Safe Roads to Prosperity

GEOMETRICS MANUAL

1ST EDITION

OCTOBER 2014

This document has been prepared for the Roads Authority of Namibia for the exclusive use of the Roads Authority and Consultants employed by the Roads Authority.

Published by the Roads Authority

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First Edition **October 2014**

PREAMBLE

Summary of Contents

Preface

The Roads Authority of Namibia is a statutory body established in terms of the Roads Authority Act, Act 17 of 1999.

Section 3 of the Act sets out the object of the Authority as follows:

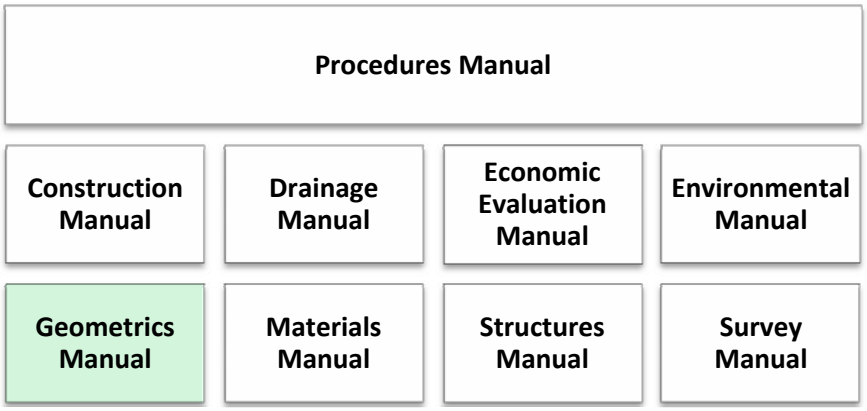
"Subject to this Act and the Road Fund Administration Act, the object of the Authority is to manage the national roads network in accordance with section 16 with a view to obtaining a safe and efficient road sector."

It is important to understand that "efficient" includes economic and financial efficiency as well as the common understanding of the word.

Key clauses of the Roads Authority Act that are of particular relevance to operational issues are Section 15 wherein the Roads Authority's functions are set out; and Section 16, which elaborates on one of these functions that being the management of the national road network including inter alia:

- The planning, design, construction and maintenance of roads;
- The quality control of materials required for the construction and maintenance of roads;
- The supervision of work contracted out; and
- The prescribing of minimum standards to achieve a safe road system and cause the least possible disruption to the environment.

These four aspects of the Roads Authority's mandate are complex and wide ranging. In order to assist it to comply with these obligations, the Roads Authority commissioned a suite of manuals applicable to road work and related matters. It consists of the following interlinked units:



The Geometrics Manual is supported by the **Standard Drawings** and the **Traffic Signs Policy**.

Additional manuals, such as a Maintenance Manual, may in future be required.

The Procedures Manual

The Procedures Manual is the controlling document of the suite of manuals depicted above. It describes the duties and responsibilities of consultants contracted to the Roads Authority for the preparation of designs, tenders for, and supervision of construction of roads by contract. It is also relevant to other projects such as feasibility studies and other investigations and studies carried out on behalf of the Roads Authority. In short, it is relevant to all projects carried out by external service providers for the Roads Authority.

Roads Authority personnel carrying out similar functions are also subject to the requirements of the Procedures Manual.

The manuals in general

The purpose of the suite of manuals is three-fold:

- To provide a basis for the attainment of uniformity of action of all persons carrying out design and related work for the Roads Authority, whether these be in-house personnel or external consultants;
- To promote the attainment of uniformity between in-house personnel and external consultants in the handling of construction projects.
- To set out the minimum standards and requirements of the Roads Authority, either directly in a specific manual or through its linkages with the other manuals in the suite.

These manuals are to be seen as books of reference and instructions to be used in the planning, design and administration of projects.

Both relevant in-house personnel and all consultants are therefore expected to make themselves thoroughly familiar with the contents of the Procedures Manual and such other manuals as may be relevant to a project, so that each project can pass through the different stages of planning, design, tendering and construction satisfactorily and that the submission of reports, records, drawings, documents, etc. is according to requirements.

Consultants must supply copies of relevant manuals to each designer and Engineer's Representative employed on construction contracts for the Roads Authority, which latter copies shall be kept at each Site Office.

