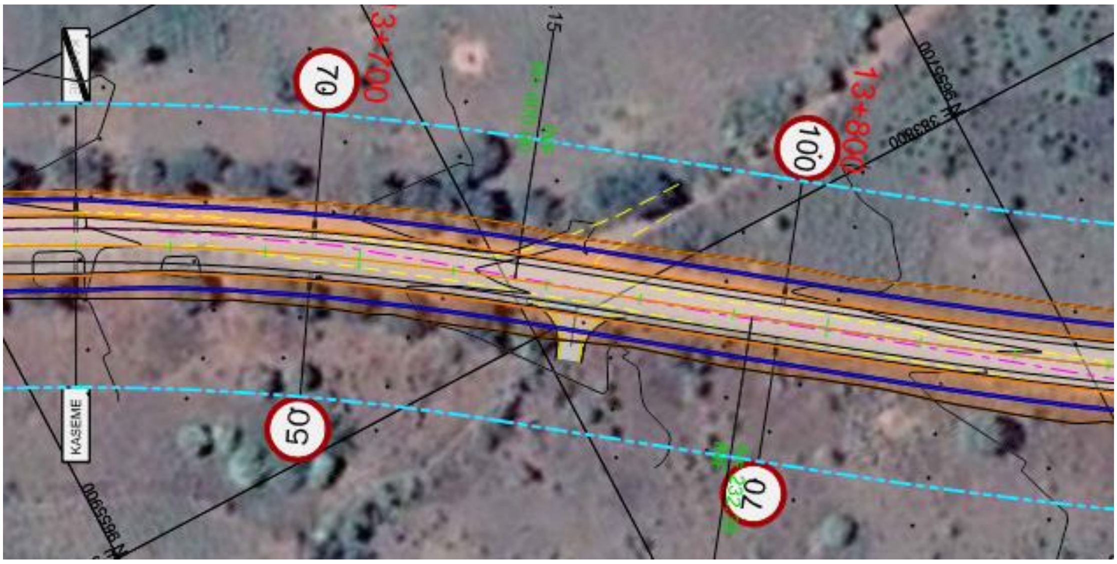
Figure 9.1-4 and Figure 9.1-5 below show examples of proposed application of gradual speed reduction and speed increase respectively, in both direction, at entry and exit to and from a village in one of the project areas in Tanzania.

Figure 9.1-4: Entry to Speed Restricted Section



Source, Grandconsult

Figure 9.1-5: Exit to Speed Restricted Section



Source, Grandconsult

Section 2.4.1 (3) of SADC Road Traffic Signs Manual, Volume 1 states that,

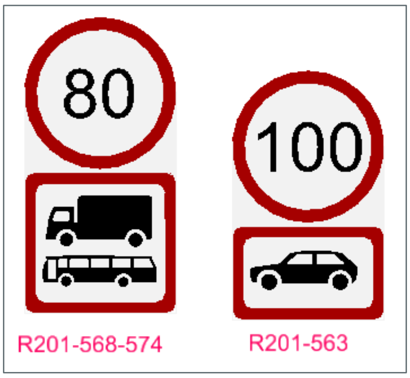
"Since R201 sign automatically cancels a different speed limit applicable to roadway immediately prior to the sign, R201 signs should not be preceded or accompanied by speed de-restriction sign. In terms of the above, ***the use of speed de-restriction signs is not recommended****"*

Section 2.9.1(3) of SADC Road Signs Manual, Volume states that,

"In isolated instances it may be of advantage to indicate the termination of some other regulation in the MANDATORY COMMAND OR MANDATORY PROHIBITION groups. However, it is recommended that the change in regulation be given by placing of a sign indicating the new level of regulation (see Subsection 2.1.1 paragraph 2.1.1.7). ***De-restriction signs (R)600 shall not be used to indicate a change in SPEED LIMIT or MINIMUM SPEED. A change in speed limit shall be indicated by display of the relevant R101 or R201 sign****".*

The Highway Code provides two upper speed limits i.e., 80 kph for heavy good vehicles including public transport and 100 kph for cars (advisory). SADC Traffic Sign Manual, Volume 1 provides guidance on SELECTIVE RESTRICTIVE SIGNS which can be used to make a combination of signs for example, Speed limit to specific vehicle type i.e., LIMIT-OBJECT. This means there will be two posted signs, one for cars and another one for trucks/public buses as shown in Figure 9.1-6 below.

