2013

Federal Republic of Nigeria

Federal Ministry of Works

Highway Manual Part 1: Design

Volume II

Secondary Design Elements

2013

SECONDARY DESIGN ELEMENTS

FOREWORD

The vision statement of the Federal Ministry of Works is to elevate Nigerian roads to a standard where they become National economic and socio-political assets, contributing to the Nation's rapid growth and development, and to make Federal roads functional, safe, pleasurable, and an avenue for redeeming Nigerians' trust and confidence in Government. This vision statement is in tune with the Transformation Agenda of the President of the Federal Republic of Nigeria, His Excellency, Dr Goodluck Ebele Jonathan, GCFR. Based on the foregoing, our mission is to use the intellectual, management and material resources available to the Ministry to make Nigerian roads functional all the time. The principal goal of the Ministry is to drive the transformation agenda by improving road transport infrastructure for the overall socio-economic derivable benefits and development of our great country, Nigeria.

In exercising this mission and in discharging its responsibilities, the Ministry identified the need for updated and locally relevant standards for the planning, design, construction, maintenance and operation of our roads, in a sustainable manner. One of the main reference documents for this purpose is the Highway Manual, which previously included Part 1: Design and Part 2: Maintenance. Both current parts of the Highway Manual were first published in 1973 and 1980 respectively and have been subjected to partial updating at various times since then. The passage of time, development in technology, and a need to capture locally relevant experience and information, in the context of global best practices, means that a comprehensive update is now warranted.

The purpose of the Highway Manual is to establish the policy of the Government of the Federal Republic of Nigeria with regard to the development and operation of roads, at the Federal, State and Local Government levels, respectively. In line with this objective, the Manual aims to guide members of staff of the Ministry and engineering practitioners, with regard to standards and procedures that the Government deem acceptable; to direct practitioners to other reference documents of established practice where the scope of the Manual is exceeded; to provide a nationally recognized standard reference document; and to provide a ready source of good practice for the development and operation of roads in a cost effective and environmentally sustainable manner.

The major benefits to be gained in applying the content of the Highway Manual include harmonization of professional practice and ensuring uniform application of appropriate levels of safety, health, economy and sustainability, with due consideration to the objective conditions and needs of our country.

The Manual has been expanded to include an overarching Code of Procedure and a series of Volumes within each Part that cover the various aspects of development and operation of highways. By their very nature, the Manual will require periodic updating from time to time, arising from the dynamic nature of technological development and changes in the field of Highway Engineering.

The Ministry therefore welcomes comments and suggestions from concerned bodies, groups or individuals, on all aspects of the document during the course of its implementation and use. All feed back received will be carefully reviewed by professional experts with a view to possible incorporation of amendments in future editions.

Arc. Mike Oziegbe Onolememen, FNIA, FNIM.
Honourable Minister
Federal Ministry of Works,
Abuja, Nigeria
May, 2013

ACKNOWLEDGEMENTS

The Highway Manual has been updated by the Road Sector Development Team (RSDT), of the Federal Ministry of Works, with credit assistance from the World Bank's Federal Roads Development Project (FRDP). This update draws upon the original Manual, which was compiled between 1973 and 1980. The new Manual reflects recent developments in Road Design and Maintenance, in addition to latest research findings and updated references. Furthermore, it includes accepted practices that have been developed with the extensive effort of numerous organisations and people involved in the road sector. The assistance of all who have contributed is hereby gratefully acknowledged. Special acknowledgement is due to the following persons, who have been particularly involved and provided specific input that has been incorporated into the Manual:

Review Project Management Team:

Person	**Organisation**
Engr. Ishaq D. Mohammed	Director Highways/Unit Manager, RSDT
Engr. Chike Ngwuocha	Highway Engineer, RSDT

Peer Review Group:

Person	**Organisation**
Engr. B Giwa	Independent Consultant
Prof. Y. A Jimoh	University of Ilorin
Prof. K. J. Osinubi	Ahmadu Bello University, Zaria
Prof. L. Oyebande	University of Lagos
Dr. D. O. A. Osula	University of Benin

Thanks are also due to the following organisations that made staff available for the Stakeholder Workshop and other meetings, in addition to making direct contributions through comments and advice:

Public Organisations	**Private Organisations**
Federal Ministry of Works – Highway Departments	AIM Consultants
Federal Ministry of Environment	Aurecon Nigeria Ltd
Federal Roads Maintenance Agency (FERMA)	Axion Consult Engineering Resources Ltd
Federal Capital Development Authority	Ben Mose & Partners
Federal Road Safety Corps	Dantata & Sawoe Construction (Nigeria) Ltd
Nigeria Meteorological Agency	Enerco Ltd
Nigerian Geological Survey Agency	Etteh Aro & Partners
Nigeria Police Force (Traffic Division)	FA Consulting Services Ltd
Nigeria Hydrological Services Agency	Intecon Partnership Ltd
Nigerian Meteorological Agency	Julius Berger Nigeria Plc
Nigerian Society of Engineers	Keeman Ltd
Nigerian Institute of Civil Engineers	Multiple Development Services Ltd
Council for the Regulation of Engineering in Nigeria	Mansion Consulting Ltd
	Property Mart Ltd
	RCC Ltd
	Sanol Engineering Consultants Ltd
	Setraco Nigeria Ltd
	Siraj International Ltd
	Yolas Consultants Ltd

This update of the Highway Manual was compiled by the Road Sector Development Team of the Federal Ministry of Works with the assistance of the consultants Royal HaskoningDHV.

Table of Contents

List of Tables

List of Figures

1 General Information

1.1 Description of the Manual

The Highway Manual aims to guide members of staff of the Ministry and engineering practitioners, with regard to standards and procedures that the Government deems acceptable for the planning, design, construction, maintenance, operation and management of roads. The Manual directs practitioners to other reference documents of established practice where the scope of the Manual is exceeded; provides a nationally recognized standard reference document; and provides a ready source of good practice for the development and operation of roads in a cost effective and environmentally sustainable manner.

1.2 Arrangement of the Manual

The Highway Manual comprises a Code of Procedure and two Parts, each of which has been divided up into separate volumes, in the manner shown in Figure 1.

1.3 Overview of this Volume

1.3.1 General

Volume II of the Highway Manual Part 1: Design deals with the Design of Secondary Elements of highways, including aspects such as road safety, lighting of highways, fencing, guardrails, road side development and special structures which includes railway crossings, pedestrian facilities and petrol filling stations.

1.3.2 Purpose

The purpose of this volume is to give the engineers responsible for design of roads, guidance and recommendations on the secondary aspects of design that need to be provided and/or taken into account, to provide a safe and operational effective road.

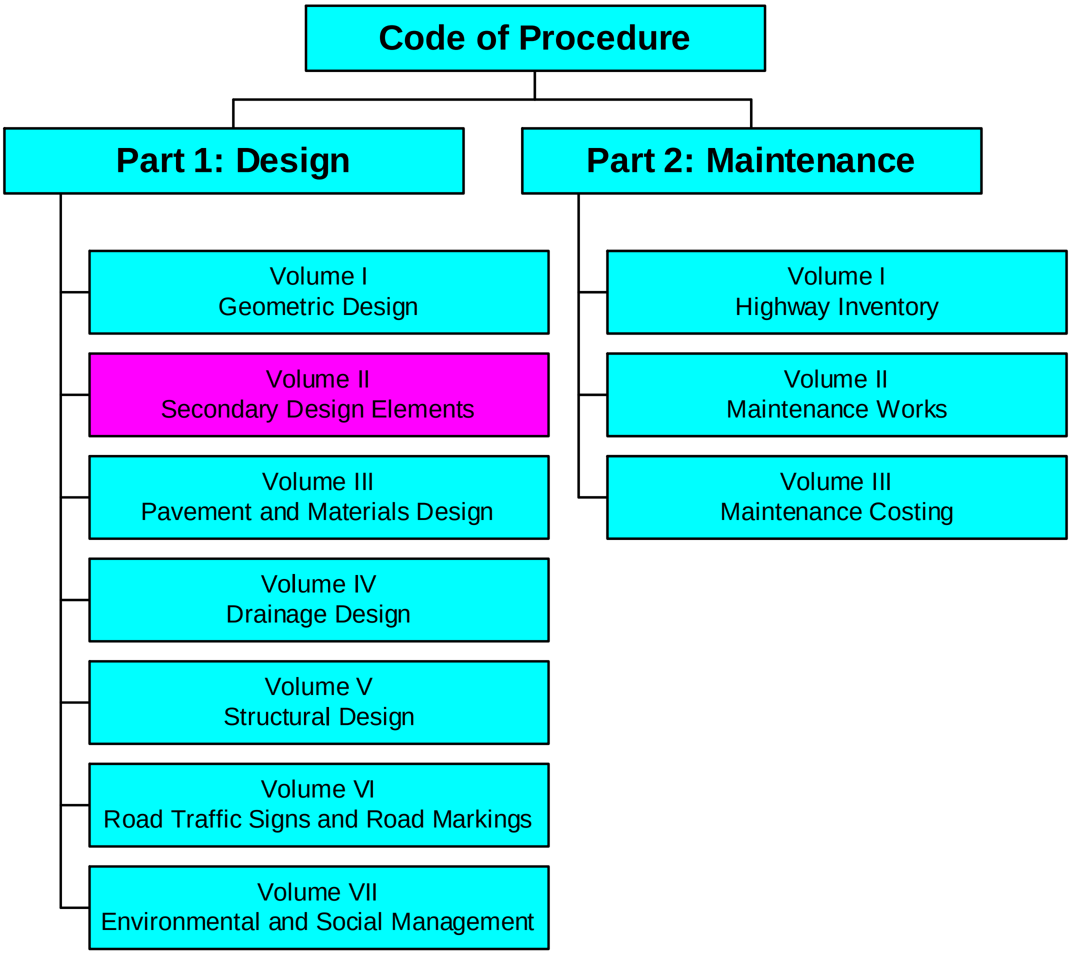


Figure 1: Arrangement of the Highway Manual showing context of Volume II

1.3.3 Scope of this volume

The contents of the volume are partly guidelines and recommendations and partly standards which as a general rule should be adhered to. The information, guidance and references contained in this volume are not intended as a substitute for sound engineering judgment. It should be recognized that situations may be encountered during the design of highways that are beyond the scope of this volume. The section on references lists numerous sources of comprehensive information that should be used as references to supplement the information contained in this volume. In some instances, special conditions may require the use of other references and/or standards and the use of these standards can only be sanctioned by the Director of Highway Design of the Federal Ministry of Works.

1.3.4 Terminologies

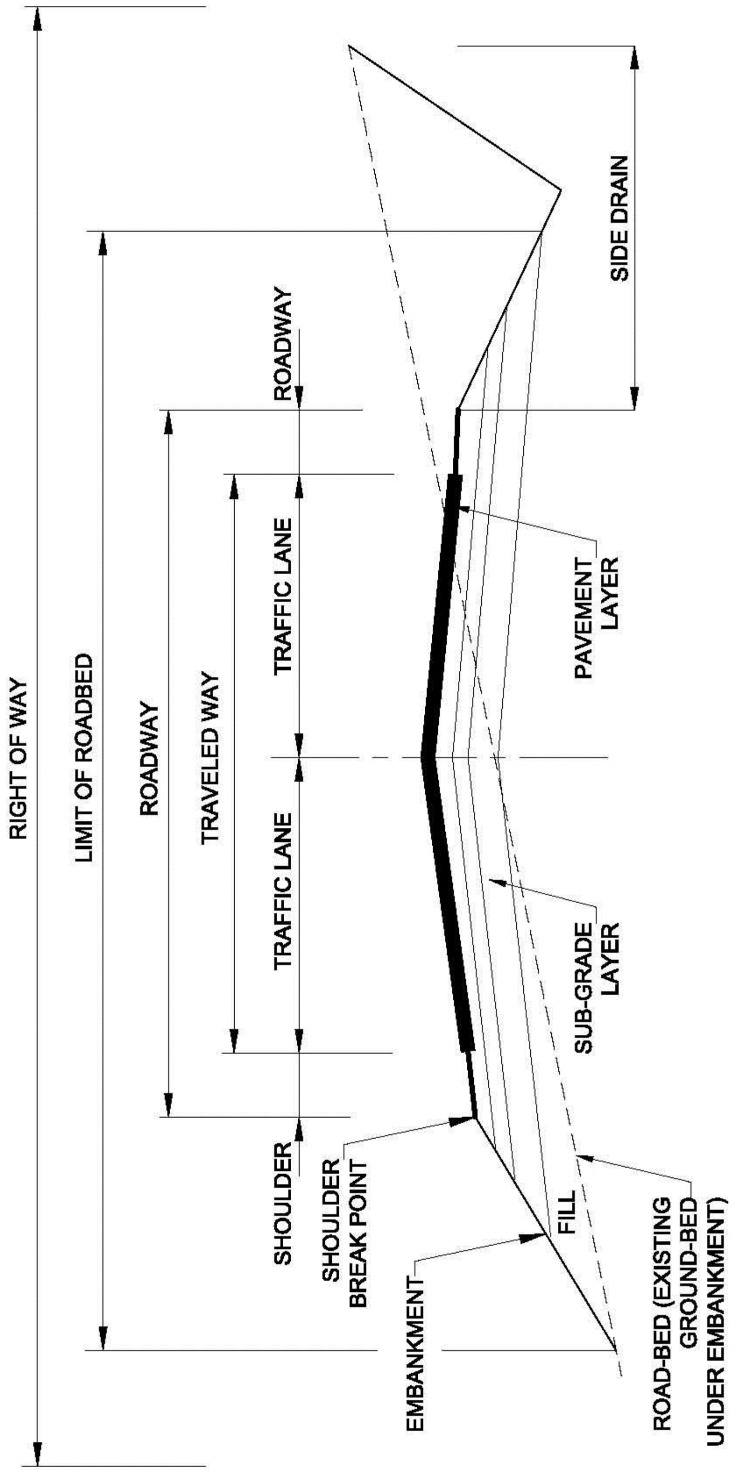


Figure 2: Road Cross Section Elements

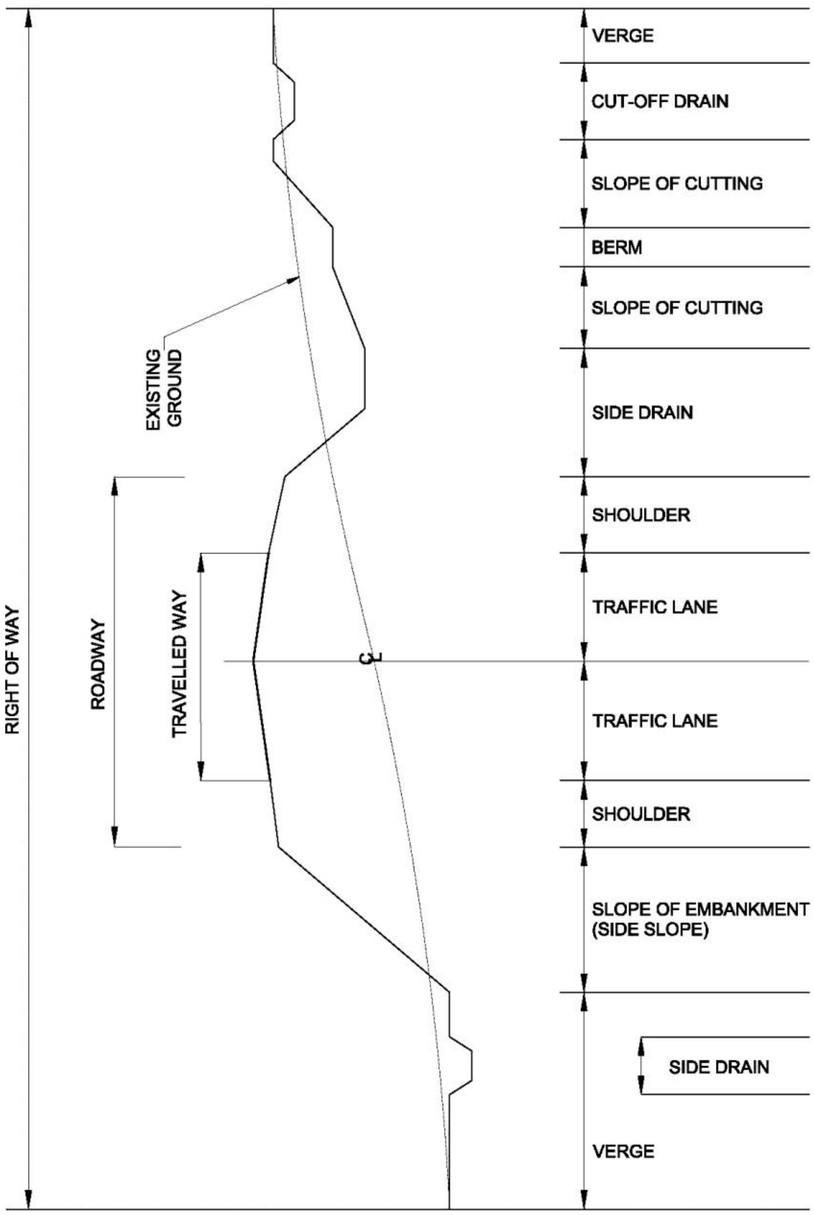


Figure 3: Cross Section Terminology

2 Road Safety Auditing

2.1 Introduction

Roads are planned, designed, constructed and maintained with a large number of criteria in mind; including facilitating efficient transportation, user convenience, fuel economy, minimising construction and operating costs, minimising negative environmental and social impacts and maximising positive socio-economic benefits. Safety is one of the criteria, but is often implicitly assumed to be achieved by adhering to prescribed standards of road alignment and layout. Although these standards are derived with safety in mind, experience shows that compromises are often made in the design process, resulting in features which have been the cause of road accidents and fatalities.

Road Authorities in several countries have developed road safety audit procedures as a proactive measure to help prevent road accidents which result from inadequate designs. These procedures are to be applied at different stages in the various stages of a road project's development and implementation. These stages are listed in the following subsection.

The choice of safety criteria is important in the design process and it is essential for the Design Engineer to have a good understanding of their origin. A design prepared by a Design Engineer who has a good understanding, not only of the criteria, but also of their background and foundation, and who has applied the community values, will probably create the desired level of service, safety and economy.

For many elements of a road, a range of dimensions is possible and the Design Engineer has the responsibility of choosing the appropriate value for a particular application. A Design Engineer with economy uppermost in mind may be tempted to apply the minimum value, reasoning that, if the value is within the accepted range, the design is "satisfactory". Making such a choice may reduce margins of safety, which can create dangerous situations in certain circumstances.

The Design Engineer might find it appropriate to reduce values of design criteria, which is not necessarily a poor decision. The consequences need to be thoroughly understood, particularly as they impact on safety, costs and benefits. Ameliorating measures, such as the use of traffic control devices, may need to be considered in the design process. If a design involves compromise, it may be more appropriate to vary several elements by a small amount, than to alter one element excessively.

The design of a road is a trade-off between standards and the cost of providing them. The cost to society of road accidents and deaths often exceeds the total annual expenditure on roads. Reducing initial construction costs of road projects can result in increased life cycle costs if the cost of accidents, injuries and deaths is included in the economic calculations. It is the design engineer's responsibility to inform the client of the consequences of inadequate expenditure on safety.

It is often difficult and expensive, to correct safety defects at a later stage. For this reason, designing for safety should occur during the design process, and be provided for in preparation of construction drawings.

Road safety audits should be carried out by an independent person who is not part of the design team.

The details presented in this chapter and in the Annex presenting the Road Safety Audit checklists, are compiled from the most recently updated documents available and are a representation of an agglomeration of international practice relating to this topic, compiled by the Road Transport Management Corporation of South Africa.[i]

2.2 Definition of a Road Safety Audit

A Road Safety Audit is a formal examination of a proposed or existing road in which an independent, qualified examination team or person reports on the accident potential and safety problems of the road, and suggests measures to mitigate these problems.

Road Safety Audits shall be conducted at six stages within the road planning, development, management and operation phases as follows:

- Stage 1 Road Safety Audit: Feasibility
- Stage 2 Road Safety Audit: Draft (Preliminary) Design
- Stage 3 Road Safety Audit: Detailed Design
- Stage 4 Road Safety Audit: Construction

- Stage 5 Road Safety Audit: Pre-opening
- Road Safety Audit or Appraisal of an Existing Road Facility

Checklists of items to be checked at each Stage Audit are provided in the Annex in Section 11.

2.3 Objectives of a Road Safety Audit

The objectives of a Road Safety Audit vary in emphasis at each stage in the development of a road, but generally include the following:

- To identify and report on the accident potential and safety problems of a road during the planning, design, construction or operating stages.
- To ensure that road elements with an accident potential are removed or that measures are implemented to reduce the risk of accident.
- To minimise the severity and risk of road traffic accidents that may be influenced by the road facility or adjacent environment.
- To minimise the need for remedial measures after the opening of a new road.
- To reduce the full life-cycle cost of a road project by reducing its accident cost.
- To create and maintain an awareness of safe design practice during all the stages of a road project.

2.4 Key Requirements for Road Safety Audits

The following aspects are key requirements for successful Road Safety Audits:

- Adequate time and information to conduct the Road Safety Audit.
- Commitment from the Road Authority.
- A recognised and agreed Road Safety Audit process.