Should any portion of this manual appear to be contradictory, either internally or in relation to any other manual; or insufficiently detailed, the Project Control Engineer must be contacted for a ruling.

Constructive criticism and suggestions for improvement of any of the manuals would be appreciated and should be addressed to:

The Chief Executive Officer, Roads Authority, Private Bag 12030, Windhoek, Namibia

with a copy to the Project Control Engineer.

Access to the manuals

The manuals can be downloaded from the RA website at: www.ra.org.na The RA will only upload the current amendment of the manuals on the site. It however remains the responsibility of the Consulting Engineer, upon his appointment, to confirm with the Project Control Engineer that the manuals on the website are the versions required for his specific appointment.

Definitions

The following definitions are relevant to all manuals:

Agreement	is the completed Agreement between the Roads Authority and the Consulting Engineer. Such Agreements may have different titles, depending on the source of funding.
Chief Executive Officer	is the person appointed under Section 14 of the Roads Authority Act to serve as Chief Executive Officer of the Roads Authority.
Date of Agreement	is the date on which it was signed by the last person signing.
Engineer	is the Consulting Engineer appointed by the Roads Authority to prepare a project or contract documents, or to supervise the execution of a contract.
Ministry	The Ministry of Works and Transport of the Government of Namibia
Permanent Secretary	is the official appointed to the post of Permanent Secretary of the Ministry of Works and Transport
Project Control Engineer	is the official appointed by the Chief Executive Officer to coordinate the execution of a specific project and to act as a link between the RA and the Consulting Engineer.
Roads Authority	is the Roads Authority constituted in terms of the Roads Authority Act, Act 17 of 1999

Guidelines for users of the manuals

The following icons are used throughout this edition of the Manuals:

CAUTION – This icon, usually accompanied by highlighted text, indicates that the user must be aware and use caution when following certain procedures or deviating from standard design methods.

YIELD – This icon indicates that the Roads Authority must be informed of an issue. This might be a deviation from the Terms of Reference; a deviation from design standards; or the achievement of milestones. Work may however continue.

STOP – Unlike for the yield icon, the stop icon indicates that the Roads Authority's written approval must be obtained before commencing with any further design or other tasks related to the issue for which approval is to be obtained.

NO ENTRY – This icon indicates no-go areas for practitioners. These could be set values for certain variables, or certain processes that may not be followed.

WORK IN PROGRESS – The "men at work" icon is used where sections can and should be extended or where work is pending. Due to funding or time constraints these parts or sections are not yet included in the manual.

Copyright of work done by the Consulting Engineer

All field books, data, calculations, plans, reports and tender documents produced in consequence of an appointment by the Roads Authority to carry out work in terms of these Manuals, become and remain the property of the RA upon submission of these items to the Roads Authority.

Acknowledgement

In preparation of this and the other manuals comprising this suite of manuals applicable to road works, considerable use, including direct application, has been made of similar work done previously by the predecessor in title of the Roads Authority and by other authorities, notably the manuals, directives and memoranda of the Western Cape Provincial Administration (South Africa), the Department of Transport (South Africa) and the South African National Roads Agency Ltd (SANRAL). These sources were used with due permission. The Roads Authority acknowledges with thanks the valuable content from these non-Namibian sources used in the Manuals, as well as that from Namibian sources such as the Meteorological Services, the Ministry of Environment and Tourism and others. It goes without saying that the Roads Authority also acknowledges with thanks all individual authors who contributed to the source documents from which content has been taken for use in these manuals.

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Tables

Abbreviations

COLTO	Committee of Land Transport Officials
FHWA	American Federal Highway Administration
PCE	Project Control Engineer
RA	Roads Authority
SADC	Southern Africa Development Community
SANRAL	South African National Roads Agency Limited
SATCC	Sothern African Transport and Communications Commission
TWRTL	Two-way Right Turn Lane

1 INTRODUCTION

1.1 Background

Although Namibia prides itself on its good public roads, it has not previously developed an unique Namibian roads geometric design manual. This is not surprising as professionals in many countries including Namibia tend to follow the American Association of State Highway and Transportation Officials (AASHTO) document entitled "A Policy on Geometric Design of Rural Highways" and the later "A Policy on Design of Urban Highways and Arterial Streets" and derivatives thereof, as a basis for the geometric design of their roads. These documents have now been combined and entitled "A Policy on Geometric Design of Highways and Streets". A further American document of note in general use, is the Highway Capacity Manual.

