Fiji Roads Authority

AUSTROADS DESIGN GUIDE SUPPLEMENT PARTS 1 TO 8

March 2019

FRA's Supplement to the Austroads Guide to Road Design Updates Record

Rev. No. Date Released	Section/s Update	Description of Revision	Authorised By
Rev 0 – 20 July 2018	New Document	NA	
Rev 1 – 5 March 2019	Minor revisions	Following workshops	

The FRA Supplement to the Austroads Guide to Road Design provides additional information, clarification or jurisdiction specific design information and procedures which may be used on FRA work.

Although this document is believed to be correct at the time of release, FRA does not accept responsibility for any consequences arising from the information contained in it. People using the information should apply, and rely upon, their own skill and judgement to the particular issue which they are considering. The procedures set out will be amended from time to time as found necessary.

CHAPTER TITLES

Contents

CHAPTER 1

INTRODUCTION TO ROAD DESIGN

PART 1 - INTRODUCTION TO ROAD DESIGN

1.0 Scope of the Guide to Road Design

1.2 Purpose

The Austroads Guide to Road Design (AGRD) allows FRA to develop supplementary material. Where FRA supplementary information is provided it will take precedence over the Austroads Guide to Road Design.

5.0 Design Process

FRA's General Managers generally take a lead role in the establishment and management of road network strategies and planning processes and shall be consulted prior to commencement of studies.

The principles outlined in the DNR Codes of Environmental Practice for Road Planning, Design, Construction and Maintenance, shall be adopted for all design and planning work. FRA's Traffic Impact Assessment Guidelines for Fiji, December 2018 should also be adopted. The objective of the TIA is to understand the impact that the proposed development or road upgrade will have on the existing network. The TIA needs to identify and assess the possible solutions that will be needed to deliver the objectives and mitigate the impact.

AGRD Part 1, Figure 5.1 is provided as a general guide only to the establishment of road network strategy and planning processes. Each project generally has its own challenges and timeframes that need to be addressed during the planning process. These need to be clarified with FRA at the commencement of the study.

Commentary

The following commentaries are not referenced in the text and are associated with the identified sections in AGRD Part 1:

Commentary 2 refers to section 1.2.
Commentary 3 refers to section 1.3.
Commentary 4 refers to section 2.0.
Commentary 5 refers to section 3.2.
Commentary 6 refers to section 3.2.1.
Commentary 7 refers to section 3.4.1.
Commentary 8 refers to section 3.2.
Commentary 9 refers to section 3.4.4.
Commentary 10 refers to section 5.1.
Commentary 11 refers to section 5.1.
Commentary 12 refers to section 5.2.
Commentary 13 refers to section 5.2.
Commentary 14 refers to section 5.2.3.
Commentary 15 refers to section 5.2.4.
Commentary 16 refers to section 5.2.5.

CHAPTER 2

DESIGN CONSIDERATIONS

PART 2 - DESIGN CONSIDERATIONS

2.0 Context Sensitive Design

2.3 Extended Design Domain (EDD)

The decision whether to adopt Extended Design Domain (EDD) criteria is an FRA corporate responsibility for projects under its control.

2.3.1 Background

Projects involving road design may range from minor improvements to small sections of existing roads, through 'restoration' projects that improve road cross-sections while retaining existing alignments, to major design of new arterial roads as part of a significant development.

Road design guidelines are developed with consideration of the need to achieve a balance between:

- competing demands or operational requirements,
- safety,
- cost and
- social and environmental impacts.

Context Sensitive Design (CSD) encourages independent designs tailored to particular situations. CSD seeks to produce a design that combines good engineering practice in harmony with the natural and built environment, and meets the required constraints and parameters of the project.

Design guidelines tend to use the concepts of absolute minimum and desirable limiting values for each of the different design elements. The desirable limits indicate good practice, while absolute values are located outside of the desirable and are subject to professional judgement. Design guidelines provide a range of acceptable values for each parameter ('the design domain') from which designers must choose the most appropriate value.

The Normal Design Domain (NDD) is a range of values that a design parameter may take and be justified in an engineering sense and can have a reasonable level of defence if questioned. Construction cost considerations sometimes lead to minimum values being elected for a single parameter. However, the use of minimum values for interrelated parameters is not recommended.

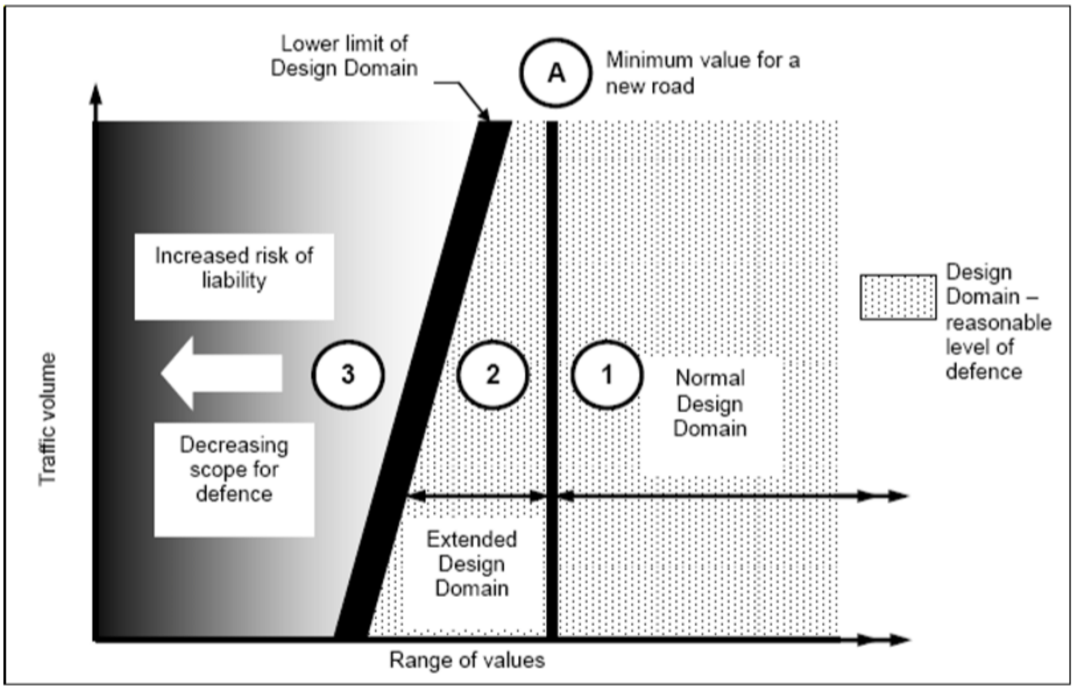
EDD is the use of criteria below the lower bound of the NDD criteria to address project constraints while ensuring that the objectives of the project and safety are still met. These lower values are generally considered less safe or less efficient. The use of design values below the design domain (i.e. below EDD) is not permitted. Figure 2.1 shows a conceptual diagram for EDD.

"EDD extends the lower bound of the Design Domain that is used. However, a value within the EDD can be used only with explicit FRA approval, supported by a documented risk assessment that fully justifies the use of that value." (Refer also note on Commentary F below.)

The use of EDD requires high levels of design skill and engineering judgement and requires the application of greater effort to include EDD and manage its use. It is essential that the intent of any standard is still applied when using EDD when considering the overall impact on all elements of the design.

There is less scope to apply EDD on high volume roads where the application of EDD, even with appropriate mitigation, does not allow acceptable safety levels to be achieved. EDD can only be applied to existing roads with no crash history where the existing pavement design and other site constraints may prohibit the upgrade to current design standards. As part of the justification process for the use of EDD, all decisions shall be validated and documented.

Figure 2.1: EDD Conceptual Design
(from AGRD Part 2, Commentary 7)



FRA Policy

The use of EDD for FRA projects shall only be applied to construction on existing roads where feasible NDD options cannot be implemented. Additional mitigation must be included to offset the lower design values to ensure that the operational and safety standards of the road are maintained.

For FRA projects, any use of EDD shall be considered at the scoping phase of a project, preferably as part of the approval process. Approval to the use of EDD criteria shall be highlighted in FRA Business Case/Scope Approval reports as appropriate.

FRA Constraints and application of EDD

In line with Austroads Guide to Road Design (AGRD), the application of EDD:

- shall be identified at the scoping stage of a project
- shall only be applied to one design criteria, with values above NDD applied to other criteria to “off-set” the lower criteria used;
- mitigation/offset measures must be implemented to ensure acceptable overall standards are maintained;
- may not be used for new “greenfield” projects, including the development of duplication proposals, where existing pavement is not part of the construction. EDD can be considered

where additional lanes are added to existing pavement. It may be possible to build the new pavement to meet current design standards, however, costs or other site constraints do not allow the existing pavement to be upgraded to fully meet current NDD design criteria.
- may be used for any project site with an existing accident/crash history that relates to the parameter being considered for EDD.
- can only be used if all decisions are thoroughly and transparently documented and justified.

Minimum Criteria - EDD

The AGRD identifies a range of minimum EDD criteria that may be applied to specific design elements. This criterion is identified in:

- AGRD Part 2 – Section 2.3 and Appendix A;
- AGRD Part 3 – Section 1.3 and Appendix A; and
- AGRD Part 4A – Sections 1.4, 2.2.4, 3.4, 8.3.4, 10.4 and Appendix A.

The AGRD identifies a range of acceptable EDD values for key design parameters including:

- cross sections for rural two lane, two way roads
- stopping sight distances
- crest vertical curves
- sag vertical curves
- horizontal sight restriction
- intersection sight distance.

FRA Standards

FRA reserves the jurisdictional right to set design criteria that must not be contravened or require specific mitigation measures to be implemented. This guidance is provided in this document and will be included in tender documentation and contract specifications.

FRA EDD Approval Process

An Extended Design Domain Application Form (refer to Attachment A) shall be used to apply for EDD approvals.

The use of EDD criteria on FRA projects is subject to approval by the delegated FRA representative.

Proponents preparing applications shall consult with the appropriate representatives and seek appropriate technical advice prior to submitting an application for approval.

The following table identifies EDD approval delegations within FRA.

If the use of EDD criteria is proposed for the project, the Extended Design Domain Application Form with recommendation(s) shall be completed.

FRA will review the broader application of EDD to monitor outcomes and ensure consistent application of the process on a regular basis.

EDD approval delegations in FRA are as follows:

Project Value	High Complexity/Risk Project	Medium Complexity/Risk Project	Low Complexity /Risk Project
>FJD10M	PRC/CEO	PRC/CEO	GM Capital Works
<FJD10M, >$5M	PRC/.CEO	Head Des & Proc	Head Des & Proc
<FJD5M, >$2M	Head Des & Proc	Head Des & Proc	GM's/ Eng to Contract
<FJD2M	Head Des & Proc	GM's/ Eng to Contract	GM's/ Eng to Contract

2.4.1 Functional Classification and Use

Further to Austroads Tables 2.2 and 2.3, the following tables document the road hierarchy adopted in Fiji for Rural and Urban Roads.

Austroads and Fiji functional classification of rural roads

AGRD ARTERIAL ROAD CLASSES	**FIJI EQUIVALENT**
Class 1 – Those roads, which form the principal avenues for communications between major regions, including direct connections between capital cities.	Kings Rd, Queens Rd (**M1 Roads**)
Class 2 – Those roads, not being Class 1, whose main function is to form the principal avenue of communication for movements between: • a capital city and adjoining states and their capital cities; or • a capital city and key towns; or • key towns.	Main (**M2 Roads**)
Class 3 – Those roads, not being Class 1 or 2, whose main function is to form an avenue of communication for movements: • between important centres and the Class 1 and Class 2 roads and/or key towns; or • between important centres; or • of an arterial nature within a town in a rural area.	Secondary (**S Roads**)
AGRD LOCAL ROAD CLASSES	**FIJI EQUIVALENT**
Class 4 – Those roads, not being Class 1, 2 or 3, whose main function is to provide access to abutting property (including property within a town in a rural area).	Country Roads (**C Roads**)
Class 5 – Those roads, which provide almost exclusively for one activity or function, which cannot be assigned to Classes 1 to 4.	Residential Roads (**R Roads)**

Austroads and Fiji Urban road functional classifications

AGRD DESCRIPTION	FUNCTION	FIJI EQUIVALENT
Controlled access highways (motorways or freeways)	Motorways and freeways have an exclusive function to carry traffic within cities and to ensure the continuity of the national or regional primary road system. As they are designed to accommodate through traffic, they do not offer pedestrian or frontage access.	NA
Urban arterial roads	Urban arterial roads have a predominant function to carry traffic but also serve other functions. They form the primary road network and link main districts of the urban area. Arterial roads that perform a secondary function are sometimes referred to as sub-arterial roads	**Arterial Roads**
Urban collector/distributor roads	These are local streets that have a greater role than others in connecting contained urban areas (e.g. residential areas, activity areas) to the arterial road system. Generally, consideration of environment and local life predominate and improved amenity is encouraged over the use of vehicles on these roads.	**Collector Roads**
Urban local roads	These are roads intended exclusively for access with no through traffic function.	**Local Streets**

Commentaries

Commentary 7 EDD

An EDD value can only be used on FRA projects with explicit approval by FRA. Applications for approval shall be supported by a documented risk assessment that justifies the use of the value and a proposal for the use of appropriate mitigation measures/devices. Refer to Section 2.3 of this chapter for guidance.

Commentary 13 Access Control

Reference shall be made to FRA for guidance on Access Management Policy and access control practices for the various road classifications.

Attachment A - Extended Design Domain Application Form

Application prepared by: (Development/Project Engineer)	(Development/Project Engineer) Technical basis of application reviewed by:
	Endorsed by: (Engineer to Contract/GM)
	Approved by: (As per Section 2.3)

Following approval, a copy of this form and supporting documentation shall be forwarded to the Head of Quality Management and Head of Governance.

Purpose of Approval

Extended Design Domain (EDD) is primarily designed to be applied to restoration or upgrade works to existing pavements where site constraints would inhibit any works to be undertaken or required a complete reconstruction of the pavement.

Normal Design Domain (NDD) criteria shall be applied where possible. If site constraints restrict the upgrade of the existing geometric alignment to current design standards, while still maintaining acceptable operational and safety levels, the use of EDD can be considered as part of the upgrade works.

This application form is to be used to ensure that all reasonable steps have been undertaken to achieve NDD prior to the consideration of EDD. The use of EDD is limited to only ONE design parameter and must be mitigated and offset by above standard design criteria for other parameters. EDD cannot be applied to greenfield alignments or other upgrade works where retention of the existing pavement or pavement levels is not a key part of the works.

General principles

- EDD can only be applied where FRA is rehabilitating or upgrading an existing facility and there are significant controls on the site.
- Significant investment would be required to ameliorate the constraint and it is unjustifiable in the scope of works.
- The existing facility is likely to have been designed to a lesser standard.
- There is no accident/crash history or operational problems associated with the site, relating to the EDD parameter under consideration.
- EDD must be applied at the scoping stage only.
- EDD can only be applied to one design element and must be accompanied with an off-set element designed above minimum NDD.

Project Details Extended Design Domain Application Form
(This section can be expanded to multiple pages to cover any discussions involved and attachments required.)

1. Road/Project Name

2. Location

3. Provide details of the project

4. Detail the project problem and why EDD is being considered. Include details of the issue/s, data available, design criteria, crash statistics, cross sections, site constraints, etc.

5. Identify options considered (NDD & EDD) to address the problem.

6. Discuss the impact and feasibility on the project outcome of the options identified in Q5 above. (a)

(b)

(c)

7. Discuss the mitigation measures to address the problem when applying NDD and EDD.

8. Attach plans, photos, drawings

9. Other information

CHAPTER 3

GEOMETRIC DESIGN

PART 3 - GEOMETRIC DESIGN

1.0 Introduction

1.3 Design Criteria

Refer to Chapter 2 for FRA's policy and approval process regarding the use of Extended Design Domain (EDD).

2.0 Fundamental Considerations

2.2 Design Parameters

2.2.2 Road Classification

FRA uses a functional classification system for its arterial road network.

For rural roads, five classifications are provided which include M1, M2, S, C and R. The classification reflects both the function and standard of the road.

M1 Roads are highways connecting the major cities and major provincial centres;

M2 Roads are serve the same role as M1 roads but carry less traffic and connect to large towns and provincial centres.

S Roads provide the primary link between towns and villages and also support tourism areas.

C Roads provide access for abutting properties to towns and villages.

R Roads connect properties to the network.

For urban roads, three classifications are provided which include Arterial, Collector and Local Roads. The classification reflects both the function and standard of the road.

Arterial Roads have a predominant function to carry traffic but also serve other functions. They form the primary road network and link main districts of the urban area

Collector Roads are local streets that have a greater role than others in connecting contained urban areas (e.g. residential areas, activity areas) to the arterial road system.

Local Streets are intended exclusively for access with no through traffic function.

Arterial Roads have a predominant function to carry traffic but also serve other functions. They form the primary road network and link main districts of the urban area

Collector Roads are local streets that have a greater role than others in connecting contained urban areas (e.g. residential areas, activity areas) to the arterial road system.

Local Streets are intended exclusively for access with no through traffic function.

2.2.7 Design Vehicle

Refer to Chapter 4 for further information regarding choice and application of Design Vehicles in Fiji.

Design Considerations for Trucks

Refer to Table V2.1 for design considerations for trucks.

Table V2.1: Provision for Trucks – Checklist

LOCATION	PROVISION FOR TRUCKS
Intersections	Provide for the swept paths of trucks. Refer to Austroads Design Vehicles and Turning Path Templates. Provide sufficient stopping distance (lateral sight distance restrictions are often critical). Provide sufficient sight distances to allow trucks to turn safely on each road. Provide radii appropriate for the turning speeds of trucks.
Horizontal curves	As far as possible, avoid locating features which are likely to require trucks to brake on curves, such as intersections where the main road is on a low radius curve. Alternatively, provide truck stopping sight distances.
Reverse curves	Provide either straights 0.6V metres long or spirals between reverse curves to allow for the spiral tracking of trucks. Where deceleration is required on the approaches to a lower radius curve, sufficient distance must be provided to enable truck drivers to react and decelerate.
Compound curves	If deceleration is likely to be required, allow sufficient distance for truck drivers to react and decelerate.
Spirals	Provide spirals where required for trucks, see AGRD Part 3, Section 7.5.4.
Grades	Provide sufficient signs to warn truck drivers of steep downhill grades. Provide adequate sight distance on approaches to curves on steep downhill grades.
Sag vertical curves	Provide stopping sight distance and adequate clearance beneath overpasses. Superelevation Avoid adverse superelevation wherever practicable. Check that superelevation has been increased on downgrades.

Notes:
The speed to be used for determining each sight distance referred to in Table V2.1 is the truck operating speed for the particular direction of travel.

2.2.10 Access Management

Refer to Chapter 6b for further information regarding livestock access.

3. Speed Parameters

3.3 Operating Speeds on Urban Roads

Adoption of Operating Speed approach for Fiji as described in the Guide is acceptable.

In general, an Operating Speed equivalent to the posted speed limit shall be adopted for design purposes.

3.4 Operating Speeds on Rural Roads

Adoption of Operating Speed approach for Fiji as described in the Guide is acceptable.

In general, an Operating Speed equivalent to the posted speed limit in rural towns shall be adopted for design purposes.

An Operating Speed of 10km/h greater than the posted speed limit shall be adopted for rural highways and high speed rural roads. When necessary, a risk-based approach using the available speed data may be adopted to assist in choosing an appropriate Operating Speed (less than 10 km/h greater than the posted speed limit) for a project where design controls warrant an alternative approach to ensure that a value-for-money design solution can be developed.

The Extended Design Domain (EDD) approval process included in Chapter 2 shall be used to seek approval to adopt Operating Speeds less than 10 km/h greater than the posted speed limit for rural roads.

4. Cross Section

4.1 General

4.1.1 Functional Classification of Road Network

FRA uses a functional classification system for its rural arterial road network. Five classifications are provided which include M1, M2, S, C, R. Refer Section 2.2.2 of this Chapter.

4.2.2 Road Cross Fall

The following alternative crossfalls on straights shall be adopted in order to minimise water damage of pavement:

Table V4.2: Typical pavement crossfall on straights

Type of Pavement	Crossfall (%)
Earth, loam	5
Gravel, water bound macadam	4
Bituminous sprayed seal	4
Asphalt	3 - 4
Concrete	2 - 3

4.2.4 Traffic Lane Widths

Traffic lane widths are measured to the line of kerb. Refer Section 4.6.4 of this Chapter for clearances from line of kerb to traffic lanes for different kerb types.

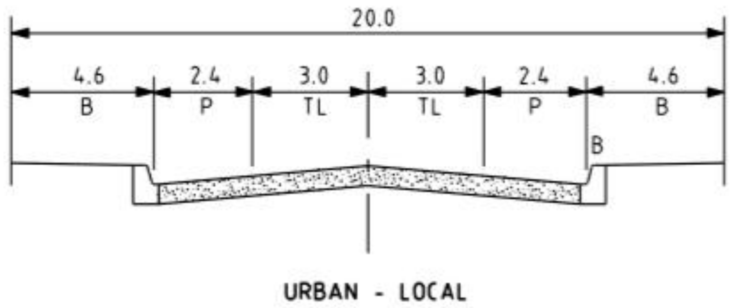
Where a temporary track is placed on a tightly curved alignment, 4.0m minimum width shall be provided for each lane and the remainder of the width shall be provided by means of a full depth sealed shoulder.

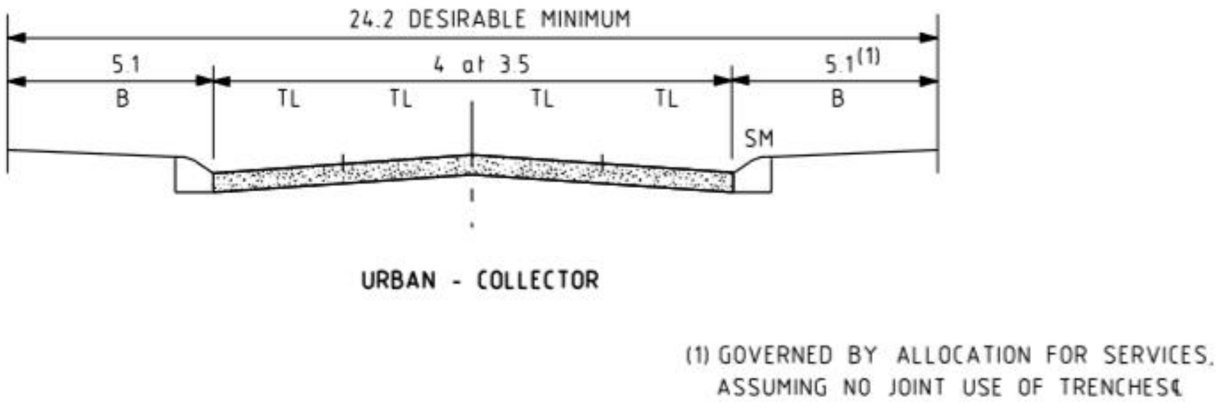
4.2.5 Urban Road Widths

Urban Arterial lane width values as per AGRD Part 3, Table 4.3 shall be adopted.

Cross section requirements for specific projects shall be confirmed during preparation of the functional design. In particular, opportunities to adopt Safe System elements into cross sections being considered for design shall be investigated as a priority as part of establishing project scope.

Urban Local and Collector Road widths are shown below – Figure V4.5a





(B) Border – 7.3m to line desirable if trunk utility services are provided, 4.3m minimum
(P) Parking
(TL) Traffic Lane
(1) Governed by allocation of services, assuming no joint use of trenches

In addition to AGRD Part 3, Table 4.3, typical Arterial Road Cross Sections are in FRA's Standard Drawings.

For housing developments refer to FRA for additional requirements.

4.2.6 Rural Road Widths

Refer Section 2.2.2 and Section 4.1.1 of this Chapter for further information regarding functional classification and traffic lane widths to be adopted on Fiji Rural Road Network.

M1, M2, S, C and R roads will have a distinctive appearance based on the minimum widths of carriageway elements.

Refer to FRA Standard drawings for typical rural road cross sections.

For C and R roads, the widths of cross section elements for new construction are mainly determined by traffic volume. The widths of carriageways are summarised in Table V4.2.

FRA's standard drawings show cross sections commonly adopted in Fiji for various road types. Cross section requirements for specific projects shall be confirmed during preparation of the functional design. In particular, opportunities to adopt Safe System elements into cross sections being considered for design shall be investigated as a priority as part of establishing project scope.

Table V4.2: Widths of Rural Carriageway Elements

Sealed Roads

Classification and (AADT)	Lane Widths (m)	Shoulder Widths (m)	Sealed Shoulder (m)	Total Seal (m)	Carriageway (m)
M1 and M2					
(AADT<1500)	2 x 3.3	2.0	1.5	9.6	10.6
(AADT>1500)	2 x 3.5	2.5	1.5	10.0(2)	12.0
S					
(AADT<1500 2 Lane)	2 x 3.3	2.0	0(3)	6.6	10.6
(AADT>1500)	2 x 3.5(1)	2.0	1.0(2)	9.0(2)	11.0
(AADT<1500 1 Lane)	1 x 4.5	1.5	0	4.5	7.5
C(6)					
(AADT<1500 2 Lane)	2 x 3.1	2.0	0.3(3)	6.8	10.2
(AADT>1500)	2 x 3.5(1)	2.0	0.3(3)	7.6(2)	11.0
(AADT<1500 2 Lane)	1 x 4.0	1.5	0.3	4.6	7.0
R					
(51 – 150)	1 x 4.0	1.5	0.1	4.2	7.0

Unsealed Roads

Classification and (AADT)	Lane Widths (m)	Shoulder Widths (m)	Carriageway (m)
M2			
(AADT<1500)	2 x 3.3	2.0	10.6
(AADT>1500)	2 x 3.5	2.5	12.0
S			
(AADT<1500 2 Lane)	2 x 3.3	2.0	10.6
(AADT>1500)	2 x 3.5(1)	2.0	11.0
(AADT<1500 1 Lane)	1 x 4.5	1.5	7.5
C(6)			
(AADT<1500 2 Lane)	2 x 3.1	2.0	10.2
(AADT>1500)	2 x 3.5(1)	2.0	11.0
(AADT<1500 1 Lane)	1 x 4.0	1.5	7.0
R			
(51 – 150)	1 x 4.0	1.5	7.0
R			
(1 – 50)	1 x 3.0	2.0	7.0

Notes

1. Where there are more than 500 trucks ADT two way on roads with unsealed shoulders
    a) Traffic lanes may be widened to 3.7 m, and
    b) Total seal on curves may be widened to provide tracking widths in AGRD Section 7.9.
2. Where road radius is less than 200 m, sealed width shall be increased to provide tracking width in AGRD Section 7.9.
3. 1.0m sealed shoulder on high tourist routes, high freight routes and where warranted by accident record.
4. For definitions of M1, M2, S, C, R Roads, see Section 2.2 of this Chapter.
5. On routes less than 200 vpd, generally maintain existing pavement and widths on 'C' and 'R' roads unless upgrading is warranted by exceptional traffic volumes or by crash records. New works in excess of 100m length will be constructed to the specified standards.

V4.2.7 Over Dimensional (OD) Vehicles

The Manager Governance and Manager Design and Procurement shall be consulted to determine specific requirements for Oversize Vehicles.
For further information regarding Over Dimensional (OD) vehicles, refer to FRA for guidance on Oversize Load Carrying Vehicles and Oversize and Overmass Special Purpose Vehicles for specific requirements.

4.3 Shoulders

4.3.3 Shoulder Sealing

Refer to Table V4.2 for sealed shoulder widths.

Additional Information

All M1 and M2 sealed roads shall have shoulders partially sealed to 1.5m width. S roads may have shoulders sealed to 1.0m on sections which have a demonstrated record of run-off-road accidents. Consideration should be given to providing 1.0m sealed shoulders on the outside of curves on C roads.

Sealed shoulders reduce accident rates and there are road safety benefits where shoulders are sealed for 1.5m width. Fully or partly sealed shoulders offer further advantages for the longevity of the pavement, which shall be considered when designing new construction or widenings. A full width seal shall be considered where long vehicles are expected to track over the shoulders.

4.5 Batters

Batter slopes that exceed the recommended minimums in AGRD, Section 4.6 shall be treated as EDD in accordance with Chapter 2 of this supplement.

4.6 Roadside Drainage

Refer Standard Drawings for Roadworks for catch drain types.

Where room permits, Catch Drain Type A may be used where the natural materials are not dispersible and erodible. The minimum practical width for construction of a flat bottomed drain is 2m, but 2.5m is preferable.

Catch Drain Type B may be used for small flows in non-erodible materials. The mounded catch drain shall be used above cut batters where the natural material is erodible, or wherever it is necessary to achieve minimum disturbance of existing vegetation.

Where space is limited or additional capacity is required, Refer Standard Drawings for typical V - Drain details.

V Drain Type 1 may be used where the natural materials are able to resist dispersion and erosion. The maximum depth shall be limited to 1m.

V Drain Type 2 shall be used where the natural materials are not able to resist dispersion and erosion or the depth is greater than 1.0m. The maximum depth shall be limited to 1.5m.

For drainage crossing details, refer to FRA Standard Drawing details.

4.6.4 Kerb and channel

For Pram Crossing details refer FRA Standard Drawing details, AGRD Part 4, Section 8.2.4, Australian Standard AS 1428.1.

V4.6.4.1 Kerb & Channel Types

There are four basic types of kerb, kerb and channel or channel combinations used in Fiji:

a) Semi-Mountable Kerb
b) Barrier Kerbs
c) Channels
d) Fully-Mountable Kerb

Refer to FRA Standard Drawings for typical kerb and channel types.

V4.6.4.2 Mountable Kerb and Channel

Mountable kerb is suitable for:

- the approach noses of traffic islands which are likely to be trafficked;
- for separation of normal traffic lanes from special areas intended for use by long or over dimensional vehicles in medians or on roundabouts. These shall not be placed where pedestrians or cyclists will cross the kerb, as they could pose a tripping hazard.

V4.6.4.3 Barrier Kerbs

Barrier kerbs shall not be used on high speed and intermediate speed roads (70km/hr or greater), as it is more likely to trip and overturn an errant vehicle. They shall not be used under safety barriers on high speed routes (80km/hr) because the rail deflects on impact and the barrier kerb and rail combination may form a ramp to launch an errant vehicle.

Barrier kerb is suitable for:

- drainage behind guardrail;
- car parks, shopping areas;
- matching into council kerbing;
- under or close to bridge railing;

- indented bus bays.