Figure 9.1-6: Speed Limit with Selective Restrictive Sign



Source, Grandconsult Proposal

R201-568-574 is a speed limit for goods vehicles and public buses. R201-563 is for cars and other light vehicles. These signs could be separated by 100m with R201-568-574 starting followed by R201-563.

Amendment

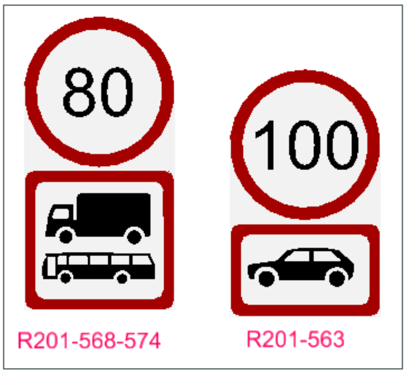
1. Add the following after 3rd Paragraph, Page 9.2 Section 9.2 of RGDM 2011.

   Upper speed limits related to design speed of the road must be provided to ensure vehicles are driven within safe speeds to reduce fatal crashes as result of loss of control due to over speeding.

   Vehicle speed along the road section outside speed restricted sections e.g., urban, villages etc. shall be regulated by posted speed limit signs depending on design speed of that particular section and wherever there is a change in speed. On long stretches with same speed limit, repeater signs should be at regular intervals.

Example of Selective Restrictive Signs, Speed Limit-Object is shown in Figure 9.1-7 *below*

Figure 9.1-7: Speed Limit with Selective Restrictive Sign



9.2. Bus bays

Current Practices

RGDM 2011, Chapter 9.4 describes the geometry of the bus bays in relation to buses. The Manual has not provided guidance on how to provide safe access to pedestrian and cyclists passing through the bus bays themselves. Last sentence in Chapter 9.4 mentions that it is important to provide passengers with a convenient and safe path to and from the bus stop.

Second paragraph of page 9.8 mention that bus bays should be located adjacent to the shoulder while Figure 9-5(a) indicates that the shoulder with a width of 3.25m is adjacent to the carriageway.

Some designers will ignore the shoulder through the bus bay therefore using a bus bay width of 3.25m from the carriageway.

Identified Issues

In congested areas, pedestrians passing through the bus bays will negotiate their way through parked buses or pass behind the bus bay. Cyclists will normally move to the carriageway to continue with their journey and negotiate their way through parked buses and moving traffic. This situation has been putting pedestrians and cyclists at high risk because of sight visibility issues.

In Tanzania, it is very common in urban areas for buses to park at the beginning of the bus bay with part of the bus body distended into the traffic lane. The next bus will often stop adjacent to previous one, further blocking the road especially during morning and evening rush hours. This situation has contributed to putting pedestrians and cyclists at high risk because of sight visibility issues.

Despite the presence of traffic police in the areas, this problem has never been resolved. The picture below shows commuter buses utilizing part of the outer lane for parking thereby reducing the capacity of the main road, and reducing passenger sight visibility against vehicular traffic on this dual carriageway road. The picture was taken at Tegeta Kwa Ndevu in Dar es Salaam. See Figure 9.2-1 and Figure 9.2-2 below.