1.2 Historic Namibian practice

The need for design practice oriented towards southern African conditions, together with the need to achieve uniformity in the design methodology used by the various provinces in South Africa and in Namibia, led to the development of procedures and guidelines developed in South Africa for the Committee of State Road Authorities. Namibia also served on this Committee. The two AASHTO derivative documents TRH 17: "Geometric Design of Rural Roads", 1988 and Draft UTG 1: "Guidelines for the Geometric Design of Urban Arterial Roads", 1986, both developed by the National Institute for Transport and Road Research of the Council for Scientific and Industrial Research, South Africa, have formed the basis for geometric design of rural and urban roads in Namibia since their inception.

More recently the South African National Roads Agency Limited's (SANRAL) G2 Manual: "Geometric Design Guidelines", 2002 was introduced in South Africa, replacing the previous G2 Manual. It soon became the benchmark for that country. Although not referred to in the Procedures Manual, Namibian practitioners followed suit. Namibian designs have also sometimes been compared with the design standards adopted by the Southern African Transport and Communications Commission (SATCC) for the Southern African Development Community (SADC) Region.

In following the American, South and southern Africa practice, road geometric design in Namibia has generally kept up to date with developments in this field of civil engineering, but may lack formality in dealing with specific local issues. This document sets out to assist in overcoming this difficulty.

This document is augmented by a volume of Standard Drawings, updating the Standard or Typical Drawings of the Roads Authority (RA), which have been in use since the late 1960s. Use of these drawings is compulsory in the execution of designs, unless specifically approved in writing by the RA.

Namibia has also developed its own Road Traffic Signs Policy, for road signage and road marking design as well as for construction and maintenance purposes, promulgated under the Road Traffic and Transportation Act 1999 and its regulations. The use of this Policy is also compulsory when designs are carried out for the Roads Authority.

In the event that there is any conflict between the Standard Drawings or the Road Traffic Signs Policy on the one hand and any other document mentioned in this manual, such as the SANRAL G2 Manual, then the Standard Drawings and Road Traffic Signs Policy shall be taken as the ruling documents.

1.3 SADC practice

In view of the large and rapidly growing volume of international road transport and tourism in southern Africa, the SATCC issued a set of documents in 1997 in order to pursue a policy of uniformity of road and bridge design standards for the SADC region. One of the documents issued is entitled "Geometric Design of Trunk Roads" which sets out minimum geometric standards that must be applied by all SADC countries. No restrictions are placed on the adoption of higher standards should a country so choose. With regard to signage, the SATCC adopted the Southern African Road Traffic Signs Manual.

In the drafting of this Manual, the Standard Drawings and the Road Traffic Signs Policy, due cognisance was taken of these stipulated minimum standards.

1.4 South African practice

The National Road function in South Africa has been transferred to the SANRAL who undertook a complete overhaul of the national road geometric design manual and issued its updated "Geometric Design Guidelines" in 2002. These guidelines are still predominantly based on AASHTO principles, albeit with much more onus placed on the design engineer to evaluate and assess situations and design decisions in the light of particular considerations. In this regard and in keeping with international trends, the new manual took steps in the direction of the "Design Domain", "Context Sensitive Design" and "Human Factors" as paradigm shifts of note.

"Design Domain" is derived from Canadian and Australian practice and makes provision for the application of "Design Exceptions", which allow for flexibility in the application of standards, should circumstances so dictate, as opposed to the previous prescriptive approach. These concepts are dealt with more fully in Section 0 below.

1.5 Namibian practice

In view of the foregoing it has been decided by the RA to adopt the SANRAL G2 Guidelines for use in Namibia. Guidance on issues particular to Namibia as well as information on benchmark values to be used for Namibia, where G2 provides design domain data, are contained in this document, in the Standard Drawings and in the Road Traffic Signs Policy.

The fact that the three documents mentioned above may be seen as somewhat prescriptive is intended to avoid unnecessary proliferation of interpretations of the G2 manual and other sources. However, this in no way absolves the designer of the duty to apply his mind to the circumstances of a particular project. Where appropriate, he must raise a fully motivated request for a design exception with the RA, as contemplated by Clause 2.3 hereof.