- An independent and properly trained road safety audit team or auditor.
- A checklist appropriate for the stages at which the road project is audited as shown in Section 11.
- Evaluation and monitoring of the Road Safety Audit Process.

Adequate time should be provided during the process to allow for:

- The scrutiny and evaluation of safety related aspects of all plans, drawings and related project documents.
- The collection of any additional information required to carry out the Road Safety Audit.
- The preparation of a formal Road Safety Audit Report.

2.5 Conducting Road Safety Audits

The greatest potential to improve road safety is in the planning and design stages in the pre-construction phase of a project, when the design of a project can be positively influenced to improve the road safety characteristics of the road. Pre-construction phase audits can be conducted on any proposal that is likely to influence the interactions between road users, or between road users and their physical environment.

During the planning and design process, road safety audits are required at two stages; at feasibility, after preliminary design and again after detailed design, prior to construction drawings being issued for implementation.

Check lists for conducting these three road safety audits are included in the Annex in Section 11.

2.5.1 Stage 1 Road Safety Audit: Feasibility

The Feasibility Stage Road Safety Audit is conducted as soon as the feasibility of a road project is considered and has the following purposes:

- To identify the potential safety problems that can influence the:
  - Project scope
  - Choice of route, layout and/or treatment
  - Design standard selection
  - Impact on the adjacent road network
  - Access Control: Provision of accesses/ intersections/ interchanges
  - Continuity of routes
- To consider the design and operating speeds;
- To assess the relative safety performance of various alternatives for the road project.

2.5.2 Stage 2 Road Safety Audit: Draft (Preliminary) Design

The Preliminary Design Road Safety Audit is done after completion of a draft design. If alternative schemes have been developed, each scheme should be audited.

A Preliminary Design Stage Road Safety Audit has the following objectives:

- To address the design standards utilised for the draft design
- To consider, among others, the following:
  - Alignment (horizontal, vertical)
  - Sight distances
  - Layout of intersections and configuration of interchanges
  - Widths: Lanes and shoulders

  - Cross-section and super elevation of pavement
  - Location of accesses
  - Provision for different road user groups: Pedestrians, Cyclists, Heavy vehicles, etc
- To evaluate whether any deviation from guidelines and design standards would impact safety negatively
- To determine how possible staged implementation of the project could influence road safety- if staging is proposed then the safety of each stage should be considered, as well as the transition from one stage to the next
- To evaluate the possible departures from standards and the effect thereof from a safety perspective;
- To evaluate that all road user groups have been considered, such as:
  - Can vehicles turn safely?
  - Can road users see each other?
  - Can road users see traffic control devices?
  - Is cross-section and alignment appropriate?
  - Is property access safely catered for?
- To evaluate intersection layouts for possible conflict points
- To alert Design Engineers to areas where attention on road safety aspects will be needed during the detail design stage
- To evaluate safety at the connections with existing roads, e.g.:
  - Consistency
  - Vulnerability of fixed objects, etc

In a Preliminary Design stage audit, the road safety audit team shall visit the site of the proposed project, taking special cognisance of the following:

- Locations that involve permanent changes to the existing road layout or features

- Transition areas between existing roads and the proposed projects.

At this stage of the design process, fundamental decisions regarding route choice, the overall design and layout of the project have already been decided. The audit team may still suggest physical changes to horizontal or vertical alignment, provision of a median, lane and shoulder width, provision of cycle lanes or sidewalks or channelization. Accesses provided should be reviewed for upstream and downstream effects, possible conflicting movements, sight distance and the possible consolidation of access points. Any such recommendations should be based on the consideration of safety issues only and should be supported by justifiable background reasoning, which need not necessarily be included in the road safety audit report.

The ability of the design to safely accommodate future widening, expansion or extension should also be taken into account. Specific attention needs to be given to assess the safety of different usage scenarios.

2.5.3 Stage 3 Road Safety Audit: Detailed Design

The Detailed Design Road Safety Audit normally takes place after completion of the detailed design, but before the contract documents are prepared. This stage is the last opportunity to influence the design before construction commences and is a review of those drawings that are put forward and on which the project will be constructed. This audit is very much focused on aspects of detail of the road layout, traffic arrangements and information transfer to the proposed road user groups. It is also important that any issues that have not been satisfactorily resolved from earlier audits be reiterated at this point. It may well happen that the proposed remedial measures for such an outstanding issue may be different in this stage than an earlier stage, as the flexibility to influence the design is less.

A Detailed Design Road Safety Audit has the following objectives:

- To consider, among others, the following:
  - Any changes since the Preliminary Design Audit

- Road traffic signs and markings
- Road lighting
- Intersection detail
- Roadside hazard management issues (clear zones, traffic barriers, fixed objects etc.)
- Needs and requirements for Special Road Users (pedestrians, cyclists, individuals with disabilities, heavy vehicles, buses etc.)
- Traffic management and control drawings for the proposed accommodation of traffic during construction
- Drainage
- Landscaping
- Cross-section and side-slopes, etc.

- To review the findings of the Preliminary Design Audit and the implementation of mitigating measures
- To identify anything missed in the previous audit, and confirm the mitigating measures that may have been implemented as a result of earlier findings
- To utilise the last opportunity of influencing safety, prior to the construction of the project
- To evaluate the possible departures from standards and the effect thereof from a safety perspective
- To review the safety of typical details to be used on the project
- To evaluate the signage, markings and landscape plans
- To evaluate that all road user groups have been considered such as:
  - Can vehicles turn safely?
  - Can road users see each other?

  - Can road users see traffic control devices?
  - Is cross-section and alignment appropriate?
  - Are fixed hazards located within the relevant clear zone?
- To review the interaction of the detailed elements
- To evaluate safety at the connections with existing roads, especially consistency

In the detail design stage audit, the road safety audit team shall visit the site of the proposed project, taking special cognisance of the following:

- Locations that involve permanent changes to the existing road layout or features
- Transition areas between existing roads and the proposed projects

At this stage the drawings should be completed to such a point that they could be used in the preparation of contract documentation. If the audit team are concerned about a possible lack of sufficient details, the audit team may request such additional details from the client or project manager, to allow the audit to be completed without possible conditional findings. If the project will be implemented in separate stages, each stage should be considered, as well as the transition between stages. This is specifically also applicable for the proposed traffic management for the accommodation of traffic during construction.

2.5.4 Stage 4 Road Safety Audit: Construction

The Construction Stage Road Safety Audit is undertaken to review the traffic management proposed by the Contractor. It is distinguished from the Stage five Road Safety Audit in that is concerned with the temporary measures that are used to protect safety while the construction operations are in progress. The fact that the Contractor is required to have his own Safety Management Plan, and that this is monitored by the Engineer, must be taken into account. The purposes of this Audit are to assess:

- Appropriateness of the proposed traffic management scheme, especially conditions in transition areas
- Adequacy of advance warning
- Proposed and actual speed limits
- Conflicts between permanent and temporary features
- Any aspects of the layout that could be misread by road users or aspects that violate driver expectancy
- Likelihood of mud or dust obscuring devices
- Appropriateness of vehicle restraint systems/ barriers and the correct installation and the safety of the terminals
- Adequate provision for pedestrians and public transport vehicles like minibus taxis
- Conflict points between site traffic and the general public
- The effect of congestion during peak periods
- The effect of an incident within the detour/ deviation areas

The Stage four Road Safety Audit Report must be provided to the Engineer, with a copy to the Resident Engineer.

2.5.5 Stage 5 Road Safety Audit: Pre-opening

The Pre-opening Road Safety Audit should be conducted before the opening of a road scheme to traffic, but not before substantial completion of the project; enabling the audit team to review conditions as it they would be experienced by different road user groups. The purposes of this Stage Audit are to assess that:

- Sufficient provision has been made for the different road users of the road project, in accordance with the design
- There is adequate protection from roadside hazards
- Variations between actual construction and detail design have not had a negative influence on road safety
- Road signs and markings, lighting and other night-time related issues are adequately installed and operational
- All issues listed in the Stages one, two and three Road Safety Audits have been properly addressed, or, if the Stage five Road Safety Audit is the first

audit of the road project, to assess all the matters that would have been assessed in those Stage Audits.

The potential for making significant changes to the road safety situation onsite during a Preopening stage audit is rather limited, and the audit team may have to accept that the mitigating measures that may be recommended at this stage would similarly be limited in scope. The Stage five Road Safety Audit Report should be provided to the Engineer and to the Road Authority.

2.5.6 Road Safety Audit or Appraisal of an Existing Road

The Road Safety Audit of existing facilities provides a mechanism whereby roads constructed previously and not subjected to the Road Safety Auditing processes in the planning and design stages of their development, may be assessed. Obviously priority for this stage of auditing should be placed on roads where safety records indicate problems, but this process can also be applied pro-actively without the need to have accident data available.

The Road Safety Audit or Appraisal of existing facilities is a systematic examination of an existing road location, in which an independent and qualified team reviews on-site conditions and historical evidence to identify existing or potential road safety problems, and suggest measures to mitigate those problems.

The objectives of the Road Safety Audits on existing roads are as follows:

- To ensure compatibility between the safety features of a road and the functional classification of the road
- To identify any feature that can, with time, create a safety problem – for example vegetation blocking a sign
- To identify all features in the road environment that pose a safety hazard to any road users

The report on the Road Safety Audit of any existing road shall be submitted to Road Authority responsible for that road.

2.6 Road Safety Audit Reports

Road Safety Audit reports shall be prepared at each stage and shall include the following:

- A brief description of the audited project
- Identification of the audit stage and the team members, as well as the names and affiliation of other contributors to the audit
- Details of who was present at the site visit/s, when it was undertaken and what the conditions were on the day of the visit (weather, traffic, etc.)
- The specific road safety problems identified, supported with the background reasoning, stating:
    - The location of the problem
    - The nature of the problem
    - The type of accident that is likely to occur as a result of the problem
- Recommendations for action to mitigate or remove the problems, taking cognisance that:
    - The recommended remedial measure shall be appropriate and viable for that particular stage of the audit
    - Recommendations should be proportionate to the scale of the identified problem
    - Recommendations worded as "to consider...", "to study....", "to monitor...", "to investigate possible treatments and implement the most appropriate...", etc. should be avoided
    - Recommendations shall not be motivated for implementation in a way that could be construed as the audit team trying to convince the client to take a specific action.
- An A3 or A4 location map, marked up and referenced to the problems and, where available, photographs of the problems identified

- A statement, signed by the audit team leader in the recommended format
- A list of the documents and drawings considered for the audit

The Audit Team shall send a draft report directly to the client representative. The Audit Team Leader shall discuss the draft report with the client representative, prior to formal submission. The purpose of this discussion is solely to ensure that the findings and recommendations are within the scope of the audit, as defined in the audit brief. The client representative shall refrain from requesting amendments to the findings or the recommendations. Once the Road Safety Audit Report is issued, it is a FINAL report – the report cannot be amended, and the Client may not request amendments or ask team members to omit certain details or findings.

3 Illumination

3.1 General

The primary reason for installing highway lighting is to improve the safety of night time driving for the motorist. Statistics indicate that the night-time accident rate is higher than the daytime rate largely due to the restriction of the driver's vision to that illuminated by his vehicles headlights. The general warrants for providing highway lighting are based on considering the cost of installing and maintaining an illumination system balanced against the benefits derived from providing highway lighting.

3.2 Conditions warranting lighting on roadways

3.2.1 Freeways

Lighting on freeways can be either continuous or partial i.e. only provided at interchanges areas. Continuous lighting should be provided when:

- The freeway, for a length of two or more kilometres passes through a substantially developed suburban or urban area, in which one or more of the following conditions exist:
    - Local traffic operates on a complete street grid having some form of street lighting, portions of which are visible from the freeway.
    - The freeway passes through a series of developments such as residential, commercial, industrial and civic areas, colleges, parks, terminals, etc, which include roads, streets and parking areas, yards, etc, that are lighted.
    - Separate cross streets both with and without connecting ramps; occur with an average spacing of 0.8 km or less, some of which are lighted as part of the local street system.

- The freeway cross section elements such as median and verges are substantially reduced below desirable sections, used in relatively open country, because the high costs of right of way are due to proximity of existing land developments.

- The freeway has three or more successive interchanges located with an average spacing of 2.5 km or less and adjacent areas outside the right of way are substantially urban in character.
- The freeway has a design year ADT of 30 000 or more in or near a city.
- The freeway has a high ratio of night to day accidents.
- Governmental agencies find sufficient benefit in the form of convenience, safety, policing, community promotion, public relations, etc to pay an appreciable percentage of the cost of or wholly finance the installation, maintenance and operation of the lighting facilities.

When roadway lighting is only provided at interchanges on the freeway the following warrants are used:

- Complete interchange lighting on unlighted freeways is considered to be warranted at locations where existing substantial commercial or industrial development which is lighted during hours of darkness is located in the immediate vicinity of the interchange, or where the cross road approach legs are lighted for 800 metres or more on each side of the interchange.
- Complete interchange lighting is considered to be warranted where the total design year ADT ramp traffic entering and leaving the freeway within the interchange area exceeds 10 000 for urban conditions, 8 000 for suburban conditions or 5 000 for rural conditions.
- Complete interchange lighting is considered to be warranted where the design year ADT on the cross road exceeds 10 000 for urban conditions, 8 000 for suburban conditions or 5 000 for rural conditions.

- Partial interchange lighting is considered to be warranted where the total design year ADT ramp traffic entering and leaving the freeway within the interchange areas exceeds 5 000 for urban conditions, 3 000 for suburban conditions or 1 000 for rural conditions.

- Partial interchange lighting is considered to be warranted where the design year ADT on the freeway through traffic lanes exceeds 25 000 for urban conditions, 20 000 for suburban conditions or 10 000 for rural conditions.

- Complete or partial interchange lighting is considered to be warranted where the ratio of night to day accident experience is high (higher than the average for all unlighted interchanges similar in nature), and a study of conditions indicates that lighting may be expected to result in a significant reduction in the night accident rate.

- Complete or partial interchange lighting is considered to be warranted where governmental agencies find sufficient benefit in the form of convenience, safety, policing, community promotion, public relations, etc, to pay an appreciable percentage of the cost of or wholly finance the installation, maintenance, and operation of the lighting facilities.

- *Special Considerations* Where there is continuous freeway lighting; there should be complete interchange lighting. Lighting of cross road ramp terminals should be considered, regardless of traffic volumes, where the design requires the use of raised channelization or divisional islands. Complete interchange lighting shall mean the lighting of the freeway through traffic lanes within the interchange, the traffic lanes of all ramps, the acceleration and deceleration lanes, all ramp terminals and the cross road between the outermost ramp terminals. Partial interchange lighting shall mean lighting which consists of a luminaires located in the vicinity of some or all the ramp terminals. The usual practice is to light those general areas where the exit and entrance ramps connect with the through traffic lanes of the freeway, and generally those areas where the ramps intersect the crossroad and shows typical luminaire placement to provide partial lighting.

3.2.2 Streets and Highways other than Freeways

There is substantial evidence to support the lighting of streets and highways in urbanized areas. Grade intersections, turning movements, signalization, parking and the presence of pedestrian traffic are some of the elements which make the operating characteristics of these streets and highways, substantially different from those of freeways. Roadway lighting is generally accepted as an important contributor to safe and efficient traffic operation under these conditions. In addition, good street lighting is a deterrent for crime and vandalism.

It is not practical at this time to establish specific warrants for the installation of roadway lighting to satisfy all prevailing or anticipated conditions. In general, lighting is considered to be warranted for those locations where the respective governmental agencies concur that lighting will contribute substantially to the efficiency, safety, and comfort of vehicle and pedestrian traffic. Lighting should be provided for all major arterials to urbanized areas and for locations or sections of streets and highways where the ratio of night to day accident rates is high, and a study indicates that lighting may be expected to significantly reduce the night accident rate.

3.3 Level and Uniformity of Illumination

The level and uniformity of illumination along a highway depends on several controlling items, including the type and output in terms of lux of the light source, luminaire equipment, mounting height, mast arm length, spacing and arrangement of lighting masts. The same average level can be obtained by different installation arrangements, such as a few high-output light sources or a greater number of low output sources. A factor of concern is comparison of such alternate systems is the uniformity of light over the whole of the travelled way to be lighted.

Luminaires are available in a wide range of types and sizes. Lighting systems using high-efficiency and large-lumen lamps can be designed to provide a satisfactory level and uniformity of illumination, but care should be used in selecting equipment to ensure the desired lighting results with lowest compatible costs for installation, operation and maintenance. Higher luminaire mounting heights offer a number of advantages and should have full consideration when selecting design criteria. There is increasing use of mounting heights ranging from 12 to 30 metres, as evident in recent lighting projects. A discussion of the effects of higher luminaire mounting heights is given in paragraph 2.7.

Level of illumination and uniformity of illumination shall be as follows:

3.3.1 Freeways

Continuous freeway lighting should be designed to provide average maintained horizontal illumination over the travelled way of not less than 6.5 Lux - this value representing the condition when the light source is at its lowest output and the luminaire is in the dirtiest condition. For conditions where a maintenance factor of 0.6 would be applicable, this would call for an average initial illumination of 10.0 Lux.

When there is continuous freeway lighting or where an individual interchange is completely lighted, the illumination on the travelled way should be reasonably uniform, particularly on the freeway through traffic lanes. The uniformity of illumination is expressed as a ratio of the average level of illumination on the roadway, to the minimum level of illumination on the roadway. This ratio is called the uniformity ratio and should have a value in the range of 3:1 to 4:1. In some cases, better uniformity can be economically attained by using higher luminaire mounting heights.

3.3.2 Streets and Highways other than Freeways

Suggested average horizontal Lux of roadway illumination are contained in Table 3.

For the roadway classifications in Table 3, an average to minimum uniformity ratio of 3:1 to 4:1 is reasonable whenever an average illumination of 6.5 Lux or more is indicated. Where an average illumination of 6.5 Lux or more is indicated, a 6:1 ratio applies.

Table 1: Average Maintained Illumination for Streets and Highways other than Freeways

Roadway Classification	Average Maintained Horizontal Lux* Area Classification		
	City Centres	Intermediate	Outlying and Rural
Major**	21.6	15.1	10.8
Collector	13.0	9.7	6.5
Local or Minor	9.7	6.5	2.2***

* Average illumination on the travelled way or on the pavement area between kerb lines of kerbed roadways, with the illuminating source at its lowest output when the luminaire is in its dirtiest conditions.

** Includes expressways with partial control of access. Expressways with full control of access are treated for lighting purposes as freeways.

*** Includes residential streets.

In using the Lux values in Table 1: there may be conditions under which somewhat different illumination levels are desirable or necessary. For example, intersections with raised channelizing of divisional islands may require greater illumination than set out in the table. The lighting designer should use all available pertinent information in reaching a decision regarding the lighting level to be used for any specific street or highway.

3.4 Lighting Design

The 'design' of a highway lighting installation is a process of utilizing known photometric characteristics of a selected lamp and luminaire in a trial and adjust process of assumed luminaire locations on the roadway, for which is made a calculation of the average amount, or level, of illumination and distribution of light over the roadway area. For each lamp/luminaire combination there are manufacturer's photometric data which includes index charts showing the 'contours' of various horizontal Lux values over the area illuminated by that unit. Combinations of these with certain horizontal overlap can be used theoretically to determine luminaire positions to produce the desired average amount of light, over a given pavement area and distribution thereof.

The design method uses a formula to select spacing for the luminaires after which the uniformity ratio is checked. Adjustments of the spacing are then made to bring the uniformity ratio into the acceptable limits.

The following formula is used to determine the spacing:

$$\text{Spacing} = \frac{\text{Lamp Lumens x CU x ME}}{\text{Width of Roadway x Design Maintenance Light Level}}$$

Where:

Spacing = The distance parallel to the centreline of the roadway between successive luminaires.

Lamp Lumens = The amount of light from the lamp (not luminaire) which manufacturer data indicates is produced by the lamp at the end of its rated life. This figure shall be the amount of light produced for the position in which the lamp is maintained.

Coefficient of Utilization (CU) = The ratio of the amount of light produced by the luminaire (not lamp), that actually falls on the roadway, to the total amount of light produced by the luminaire. It is determined by applying utilization curves distributed by luminaire manufacturers for the light types to be used.

Maintenance Factor (MF) = Consideration of the amount of dirt on the luminaire, the reduced reflectance of the reflector, unusual operating temperatures when florescent lighting is being used and unusual deposit of hydrocarbons. Unless evidence is furnished substantiating a materially different maintenance factor, the factor shall be considered as 0.85.

Width of Illuminated Roadway = The travelled surface exclusive of shoulders. For roadways of varying width (tapers), the width shall be the mean roadway width of the representative roadway length.

Designed Maintained Light Level = As specified by the FMW policy on illumination consistent with the nature of the illumination projects.

The lamp lumens and coefficient utilization are from charts prepared by the manufacturer for each individual type of lamp luminaire combination.

The spacing derived from the formula should be adjusted for horizontal curvature and spacing reduction values for short radius curves.

The uniformity of illumination (uniformity ratio) is the ratio of the average amount of light on the roadway surface, to the amount of light striking the roadway surface at its darkest point.