Figure 9.2-1: Bus Bay at Tegeta Kwa Ndevu, Dar es Salaam

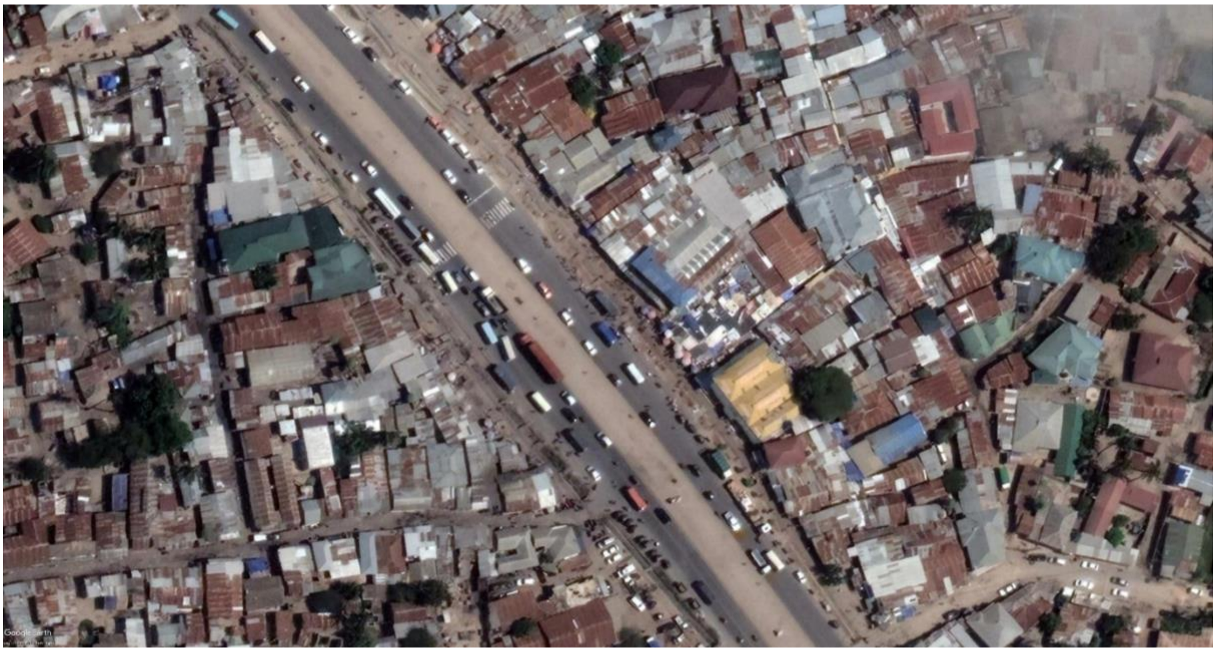
Source, Grandconsult

Figure 9.2-2: Bus bay at Tegeta Kwa Ndevu, different angle, Dar es Salaam

Source, Grandconsult

Figure 9.2-3 below shows an aerial view of how a dual carriageway is reduced to a single carriageway at a bus bay at Tegeta Kwa Ndevu, Dar es Salaam.

Figure 9.2-3: Bus bays at Tegeta Kwa Ndevu, New Bagamoyo Road, Dar es Salaam



Source, Grandconsult

Recommendations

Figure 9-5(a) should be amended so that a minimum width of 3.25m is imparted to an area adjacent to the shoulder and not carriageway. The road shoulder should provide passage for cyclists between bus bay and carriageway.

In congested areas, the bus bay must be provided with a physical median, normally 1.0m wide, to ensure that the bus bay is completely off the shoulder or the carriageway, in case there are no shoulders.

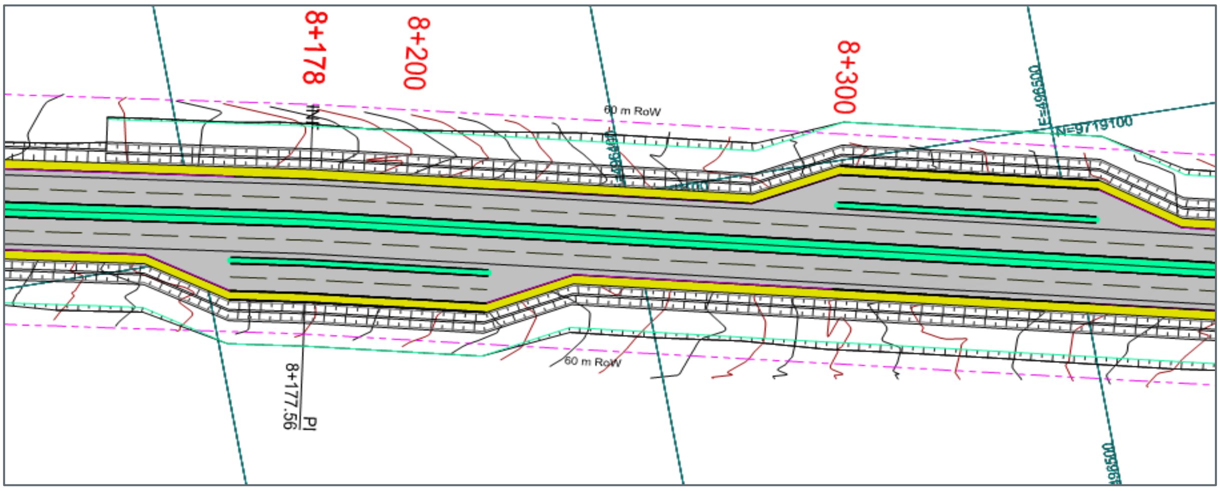
Further, whenever possible, bus bays should have two lanes, outer one used for parking and an inner one (close to the road) for passing (entry and exit). This arrangement has been adopted at Ukonga Banana Bus bays along Nyerere Road as shown in Figure 9.2-4below.