NOTE: For ease of reference the main section headings of the remainder of this document correspond with those of the G2 Guidelines.

2 DESIGN PHILOSOPHY

2.1 Road safety audits

Road safety is considered of paramount importance and although the RA does not as a rule undertake Road Safety Audits of completed designs at this time, it may well do so in the future[1]. However, geometric design issues which would generally feature in a road safety audit are discussed in the G2 Guidelines and also in part in this Manual.

It is incumbent on designers to ensure that these safety-related issues are addressed adequately in all projects. Effective review systems must be used to ensure that this requirement is met.

Road Safety Audits on existing roads would generally best be undertaken as forerunners of heavy rehabilitation or upgrading, or in response to complaints received from the public and accident/incident occurrences.

In the case of the latter, care must be taken not to rely heavily on short-term overviews of accidents and public complaints, which may give rise to distortions in the true long-term frequency of incidents.

2.2 Construction site safety

Due attention to the geometric design aspects of traffic deviations is essential. The issue of Roadworks Signing is dealt with in Chapter 7 of the Namibian Road Traffic Signs Policy and on the Roads Authority's Standard Drawings. The COLTO Standard Specifications adopted by the RA deal with issues such as the provision of a Traffic Safety Officer and Temporary Traffic Control Facilities.

2.3 Design exceptions

The normal design domain comprises the range of norms and standards defined by the limitations of vehicular capability and human factors. Anything beyond this range requires a conscious decision to be taken and properly documented by the RA. In view of the fact that this departure constitutes a potential risk and hence the possibility of litigation, the RA must be able to prove in court that it applied its mind in the granting of the exception.

A case in point could be, for example a section of road that has become substandard because of newer and higher standards being adopted. If it now were to form part of a road rehabilitation project, but does not have a significant accident history, a strong case could be made in favour of not incurring the expense of upgrading, but rather using the funds to some better effect elsewhere.

2.4 Context sensitive designs

2.4.1 Urban and rural contexts

The traditional differences in context considered in road geometric design are those relating to topography. Other obvious differences are those of the urban and rural areas. These latter differences have been somewhat neglected in the past, but are taking much more of a central stage currently.

Generally in the rural environment low volumes of traffic occur, moving at high speed for considerable distances. In contrast, the urban environment is characterised by high traffic volumes, moving at moderate to low speeds. High speeds require limitations on gradients and high standards of horizontal and vertical curvature that can result in fairly heavy earthworks. The lower speeds prevailing in urban areas make it easier to follow the natural contours of the land.

Rural intersections are typically widely spaced with simple layouts. Their impact on the efficiency of the road network is thus minimal. Urban intersections are closer spaced and can have sophisticated and complex layouts. The efficiency of the urban network is thus dictated by the efficiency of the intersections.

In the rural environment, differences between the various motorised vehicles found on the roads generally are not critical. In the absence of steep gradients, cars, buses and trucks all move at about the same pace and there is relatively little impedance to overtaking. An exception may be during holiday periods, especially some long week-ends and then specifically on routes serving holiday traffic.

In the urban environment, physical dimensions of vehicles start to play a role, because of their closer proximity. An articulated vehicle takes as much space as a number of cars and its ability to accelerate from stop is

[1] For more information on Road Safety Audits, the attention of designers is directed to the FHWA Road Safety Audit Manual which is available at no charge from: http://safety.fhwa.dot.gov/rsa/guidelines/

significantly lower than that of a car. Similarly such a vehicle often requires courtesy assistance from the drivers of opposing vehicles to execute a turning manoeuvre.

2.4.2 The sub-context in which design is considered

An important feature of context sensitive design is the competing activities other than vehicle movements that require a share of the road space. These are minimal in rural areas. In urban areas, there is a high proportion of competing, essentially social, activities which cannot be gainsaid. Ignoring these in the interest of mobility is often the cause of much friction between communities and transportation planners and officials. It is these competing activities that largely dictate the need for the sub-categories identified below. There are significant differences between these sub-contexts in the types and numbers of vehicles present. Traffic patterns and speeds differ and the needs of the people in each are also different. These sub-contexts are:

- Urban centres;
- Urban corridors;
- Sub-urban corridors and nodes;
- Industrial corridors;
- Residential areas;
- Rural town centres;
- Transitional areas; and
- Rural connecting corridors.