A uniformity ratio of 3:1 means that the average Lux value on the roadway is three times the Lux value at the point of least illumination.

The point of least illumination is found by examining the light contour pattern from adjacent luminaires and**Error! Reference source not found.** shows locations here minimum illumination may occur for staggered spacing.

All light sources must be taken into consideration when finding the value of illumination at any point.

3.5 Location of Lighting Masts, Poles and Luminaires

Lighting poles normally should be located on the right in the direction of travel. Median location may be considered where the width is appropriate and rigid median barriers are used.

The inner face of the base of the lighting poles shall be located outside and clear of the usable right shoulder width.

Where there is a guardrail on the highway section, the poles shall be at the back of the rail. The pole inner face should be at least 600 to 900 mm outside the rail, and offset sufficiently to allow for guardrail deflection.

Where walls parallel to the roadway are located at the outer edge of shoulder, poles shall be located on top of or behind the walls. In some cases, poles may be eliminated by attaching mast arms to the walls.

When lighting poles are required to be located to the left of the direction of travel, the lighting poles should have the same minimum clearances and be subject to the same safety considerations as when placed on the right.

Lighting of short radius curves such as the inner loops of a cloverleaf interchange are most effective when the luminaires are located on the outside of the curve. For safety reasons, however, exposed lighting poles on these ramps should be placed on the inside (shorter radius) edge of curves. Under these conditions, closer spacing of luminaires will usually be necessary for satisfactory lighting uniformity. Where there is a guardrail on the outside of the curve, poles may be located behind the guardrail.

In the design of lighting systems it is important that the location of lighting equipment, signs and sign supporting structures be so co-ordinated that there will be as little interference as possible with either the sign legibility, or the roadway illumination. Lighting standards and luminaires should be so located that they do not interfere with the driver’s view of the sign legend and luminaire brightness does not seriously detract from sign legibility at night. A driver should not have to look directly into a bright source of light when reading a sign. Also overhead signs and supporting structures should be located that they do not cast distracting shadows on the roadway surface at night.

In all cases where poles are located within the clear roadside recover area, regardless of the distance from the travelled way, they should be designed to have a suitable impact attention feature. This safety feature may take any one of several forms which have been used by highway agencies, apparently with satisfactory results. These include poles equipped with (1) a cast aluminium transformer base, (2) a frangible base insert or adaptor normally cast aluminium, (3) a breakaway or progressive shear base or (4) a skip base. Poles made of light weight metals may have some value in reducing vehicle damage from secondary impact, particularly when the collision speed is relatively low and the falling pole makes secondary contact with the vehicle.

The luminaire should be positioned over the edge of the travelled way by using a mast arm of sufficient length from the position of the light standard.

3.6 Lighting for Bridges, Tunnels and Underpasses

3.6.1 Bridges

On a continuously lighted freeway, the lighting on bridges and overpasses should be to the same standard as the remainder of the freeway.

Lighting on long bridges with unlighted approaches is not justified except to provide illumination in case of accidents and for vehicles disabled or broken down, especially on bridges without full shoulders.

3.6.2 Tunnels

Continuous lighting is considered to be warranted in both long and short tunnels, during day and night periods.

Along a lighted highway, additional underpass lighting usually should be provided where the length is more than approximately23 metres. Where the length is less than approximately 23 metres, supplementary underpass lighting is needed only where there are pedestrians or other special conditions.

Underpass lighting is normally not needed along unlighted highways.

Table 2 is a summary of the design values for the development of tunnel and underpass lighting. Since the conditions which influence lighting requirements vary considerably, the need for judgment in applying these guide values is apparent. They are considered suitable for most situations, but should not be adopted universally without an evaluation of all factors which may dictate a need for modifications.

The lengths specified for underpasses, short tunnels, and long tunnels are intended for general classification purposes, and the lighting requirements as outlined should not be considered inflexible. For example, some short tunnels up to approximately 100 metres in length may not require daytime illumination if the facility is straight, level and has a high width to length ratio. This could apply to a tunnel with three or more lanes, as compared to a two lane tunnel. In such a case light penetration from each end, plus the silhouette effect of the opposite end brightness generally assures satisfactory daytime visibility.

Table 2: Average Maintained Illumination on Tunnel Walls

Lighting System	Average Maintained Lux on Walls*		
	Underpass (Less than 30m)	Short Tunnel (30 m to 150 m)	Long Tunnel (150 m and longer)
Day Entrance	None	323 - 646	323 – 646
Day Interior	None	323 – 646	53.8 – 107.6
Night	**	7.5 – 21.5	7.5 – 21.5

Lighting design values for tunnels herein are expressed as average maintained Lux on the tunnel walls. It is to be noted that this differs from that used elsewhere on highways, which is the average on the roadway. In tunnels where there is adequate wall brightness, there normally will be adequate roadway brightness.

Space in this manual does not permit a full analysis of the several factors which influence tunnel lighting. For more details refer to the references in Chapter 1.2.7

3.6.3 Underpasses

Underpasses less than about 23 metres in length usually can be adequately lighted at night from roadway luminaires outside the underpass. Lighting poles should be located near each portal, so that the maximum amount of light can be projected to light the roadway of the underpass. For underpasses longer than 23 metres, supplemental lighting may be required in which case the roadway illumination in the underpass should be no greater than two times the Lux on the approach and exit roadway. In urban areas, additional illumination may be required for pedestrians and for policing of underpasses. In these cases, the underpass lighting should be no greater than three times the lighting level on the roadway outside the underpass.

3.7 High Luminaire Mounting Heights

When considering mounting heights of 12 m or above, the use of 700 to 1 000 watt luminaires should be evaluated. Depending on highway geometrics and other related conditions, they may prove to be more efficient and economical than lower wattage luminaires. The greater lumen output of these lamps is advantageous for wide roadways in conjunction with relatively long spacing’s and high mountings.

The taller poles to provide luminaire mounting heights of 12 to 15 metres cost more than poles for the conventional 9 metre mounting height. The unit increases in cost is usually offset by the reduced number of poles required, and may not increase the cost of the complete lighting system.

For most highway lighting applications using 400 watt luminaires, it is practical to employ mounting heights up to about 12 metres. For the 700 and 1000 watt luminaires, mounting heights of 12 to 15 metres are advantageous and should receive full consideration in lighting designs.

Higher mounting heights up to 30 metres offer certain advantages and within reasonable limits, should be considered in design.

Among the advantages of higher mountings are improvement in the uniformity of illumination and reduction in relative glare effect from the luminaires, assuming there is no change in luminous intensity (Lux power) and vertical light distribution. Since luminous intensity and vertical light distribution characteristics vary with individual luminaires and the wattage of the light source used, reduction in glare can only be stated on a relative basis. There is also reason to believe that higher mounted luminaires will receive less accumulation of dirt from highway traffic. Some reduction in the frequency of luminaire cleaning and a saving in maintenance costs per lighting unit may be expected. Operating experience with recent installations having mounting heights up to 15 metres should provide information for judging the improvement in luminaire maintenance conditions. In many cases, higher luminaire mountings permit longer pole spacing’s, fewer poles and less luminaires. However, there are spacing limits which must not be exceeded if both the desired average Lux and uniformity of illumination are to be obtained. In some cases, it may be necessary to use higher wattage light sources and larger luminaires to ensure adequate illumination.

Against the above advantages of higher mountings there are certain disadvantages; For the same luminaire lamp and spacing, the average value of horizontal illumination is reduced as the mounting height is increased. Poles must be larger and generally are higher in price, but this is usually offset by the reduction in quantity made possible by longer spacing.

In design, both the average level of illumination and uniformity ratio are considered jointly since changes in mounting height affects both.

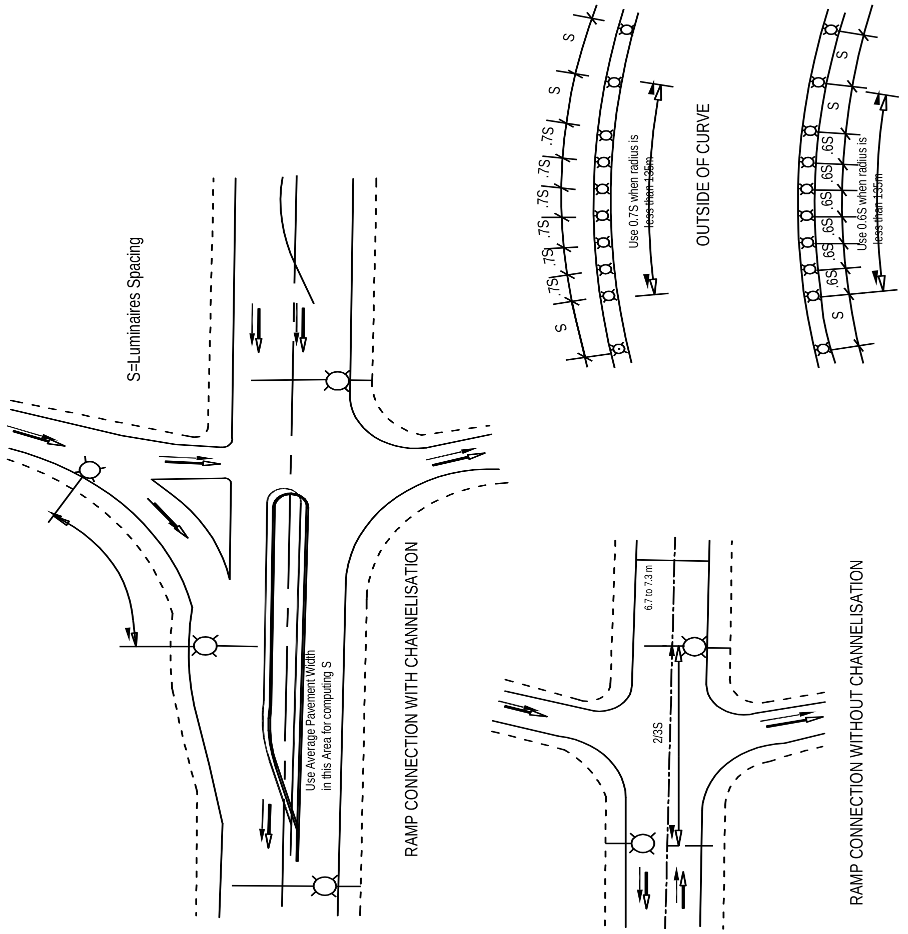


Figure 4: Light Spacing on Curves and Ramps

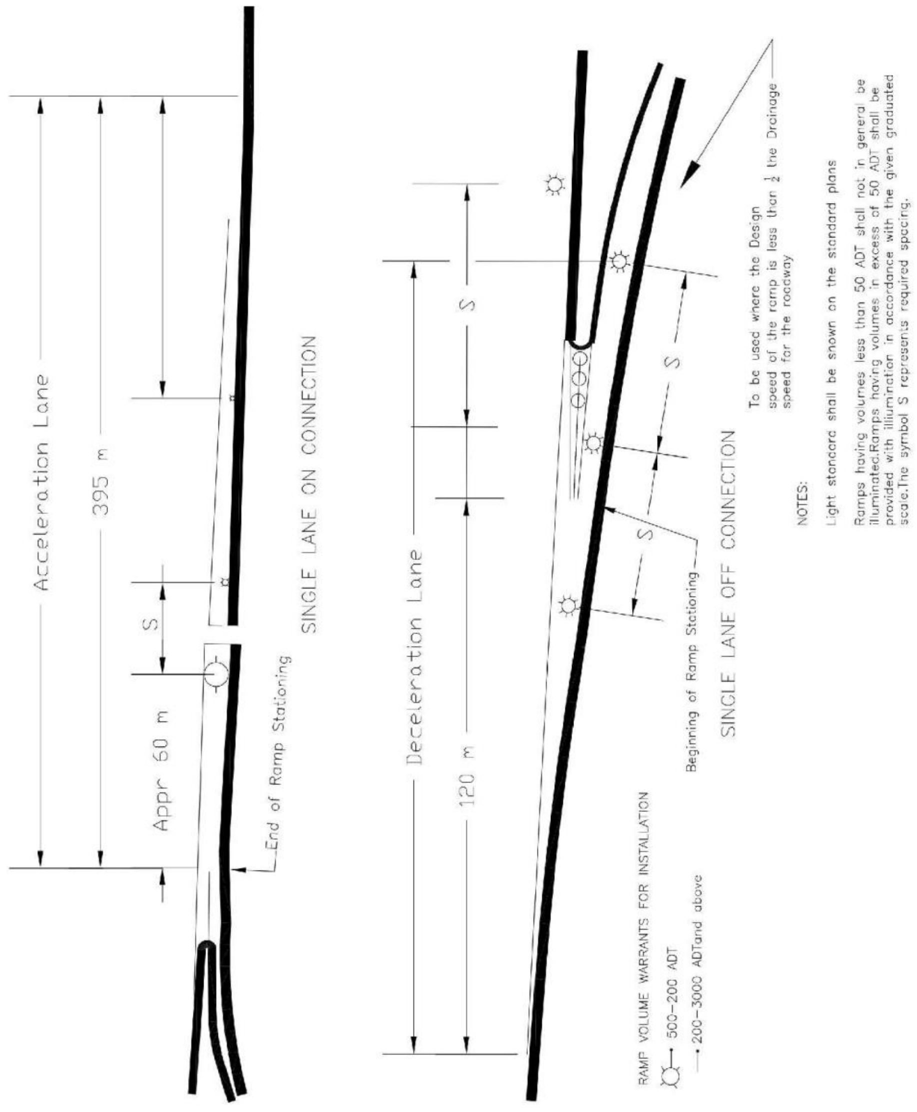
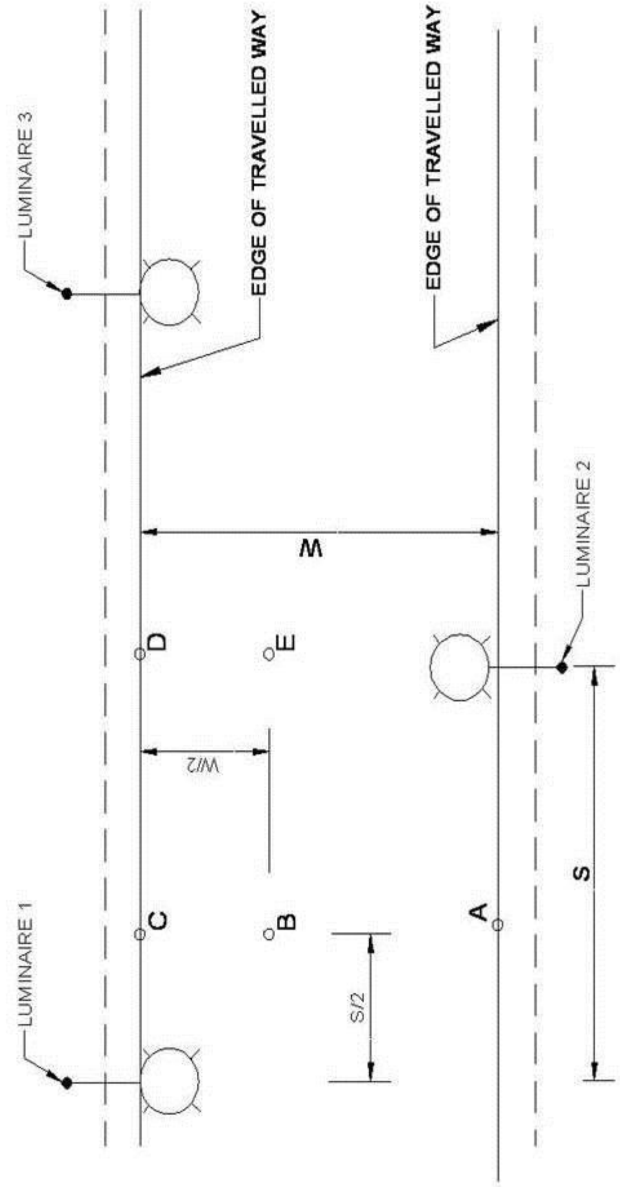


Figure 5: Light Spacing Freeway Exits and Entrances



S=LUMINAIRE SPACING
W=WIDTH OF ILLUMINATED ROADWAY

IN DETERMINING THE UNIFORMITY OF ILLUMINATION (UNIFORMITY RATIO) POINTS A,B,C,D AND E SHOULD BE CHECKED TO DETERMINE WHICH OF THE POINTS RECEIVES THE LOWEST LIGHT FROM ALL LIGHT SOURCES ISO-LUX CHARTS WITH LIGHT DISTRIBUTION CONTOURS,PROVIDED BY MANUFACTURERS,ARE USED TO DETERMINE THE AMOUNT OF LIGHT CONTRIBUTED TO EACH POINT BY EACH SOURCE OF LIGHT.

Figure 6: Points of Minimum Illumination Staggered

4 Fencing

4.1 General

There are two purposes for fencing on highways;1)On controlled access highways, fencing is provided as part of the highway construction to protect the travelled lanes from encroachment through adjacent properties.2)On non-controlled access highways, fencing is provided where needed to protect the highway facility from unsafe encroachment by pedestrians, livestock, etc, or as a replacement for existing fencing.

The following policy is in accordance with AASHTO's "An Informal Guide on Fencing Controlled Access Highways."

4.2 Design Criteria

a. *Controlled Access Highways*

On controlled access highways, continuous fencing is mandatory, unless it has been established that such fencing is not necessary for the effective preservation of access control. Fencing is required between frontage roads and highway lanes or ramps, unless there is a physical barrier serving the same purpose.

In rural areas on new alignment, fencing is not warranted for the outside line of a frontage road, unless the neighbouring property was enclosed previous to highway construction.

Installation of fencing at the following locations may be deferred until the need arises, unless there is a possibility of violation of access control:

- Areas where rugged topography or dense vegetation provides a natural barrier.
- Along rivers or other natural bodies of water.

- In brush country which is very sparsely settled.
- On long sections of undeveloped private or public lands not previously fenced.

b. Non-Controlled Access Highways

On non-controlled access highways, fencing will normally be provided only as a replacement of existing fencing. In most instances, the fence should be included in the right of way settlement. The fence should be constructed and permanently maintained by the neighbouring owner. Where fencing is essential to safe operation of the highway, it should be constructed and maintained by the FMW.

4.3 Ownership of Fencing

All fencing for access control should be owned by FMW, so that the FMW has complete control of the type of fence and is responsible for proper maintenance. If new property fencing is a replacement and specified in a right of way agreement but not needed for access control, as for example adjacent to a frontage road, such fencing should be the property of the adjacent landowner.

4.4 Time of Erection

In many cases the need for immediate fencing is obvious, as to enclose a pasture or hog yard, or to confine pedestrians leaving a sporting area. The proper type of fence should be provided before the highway is opened, and in such cases, the fence should be erected as soon as the right of way is cleared. The remainder of the fence may be erected at a later time.

In cases where there is an existing adequate fence, the erection of a fence by the FMW can be deferred to such time as required.

4.5 Types of Fence

The lowest cost type of fence suited to the specific purpose should be provided. Consideration should be given to the likely extent and type of maintenance work that will be required, as well as initial costs. Depending upon the specific purpose to be served, the following types of fencing generally apply, either separately or in combination:

- Multi-strand wire, barbed or smooth: for controlling livestock.
- Woven wire: for controlling small livestock and in residential areas for controlling small children and pets.
- Chain link, usually 1.20 to 1.80 metres high - for controlling pedestrians in developed areas, particularly those containing multiple dwelling units, industrial establishments, business districts, parks, sporting areas, schools or other institutional buildings.
- Fences 2.10m to 3.00 metres high - for limited special areas where there are exceptional hazards.
- Miscellaneous types of fences such as stones, rail, board screen, hedge, etc, as applicable in special cases only.

The purpose of fencing may change within a relatively short length of highway and as a consequence, frequent changes in the type of fence may be suggested. Where the fence is continuous, changes in type of fence at short intervals are undesirable. For an isolated section of fence, the minimum length is not of concern.

To decide on the type of material best suited to a particular purpose, consideration should be given to some of the characteristics of the fencing material other than its deterrent qualities. Chain link fencing for example may restrict sight distance, particularly on curves and along lines approximately parallel to the direction of the fence and close to it. Woven wire fence may also offer a restriction to view, but to a lesser degree than the chain link variety. A chain link fence is more of a trash and waste paper collector than other more open type fences and in some areas can result in soil drifting problems.

4.6 Location of Fences

Normally fences of the strand and woven wire type, used in rural and some urban areas, should be placed on or just inside the highway right of way. For continuity however, these fences may be erected substantially on a continuous line, even though there may be some irregular right of way corners that are outside the fence line. Under some suburban or urban conditions, a chain link fence would be similarly located.

Along urban freeways with frontage roads within the right of way, fences for both animal and pedestrian control may be located just inside the frontage road. The same condition for a limited length of freeway may occur in rural areas. In these cases, the frontage road is a land service road and there may be no reason in so far as overall highway purposes are concerned, to erect a duplicate fence of any type along the right of way line. This may be done however, as the property owner sees fit, but normally the necessary safeguards can be affected by a single fence. Where an otherwise continuous fence inside a frontage road (between the through-traffic lanes and the frontage road) is interrupted by ramps at an interchange, it may be necessary to place sections of fence in the median to discourage pedestrians from crossing. It may also be necessary in some cases to provide cattle grids at interchange ramp terminals, just off of the cross road.