Figure 9.2-4: Bus bays at Ukonga Banana, Dar es Salaam

Source, Grandconsult

A similar proposal has been made to Mwanza-Nyanguge for upgrading to dual Carriageway. See Figure 9.2-5 below.

Figure 9.2-5: Bus bay with two lanes and physical separation



Source, Grandconsult

Safety to all road user is greatly improved when sight visibility is ensured. The level of safety will definitely improve because of minimized unnecessary queues.

Amendment

1. The following amendments/additions/deletions are recommended.

   Amend the 2nd Paragraph on Page 9.8 of RGDM2011 to read as follow.

   > *"Bus bays should be at least 3.25 m wide and should be placed adjacent to the paved or gravel shoulder so that buses can stop clear of the carriageway. The length of a full width of a bus bay in rural areas should be not less than 15m. Where multiple bus bays are provided, when the road passes urban areas, the length of the individual bus bays should not be less than 15m. The actual length of bus bays in urban areas shall be determined by the expected number of buses required to be parked at the same time. On heavily trafficked roads, a physical channelizing island with a minimum width of 0.5m may be provided along the shoulder edge line to direct bus drivers to stop clear of the road shoulder."*

2. Add the following after above paragraph:

   The bus bay should provide safe passage for vulnerable road users. In rural areas, the shoulder is normally used by both cyclist and pedestrians. Pedestrians shall be given safe access to bus bay platforms through footpaths.

   Whenever possible, cyclists passing though the bus bays should be provided with a passage behind the footpath and bus bay. If this is not possible, cyclist should use the shoulder which is extended in front of bus bays.

   In urban areas, the physical separation between bus bay and carriageway must be provided. Note that if the road has a shoulder, the shoulder should always be continued across the bus bay.

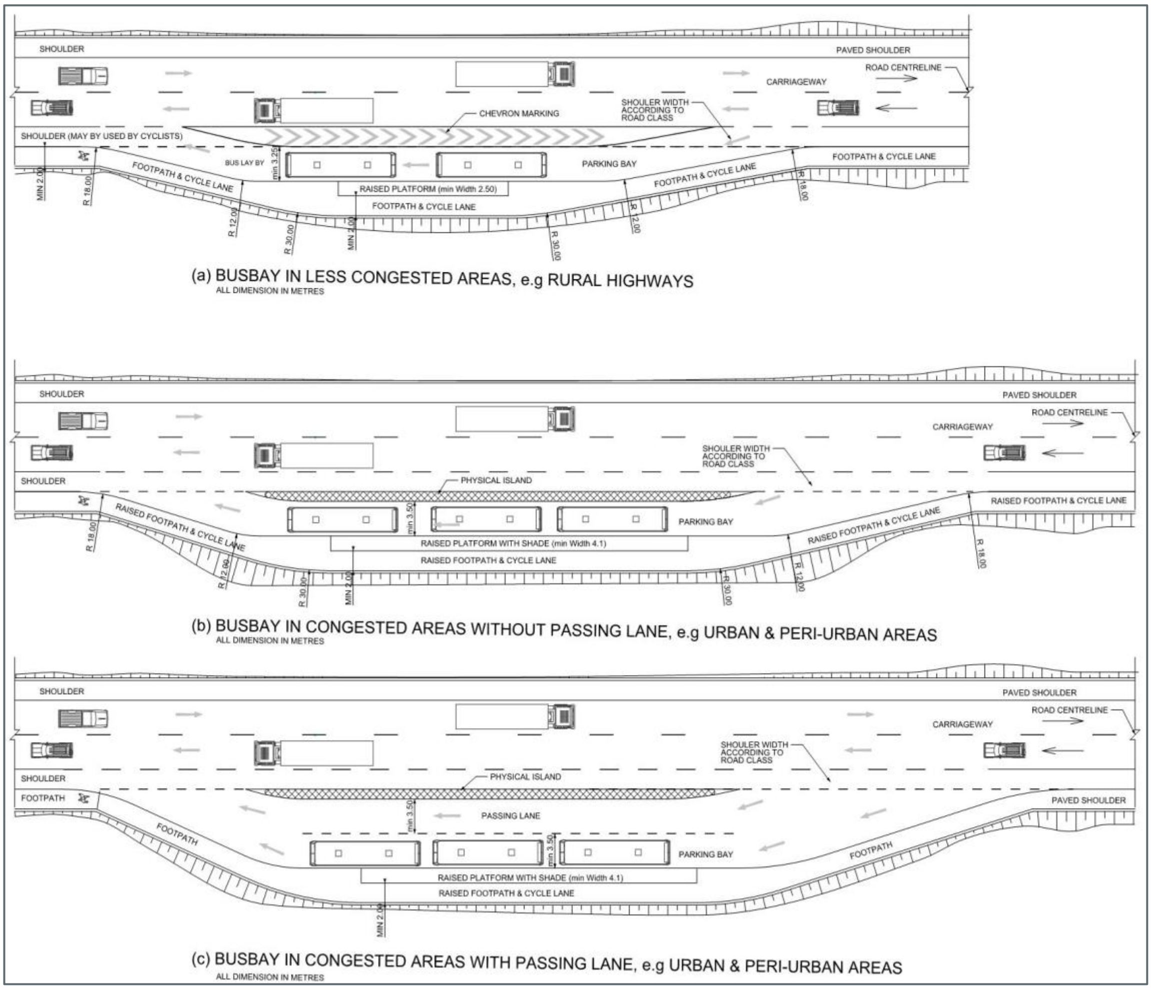
   When there is a significant number of buses in a bus bay, there may occur a tendency of some buses to block others because they are not ready to depart. This problem can be reduced by providing both passing lanes and parking lanes (parking bay) at the same time.