V4.6.4.4 Channels

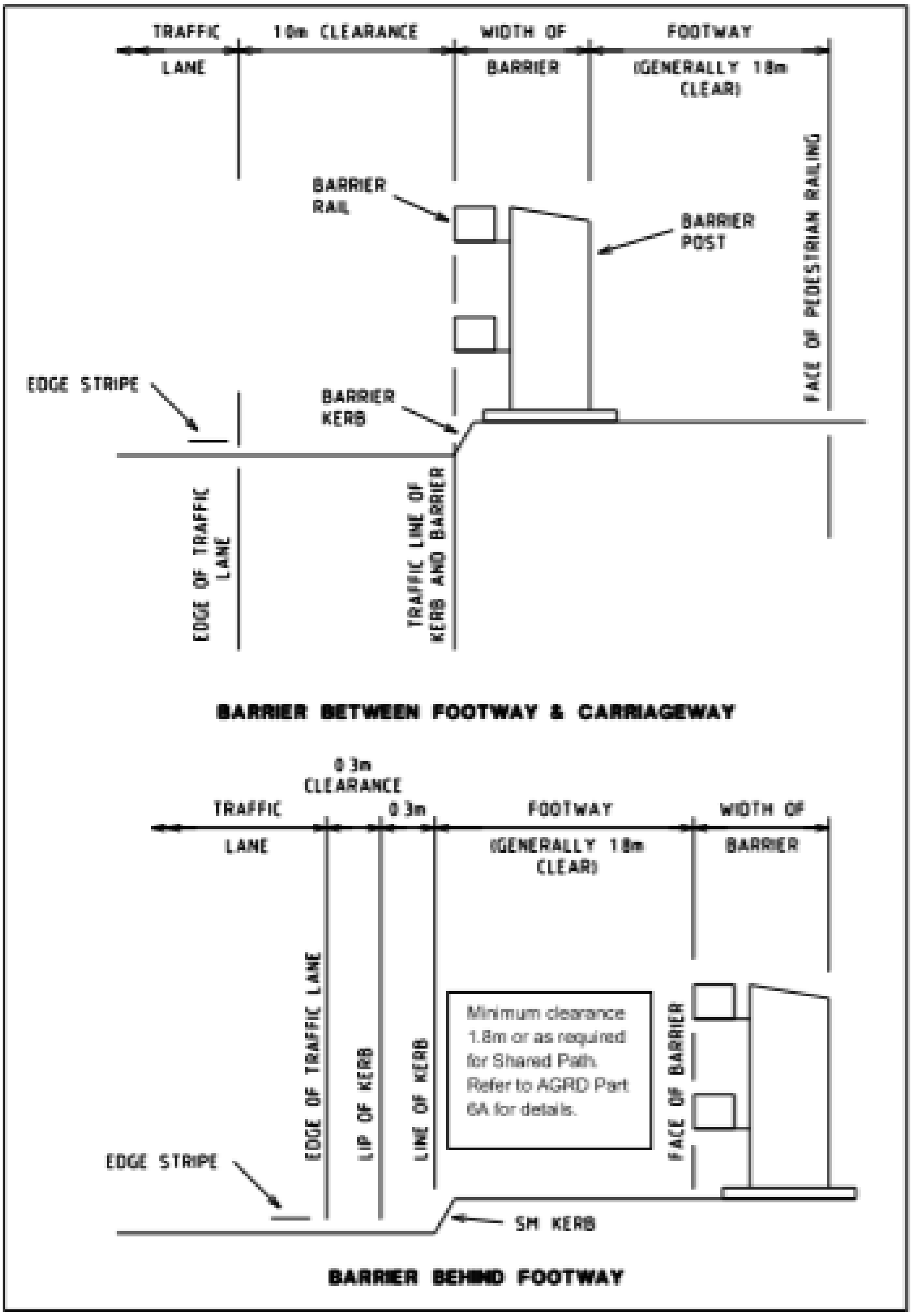
Channel types as shown in FRA,s Standard Drawings have more drainage capacity than kerb and channel, and may be used as a catch drain adjacent to the high side of carriageway provided that the specified clearance is provided to the nearest traffic lane.

The curved channels could create steering problems, and shall not be located adjacent to or close to the edge of traffic lanes. As vehicles can roll when tripped at relatively low speeds, other options shall be considered before channels are located on the outside of curves.

V4.6.4.5 Kerb and Channel on Structures

Where there is a footpath in front of a bridge barrier or road safety barrier, SM type kerb and channel shall be used. Where barrier type kerb and channel is used, the face of the kerb shall be located directly below the face of barrier rail. Refer to Figure V4.9 for layout details.

Figure V4.9: Kerb and Channel for Structures



V4.6.4.6 Clearance to Kerbs

<u>Clarification</u>

When longitudinal barriers such as kerb and channel, safety barriers, or retaining walls are located adjacent to traffic lanes, drivers tend to position their vehicles away from the barrier. This may reduce the effective capacity of the road. This behaviour may be countered by providing a clearance between the barrier and the traffic lane or shoulder.

CHAPTER 4

INTERSECTIONS AND CROSSINGS

PART 4 - INTERSECTIONS AND CROSSINGS

1.0 Introduction

1.4 Design Criteria in Part 4

Refer to Chapter 2 for further information regarding the application of Extended Design Domain criteria in Fiji.

2.0 Types of Intersections

Additional Information
Further information should be sought for the selection of roundabout and signalised control type intersections. Eg, Austroads Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings.

3.0 Road Design Considerations for Intersections

3.1 Road Users

Table 3.1: Considerations for road users in intersection design

Clarification / Additional Information
Pedestrians – The AGRD recommends avoiding staged crossings wherever practicable. In a number of circumstances, staged crossings are desirable.

Bus Drivers – Consider limited vision for drivers when considering locations with required lane changing / merging, especially on the far side of the vehicle from the driver.

Motorcyclists (not included in table) – Limit the use of excessive painted areas.

Avoid treatments that can result in the build up of debris where motorcycles would potentially be turning. Longitudinal grooving in intersections and on curves is not permitted.

Refer also to Austroads Guide to Traffic Management (AGTM) Part 6, Table 3.3 and Chapter 6 for additional motorcyclist considerations.

3.2 Provision for Large/Special Vehicles

Additional Information
Designers shall clarify if intersections on major arterial routes need to cater for Larger Freight Vehicles prior to the commencement of functional design. Fiji's Land Transport Authority and

FRA's Manager Governance shall be consulted regarding possible routes for these vehicles.

3.5 Physical Constraints

Additional Information

Also consider existing and possible future access conditions.

3.7 Other Considerations

3.7.1 Pavement Markings and Signs

Additional Information

Refer FRA's Manual of Traffic Signs and Markings (MOTSAM) for design information concerning Pavement Marking and Signs.

3.7.2 Road Lighting

Additional Information

Refer FRA Road Lighting Design Standards for Current and Future Upgrades for design information concerning Street Lighting.

4.0 Design Process

4.2 Basic Data for Design

Additional Information

For the selection of the appropriate intersection control type refer to AGTM, Part 6, Section 2 and AS1742.2, Clause 2.4.

Table 4.1
Additional Information

For the "What Function" section (first row), refer also to AGTM Part 4: Network Management, Section 4.1.

4.3 Location of Intersections

Additional Information
FRA shall be consulted regarding Access Management Policy and further guidance regarding desirable intersection location/spacing. FRA will determine the appropriate degree of access according to the road classification and/or local constraints.

4.5 Road Cross-section

4.5.2 Traffic Lanes - General

Clarification
Lane widths are measured to the Line or Face of kerb.

Lane Widths (last paragraph)

Substitute Information
The distance of 5.0m between kerbs is an absolute minimum, not desirable minimum.

5.0 Design Vehicle

5.1 General

Additional Information
Additional consideration for turning movements includes adequate clearances to other vehicles' turning paths within the intersection.

5.2 Design vehicle

Additional Information

Refer to AGDR for adoption of appropriate design vehicles. Design vehicles shall be clarified with FRA prior to the commencement of functional design. Refer also the Land Transport Act, Clause 79 for legal vehicle dimensions in Fiji.

The designer shall seek FRA advice concerning the need to consider restricted access vehicles (25m long) before commencing geometric design. Where restricted access vehicles are to be allowed for, placement of pits and road furniture at arterial road to arterial road intersections and along truck routes shall not obstruct turning of the restricted access vehicle. This vehicle may be permitted to intrude into adjacent traffic lanes and may be provided with fully mountable paved areas behind the face of kerb.

More than one design vehicle may govern design of a particular intersection. For example, on roundabouts the swept width may be designed to suit a semi-trailer and the area adjacent to the outer kerb designed to provide clearance for the front overhang of a bus. Drainage pits, road furniture and extent of full depth pavement are generally located to provide clear passage for a 25m restricted access truck.

Large over dimensional (OD) vehicles generally have all-wheel steering which enables them to negotiate alignments designed for 19m prime mover and semitrailers. Therefore, unless there is an extraordinary OD vehicle specified, the 19m prime mover and semi-trailer may be used as the design vehicle for OD routes.

5.6 Design Vehicle Swept Path

5.6.2 Radius of Turn

Alternative Information

Preference for turn radii within intersections is to utilise the available turning templates for 5-15km/h as appropriate. Table V5.1 provides alternative minimum turning radii for design turn speeds.

Table V5.1: Minimum Radii for Turns within Intersections

	Car Speed km/h	Minimum Radii (m)							
		Superelevation (m/m)							
		0.06	**0.05**	**0.04**	**0.03**	**0.02**	**0.01**	**0.0**	**-0.02**
Turns Within Intersections	**16**	6	6	6	6	6	7	7	8
	18	7	7	8	8	8	8	8	10
	20	9	9	9	9	10	10	10	12
	22	11	11	11	11	12	12	12	14
	24	12	13	13	13	14	14	15	17
	26	15	15	15	16	16	17	17	20
	28	17	17	18	18	19	19	20	23
	30	19	20	20	21	21	22	23	60

Notes:

1. This table shows car speeds. Trucks generally travel slower on curves than cars (see AGRD Part 3, Table 4.3). On low radius curves within intersections, trucks can become unstable and roll. AGRD Part 4A, Appendix C provides details of speeds and turning radii for trucks within intersections. Chapter 4a of this Guide, Section 2.2 provides calculation details of maximum adverse crossfall at intersections.
2. Adverse crossfall on through traffic lanes should be avoided. Adverse crossfall where unavoidable shall be 0.020 to 0.025 m/m (maximum).
3. On downhill grades, steeper than 2 per cent the effect of adverse crossfall increases (see AGRD Part 4, Section 7.8). Adverse crossfall further reduces the safe speed for turning vehicles within intersections. The maximum vector slope shall not exceed 5 per cent (refer Chapter 4a of this Guide, Section 2.2.
4. On low and intermediate speed roads, curves located at the end of straights must be compatible with the operating speed.
5. The curve radii shown are minimum figures. Whenever possible, designers shall adopt larger radii. Minimum radii shall not be used on the approaches to intersections where braking occurs.
6. Where speeds on left turn slip lanes at intersections can exceed 30 km/h, radii and adverse superelevation (if present) shall be read from the lower part of the table.

6.0 Public Transport at Intersections

6.3 Bus Facilities

6.3.1 Bus Lanes

Additional Information

A bus lane on an approach without a left turn slip lane (which caters for a through movement) must not be located to the left of a general traffic lane used by left turning vehicles. A bus (undertaking a through movement) can share a left turn lane with other vehicles to gain priority, or have an exclusive lane provided to the right of a left turn lane.

6.3.1 Bus Lanes Table 6.1 – Note 1

Note 1: Based on four seconds of travel time for the bus driver to observe traffic in the adjacent lane in order to accept a gap plus the taper length (see Note 2).

Clarification Information

Replace Note 1 with:

Note 1: Based on four seconds of travel time for the bus driver to observe traffic in the adjacent lane in order to accept a gap plus the taper length (see Note 2) and is measured from the pedestrian crosswalk across the intersection departure or similar location on the intersection departure if no crosswalk is present.

Figure 6.5: Wide kerbside bus lane

Substitute Information
The 35m taper at the start of the wide kerbside lane is very short, especially for the >3.5m lateral shift. The taper length shall be based on lateral shift length for unexpected lane termination with lateral shift rate of 0.6m/s.

Figure 6.6: Separate bus lane and bicycle lane treatment

Substitute Information
The 35m taper at the start of the exclusive lanes is very short, especially for the >3.5m lateral shift. The taper length shall be based on lateral shift length for unexpected lane termination with lateral shift rate of 0.6m/s.

6.3.3 Bus Facilities in Medians

Additional Information
If considering bus facilities in a median, detailed analysis shall be undertaken to determine the possible excessive delays that may occur for buses when entering and/or exiting the median facility. If the median facility can only be provided over limited lengths, the delays in accessing the median facility may negate the benefits provided by the priority measure(s).

6.3.4 Bus Stops – Location

Additional Information

….a number of factors shall be considered, such as:

- whether it is reasonable and safe for pedestrians to access the stop at the proposed location - this could depend on pedestrian demand, pedestrian types and desire lines
- the requirement to provide facilities that meet DDA requirements with respect to access, manoeuvring space, grades etc.

Substitute Information

For information and requirements for locating bus stops and associated infrastructure refer to FRA for guidance on:

- Bus Stops
- Bus Stops on Shoulders

Bus bays shall not be combined with acceleration/deceleration lanes.

7.0 Property Access & Median Openings

7.1 General

Additional Information

Refer to FRA for Access Management Policies.

7.2 Property Access

7.2.1 Access Spacing and Proximity of Driveways to Intersections – Access spacing

Additional Information

Refer to FRA for Access Management Policies.

7.2.2 Urban Roads

Additional Information

Vehicle clearances shall also be considered as outlined in the AGRD Part 3, Section 8.2.5 – Vehicle Clearances.

Additional Information

Urban Driveways

There are generally two cases:

(a) footpath close to the property boundary, or

(b) footpath abutting the kerb.

The width of the driveway across the border may have to be increased where the access road is less than 7m wide and onstreet parking is permitted.

Factors affecting the driveway vertical design are:

(a) the differences in levels across the border
(b) the width of the border
(c) the location and slope of the footpath
(d) the type of kerb and channel
(e) the crossfall of the road
(f) the ground clearance of the design vehicle.

The profiles of driveway designs beyond the normal limits shall be checked using scale silhouettes of design cars, to ensure that long front or rear overhangs would not touch the proposed surface. The relative grade change within the driveway desirably shall not exceed 12 per cent, and shall not exceed 16 per cent.

Minimum vehicle clearance requirements for driveways are specified in AGRD Part 3, Section 8.2.5.

Refer FRA Standard Drawings for typical footpath crossing and kerb ramp details.

7.2.3 Rural Roads

Alternative / Substitute Information
Appropriate consultation is required with local councils and land owners to determine access needs. For further details on rural driveways, refer to FRA Standard Drawings for Roadworks.

8.0 Pedestrian Crossings

8.1 Introduction

8.1.1 General Additional Information

The appropriate reference for planning, warrants and design of pedestrian crossing is AGTM Part 6, Chapter 8 and AS1742-10

8.2 Mid-block Crossings on Roads

Table 8.1: Crossing features and considerations – Crossing width

Clarification Information
A marked crosswalk at a mid-block signalised pedestrian or children's crossing shall not be less than 3.0m between the lines.

It is noted that AS1742.10 shows a 2.4m minimum width in Figures 3-6. The minimum width of a midblock crossing shall be 3.0m.

Table 8.1: Crossing features and considerations – Stopline location

Substitute Information

Refer to AS1742-10 and FRA,s Manual for Signs and Markings for stopline details at mid-block crossings.

Additional Information
Grade separated facilities are not addressed. Refer to AGTM Part 6, Chapter 8 for warrants for grade separated pedestrian facilities.

8.2.2 General Crossing Treatments

Substitute Information
Refer to FRA Standard Drawings for an example of a pedestrian refuge.

8.2.2 General Crossing Treatments – Staged crossing of a median

Additional Information
Note: The first paragraph in this section is better related to AGRD Part 4, Section 8.2.3 Time Separated (Controlled Traffic) Facilities. However, the principles for median width and stagger arrangements apply to signalised and unsignalised crossings.

Consideration shall also be given to the number of lanes being crossed on each carriageway, as the greater the number of lanes, the greater clearance times are required at signal controlled facilities - especially where staging in the median cannot be provided.

8.2.2 General Crossing Treatments – Footpath kerb extension

Additional Information
Unnecessary road furniture and vegetation shall be avoided on kerb extensions to maintain sightlines between drivers and pedestrians.

9.0 Cyclist Crossings

9.3 Path Crossings of Intersecting Local Access Roads

Additional Information
Reference shall be made to AGTM Part 6, Chapter 8 and AS1742-9 for further guidance on cyclist crossings.

10.0 Rail Crossings

Traffic management considerations for railway crossings are provided in AGTM Part 6. For Geometric Design requirements, refer AGRD Part 4, Section 10.

Appendices

Appendix A.1 Access Spacing

Refer to FRA Access Management Policies for further information.

Commentaries

Commentary 7 Warrants & Guides

Reference shall be made to AGTM Part 6, Chapter 8 and AS1742-9 for further guidance on cyclist crossings and warrants.

CHAPTER 4a

UNSIGNALISED AND SIGNALISED INTERSECTIONS

PART 4a - UNSIGNALISED AND SIGNALISED INTERSECTIONS

2.0 Layout Design Process

2.2 Alignment of Intersection Approaches

2.2.1 Horizontal Alignment

Departure tapers are not supported as they do not provide sufficient length for vehicles to accelerate in and select appropriate gaps in traffic to merge. Therefore design between points C and D in AGRD Part 4A, Figure 2.3 are not supported.

2.2.4 Superelevation at or near Intersections

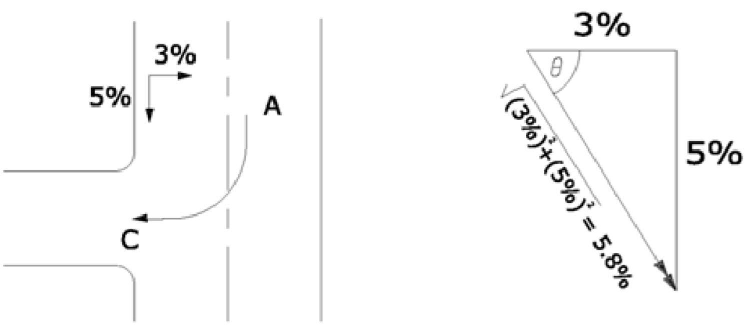
<u>Additional Information</u>

Maximum Effective Adverse Crossfall

The maximum 'effective adverse crossfall' for turning movements at intersections can be determined using vector diagrams. The procedure is explained in the examples which follow.

Example 1
In this example the road has 3% one way crossfall and 5% grade as shown on Figure V2.1(a). At point A, the effective adverse crossfall is 3%. At point C the effective adverse crossfall is 5%. Figure

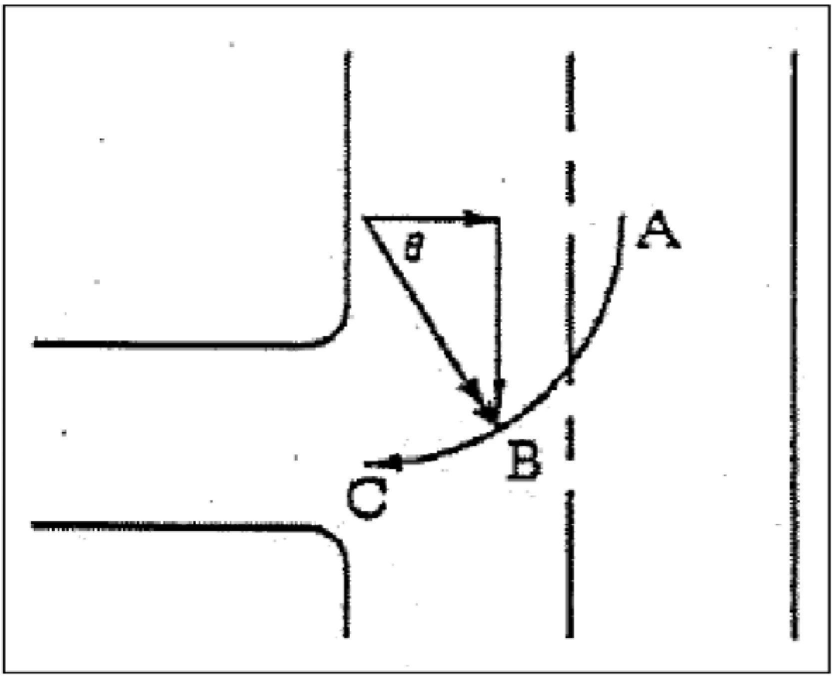
V2.1(a): Vectorial Calculation of Maximum Effective Adverse Crossfall



The maximum effective adverse crossfall is obtained as the vector sum of the grade and crossfall on the road, as shown on the right of Figure V2.1 (a) the maximum grade is 5.8% and the direction of the maximum grade corresponds to the direction of the resultant vector. (Note that vectors being added must be located head to tail).

As effective adverse crossfall is defined as being at 90º to the vehicle path, the place where the maximum resultant vector is at right angles to the curve identifies the point where the maximum crossfall occurs (point B on Figure V2.1 (b)

Figure V2.1(b): Location of Maximum Adverse Crossfall



Example 2

In this example, the pavement slopes downwards towards the side road. The crossfall initially creates positive superelevation for turning vehicles (Figure V2.3(c)).

The vectorial diagram which applies in this case is shown on Figure V2.1 (d)

Figure V2.1(c): Diagram for Example 2

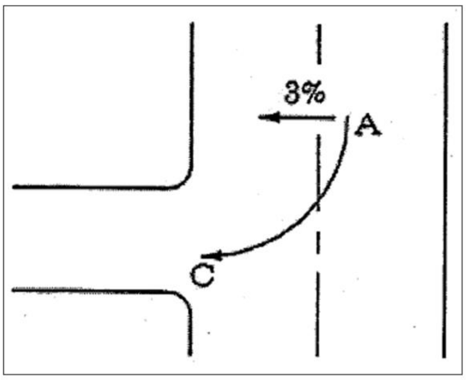
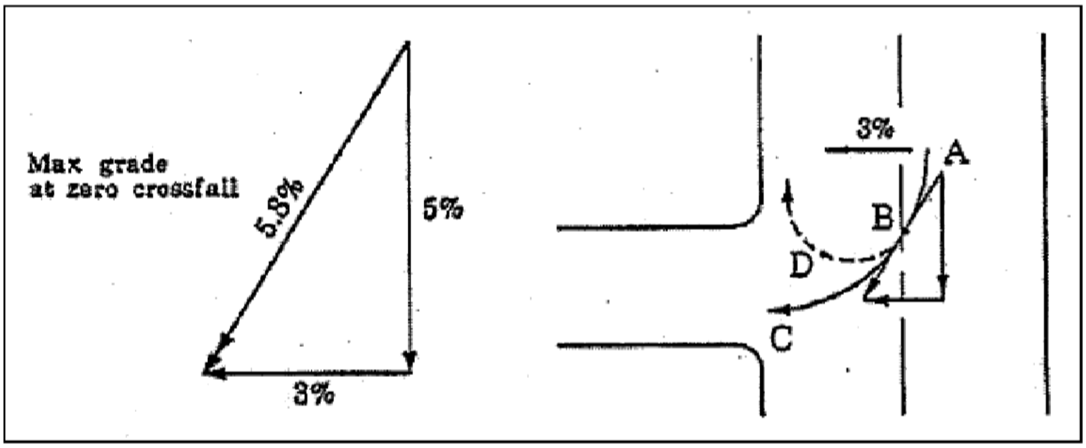


Figure V2.1(d): Solutions for Example 2



At point B on Figure V2.1 (d), the vehicle is travelling on a grade of 5.8 % with zero effective crossfall. The effective adverse crossfall increases from 0% at B to 5% at point C.

If the vehicle were making a U turn, 5.8% maximum effective adverse crossfall would be experienced at point D where the direction of travel is 90 degrees to the resultant on the vector triangle.

Reference shall be made to AGRD Part 4A, Appendix C – Truck Stability at Intersections, for further information.

3.0 Sight Distance

3.1 General

Additional Information

Size of Intersection

At speed, drivers concentrate and focus on the road ahead. The area seen with maximum clarity is relatively small and a limit is reached outside which objects may not be detected. This limit is the side of the driver's cone of vision. At higher speeds, the concentration of drivers increases and the cone of vision narrows as follows:

- at 60 km/h, the angle is about 40°.
- at 80 km/h, the angle is about 30°.

Intersections (especially roundabouts) shall be located within the cone of vision.

For example, at 100 km/h, drivers require an unobstructed view of the approaches for approximately 170 m to ensure that they have time to see a roundabout, recognize it and then slow to a safe approach speed. The limit of the cone of vision is about 60 metres (see Figure V3.1 (a)).

An example with a curved approach is shown on Figure V3.1 (b).

Figure V3.1(a): Intersection on a Straight
(from RDG Figure 2.3.3.1(a))

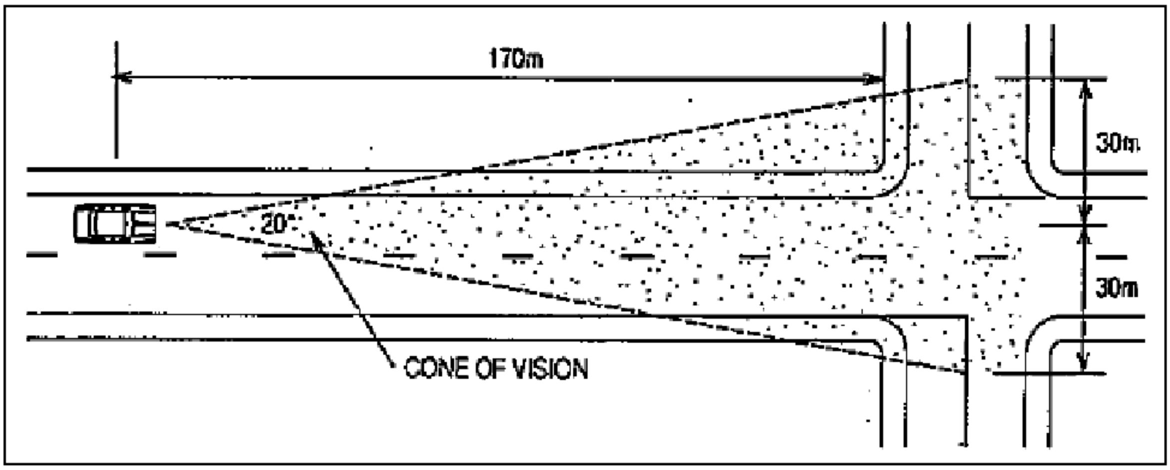
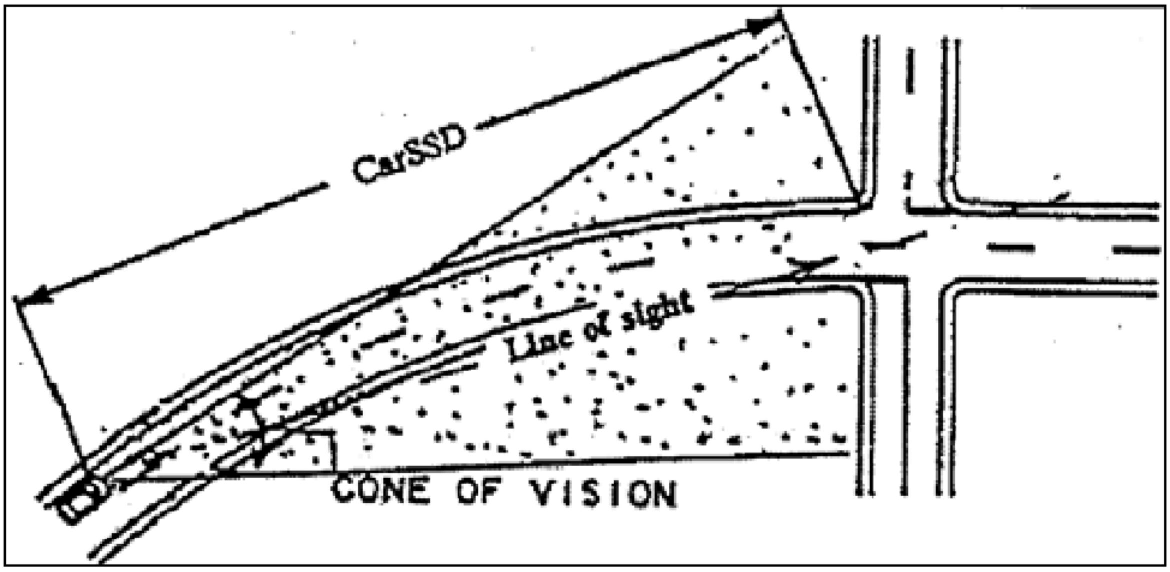


Figure V3.1(b): Intersection on a Curve
(from RDG Figure 2.3.3.1(b))



Under normal circumstances the provision of the sight distance controls on Figure 3.2 will be sufficient to ensure that the intersection is located within this cone of vision of both car and truck drivers.

Truck Stopping Sight Distance (AGRD Part 3, Table 5.5) shall be used for providing stopping sight distances and deceleration distances on the approaches to areas which could be potentially hazardous for trucks or buses. Significant areas include:

- intersections with lateral sight distance restrictions. For example, intersections in hilly terrain and intersections near bridge piers.
- intersections on or near crest vertical curves.
- on intersection approaches where truck speeds are close or equal to car speeds.
- on the legs of intersections which do not meet the sight distance requirements on AGRD Part 4A, Figure 3.2.

3.2 Sight Distance Requirements for Vehicles at Intersections

Reference shall be made to Commentary 1 for further information regarding the exclusion of Entering Sight Distance (ESD).

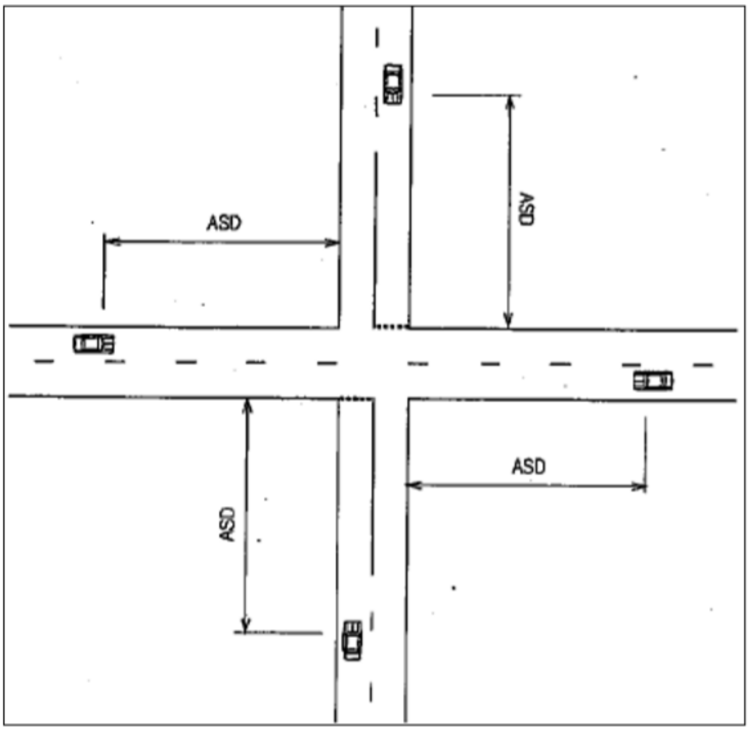
3.2.1 Approach Sight Distance (ASD)

Additional Information

Approach Sight Distance also applies to:
- merge areas on all roads, and
- start and end of overtaking lanes
- fords and floodways
- pedestrian movements

It is desirable to provide Approach Sight Distance on all approaches to an intersection as shown in Figure V3.2.