Within each sub-context the designer should carefully consider:

- All the vehicular activities that are likely to occur;
- The vehicles involved in each activity, including their function, dimensions and operational characteristics;
- The competing social activities; and
- The space that all of these require, including how this space is to be arranged. This includes consideration of public transport and provision of various utility services in the road reserve.

It is evident that many of these issues lie to a large degree outside the realm of road geometric design, but are nevertheless highlighted here in the interest of sustainable community living and as a caveat against blindly applying road geometric standards.

3 DESIGN CONTROLS

3.1 Design speed

The RA subscribes to the current definition of design speed given in the G2 Manual, namely "the speed selected as the basis for establishing appropriate geometric elements for a section of a road." In essence "design speed" does not truly represent a speed, but rather a grouping of complementary considerations that define a particular road or road section.

In all instances the designer and the Project Control Engineer must agree on the design speed to be used for a particular design brief, taking full cognisance of the design speeds used or intended to be used on adjacent sections of the route concerned.

The G2 Guidelines do not make specific mention of 2+1 lane roads as contemplated in this Manual. These roads comprise two lanes in the one direction and one lane in the other, with the two-lane sections alternating between the two directions of travel, ideally at 1,0 km to 2,0 km intervals, but as modified by the topography. They would resort under the category "expressways in rural areas" in Table 3.1 in the G2 Guidelines and Class IIA, Primary Rural Arterial in terms of Design Type Classification in Section 3.8.4.

It may also be noted that the design speeds given for freeways and expressways are equally applicable to these divided facilities and to any first phase undivided developments of such facilities in a stage-construction approach.

3.2 Sight distance

At interchange off ramps where drivers will be required to respond to road markings, the decision sight distance should be measured to the point where the road and ramp edges meet.

To reduce the risk that vegetation outside the shoulder breakpoint might obstruct sight distance, sight lines to determine the available sight distance around horizontal curves should where practicable lie inside the shoulder breakpoint.

Care is to be exercised in assessing the influence of guardrails, bridge columns and handrails, median safety barriers, signs and the like on the available sight distance.

3.3 Passing opportunities

Great care is to be exercised in ensuring adequate passing opportunities for motorists. To this end due cognisance is to be taken of the traffic volumes and traffic composition expected. Should the traffic volume exceed 4000 vehicles per day, or should the percentage of heavy vehicles exceed 8%, serious consideration should be given to providing a 2+1 lane cross section.

3.4 Hidden dips

Hidden dips, as discussed in the G2 Guidelines in Section 3.5.10, are not only poor design practice, but present lethal risks to the motorist and as such will not be allowed in the design of new Namibian roads. Hidden dips on existing roads must be eliminated when such roads are rehabilitated.

3.5 Environmental legislation

Environmental legislation applicable to infrastructure development in Namibia is contained in the Environmental Management Act, Act No 7 of 2007 and its Regulations. Geometric design will also have to be in compliance with the requirements of the RA's Environmental Manual.

3.6 Cadastral boundaries

Wherever possible within the requirements of aesthetically pleasing and safe road alignment, new road alignments should generally follow cadastral boundaries.

3.7 Road classification and access control

The following definitions for different types of proclaimed roads have been adopted for Namibia as promulgated in the Roads Ordinance of 1972:

1. **Trunk Road:** A public road that forms part of the road system connecting Namibia as a whole with neighbouring countries or major ports.
2. **Main Road:** A public road connecting important centres in Namibia.
3. **District Road:** A public road carrying a reasonable amount of traffic.

4. **Farm Road:** A public road of importance, usually providing right of way across farms or property.

It may also be mentioned that roads, as single entities or in combination, form routes as set out below. Inclusion of a road in a route has no direct design implication other than that pertaining to the type of road mentioned above. The following classification has been extracted from the Road Traffic Signs Policy:

1. **A-routes:** Freeways of considerable length forming key transport routes.
2. **B-routes:** Major or important transport routes regularly used by cross-border traffic and connecting major centres and border posts with each other.
3. **C-routes:** Secondary routes of satisfactory standard, connecting towns or tourist areas with each other or with other routes; or routes regularly used by heavy vehicles.