   The pedestrians and cyclist passing by the bus bays should be directed behind the bus bays as suggested in the Figures below. Footpath and Cycle Lane can be combined or separated.

3. Include a table defining desirable entry and exit lane lengths and tapers for varying speeds and volumes.

4. Figure 9.2-6 below presents a proposed Bus bay layout.

Figure 9.2-6: Proposed Standard Bus bays Layout



Source, Grandconsult

5. Delete Figure 9-5: Standard bus bays (now replaced by Figure 9.2-6)

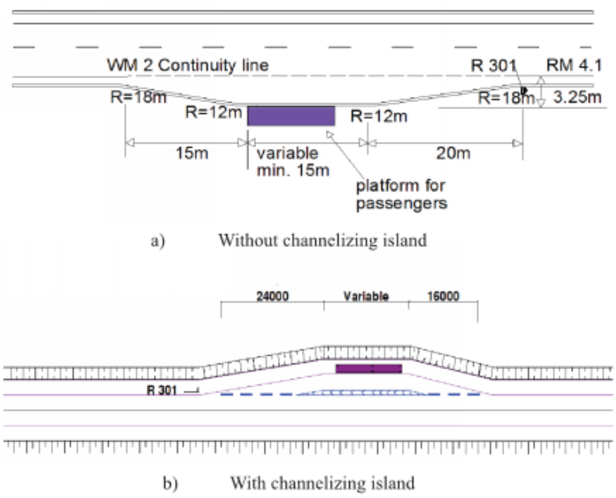


Figure 9-5: Standard bus bays

9.3. Pedestrian Fence

Current Practices

RGDM201, Chapter 9.7.14, discusses the channelizing of pedestrians when crossing the junction. Figure 9.24 in RGDM2011 provides some details on two types of Fences, one for speed less than 50 kph and another for speed higher than 50 kph.

Generally, fences for channelizing pedestrians are not given high emphasis by designers and are often overlooked by the client. Pedestrians tend to cross roads away from provided pedestrian crossings because of lack of control and direction of their movements by anyone.

It has been difficult for traffic police to control pedestrians when they cross everywhere and anywhere.

Identified Issues

Lack of control of pedestrians who are crossing at various locations such as at intersections, bus bays, schools, et cetera, normally results in exposing them to conflicts with other road users.

It is almost impossible for vehicular drivers to predict whether there will be a pedestrian who will suddenly cross in front of them. The situation becomes worse when the commuter buses are parked and other vehicles need to pass as part of the traffic flow.

Figure 9.3-1, Figure 9.3-2 and Figure 9.3-3 presents the described situation in Tegeta Kwa Ndevu, Kinondoni, Dar es Salaam.

Figure 9.3-1: Pedestrian crossing outside Zebra Crossing, Tegeta Kwa Ndevu

Source, Grandconsult

Figure 9.3-2: Pedestrian crossing outside Zebra Crossing, Tegeta Kwa Ndevu

Source, Grandconsult

Figure 9.3-3: Pedestrian waiting to cross outside Zebra Crossing, Tegeta Kwa Ndevu

Source, Grandconsult

The uncontrolled pedestrian crossings also cause ad hoc interruptions to vehicular traffic flow resulting in unnecessary queues and delays. Some impatient drivers will not give way to pedestrians crossing at undesignated locations and are therefore likely to collide with them.

This situation is typical and common in many urban centres especially around Bus bays.