Figure V3.2: Approach Sight Distance



Clear triangulated areas for ASD shall not include planting, hard landscaping or other road furniture that would reduce ASD. Set back of 5 metres for this area, at pedestrian crossings / paths shall be adopted. This is an appropriate offset to allow for pedestrian movement as a vehicle approaches. For any functional change resulting in a kerb realignment sight clear zone area shall be provided to allow a motorist to view the change in road functionality.

3.2.2 Safe Intersection Sight Distance (SISD)

Clarification of Information

AGRD Part 4A, dot point 3 and Figure 3.2:

Instead of the driver on the minor road being situated at a distance of 5.0m (3.0m minimum) from the lip of the channel or edge line project of the major road, the driver location shall be taken as 7.0m (5.0m minimum) from the conflict point.

The conflict point is to be taken as the centre of the main road lane. Note that this will not change the sight triangle but clarifies the issue when there is a shoulder or left turn lane on the major road.

When there is a left turn lane on the major road with a high left turn volume, the left turn lane shall be set back further to ensure the sight triangle remains clear.

3.3 Pedestrian Sight Distance Requirements

Additional Information

The setback distance for the pedestrian crossing for working out the sight triangle shall be taken as 1.6m from the lip of kerb.

Correction to Equation 3 description for “tc”

$$CSD = t_c \times V/3.6$$

where:
CSD = sight distance required for a pedestrian to safely cross the roadway
tc = critical safe gap,
(s) = crossing length divided (not multiplied) by walking speed.

It is the minimum time in seconds required for a pedestrian to safely cross the road.
V = 85th percentile approach speed (km/h).

4.0 Types of Intersections and their Selection

4.1 General

Clarification

Traffic islands shall only be set back from the edge of the traffic lane where there is a demonstrated need.

5.0 Auxiliary Lanes

5.2 Deceleration Turn Lane Length

5.2.1 Components of Deceleration Turn Lanes

It is desirable that Deceleration plus Storage Length be provided, but it should be noted that sometimes this distance can be unreasonably long and there may be constraints that prohibit providing this length. Deceleration length must be the minimum length provided in all situations.

5.5 Auxiliary through Lane Design

<u>Additional Information</u>

See Figures V5.1 and V5.2 below for further details.

Figure V5.1: Diverge Taper of Auxiliary Through Lane

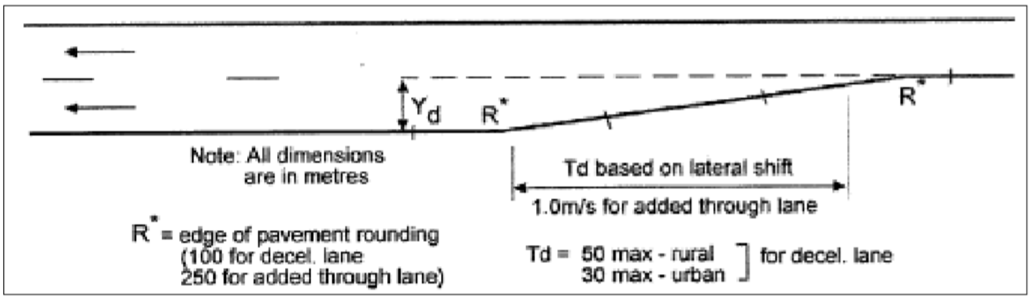
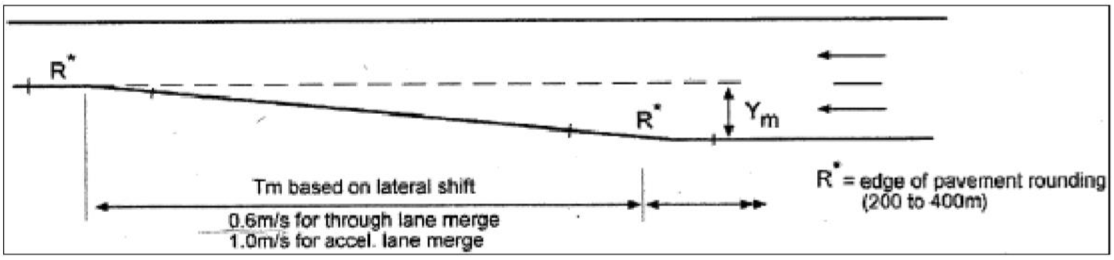


Figure V5.2: Merge Taper of Auxiliary Through Lane



6.0 Traffic Islands and Medians

6.1 Raised Traffic Islands and Medians

6.1.1 Raised Islands

Adopt island nose offset of 0.2m per 10km/h of approach speed.

6.1.2 Raised Medians

Note for AGRD Part 4A, Figure 6.2

An island nose offset of 0.2m per 10km/h of approach speed shall be adopted.

6.1.3 Raised High Entry and Free-flow Left-Turn Islands

Note for AGRD Part 4A, Figure 6.4

Refer to Appendix D of AGRD Part 4A for comments on what is appropriate use.

Figure 6.4. Note 1 refers to AGRD Part 4A.

Figure 6.3 is referenced for clearance to a raised median island but Figure 6.3 does not provide a value for the clearance. The clearance shall be in accordance with the appropriate figure in AGRD Part 4A, Appendix D.

6.4 Road Width between Kerbs and between Kerb and Safety barrier

6.4.1 General

Second paragraph states "It is desirable to provide a width no less than 5.0m between kerbs…." This shall be an absolute minimum of 5.0m.

AGRD Part 4A, Figure 6.8, Note 1 should read "Absolute Minimum" not Minimum Desirable.

6.5 Kerb and Channel

6.5.2 Kerb and Channel Types

Kerb and channel types used by FRA are included in FRA's Standard Drawings for Roadworks.

7.0 Right-turn Treatments

7.2 Rural Right-left Staggered T-intersection

Correction to AGRD Part 4A, Figure 7.1

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

7.3 Rural Right-turn Treatment – Divided Roads

7.3.1 Two Staged Crossing on Rural Road

Correction to AGRD Part 4A, Figure 7.2

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

Clarification Note 1 AGRD Part 4A, Figure 7.2

Offset right turn lanes are not common practice in Fiji.

7.3.2 Left-Right Staggered T – Divided Road

Correction to AGRD Part 4A, Figure 7.3

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

7.3.3 Back-to-back Right Turns on a Divided Road

Correction to AGRD Part 4A, Figure 7.4

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

7.5 Urban Right-turn Treatment – Undivided Roads

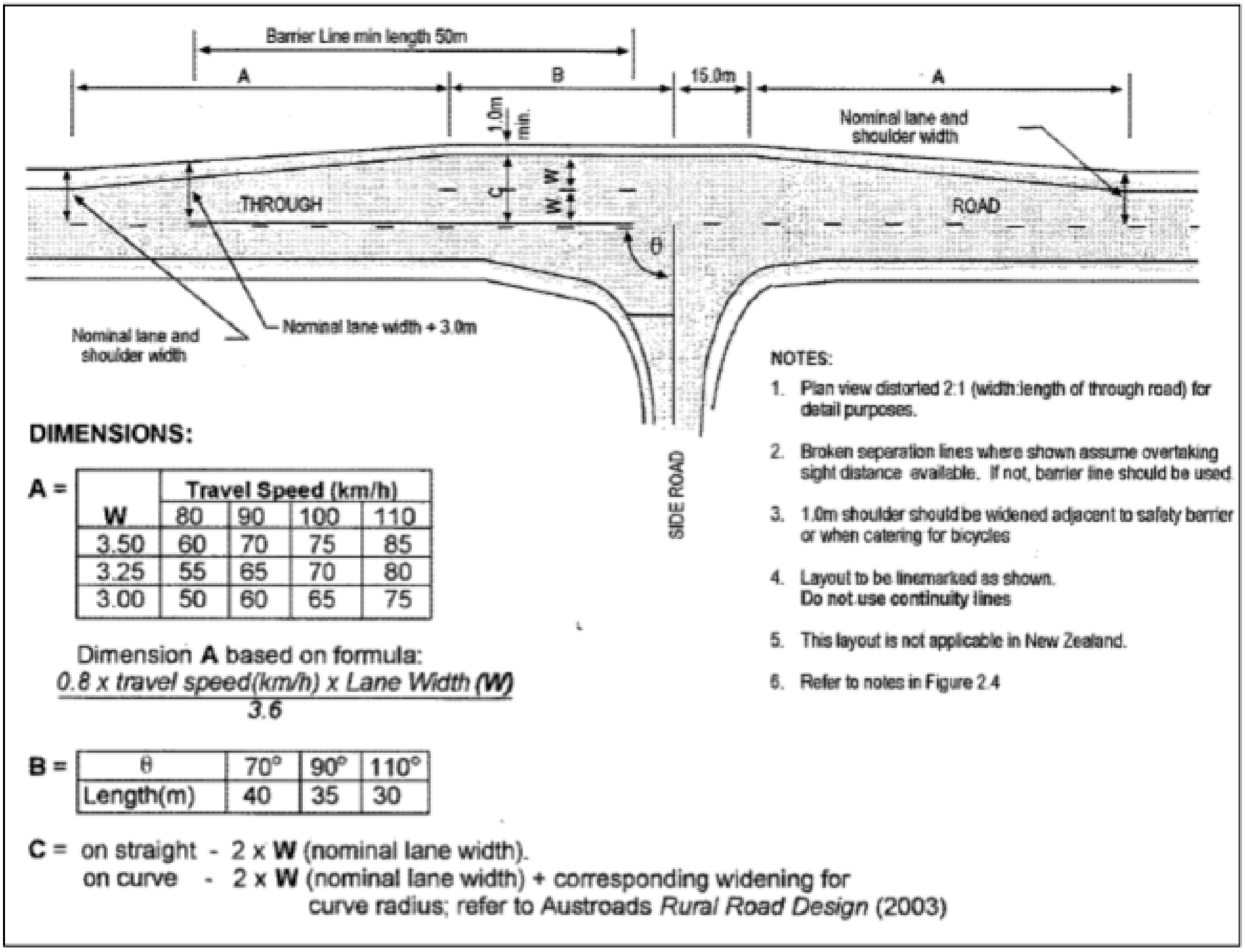
7.5.2 Urban Channelised T-Junction – Short Lane Type CHR(S)

Correction to AGRD Part 4A, Figure 7.7

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

The use of an AUR treatment (see Figure V7.2) is still allowed as a substitute to the CHR(S) treatment. Practitioners shall consult with FRA before implementing either treatment.

Figure V7.2: Type AUR Right Turn Treatment



A =

W	Travel Speed (km/h) 80	90	100	110
3.50	60	70	75	85
3.25	55	65	70	80
3.00	50	60	65	75

B =

θ	70°	90°	110°
Length(m)	40	35	30

7.6 Urban Right-turn Treatment – Divided Roads

7.6.1 Channelised Right-turn Treatments – Divided Roads

<u>Correction to AGRD Part 4A, Figure 7.8</u>

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

8.0 Left-turn Treatments

8.2 Rural Left-turn Treatments

8.2.1 Rural Basic Left-turn (BAL) Treatment

<u>Clarification of Sb value</u>

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

8.2.2 Rural Auxiliary Left-turn Treatment – Short Turn Lane [AUL(S)] on the Major Road

Correction to AGRD Part 4A, Figure 8.3

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

'F' shall be defined as 'Formation/carriageway widening (m)'. Refer to AGRD Part 4A, Figure 8.2 for location of 'F'.

8.2.3 Rural Auxiliary Left-turn Lane (AUL) Treatment

Correction to AGRD Part 4A, Figure 8.4

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

8.2.4 Rural Channelised Left-turn (CHL)

Treatments with High Entry Angle Alternative CHL layouts which are provided in AGRD Part 4A, Appendix D with guidance of use provided in this document.

Linemarking shown around the island is not something that would be done to that extent in Fiji. See comments regarding figures in AGRD Part 4A, Appendix D for further guidance.

Correction to AGRD Part 4A, Figure 8.5

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

8.3 Urban Left-turn Treatments

8.3.1 Urban Auxiliary Left-turn Treatment (AUL) on the Major Road

Correction to AGRD Part 4A, Figure 8.6

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

8.3.2 Left-turn Treatments for Large Vehicles

Correction to AGRD Part 4A, Figure 8.7

The holding/stop line shall be located in accordance with FRA's Manual of Signs and Markings.

Appendices

Appendix D.2 Simple High Entry Angle Design Process

AGRD Part 4A, Figure D1 can be used.

C_x to be a minimum of 2.0m.

For O_A value use 0.2m per 10km/h of approach speed.

Correction to second dot point

Line should read "plot the distances O1 + Cx +Wp +Cs +6.0".

AGRD Part 4A, Figure D2 can be used.

Appendix D.3.1 Alternative Layout Designs – A Alternative A

AGRD Part 4A, Figure D3 should be used. The value for W should be 5.0m absolute minimum and measured between line of kerb (not linemarking).

AGRD Part 4A, Figure D4 can be used.

Appendix D.3.2 Alternative Layout Designs – Alternative B

AGRD Part 4A, Figure D5 can be used. Lane width shall be 5.0m abs min and measured between line of kerb (not linemarking).

AGRD Part 4A, Figure D6 can be used. Lane width at the nose shall be 5.0m absolute minimum and measured between line of kerb (not linemarking).

AGRD Part 4A, Figure D7 can be used. Lane width shall be 5.0m absolute minimum and measured between line of kerb (not linemarking). The provision of flared kerb between points c and d is not desirable as it encourages motorists to use it as an acceleration lane and it is not long enough for that purpose. Kerb lines shall be designed to cater for the design vehicle.

AGRD Part 4A, Figure D8 can be used. Lane width at the nose shall be 5.0m absolute minimum and measured between line of kerb (not linemarking).

Appendix E.3 Detailed Examples from Main Roads WA

AGRD Part 4A, Figures E3 and E4 shall not be used.

Commentaries

Commentary 1 – Refer also to Section 3.2 of this Chapter.

CHAPTER 4b

ROUNDABOUTS

PART 4b - ROUNDABOUTS

3.2 Sight Distance Criteria

3.2.3 Criterion 3

Note that an absolute minimum sight distance is used in Austroads Guide to Road Design (AGRD) Part 4B, Figure 3.1.

3.2.4 Other Visibility Considerations

To enhance the prominence of the roundabout, the kerbs on both the splitter island and central island shall be light coloured or painted to provide a contrast with the pavement. The use of dark coloured kerbing is not permitted.

4.0 Geometric Design

The design method outlined in the AGRD Part 4B has been adopted by FRA, however its use is relatively untested in Fiji. It is known that there may be some issues/challenges that designers will encounter when developing designs - especially with incorporation of non perpendicular approaches and duplicated carriageways at roundabout approaches and departures.

It should be noted that use of the new Austroads method generally results in larger diameter roundabouts than previous design methods, especially in lower speed environments.

Where this approach is not considered practical or feasible, approval shall be sought using the EDD process outlined in Chapter 2 of this supplement.

4.3 Number of Entry, Circulating and Exit Lanes

4.3.1 Number of Circulating Lanes

<u>Correction</u>

The first sentence "The number of circulating lanes from any particular approach must be equal to or greater than the number of entry lanes on that approach" is not correct and should read:

"The number of circulating lanes is determined by the number of through lanes on the approach and also considering the right turn movements from the preceding approach."

4.4 Central Island

4.4.2 Factors Affecting Central Island Size

<u>Additional Information</u>

Roundabouts with a larger inscribed diameter, and consequently a larger central island, have a slightly greater entry capacity. In general, a large central island provides greater separation between adjacent conflict areas and makes it easier for entering drivers to determine whether vehicles, already on the circulating carriageway, are exiting or continuing on around the circulating carriageway. Larger central islands are usually necessary for roundabouts in high speed areas and at multi-leg intersections. Large central islands can also improve driver recognition of the form of intersection treatment.

4.4.3 Minimum Central Island Radius

Adoption of absolute minimum figures in AGRD Part 4B, Table 4.1 shall be subject to the EDD approval process outlined in Chapter 2 of this supplement.

4.6 Circulating Carriageway

4.6.1 Design Vehicle and Vehicle Swept Paths

To cater for vehicles that only occasionally use the roundabout, it may be acceptable for these vehicles (i.e. checking vehicle) to use multiple lanes to make their turn. FRA shall be consulted regarding the appropriate checking vehicle to be used if this is not specified.

5.0 Pedestrian and Cyclist Treatments

5.3 Cyclists

5.3.3 Bicycle Lanes at Single-lane Roundabouts

When designing a roundabout to cater for cyclists through the roundabout, the geometric design criteria set out in AGRD Part 4B, Section 4.5.5 must be measured from the kerb and not the edge of the bicycle lane.

Swept paths shall not encroach into the bicycle lane.

5.3.4 Multi Lane Roundabouts on Arterial Roads

Where it is proposed to provide circulating bicycle lanes on multi lane roundabouts on arterial roads, proposals shall be subject to review prior to design development and at the functional design stage by the Head of Design and Procurement and General Manager Network Operations and Maintenance.

As a minimum, the following information should be available for review:
- Strategic importance of the bicycle route in the network;
- Predicted numbers and types of cyclists using the roundabout (recreation, commuter etc.);
- Predicted traffic volumes including turning volumes;
- Predicted commercial vehicle volumes and mix.

6.0 Pavement Markings and Signing

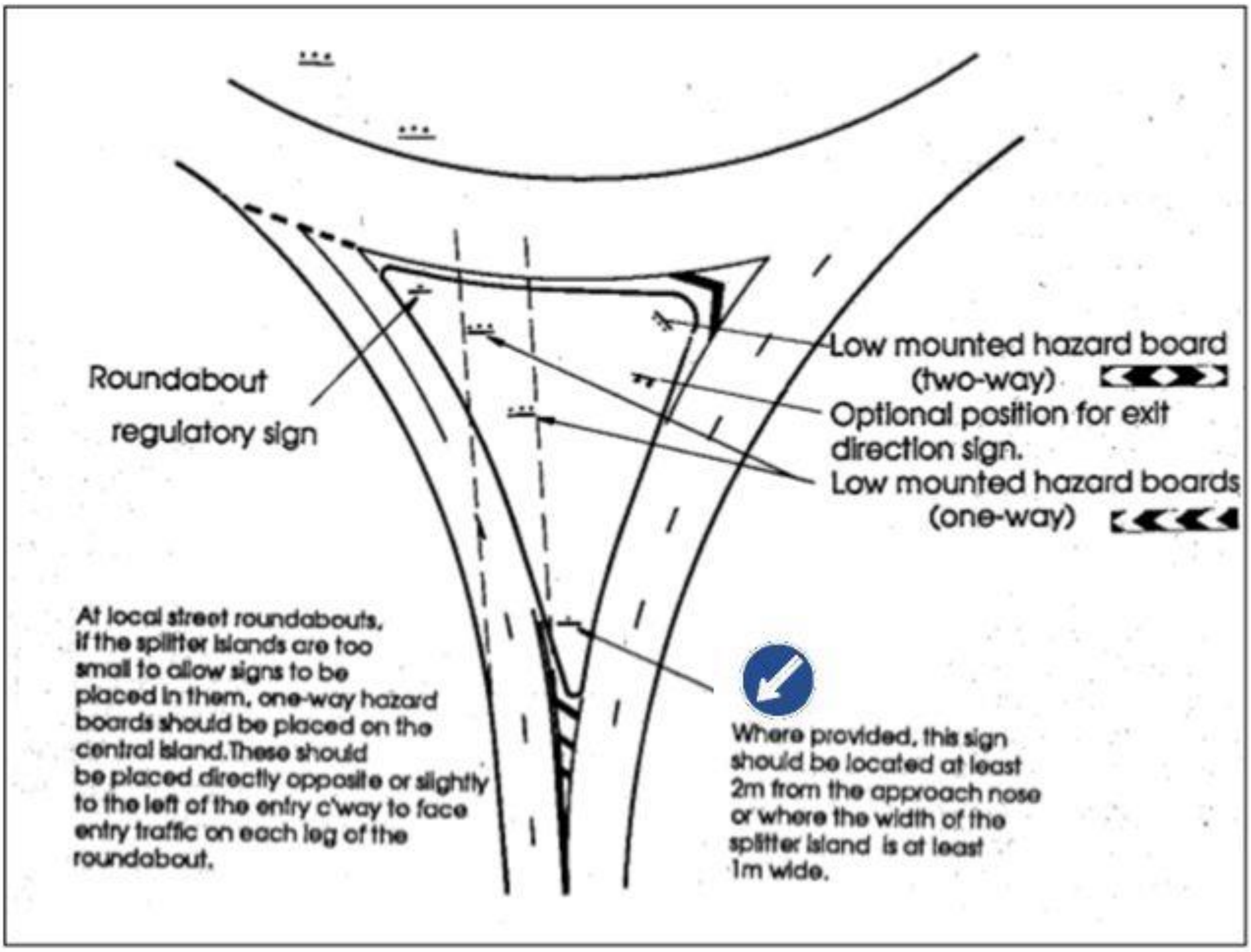
Refer to FRA’s Manual for Signs and Marking for details on pavement markings and signing.

6.1 Introduction

Additional information

Hazard boards can be placed in large splitter islands as shown in Figure V6.1 below.

Figure V6.1: Signing on larger Splitter Islands



7.0 Roadway Lighting at Roundabout

Roadway lighting is to be in accordance with the FRA Lighting Guide and Standards. FRA's Manual of Signing and Marking shall also be referenced.

Appendices

Appendix C Methods of Improving Roundabout Entries – Figure C2

Correction

This appendix contains additional information on trial installations. The speed “S c” value in box on the right hand side of Figure C2 should be 40km/h (not 48km/h as shown).

Appendix D.1 Linemarking of Multi-lane Roundabouts

Refer to FRA’s Manual of Signs and Marking for linemarking details.

Appendix D.2 Single-lane Exits Adjacent to Two Circulating lanes

The use of ‘spiral’ linemarking is acceptable.

Appendix VA Performance of Roundabouts

This appendix contains additional information on capacity analysis.

Appendix VB Worked Examples

This appendix contains information on gap acceptance parameters.

Appendix VC Trial Installations

This appendix contains additional information on trial installations.

Appendix D Case Studies

This appendix contains additional case studies.

CHAPTER 5

DRAINAGE - GENERAL & HYDROLOGY CONSIDERATIONS

PART 5 - DRAINAGE - GENERAL & HYDROLOGY CONSIDERATIONS

1.0 Introduction

1.4 Inter-agency Relations

At the start of each project, designers shall identify related external agencies to ensure their statutory responsibilities, and other requirements are understood, and appropriate action is taken to address them. This includes an understanding of drainage plans and strategies, environmental requirements, catchment management plans etc. Related agencies in Fiji are including but not limited to the following agencies.

1. Local councils
2. Department of Environment
3. Department of Town and Country Planning
4. Ministry of waterways (LWRM)
5. Ministry of Infrastructure and Transport (Dept of Water and Sewerage)

1.5 Management and Planning Framework

Fiji Road Authority is responsible for the design and construction of stormwater drainage network in urban areas in Fiji. However, urban drainage policies are developed by Ministry of Waterways (LWRM) in Fiji. Therefore, consultants and contractors shall search for existing drainage schemes and standards from LWRM in regard to water quality and quantity prior to commencing design.

Practitioners shall consult with the Department of Town and Country Planning (DTCP) to ensure that the road drainage complies with the overall strategy of DTCP.

1.8 Use of Software

The following software packages are recommended for design of drainage elements in Fiji. This approach will standardise the calculations and facilitate better quality control of calculations by FRA engineers.

Discipline	Package
Hydrology	• HEC-HMS • RORB • HEC-SSP
Hydraulic design	• HEC-RAS • PC DRAIN • DRAINS • CulvertMaster and Flowmaster • Tuflow
Water quality	• MUSIC (eWater)

Discipline	Package
Erosion protection	• Riprap (eWater) • Chute (eWater)
Drainage network	• 12D • Civil 3D

2.0 Safety in Design

2.5 On-road Safety

2.5.2 Floodways

Additional Information
Any proposal for adoption of a floodway on FRA controlled assets shall be subject to the approval of the FRA. EDD approval levels provided in Section 2 of this Supplement shall be adopted.

3.0 Environment

There have been a number of studies that estimate implications of global warming on sea levels and rainfall intensity in Fiji. Details of these studies are provided in the Appendix to this Chapter.

Based on these studies, a minimum sea level rise of 780 mm and an increase of rainfall intensity of 10% are the most appropriate scenarios to be adopted in allowing for climate change in Fiji.

Because of the uncertainty in predicting the consequences of climate change, a risk assessment is also required to consider the consequences of variations compared with the design criteria.

3.2.2 Sea level rise

Having prepared a preliminary design based on a sea level rise of 780 mm, the designer shall then assess the performance of this design operating in an environment where the sea level rises to 1050 mm. This assessment will then allow the designer to determine the consequences of potentially under designing for seal level rise. That is, designing for a sea level rise of 780 mm when in fact a 1050 mm sea level rise occurs.

The consequences can then be used as an input into a risk assessment (refer Table 5-1). The risk assessment will then be undertaken using the Decision Matrix (Table 5-2) to determine the appropriate sea level rise to be adopted for detailed design (ie 780 mm or 1050 mm).

Where, the project and surrounding land is not affected by sea levels, this analysis is not required.

The designer shall adopt the following steps:

Part a – Consequence Estimation
1. prepare a preliminary design based on a sea level rise of 780 mm
2. assess the consequences of the sea level actually rising 1050mm, assuming the road is built for a rise of 780mm
3. Use the Consequences Table below to determine a consequence score

Part b – Cost and Risk Estimation

1. Estimate the cost of the project designed for a sea level rise of 780mm
2. Estimate the cost of a project designed for a sea level rise of 1050mm
3. Use the Decision Matrix table below to determine the appropriate sea level rise to be adopted for design

Table 5.1 - Consequence Assessment Table

Score	**Consequences of increased sea level as per Part a above**
Severe	1- Loss of life. 2- Severe damage to major infrastructures such as bridges, etc. 3- Long-term inundation of M1, M2 and Auxiliary Roads. 4- Inundation of properties in urban areas.
Moderate	1- Risk of injury for residents. 2- Damage to moderate and small size urban infrastructures. 3- Long-term inundation of collector and local roads. 4- inundation of properties in areas other than urban.
Minor	1- Minor inundation of roads. 2- Damage to small infrastructures such as clogging of culverts, need for minor maintenance, etc. 3- Inundation of urban passages for longer than they have designed for but with no damage to nearby properties.

The following decision matrix shall be applied to determine if a sea level rise of 780mm or 1050mm should be applied to the design.

Table 5.2 - Decision Matrix

PC_{1050}/PC_{780}	Consequences rating based on the above table		
	Severe	Moderate	Minor
< 1.1	Adopt Sea level rise of 1050mm	Adopt Sea level rise of 1050mm	Seek FRA approval to adopt sea level rise of 780mm
1.1 to 1.3	Adopt Sea level rise of 1050mm	Seek FRA approval to adopt sea level rise of 1050mm	Adopt sea level rise of 780mm
1.3 to 1.6	Seek FRA approval to adopt sea level rise of 1050mm	Seek FRA approval to adopt sea level rise of 780mm	Adopt sea level rise of 780mm
> 1.6	Seek FRA approval to adopt sea level rise of 1050mm	Adopt sea level rise of 780mm	Adopt sea level rise of 780mm

PC_{1050} = Cost of project designed for a sea level rise of 1050mm
PC_{780} = Cost of project designed for a sea level rise of 750mm

Approval to:

- adopt a sea level rise less than 780mm or
- not adopt the requirements of the above table

shall be subject to EDD requirements outlined in chapter 2.

Further details on Climate Change studies are provided in the Appendix to this Chapter.

3.2.4 Increase/Decrease in Rainfall Patterns Due to Climate Change

There are few studies that demonstrate the results of climate change investigations and its impacts on rainfall intensity for the Pacific region and Australia. The most relevant study is “Current and future climate of the Fiji Islands” which is part of the International Climate Change Adaption Initiative.

According to this report, there is a high level of confidence in increasing the frequency and intensity of extreme rainfall in the future. For the magnitude of change in the rainfall intensity, designers shall refer to section 6.3.2 below.

3.3.4 Identify the Species Group

Designers shall review all existing environmental studies for the study area and nearby areas that might be impacted (hydraulically and hydrologically) from their project and report to FRA. This includes all existing environmental reports from the Department of Environment.

Where there is evidence of endangered species in the vicinity of the project area, designers shall identify the relevant species and species group from the following list:

- Fishes
- Amphibians (frogs)
- Small mammals
- Large mammals
- Reptiles (e.g. snakes, lizards and turtles)

3.5.4 Performance Objectives

Major FRA projects with adverse impact on the environment should meet annual pollutant load reduction targets (source: Road Drainage Manual, Queensland Department of Transport and Main Roads, July 2015):

- 80% minimum reduction in total suspended solids from unmitigated development
- 60% reduction in total phosphorus
- 40% reduction in total nitrogen
- 90% reduction in gross pollutants (> 5mm).

3.5.9 Wetlands

Wetlands have the potential to be more productive breeding sites for mosquitoes compared to natural wetlands due to high nutrient from urban runoff.

Considering the history of dengue fever in recent years in Fiji, consideration needs to be given to the increased risk of mosquito breeding as a result wetland construction.

Designers shall seek FRA approval before commencing design of such structures.

3.7.3 Storm Surge

Additional information:
Department of Transport and Main Roads Queensland (TMR) has provided guidance for calculation of storm tide for road design in coastal areas. This guide shall be utilised by designers in Fiji.