A combination of functional and design type classification is used for geometric design and access control purposes with design parameters included in Table 3.1 of the G2 Manual. Minimum design speeds are recommended accordingly as in Section 3.8.4 of the G2 Guidelines.

3.8 Two Way Right Turn Lane (TWRTL)

Where major routes go through the central business district (CBD) of a town, with increased conflict due to turning movements, consideration might be given to the use of a continuous two way right turn lane down the middle of the road. TWRTL facilities would resort under the category “Arterial streets with extensive development” in Table 3.1 of the G2 Guidelines.

In order to compare the Namibian classification with that of the G2 Guideline the mentioned G2 table is included hereafter as Table 3-1 in a slightly adjusted format:

CLASSIFICATION	PRIMARY FUNCTION	DESCRIPTION	ACCESS TYPE	ACCESS SPACING
Trunk Road Class 1	Principal Arterial	Freeway rural	Interchange	≥ 10 km***
		Freeway urban	Interchange	≥ 2,4 km
		Cross-border road link	Priority	≥ 1,2 km
Main Road Class 2	Major Arterial	National road link	Priority	≥ 1,2 km
		Urban and peri-urban expressway	Signal or Priority	≥ 0,6 km
		Major urban road	Signal or Priority	≥ 0,6 km
District Road* Class 3	Minor Arterial	District road	Priority	± 1,2 km
		Minor urban arterial road	Signal or Priority	± 0,5 km
Urban Class 3A	Activity Arterial	Urban “high street” minor urban arterial with roadside activity	Signal or Priority or Roundabout	± 0,3 km to 0,4 km street access from the back
District Road Class 4**	Collector	District road rural feeder roads	Priority	± 1,2 km
Urban Class 4	Collector	Collector road	Priority	
		CBD street	Priority or Roundabout	Intersections: 0,15 km to 0,3 km individual accesses: ± 40 m
Farm Road Urban Class 5	Street / Access Road	Rural access road	N/A	N/A
		Local residential and commercial/industrial streets	Priority or Mini-circle	N/A

* - or urban road forming part of a C-route ** - not forming part of a C-route *** - initial aim for cost-efficiency

Table 3-1 : Road classification and access control

4 ROAD DESIGN ELEMENTS

4.1 Length of tangents

As a guide and where possible, the length of tangents of new road alignments should not exceed 6 minutes drive at the design speed, unless a cadastral boundary is followed. This limitation is set to assist in keeping the driver's attention focused on the driving task.

4.2 Superelevation and curve radii

With the exception of loop ramps at interchanges, the recommended value for e_{max} applicable in Namibia is set at 8% for surfaced roads and 5 % for gravel roads. In the case of gravel roads, taking longitudinal gradient into consideration, the resultant gradient should not exceed 6%.

Specific written approval must be obtained from the Roads Authority where short radius curves have to be used and where these values of e_{max} are exceeded.

4.3 Cross section

The following cross-sectional widths are prescribed in Namibia (for gravel roads refer to Standard Drawings):

Single carriageway roads: 3,15m and 3,45m basic lane width measured from road centre line to inner edge of yellow line (these relate to the standard 6,8m and 7,4m wide surfacing adopted in Namibia).

Dual Carriageway roads including freeways: 3,70 m basic lane width measured from the centre of lines between lanes, or otherwise centre of the road, to the inner edge of the yellow line - as applicable.

Roads in a 2+1 configuration: 3,30m and 3,45m measured as for dual carriageway roads; the "additional lane" to the normal 2-lane facility is the narrower lane.

Auxiliary lane and isolated climbing lanes: 3,30m measured as for dual carriageway roads.

Shoulder rounding: 0,50m centred around shoulder breakpoint.

Unsurfaced shoulders: 1,75m; 2,25m and 2,75m depending on traffic volumes, measured between the edge of the travelled way and the shoulder breakpoint, of which the first 0,25m should be surfaced to accommodate a yellow edge line (These add up to 2,0; 2,5 and 3,0m wide effective shoulder widths) .

Inner shoulders: 2,0m (on freeways and dual carriageway roads) where no kerbing is involved, of which the first 0,25m must be surfaced to accommodate the edge line. Should kerbing be provided, as often is the case in urban areas on dual carriageway roads, a nominal 0,5m surfaced shoulder inclusive of any concrete channelling, is to be provided between the edge of the travelled way and the face of the kerb.