Recommendations

It is always best to place pedestrian crossing facilities at the desired crossing locations aligning crossings with sidewalks for a direct and continuous clear path. This can lead to the desired situation where pedestrian fences are not required.

However, where necessary, properly positioned pedestrian fences can channelize pedestrian movement and make them cross at designated locations. This could improve pedestrian safety by guiding pedestrians to safer crossing locations. Channelization of pedestrians can be considered at critical locations such as intersections and bus bays in urban areas to manage the potentially high crossing flows.

Amendment

1. The following amendments/additions/deletions are recommended

   Add the following paragraph after the 6th bullet on Page 9.31 of RGDM 2011.

   > *The pedestrian barriers or fences are to be provided at critical areas where pedestrian crossing movements need to be managed – especially in Urban areas. The barriers/fences shall be placed in such a way that they channelize the pedestrians to cross the road at designated areas. The width of opening on a continuous fence shall be a maximum of 2m wider than the pedestrian crossing i.e., 1m on each side.*

   Figure 9.3-4a and Figure 9.3-4b illustrates the typical use of fences for channelizing pedestrian movement.

Figure 9.3-4a: Bus bays with Pedestrian Fence

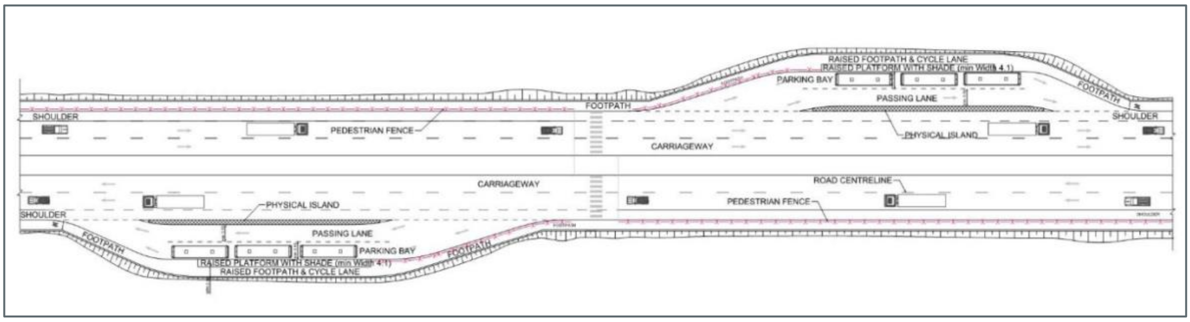
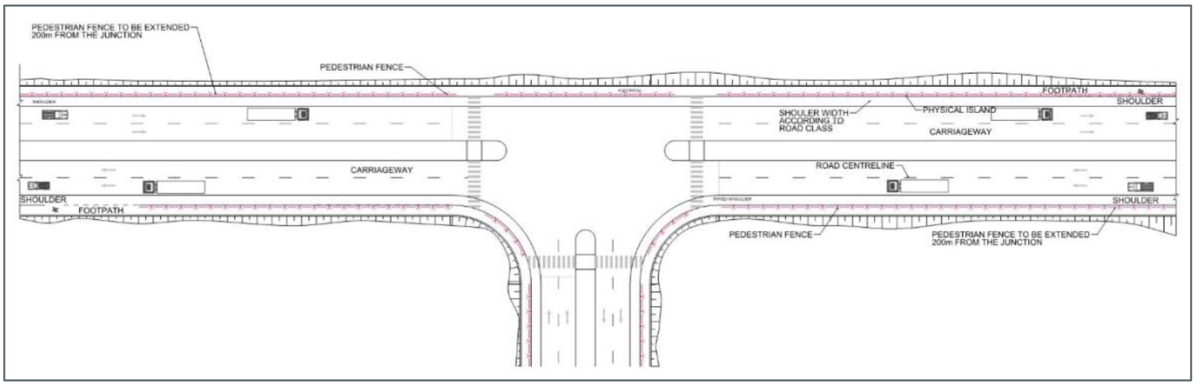


Figure 9.3-4b: T Junction with Pedestrian Fences



10 Training Needs for Revised Standards / Manuals

Improvement of Safety Awareness in Tanzania has resulted on the need to improve the current standards and manuals. The recommendations for improvement of the Standards and Manuals need to be understood by the users to ensure that they are properly implemented. In that aspect, there is need for training of users on the recommended changes as well as the general use of manuals and standards.

Current Practice

The users of these manuals are normally Engineers who graduated from various Engineering Institutions and Technical Colleges in Tanzania and elsewhere.