"Storm Tide – Issues for Design of Road Infrastructure in Coastal Areas" (TMR 2014e), shall be used for the design:

https://www.tmr.qld.gov.au/-/media/busind/techstdpubs/Hydraulics-and-drainage/Storm-Tide-Issues-for-Design/StormTideGuideforDesign.pdf?la=en

4.0 Drainage Considerations

4.1 General Considerations

4.1.1 Australian Rainfall and Run-off (AR&R)

Designers shall adopt the latest version of AR&R (December 2016). Refer

http://arr.ga.gov.au/arr-guideline

4.6 Selection of ARI

Selection of ARI has been revised in Table 4-3 based on road classification in Fiji.

Table 4-3. Guide to selection of average recurrence intervals for flood immunity

Element	Fiji's road classification	Suggested ARI
Cross drainage (culverts & bridges)	M1 Roads	100-year ARI
	M2 Roads and S Roads	50-year ARI
	C Roads	20-year ARI
	R Roads	10-year ARI
	Arterial Roads	50-year ARI
	Collector Roads	20-year ARI
	Local Streets	10-year ARI
Diversion channels	All roads	Adopt the ARI for cross drainage
Cross drainage (floodways)	S Roads	20-year ARI
	C Roads	10-year ARI
	R Roads	5-year ARI
	Local Streets	10-year ARI
Road surface (network drainage including kerb and channel, inlet pit & pipe systems, bridge decks)	All roads other than C Roads and R Roads	10-year ARI
	C Roads and R Roads	5-year ARI
Trapped flows (roads where there is no escape path for water including at a sag in cut)	All roads	50-year ARI
Longitudinal open drainage (table drains, diversion drains, catch drains and banks etc.)	All roads	10-year ARI

4.10 Waterway Structures

4.10.1 Factors Affecting Selection of Waterway Structures

Additional Information
Culvert/Bridge structures with a minimum span or diameter of 1.8m, or a minimum waterway area of 3m^2 per cell (for multi-cell culverts), shall be classified as a structure subject to FRA's requirements for structural design and proof engineering by appropriate prequalified structural engineers.

6.0 Hydrology

6.1 General

There are three methods to estimate the magnitude peak flow and/or their hydrograph for the design of drainage structures. Application of these methods are mostly depending on availability and quality of data. These methods are listed in the order of preference below:

1. Flood Frequency Analysis (FFA) of stream flow data to estimate the magnitude of peak flows
2. Development of Rainfall-Runoff models and estimation of peak flows and their hydrographs
3. Empirical hydrological methods (such as Rational method) to estimate the magnitude of peak flows

Flood Frequency Analysis
FFA is the best and most accurate method for the design of road crossing structures such as culverts and bridges. Stream flow data can be provided as water level or discharge at stream flow gauges. Water level data shall be converted to discharge data using rating curves which is developed by FMS for that specific gauge station.

Application of this method is dependent on quality of available stream flow data in stream flow gauges.

This method shall not be used when there is less than 20 years stream flow record.

If there is less than 20 years of data available for a station, but there is a nearby station with a similar climate, data can be built using hydrological methods. For further information designers shall refer to:

AR&R 2016, Book 3-peak flow estimation, chapters 1, 2 and 3.

Figure 5-1 and Table 5-4 indicate the location and availability of data in rain gauge and stream flow gauge stations across Fiji.

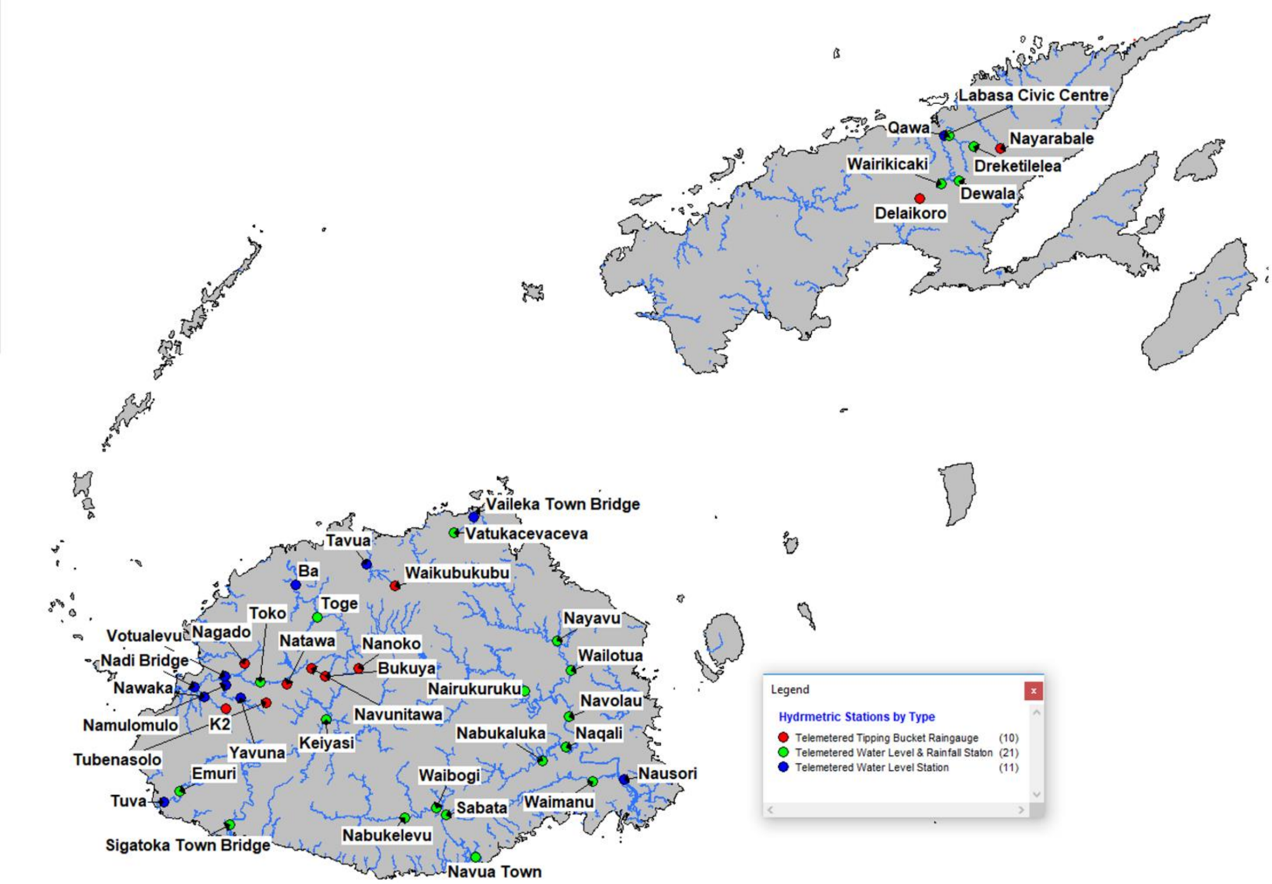


Figure 5-1: location of hydrometric stations in Fiji (source: FMS)

Table 5-4: name, location and length of data for hydrometric stations in Fiji (source: FMS)

Site Name	Latitude	Longitude	Type	Data Period
K2	-17.85386	177.50009	TB3[1]	7/12/2010 - 5/11/2014
Nadi Bridge	-17.799054	177.416287	WL[2]	7/12/2010 - current
Nagado	-17.739775	177.546702	TB3	7/10/2010 -current
Namulomulo	-17.794981	177.499643	WL	10/12/10 - current
Natawa	-17.793273	177.65818	TB3	7/12/10 -current
Navunitawa	-17.75347	177.721135	TB3	8/12/2010 - current
Toko	-17.786607	177.589596	WL&RF[3]	12/12/2008 - 21/01/11
Tubenasolo	-17.838352	177.603304	TB3	8/12/2010 - current
Votualevu	-17.773458	177.497267	WL	26/01/11 - current
Yavuna	-17.826758	177.537252	WL	8/12/10 -current
Nabukaluka	-17.981944	178.322222	WL&RF	4/12/2008 - current
Nabukelevu	-18.125444	177.966	WL&RF	31/07/2008 - current

Nairukuruku	-17.808333	178.276389	WL&RF	6/12/2008 - current
Nausori	-18.029722	178.536111	WL	17/01/1985 - current
Navolau	-17.873611	178.391667	WL&RF	5/12/2008 - current
Nayavu	-17.683889	178.3625	WL&RF	8/12/2008 - current
Sabata	-18.11667	178.071298	WL&RF	31/07/2008 - current
Waimanu	-18.034722	178.452778	WL&RF	3/12/2008 - current
Bukuya	-17.771693	177.757711	TB3	9/09/2013 - current
Labasa Civic Centre	-16.430528	179.377111	WL	7/08/2013 - current
Dewala	-16.543116	179.415276	WL&RF	7/08/2013 - current
Wairikicaki	-16.550984	179.36988	WL&RF	
Sigatoka Town Bridge	-18.141287	177.508457	WL&RF	7/029/2013 - current
Keiyasi	-17.880339	177.760914	WL&RF	6/09/2013 - current
Nayarabale	-16.462179	179.524662	TB3	8/8/13 - current
Waibogi	-18.100798	178.047916	WL&RF	7/10/13 - 4/12/2016
Delaikoro	-16.587227	179.314688	TB3	9/8/2013 - 20/11/2017
Navua Town	-17.379	178.155	WL&RF	1/8/2014 - 11/03/18
Dreketilelea	-16.4577	179.455	WL&RF	23/07/2014 - current
Emuri	-18.058	177.378	WL&RF	25/07/14 - current
Vatukacevaceva	-17.4158	178.093	WL&RF	28/07/2014 - current
Town Bridge	-18.219	178.16	WL	28/07/2014 - current
Toge	-17.625	177.736	WL&RF	2015 -current
Qawa	-16.431	179.392	WL&RF	2015 -current
Wailotua	-17.7586	178.397	WL&RF	2015 -current
Naqali	-17.949794	178.384539	WL&RF	12/07/2017 -current
Tuva	-18.084531	177.337949	WL	5/7/2017 -current
Nawaka	-17.822899	177.442513	WL	7/12/10 - 7/03/2012
Tavua	-17.494707	177.863854	WL	28/08/2009 - current
Ba	-17.546546	177.680924	WL	11/07/2017 - current
Waikubukubu	-17.547425	177.939689	TB3	11/07/2017 -current

Nanoko	-17.754353	177.844496	TB3	14/07/17 - current

[1] TB3: Telemetered Tipping Bucket Raingauge station
[2] WL: Telemetered Water Level Station
[3] RF: Telemetered Water Level & Rainfall Station

6.3 Rainfall

Rainfall data from the closest rain gauge station with the following characteristics shall be requested and used from Fiji Meteorological services.

1. Similar climate condition to the study area with more than 20 years of data. Similar climate means no significant difference between the average annual rainfall of rain gauge station and study area can be noticed by normal people.
2. Difference between the altitude of rain gauge station and the average altitude of study area less than 500 m.

Designers shall document their reasons for the selection of rain gauge station and seek approval from FRA to the proposed methodology.

6.3.2 IFD Tables

In order to compute design flows, a rainfall intensity, duration and frequency (IDF or IFD) relationship is required. FMS is currently generating this information for all rain gauges across the country. Designers shall request this information from FMS for the closest rain gauge station to the study area.

Climate change impact on rainfall intensity

Climate change studies in Australia and Fiji recommend considering an increase in intensity of rainfall in design works based on the extended design life of transport structures by 2100.

The results of these studies demonstrate a low level of confidence in estimation of the magnitude of change in rainfall intensity.

Australian AR&R guideline has recommended the following equation to estimate the change in rainfall intensity as a function of the average increase in air temperature as a climate change.

$$I_p = I_{ARR} \times 1.05^{T_m}$$

Where:

I_p = projected rainfall intensity

I_{ARR}= design rainfall intensity from current IFD curves

T_m = average air temperature increase by 2100

The results of climate change studies for Fiji demonstrate an average increase of 1.9 Celsius degree in air temperature by 2100. Therefore, as a minimum, **all calculated rainfall intensities shall be increased by 10% in the design of drainage works.**

Risk Assessment

Having prepared a preliminary design based on an increase in rainfall intensity of 10%, the designer shall then assess the performance of this design operating in an environment where the rainfall intensity actually increases by 40%. This assessment will then allow the designer to determine the consequences of potentially under designing for increased rainfall intensity. That is, designing for a rainfall intensity increase of 10%, when in fact an increase of 40% occurs.

The consequences can then be used as an input into a risk assessment (refer Table ##). The risk assessment will then allow through the Decision Matrix (Table **) for the appropriate rainfall intensity increase, 10% or 40%, to be selected for detailed design.

The designer shall follow the following steps:

Part a – Consequence Estimation
1. prepare a preliminary design based on an increased rainfall intensity of 10%
2. assess the consequences of the rainfall intensity actually increasing by 40%, assuming the road is built for an increase of 10%
3. Use the Consequences Table below to determine a consequence score

Part b – Cost and Risk Estimation
1. Estimate the cost of the project designed for a rainfall intensity increase of 10%
2. Estimate the cost of a project designed for a rainfall intensity increase of 40%
3. Use the Decision Matrix table below to determine the appropriate rainfall intensity increase to be adopted for design

Table 5.5 - Classification of the level of risk

Score	Consequences of increased rainfall intensity as per Part a above
Severe	1- Loss of life. 2- Severe damage to major infrastructures such as bridges, etc. 3- Long-term inundation of M1, M2 and Auxiliary Roads. 4- Inundation of properties in urban areas.
Moderate	1- Risk of injury for residents. 2- Damage to moderate and small size urban infrastructures. 3- Long-term inundation of collector and local roads. 4- inundation of properties in areas other than urban.
Minor	1- Minor inundation of roads. 2- Damage to small infrastructures such as clogging of culverts, need for minor maintenance, etc. 3- Inundation of urban passages for longer than they have designed for but with no damage to nearby properties.

The following decision matrix shall then be applied to determine if an increase in rainfall intensity of 10% or 40% should be applied to the design.

Table 5.6 - Decision Matrix

PC_{40}/PC_{10}	Consequence rating based on the above table		
	Severe	Moderate	Minor
< 1.3	Adopt rainfall intensity increase of 40%	Seek FRA approval to adopt rainfall intensity increase of 40%	Seek FRA approval to adopt rainfall intensity increase of 10%
1.3 to 1.6	Seek FRA approval to adopt rainfall intensity increase of 40%	Seek FRA approval to adopt rainfall intensity increase of 10%	Adopt rainfall intensity increase of 10%
> 1.6	Seek FRA approval to adopt rainfall intensity increase of 40%	Adopt rainfall intensity increase of 10%	Adopt rainfall intensity increase of 10%

PC_{40} = Cost of project allowing for a 40% increase in rainfall intensity due to climate change
PC_{10} = Cost of project allowing for a 10% increase in rainfall intensity due to climate change

Approval to:

- adopt an increase in rainfall intensity of less than 10% or
- not adopt the requirements of the above table

shall be subject to EDD requirements outlined in chapter 2.

Further details on Climate Change studies are provided in the Appendix to this Chapter.

6.6 Rural Hydrology

6.6.1 Rational Method

For calculation of runoff coefficients in Fiji, designers shall refer to Appendix E of AGRD, Part 5.

Calculation of time of concentration in rural areas shall be undertaken using the equation provided for Queensland in table 6.1. For calculation of time of concentration in urban areas refer to section 6.7.2 of AGRD.

6.6.3 Run-off Coefficient

Additional information:

1. The runoff coefficient, ‘C’, is a statistical composite of several inputs, including the effects of rainfall intensity, catchment characteristics, infiltration (and other losses) and channel storage. It should not be confused with the volumetric runoff coefficient which is the ratio of total runoff to total rainfall.
2. The runoff coefficient must account for the future development of the catchment as depicted in the planning scheme, but should not be less than the value determined for the catchment under existing conditions.

6.7 Rural Hydrology

6.7.3 Run-off Coefficient

Appendix B – Table B1: Drainage Construction Material Considerations

Fibre Reinforced Concrete (FRC) Pipes

Additional Information
Refer to FRA Specification Section 501 for further details.

Nominal Sizes for Culverts

Additional information
Box culverts shall comply with the requirements of AS1597.1 (2010) - Table 5-3, as follows

Preferred Internal Dimensions – Culvert Units
(from Table 5-3: AS1597.2 (2013)

Size class mm	Nominal Span mm	Nominal height mm
300 x 225	300	225
450 x 300	450	300
600 x 300	600	300
600 x 450	600	450
900 x 300	900	300
900 x 600	900	600
1200 x 300	1200	300
1200 x 600	1200	600
1200 x 900	1200	900
1200 x 1200	1200	1200

Notes:
1. The size class is designated as 'the nominal span' x 'the nominal height' in millimetres, for example '450 x 200'.
2. Other size culverts may be made to a specific order.
3. Actual size should be checked with the manufacturer.

Appendix D - Obtaining Rainfall Information (Australia)

Not applicable to Fiji.

Appendix to Part 5 Supplement – Climate Change Studies

Australian studies (source: Queensland road design guide):

The basic data for determining sea level rise for drainage design projects are included in the Intergovernmental Panel on Climate Change (IPCC) reports. The 4th and 5th edition of this report released in 2007 and 2013 respectively.

IPCC (2007) projected an increase in sea level of 0.28–0.43 m, with the possible addition of 0.1–0.2 m to allow for ice sheet contributions by 2100.
IPCC (2013) projected an increase of 0.43–0.73 m by 2100. The range covers different emission scenarios.

The Queensland Coastal Plan (DEHP, 2012) adopted an increase in mean sea level of 0.8 m to be used in the assessment of coastal hazards in coastal regions of Queensland

CSIRO has continued IPCC (2007) and has shown a possible range of sea level increase projections from 0.34– 0.54 m by 2100.

Based on the results of these studies, Road Drainage Manual, Queensland Department of Transport and Main Roads, July 2015 (hereafter called as Queensland road design guide) concluded that the allowance for sea level rise in coastal areas of Queensland should be based on the higher end of the IPCC Fifth Assessment Report at 0.6 m by 2100. Table 5-1 represents a summary of results.

Table 5-4. Summary of climate change studies for sea level rise in Australia- in mm

	IPCC (2007)	IPCC (2013)	DEHP	CSIRO	Queensland road design guide
Sea level rise	280-430	430-730	800	340-540	600
Ice sheet contribution	100-200				
Total	380-630	430-730	800	340-540	600

Climate change in Pacific, Fiji Islands:

A climate change study has been undertaken by the collaboration between FMS and the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) program in 2015. The outcome of this study is a report called “Current and future climate of the Fiji Islands”. PACCSAP program is a program delivered targeted information for 15 countries in the Pacific Ocean including Fiji. This program is jointly delivered by the Australian Bureau of Meteorology and CSIRO Australia.

This study has developed four scenarios of very low emissions, low emissions, medium emissions and very high emissions for investigating the impact of climate change on the mean sea level rise, tidal level and storm tides. The results of this study show no significant change in the height of storm tides for Fiji. Figure 5-2 demonstrates the summary of sea level rise and tidal level under the three scenarios of very low, medium and very high emissions. For the purposes of this Supplement, the Medium Level Emission Scenario has been adopted with risk assessments undertaken for higher level scenarios.

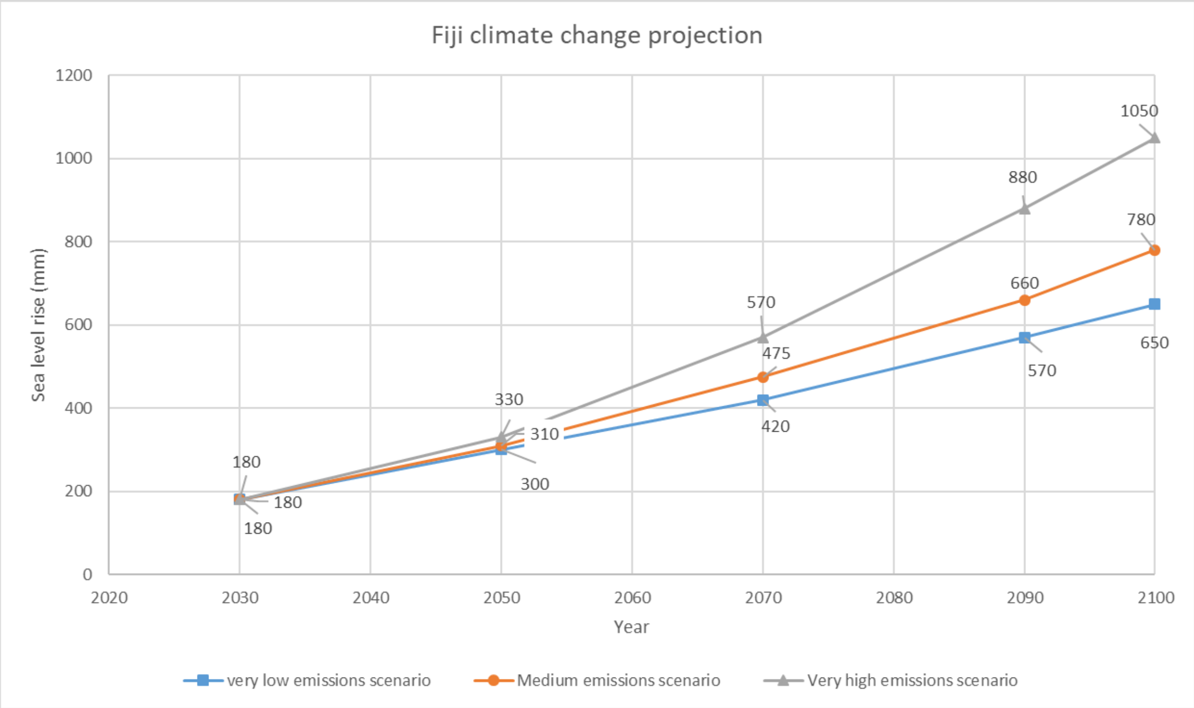


Figure 5-2. The projection of change for sea level rise under three scenarios of very low, medium and very high emissions.

The following recommendations have been made concerning the impacts of climate change on IFD data.

IPCC (2013)	ARR	Queensland road design guide
The return period of storm events will be half by 2100.	AR&R has provided an eqution to estimate the increase in rainfall intensity based on increase in wether tempareture in the furtur. Application of this equation for Fiji will results in 10% increase in rainfall intensity by 2100.	Not enough information about climate change at the time of the development of the guideline. Queensland road authority had been postponed the decision to further studies until AR&R 2016 released.

CHAPTER 5A

DRAINAGE: ROAD SURFACE, NETWORKS, BASINS & SUBSURFACE

PART 5a - ROAD SURFACE, NETWORKS, BASINS & SUBSURFACE

5.0 Kerbed Drainage

5.3 Kerbed Drainage Elements

5.3.4 Inlet Locations

For FRA projects, an extra pit near the lowest point with a separate pipeline to an alternative outlet shall be provided at land locked sags.

5.4 Design Criteria

5.4.2 Pavement Spread and Gutter Flow Limits

Allowed water spread width has been revised on Table 5A-1 based on existing speed limits in Fiji.

Table 5A-1 Allowed spread width on street

Road type	Allowable spread widths (m) during a 10-year ARI	
	<=50 km/h	>50 km/h
1 lane in any one direction	1	0.75
2+ lanes in any one direction	1.5	1.25
Where a combined purpose lane is being utilised such as a bus lane or cycle lane at 4 m wide, the maximum allowable spread is 1.0 m. Additional information		
M1 Roads, M2 Roads and Arterial Roads	There should be no need to change lanes during the design storm. Where traffic lanes less than 3.5 m are used, it is not practical to achieve the goal of not changing lanes during the design storm when trucks and buses are considered. Where commercial vehicles comprise a significant proportion of the traffic, consider redistribution of lane widths to give a wider outer lane.	
Auxiliary and turning lanes	Spread at the commencement of auxiliary/turning lane tapers, should be limited to 1.5 m during a 10-year storm except where cycle lanes, or sealed shoulders are extended through the taper. In such cases up to 1.0 m of the cycle lane may be utilised for spread allowance.	
Local Streets	At least one lane width shall remain trafficable during a 5-year ARI storm.	
On-street parking and car parks	Flow width should be restricted to 2.0 m for the 2-year ARI.	
Pedestrians	Maximum spread from the kerb immediately upstream of pedestrian crossing points should be 0.5 m during a 5-year storm. At perambulator crossing and pedestrian crossings, spread shall be restricted to less than 1.0 m in the 50-year ARI storm. Maximum spread into the kerbside lane adjacent to bus stops or other locations where pedestrians are expected in significant numbers shall be 0.75 m during 5-year storm.	
Cross carriageway flows	Flows across the carriageway such as those occurring at superelevation changes, median breaks, T-intersections of local streets and at the ends of traffic islands to be less than 0.005 m 3 /s to reduce the risk of aquaplaning.	

	The rainfall intensity to use for this situation shall be 50 mm/h. See Section 4.9.5 for further information.

7.0 Basins

7.2 Detention Basins

7.2.3 Advantages and Disadvantages of Detention Basins

Additional information:
Urbanisation has a significant impact on the hydrology of catchments. This increases the magnitude of generated peak flows that move to the urban drainage network. To reverse the negative impact of urbanisation, detention basins can reduce the magnitude of the peak flows to their original condition before urbanisation.

Detention basins are normally designed for a major design flow (e.g.100 year ARI) to provide safety for downstream areas.

However, it should be noted that because the size of the outlet structure is fixed, these structures have the biggest attenuation impact on the design flow and lower attenuation impact of flows with different return periods. Detention basins cannot reduce all flows with different return periods to their original state.

7.2.9 Other Design Considerations

Austroads recommends that if a failure of spillway and embankments could be expected to result in loss of life then the spillway should be designed for the probable maximum flood (PMF).

Because adoption of PMF as the design flow of the spillway for a detention basin is too conservative, a risk analysis shall be undertaken by designers to estimate the appropriate flood recurrence interval. Approval for the proposed flood level shall be sought in accordance with EDD requirements (Chapter 2).

8.0 Subsurface Drainage

8.6 Location of Subsurface Drainage

8.6.5 Locations of Subsurface Drains on Rural Roads

Clarification
Subsurface drains shall be provided on all FRA class M, S and C roads unless approved otherwise by the Head of Design and Procurement.

CHAPTER 5B

OPEN CHANNELS, CULVERTS & FLOODWAYS

PART 5b - OPEN CHANNELS, CULVERTS & FLOODWAYS

2.0 Open Drains and Channels

2.1.4 Types of Open Drains

Table Drains

Addition(s):
In urban areas, underground drainage systems are preferred due to space limitations and safety. Where open drains are proposed for urban areas, designers shall seek FRA approval for the design and construction of these structures.

Batter Drains

Addition(s):
Stormwater drainage network culvert outlets on batters shall discharge at the base of the batter, in preference to the use of batter drains and chutes, where batters are steeper than 6:1 or where excessive scour is likely to occur in the batter.

2.2.1 Scenario development (new)

Designers shall consider all possible hydrological and hydraulic conditions and develop a scenario for every condition. Designers shall provide details of their scenarios and investigations in their design reports.

2.5.2 Downstream Tributary

Addition(s):
The coincidence of flows in tributaries shall be investigated using hydrological analysis. If a stream flow gauge is available on tributaries downstream of the river confluence, designers shall investigate historical data to understand the nature of catchments and the chance of coincidental flooding.

In the absence of stream flow data, in complex catchments with multiple tributaries, development of a rainfall-runoff model is required to be able to route the flows and investigate the chance of coincidental flooding at the junction and have a better estimation of runoff hydrographs and flows magnitude.

2.7 Open Channel Design

2.7.1 Design Methodology

The preferred channel slope for the design of open drains is 1V:2H for unprotected channels to maximum 2V:1H for protected drains. Designers shall:

1. Check the velocity of flow against the maximum permissible velocity (Table 2.6 AGRD Part 5B) in unprotected drains to avoid erosion.

2. Check the velocity of flow for safety in the vicinity of residential areas to ensure there is no risk of injury or drowning for residents. Safety Barriers shall be provided wherever, the flow velocity is higher than 1.2 m/s.
3. Adopt flatter channel side slopes wherever possible.

2.9 Channels Lined with Hard Facings

2.9.2 Riprap and Rock Filled Wire Mattresses/Gabions

Riprap is a conventional method to protect river banks downstream of road crossing and road embankment where located on a floodplain. This protection is flexible to allow for minor soil settlements and cheaper than the other protections such as gabions. A typical section of riprap is provided in Figure 5B-1.

Designers shall use the open source software package which is provided by eWater to calculate d_{50} of rocks.

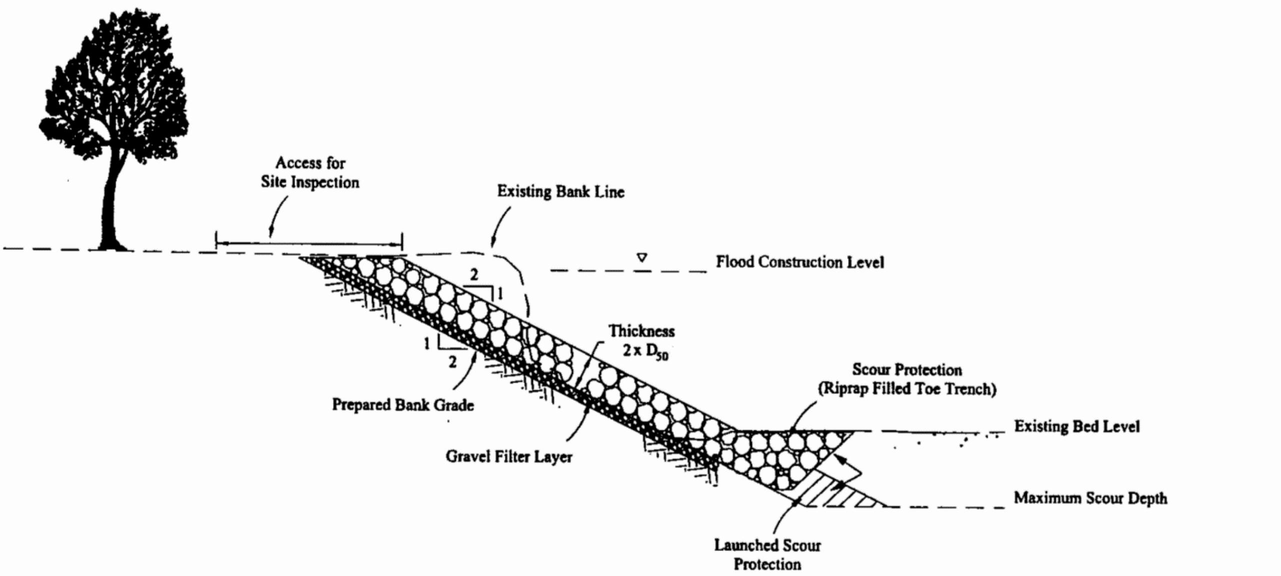


Figure 5B-1: a typical section of riprap

3.0 Culverts

3.4 Culvert Type

3.4.2 Materials

<u>Addition(s):</u>

1- Culverts shall be designed for a minimum design life of 100 years.
2- Table 5B-1 provides guidance for selection of the type of culverts based on the exposure environment.