NOTES:

1. Narrower than normal shoulder widths are required along a road with a 2+1 lane configuration. The currently adopted widths are 1,95m along the single lane, and 1,45 m along the double lane, including the 0,25 m portion of the surfaced shoulder (outside the inside of the yellow edge line).
2. Along a fully developed auxiliary lane or isolated climbing lane, a shoulder width of 1,5 m is required, which width would include the 0,25 m surfaced section to accommodate an edge line.
3. Where a guardrail is to be provided, the fill and gravelled section of the shoulder is to be widened by 0,3 m to provide space for guardrail poles.
4. In a 2+1 lane configuration, a separation strip of between 0,9 m and 1,5 m in width should be provided between opposing directions of traffic flow. A 1,5 m strip can accommodate a median separator barrier, should poor sight conditions so indicate. Should a barrier not be provided, a separation strip width of 0,9 m is required, to accommodate the necessary paint marking and ribbed or slotted noise generators. Transition tapers for 2+1 lane roads must be designed in accordance with the G2 Guidelines.

Specific written approval must be obtained from the Roads Authority before specifying the bitumen surfacing of shoulders on a single carriageway road.

4.4 Climbing lanes

Climbing lanes should be provided in terms of the warrant provided in Table 4.15 of the G2 Guidelines. The climbing lane terminal is to take the form of a simple taper. Where a 2+1 lane configured cross section is used, the interval of alternating the two lanes may be interrupted and adjusted to coincide with the need for an auxiliary lane or climbing lane for passing opportunity on a steep grade.

4.5 Medians

The following guidance is provided on median widths (inclusive of the inner shoulders):

- freeways 26,6m
- dual carriageway urban and peri-urban roads: 5.0m
- 2+1 lane road: Barrier lines: 0,9m
  Median separator: 1,5m

NOTES:

1. The median widths given above are premised on the principle of future road widening along the inside of the carriageways, to avoid future widening or lengthening of interchange and river bridges.
2. In instances where one carriageway of a future freeway or other dual carriageway road is constructed initially to serve in the interim as an undivided three or four-lane road, a painted and preferably also ribbed/slotted median of 0,5 m wide should be provided to separate traffic.

4.6 Pedestrian facilities

In rural areas where heavy pedestrian activity is evident, or can be expected, the road shoulders should be extended by a 0,9 m wide footway, provided with a fine graded gravel surface to subbase standard.

If the road shoulder is surfaced, a pedestrian footway should be provided. This shall be located not less than 3,0m from the road prism, shall be provided with a 150mm subbase quality gravel layer and surfaced with a 6,7mm single seal. More sophisticated walkways, if required, should be provided in terms of the warrants provided in Table 4.17 of the G2 Guidelines.

The provision of pedestrian footways has long-term maintenance responsibility and cost implications and need to be motivated and planned in consultation with the Project Control Engineer.

4.7 Cycle lanes

Where RA instructs that a section of road forms part of a cycle route, the travelled way should be widened in accordance with the requirements of the G2 Guidelines, Figure 4.13, on each side and these widths demarcated as cycle lanes. No cycle lanes should for traffic safety and legal reasons be allowed along a freeway.

The need for and configuration of pedestrian facilities in both rural and urban situations must be discussed and agreed with the Project Control Engineer at the outset of the project.

5 ALIGNMENT DESIGN

5.1 Curve length

As indicated in Section 5.4.2 of the G2 Guidelines, intermediate length curves often result in the reduction of proper sight distance for overtaking on single carriageway roads. Great care and judgement thus are required in alignment design to meet the objectives of aesthetically pleasing yet operationally acceptable alignments. The use of computerised visualisation programs is helpful in these circumstances. This holds particularly true when designing a dual carriageway facility of which only one carriageway will be constructed initially to operate as a two-lane road.

6 INTERSECTION DESIGN

6.1 Spacing of intersections

The preferred ranges of intersection spacings for various roads are as given in Table 3-1 of this manual.

Figure 6.3 of the G2 Guidelines allows the selection of desirable signal spacings for various average running speeds and cycle lengths. On Class 1 and Class 2 roads and even on Class 3 roads in urban or peri-urban areas, the possibility of the future need for traffic signals always exists and as such the indicated signal spacings also accord with full intersection spacings. Intermediate accesses could be considered should traffic impact studies so indicate and the recommended minimum access separations given in Table 6.5 of the G2 Guidelines are met.