Continuous fencing located inside the frontage road is not always warranted as a means of preventing indiscriminate vehicle crossings of the outer separation. Under some conditions such controls are affected by cross section design, planting, construction of guardrails and policing rather than by fencing.

4.7 Gates

Gates in fences along controlled access highways, through which access is provided to the right of way or through traffic roadways should be kept to a minimum number, and provided only where locks or other effective regulations will ensure use in a manner not detrimental to the traffic flow. Each gate should be of the appropriate type and installation and in keeping with the particular fence and conditions. Except along the outside of frontage roads, such gates generally are needed only for use by essential highway maintenance and operating personnel and equipment to reach the roadway border areas, avoiding the necessity for access via the through traffic roadways. Gates may be needed in special cases as a means of outside access to utility lines crossing the roadway, such as a utility support or manhole located within the right of way.

Fences along the outside of frontage roads should have gates only to the minimum extent necessary to serve the neighbouring property. While there may be advantages, such gates need not necessarily be under lock control where the control of access line lies inside the frontage road.

4.8 Openings for Cattle

In general, the highway shall be fenced off so that the road reservation shall be free from grazing cattle or cattle herded to market. Crossing points shall be provided at reasonable intervals where the highway passes through traditional grazing grounds. The guard fences and opening shall be designed to ensure crossing the highway at a right angle. Crossing at grade at frequent intervals shall be discouraged. In general culverts widened to serve as underpasses are recommended, especially where the size of herds and the frequency of crossing at grade are likely to cause delay or travel hazards. See Section 6.2 for additional information.

4.9

5 Guardrail and Vehicular Barriers

5.1 General

Traffic safety barriers are systems utilized to shield road users from potential hazards alongside the travelled way and should be able to redirect or contain:

- An errant vehicle without imposing intolerable vehicle occupant forces
- Vehicles in a range of sizes, weights and designs
- An errant vehicle over a range of impact speeds and impact angles

Traffic barriers are obstacles on the roadside, and vehicles striking barriers can cause occupant injury and/or vehicle damage. A traffic barrier should be installed only if it is likely to reduce the severity of potential collisions. It is therefore of the utmost importance that in selection of the traffic barrier, due cognisance be taken of the characteristics of the particular barrier system. Barrier systems differ not only in purpose, but also in terms of deflection and redirecting properties.

5.2 Criteria for Installing a Guardrail

Figure 7 shows the classification of longitudinal barriers based on their deflection characteristics. Misconceptions exist regarding the advantages of the different longitudinal barrier types. Some design engineers firmly believe that one system is better than another, based on its deflection characteristics, but it must be noted that the deflection characteristics of a particular system are not a measure of its effectiveness. The mechanisms by which a vehicle is restrained after impacting a traffic barrier differ completely, depending on the type of barrier selected. The reaction of a vehicle on impact with different types of barriers is thus also different.

In accomplishing their task of guiding and redirecting impacting vehicles, a longitudinal barrier should balance the need to prevent penetration of the barrier, with the need to protect the occupants of the vehicle. Various barrier technologies achieve this in various ways and can be grouped into three distinct types:

- Flexible systems, resulting in large lateral barrier deflections, but the lowest vehicle deceleration rates. Such systems have application in places where a substantial area behind the barrier is free of obstructions and/or other hazards within the zone of anticipated lateral deflection. These barriers usually consist of a weak post-and-beam system, and their design deflections are typically in the range of 3.2 metres to 3.7 metres, but can be as low as 1.7 metres.

- Semi-rigid systems, providing reduced lateral barrier deflections, but higher vehicle deceleration rates. These barrier systems have application in areas where lateral restrictions exist and where anticipated deflections have to be limited. They usually consist of a strong post-and-beam system and have design deflections ranging from 0.5 to 1.7 metres.

- Rigid systems, usually taking the form of a continuous concrete barrier. These technologies result in no lateral deflection, but impose the highest vehicle deceleration rates. They are usually applied in areas where there is very little room for deflection, or where the consequences of penetrating the barrier are very serious. Numerous shapes and heights are available.

Designers should familiarize themselves with, and design to, the specific performance characteristics of their selected or candidate technologies, in order to achieve the desired results for shielding errant vehicle occupants from potential hazards.

5.3 Warrants for Use

Roadside hazards that warrant shielding by barriers include embankments and roadside obstacles, including oncoming vehicles. Warrants for the use of barriers on embankments generally use embankment height and side slope as the parameters in the analysis, and essentially compare the collision severity of hitting a barrier with the severity of going down the embankment. Figure 8, adapted from Australian guidelines, provides guidance for the installation of such barriers on embankments.

This figure provides a range of values of fill slope for which, at certain heights of fill, a barrier may be more or less hazardous than the embankment it protects. For example, at a fill height of six metres, a fill slope steeper than 1:3 would warrant the use of a barrier, while a fill slope flatter than 1:4 would not require protection. On the intervening slopes, the designer should use his or her discretion in determining the need for a barrier.

5.4 Longitudinal Barrier Placement

A typical longitudinal roadside barrier installation, with its associated elements for a two-lane, two-way road, is illustrated in Figure 9. The length of need as indicated in this figure is illustrated in more detail in Figure 10 and Figure 11.

Table 3: Recommended Minimum Offset Distance

Design Speed (km/h)	Offset Distance (m) measured from the edge of the travelled way
50	1.1
60	1.4
80	2.0
100	2.4
120	3.2
130	3.7

Recommended offset distances measured from the edge of the travelled way are shown in Table 3. Barriers are typically placed at a distance of 0.3 metres beyond the edge of the usable shoulder, so that the greater of the distance in Table 3 or the width of the shoulder plus 0.3 metres should be used.

5.5 Length of Need

The variables to be considered in the design process of barriers are shown in Figure 10 for the approach side towards a hazard, and in Figure 11 for the trailing side beyond the hazard, providing for the shielding of the hazard for opposing traffic.

Run-out length is the theoretical distance required for a vehicle leaving the roadway to come to a stop prior to impacting a hazard. The design of a traffic barrier requires provision to be made for sufficient length to restrict such a vehicle from reaching the hazard. The recommended run-out lengths are shown in Table 4.

Table 4: Recommended Run-out Lengths for Barrier Design

Design Speed (km/h)	Run-out Length (m)			
	ADT <800	800<ADT<2000	2000<ADT<6000	ADT>6000
50	40	45	50	50
60	50	55	60	70
80	75	80	90	100
100	100	105	120	130
110	110	120	135	145
120 or higher	125	135	150	160

The run-out length is measured along the edge of the road. A control line is established between the end of the run-out length and the far side of the hazard to be shielded. The length of need for a standard barrier would then be the length between the near side of the hazard, and the position where the barrier intersects the control line. If the barrier is designed for a continuous hazard such as a river or a critical fill embankment, then the control line would be between the end of the run-out length and the end of the desirable clear zone. The same principle is adopted to determine the length of need for opposing traffic.

The standard guardrail ends at the end of the length of need. An acceptable end-treatment should be added to this length to determine the total length of installation.

5.6 Median barriers

Most of the principles with respect to longitudinal barriers also apply to median barriers. Regarding warrants for their use, median barriers should only be installed if the consequences that would result if they did not exist, are more severe than the consequences of striking them. However, excessive incidence of illegal cross-median movements might justify the use of median barriers.

For median widths of 15 metres or greater, median barriers are generally not required, whilst, for median widths of 10 metres and less with ADT's in excess of 30 000 vpd, and for widths less than 8 metres irrespective of ADT, median barriers are generally justified. These figures presuppose that the particular section of roadway under consideration does not suffer from an adverse cross-median collision history and that unauthorized cross-median U-turns do not take place.

5.7 Single-slope Rigid Barrier

The single-slope concrete barrier shown in Figure 12 smoothly redirects a 2 000 kg vehicle impacting at 100 km/h and 25 degrees without snagging. It has a low rollover probability when impacted by smaller vehicles, and a low vehicle occupant impact velocity. The barrier performance is maintained irrespective of subsequent overlays to the road surface because of the constant sloped face.

The single-slope barrier is recommended for high speed roads provided with narrow medians (less than 10 m), and with an ADT of more than 30 000 vpd.

Classification of Longitudinal Barriers
Based on Deflection Characteristics

Longitudinal Barriers

Flexible systems	Semi-rigid systems	Rigid systems
Cable systems	Guardrail systems	Concrete barriers

Figure 7: Classification of longitudinal barriers

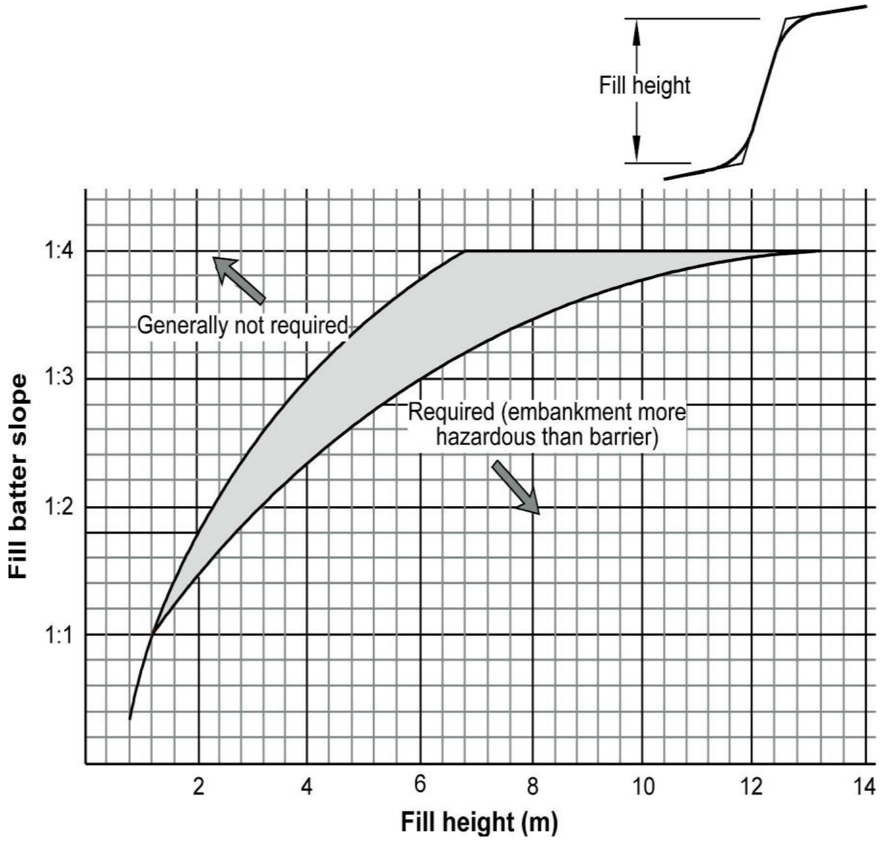


Figure 8: Warrants for use of roadside barriers on fill embankments

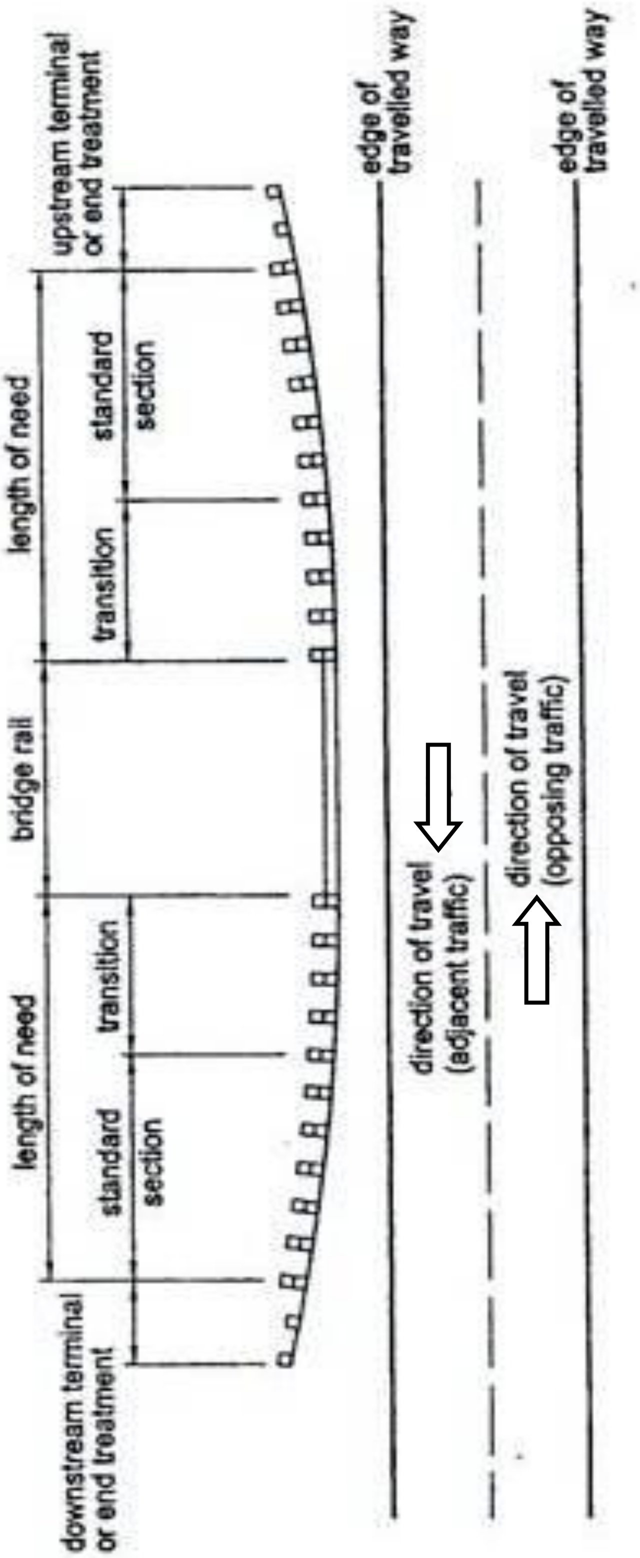


Figure 9: Roadside barrier elements

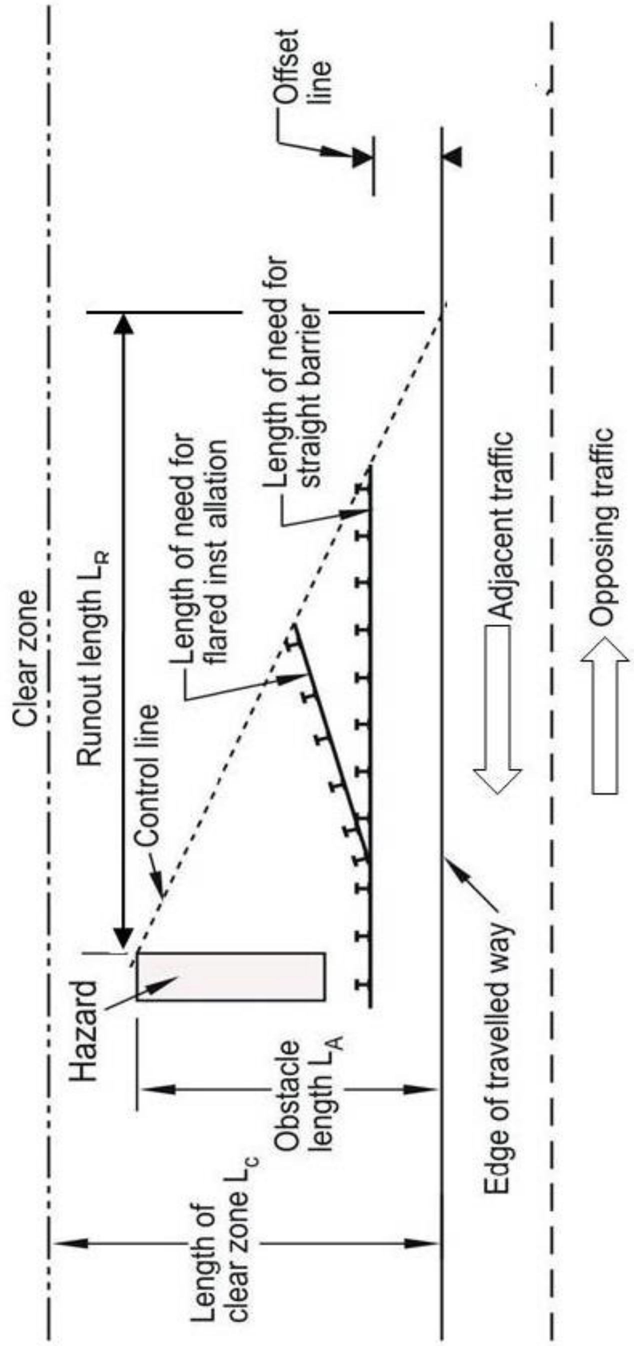


Figure 10: Length of need for adjacent traffic

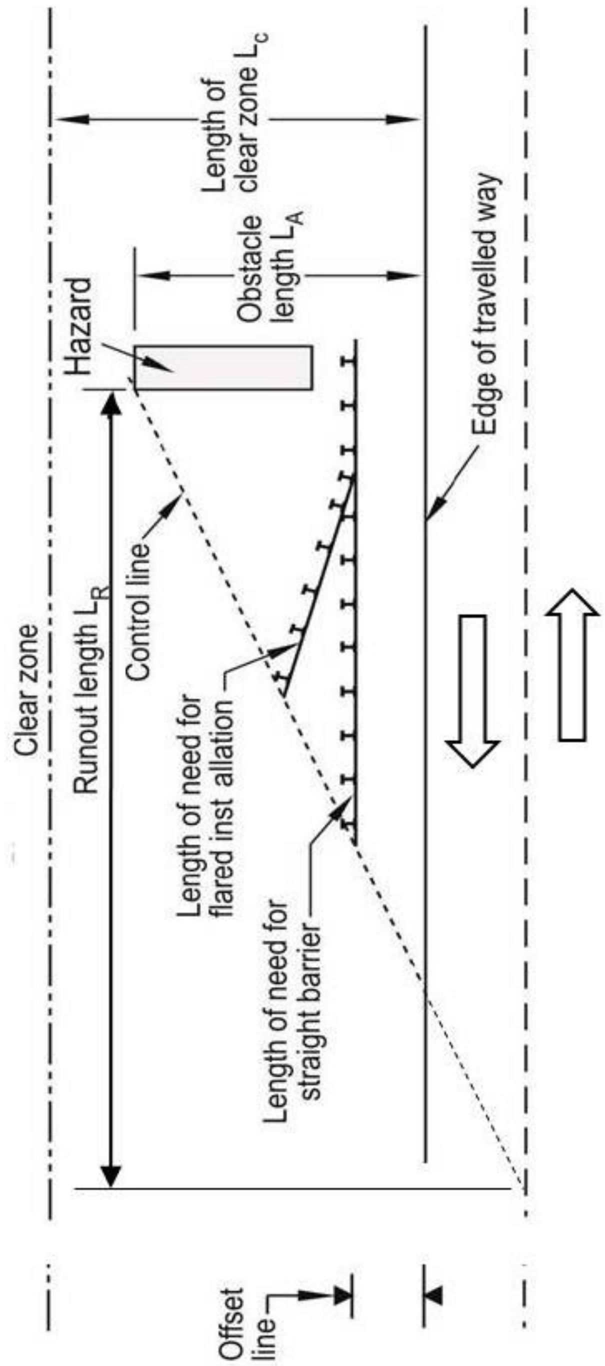


Figure 11: Length of need for opposing traffic

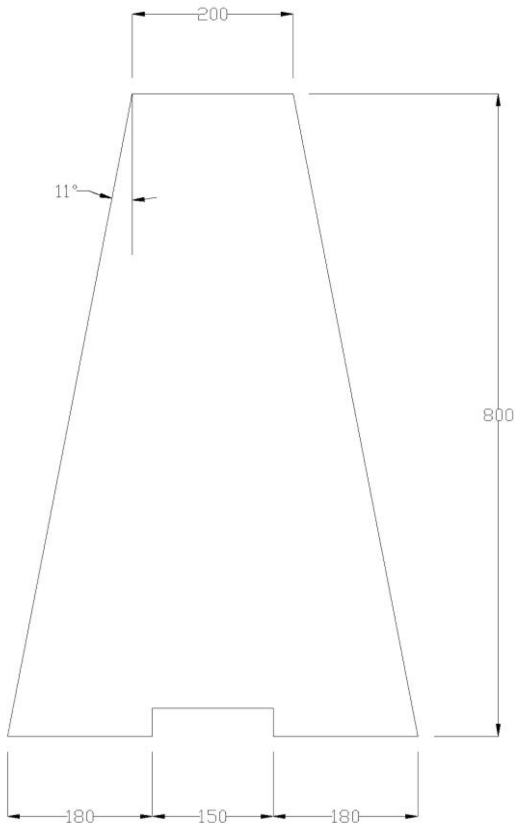


Figure 12: The single-slope concrete barrier design

Alternative median barrier types can be typically “New Jersey” or wire rope median barriers. These can be specified in particular circumstances.