Road and Highway Engineers are normally taught the Principles of Design and Maintenance of Roads while in these colleges. On the Design part, the courses focus more on design of road geometry elements, pavement and drainage. Although, there are some safety elements in the design principles, the critical element of prioritizing safety of the end user is often neglected.

Identified Issues

Unless exposed to designers who have been involved in the design with safety consideration, newly graduated engineers will continue with road designs which have little consideration for safety.

Further, focus during the design has been on ensuring, the design speeds being met, the cross section being able to accommodate the intended traffic, the pavement accommodating the designed traffic load for the design life and so on, overlooking the need for all road users being safely accommodated. Indeed, it has been the case that roads in Tanzania are designed and built with the primary focus being on the vehicle occupant and little regard given to the interaction between the vehicles and other road users especially the pedestrians and bicyclists.

Therefore, it so often that safety is considered as afterthought due to lack of emphasis on the importance of Safety in the design and construction Processes. Safety elements have been tackled as an unnecessary increase in construction cost to the client and are often the first to be removed when the project budget is limited.

Although some Roads will undergo Road Safety Audits, it is often considered too late to change design or the road is already constructed and recommendations are considered too expensive to install. Safety for all road users should be a priority from the start of the design process.

Recommendations

To ensure that the safer road design approach is given the highest priority and becomes the norm in Tanzania, we recommend the following to be done

- Engineering Institutions and Technical Colleges to introduce a separate Course / Modules on Road Safety Engineering in the road and highway design courses. The Module should clearly put emphasis on the importance of accommodating all road users into the design. Proactive tools such as Road Safety Auditing and the iRAP Methodology should be introduced to students in the early stages of their course so that it becomes a standard activity when carrying out road design.
- It may be worthwhile establishing a body to conduct certification and/or accreditation of road safety specialists such as Auditors. This could be a “Road Safety Board” established under Ministry of Works and Transport (MoWT)
- The “Road Safety Board” can be charged with conducting regular training on safer road design and construction to road engineers. It can also be responsible in updating the engineers with changes and innovations on Safety matters.
- The Ministry of Works and Transport (MoWT) can ensure that training on the use of the Tanzania Geometric Design Manual is undertaken from time to time to ensure the users are using the Manuals and Standards as intended. In this process the users will have the opportunity to highlight shortcomings which eventually shall be updated by the MoWT. The Geometric Design Manual shall be a live document – renewed at regular intervals to align where appropriate with global best practices.

11 Standards/Manuals Upgrade Process

Current Practice

The current Road Geometric Design Manual (RGDM2011) has been used since it was officially launched in 2011. This manual was a significant upgrade from the previous Ministry of Communications and Works, Draft Road Manual, 1989 Edition.

The RGDM2011 covered a number of aspects of Design which were missing in the Draft Road Manual, 1989 Edition. However, Designers have been encountering design aspects which are not covered well in the 2011 revision. As such, some designers have taken to neglecting areas not covered in the manual and which is detrimental for road development in Tanzania. In some instances, where the manuals have failed to address some gaps, designers have referred to other manuals which they consider to have a similar environment to Tanzania. Indeed, recommendations from manuals with a different environment to Tanzania have also been considered.

Identified Issues

The lack of guidance in RGDM2011 on some design issues has led to significant variations in the designs produced over the years. This has resulted in designs with significant variations on road safety as well.

The RGDM2011 can only cover areas related to roads. However, the road environment contains other important components such as Drainage, Pavement (Already Covered in Tanzania), Bridge Design, Traffic Studies, Geotechnical Design and Road Safety Design, amongst others

Recommendations

To ensure the Tanzania Road Geometric Design Manual goes hand in hand with changes in technology on Safety and vehicle technology, we recommend the following:

- Ministry of Works and Transport shall establish feedback mechanism with road development agencies (TANROADS, TARURA), Road Designers (Consultants) and Road Contractors. This will assist Mowat to take into consideration some good practices and remove those which bring safety concerns. These good practices should be incorporated into the Design Manual during the updating process.

- As the Tanzania Road Design Manual is reviewed and updated, all other associated manuals, Standards and Specifications should be considered for review and update ensuring road safety management and engineering principles and practices are adopted across the board. Ministry of Works and Transport should develop, refine and update other Design Manuals that are naturally directly linked to the Road Geometric Design Manual. These should include – but are not limited to - Urban Road Design, Drainage Design, Highway Structures and Bridge Design, Traffic Studies, Pavement Design, Road furniture Design, Geotechnical Design, and Road Safety Design. The Ministry of Works and Transport should establish a similar feedback mechanism to ensure these additional manuals are updated regularly.