Table 5B-1: Culvert types for different conditions (source: Queensland Road Design Guideline)

Exposure condition	Concrete box culverts (normal cover)	Concrete box culvert (saltwater cover)	Concrete pipes	Steel corrugated arch	Steel helical pipe	Aluminium helical pipe
Saltwater	×	✓	✓	×	×	✓
Aggressive soil (e.g. low pH, high chloride high sulphate)	×	×	×	×	×	✓
Invert in fresh water for prolonged periods	✓	N/A	✓	×	×	Not economic
Typical condition (i.e. none of above)	✓	N/A	✓	✓	✓	Not economic

3.6 Batter Drains and Chutes

3.6.5 Rock chutes (new)

Rock chutes are essential structures for protection of slopes and downstream of road crossings. These structures are required when there is a high chance of erosion in a channel or downstream of culvert and floodway structures. Hydraulic jumps shall always happen on the rock chutes and not upstream or downstream of the structures.

Designers shall use the following to calculate the average size (d50) of rocks.

An open source software package is also provided by eWater, Australia that can be used by designers.

$$d_{50} = \frac{1.27.SF.K_1.K_2.S_0^{0.5}.q^{0.5}.y^{0.25}}{(s_r - 1)}$$

d_{50}= nominal rock size (diameter) of which 50% of the rocks are smaller (m)
K_1= correction factor for rock shape.
= 1.0 for angular (fractured) rock, 1.36 for rounded rock (i.e. smooth, spherical rock)
K_2= correction factor for rock grading
= 0.95 for poorly graded rock ($C_u = d_{60}/d_{10} < 1.5$), 1.05 for well graded rock (C_u>2.5).
q = flow per unit width down the embankment (m^3/s/m).
s_r = specific gravity of rock.
S_0= bed slope = tan (θ) (m/m)
SF= factor of safety (refer to Table 5B-2)
y = depth of flow at a given location (m)

Table 5B-2: Safety of factor for the design of rock chute.

Safety factor (SF)	Usage	Example site conditions
1.2	• Low-risk structures. • Failure of structure is most unlikely to cause loss of life or irreversible property damage. • Design of permanent rock chutes with all voids filled with soil and pocket planted.	• Rock chutes located within most rural gullies and low-risk urban gullies. • Permanent rock shuts that are likely to experience significant sedimentation and vegetation growth before experiencing high flows.
1.5	• High-risk structures. • Failure of structure may cause loss of life or irreversible property damage. • Gullies where the failure of the chute is likely to cause ongoing, severe gully erosion and/or damage to assets.	• Rock chutes in urban gullies located close to homes. • Rock chutes designed for a storm frequency of less than 1 in 10 years.

3.7 Hydraulic Design Considerations

3.7.2 Outlet Velocity

Addition(s):
The calculation of velocity of flow at the outlet of culverts structures is required for every culvert, the type and extent of protection should be selected based on the calculated velocity, the natural downstream ground conditions and the stream velocities at downstream section.

3.13 Culvert Outlet Protection

The depth of rock protection downstream of culvert outlets is dependent on the calculated average size of rocks (d50). The depth of rock protection ranges from 3.5 * d50 for the smallest riprap to a limit of 2.0 * d50, for minimum depth of rock protection, designers shall refer to Table 5B-3.

Table 5B-3: The minimum depth of rock protection based on calculated d50

Average size of rocks (d50)-mm	Depth of rock protection (mm)
125	3.5*d50
150	3.3*d50
250	2.4*d50
350	2.2*d50
500	2.0*d50
550	2.0*d50

3.7.1 Concrete energy dissipators for culvert outlets (source: HEC 14)

This chapter contains energy dissipators for culvert outlets that are designed to operate at the streambed level.

Designers should note this structure is the last option when the design and construction of rock chutes are not possible or when there is a limitation in space. This method is suitable if the channel bed is relatively flat (less than 10%) and the flow velocity is high.

As illustrated in Figure 5B-2, the concrete baffles are designed and constructed to initiate an hydraulic jump. Figure 5B-3, demonstrates a typical long section of energy dissipators basin. In the design of this structure, the following points should be noted:

1. The height of the concrete baffles, h, must be between 0.31 and 0.91 of the approach flow average depth, Y_A.
2. The relative spacing, $\frac{L}{H}$, between rows of concrete elements, must be either 6 or 12

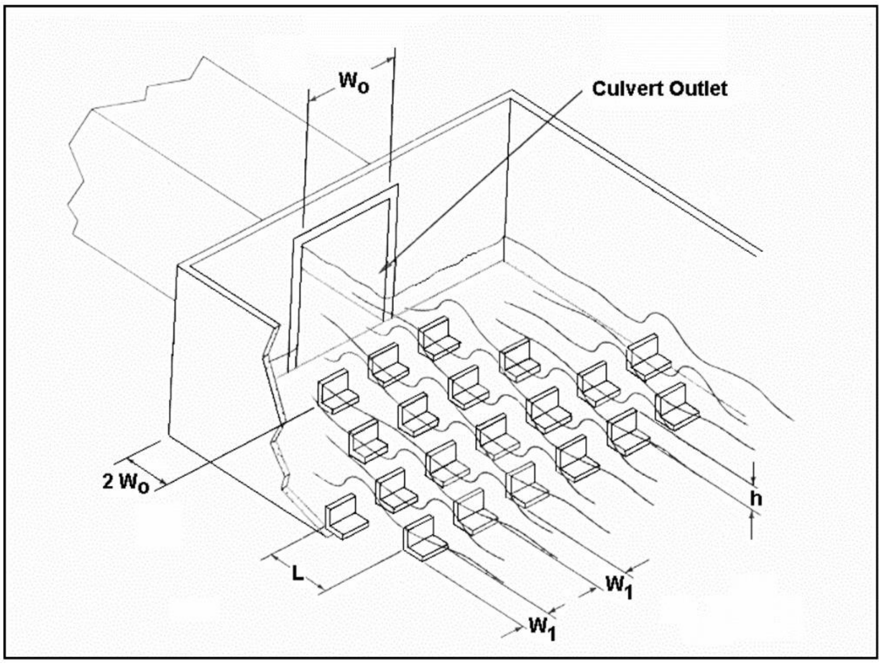


Figure 5B-2: a perspective view of concrete energy dissipators at the outlet of culverts

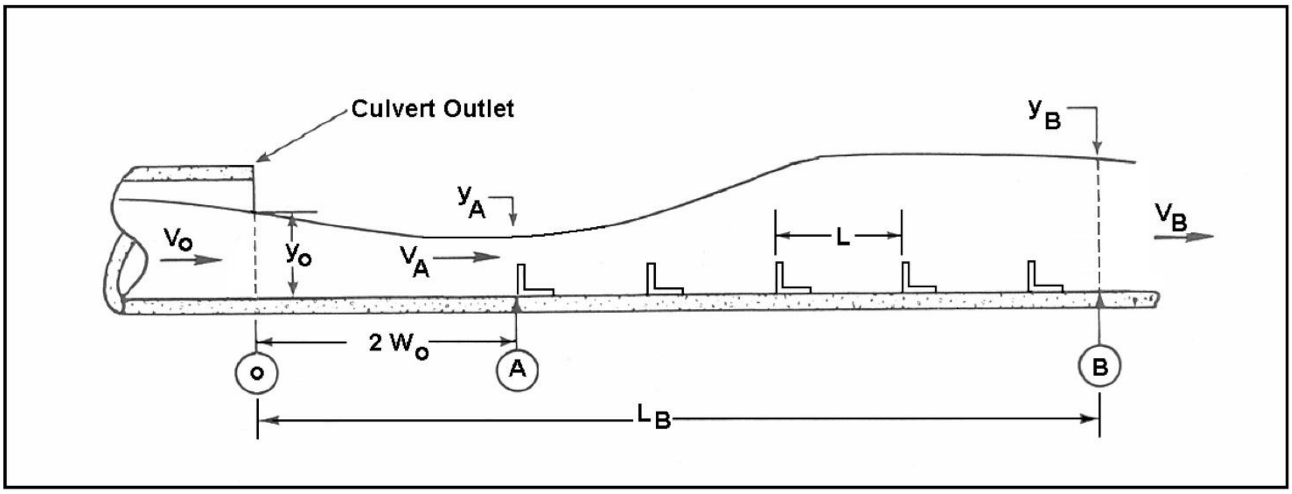


Figure 5B-3: a long section of concrete energy dissipators basin

To design a basin, the designer selects a basin from Figure 5B-4 and uses the C_B value from Table 5B-4. The following equation is provided to design different elements of this basin.

$$1000V_0Q + 4905C_pW_oY_0^2 = 500C_BA_FNV_A^2 + 1000V_BQ + \frac{4905Q^2}{V_B^2W_B}$$

Where:
Y_0 = depth at culvert outlet (m)
V_0 = velocity at culvert outlet (m/s)
W_o = culvert width at the culvert outlet (m)
V_A = approach velocity downstream of culvert outlet (m/s).
V_B = exist velocity downstream of the last row of concrete elements (m/s).
W_B = basin width downstream of the last row of concrete elements (m).
N = total number of concrete elements in basin
A_F = area of one concrete elements (m^2)
C_B = basin drag coefficient W_B/W_o, refer to Figure 5B-4
C_P = momentum correction coefficient for pressure at the culvert outlet. 0.7 for rectangular culverts. For circular culverts see Table 5B-5.

V_A can be calculated using the following equations:.

$$\frac{V_A}{V_0} = 1.65 - 0.3Fr \quad for\ box\ culvert$$

Equation 1

$$\frac{V_A}{V_0} = 1.65 - 0.45Fr \quad for\ box\ culvert$$

Equation 2

Where Fr is Froude number of flow

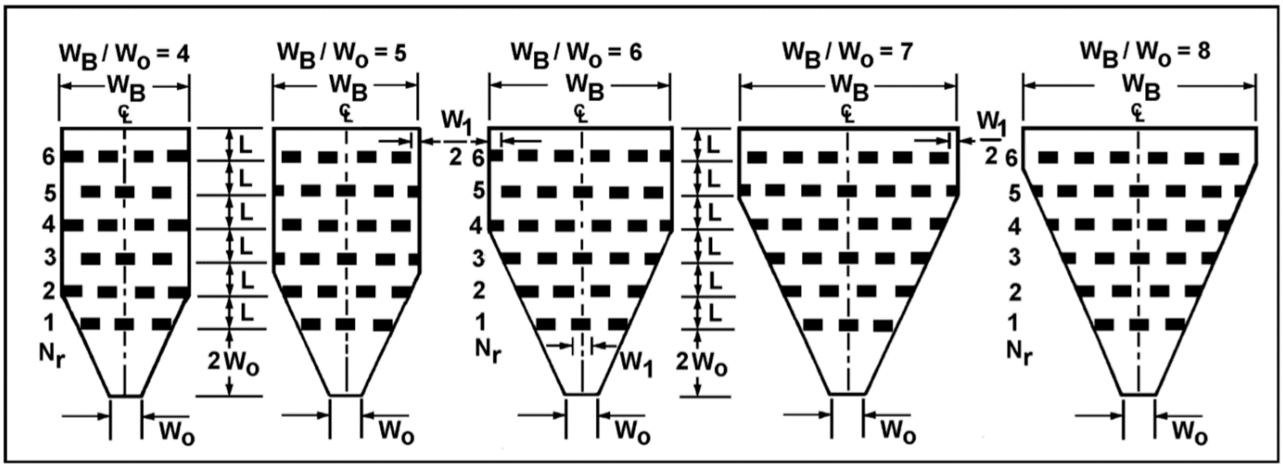


Figure 5B-4: different types and arrangements of concrete baffles and basin.

Table 5B-4: Design value for different types of basin.

W_B/W_0			2 to 4			5			6			7		8
W_1/W_0			0.57			0.63			0.6			0.58		0.62
Rows N_r			4	5	6	4	5	6	4	5	6	5	6	6
Elements (N)			14	17	21	15	19	23	17	22	27	24	30	30
Rectangular culvert	h/Y_A	L/h	Basin Drag Coefficient, C_B											
	0.91	6	0.32	0.28	0.24	0.32	0.28	0.24	0.31	0.27	0.23	0.26	0.22	0.22
	0.71	6	0.44	0.4	0.37	0.42	0.38	0.35	0.4	0.36	0.33	0.34	0.31	0.29
	0.48	12	0.6	0.55	0.51	0.56	0.51	0.47	0.53	0.48	0.43	0.46	0.39	0.35
	0.37	12	0.68	0.66	0.65	0.65	0.62	0.6	0.62	0.58	0.55	0.54	0.5	0.45
Circular culvert	0.91	6	0.21	0.2	0.48	0.21	0.19	0.17	0.21	0.19	0.17	0.18	0.16	
	0.71	6	0.29	0.27	0.4	0.27	0.25	0.23	0.25	0.23	0.22	0.22	0.2	
	0.31	6	0.38	0.36	0.34	0.36	0.34	0.32	0.34	0.32	0.3	0.3	0.28	
	0.48	12	0.45	0.42	0.25	0.4	0.38	0.36	0.36	0.34	0.32	0.3	0.28	
	0.37	12	0.52	0.5	0.18	0.48	0.46	0.44	0.44	0.42	0.4	0.38	0.36	

Table 5B-5: momentum correction coefficient

Q/D (pipe diameter)	<=0.58	5	4.2	>=3.8
C_P	0.3	0.4	0.5	0.55

Design procedure:

The design procedure is outlined below:

1. Compute the velocity, V_0, depth, Y_0, and Froude number, Fr, at the culvert outlet.

2. Based on the W_B/W_o expansion ratio, select a trial basin from Figure 5B-4. Then from Table 5B-4 select number of rows, Nr, number of elements, N.

3. Determine the flow condition V_A from supplied equation in this section.

   For $4 < W_B /W_o < 8$, read y_A from Figure 5B-5 and Figure 5B-6.
   For $W_B /W_o < 4$, compute y_A using Equation 5 and Equation 6.

4. For the trial height concrete elements to depth ratio, h/y_A and length to height ratio, L/h, determine the following dissipator parameters:
   - Concrete element height, h. Calculate it based on calculated Y_A.
   - Longitudinal spacing between rows of elements, L. From Figure 5B-4.
   - Element width, W_1, which equals to concrete element spacing. From Table 5B-4.
   - Divergence, u_e. Using Equation 7.
   - Basin drag, C_B. From Table 5B-4.
   - Area of one concrete elements, A_F = W1 h
   - C_P from Table 5B-5.
   - Total basin length, $L_B = 2W_o + LN_r$.

5. Calculate V_B and Y_B for the downstream channel using hydraulic calculation or hydraulic models.
6. If calculate W_B in step 4 matches (or slightly smaller) with the real width of the channel at downstream section, follow the option 1. Otherwise, go to option 2.
   - Option 1. Use the downstream depth, Y_n, and calculated C_B, A_F, and N values in steps 2 and 4 to compute C_B*A_F*N. The result of C_B*A_F*N using figures from Table 5B-4 should be greater than or equal to the C_B*A_F*N value from the equation. If not, select a new concrete elements configuration from Table 5B-4.

- Option 2. Use the C_B, A_F, and N values found in steps 2 and 4 to solve for V_B in Equation 2. Three solutions for V_B are determined by trial and error: two positive roots and a negative root. The negative root shall be discarded. The larger positive root is normally used for V_B. If V_B does not match the downstream velocity, select a new roughness configuration. If V_B is satisfactory, calculate Y_B. Compare Y_B to Y_n. If $Y_B < Y_n$, use the smaller positive root for V_B and calculate Y_B. If tailwater is greater than Y_B, V_B should be calculated using the tailwater depth and the trial basin checked using option 1.

$$2W_oS_o + Y_A + 0.0127(\frac{Q}{W_AY_A})^2 = Y_o + 0.0127V^2 \quad \text{Equation 3}$$

Where

$$W_A = W_o(\frac{4}{3Fr} + 1) \quad \text{Equation 4}$$

$$u_e = \frac{4}{7} + \frac{10}{7} * \frac{L}{W_o} \quad \text{Equation 5}$$

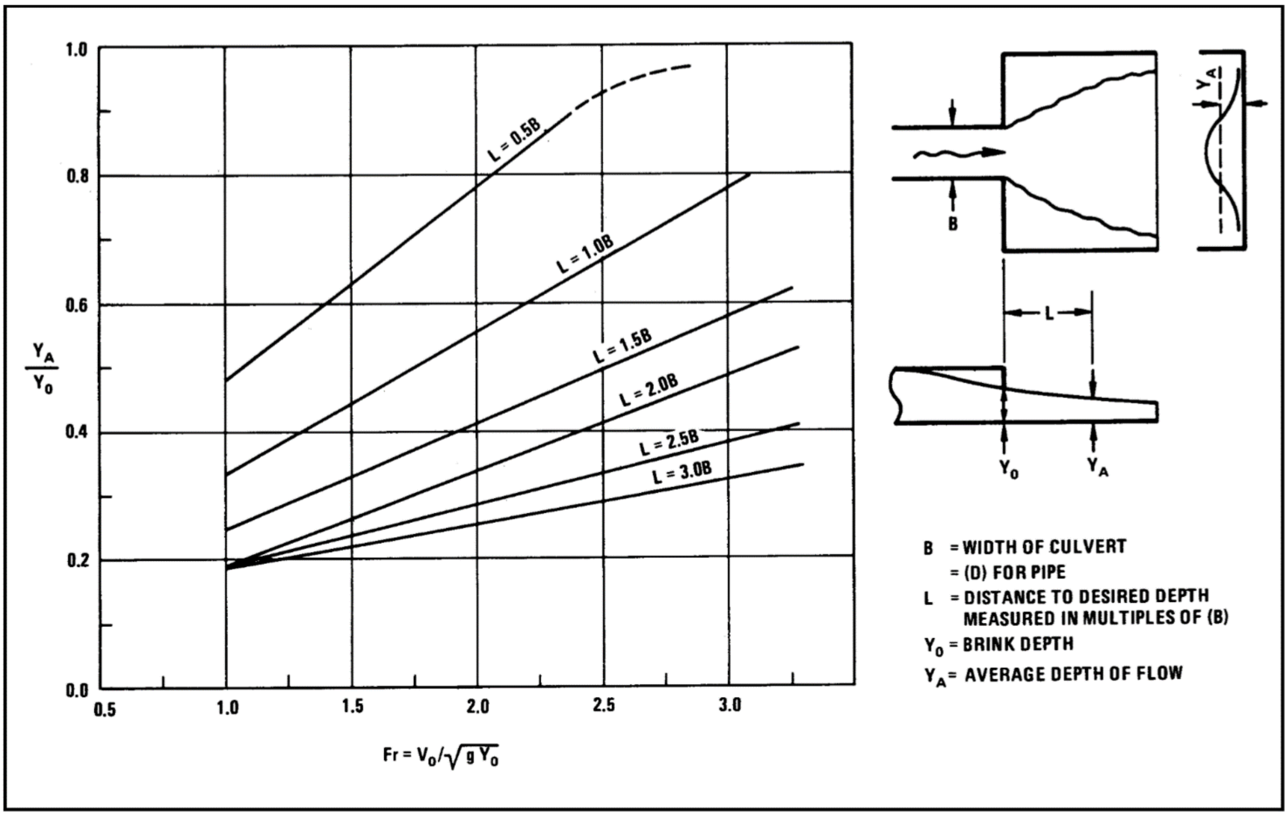


Figure 5B-5: the value of YA for rectangular culvert

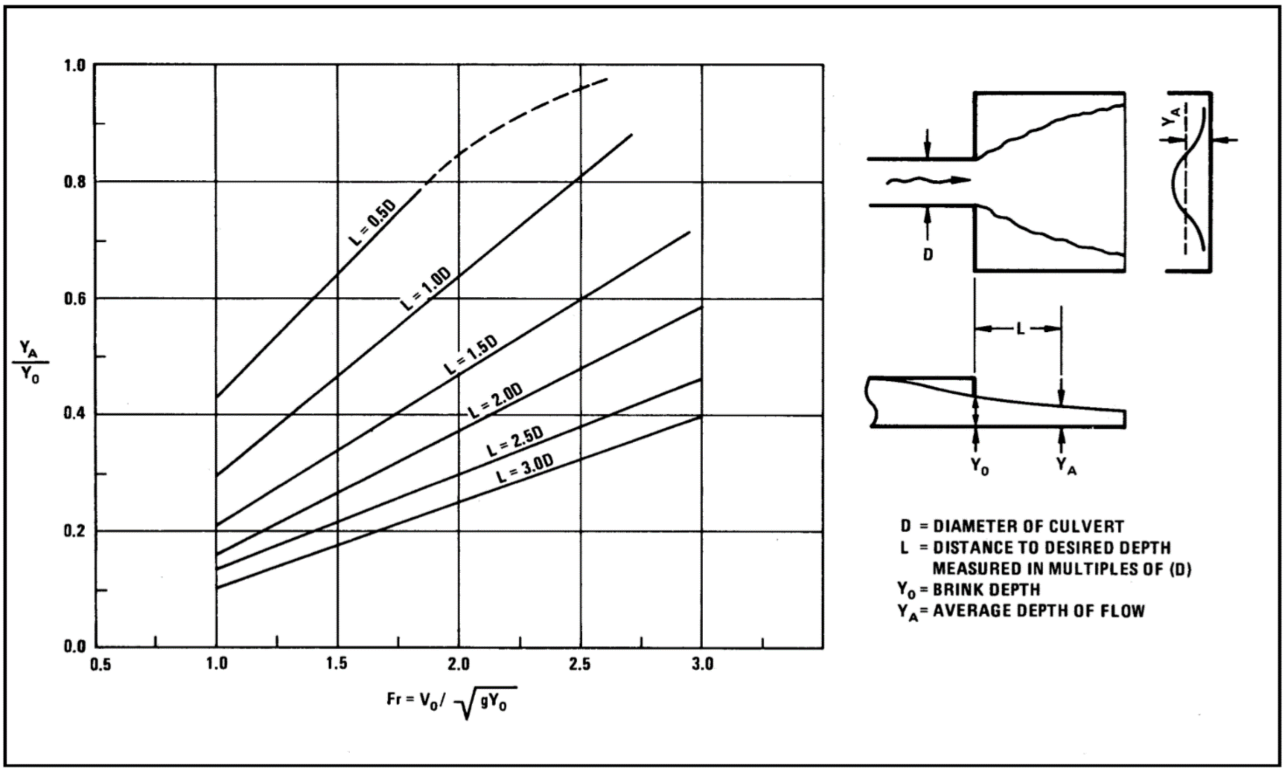


Figure 5B-6: the value of YA for circular culvert

CHAPTER 6

ROADSIDE DESIGN, SAFETY AND BARRIERS

PART 6 - ROADSIDE DESIGN, SAFETY AND BARRIERS

4.0 Design to Mitigate Hazards

4.2 Design Step D1: Determine Area of Interest

4.2.2 Determine the Clear Zone

Additional Information

V4.2.2.1 General

Recovery area is the area required for errant vehicles which leave the carriageway to regain control or stop safely. It has been found that about 80 to 85 per cent of vehicles travelling at 80 km/h can recover in a width of about 7m when measured from the edge of traffic lane.

The width needed to enable recovery of 100 per cent of vehicles is substantially wider and generally impractical to achieve. To provide a reasonable degree of safety, road designers use an area smaller than the recovery area, called the 'clear zone'.

Clear zones are areas adjacent to traffic lanes which shall be kept free from features that would be potentially hazardous to errant vehicles; such as trees, poles, culvert end walls and steep batters.

The clear zone is a compromise between the recovery area for every errant vehicle, the cost of providing that area, and the probability of an errant vehicle encountering a hazard. The clear zone shall be kept free of non-frangible hazards where economically and environmentally possible.

Should a major hazard be present just outside the clear zone, consideration must be given as to what protection should be provided, even though the hazard is outside the defined clear zone.

For new tree planting on road reserves, the following principles shall be applied:

Safe System Risk Principle

The risk of death and serious injury is directly related to the forces on the vehicle occupants when a vehicle impacts an object, and the likelihood of impact with that object.

- Where the planting of trees would clearly result in an impact force exceeding human tolerances for vehicles that leave the carriageway, then mitigation measures shall be undertaken to reduce the impact force within human tolerances
- Where the planting of trees is in a location with a higher likelihood of vehicles leaving the carriageway (i.e. curves, intersections etc.) AND there is potential for the impact force to exceed human tolerances, then mitigation measures shall be undertaken to reduce the impact force within human tolerances.
- The planting of trees may not impact on sight lines for the safe operation of the road for the whole life of the trees.

Road Network Efficiency Principle

- Where roads are designated as significant freight or traffic routes, then tree planting shall have no adverse impact on the efficiency of vehicle movement on those roads

Sustainable Transport Principle

- Where the planting of trees will significantly enhance the opportunity for walking and cycling, and the road is a priority area for walking, then tree planting should be supported.

Maintenance Responsibility and Cost Principle

- Where tree planting increases the long term cost to maintain the road, then the planting of trees and the tree management arrangements should be implemented in a way that minimises any cost increase to FRA.
- If the planting of trees will significantly increase the cost to maintain or provide utility services in the road reserve, then planting should minimise the impact.

Environmental Sustainability Principle

- Where roadsides allow scope for tree planting, then consideration shall be given to adopting environmentally sensitive landscape designs that protect and enhance the environment.

Community Wellbeing Principle

- Where roadsides allow scope for tree planting, and all the other principles can be met, then tree planting should be encouraged in a way that aligns species selection and planting design with local planting strategies, improves amenity and reduces visual clutter.

In the case of established roadside trees, it may be environmentally unacceptable to provide the full clear zone width. Careful consideration shall be given as to the best treatment of hazards where conflicts occur between environmental requirements, safety, and economy. Where the full clear zone width is not proposed, EDD approval in accordance with Chapter 2 of this supplement shall be obtained.

V4.2.2.2 Basic Clear Zone Width

Substitute Information

The alternative process to determine clear zone widths on straights for all roads is shown in Figure V4.1.

Consideration may be given to a reduced basic clear zone width on urban roads with a speed limit less than 70 km/h – refer Note 2 in Figure V4.1.

Refer also to Section V4.2.2.3 of this Chapter for additional information regarding designing for the effects of embankments/batter slopes.

V4.2.2.3 Effects of Batter Slopes

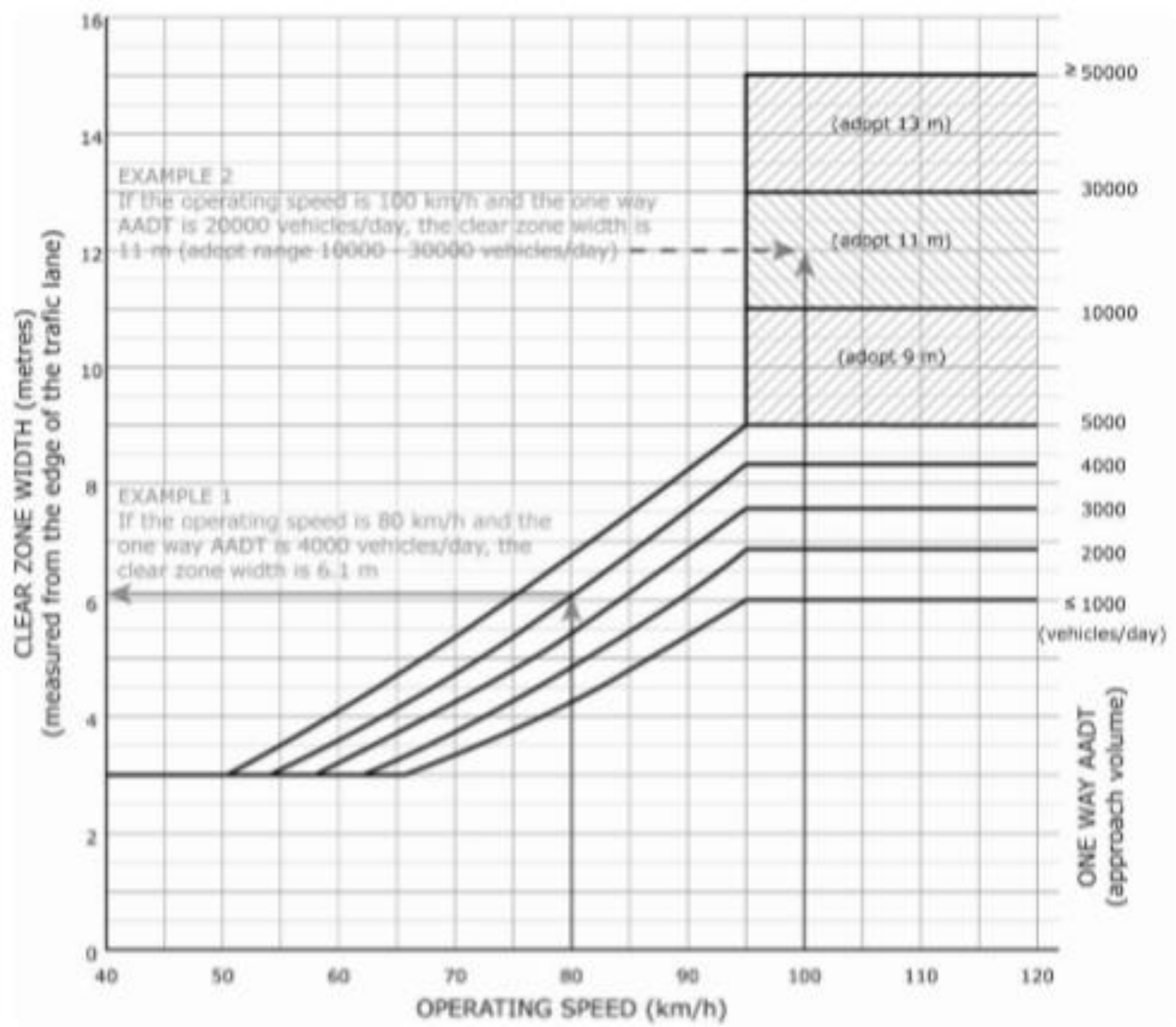
Substitute Information

Additional clear zone width may be required to provide for fill batter slopes. Reduction of clear zone widths may be permissible on cut batter slopes where the face of the batter is smooth, well compacted and unlikely to snag a vehicle. The clear zone width calculated from Section V4.2.2.2 of this Chapter and AGRD Part 6, Table 4.2 is corrected for batter effects to determine the Effective Clear Zone (ECZ) width.