6 Special Structures and Installations

6.1 Truck Scales

a. General

Truck weighing station installations are constructed as needed, to provide protection to highways from overweight vehicles and/or to provide a source of data for planning and research.

b. Site Location

The location of a truck weighing station sites is not generally dictated by exact kilometre post locations, but rather is controlled by right of way, geometric and topographical features. It is desirable to select these sites in locations where there is adequate right of way available and the geometric, topographical features and environment lend themselves to the most economical development, without undue site preparation and expense.

The Director of Highway Design will be responsible for selecting the truck scale sites.

c. Design Features

All connections to weighing stations shall be constructed to the established highway standards. On multi-lane, limited access highways standard acceleration and deceleration lanes shall be utilized. Figure 13 is a guide for constructing weighing stations on multi - lane controlled access highways.

Weighing stations to be constructed along two lane highways shall be so designed as to best fit the existing conditions, with particular consideration being given to proper access to and from the site. It is generally not desirable to develop a weighing station on just one side of a high volume two lane facility that requires control of vehicles from both directions of travel. The use of standard acceleration and deceleration lanes should be considered very carefully when designing the weighing station site on this type of facility.

d. Parking and Storage

- Parking and storage space at each individual site shall be carefully studied to meet the required space.

e. Signing

- An electronically controlled open and closed message sign that can be operated from the scale house should be considered for those installations where hazardous and circuitous travel exist for the manual changing of the ‘scales open’ or ‘scales closed’ sign.

6.2 Cattle Passes

The approved cattle passes shall consist of either a standard box culvert with an opening 1.8m wide and 2.1m high, or a metal pipe 2250 mm in diameter. After installation, the invert may be paved with concrete or bituminous paving material.

If usual conditions clearly indicate the need for a larger cattle pass, full details concerning the proposed size of structure, local conditions, right of way considerations, comparative costs and all other pertinent data shall be submitted to the Director of Highway Design.

Design effort shall not be expended or agreements made for any size of cattle pass greater than the standard without prior approval by the Director of Highway Design.

6.3 Railway Grade Crossing

a. General

Railway grade crossing shall have protection as shown in Table 5. The minimum geometric design standards for railway grade crossings are shown in Figure 14.

All conditions not covered in this table and marginal situations are to be referred to the Director of Highways Planning and Design.

Table 5: Guidelines for Railway Crossing Protection (New Highways)

Class of Highway	Exposure Factor*	Type of Railway Facility		
		Non Main Line	Single Main Line (Under 100 km/h)	Double Track or High Speed Single Main Line
Two Lane	Under 1 500	Reflectorized signs	Flashing Lights	Flashing Lights
	1 500 to 5 000	Flashing lights	Flashing Lights	Flashing Lights
	5 000 to 50 000	Auto Gates**	Auto Gates**	Auto Gates**
	Over 50 000	Separation	Separation	Separation
Multi-Lane	Under 50 000	Auto Gates	Auto Gates	Auto Gates
	Over 50 000	Separation	Separation	Separation
All Fully Controlled Access	Mandatory	Separation	Separation	Separation

* Exposure factor = Trains per day x vehicle ADT

** Automatic gates to be used in urban areas and flashing lights in rural areas, unless conditions warrant otherwise.

b. Stopping Lanes

Stopping lanes must be designed so that the signals are clearly visible from all lanes of traffic, at all times.

c. Signals

Signals adjacent to truck and bus stopping lanes on two or four lane highways will be installed so that the signal head will be cantered on the edge of the through lane, with a minimum vertical clearance of 5,2 metres between the lowest portion of the signal arm, and the crown of the highway pavement.

Signal installations in the median adjacent to the through roadway lanes will use the type of signal head shown by Figure 16.

All signals installed must be adequately protected by a barrier device of suitable design.

Signal installations are separate projects. Their costs are not to be included in the cost of widening the highway for stopping and acceleration lanes.

d. Profile

If the railway track is super elevated, the highway profile must conform closely to the grade across the top of the rails.

e. Illumination

Where a majority of the train movements are at night or when other conditions so indicate, crossing illumination should be considered.

6.4 Pedestrian Facilities

a. General

Areas with the highest incidence of pedestrian accidents are often the poorer areas with low vehicle ownership. The severity of pedestrian accidents is also normally higher in rural areas than in urban areas. Most pedestrian accidents occur in more densely populated rural areas and in urbanised areas. These facts need to be considered together with pedestrian volumes before deciding on the provision of pedestrian facilities. Walkways should not normally be provided along rural roads unless the road traverses urbanised areas or an informal footpath exists and is well utilised.

b. Guidelines

Identify adjacent pedestrian attractions such as schools, shops, bus stops and places of employment or sports facilities. Determine popular pedestrian paths to and from such attractions.

Where popular pedestrian paths cross a road, ensure that adequate visibility is available for pedestrians and stopping sight distance is adequate for drivers of vehicles.

Erect large pedestrian warning signs in advance of the crossing.

Consider providing a pedestrian refuge island to facilitate crossing multi-lane undivided roads. Where pedestrian paths are parallel to a road and a pedestrian facility is warranted, consider introducing a reduced speed limit, together with frequent pedestrian warning signs if the road reserve width is narrow and pedestrians walk near the road edge.

In rural or semi- rural areas where a pedestrian facility is warranted and the road reserve width is adequate provide a walkway in the roadside verge area, and not adjacent to the travelled way or road shoulder. In urban areas, where practical, provide a sidewalk next to the road reserve boundary, even if mountable or barrier kerbing is provided along the roadway edge.

c. Warrants for Walkways in Urban Areas

Warrants for the provision of walkways are specified in Table 6. It must be recognised that in some instances walkways may be justified on the basis of mutual hazard or of avoiding a considerable amount of pedestrian cross traffic. Crowds attracted by sporting events move efficiently at 33 people per 600 mm lane per minute. Eighteen to 27 people per 600 mm lane shall be considered the designable maximum. Average walking speeds on level walkways have been found to vary from 1.05 metres to 1.35 metres per second.

The minimum width of walkways shall be 1.50 metres to accommodate bi-directional pedestrian traffic.

Table 6: Warrants for Urban Walkways

Design Speed of Highway (km/h)	One Walkway		Two Walkways	
	Vehicles per hour	Pedestrians per hour	Vehicles per hour	Pedestrians per hour
50 – 80	30 – 100	150	50 – 100	500
	Over 100	100	Over 100	300
100 – 110	30 – 100	100	50 – 100	300
	Over 100	50	Over 100	200

d. Pedestrian Facilities on Bridges

A minimum width of 0.6 m behind a barrier kerb should always be provided for pedestrians on both sides of a bridge even if there is no sidewalk on the road approaches.

If there is an existing walkway on the road approaches and it is well utilised the same width should be used across the bridge behind a barrier kerb.

6.5 Public Utilities

Public water mains, oil or gas mains, electric or telephone cables shall not be located within the median. These utilities may, with permission, be located within the right of way, but in no case shall any installation be within three metres of the shoulder of the existing highway or highway in stage construction.

Where installation is within the right of way, permanent markers indicating the offset distance and depth of cables and pipes shall be installed at owners cost.

Highway crossings of utilities overhead, underground or along bridge structures shall be approved by the Director- Highway Design and the safety of road users and maintenance crews guaranteed.

General electric cables will be buried nearest the surface and located below telephone cables, gas or oil mains, with water mains at the lowest depth. In urban areas, public utilities are usually located under the footway. The relative positions shall be as indicated in Figure 17, which shows minimum dimensions.

6.6 Bus Stops

Location of bus stops should be coordinated with the local transit agency. Bus stops shall not be located closer than 100 metres apart, nor nearer than 60 metres to the closest intersection.

The design shall conform to: the recommended pavement is Portland cement concrete, 200 mm thick reinforced with 150 x 150 x 16 mm welded wire fabric.

When the parking frequency exceeds 10 busses a day for periods longer than 5 minutes, motor parks shall be provided. The parking lots provided for commercial vehicles and taxis in approved motor parks, shall be laid out as shown for petrol stations.

6.7 Maintenance Depots

Maintenance depots may be located on the right of way in the case of ordinary highways, but no structure, plant or material shall be located closer than 15 metres from the outside edge of the outer lane of the highway. Only one means of entry or exit shall be provided. The location of the maintenance depot shall anticipate the ultimate development of the highway.

For limited access, multi- lane divided highways, direct entrances and exits shall not be provided. The depot shall be located near and connected to a cross road having an interchange which provides for all turning movements.