- The revised Manuals are to be updated referencing and in-line with global best practices in place such as the NACTO, Global Street Design Guide[2] and the associated iRAP-Star Ratings of the NACTO Global Street Design Guide (2019[3]); WRI, Cities Safer by Design[4]; iRAP, Road Safety Toolkit[5]; Road Safety Manual: A Manual for Practitioners and Decision Makers on Implementing Safe System Infrastructure[6]; amongst others.

- 2 https://globaldesigningcities.org/publication/global-street-design-guide/
- 3 https://globaldesigningcities.org/wp-content/uploads/2020/10/iRAP-Star-Ratings-of-the-GSDG.pdf
- 4https://www.wri.org/research/cities-safer-design
- 5 https://toolkit.irap.org/
- 6 https://www.roadsafetyfacility.org/publications/road-safety-manual-manual-practitioners-and-decision-makers-implementing-safe-system

Appendix 7.1 Superelevation Comparison

	Superelevation Gravel Road											Superelevation Paved Road									
Design Speed (vph)	30	40	50	60	70	80	90	100	110	120	Design Speed (vph)	30	40	50	60	70	80	90	100	110	120
											friction *f*	0.17	0.17	0.16	0.15	0.14	0.14	0.13	0.12	0.11	0.09
Radius (m)	Typical NC=4.0										Radius (m)	Typical NC									
30	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	30	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
40	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	40	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
50	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	50	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
60	5.77%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	60	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
70	4.95%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	70	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
80	4.33%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	80	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
90	NC	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	90	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
100	NC	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	100	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
110	NC	5.59%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	110	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
120	NC	5.13%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	120	5.74%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
130	NC	4.73%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	130	5.28%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
140	NC	4.40%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	140	4.89%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
150	NC	4.10%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	150	4.55%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
175	NC	NC	5.49%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	175	3.88%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
200	NC	NC	4.81%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	200	3.37%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
250	NC	NC	NC	5.54%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	250	2.66%	4.87%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
300	NC	NC	NC	4.62%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	300	NC	4.03%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
400	NC	NC	NC	NC	4.71%	6.00%	6.00%	6.00%	6.00%	6.00%	400	NC	2.98%	4.76%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
500	NC	NC	NC	NC	NC	4.92%	6.00%	6.00%	6.00%	6.00%	500	NC	NC	3.78%	5.52%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
600	NC	NC	NC	NC	NC	4.10%	5.19%	6.00%	6.00%	6.00%	600	NC	NC	3.12%	4.57%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
700	NC	NC	NC	NC	NC	NC	4.45%	5.49%	6.00%	6.00%	700	NC	NC	2.65%	3.90%	5.37%	6.00%	6.00%	6.00%	6.00%	6.00%
800	NC	NC	NC	NC	NC	NC	NC	4.81%	5.82%	6.00%	800	NC	NC	NC	3.39%	4.68%	6.00%	6.00%	6.00%	6.00%	6.00%
900	NC	NC	NC	NC	NC	NC	NC	4.27%	5.17%	6.00%	900	NC	NC	NC	3.00%	4.15%	5.46%	6.00%	6.00%	6.00%	6.00%
1000	NC	NC	NC	NC	NC	NC	NC	NC	4.65%	5.54%	1000	NC	NC	NC	2.68%	3.72%	4.90%	6.00%	6.00%	6.00%	6.00%
1200	NC	NC	NC	NC	NC	NC	NC	NC	NC	4.62%	1200	NC	NC	NC	NC	3.08%	4.06%	5.18%	6.00%	6.00%	6.00%
1300	NC	NC	NC	NC	NC	NC	NC	NC	NC	4.26%	1300	NC	NC	NC	NC	2.83%	3.74%	4.78%	5.94%	6.00%	6.00%
1400	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	1400	NC	NC	NC	NC	2.62%	3.46%	4.43%	5.50%	6.00%	6.00%
1500	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	1500	NC	NC	NC	NC	NC	3.22%	4.12%	5.13%	6.00%	6.00%
2000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	2000	NC	NC	NC	NC	NC	NC	3.06%	3.82%	4.65%	5.58%
2500	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	2500	NC	NC	NC	NC	NC	NC	NC	3.03%	3.70%	4.45%
3000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	3000	NC	NC	NC	NC	NC	NC	NC	2.50%	3.07%	3.69%
5000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	5000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
7000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	7000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

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