Case 1:

Fill batter slopes of 6 to 1 or flatter are considered recoverable for errant vehicles. No clear zone correction is required and the full width of the batter can be accepted as part of the clear zone. ECZ = CZ

Figure V4.1: Basic Clear Zone Widths on Straights – All Roads



Notes for Figure V4.1 (above)

1. AADT is the average annual daily traffic volume. The AADT used for clear zone calculations shall be based on the projected traffic volume for the design year of the project. If a design year has not been specified, a minimum design life of 10 years shall be used. Where estimated future volumes are not available, current volumes multiplied by an appropriate growth rate may be used. Where growth rates are unknown, an annual growth rate of 3% per annum may be assumed.
2. On urban roads with a speed limit less than 70 km/h a reduced clear zone may be considered where there are hazards within the clear zone defined in Figure V4.1 and it is impractical to remove these hazards or shield them with safety barriers. Where reduced clear zones are proposed the desirable width is at least 3.0m with a minimum of 1.0m.

3. Refer to AGRD Part 6, Section 6.3.19 and this Supplement for methodology to calculate barrier lengths for all clear zone widths.
4. 15m wide clear zone to be adopted where one way AADT is greater than 50,000 vehicles per day.
5. Adopt the upper limit on graph for one way AADT greater than 5,000 vehicles per day and Operating Speed less than 95km/h (e.g. for AADT of 10,000 vehicles per day and Operating Speed of 80km/h, clear zone width is 6.8m)

Case 2:

Fill batter slopes between 3.5 to 1 and steeper than 6 to 1 are considered partially recoverable for errant vehicles. Errant vehicles on these slopes may travel further than on flatter batters. The additional clear zone width required is dependent on the width of the batter as described in Case 2(a) and Case 2(b).

Case 2(a):

On batters where the clear zone falls within the top half of the batter, the width between the clear zone and batter hinge point is doubled to obtain the effective clear zone.

ECZ = W1 + 2 (CZ – W1)

Case 2(b):

On batters where the clear zone falls within the bottom half of the batter, allowance is made for a vehicle to travel beyond the toe of batter.

ECZ = CZ + WB /2, or
ECZ = W1 + WB + W2
Where:
W2 = CZ – W1 – WB/2

Case 3:

Fill batter slopes steeper than 3.5 to 1 are considered non-recoverable for errant vehicles, so the batter width cannot be included as part of the effective clear zone.

ECZ = W1 + WB + W2

To allow a vehicle to stabilise at the toe of batter the effective clear zone shall extend a minimum of 3m beyond the toe of batter for Case 2(b) and Case (3).

ECZ = Effective Clear Zone (m)

CZ = Clear Zone (m) from Section V4.2.2.2 of this Supplement and AGRD Part 6, Table 4.2.
W1 = Traffic Lane to Batter Hinge Point (m)
W2 = Toe of Batter to Limit of ECZ (m)
WB = Batter Width (m)

Refer to Figure V4.2 for diagrams showing the above cases.

Cut Batter Slopes

Cut batter slopes may reduce the clear zone width required where the batter is both steep and high enough to contribute to redirecting an errant vehicle. The corrections available for cut batters are described in Cases 1 to 4.

Case 1:

Cut batter slopes of 6 to 1 or flatter have no effect on clear zone requirements.

ECZ = CZ

Case 2:

Effective clear zones on cut batter slopes between 4 to 1 and steeper than 6 to 1 may be the lesser of: (a) Clear zone width from Section V4.2.2.2 of this Supplement and AGRD Part 6, Table 4.2, or (b) Width measured between the edge of traffic lane and a point 2.0m above the toe of batter – i.e. slope x 2.

Case 3:

Effective clear zones on cut batter slopes flatter than 2 to 1 and steeper than 4 to 1 may be the lesser of:

(a) Clear zone width from Section V4.2.2.2 of this Supplement and AGRD Part 6, Table 4.2, or
(b) Width measured between the edge of traffic lane and a point 1.6m above the toe of batter – i.e. slope x 1.6.

Case 4:

Effective clear zones on cut batter slopes of 2 to 1 and steeper may be the lesser of:

(a) Clear zone width Section V4.2.2.2 of this Supplement and AGRD Part 6, Table 4.2, or

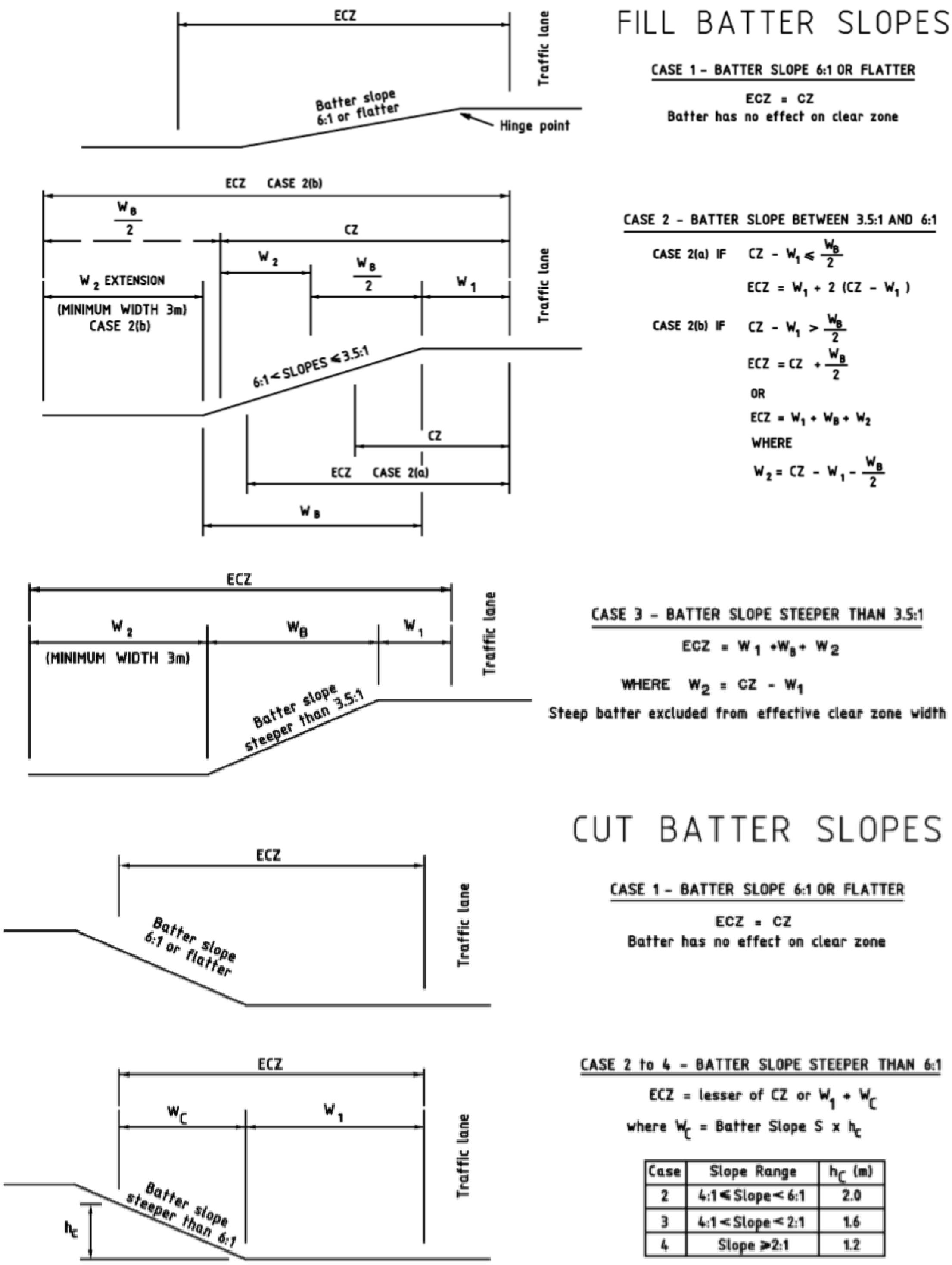
(b) Width measured between the edge of traffic lane and a point 1.2m above the toe of batter – i.e. slope x 1.2. Refer to Figure V4.2 for diagrams showing the above cases.

4.2.3 Application of Clear Zones to Design

Substitute Information

The reference to AGRD Part 6, Table 4.1 in the second paragraph shall be replaced with reference to the basic clear zone width provided in Section 4.2.2 of this Supplement.

Figure V4.2: Effective Clear Zone Width



Notes:

(1) (CZ) Is the clear zone width determined from Figure V4.1
(2) ECZ) Effective Clear Zone Width
(3) W_1 is the width from edge of through lane to batter hinge point
(4) W_B is the batter width
(5) W_2 is width from toe of batter
(6) W_C is the cut batter width
(7) S is the batter slope (m/m)
(8) Provide batter rounding to all batter top and toe hinge points

4.3 Design Step D2: Identify Hazards

4.3.4 Embankment Assessment Process

Additional Information

The decision as to whether a safety barrier should be installed to protect errant drivers from traversing embankments depends on the relative accident severity of striking the barrier as compared to running down the embankment. The warrants indicated in AGRD Part 6, Figure 4.6 apply to all barrier types.

When assessing the need to treat existing embankments, any proposed works will need to be prioritised against other road safety initiatives on a benefit/cost basis. In general, the use of safety barriers should be considered only after due thought has been given to other measures such as batter flattening, verge rounding and improved delineation.

In assessing the likelihood and consequences of vehicles encroaching on existing batter slopes, the factors to be taken into account include:

(a) whether the horizontal alignment is substandard, see Section 6.7.10 of this Chapter;

(b) whether steep down grades are combined with curves, see Section 6.7.11 of this Chapter;

(c) whether operating speeds exceed 60 km/h;

(d) whether there can be adverse climatic conditions such as ice, snow or fog; and

(e) whether there are significant hazards just beyond the clear zone.

4.3.5 High-consequence Hazards – Opposing vehicles and medians

Additional Information

Refer to FRA for approval regarding the provision of barriers for severe cross-median crashes.

4.3.5.1 Approaches to Structures

Additional Information
W-beam guard fence shall be strengthened near bridge end posts or concrete bridge approach barriers to ensure an appropriate transition in stiffness is provided.

4.3.5.2 Roadside Objects

Additional Information

Safety barriers shall be located where the following roadside objects create a potential hazard within the clear zone:

(a) structures, such as retaining walls, bridge end posts, bridge piers, or a building;

(b) features adjacent to or lower than the carriageway, such as a stream, a cliff, or another road;

(c) fixed rigid objects such as major sign supports and lighting poles which are not frangible or trees with trunks greater than 0.1m in diameter.

Where the object is located on a cut batter, the need for protection will depend on its position relative to the batter toe and the batter slope surrounding the object. Refer to Section V4.2.2.3 for details of the required height, measured from the toe of batter, above which an object would not require shielding.

Where safety barriers are warranted, it is preferable to locate them as far from the carriageway as practical to provide the greatest opportunity for a driver to recover. Where barriers are installed greater than 4m from the edge of traffic lane, there is potential for the vehicle to rotate and strike the barrier at an angle which is higher than desirable (25^0), leading to increased forces applied to the occupants of the vehicle. The slope in front of the safety barrier shall be 10 to 1 or flatter.

Alternatively, for semi rigid barriers only, a slope as steep as 5 to 1 may be used if a berm at least 2 metres wide with a 10 to 1 slope is placed in front of the safety barrier, see Figure V6.1.

It is estimated that about 15 to 20 per cent of errant vehicles may travel beyond the clear zone. Where persons in a vehicle travelling beyond the clear zone are expected to suffer serious injuries or death, (e.g. where there is a vertical cliff or significant structural elements like bridge piers or large sign supports just beyond the clear zone), it is desirable to install a safety barrier.

Consideration shall also be given to the containment level of that safety barrier and likely consequences, should that barrier fail if struck by a heavy vehicle.

4.3.5.3 Provision for Motorcyclists

The following issues shall be considered when considering roadside design for motorcyclists, see Table V4.1 for a summary of good practice):

(a) The concept of providing a clear zone beside a road is based on the width needed for a driver to regain control of a vehicle. For motorcyclists, it also provides an area free of obstructions in the event that a rider falls or is thrown from a vehicle.

(b) Sealed shoulders in rural areas have been shown to be very cost effective in reducing run off accidents. For motorcyclists, the benefits may be significant. The most cost effective width for sealed shoulders is not yet known (although any sealed shoulder width is safer than unsealed shoulders).

(c) Barrier kerbing is a severe hazard to motorcyclists in the event of falling off their motorcycle. Its main benefits are in areas used by pedestrians and where people wish to park cars against it. Where these are not important considerations, semi-mountable kerb profiles shall be used.

(d) Lips on kerbs can snag motorcycle foot pegs and create instability when ridden over.

(e) Kerb colours which blend into road pavement colours create inadequate definition of vehicle paths and necessary tyre clearances in poor light conditions and may not be used where alignments are tight or deviations in alignment are created.

Table V4.1: Good practice needs for motorcyclists and general road users

Good Practice		
Issue General	**The Special Needs of Motorcyclists**	**Good Practice for All Road Users**
Reducing run-off road accidents		Seal Shoulders
Reducing injury if run off road	More Critical for motorcyclists, due to a lack of protection	Provide clear zone free obstructions, use semi mountable kerbing instead of barrier kerbing. Provide appropriate verge and batter toe rounding.
Tree planting and landscaping		Avoid non-frangible planting and landscaping features near the carriageway where the risk of running off road is high.
Kerbing		Use semi mountable kerbing, not barrier kerbing. Use contrasting colour.

4.5 Design Step D4: Evaluation of Treatment Options

<u>Substitute Information</u>

Correct practice is to treat all identified hazards. An appropriate risk assessment may be used to assess high consequence hazards or hazards outside the clear zone.

4.6 Hazard Risk Assessment

<u>Substitute Information</u>

Correct practice is to treat all identified hazards. An appropriate risk assessment may be used to assess high consequence hazards or hazards outside the clear zone.

4.7 Design Step D5: Rank Treatment Options and Recommended Preferred Action

FRA has no supplementary comments for this section.

4.8 Design Step D6: Design the Roadside Treatments

FRA has no supplementary comments for this section.

5.0 Treatment Options

5.4 Types of Treatment

5.4.3 Treatments for Medians

Additional information

Median barriers shall be considered on new divided roads with a proposed speed limit of 80km/h.

A risk assessment shall be carried out to evaluate the safety implications and need for a median barrier. The risk assessment shall include consideration of traffic volume and median width.

Medians shall be designed so that there are minimal hazards. Where hazards cannot be avoided (e.g. bridge piers, large sign supports and trees etc), barriers shall be installed in addition to the requirements of the above assessment.

5.4.6 Treatments for Drainage Features

Additional Information

Driveable Slopes

To be driveable, batter slopes desirably should be 4:1 or flatter. To be relatively safe for trucks, batter slopes should be 6:1 or flatter.

Height 0.6 metres maximum

The channel downstream may not be deeper than the height of the culvert. Beaching will be required to prevent erosion of the batter and the channel. Beaching within the clear zone must be traversable, relatively smooth and no steeper than 4:1. Any rough textured beaching for energy dissipation shall be located beyond the clear zone.

Height 0.6 m to 2 m

For pipe diameter or box culverts heights between 0.6 metres and 2 metres, it would be preferable for safety to extend the pipe or box culvert to the edge of the clear zone, and to warp the batter around the culvert using driveable batter slopes.

Where it is not practical to extend the culvert, or where regular maintenance can be assured, grates may be provided to span between the wingwalls. Each grate must be hydraulically and structurally adequate.

Safety barrier protection may be provided as an alternative where the height is between 0.6 metres and 2 metres, and shall be provided where the height is 2 metres or greater.

Culverts Parallel to Traffic Lanes

Conventional endwalls on culverts under driveways and median openings are hazardous because they can be hit head on. The preferred treatment is to locate them outside of the clear zones of traffic flows in both directions. If the endwall cannot be located beyond the clear zone, a driveable endwall with transverse bars as shown on FRA’s Standard Drawings may be provided.

6.0 Road Safety Barriers

6.1 Introduction

6.1.1 General

Additional Information

Only road safety barriers and end treatments accepted by FRA shall be used. For Austroads recommended barriers refer attached website:

https://austroads.com.au/safety-and-design/barrier-assessment/products-recommended

The protection of pedestrians and cyclists should also be considered, but the use of a safety barrier on this account is seldom justified. Safety barriers shall not be used to shield commercial developments and private residences unless there is an established accident history, or the potential for accidents is high.

V6.1.3 WARRANTS – General

Additional Information

Engineering judgement, based on the particular site conditions and current road safety practice, needs to be exercised when determining if a safety barrier is required.

The warrants may not apply where:
- traffic volumes are low, a consistent road environment is provided, and speeds are restricted by the road alignment to less than 60 km/h; or
- the combination of the low number of likely encroachments, the high cost of continuous safety barrier and driver expectations may mean that the installation of safety barrier is not justified.

6.2 Factors Considered in Barrier Selection

Additional Information

V6.2.2 Factors for Consideration when Designing Barrier Systems for Motorcycles

Issues that need to be considered when designing barrier systems to take into account motorcyclists are discussed below and summarised in Table V6.1.

(a) Safety barriers should only be used where the likely damage or injury from hitting the barrier is less than that of hitting the hazard it shields. The choice of barrier type shall take into account the likely vehicle types and location characteristics.

(b) The incidence of motorcyclists hitting safety barriers is a very small part of the total motorcycle accident problem.

(c) Before motorcyclists hit safety barriers, they are usually separated from their motorcycle. It is usually the posts on a safety barrier which cause injury, as the motorcyclist is sliding along the ground. With the current range of safety barriers, continuous concrete barriers may offer the potential for least injury, but they are costly.

(d) Concerns about adverse effects on motorcyclists caused through impacts with wire rope barriers have not been realised. Given the mass of a motorcyclist and the flexing of the wire rope, the likelihood of this type of injury is extremely low. As with other barriers, the posts present a greater potential for injury.

(e) Drivable pavement or shoulder surface shall be extended up to the barrier.

(f) Barriers need to have surfaces (sides, tops and under barrier areas) as smooth as possible. Protrusions, added devices or entrapment areas shall be avoided. Systems which provide an unbroken surface are preferred where motorcycle impacts are likely.

(g) Posts on barriers (whether wire rope or steel rail) are the main safety hazard for motorcyclists. With 'W' beam barriers, an additional under-rail or top cover rail may reduce motorcyclist injuries. It is important to know the effect any 'add-on' fittings will have on the dynamics of the barrier when struck by cars and trucks.

(h) Methods of crash testing road safety barrier systems from the perspective of motorcyclists are yet to be developed.

(i) Wire rope barrier posts bend during impact, but remain embedded, presenting a potential subsequent hazard to motorcyclists.

(j) The benefit of shrub planting in front of barriers to 'cushion' motorcyclist impacts is unknown, although intuitively it is desirable.

Table V6.1: Good Practice Needs for Motorcyclists and Road Users

Good Practice		
Issue General	**The Special Needs of Motorcyclists**	**Good Practice for all Road Users**
W-beam barriers	Reflectors need to be frangible, not sharp in case motorcyclist slides along the top. Consider under mounted rail or other accepted treatment in high risk locations	Don't put reflectors within the W shape. Avoid adding other protrusions.
Concrete barrier systems	Small obstructions and indentations can snag a motorcycle or motorcyclist.	Ensure that the surface is smooth and free of obstructions and indentations.
Repairs after impact	Due to the lack of protection for motorcyclists, any hazardous, protruding fittings or posts need to be replaced promptly.	Repair of the whole system needs to be carried out promptly.
Kerbing near barriers		Locate kerbing (if used) where it doesn't lead to vehicle going under or over the barrier.

6.3 Road Safety Barrier Design Process

6.3.5 Offset to Travel Lane

<u>Additional Information</u>

The desirable offset for safety barriers from the nearest traffic lane shall be 4.0 metres, with a minimum offset of 3.0 metres. Every effort should be made to achieve the desirable offset of 4.0 metres as it allows broken down vehicles to pull over clear of traffic lanes and provides space for maintenance vehicles and workers. It also maximises the opportunity for the driver of an errant vehicle to recover control before striking the barrier.

Where site conditions dictate that the offset must be less than 3.0 metres, the consent of the Head of Design and Procurement must be obtained using the 'Safety Barrier <3m Offset Approval Form' – a sample is attached as Appendix VA.

V6.3.5.1 Location Relative to Cross Section

Additional/Substitute Information

General clearance requirements between traffic lanes and all barrier types are set out in Table V6.3.

Table V6.3: Clearance to Barrier

CLEARANCE FROM TRAFFIC LANE TO BARRIER (m)	
Desirable (without approval)	4.0
Minimum (without approval)	3.0
Absolute minimum clearance with FRA approval	1.0
Absolute minimum clearance with FRA approval and FRA technical review	0.6
Note: FRA approval process for barrier clearances less than 3.0m shall be in accordance with the form in Appendix VA.	

Where barrier offsets between 3 metres and 6 metres from the traffic lane an appropriate trafficable pavement shall be provided between the edge of shoulder and the road safety barrier. Sealing is required where the distance between the edge of shoulder and the barrier is 3m or less.

The General Manager must be consulted to establish acceptable maintenance practices when determining the surfacing treatment to be adopted between the edge of shoulder and barrier.

Clearances to guard fence from kerbs are shown on Table V6.4 (see below).

6.3.14 Step 6B – Choose the Barrier Type

Additional Information

V6.3.14.1 Barrier Types

Permanent safety barriers can be classified into three types:

(a) Flexible systems
(b) Semi-rigid systems
(b) Rigid systems

V6.3.14.2 Flexible Systems

Due to the relatively low decelerations experienced by vehicle occupants, flexible systems provide lower injury risk to vehicle occupants than both the rigid and semi-rigid systems, along with acceptable vehicle trajectories after impact. Where site conditions are compatible with their use, wire rope safety barriers should be considered.

V6.3.14.3 Semi-Rigid Systems

The W-Beam barrier is the system most commonly used in Australia It is capable of restraining vehicles in the 800 kg to 2000 kg range, has deflections somewhat less than flexible systems and is considerably cheaper to install than the rigid barrier.

Table V6.4: Clearance to Guard Fence or Wire Rope Safety Barrier from Kerb

KERB TYPE OR SHOULDER	CLEARANCE TO GUARD FENCE(1)
BARRIER KERB	On high speed roads the guard fence shall be either in front of kerb or at least 3 metres behind the kerb. These offsets remain as desirable standards on intermediate standard roads although the kerbing could be located below the guard fence if necessary.
SEMI-MOUNTABLE KERB	Guard fence either 0 metre to 1 metre behind the kerb or at least 3 metres behind the kerb.
MOUNTABLE KERB	No restrictions – note FRA approval process is required for barrier offsets less than 3.0m.

Notes:
1. Guard fence clearances in the table are appropriate for use where vehicle speeds are sufficient to cause vaulting. In low speed areas such as car parks, there are no restrictions on the location of kerbs and guard fence, and B type kerbs can be located 0.3 metres to 0.5 metres from the face of the rail to minimise the likelihood of panel damage with low speed impacts.
2. All clearances measured to back of kerb unless otherwise noted.
3. Guard fence offsets are measured to the face of the guardrail.

The following restrictions apply:

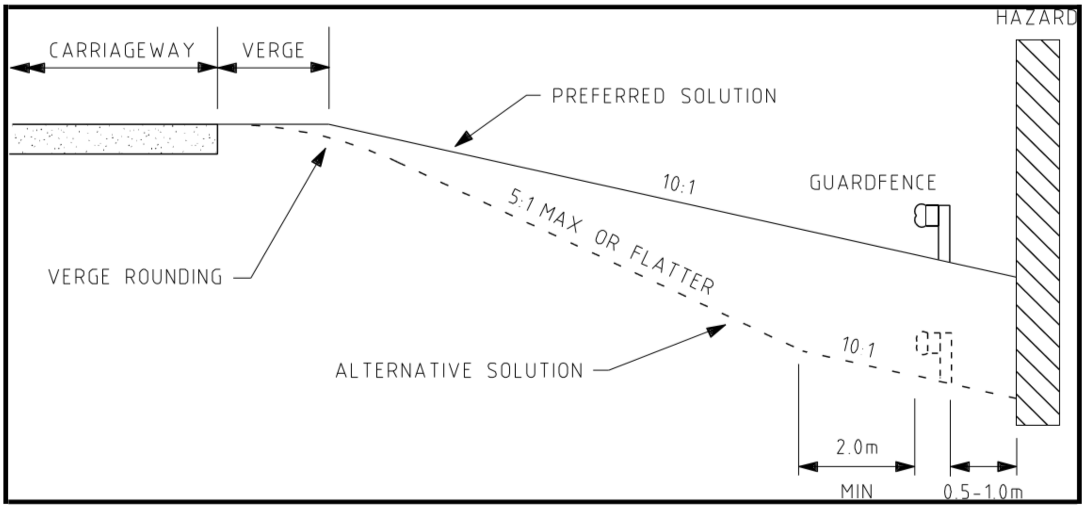
(a) The ground slope on the approach to Wbeam guard fence shall be 10 to 1 or flatter (see Figure V6.1), as otherwise the errant vehicle may not be redirected. A slope as steep as 5 to 1 may be used if a berm at least 2 metres wide with a 10 to 1 slope is placed in front of the safety barrier (see Figure V6.1)

(b) Where the 1.0m desirable clearance between W-beam guard fence and a fixed roadside hazard cannot be achieved, reducing the post spacing and nesting two rails will enable smaller offsets to be used. However this stiffening of the barrier will increase the potential for vehicle occupant injury. Consideration should also be given to an appropriate length of double nested rail, immediately upstream of the fixed hazard.

(c) Double sided blocked out W-beam guard fence may not be used as a median barrier. Where traffic volumes are high and the median is narrow, rigid concrete barrier would generally be the desirable choice.

(d) On roads where vehicle speeds exceed 70 km/h, kerb and channel may not be placed in front of W-beam guard fence. Where this requirement cannot reasonably be achieved: - only a mountable or semi mountable kerb may be used,

Figure V6.1: Slopes in Front of Guard Fence on Embankment



V6.3.14.4 Rigid Systems

The following concrete barriers represent this group:

- F-Shape Concrete Barrier;
- Vertical Face Concrete Barrier; and
- Constant Slope Safety Barrier.

The F-shape is the preferred profile for concrete barriers. Previously, the New Jersey profile had been accepted and had performed satisfactorily for the design range of passenger vehicles. However, under high speed or high angle impacts, it has greater potential to overturn small vehicles than FShape barriers. Constant slope and vertical face profiles may be considered as alternatives to the F-Shape, although the vertical face barrier is only suitable for lower speed environments. Rigid systems are suitable where there is limited width for barrier deflection, and also where traffic volumes are high, as maintenance and repair costs are small.

The following restrictions apply:

(a) F-shape is designed to allow vehicles impacting at angles of up to 25 degrees to ride up the lower safety profile, and then be redirected by the upper sloped face. To enable vehicles to perform this manoeuvre safely, the approach surface must be paved.

(b) concrete barriers shall not be located more than 4 metres from the edge of the trafficked lane as at larger angles of impact, the safety profile becomes less effective and the severity of impact increases. Also, a wide paved shoulder could be used as a through lane;

(e) kerb and channel must not be located in front of concrete safety barriers as it could cause errant vehicles to strike it in such a way that the vehicle will overturn.

V6.3.14.5 Selection of Barrier Type

If a safety barrier is warranted, and other countermeasures are not viable, then the applicable barrier type needs to be determined.

The designer needs to estimate the traffic volume and the types of vehicles, to identify critical site features, estimate the allowable barrier deflection, and to assess the consequences of barrier penetration. When considering allowable deflection, allowance shall be made for the roll effect of vehicles having a high centre of gravity. Rotation of the upper part of the vehicle could still cause impact with the object being protected, such as a lighting pole mounted on rigid barrier; a sign gantry behind guard fence; or a bridge pier shielded by a rigid or semi rigid barrier.

Clearances are required behind barriers to accommodate deflection of the system on impact and for support of structural elements. The clearances available will often determine which type of barrier should be adopted for a particular site, together with the containment required.

Generally, the most flexible system should be adopted where its containment and deflection characteristics are appropriate to the constraints of the site.

Irrespective of the type of barrier being used, it is preferable that the approach slope is essentially flat, as safety barriers perform best when struck by vehicles that have not been de-stabilised by traversing uneven terrain.

Factors to be considered include:

(a) Restraint Requirements

The barrier must be capable of restraining and redirecting the design vehicle. Generally this will be the passenger car, but where the number of commercial vehicles is high and the site geometry poor, or the consequences of barrier penetration would be catastrophic, then a barrier with a higher performance may be required.

(b) Deflection
Sufficient clearance from the hazard must be provided for the expected deflection of the barrier. Indicative dynamic deflections for the various systems during high speed impacts by the heavier passenger car are shown in Table V6.5.

Table V6.5: Indicative Barrier Displacement

BARRIER TYPE	DISPLACEMENT
Wire rope safety barrier	1.3 – 3.0+m
Blocked-out steel W beam	0.5 – 1.0m
F-shape concrete barrier	0.1m

(c) Site Conditions

Steeper cross slopes, insufficient clearance from the traffic lanes or road curvature may preclude the use of some barrier types

(d) Safety Performance

A barrier system must be structurally adequate for the design vehicle, present the lowest possible risk to vehicle occupants, and provide an appropriate trajectory after impact.

(e) Continuity and Consistency

Short gaps between safety barriers shall be avoided so as to minimise the number of barrier terminals, which can be the most hazardous part of a barrier installation.

(f) End Treatments

Appropriate terminations need to be provided so that the end of the barrier will not spear or snag an errant vehicle, causing it to overturn or vault the barrier. In addition, an appropriate terminal will ensure that vehicle decelerations will not exceed the recommended limits. Where an end treatment is designed to allow an impacting vehicle to pass through the terminal – i.e. a gating terminal, an appropriately graded runout area free of hazards is required behind the barrier

(g) Maintenance

Maintenance factors which need to be considered are:
- routine maintenance of the barrier itself;
- impact repair; and
- effect of the barrier on adjacent road and roadside maintenance (pavement overlays, etc)

Designers shall consider the OH&S implications of maintenance and repair of safety barriers. This may influence the choice and location of the type of safety barrier to be installed.

(h) Sight Distance

The effect of the safety barrier on sight distance needs to be taken into account, especially in the vicinity of intersections. All barriers shall be assumed to be solid from a visual perspective.

(i) Cost

The life cycle cost of alternative systems together with their probable average injury level and property damage performance need to be assessed, as initial cost is only one component of the economic evaluation.

6.3.15 Step B7 – Determine Dynamic Deflection

Additional Information

AGRD Part 6, Table 6.7 includes indicative deflections for concept/feasibility design.