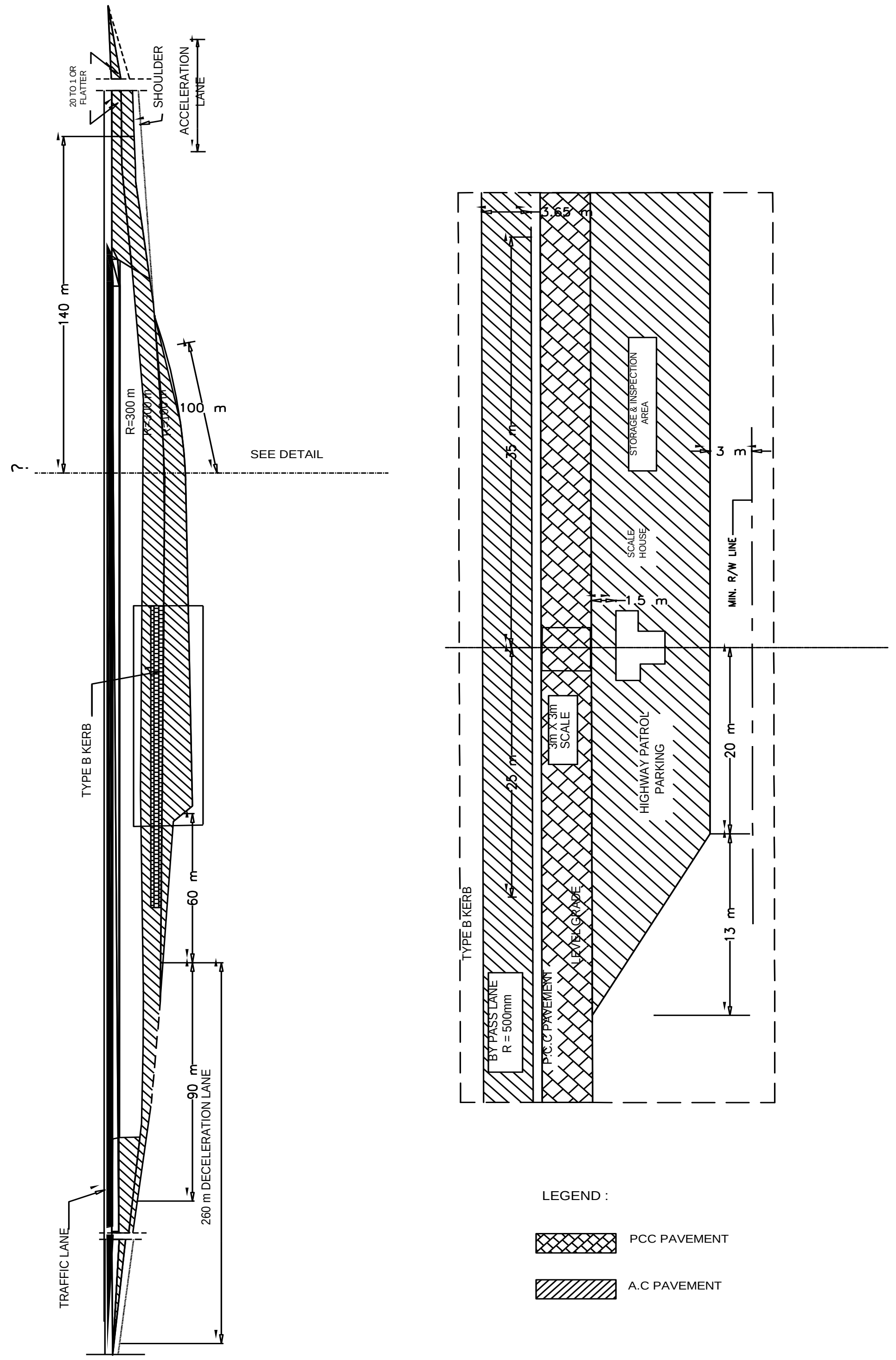


Figure 13: Standard Plan for Truck Scale Installation for Divided Highways

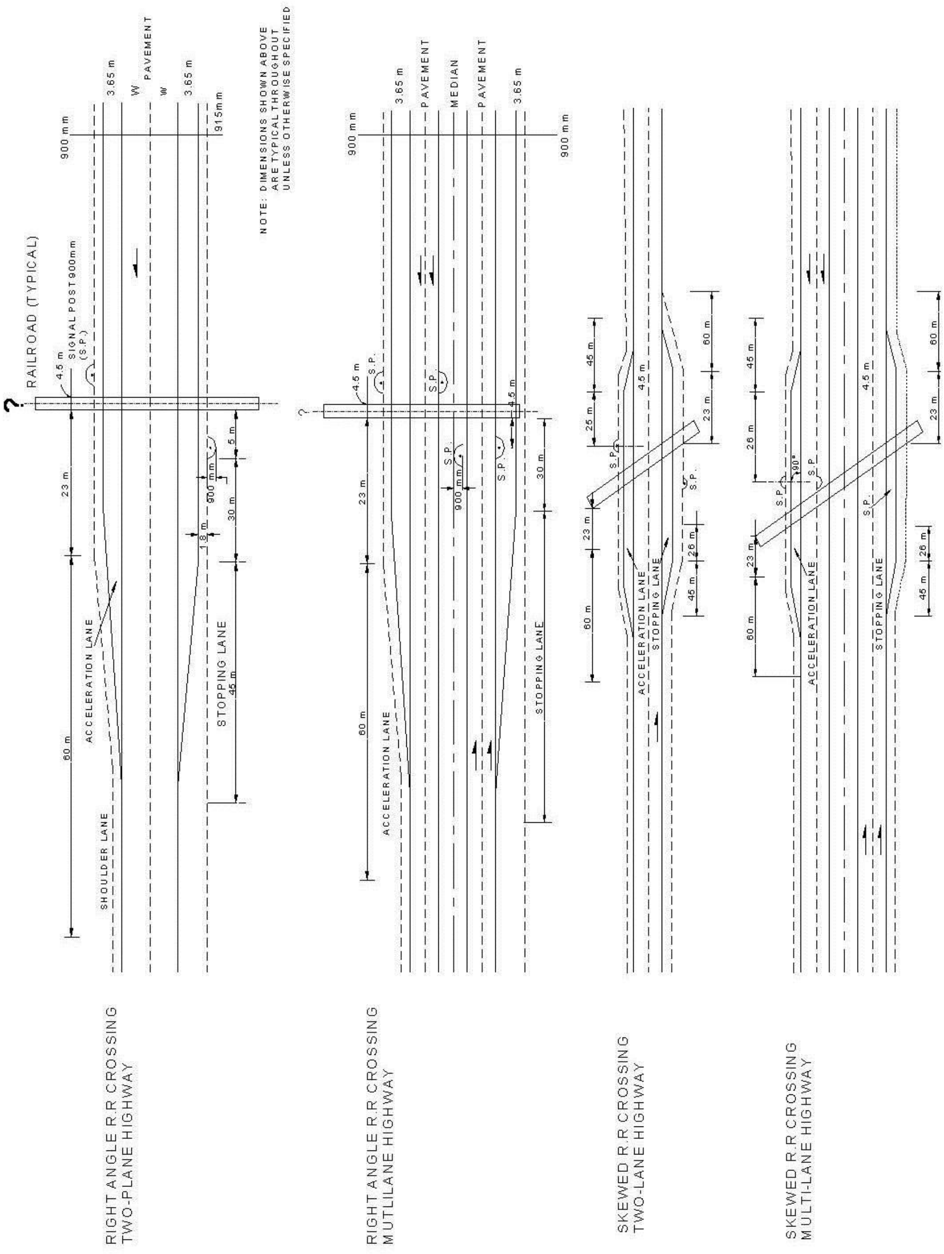


Figure 15: Roadway and Traffic Control at Railway Grade Crossing

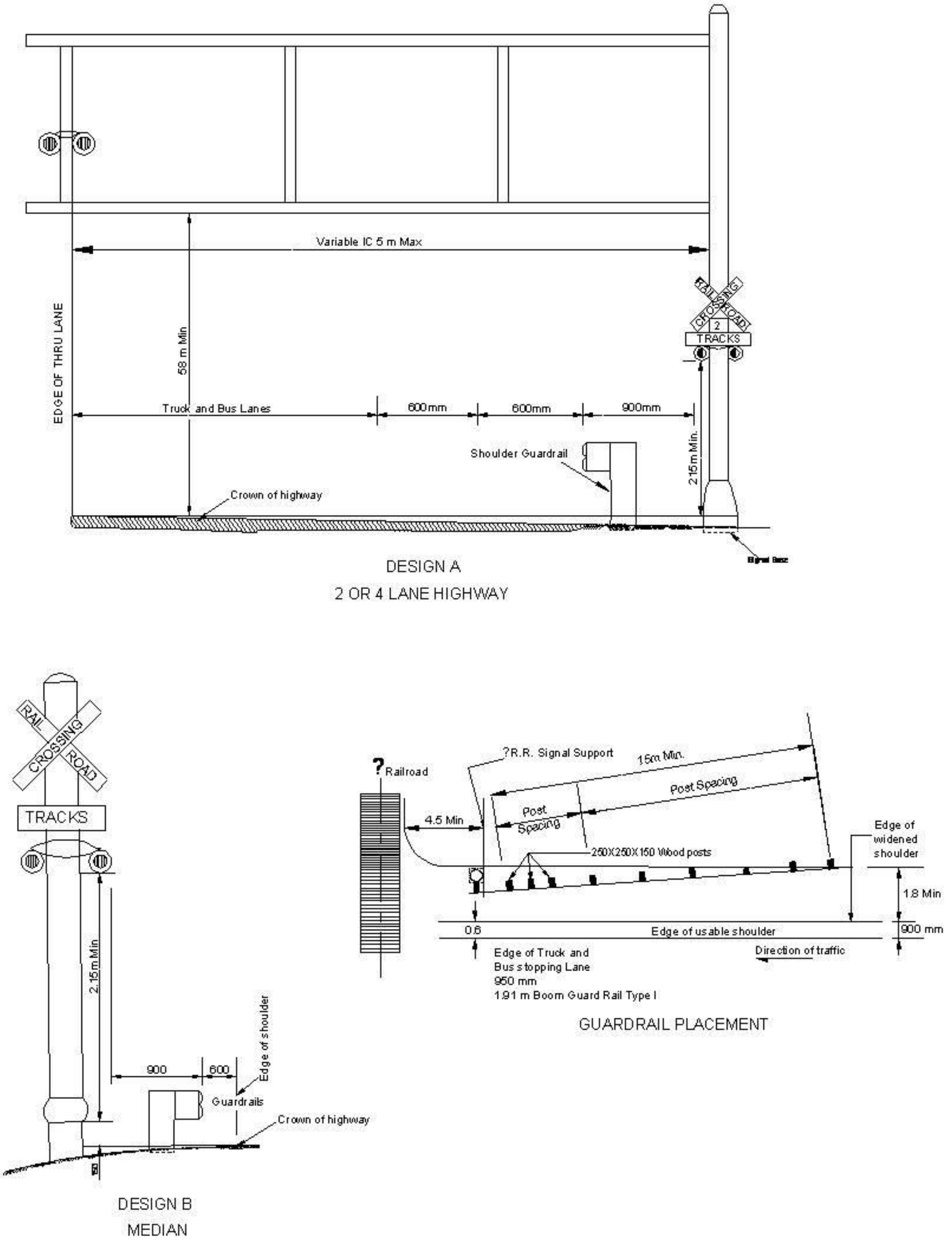


Figure 16: Railway Grade Crossing Signals

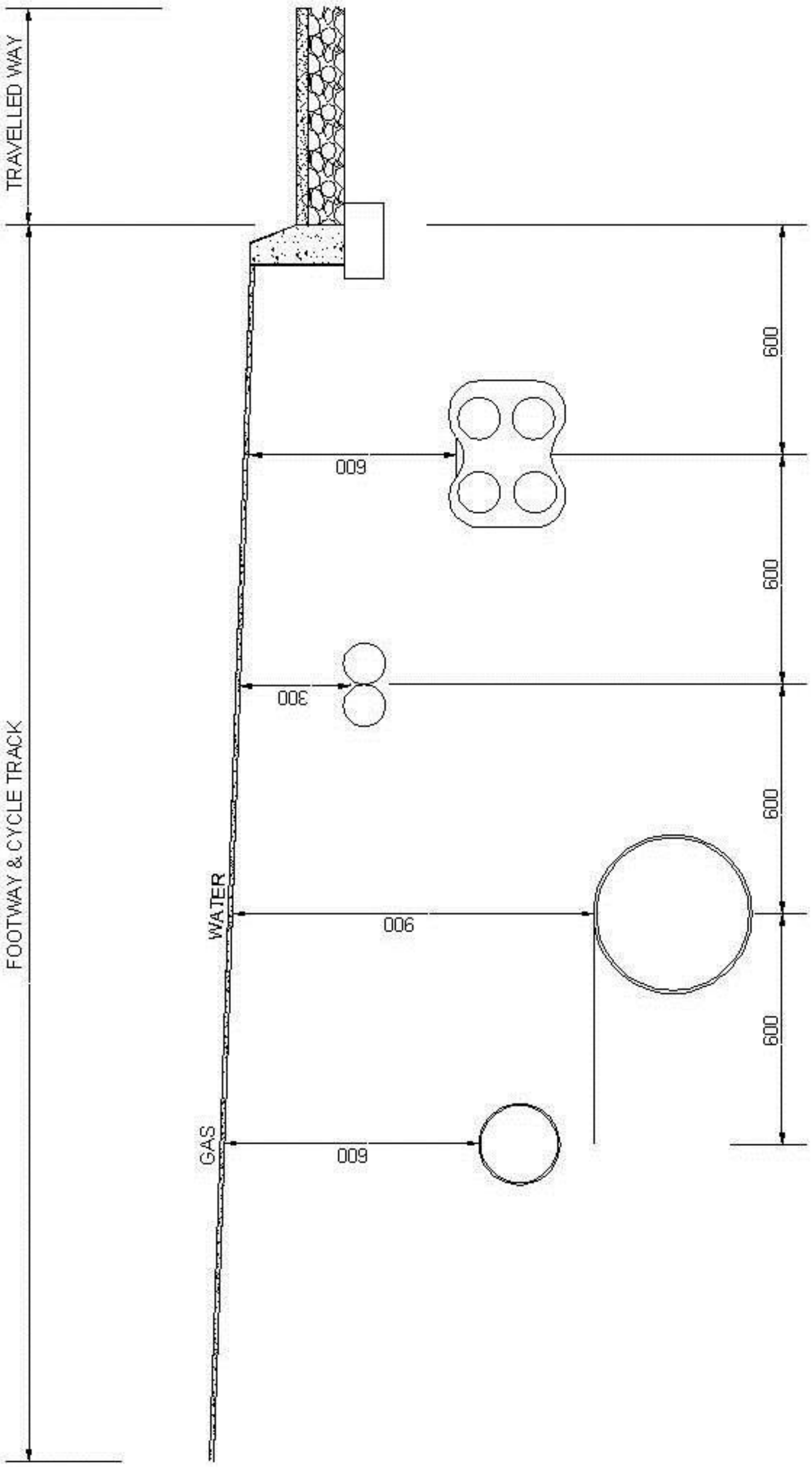
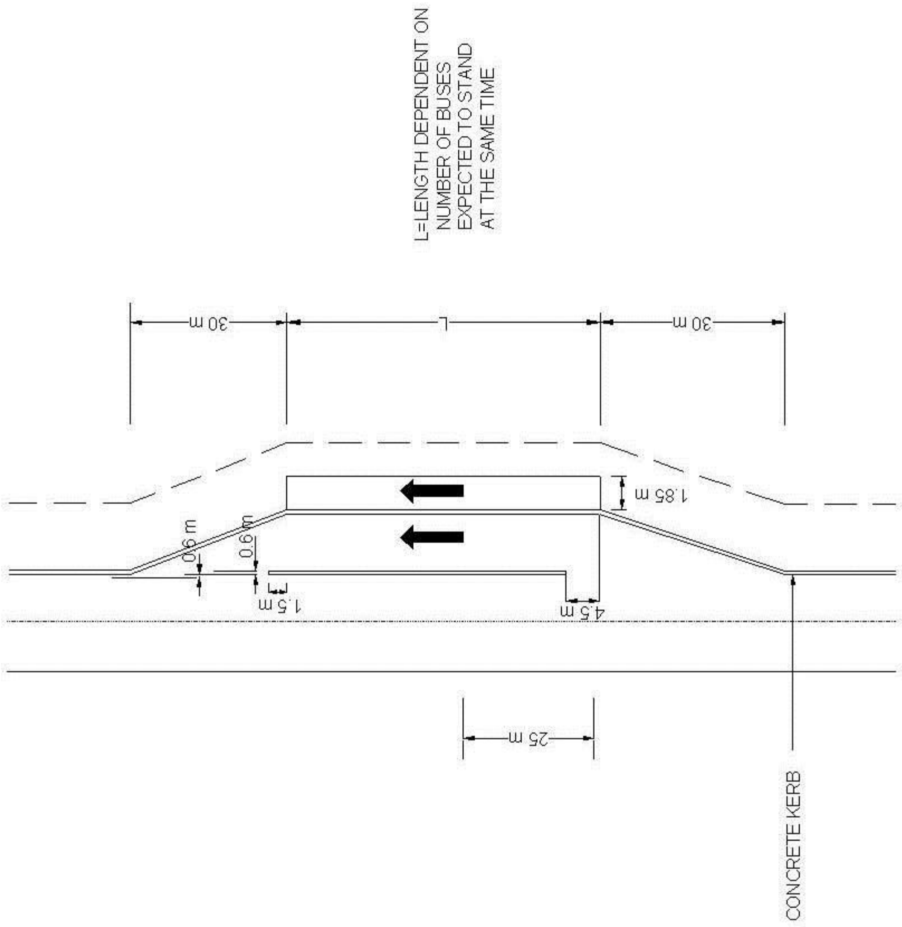


Figure 17: Public Utilities under Shoulder – Urban



NO. OF BUSES	LENGTH(m)
1	15
2	25
3	40
4	60

Figure 18: Standard Bus Stop on a Straight Road

7 Safety Rest Areas

7.1 General

Rest areas are intended to provide the travelling public with areas in which to rest and refresh themselves for short periods of time. They are to be located at attractive spots where ingress and egress from the highway can be easily and safely accomplished. Safety rest areas are to be provided in rural areas and sections where adequate and desirable motorist services and conveniences are not available. Rest areas are intended for short time occupancy and are not provided for overnight use or active recreation. They shall be maintained in a clean and inviting condition at all times.

All of the sites when fully developed, will provide the facilities necessary to satisfy the basic needs of the motorist, and will be designed in such a manner as to permit future development to their full extent, if this cannot be achieve in the initial stage.

Rest areas when fully developed, should provide permanent restroom buildings, shelters, garbage containers, drinking water, waste water disposal, parking for automobiles, trailers and trucks, landscaping consisting of tree and shrub plantings where appropriate, facilities and space to accommodate short term relaxation, safe entrances and exits constructed in accordance with access control policies and appropriate signing and illumination.

7.2 Locating Rest Areas

Safe rest areas should be located at sites which are attractive and aesthetically pleasing, and spaced reasonably with respect to other safe rest areas or facilities of a similar type which are available to the travelling public. It is important that the site be chosen for its appropriateness and natural values within the bounds of desirable spacing. If a local water supply is not available, first consideration shall be given to securing a potable water supply by drilling boreholes or by other means before final selection of the site or proceeding with any further development. Drainage, waste water disposal, power sources, trees, adequate site distance on the main highway to meet safety requirements, future lane use and relationship to other facilities, are all essential features which are to be considered in selecting rest area sites.

A spacing of approximately 80 kilometres between rest areas is reasonably attainable and should provide a proper interval of driving time between sites. On rural freeways, safety rest areas should be at least 1.5 km from the nearest ramp of an interchange, except for those locations within interchange areas or those which have their access from a cross road.

7.3 Access Control

The spacing of ramps or approaches to safety rest areas in relation to adjacent ramps or points of access shall meet the requirements of established policies on ramp spacing on freeways, and spacing of intersections at grade on highways with partial access control.

In order to preserve the public investment in highway rest areas, and to maintain the safety of the highway user, it is desirable to either establish partial control of access in the vicinity of rest areas which are located upon otherwise non-controlled access facilities, or acquire scenic easements to preserve the land characteristics.

Access control should be considered for 1 km in either direction on both sides of the highway, from the rest area at grade intersection, which will serve both directions of traffic, for either a two lane or multi-lane highway. Access control should be considered for 1 km beyond the ends of the ramp tapers at rest areas which serve in one direction only.

Scenic easements may be acquired in lieu of access control, provided that such easements incorporate control of land use and restrictions against the establishment of future at grade intersections, in order to ensure adequate intersection spacing to protect the rest area facility.

Rest areas should not be located between public grade intersections that are spaced less than 1.5 km apart.

Approaches to property neighbouring a rest area will not be allowed from within the rest area proper.

7.4 Entrances and Exits

Entrances and exits to rest areas on fully controlled access highways will be by means of a ramp, with standard acceleration and deceleration lanes. On undivided highways with partial or no access control, where the use of the rest area is rather infrequent, the traffic can be accommodated by means of a single approach. However, those sites having a greater frequency of use, will require double entrances and provision for operation of traffic in both directions, upon the interior roadway and should be signed to allow entrance from both approaches. Exits from the site should be from the approach located in the desired direction of travel, which would avoid acute left turns from the site. Where left turns into the site from the two lane roadway cannot be accommodated satisfactorily or safely, traffic control devices shall be used to prohibit left turns, and consideration shall be given to providing separate sites for each direction of travel.

7.5 Right of Way Requirements

Highway right of way is considered to pertain to that area normally required for the development and construction of an adequate highway, including appropriate safety rest areas and view sites.

Scenic strips may be acquired in conjunction with the rest area for enhancement purposes, or for protection of existing natural features against encroachments, as mentioned under the previous paragraph on Access Control. Scenic easements acquired for these purposes should include the following restrictions:

- No commercial use permitted
- Selecting cutting of trees permitted
- No unsightly or unsanitary use of land permitted
- No advertising or signs permitted
- No installation of new overhead utilities permitted
- No public approaches allowed

7.6 Fencing

Safety rest areas shall be fenced to avoid misuse from unauthorized access to neighbouring properties, and to regulate and protect against children or pets entering on the through roadway. Fencing may not be required where there are natural barriers or obstacles preventing local misuse. Fencing along edges of bodies of water may be required.

7.7 Signing

Signing for safety rest areas shall be accomplished in accordance with the requirements of Volume VI: Road Traffic Signs and Road Markings of the Highway Manual Part 1: Design.

Safety rest areas on multi - lane divided highways shall have a guide sign indicating the distance to the rest area and located preferably three kilometres in advance of the site. An exit direction sign with an arrow shall be placed in advance of the exit. An advisory message indicating the distance to the next safety rest area site shall be used in conjunction with the exit direction sign.

Rest areas and view points that are not on rural highways shall have a rest area sign located approximately three kilometres in advance of the site, indicating the distance to the rest area. This applies to traffic in both directions, if left turns into the site are being permitted. The standard rest area sign with an arrow will be placed in advance of the exit.

7.8 Illumination

Illumination of ramps to safe rest areas and view sites shall be provided. Interior lighting shall be provided within the rest room buildings. External lighting around the buildings and parking area should be of a minimum level that would suffice for the protection of visitors and discourage vandalism.

7.9 Parking

Minimum parking requirements for safe rest areas should reasonably accommodate traffic volumes predicted to use the rest area facility, in the design year, based upon the full development of the site.

Rest areas intended for use by passenger cars with trailers and by commercial trucks should be provided with drive through parking. Parking areas should be surfaced and clearly designated.

7.10 Rest Room Facilities

The design of minor rest area sites shall include provisions for a permanent rest room building; however, in remote areas or at sites with low tourist usage, initial installation of chemical toilets may be desirable, until the need for permanent facilities in relation to those of other sites becomes evident.

7.11 Drinking Water

Drinking water should be provided at all major rest areas and at minor rest areas when readily available. Drinking water obtained from drilled boreholes, springs or other local sources must be safe for human consumption, and periodic tests will be required to ensure a continued safe supply.

7.12 Sun or Rain Shelters

All rest areas should contain some shelters from the sun or rain, for the protection of the users of the rest area. The design of these protective shelters should be based on the form of local custom and/or architecture of the area, so as to be in keeping with the environment.

7.13 Landscaping

Natural growth should be retained around the outer perimetre of the safe rest area to provide a buffer strip to prevent encroachment from adjacent properties. Undesirable underbrush and trees to eliminate possible hazards to visitors should be cleared and desirable view sites that may be available, should be opened up to encourage travellers who are using the facilities to enjoy the views.

Planting of trees and shrubs will generally not be required in minor rest areas, however, tree and shrub plantings as deemed appropriate should be considered in the major rest areas. Plantings should be native in character and selected for minimum maintenance requirements.

7.14 Maintenance

Safe rest areas are to be maintained and kept in a clean, well repaired and inviting condition at all times, and sufficient equipment and manpower are to be provided for this purpose.

8 Petrol Filling Stations

8.1 General

Vehicles leaving or entering a petrol filling station not only reduce the effective capacity of the roadway, they are also more likely to cause accidents. The minimum distance between two petrol filling stations along a road shall be 100 metres. It is desirable to space petrol stations at least 500 metres apart. Table 7 gives the minimum requirements concerning the design of access roadways and the location of installations.

Table 7: Oil or Petrol Stations Minimum Distances

Distance from an intersection (C)	50 to 70m
Distance apart	100m
Frontage width	30m
Driveway width entry and exit (W)	10m
Driveway width entry or exit only (W)	3m
Radius of kerb line (R)	12m
Set-back of pump from pavement edge	15m
Set-back of service station from pavement edge	10m
Angle of driveway (Y)	75^{o} to 105^{o}

The location plan shall conform to the standard plans shown in Figure 19 to Figure 24 for the area of the station within the right of way.

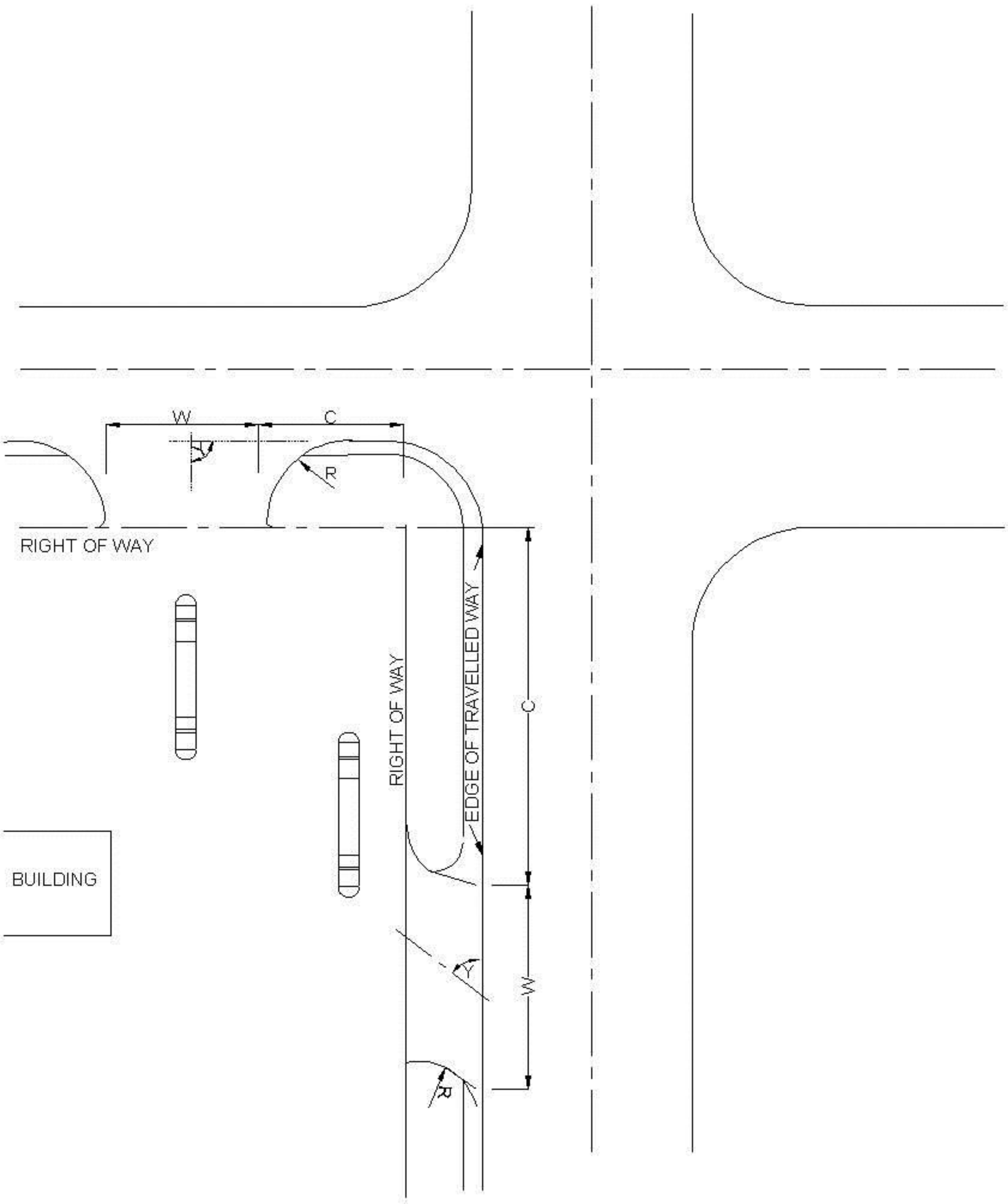


Figure 19: Petrol Station Entrance Locations – Driveways for Corner Installations