6.2 Channelisation

Pedestrians should not be expected to cross more than a total of three through traffic lanes and two turning lanes without a pause. Should more lanes have to be crossed, a kerbed refuge must be provided.

Where channelisation is provided at intersections, the road shoulder is to be interrupted as indicated in the Standard Drawings.

Channelisation to provide for a turning (slip) lane should ensure that the turning lane cannot be construed and used as a through lane through the intersection.

Unless a longer stacking area is required for right-turning at intersections, turning lanes should comprise a short deceleration or acceleration lane of 60m length proceeded or followed by a taper of 60m length.

After allowance has been made for a right turning lane at an intersection on a dual carriageway road, the remaining minimum width of the median should not be less than 2,2 m to accommodate double-headed traffic signals. Such narrow median islands should be kerbed.

7 INTERCHANGES

7.1 Spacing

The ideal minimum spacing of successive interchanges with direct on- and off- ramps from the freeway basic lanes lies between 2,0 to 2,5 km. Should circumstances dictate closer spacing, a minimum of 1,6 km could be investigated for traffic weaving and location of road signage. Alternatively use would have to be made of collector/distributor (C/D) roads separated from the through lanes.

In terms of AASHTO recommendations the minimum distances between successive ramps are listed below. However, at these short distances location of the ramp terminals on a collector/distributor road, or the use of an auxiliary lane, may already be necessary and should be evaluated:

- Two successive off-ramps: 300m
- Two successive on-ramps: 300m
- Off-ramp followed by on-ramp: 150m
- On-ramp followed by off-ramp: to be determined by weaving analysis

7.2 Auxiliary lanes

Off- and on-ramps are to be preceded or followed by short sections of auxiliary lanes of lengths as given Tables 7.5 and 7.6 in the G2 Guidelines, in addition to the normally prescribed 1:15 and 1:50 tapers. Distances are measured between yellow-line break points (YLBPs).

8 ROADSIDE SAFETY

8.1 Permitted developments

Building lines are applicable to all building restriction roads under Roads Authority jurisdiction, as set out in the Advertising on Roads and Ribbon Development Ordinance, 1960, as amended.

In addition to intersection and access spacing, the maintenance of building lines and control of the type of development alongside mobility routes play a major part in road safety considerations. In this regard the establishment of schools, créches and similar sensitive facilities, although outside the building restriction area, should not be permitted alongside Trunk Roads and Main Roads and should also be discouraged along District Roads forming part of a route.

Allowing buildings to be constructed or remain within the road reserve already have, and will again in the future, cause fatal injuries of residents during accidents caused by out of control vehicles. These must be reported to the Project Control Engineer where noticed during the provision of consultancy services on a project.

Direct access to any existing facilities within the 100m building restriction zone must not be granted and the erection of a security erf boundary fence next to the road to avoid direct access, should be enforced in cases where the building restriction is or cannot be enforced.

9 ROAD BETTERMENT

9.1 Expert judgement

The RA relies heavily on the expert judgment of experienced practitioners in deciding on appropriate road betterment actions.

Some road betterment actions are decided on in isolation by maintenance personnel. Existing practices should ideally be reviewed and agreed upon by a panel of three officials of the RA having appropriate experience.

Proposals for alternative betterment actions should be provided in studies carried out for the RA. The RA is also at liberty to co-opt a suitably experienced person from outside the RA to assist in this review function or to outsource the problem and treat it as a normal feasibility study.

10 GRADE SEPARATION STRUCTURES

10.1 Pedestrian facilities

Where pedestrian walkways are provided alongside a road, the facility should be continued through or over any structure involved.

It is not Roads Authority policy to provide pedestrian underpasses and great care is to be exercised when positioning pedestrian overpasses, to ensure effective use. The road to be crossed generally should be in cut and the pedestrian bridge may have to be angled to ensure as level and as short a route as possible for pedestrians.

Pedestrian accidents are virtually always fatal. Thus for the purposes of cost-benefit analyses relating to the provision of pedestrian facilities, the costs ascribed to pedestrian accidents should reflect this situation and average accident costs should not be used.