6.3.19 Step B11 – Determine the Barrier Points of Need

Additional Information

The Run Out Length Method shall be used to determine barrier points of need.

6.3.21 Step B13 – Check Sight Distance

Additional Information

All barriers shall be considered non-permeable for the purpose of assessing sight distance.

6.3.22 Step B14 – Choose Terminal Treatments

Additional Information

Appropriate run out areas shall be provided at all gating terminals for barrier treatments in accordance with the following Standard Drawings:

Where an appropriate run out area for a gating type barrier terminal cannot be provided, an appropriate non-gating barrier terminal shall be adopted.

The most common terminal treatment for guard fence is the Breakaway Cable Terminal (BCT).

The BCT is a gating terminal. It is designed to allow the impacting vehicle to break through and pass safely behind the barrier. A flat, driveable area behind guard fence about 20 m long by 6 m wide shall be provided to enable an errant vehicle to come to a safe stop.

Where rigid barriers need to be terminated (e.g. at bridge end posts), it is normal to transition the stiffness of the barrier system to a semi-rigid barrier.

Where the rigid barrier is to be terminated in a constrained location and the appropriate lengths of barrier transition cannot be accommodated, the barrier shall be protected by a crash cushion.

6.3.23 Step B15 – Design the Transitions between Barriers

Additional Information

It is important to provide appropriate transition in barrier stiffness between different barrier types as described in the Austroads Guide to Road Design to ensure that the barrier in the overall system with greater stiffness does not become a hazard for errant vehicles. Some guidance for specific situations is provided in the Standard Drawings referred to in Section 4.8 of this Chapter.

6.4 General Access through Road Safety barriers

Additional Information

Refer to Appendix A of this Chapter for further guidance on access through road safety barriers where offsets to traffic lanes are less than 3m:

a) Maximum length of barrier shall be 500m where the barrier offset from the traffic lane is less than 3m.

(b) For barriers that have an offset from the traffic lane less than 3m, an offset/gap at least 3m wide and with a desirable length of 50m (30m minimum length) between barriers or within a section of barrier is required for a vehicle to stop safely.

6.5 Road Safety Barriers for Vulnerable Road Users

6.5.1 Motorcyclists

Additional Information

Road Safety Barrier Systems
(from AS3845, 1999) Cl. 2.3.18

Motorcycle road safety barrier system: road safety barrier systems crash tested for motorcycle impact shall provide smooth unbroken surfaces without sharp edges.

Additional References
EuroRAP (2008). Barriers to Change: designing safe roads for motorcyclists. Position paper on motorcycles and crash barriers. Pub No. 01/08. www.eurorap.org

6.7 Other Road Safety Barrier Design Considerations

V6.7.10 Sub-Standard Curves

Additional Information

Installation of safety barriers on either or both sides of the road shall be considered where a curve has a safe operating speed 10 km/h or more below the 85 percentile approach speed, and there are potential hazards on the roadside.

V6.7.11 Curves on Steep Down-Grades

Additional Information

Safety barriers may be installed on either or both sides of the road where a roadside hazard exists and:

(a) the down grade is 8 per cent or steeper; and
(b) the traffic volume exceeds 100 vehicles per day; and
(c) the operating speed is 60 km/h or more.

V6.7.12 Provision of Concrete Paving Adjacent to Traffic Barriers

Additional Information

The following areas adjacent to traffic barriers shall be paved with either a 100mm thick layer of 25MPa concrete placed on a 75mm thick layer of 20mm Class 4 crushed rock bedding or other pavement as specified:

(a) the full width between any overlapping median barriers where the width between the traffic barriers is less than or equal to 2.5m;

(b) the full width between any traffic barrier and adjacent road furniture where the width between the traffic barrier and the road furniture is less than or equal to 2.5m. The minimum length of the concrete paving shall extend a minimum distance of 1m beyond each end of the road furniture. Any length/area between the end of the paving described above and other paving located within 3m shall be paved and made continuous;

(c) the full width between any traffic barrier and the edge of the sealed pavement where the width between the traffic barrier to the edge of the sealed pavement is less than or equal to 3m. Where paving adjoins a sealed carriageway, the surface level shall match the level of the adjacent shoulder.

8.0 Appendices

Appendix B – Hazard Mitigation Worksheet

The Hazard Mitigation Worksheet is not generally required. Consideration may be given to use this process as part of a risk assessment.

Appendix C – RTA Method

The RTA Method is not required to be used.

Appendix G – RISC Method and Process

The RISC Method and Process is not required to be used.

Appendix I – Examples of length of need Calculations

The Run Out Length Method shall be used to determine barrier points of need.

Commentaries

Commentary 12.1 – Constrained locations

Refer to Chapter 2 regarding the use of Extended Design Domain criteria.

Extended Design Domain criteria can only be used with the specific written approval from FRA.

APPENDIX VA: FRA Supplement – Part 6

SAFETY BARRIER < 3m OFFSET APPROVAL

IMPORTANT: This approval must be obtained prior to the installation of any roadside safety barriers at offsets less than 3.0 metres from the edge of the traffic lane.

Road Name/ Location:	
Check list prepared by: (Engineer/Officer) Name: Date:	Recommended by: (Team Leader) Name: Date:
Endorsed by: (General Manager) Name: Date:	Approved by: (Head of Design and Procurement) Name: Date:

The applicable roadside clear zone standard should be provided where possible. If the desired clear zone cannot be achieved or when required to improve road safety outcome, the use of safety barriers can be considered to prevent errant vehicles from striking hazards within the road reserve. In addition, every effort must be made to remove any lone tree or power/light pole or modify culverts to allow the barrier to be set back as far as is practicable.

This approval form is used to ensure that all reasonable steps have been taken to achieve the most appropriate offsets for the roadside barriers. The desirable offset between a barrier and the edge of the traffic lane is 4 metres, with the minimum offset of 3 metres or more. This is to allow broken down vehicles to pull over clear of traffic lanes and to maximise the opportunity for the driver of an errant vehicle to recover control before striking the barrier. This is also to allow for the safe maintenance of the barrier and the roadside.

General principles and guidelines

- All barrier offsets to be maximised if less than 4 metres. The length over which barrier offsets are less than 4 metres shall be minimised. All barrier offsets to be at least 1m, by removing trees if necessary.
- Maximum length of offset <3 metres to be 500m. Maximum length of offset <2 metres to be 200m.
- For barriers that have offset <3m, provide a gap (at least 3 metres wide and desirable minimum length 50 metres/absolute minimum length 30 metres) between barriers or within a section of barrier for a vehicle to stop safely.
- If offset is less than 3 metres, provide a sight distance as shown in AGRD - Part 3: Geometric Design, Table 5.5 (Truck Stopping Sight Distances). The sight distance required will depend on the operating speed and any correction due to grade as obtained from Table 5.5.
- At any point where a 3 metres offset cannot be provided on the median side of a divided road, provide a 3 metres stopping width or barrier offset on the left side of the road within a distance of 200m.

PROJECT DETAILS

SAFETY BARRIERS <3m OFFSET CHECKLIST

(This section can be expanded to multiple pages to cover any discussions involved)

1. Details of proposal including number and length of each barrier and offsets:

2. Main reasons for why the offset of 3 metres is not achievable:

3. What alternatives were considered and why were they not feasible:

4. Detailed response and actions carried out to address the following issues:

    a. Can the hazards (trees, poles, etc.) be removed or eliminated?
    b. Can the hazards (street lighting poles, power poles, etc.) be relocated?
    c. Can the hazards be retrofitted (making poles frangible or slip based)?
    d. Has the appropriate type of barrier been used (Wire rope safety barrier where possible)?
    e. Has offset been maximised where it is less than 4m? f. Have multiple short lengths of barrier or wider offsets within the barrier length been used to provide areas where vehicles can stop?
    g. On divided roads where a 3m offset cannot be provided on the median side, have stopping opportunities on the left side of the road been maximised or vice versa?
    h. Has the probability of conflict between moving and stopped vehicles where the barrier is installed been considered?
    i. Have traffic volumes (including truck volumes), and vehicle speeds been considered? – There are higher risks on roads with high traffic volume, speed and high percentage of trucks
    j. Have traffic lane widths been considered? – Wider lane width is desirable where barrier at offset <3m is installed
    k. Has sealing shoulder between traffic lane and barrier to provide areas for errant vehicles to re-gain control been considered?
    l. Has sight distance on the approach to barriers with offsets <3m been considered to ensure that a parked vehicle protruding onto traffic lane can be seen by approaching traffic?
    m. Has the needs of pedestrians, cyclists, motorcyclists (especially at bends), horse riders, etc. been considered?
    n. Has the need and ability for a vehicle with disabled driver/passenger to stop on the side of the road and the risk of a collision involving such a vehicle been considered?
    o. Has the ability for maintenance activities (including repairs to barrier, grass mowing and weeds spraying) to be carried out safely been considered?
    p. Has the ability for motorists to identify safe locations to stop both at day times and night times been considered?

5. Other comments, justifications and details:

6. Maps/Photos attached.

Appendix VB Road Humps and Platforms

VB1 Introduction

Speed humps and platforms are important speed control devises currently used in Fiji.

Austroads Guide to Traffic Management, Part 8 – Section 7.2 provides guidance on the design of road humps for Local Area Traffic Management (LATM) purposes.

AS 1742.13, Appendix C provides further guidance on the use of road humps as LATM devices.

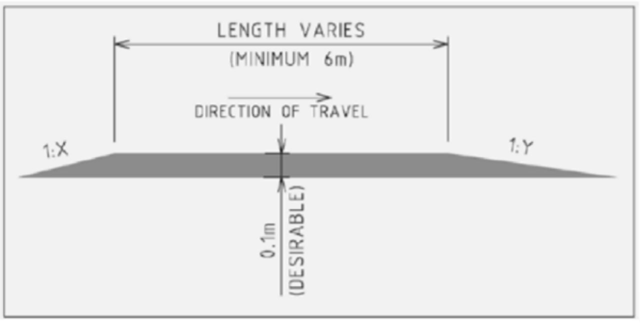
Both these guides provide guidance for use of road humps on low speed, low volume roads.

FRA uses speed control devises on high volume, higher speed roads to help control speeds through towns and villages. VicRoads has developed a Roads Design Note for Raised Safety Platforms which can be installed on Arterial Roads (RDN 03-07) - https://www.vicroads.vic.gov.au/business-and-industry/technical-publications/road-design

Details from this note are provided below:

VB2 Road Safety Platforms (RSP) Introduction

RSPs may be designed for a range of vehicle speeds and types. Design speeds ≤ 50km/h are encouraged to reduce the side-impact severity for a vehicle to a survivable level, i.e. a Safe System collision speed. Design speeds ≤ 30km/h are encouraged to reduce the severity of any pedestrian related crashes to a survivable level.



Typical RSP Section

The implementation of RSPs should include supporting treatments to achieve the desired outcome.

When installing RSPs at intersections, the entire intersection can be raised with approach and departure ramps. RSPs can also be placed on the approach to an intersection (sometimes referred to as raised stop bars) in order to achieve a similar outcome. On local roads and low speed arterial roads, RSPs can be installed in mid block locations as a traffic calming device or to improve safety at pedestrian crossings. RSPs could be painted and paved to further increase driver awareness and highlight the presence of the platform on approach to the intersection.

VB3 RSP Scope

VicRoads' Road Design Note (RDN 03-07) is applicable to RSPs in the following locations, with a focus at the moment on posted speeds of 70km/h or less:

- intersections (uncontrolled or controlled)
- roundabouts
- pedestrian crossings (uncontrolled or controlled)
- mid-block locations.

RSPs have not been widely implemented on arterial roads, particularly those with an operating speed of 80km/h and above. As such, the overall benefit and risk including noise implications have not yet been thoroughly evaluated or documented.

Achieving an operating speed of ≤ 50km/h is a significant reduction in speed from 80km/h. Therefore, additional speed management treatments should be considered to gain the expected speed reduction.

Practitioners considering the use of RSPs on higher speed roads should consider the principles contained within the Road Design Note.

VB4 Design Guidance

Design guidance for RSP's is provided in VicRoads' Road Design Note Roads (RDN 03-07) - https://www.vicroads.vic.gov.au/business-and-industry/technical-publications/road-design

In particular, Appendix B of this design note provides guidance on designing ramp gradients for higher operating speeds.

VB5 Signing and Linemarking

Signing and linemarking of road humps shall comply with FRA's signing and linemarking guides (MOTSAM Part 1 Section 4 Permanent Warning Signs and MOTSAM Part 2 Linemarking).

CHAPTER 6a

PEDESTRIAN AND CYCLE PATHS

PART 6a - PEDESTRIAN AND CYCLE PATHS

2.0 Planning and Need for a Path

2.1 Planning

Refer to Austroads Guide to Traffic Management (AGTM) Part 4 and AGTM Part 6 for further information on planning for pedestrians and cyclists.

2.2 Need for a Path

Refer to FRA for advice as to whether bicycle facilities should be provided as part of a road project.

4.0 Path User Requirements

4.1 Pedestrians

4.1.1 Principles

For designs involving pedestrian walkways the following additional principals and information shall be considered.

Additional information

Implications for Pedestrian Design
Pedestrian devices are often designed to cater for the 'average' or 'normal' pedestrian. It is generally assumed that the pedestrian has satisfactory eyesight and hearing, is paying attention and is not physically hindered in any way. By virtue of these implicit assumptions, pedestrians under 12 and over 50 years old are misrepresented, as also are intoxicated persons, the vision and hearing impaired and possibly, people with prams or in wheelchairs. These pedestrians will all potentially experience difficulty and inconvenience with access. For these reasons, many people with mobility disabilities do not use the street system at all.

It is interesting to note that it is those groups who are most dependent on walking and who often do not have the option of driving a car are most impeded by some current accessibility design practices. The following is a description of some of the factors which need to be considered in planning works to reflect the needs of all pedestrians.

Additional information

People with Disabilities
Disabilities result in some form of functional loss or mobility impairment. People with disabilities, range from those who have the ability to walk, but have difficulty in doing so, (especially in negotiating steps and changes of grade), to those who require assistance to maintain balance and interpret directions, those that have impaired vision and those who require a mobility aid such as a wheelchair.

Some commonly stated problems in moving about the street system are summarised below:

- People with impaired vision have difficulty in using visual cues; consequently, strong contrast/delineation is required between the road and pedestrian areas, usually in a form of physical guidance (e.g. kerbs, strips of textured paving). Vision impaired pedestrians have trouble with obstructions in their path, therefore sign posts and other street furniture can be the cause of annoyance and confusion, particularly at signals or other crossing points.
- People with hearing impairments may be unable to hear oncoming vehicles early enough and therefore have to rely more on seeing vehicles in order to cross a road safely. Therefore, a clear view from the side of the road becomes more critical.
- Wheelchair users have difficulty in using uneven, discontinuous, soft or loose surfaces. They need a ramp to change levels. In order to cross a road, an appropriately designed kerb edge is required which can be mounted and which will not cause a wheelchair to tip over.

Additional information

Young Children

A child's physical size limits their ability to be seen and to see from the kerb. This is particularly so when there are parked cars or plantations along the verge of the road. It is important to recognise however that there are additional factors which significantly contribute to the vulnerability of children in the road environment.

Children's intellectual, psychological and sensory capacities are limited by virtue of their age and stage of development. Hoffman (1978) has shown experimentally that children do not reach an adult level of performance in traffic, i.e. do not have the perceptual and cognitive capacity to make sound judgements about traffic safety, until about 12 years of age.

Traffic devices and treatments need to be reviewed from the child's perspective and appropriate measures taken to ensure their applicability in some situations. In order to maximise their safety, primary school age children generally need to be supervised.

Additional information

Elderly Pedestrians

Changes in physical factors associated with ageing affect the ability of elderly to function on the traffic environment. Their deteriorating eye sight and balance affect their walking speed and reaction times and this is not always adequately accounted for in the design of traffic facilities. The 1990 Western Australian study of senior pedestrians identified the mean walking speeds and those which only the slowest 10% of pedestrians over 65 years cannot manage, as shown in Table V4.1.

Table V4.1: Walking Speeds for Senior Pedestrians

Walking Pace	Mean Speed	10th Percentile Speed
Normal	1.13 m/s	0.8 m/s
Hurried	1.41 m/s	1.0 m/s
Rushing to catch a bus	1.71 m/s	1.0 m/s

Source: Main Roads (1990)

In contrast to younger pedestrians, elderly people are aware of their limitations and will compensate for these. Consequently, the elderly pedestrian will wait longer before leaving the kerb to cross a road, knowing it takes longer to react to danger should they misjudge a situation. Grayson (1975) found kerb delays of 3-4 seconds were apparent in seniors over 60 years.

4.1.2 Pedestrian Operating Space and Clearances

Additional information

Walking Speed

Walking speeds vary over a wide range, generally determined by crowd density and other traffic impediments. The distribution of free-flowing walking speeds varies as follows:

- Minimum walking speed 0.74 m/s
- Maximum walking speed 2.39 m/s
- Average unimpeded free- flowing walking speed 1.35 m/s

Calculation of the duration of the green walk phase at traffic signals which is generally based on an ‘average’ pedestrian walking speed of 1.2 m/s, does not always ensure a safe and comfortable crossing for all pedestrians.

At busy intersections where crowding would reduce crossing speeds, or where elderly or physically impaired persons cross, the design speed shall be reduced to 1.0 m/s.

4.1.2 Pedestrian Operating Space and Clearances – Pedestrian Space

Additional information

Pedestrian Capacity

The pedestrian transportation network consists of a number of elements including:

- footways
- elevated walkways/subways
- stairs
- ramps
- escalators
- travelators.

Level of Service provides a useful model which can be applied to the design of pedestrian spaces, such as footpaths, stairs, entrances and queuing areas.

Pedestrian service standards are based on the freedom to select normal travel speed, the ability to bypass slow moving pedestrians, and the relative ease of cross and reverse flow movements at various pedestrian traffic concentrations.

Six levels of service based on service volumes and qualitative evaluation of user convenience have been defined. These are depicted in Figure V4.1 and are described below as follows:

Level of Service A provides space for a free flow condition, which allows the bypass of slower pedestrians and avoids crossing conflicts with others.

Level of Service B provides space which permits the selection of normal walking speeds and the bypass of other pedestrians in primarily one-directional flows. For a situation of bi-directional or crossing flows, minor conflict will occur, resulting in slightly lower mead pedestrian speeds and potential volumes.

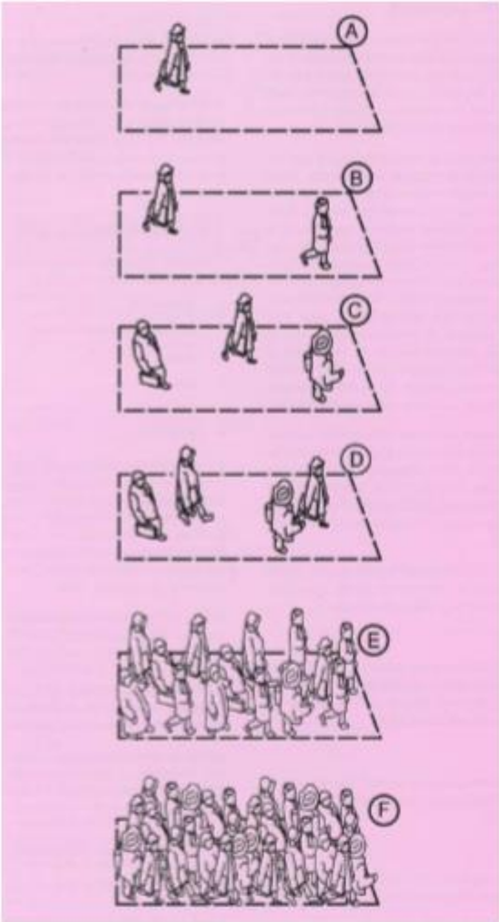
Level of Service C is a condition restrictive in the freedom to select individual walking speeds and to freely pass other pedestrians. With reverse and crossing flows, frequent adjustment of speed and direction would be required.

Level of Service D walkway conditions would have the majority of pedestrians with restricted and reduced normal walking speeds, due to the difficulties experienced in bypassing others and therefore avoiding conflicts. Reverse and crossing flows would be severely restricted due to frequent conflicts with others.

Level of Service E approaches the maximum attainable flow volume (capacity) of the walkway. Frequent stoppages and interruptions to the flow would be experienced by virtually all persons, due to insufficient area available to bypass others. Reverse and cross flow movements would be extremely difficult.

Level of Service F conditions would result in frequent, unavoidable contact with other pedestrians, and reverse and crossing movements would be virtually impossible. Walking speeds are extremely restricted with forward progress reduced to a shuffle.

Figure V4.1: Illustration of Walkway Levels of Service



Given the pedestrian area module, M (m2/ped), an expression of flow rate is derived, similar to the form of the traffic flow equation.

i.e. $P = S/M$

where:

P is the flow rate in pedestrians per metre width per minute (ped/m/min)
S is the mean horizontal space speed (m/min).

The six levels of service of pedestrian flow were derived and the results are summarised in Table V4.2. These show that as crowding increase, walking speed falls, while flow rate increase up to a critical point at which speeds become slow that movement virtually ceases.

When designing for extreme peak demands of short duration, a lower level of service may apply in order to obtain a more economical design. This in effect accepts that some ‘backing up’ of pedestrians will occur at critical bottlenecks.

Delay to pedestrians in crossing the road and pedestrian safety are additional measures of the level of service provided and the impacts of traffic on the pedestrian environment.

Details of calculation of delay and exposure are given in Appendix VA.

Table V4.2: Levels of Service for Horizontal Pedestrian Movement

Level of Service	Module Size M (m2/ped.)	Flow Rate (ped/m/min)	Sample Applications
A	> 3.3	23	Public buildings or plazas without severe peaking fit this level.
B	2.3 – 3.3	23 – 33	Suitable for transport terminals or buildings with recurrent but not severe peaks.
C	1.4 – 2.3	33 – 49	Recommended design level for heavily – used transport terminals, public buildings or open space where severe peaking and space restrictions limit design feasibility.
D	0.9 – 1.4	49 – 66	Found in crowded public spaces where continual alteration of walking speed and directions required to maintain reasonable forward progress.
E	0.5 – 0.9	66 – 82	To be used only where peaks are very short (e.g. sports stadia or on a railway platform as passengers disembark.) A need exists for holding areas for pedestrians to seek refuge from the flow.
F	0.5	Variable up to 82	The flow becomes a moving queue, and this is not suitable for design purposed.

<u>Additional information</u>

Obstruction Free Path

Any piece of street furniture on or near the footpath is a potential obstruction to free movement and should wherever possible be located to preserve an obstacle-free footpath width. People with physical and visual disabilities have particular difficulty in avoiding and moving around obstacles in their path.

Street furniture of concern to pedestrians includes temporary or permanent structures or pieces of equipment located within a pedestrian environment. Obstructions shall be kept clear of footpaths and overhanging objects (including trees) shall not be lower than 2.0 m. Refer to Austroads Guide to Road Design (AGRD) – Part 6A, Section 6.2.2 and Figure 6.4 for minimum envelope requirements.

Examples of street furniture include trees, signposts, traffic signals and light poles, parking meters, rubbish bins, seats, telephones, advertising signs and vending machines. In pedestrianised areas, street furniture shall be carefully located (and preferably grouped) away from commonly used pedestrian routes.

Additional information

Covers and Gratings

Placing manhole covers and gratings in major pedestrian walkways should be avoided. However, this is not always practicable and where it is necessary to locate them in the footpath area, they shall be of a non-slip surface, laid flush with the footway. In the case of drainage grates, the openings shall not be more than 13mm wide and not more than 150mm long (AS1428, 1992) and arranged perpendicular to the direction of pedestrian movement to prevent wheelchair wheels and canes from becoming trapped in the gratings.

Additional information

Setback Distance

The setback distance of the footpath from the roadway is an important safety and design factor. Footpaths located too close to highspeed traffic discourage pedestrian travel, due to the high noise level and perception of hazard. Wider setbacks will add to the convenience and perceived safety of travel and should be used whenever possible.

4.2 Cyclists

Refer also to Austroads web site for further information on bicycles:
Australian Bicycle Council http://www.austroads.com.au/abc/

4.2.1 Principles

Surveys to establish likely user demand shall be used to assist in determining the space required for new major bicycle paths.

5.0 Location of Paths

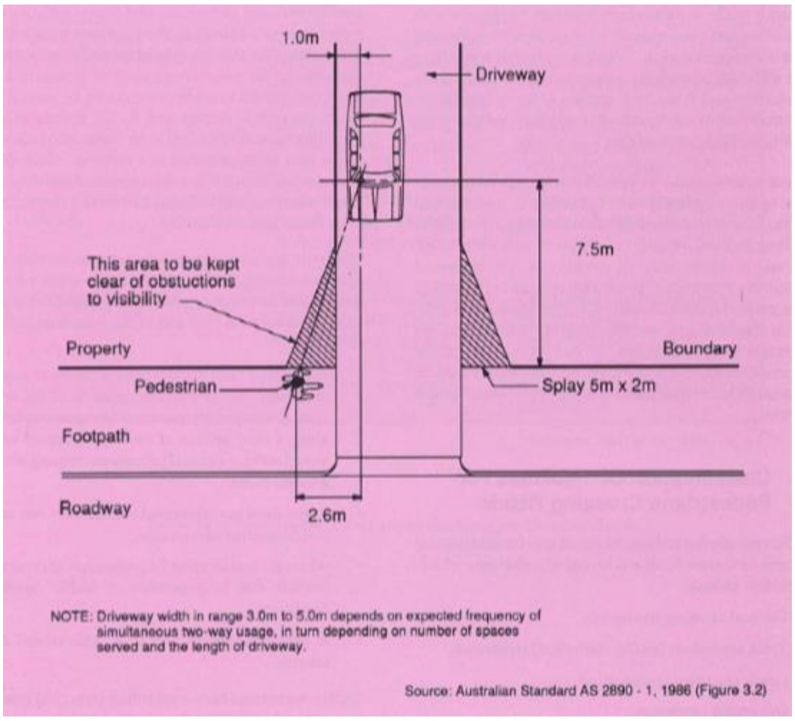
5.3 Factors Influencing Roadside Alignment

Additional information

Driveways Across Footpaths

Driveway location will be determined by factors other than pedestrian activity, however, off-street developments and carparking facilities shall be designed so that pedestrian entrances/exits are separate from vehicular entrances/exits. Circulation roadways and access driveways shall be located where there is minimum conflict with heavy pedestrian movements between car parks, public transport stations and associated shopping facilities, etc. Splays, clear of obstructions, are required at the property line to ensure adequate visibility between vehicles on a driveway and pedestrians on the footpath, as shown in Figure V5.1. Suitable information or warning signs may need to be provided in order to control the speed of traffic and warn of the presence of pedestrians. Vehicle drivers exiting buildings and off-street car parks should be encouraged to give pedestrians an audible warning where sight distance is severely restricted.

Figure V5.1: Minimum Sight Line Splays



6.0 Design Criteria for Pedestrian Paths

6.2 Clear Width and Height

6.2.1 Width

Provision of pedestrian paths needs to comply with the objectives of an urban design strategy or existing Council standards.

Any requirements shall be clarified prior to the commencement of design.

6.2.2 Height

FRA agreement shall be obtained before using the minimum clearance

6.3 Changes in Level

<u>Additional information</u>

Walkways, ramps and landings (from AS1428.1, Clause 10).

Changes in the vertical level that paths may need to negotiate will require compliance with AS1428: Design for Access and Mobility. Table V6.1 summarises the maximum gradients allowable and the landing spacing where required.

Typical road gradients will generally result in grades flatter than 3% and hence landings are not usually provided. Where a road is constructed on a steeper grade as part of an overpass or similar, consideration must be given to the gradient that an adjacent path will follow. Should the requirements of Table V6.1 be incorporated, independent grading of the path will most likely be required and will result in a level difference between the path and the road.

Where there is difficulty meeting the requirements of AS1428, the Disability Discrimination Act (Cth.) requires proponents to show why provision of the standard will result in undue hardship.

Table V6.1: Summary Clause 10, AS1428.1

Walkways - gradient	**Landing Spacing**
Less than 1 in 33	N/A
1 in 33 (3%)	25m maximum
1 in 20 (5%)	15m maximum
Between 1 in 33 and 1 in 20 4%	Linear interpolation 20m
Ramp - gradient	
1 in 14 (7%)	9m maximum
1 in 20 (5%)	15m maximum
Between 1 in 14 and 1 in 20	Linear interpolation
Landing Length No change in direction = no less than 1200mm Change in direction <900 = no less than 1500mm 1800 turn = at least 2000mm x 1540mm The intervals specified above may be increased by 30% where at least one side of a walkway is bounded by: (a) a kerb or kerb rail and a handrail (b) a wall or handrail	

6.4 Surface Treatments

Refer to FRA for guidance on surface treatments for shared users.

6.5 Pedestrian Path Lighting

FRA Street Lighting Manual and Standards provides guidance on the design of new road lighting schemes.

7.0 Path Design Criteria for Bicycles

7.3 Horizontal Curvature

<u>Clarification</u>
A minimum radius of at least 30 metres is generally preferred for paths not constrained by topography or other physical features.

Curves with a radius less than 15 metres are generally considered to be ‘sharp’ and may not be used to achieve landscaping objectives to the detriment of the path operation for cyclists.

A small radius may be appropriate on the approach to intersections (e.g. 5.0 metres) and at ‘hairpin’ bends (e.g. 2.5 metres min.) of paths traversing steeply sloping land.

7.5 Widths of Paths

7.5.1 General

<u>Additional information</u>

Capacity of Paths
The capacity of a 1.5 metre wide path in one direction is in the order of 150 cyclists per hour. In general this width is sufficient for the passage of a single stream of cyclists.

Generally it is impractical to design for the peak annual or lifetime use of a path. For many paths the nature of use varies over the period of a day or week. In considering the suitability of a path to handle the anticipated number of cyclists, and pedestrians if appropriate, it is recommended that path volumes be assessed in the basis of the highest demand over the period of 2 separate hours of a typical day (weekday or weekend).

In the case of shared use paths, the volume of pedestrians can be added to that of cyclists. Opportunities for passing would be required either through the provision of additional path width (minimum width of 1.8 – 2.0 metres in each direction), or through passing on the side of the path with opposing flow provided sufficient opportunities exist.

7.5.2 Bicycle Paths

<u>Clarification</u>

New grade separated crossings shall not have a width less than 3.0 metres, with a minimum of 2.5 metres between handrails. The geometry of the approaches to the overpass shall reduce the speed of cyclists.