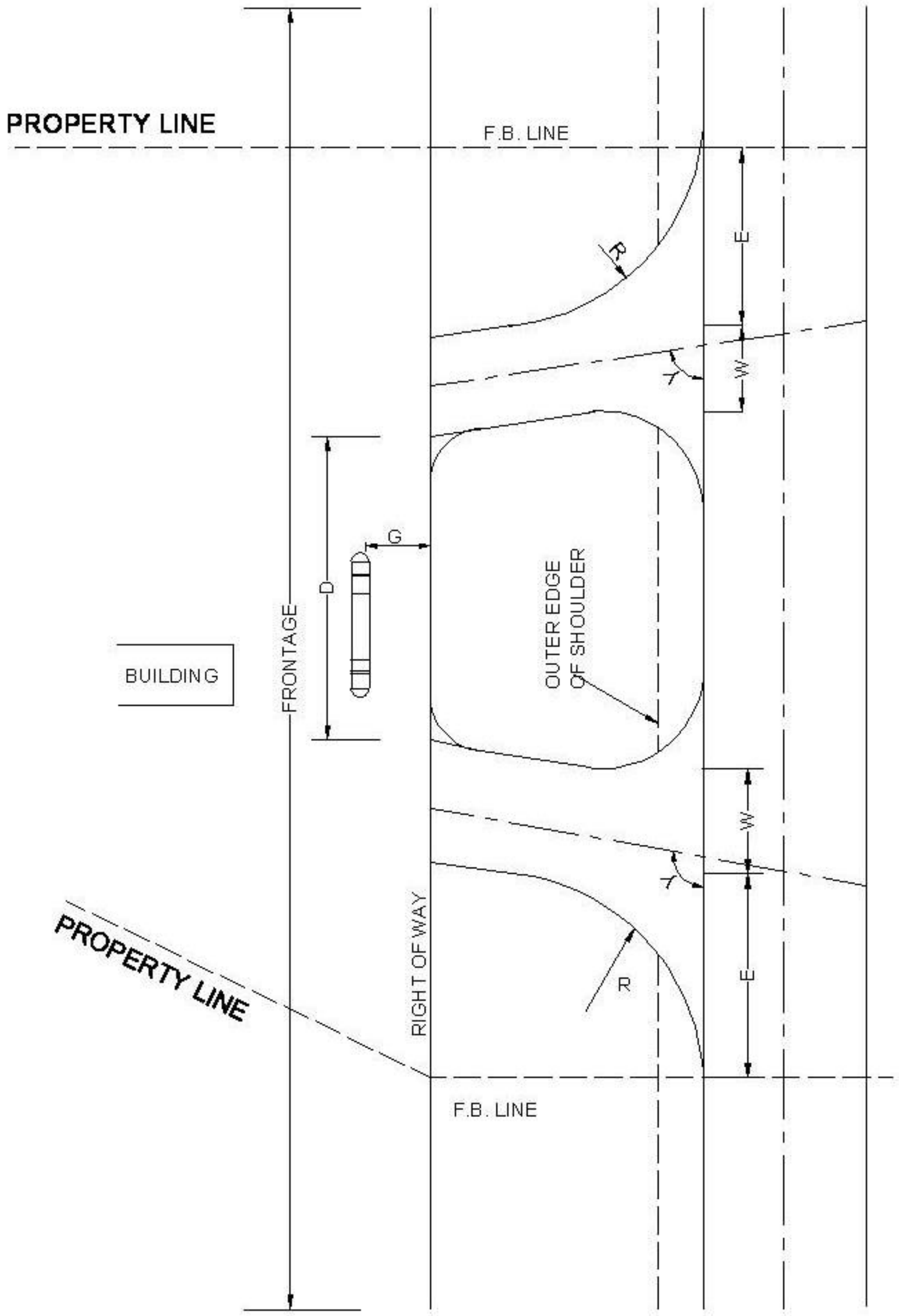


Figure 20: Petrol Station Entrance Locations – Double Driveways

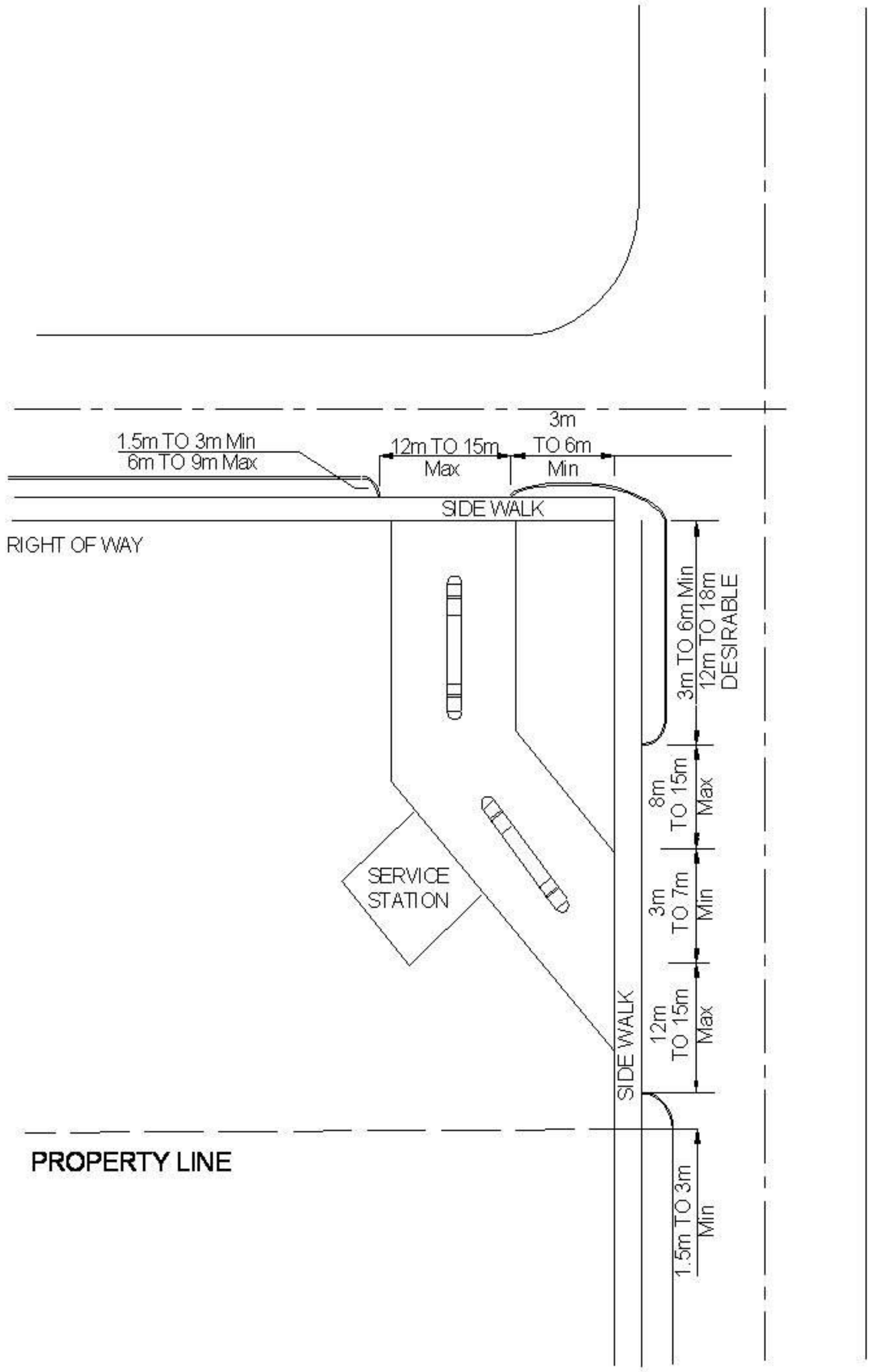


Figure 21: Petrol Station Entrance Locations – Single Driveways to a Corner Service Station Urban

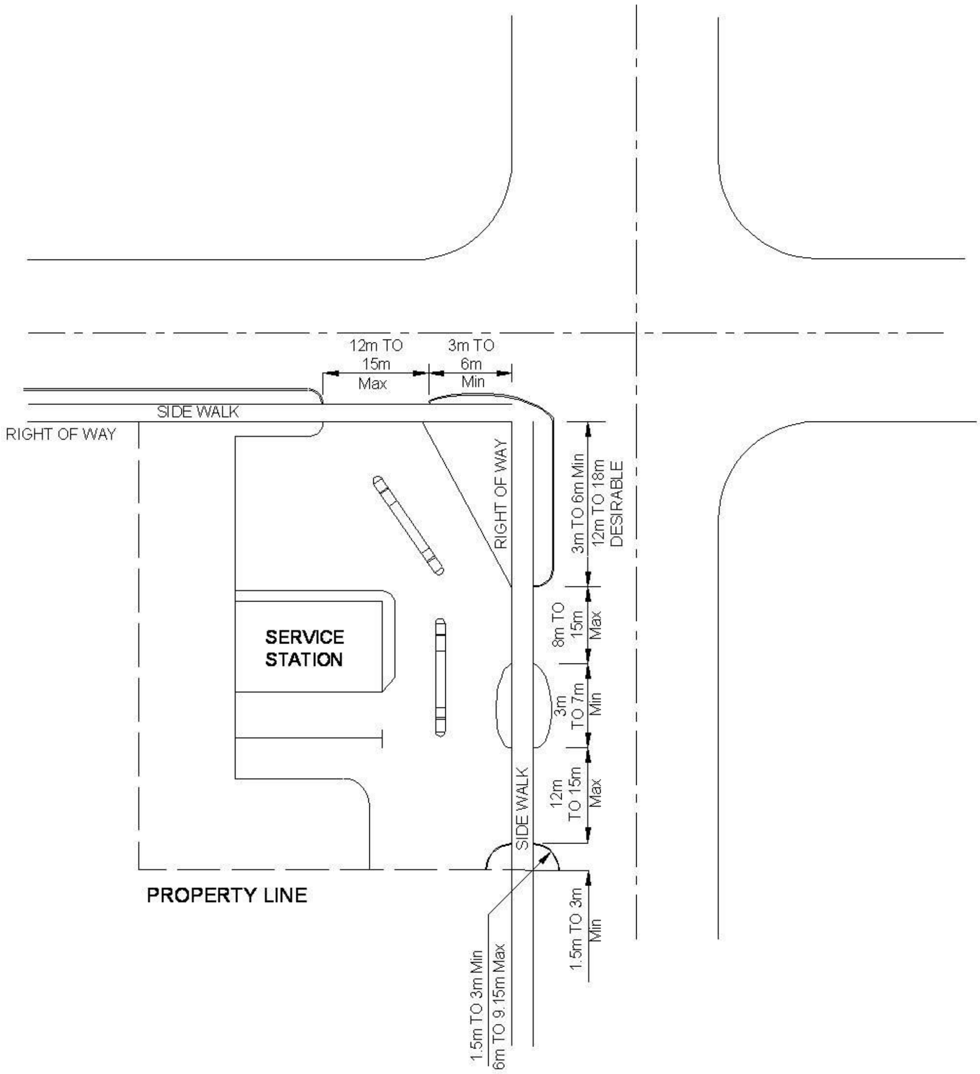


Figure 22: Petrol Station Entrance Locations – Double Driveways to a Corner Service Station (Urban)

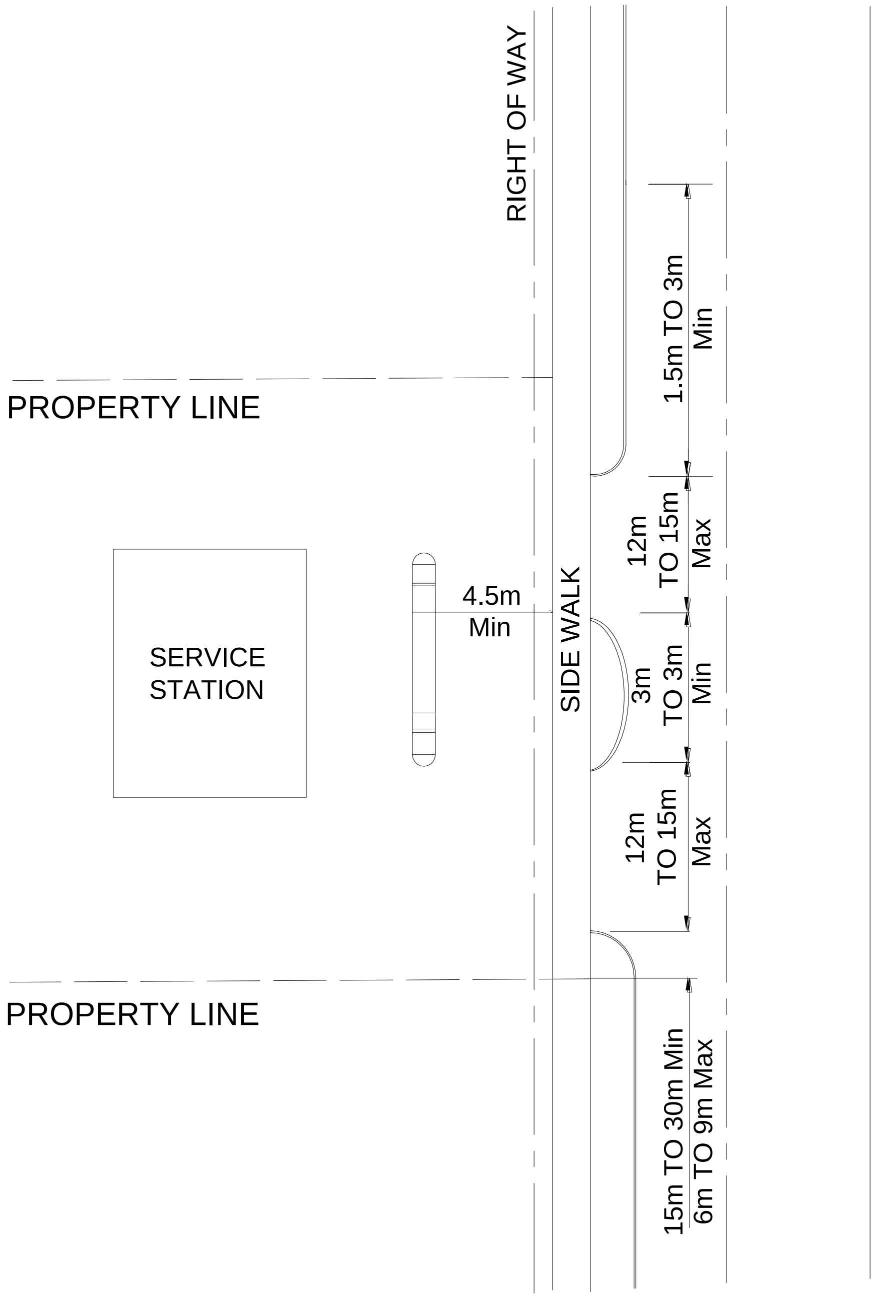


Figure 23: Petrol Station Entrance Locations – Double Driveways to a Mid-block Service Station Urban

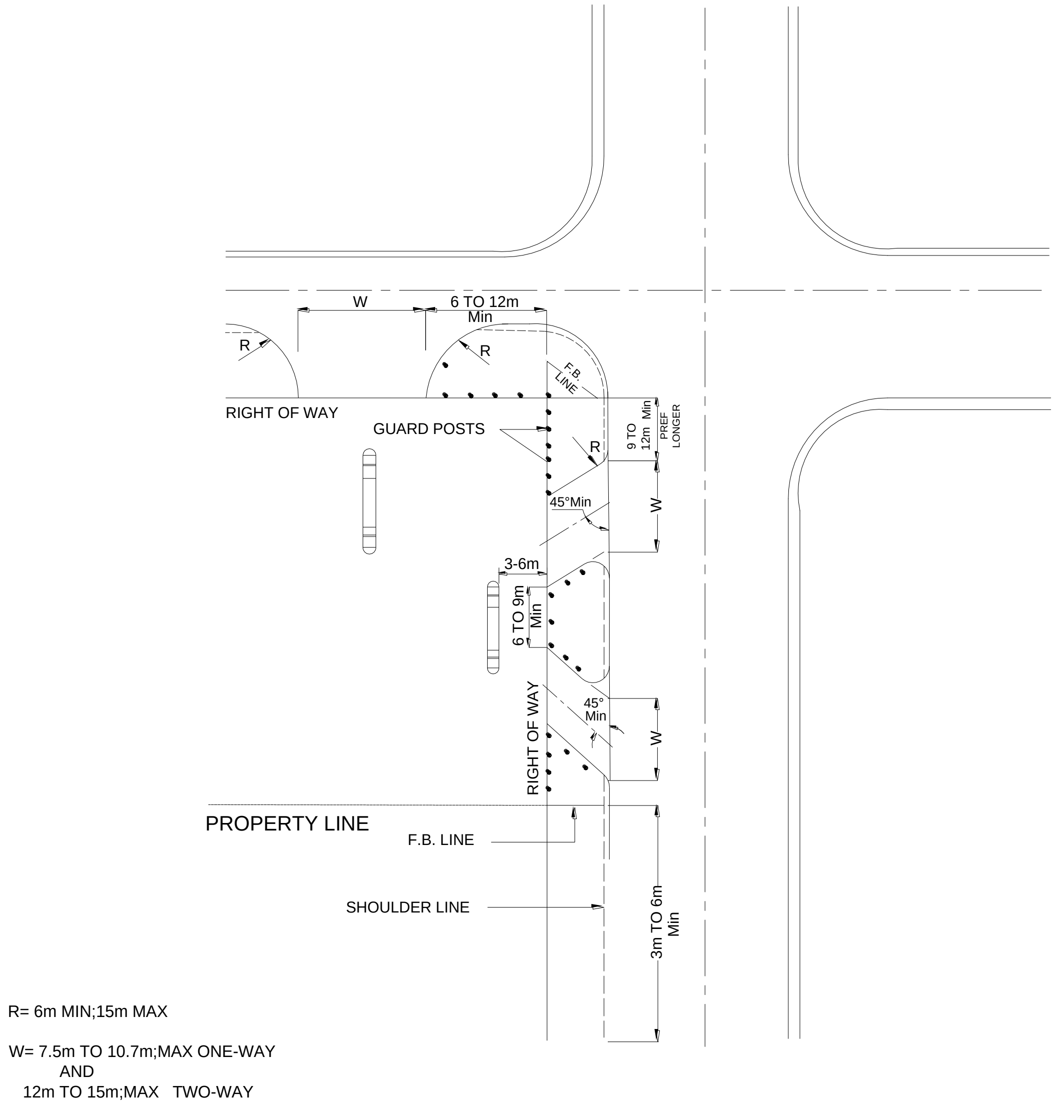


Figure 24: Petrol Station Entrance Locations - Double Driveways to a Corner Service Station Rural

9 Markers

9.1 Kilometre Markers

The standard kilometre post shown in Figure 25 shall be used to indicate kilometre distances along all Federal Trunk Roads, ‘Routes’. Except where pre-casting the foundation block is cheaper, the foundation block to standard kilometre posts shall be mass concrete.

All kilometre posts shall be painted white (non-reflective), with the letters and figures stencilled on them, preferably in green reflective paint. Where white reflective paint, and not green is available, kilometre posts shall be painted with white reflective paint with letters and figures stencilled on in black paint. Where neither green nor white reflective paint is available, kilometre posts shall be painted with non-reflective white paint with the letters and figures stencilled on in black. For ease in altering of information on kilometre posts, letters and figures shall not be engraved in the kilometre post.

Kilometre posts shall have inscriptions on both faces (A) and (B). The face of the kilometre post (A) or (B) seen by a road user looking forward while in motion shall give the road user the name of the town (in code letters if possible), at the end of the route in his direction of motion, and the number of kilometres his is from that town. For example, the town for kilometre posts for Trunk Route **R20** shall be Shagamu and Umu Uvo.

Kilometre posts shall be fixed on the right-hand side of the road and located just outside the outer edge of the shoulder. The distance of the nearest face of kilometre post from the outer edge of the ultimate outside lane of the road shall be no less than 3 metres.

Distance for kilometre post placement may be measured by survey odometer methods between the kilometre controls furnished. When the actual point of zero kilometres is difficult to determine (e.g. at interchanges), place the zero kilometre post as accurately as possible.

Where two or more routes are parallel along a section of highway, the kilometre post markers should reflect the kilometre of the major route. Coincident kilometres should be included for the minor route following a junction. Figure 25 shows the standard kilometre marker details.

9.2 Culvert Markers

Culvert markets serve two purposes: (a) they indicate the location of drainage structures and (b) alert maintenance crews of obstructions created by drainage structures which could interfere with maintenance equipment.

Culverts generally require two markers, one at each end of the culvert. They shall be set at the ends of the culvert, provided they are readily visible from the travelled way; otherwise they shall be placed adjacent to the shoulder and at least 1.8 metres from the outer edge of the travelled way.

When feasible, a culvert marker falling within a series of guide posts should be made a part of the installation. In such cases, it must be in line with the guide posts and their spacing adjusted to include the culvert marker. If the guide posts are reflectorized, the culvert markers shall be reflectorized.

In general, an under drain requires a marker. It is placed along the centre line of the drain, and opposite the outlet in the same manner as for culverts. Additional markers may be used, where the location of rodding eyes or manholes is not clearly apparent. In addition to the station mark, the abbreviation ‘Und’ should be shown on the culvert marker.

9.3 Special Markers

Special markers shall be used to mark special or experimental installations subject to periodic inspection which otherwise cannot be readily located. These markers shall be painted with a yellow top similar to the black top of a culvert marker, and shall show the stations mark on one side. A typical installation would be a marker both at the beginning and at the end of an experimental pavement section. In this case the word ‘begin’ or ‘end’ as the case may be, is shown together with the station or status kilometre. Other pertinent information may be added if feasible.

9.4 Right of Way Markers

The setting of right of way monument markers shall be the absolute minimum necessary to delineate the right of way, when such delineation is necessary and no other economical means exists. Where the right of way is adequately delineated by fences or other means, the right of way line shall not be delineated by markers. Where required, markers are ordinarily placed at breaks in the right of way line, at beginnings and ends of curves, and only at such intermediate points that are necessary.

When used, right of way markers shall preferably be of corrosive resistant metal. Concrete markers maybe used where metal markers are not feasible.

9.5 Highway Control Points

All projects, regardless of ultimate pavement type should have permanent monuments locating points of tangency and curvature for geometric control. These monuments serve as ready reference points for future surveys and for future improvements of the highway.

These monuments should be located out of the travelled way and their locations recorded in the alignment or construction notes.

Monuments locate alignment control points such as the PC and PT; they may also be placed at intermediate points on tangent (POT), to supplement other monuments. The monuments should be located in an offset line from the travel way which will give a clear line of sight. Normally, 4,5 metres from the outer edge of the travelled way will give less sight interference from signs, guardrails, speed change lanes, etc. Other offsets may be used to better fulfil requirements.

Every effort should be made to locate and preserve existing monuments. If destruction is unavoidable, notify the agency that established the monument and co-operate in every way to establish an approved alternate before attempting relocation or removal.

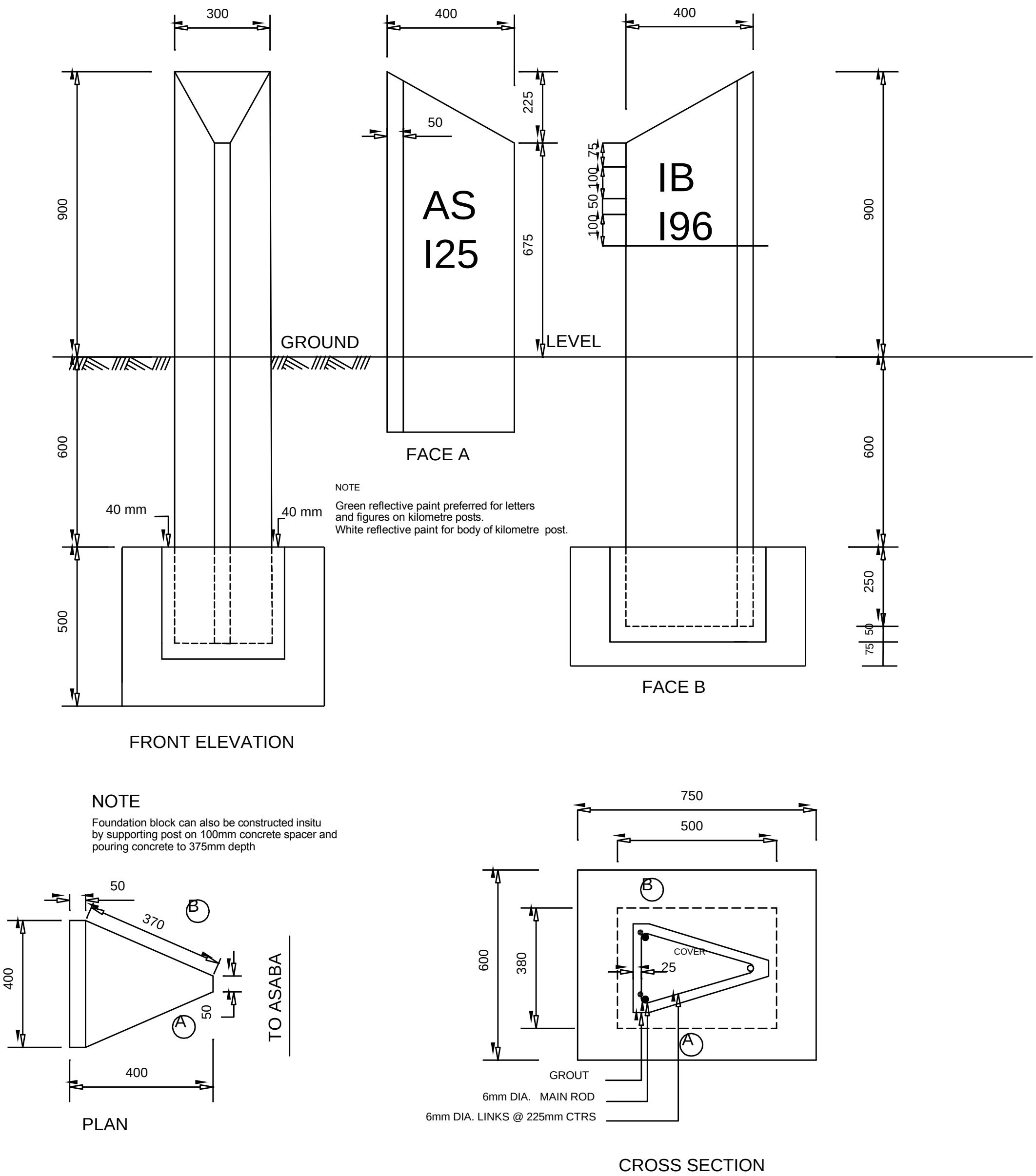


Figure 25: Standard Kilometre Post

10 Right of Way and Roadside Development

10.1 General

The primary purpose of protection of the Right of Way and roadside development is to create a harmonious integration of the highway corridor, and the environment through which it passes. The development of the highway corridor must be based not only on the functional aspect of highway geometrics, but also on aesthetic qualities as it relates to the highway user and the immediate environs.