7.6 Crossfall and Drainage

7.6.2 Drainage

<u>Additional information</u>

All works associated with a shared use path design and construction shall be undertaken in accordance with AGRD and this Guide. Where the path may traverse a floodway or overland flow path, the shared user path shall meet criterion for a 100 year ARI flood where the product of water depth (metre) and water velocity (metres per second) shall be less than 0.35, i.e. $V_{av} \times d_{av} \leq 0.35$ m2/s along footpath/cycle path alignments.

7.7 Clearances, Batters and Need for Fences

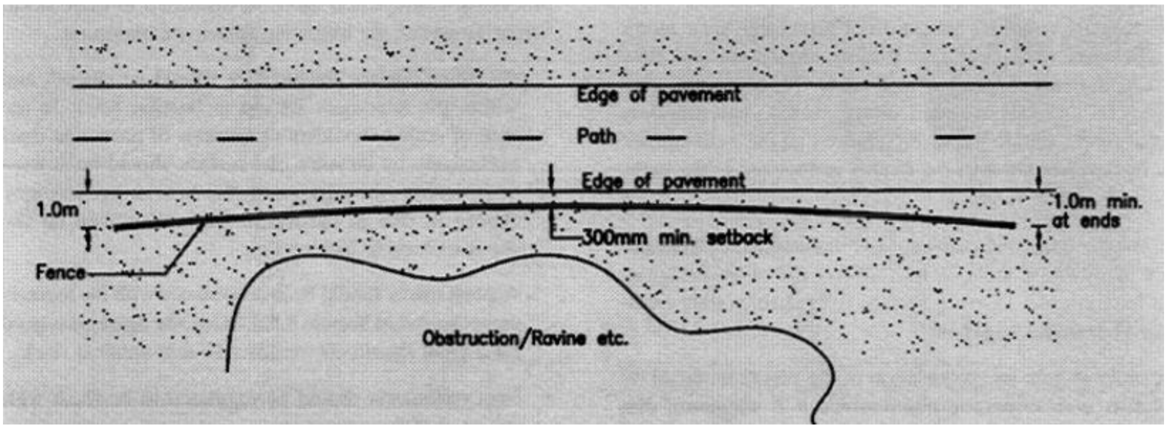
7.7.2 Batters and Fences

Fences constructed in close proximity to bicycle lanes or paths shall be designed to prevent injury to cyclists who may brush against it at speed, or get caught. Refer to AGRD Part 6A, Appendix C – Bicycle Safety Audit Checklist for further information.

Where it is proposed to use fences or similar structures in association with bicycle lanes or path facilities, the following factors must also be considered:

- The various fence elements (posts, railings, etc) shall be designed to minimise the possibility of cyclists snagging their handlebars or pedals;
- Care needs to be exercised in the choice of fences to avoid those that would give rise to spearing injuries if struck (by any vehicle);
- The ends of fences shall be at least 1 metre away from the riding surface, but may taper closer to the edge of the path if necessary (refer to Figure V7.1). They should also be appropriately delineated by signs and reflective tape, and preferably be of a light colour;
- The width of paths and lanes shall account for the presences of fences (see AGRD Part 6A, Section 7.7.1 for further details on clearances).

Figure V7.1: Fence Construction Details



10.0 Path Terminal Treatments

10.5 Holding Rails

Additional Information

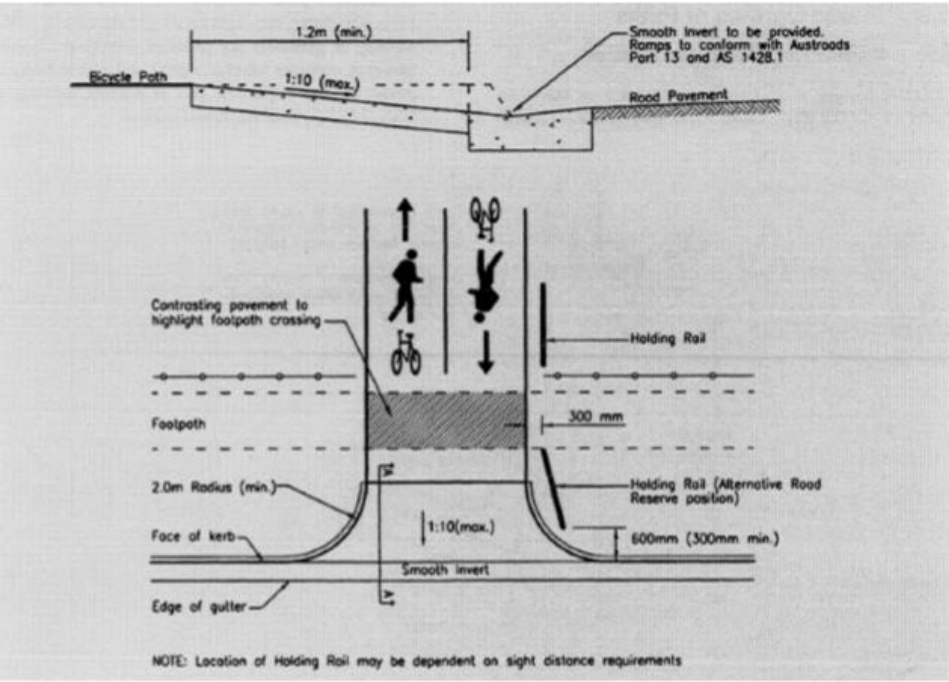
Holdings rails (AGRD Part 6A, Figure 10.8) may only be provided where there is a reasonable likelihood that cyclists will have to stop at intersections with roadways or paths. For example, they should not be provided at the intersections of paths with local streets where it is unlikely cyclists will have to stop and wait.

To avoid the unnecessary proliferation of holding rails, they should not be installed at traffic islands or approaches to signalised intersections unless demand has been identified.

A sign extension (AGRD Part 6A, Figure 10.8) may not be used in close proximity to road carriageways or where cyclists would turn in close proximity to the sign extension.

Figure V10.1 shows FRA preferred kerb ramp and holding rail layout details.

Figure V10.1: Kerb Ramp & Holding Rail Layout Details



Appendices

Appendix B.1 Path Construction and Maintenance – General Requirements

An effective management and maintenance regime shall be in place when providing bicycle paths.

Appendix B.5.2 Bicycle Safety Audits

The reference cited should be Austroads Guide to Road Safety Part 6: Road Safety Audit (Austroads, 2000) not 2009g.

Appendix VA

Appendix E

Pedestrian Delay and Exposure

E1 DELAY TO PEDESTRIANS CROSSING THE ROAD

Considerable research effort has been expended in developing methods of predicting the proportion of pedestrians likely to be delayed and their average delay for a variety of road crossing situations. In the case of an uncontrolled crossing situation on a road having a low degree of platooning, the proportion delayed may be calculated using traditional gap acceptance theory:

$$Pr = 1 - (1 - t_m q)e^{-\lambda(t_c - t_m)}$$

where

Pr is the probability of a pedestrian being delayed

q is the vehicle flow on the road to be crossed (veh/s)

t_m is the average headway between bunched vehicles. Use 2 divided by the number of lanes.

t_c is the critical acceptance gap required by pedestrians to cross the road (s). This is dependant upon the assumed walking speed of pedestrians.

λ is the delay constant given by

$$\lambda = \frac{(1 - \theta)q}{1 - t_m q}$$

θ is the proportion of bunched vehicles. A good estimate of the proportion of bunched vehicles is given in the AUSTROADS GTEP Part 6 (Roundabouts) for circulating flow. Recommended values are between

$$1 - e^{-2.5 t_m q} \quad \text{and} \quad 1 - e^{-3.0 t_m q}$$

The average delay to all pedestrians is given by:

$$d = \frac{e^{\lambda(t_c - t_m)}}{(1 - \theta)q} - t_c - \frac{1}{\lambda} + \frac{\lambda t_m^2 - 2 t_m \theta}{2(\lambda t_m - 1 - \theta)}$$

The average delay to those pedestrians who are delayed is given by the following equation:

$$d_{d>0} = \frac{d}{Pr}$$

However, when platooning of the flow exists (as it does on most urban arterial roads), or where the crossing occurs at a 'controlled traffic' facility, the relationships become somewhat more complex and the data input requirements increase. Models for the latter have been developed in the UK (by Compton and Goldschmidt). No similar pedestrian related research has been undertaken in Australia although the work done by Troutbeck (1990a), (1990b) and Akcelik and Troutbeck (1991), in taking account of 'traffic bunching' in the analysis of traffic operation at roundabouts and other unsignalised intersections, could be applied to the analysis of delay to pedestrians crossing heavily trafficked urban roads.

E2 PEDESTRIAN SAFETY: EXPOSURE AND CONFLICT

Any street in which space is intermittently shared by pedestrians and vehicles places pedestrians at "risk". Whilst it is not easy to predict this "risk" directly, positive correlations have been found between levels of pedestrian activity and vehicular traffic volumes.

Hence in streets where pedestrian activity is high, aceptable traffic volumes may be determined by consideration of conflict between pedestrians and vehicles as well as by consideration of the delay caused to pedestrians when crossing the road. The approach to defining pedestrian/ vehicle conflict standards may be based on two measures of pedestrian activity: pedestrian volumes crossing the road and pedestrian densities on the footpaths.

These two measures reflect different types of pedestrian activity; in the case of pedestrian travel through an area from,say, home to shops or to school, pedestrian crossing volumes will be appropriate criterion, as these pedestrian flows will tend to be concentrated at intersections. Where the pedestrian movements are directly associated with an activity , such as "window shopping" or waiting at a bus stop, the pedestrian density on the footpath will be the criterion. In this situation, crossings of the road (when conflict may occur) are likely to occur randomly at places along the road rather than at intersections or other specific locations at which pedestrian flow can be channelised and controlled.

Work in the UK (Compton and Gilbert, 1976) has shown that both measures are positively correlated with pedestrian accident rates and vehicular flow, with the relationships being of the following form:

Pedestrian Crossing Volumes

$P_c V^2 \propto$ accident rates

where P_c = pedestrian crossing /hour/100m of road

V = traffic volume (vehicle/hour)

Pedestrian Density

$P_d V^2 \propto$ accident rates

where P_d = pedestrian density on both footpaths/ 100m of road

V = traffic volume (vehicle/hour)

The United Kingdom Department of the Environment has stated that a case for a pedestrian crossing facility exists when the average value of the product $P_c V^2$ exceeds 1×10^8 during the four "peak" hours of the day (United Kingdom Department of the Environment, 1973). With a P_c value of 200 pedestrians/hour/100m, this yields an acceptable traffic volume of 700 vehicles/hour. This may be compared with the Australian standards in which a $P_c V^2$ product value of 9×10^4 is recommended.

CHAPTER 6b

ROADSIDE ENVIRONMENT

PART 6b - ROADSIDE ENVIRONMENT

1.0 Introduction

1.4 Factors to be considered

1.4.1 Ecologically sustainable development

In order to lessen the environmental impact of the arterial road network, FRA has adopted the Codes of Environmental Practice for Road Planning, Design, Construction and Maintenance. FRA is also subject to the Environmental Management Act, and the Rivers and Streams Act.

This Codes of Practice and Acts inform FRA activities when developing and maintaining the road network, through effectively managing environmental issues through project planning and delivery.

Integrating roads with existing infrastructure, and addressing the needs of drivers, pedestrians, cyclists and public transport users are key elements of a well-planned and functional environment.

2.0 Environmental Aspects

2.1 Stormwater Run-off

Drainage systems for arterial roads are designed to remove water quickly, in order to provide for the safety of traffic, to preserve the pavement strength and to prevent damage. However, some residential streets may be designed to act as drainage channels for storms greater than the design ARI. Road drainage includes removal of water entering the pavement from the surface or through the soil, by provision of a system of subsurface drains.

FRA requires water quality, erosion control, and water sensitive road design for operational and maintenance stages of the road network as well as construction site management.

Best practice is the required minimum standard, and where available best practice guides and design tools have been referenced.

2.2 Fauna and Livestock Management

Road projects are designed to have minimal impact on fauna-rich areas, such as wildlife corridors. Wildlife corridors are often located along creek lines intersecting highways or within the remnant indigenous vegetation along the road reserve. FRA aims to protect fauna movement where possible.

V2.2.4 Livestock Crossings

Crossings shall provide an absolute minimum height of 3.0m with an absolute minimum width of 3.5m at its narrowest point to allow for vehicle access and driver and passenger entrance/exit from the vehicle. Minimum width requirements can be equally applied to other types of livestock crossings e.g. fenced crossings under bridges.

Where emergency vehicles or farm machinery are required to access the livestock crossing, consideration shall be given to adopting a larger cross section such as 4m high and 4m wide (minimum). Emergency Services and adjacent farmers shall be consulted during determination of appropriate cross section for specific sites.

2.3 Noise Control

2.3.1 General

Where a new arterial road that does not have direct property access is constructed, or where an existing road is widened by two or more lanes AND buildings are removed, the project must be referred to FRA for noise attenuation consideration.

2.3.3 Noise barriers

It is generally preferable for noise mitigation to be achieved by the use of barriers and low noise pavement materials. However, where unreasonably high noise barriers would be required to achieve the noise requirements, it may be acceptable to supplement the barriers with acoustic architectural treatment to the affected buildings.

Aesthetic requirements
There is a need to consider community and local government acceptance of proposed noise barrier in relation to appearance, location and maximum height.

2.3.4 Barrier Types

For cross-sectional purposes, there are four main barrier variants:

(a) noise attenuation mound
(b) noise attenuation fence
(c) fence mounted on mound
(d) fence mounted on concrete barrier

Regardless of the barrier type chosen, consideration shall be given to the requirements for future maintenance, including access for the relevant types of machinery.

Mound Slopes
The foreslopes on noise attenuation mounds preferably shall be 3:1, which provides for a variety of landscape treatments including grassing or planting with shrubs. Backslopes may be as steep as 1.5:1 where right-of-way width is limited. Such steep slopes should be closely planted with shrubs to minimise maintenance.

If it is proposed to use 2:1 on foreslopes, the designer shall ensure that sight distance is not restricted by the planting. Shrubs can be assumed to be at least 1.5 metres high, unless otherwise advised by the landscape architect.

Berm Width
The minimum width of berm at the top of a noise attenuation mound with or without a fence is 2 metres. Where access is required for maintenance vehicles, a width of 3 metres is required in front of any noise attenuation fence and consideration needs to be given to how maintenance vehicles will safely access berms.

Noise Attenuation Fence

Due to ongoing durability problems with timber posts, the use of timber posts to support noise attenuation fences are prohibited for the construction of new noise attenuation fences.

Where noise attenuation fences are attached or constructed in close proximity to a concrete barrier or similar, designers shall consider the working width of that barrier and roll angle for taller vehicles that may strike the barrier. AGRD Part 6 provides further guidance regarding the design envelope for road safety barriers.

4.0 Roadside Infrastructure

4.1 Road Furniture

4.1.2 Signs, markings and delineation

Kilometre posts

Refer to FRA for the provision and spacing of posts.

4.1.3 Poles

Lighting poles

Refer to FRA Road Lighting Design Guide and Standards for the use of poles for combined support for road lighting and other uses such as traffic signals, road signs and telecommunications.

4.1.5 Supports for road signs

Refer to FRA' Manual of Signs and Markings for details on various types of sign supports and gantry requirements.

4.2 Road lighting

4.2.4 Warrants for lighting

FRA Road Lighting Design Guide and Standards for Current and Future Upgrades for lighting requirements and warrants.

4.2.5 Road lighting design

Refer FRA's Road Lighting Design Guide and Standards for further details.

4.4 Off-street Parking

4.4.6 Parking for Large Vehicles

Location of truck parking bays shall be considered during preparation of a strategic plan for rest areas, truck parking bays and wayside stops along rural highways. The layout design shall cater for truck fleet and demand (type and number) at a specific location and be developed in consultation with environmental and landscape practitioners.

In rolling or mountainous country, truck parking bays shall be located at the crest of a hill, so that the exit taper assists acceleration of trucks.

4.5 Utilities

During the design process, reference usually needs to be made to relevant service authorities for specific requirements regarding their assets. Some guidance regarding FRA' requirements is provided in FRA Standard Specification for Roadworks.

The location of future services and the required maintenance regime shall be taken into consideration during the development of a design.

Appendix A

Examples of post selection charts and sign support gantries

Refer to FRA's Manual of Signs and Marking regarding the types of supports used for all signs, including large signs.

CHAPTER 7

GEOTECHNICAL DESIGN AND INVESTIGATION

PART 7 - GEOTECHNICAL DESIGN AND INVESTIGATION

2.0 Overview of Geotechnical Investigations

2.1 Preliminary Investigation

2.1.1 Desktop Assessment

As part of the desktop study it is essential that previous land ownership and land use is established for all land within an alignment. This should date back as far as records are available and include the use of photos and land titles as a minimum.

The following sources of data should be reviewed during a desktop assessment:

- existing geotechnical investigation results held or archived by FRA;
- existing geotechnical investigation results held by other government departments, agencies (usually difficult to obtain) and from the private sector;
- pile driving records, earthworks testing results and other details held or archived by FRA;
- geological maps;
- topographical maps;
- mining records;
- FRA records of roadside geotechnical hazards;
- FRA records of contaminated sites;
- surface water and groundwater data;
- aerial photographs;
- seismicity data – the epicentre and magnitude of all previously recorded earthquakes in Fiji.
- historical records – access to historical records is best obtained by engaging the local historical society to undertake a search of all local records.
- records of roadworks undertaken;
- knowledge of the site held by local FRA staff.

2.1.3 Field Reconnaissance

The following should be investigated and recorded during field reconnaissance to allow preparation of the preliminary geotechnical report:

- overall land form and drainage pattern
- rock outcrop types, weathering and discontinuities
- exposed soil and rock types in stream beds and banks
- exposed soil types and rock types, weathering and discontinuities in existing cuttings, quarries and mine workings
- surface and subsurface erosion or potential for erosion
- slope instability
- expansive soils
- soft ground, silt, peat and existing fill

- swamps
- groundwater bores
- groundwater seeps and springs
- water levels in streams, including tidal movements
- dams
- potential acid sulphate soils and saline soils
- previous and current industrial sites, which may have contaminated soil and groundwater
- significant changes in vegetation which may indicate changes in geology or soil contamination
- proximity and condition of existing structures and nearby buildings
- existing batter slope angles and performance
- existing services type and location.

The following should be investigated and recorded during field reconnaissance to allow planning of the detailed geotechnical investigation:

- vehicle access points, clearances (horizontal and vertical) and load limits requirements for access tracks on soft ground
- water supply source and access arrangements
- traffic management requirements
- status of land acquisition of private property.

2.2 Approvals for Site Investigations

A Cultural Heritage Management Plan (CHMP) is required before any geotechnical investigation can be undertaken at all greenfield sites and some previously developed sites.

Trimming and removal of vegetation shall be avoided during geotechnical investigations. If vegetation trimming or removal is required, it should only be undertaken with FRA approval.

2.3 Detailed Geotechnical Investigation

The investigation of contaminated soil and groundwater is not discussed in the AGRD Part 7. The presence, quantity and quality of contaminated soil and groundwater shall be determined so that appropriate treatments complying with legislative requirements can be designed.

3.6 Sampling of Materials

3.6.2 Test Properties

Refer to Austroads Guide to Pavement Technology (AGPT) Part 4I: Earthworks Materials for a full description of most laboratory tests described in this section.

Refer to the FRA Supplement to the AGPT Part 4H: Test Methods for a list of FRA Test Methods for laboratory tests described in this section.

4.0 Design Elements

4.7 Sub Surface Drainage System

4.7.2 Pavement Drains

The location and configuration of sub-surface drainage systems is shown in Standard Drawings for Roadworks and AGRD Part 5: Drainage Design and Austroads Guide to Pavement Technology and (AGPT) Part 10: Subsurface Drainage.

5.0 Sustainable Design Practices

5.3 Minimisation of Erosion

Refer to Chapter 5 of this supplement for further information regarding erosion control.

5.6 Use of Non-standard or Recycled Materials

FRA encourages the use of non-standard or recycled materials during the construction and maintenance of the road network. FRA approval in accordance with Chapter 2 of this supplement shall be sought for the use of non standard or recycled materials.

CHAPTER 8

PROCESS AND DOCUMENTATION

PART 8 - PROCESS AND DOCUMENTATION

1.0 Introduction

1.2 International Standard

As noted in the Austroads Guide to Road Design (AGRD) Part 8: Process & Documentation, the Guide does not seek to prescribe the management systems required to undertake road design.

1.4 Terminology

FRA Glossary of Terms

Additional Information

Design Brief:
A document detailing the scope, content, and the design outputs of a project.

Design Review:
The planned and formally documented process carried out at appropriate stages of design where representatives of all functions and specialist advisers evaluate the total design for function, safety, constructability, project specific requirements, aesthetics and economy.

Distinct Work Package:
A design task or section of design that all design data, acceptance criteria has been obtained, and the extent of the design work can be clearly defined.

Concept Design:
A schematic drawing that may show the approximate location of the road alignment, and road configuration but does not necessarily specify any dimensions or geometry set out details. Concept design is used to develop a functional layout.

Functional Design:
Is a dimensioned drawing that shows the location of the road alignment, and complete road configuration and may include geometry set out details. Functional design is sufficiently detailed to enable detail design to proceed.

Project Leader:
Person responsible for managing the project resources and design activities.

Quality Plan:
A document setting out the specific quality practices, resources, project responsibilities and sequence of activities, and cross reference to the design brief.

Verification:
The formal documented processes carried out at appropriate stages of design by suitably qualified and competent persons to ensure that the design stage output has been accurately produced and meets the design stage input requirements.

2.0 Preparation for Design

2.3 Use of Design Control Aids

This Section includes a range of design control aids which may be used to assist in the preparation of a road design. These control aids are included in the appendices.

2.4 Client and Designer Interaction

Additional Information

V2.4.4 Project Leader's Responsibilities

The Project Leader shall determine the degree of checking and review required for a project based on the assessment of:
(a) the type of project
(b) project complexity
(c) knowledge and skills of the designer(s) involved and
(d) technology being utilised, taking into account the clients requirements.

The Project Leader shall ensure that the control activities are adequately resourced, and sufficient time has been allocated. The verification activities shall be included in the project design program.

Where a verification activity identifies a conflict between the client's requirements and good design standards, principles, road safety, constructability and/or cost the Project Leader shall resolve the conflict with the client.

2.5 Scope of the Design

V2.5.3.1 Guidance for Contract Review Additional Information

The checking aids provided in the appendices are in two parts:

Appendix VA.1: Contract Review Checklist – Client Relationship; and

Appendix VA.2: Contract Review Checklist – Technical Review.

The checklists have been structured into four columns covering:
(a) Reference: to provide a list of design references, or documentation that can be used to locate applicable standards and/or policy.
(b) Checklist Item: to provide a list of prompts that can be used as a reference during the contract review process.
(c) Check Date: to assist in the tracking of the contract review process and recording the depth of the review.
(d) Comments: to provide for recording the outcomes of checks or responses that require further follow up.

2.6 Design Development Inputs

2.6.5 Road Safety Audits

Additional Information

FRA maintains a policy to undertake road safety audits throughout the planning, design and construction stages of road and bridge projects in accordance with the Austroads Guide to Road Safety - Part 6: Road Safety Audit AGRS 06/09 (Austroads, 2009).

Risk assessments must be undertaken to determine the stage or stages at which road safety audits will be required. The reasons for selection of audit stages, or exemptions to the requirement for road safety audits shall be documented. Road safety audits shall be undertaken as follows:

Project Cost	Audit Stages Required
> $5.0m	Audits shall be undertaken at all stages
$0.15m to $5.0m	Risk assessments shall be undertaken to determine the stages of audit. In general, at a minimum, audits shall be undertaken at one of the design stages.
< $0.15m	Risk assessments shall be undertaken to determine the stages that the audits shall be carried out.

3.0 Design Development

3.2 Producing the Road Design

3.2.5 Stage(s) of Completion

V3.2.5.1 Designer's Responsibilities

<u>Additional Information</u>

A designer shall progressively check his/her own work during development of the design, recording clearly and concisely any design data used, calculations, analysis, considerations and assumption adopted. The design outputs shall be in accordance with the project requirements and presentation standards.

A designer on reaching a checking hold point or completion of the design task shall:

- Compile all design data, design outputs and other relevant details
- Sign and date the above design documentation
- Advise the Project Leader that a checking hold point has been reached, or that the design task has been completed.

Where a design discrepancy has been identified either through self checking or by another checker, the designer shall review the implications of an amendment on associated design components.

3.4 Design Control

3.4.3 Detailing the Design

Refer to FRA Standard Drawings for Roadworks where they exist for specific design elements. The Standard Drawings are available on FRA website.

3.7 Workplace Health and Safety/Safe Design

FRA, along with all agencies, consultants and contractors involved in the procurement and maintenance of assets, shall consider the Occupational Health and Safety implications of their designs.

3.9 Extending the Design Domain

Refer to Chapter 2 for further details on the application of EDD criteria.

4.0 Design Review, Verification and Validation

4.7 Dealing with Design Nonconformance/Departures

4.7.1 Control of Non-conforming Product in Design

Refer to Chapter 2 for further details on the application of EDD for non-conforming designs.

4.7.2 Design Departures/Exceptions

Additional Information

Should a design exception be identified during the development of a road design, it is incumbent upon the designer to notify the client of this non-conformance with the design brief.

Appropriate documentation regarding the design exception and reasons for acceptance is required. A risk assessment process similar to that discussed for Extended Design Domain shall be followed.

5.0 Design Audit Process

5.1 Overview

V5.1.1 Documentation

Additional Information

The completed audit checklists provide a summary of the depth of design process review.

Supportive evidence of the satisfactory completion and compliance with the control process needs to be maintained and would generally include:

- Minutes of meetings and discussions,
- Record of design variations,
- Record of design discrepancies,
- Correspondence (including e-mail and faxes) seeking clarification or requests for information.
- Program of works

- Checking documentation
- Design files, including package files.
- Corrective Action Requests.

APPENDIX A - REFERENCES

Austroads Documents - www.onlinepublications.austroads.com.au

Guide to Road Design - Part 1 : Introduction to Road Design (Austroads 2006)
Guide to Road Design - Part 2 : Design Considerations (Austroads 2006)
Guide to Road Design - Part 3 : Geometric Design (Austroads 2010)
Guide to Road Design - Part 4 : Intersections and Crossings – General
Guide to Road Design - Part 4A : Unsignalised and Signalised Intersections (Austroads 2009)
Guide to Road Design - Part 4B : Roundabouts (Austroads 2011)
Guide to Road Design - Part 4C : Interchanges (Austroads 2009)
Guide to Road Design - Part 5 : Drainage Design (Austroads 2010)
Guide to Road Design - Part 6 : Roadside Design, Safety and Barriers (Austroads 2009)
Guide to Road Design - Part 6A : Pedestrian and Cyclist Paths (Austroads 2009)
Guide to Road Design - Part 6B : Roadside Environment (Austroads 2009)
Guide to Road Design - Part 7 : Geotechnical Investigation and Design (Austroads 2008)
Guide to Road Design - Part 8 : Process and Documentation (Austroads 2009)

Guide to Traffic Management – Part 1 Introduction to Traffic Management
Guide to Traffic Management – Part 2 Traffic Theory
Guide to Traffic Management – Part 3 Traffic Studies and Analysis
Guide to Traffic Management – Part 4 Network Management
Guide to Traffic Management – Part 5 Road Management
Guide to Traffic Management – Part 6 Intersections, Interchanges and Crossings
Guide to Traffic Management – Part 7 Traffic Management in Activity Centres
Guide to Traffic Management – Part 8 Local Area Traffic Management
Guide to Traffic Management – Part 9 Traffic Operations
Guide to Traffic Management – Part 10 Traffic Control and Communication Devices
Guide to Traffic Management – Part 11 Parking
Guide to Traffic Management – Part 12 Traffic Impacts on Developments
Guide to Traffic Management – Part 13 Road Environment Safety

Austroads Guide to Road Transport Planning

Austroads Guide to Pavement Technology:
Part 1: Introduction to Pavement Technology
Part 2: Pavement Structural Design
Part 3: Pavement Surfacings
Part 4: Pavement Materials
Part 4A: Granular Base and Sub Base Materials
Part 4B: Asphalt
Part 4C: Materials for Concrete Road Pavements
Part 4D: Stabilised Materials
Part 4E: Recycled Materials
Part 4F: Bituminous Binders
Part 4G: Geotextiles and Geogrids
Part 4H: Test Methods
Part 4I: Earthworks Materials
Part 4J: Aggregate and Source Rock
Part 4K: Seals
Part 4L: Stabilising Binders

Part 5: Pavement Evaluation and Treatment Design
Part 6: Unsealed Pavements
Part 7: Pavement Maintenance
Part 8: Pavement Construction
Part 9: Pavement Work Practices
Part 10: Sub-Surface Drainage

FRA' Road Design Supplements –
www.FRA.vic.gov.au/Home/Moreinfoandservices/RoadManagementAndDesign/DesignStandardsManualsNotes

AASHTO Documents - www.transportation.org

Geometric Design of Highways and Streets
Roadside Design Guide
Highway Drainage Guidelines, 4th Edition
Guide for the Development of Bicycle Facilities, 4th Edition
Guide on Evaluation and Abatement of Traffic Noise, Single User Digital Publication
A Guide for Transportation Landscape and Environmental Design, 2nd Edition

Canadian Roads Design Guide – www.tac-atc.ca

IS/ISO 9001:2008 Quality management systems - Requirements

ISO 14001 - Environmental management standards

APPENDIX B – ACRONYMNS

AASHTO	-	American Association of State Highway and Transportation Officials
ADT	-	Average Daily Traffic
ARI	-	Average Recurrence Interval
ASD	-	Approach Sight Distance
Austroads	-	Association of Australia and New Zealand Transport and Traffic
Authorities		
BS	-	British Standards
CA	-	Concession Agreement
CAD	-	Computer Aided Design
CADD	-	Computer Aided Design and Drafting
CAR	-	Corrective Action Request
CBR	-	California Bearing Ratio
CMA	-	Catchment Management Authority
CSD	-	Crossing Sight Distance
FMS	-	Fiji Meteorological Service
EMC	-	Equilibrium Moisture Content
HRB	-	Highway Research Board
HRJ	-	Highway Research Journal
HRR	-	Highway Research Record
ISD	-	Intersection Sight Distance
ISO	-	International Standards Organisation
MOTSAM	-	Manual of Traffic Signs and Markings
NCR	-	Non Conformance Report
OSD	-	On Site Detection
PPP	-	Public Private Partnerships
PSD	-	Permeable Site Discharge
QA	-	Quality Assurance
QAM	-	Quality Assurance Manual
QMS	-	Quality Management System
RSP	-	Road Safety Platform
SSD	-	Stopping Sight Distance
TAS	-	Traffic Assessment Report
TRB	-	Transportation Research Board