The Environmental Process is exhaustively discussed in the Highway Manual Part I: Volume VII: Environmental Management, 2007. In this chapter, discussion is limited to protection of the Right of Way and those aspects that the designer should provide in the cross-section, to ensure that the appropriate environmental measures can be incorporated in the project.

The following paragraphs describe some of the elements to be considered in roadside development.

10.2 Right of Way

10.2.1 Protection of Right of Way for Safety and Free Traffic Flow

Recent developments have seen sections of highways becoming confused as market places and shopping streets. This has become a serious safety hazard, as well as creating a loss of efficiency as traffic on the highway is constrained and even halted while traders conduct business with drivers and passengers in vehicles. In considering designs for highways, provision must therefore be made for areas to be provided where such business can be safely conducted, and to introduce measures to prevent such business being conducted where safety is compromised, and where through traffic will be adversely affected.

Service roads through “market type areas” adjacent to the road must therefore be considered, which must be coupled with consideration of access across the highway (pedestrian or minor bridges or underpasses), coupled with additional fencing measures to channel pedestrian traffic in safe areas.

Assistance with controlling this aspect must be obtained from the police.

10.2.2 Right of Way Strips for Scenic Enhancement

Right of way for the purpose of scenic enhancement consists of areas outside the highway right of way. Rights to such areas may be secured by free easement. If an easement is to be used, it must clearly indicate the purpose thereof, and reserve to Government, the rights necessary for development required. The objective is to preserve existing natural amenities and to restore where practical, those lost through thoughtless development.

10.2.3 Screening of Unsightly Areas

Areas that are conspicuous by their ugliness, or detract from desirable amenities of the surroundings, should be given first priority as screening projects. All roadside areas should be studied to determine if it will be reasonable and practical to install, construct, or plant effective screenings. Consideration should be given to permanence of screening and maintenance requirements.

10.2.4 Abandoned Facilities

Often the roadsides of newly constructed and/or updated facilities will contain remnants of previous highway developments, such as short sections of roadways, drainage facilities, etc. These obsolete and abandoned elements shall be removed or obliterated so that they blend into the forms and textures of the normal roadside.

10.3 Erosion Control

Erosion control consists of all roadside work involved in the final shaping and rounding of earth slopes, salvaging and spreading of top soil, seeding, sodding, sprigging, mulching, liming, fertilizing and other treatments to restore construction areas to a natural and non-erosive condition.

Erosion control should be considered as the minimum roadside development required on all construction projects.

10.4 Landscaping

Although roadside planting has aesthetic value, this is incidental to highway safety and ease of maintenance. The following brief outlines describe the objectives of roadside planting.

- As erosion control measure, planting serves to protect side slopes, as well as to aid in the maintenance thereof.
- Planting in the median is a safety measure; it serves as a screen against glare from opposing headlights and discourages indiscriminate crossings. Certain types of planting also cushion and help stop an uncontrolled vehicle which leaves the travelled way.
- Certain types of planting assists in weed control and reduces a fire hazard.
- Planting in a developed area acts in a limited way, as an acoustical barrier which screens neighbouring property from traffic noise.
- When used to emphasize structures, planting is an additional safety measure.
- Planting improves appearance and screens off unsightly views.

Landscaping should also include preservation, selective clearing and thinning of desirable natural growth along the alignment.

10.5 Contour Grading

The most pleasing ultimate aesthetic roadside effects can best be developed with easy flowing contours. Contour grading is the most important factor in roadside preparation, erosion control and in the maintenance of planting. Contour grading plans may be required for certain areas to facilitate anticipated roadside treatment.

These plans should illustrate, among other things, the flattening of slope that irregular widths of right of way permit.

10.6 Side Slopes in Urban Areas

The right of way line should be the control for the side slopes, particularly on urban highways. This applies to irregular, as well as uniform right of way widths. The toe of the slope shall be at least 1.5 meters from the right of way line. Side slopes shall not be steeper than 2:1. The cost of stabilizing, planting and perpetual maintenance of steeper slopes may sometimes exceed the cost of the additional grading and right of way required to provide a flatter slope.

10.7 Borrow Pits

Borrow pits shall be sited such that sheet erosion shall be kept to a minimum and shall be self-silting. Generally, the sides shall be dressed to conform to the surrounding physical features. Where ponding is not objectionable, they may be hollowed out for rainwater storage provided the depth is not dangerous to people or animals. Otherwise they shall be drained. In no case shall borrow pits be located within the limits of the ultimate road section.

10.8 Excess Road Material

No excess road material shall be deposited permanently on the right of way, except at approved spoil sites. Excess fill or cut material shall be removed or spread out neatly to conform to the general profile.

11 Annex – Checklists for Road Safety Audits

These checklists are considered to be a recent compilation of accepted practice formulated by the Road Traffic Management Corporation of South Africa.

11.1 Stage 1 Road Safety Audit: Feasibility - Checklist

Items for Stage 1	Possible Issue
General Topics	
Project scope, function and mix of traffic	What is the function of the scheme?
	Is the design consistent with the function of the road?
	Does the project make adequate provision for: • Pedestrians • Passenger vehicles • Heavy vehicles • Buses • Other road users that will make use of the facility?
	Does the project make adequate provision for the expected traffic mix?
	Is the proposed project consistent with adjacent roads, land forms and traffic management?
Type and degree of access to property and developments	Is the degree of access control consistent with the function of the road and with other sections of the road?
	Will sight distances be satisfactory at intersections and property accesses?
	Is the design speed (or the anticipated vehicle speeds) compatible with the number and type of intersections or property accesses?
	Does the width of the road satisfy access needs?
Major traffic generators	Are all major traffic generators far enough away from the project or from intersections to avoid unsafe influences on the form of the design?
	Have existing or alternative accesses been arranged to ensure that existing sub-areas are not cut off by the project?
	Have existing or alternative accesses been arranged to ensure that existing sub-areas are not cut off by the project?
	Will the proposed scheme be consistent with adjacent roads, land forms and traffic management?

Items for Stage 1	Possible Issue
Staging requirements	Will this design be implemented in one stage only? If the design is to be implemented in more than one stage, has safety been given a high priority: • in transitions between stages? • in transitions to existing roads? Will the work avoid problems with safety standards elsewhere during construction?
Future works	Will the route be free of compromises in safety if there is to be; • future widening? • the addition of a complete second carriageway? • after realignments? • major geometric changes at intersections? • linear extensions of the scheme?
Wider network effects	Have all harmful safety effects of this scheme upon the surrounding road network been identified? Have they been adequately dealt with?
Design	
Route choice	Are all aspects regarding the location of the route and the alignment thereof safe? Does the project safely tie in with the existing road network? If the route is new, is the alignment safe? Could it be safer? Does the project safely fit in with the physical constraints of the landscape? Does the project design safely take account of the existing road network?
Consistency/ continuity with the existing road section/ network	Does the project pose any safety problems where it ties in with the adjacent road network/ sections?
General design standards	Were the appropriate design standards used with specific reference to: • The project scope? • Road users that will utilise/ be influenced by the project? • The traffic mix utilising the project? Does the geometric plan and profile meet design guidelines? Does the design meet the needs of the appropriate design vehicles? Does the proposed cross-section allow for providing a forgiving road side at the design speed?
Design speed	Is the design speed appropriate for: • Vertical and horizontal alignment • Sight distances and visibility

Items for Stage 1	Possible Issue
	• Merging • Weaving • Deceleration/ acceleration of traffic at controlled intersections/ accesses Are there any changes in the design speed/ posted speed limit? Are the design speed and speed limit appropriate? Is the sight distance safe enough at: • Intersections? • Interchange on and off ramps? • Accesses to properties? • Accesses for emergency vehicles? Is the design speed and posted speed limit reconcilable with each other?
Design traffic characteristics	Is the design appropriate for the: • Design volume • Design traffic characteristics (e.g. vulnerable road users and heavy vehicles) Does the design provide for the safe accommodation of:. • An increase in traffic volume if expected? • Changes in traffic characteristics?
Intersections	
Type and number	Are all aspects of the intersections (e.g. spacing, type, layout, etc.)appropriate with respect to: • The function of the road and intersecting roads • The broad concept of the project • The traffic mix on the roads and intersecting roads • Road users to use the project • Land-use adjacent to the project • Consistent with adjacent sections. Is the frequency of intersections appropriate: • For safe access? • To avoid impacts on the surrounding network? • For emergency vehicle access? Have all physical, visibility or traffic management constraints which would influence the choice and spacing of intersections been considered? Has the vertical and horizontal alignment of the intersecting road sections been taken into account in the design, layout and spacing of intersections? Are all the intersections essential or necessary? Can the number of intersections be reduced to improve safety? Can access safety be improved by changes on the

Items for Stage 1	Possible Issue
	surrounding road network?
	Is the angle of the intersecting road sections and sight lines safe for all road users?
	Is there adequate provision for the movement of vulnerable road users? Is there adequate provision for the movement of heavy vehicles?
Environmental Issues	
Physical characteristics of the terrain	Is the surrounding terrain free from physical or vegetation characteristics which could affect the safety of the project? (for example deep cuttings, steep or rocky bluffs, heavy planting or forestry that constrain the design)
	Do the gradients, curves and general design approaches fit in with the likely weather or environmental aspects of the terrain? (for example fog-prone areas)
	Are there any vegetation-related aspects that will reduce the safety of the project?
	Does the project deal safely with possible animal conflicts? (e.g. stray cattle & game)
	Has safety been considered in the location of environmental features like noise fences?
	Are visual distractions like scenic vistas safely dealt with?
	Has the issue of unstable countryside been considered? (e.g. mining subsidence)
Day-night time aspects	Has the effect of the angles of the sun at sunrise and sunset been considered?
	Will the safety of the project be satisfactory at night-time, when it is wet or there is fog?
Other	
Pedestrians	Are there any pedestrian pathways crossing the project?
	Has provision been made for pedestrian movement along these lines?
	Will the project cause the division of existing communities or cause separation of communities from basic commodities like water, firewood or retail facilities?
Driver perception	Can the proposed project be properly signed to allow the driver sufficient reaction and manoeuvre time to respond

Items for Stage 1	Possible Issue
	without information overload?
	Have possible constraints on information transfer to the driver been considered that may limit his safe and timeous response for the driving tasks?
	Will the driver ever be exposed to sudden darkness?
Miscellaneous	Has the possibility of flooding been dealt with?
	Have all railway level crossings been identified and treated adequately?
	Have other possible distractions like advertising or low-flying aircraft been identified and adequately dealt with?
	Has the need for facilities such as laybys, parking or rest areas or safe facilities for informal trading been considered and provided where required?
	Have all unusual or hazardous conditions associated with special events been considered?
	Has the risk implications of the transport of hazardous materials been considered?
	Has any safety or accident problems on the existing network been considered to ensure that they will not be transferred to the new facility?
	Has the need for providing lighting on the design been considered?
	Has the absence of electricity that will limit the use of lighting, warning signs or flashing signals been considered?
	Has the need for drivers to stop been considered (e.g. rest areas, truck parking, overload control, enforcement, etc.)?

11.2 Stage 2 Road Safety Audit: Draft (Preliminary) Design - Checklist

Items for Stage 2	Possible Issue
General	
Changes since previous audit	Do the conditions for which the original planning had been done, still apply (e.g. no changes to the surrounding network, area activities or traffic mix)?
	Has the general form of the project design remained unchanged since the previous audit, (if any)?
Drainage	Will the project drain adequately?
	Has the probability of surface flooding or overflowing of drainage from adjacent drainage features from adjacent roads, intersecting drains or water courses been considered?
	Are there any environmental/ vegetation/ other effects that will hamper the functioning of drainage inlets (e.g. sugar cane blocking inlets)?
Climate	Has consideration been given to weather records or local experience that may indicate problems related to adverse weather conditions such as snow, fog, etc. typical in the area?
Landscaping	If landscaping proposals are available, how will they affect the safety of the project (e.g. inter-visibility of drivers and pedestrians, sight lines, shade/ sun interplay on the road and hazards in the clear zones)?
Services	Does the design adequately deal with buried and overhead services, especially overhead clearances on roads in super- elevation, etc.?
	Has the location of fixed objects or furniture associated with services been checked, including the location of specific poles
	Do any of the services intrude in the right of way of other road users (e.g. poles located on the sidewalks, etc.)?
Access to property and developments	Can all accesses be used safely?
	Is the design free from any downstream or upstream effects from points of access, particularly near intersections?
	Have truck parking and rest area accesses been checked for adequate sight distance, etc.?
Adjacent land-use	Will the project accommodate the traffic generated by adjacent developments and the adjacent road network safely?
	Is the design reconcilable with driver expectancy from the lighting and traffic signals provided on the adjacent road section/intersection/network?
	Does the design make provision for special road users that are generated by adjacent land-uses and the existing road network?
	Are there any land-use issues that will have an effect on

Items for Stage 2	Possible Issue
	the safety of the project?
Emergency vehicles and access	Has provision been made for safe access and movement by emergency vehicles (e.g. fire brigade trucks)? Does the design and position of medians and vehicle barriers allow emergency vehicles to stop and turn without unnecessarily disrupting traffic or being exposed to danger?
Future Planning	If widening is planned: • Are drivers adequately guided by the design? • Are drivers adequately informed by signage? Is the possible transition between a single and dual carriageway (both directions) being handled safely?
Project Phasing	If the project is to be constructed/implemented in different phases: • Are the phasing details adequate to ensure safety? • Is the phasing programming safe? • Are there measures to accommodate temporary traffic management between the different phases? If the construction is to be split into different contracts, are they arranged safely?
Maintenance	Can routine maintenance vehicles be safely located?
Design	
Design Standards (General)	Is the design speed and proposed posted speed limits appropriate for the terrain and function of the road? Are they appropriate for the design vehicles and the road users? Is the design speed reconcilable with the expected operational speed? Has the appropriate design vehicle/s been used (specifically also for possible constraining turning movements)?
Typical cross-sections	Are the cross-section features such as widths of lanes and shoulders, medians, etc. adequate for the function of the project? Do the cross-section features conform to the requirements set for design for safety? Are lane and shoulder widths appropriate for: • The alignment? • Road users? • The vehicles that will utilise the project? • The operating speeds? • The combinations of speed and volume? Are overtaking/ climbing/ crawler lanes provided if

Items for Stage 2	Possible Issue
	needed? • Have adequate clear zones been provided?
Variations in cross-sections	Are there any variations in cross-section that will influence safety negatively? Are the cross-falls safe (particularly where sections of existing roadways are used or accesses accommodated)? Are there any unsafe compromises such as sudden narrowing at existing bridges
Layout of roadway	Do the traffic management features: • Create unsafe conditions? • Provide adequate warning or guidance? Do the road signs and markings provide adequate warning and guidance at locations where the alignment is substandard or changing (also under night-time or low visibility conditions)?
Shoulders and edge treatment	Are .the following safety aspects of shoulder provision satisfactory • Provision of surfaced or un-surfaced shoulders? • Width and treatment on embankments? • Cross-fall of shoulders? Are the shoulders likely to be safe when used by slow moving vehicles or cyclists? Are any rest areas or truck parking areas designed safely?
Cut-and-fill	Are there any geological characteristics of the cut-and fill of the project that will endanger road users?
Deviations from and changes to standard design guidelines and standards	Do any of the deviations from accepted design guidelines or standards reduce the safety performance of the project?
Alignment	
Vertical and horizontal alignment	Does the horizontal and vertical alignment fit together appropriately? Does the vertical and horizontal alignment guide a driver accurately - is it free of visual clues that would cause the driver to misread the road characteristics? Is the vertical and horizontal alignment conducive to consistent operating speed?
Visibility and sight distance	Does the vertical and horizontal alignment provide the required sight distance and visibility? Are there any of the following objects or structures present that will obstruct sight lines or reduce sight distance that will have an adverse effect on safety: • Fencing? • Traffic barriers? • Street furniture (including trash bins)?

Items for Stage 2	Possible Issue
	• Services? • Parking facilities? • Signs? • Landscaping/ vegetation? • Bridge abutments? Are all hazards such as bridge abutments noticeable? Is there any local feature that will obstruct sight lines? Are railway crossings, bridges, intersections and other hazards clearly visible under daytime and night time driving?
Transition between project and existing adjacent road section/ intersection network	Does the transition from existing to new (and opposite) occur well away from any hazardous condition like the following: • Speed differences? • Differences in access provision? • Geometry (e.g. is it on a curve or a crest where the visibility is poor/ where the driver is likely to be distracted)? • Differences in design standards? • Differences in the physical features of the environment (e.g. for example from lit to unlit, rural to urban)? • Differences in the posted speed limit? Is adequate advance warning provided where required?
Other:	
Parking	Is on-site parking planned to minimise on-street parking? Can on-street parking be provided safely? If not, are measures provided to prevent it?
Intersections	
Visibility of intersection	Do the horizontal and vertical alignments at the intersection or on the approach to the intersection, allow safe forward visibility to the intersection and inter-visibility between the main road and the intersecting road/s? Will drivers be aware of the presence of the intersection and the control thereof? (Especially approaching on the minor road) and will they be able to react safely to it? Are there any of the following temporary features present that will obstruct sight lines: • Parked vehicles? • Public transport facilities/lay-bys? • Queuing vehicles? • Heavy vehicle loading zones?
Layout and traffic control	Are the following appropriate for the function of the two intersecting roads:

Items for Stage 2	Possible Issue
	Layout (e.g. crossroad, T-junction, roundabout, interchange)?
	Traffic control type (e.g. signalisation, Stop or Yield control)?
	Will the layout or traffic control have a negative safety impact on special road users such as: • Pedestrians? • Vulnerable road users? • Cyclists? • Heavy vehicles?
	Does the layout make provision for all design vehicles that will utilise the intersection (e.g. turning radii, swept paths of vehicles, lane widths, etc)?
	Where a roundabout is proposed: • Have cyclist movements been considered? • Have pedestrian movements been considered? • Are the details pertaining to the circulating roadway sufficient?
	Will the layout 01' traffic control affect the safety of public transport facilities (if planned)? • Is the design free from any upstream or downstream geometric features that could affect safety (e.g., lane merges)?
	Are the approach speeds on the intersecting road sections safe?
Readability by drivers	Will the general type, function and broad features be perceived correctly by the drivers?
	Are the approach speeds and likely positions of vehicles as they track through the intersection safe?
	Do successive intersections violate driver expectancy because of inconsistencies?
	Does the driver get sufficient time to perceive the upcoming situation, decide upon a course of action, prepare for and execute the necessary actions safely?
	Does the design provide for erroneous decisions?
	Is the design free from possible sunrise and sunset problems that may create a hazard?
	Will the driver experience glare from oncoming vehicles or from road lighting?
	Is the driver ever exposed to sudden darkness?
Special Road Users	
Pedestrians	Is the design safe for pedestrians?
	Is there a need for the provision of pedestrian crossings?
	Are pedestrian crossings provided along desire lines?

Items for Stage 2	Possible Issue
	Is there a need for paved footpaths? If not planned, where will the pedestrians walk and will it be safe enough?
	Is the carriageway widened to provide for pedestrian movement and can pedestrians utilise this safely?
	Is there a need for pedestrian refuge islands and are they wide enough to ensure safety?
	Is the expected operational speed appropriate for the pedestrian facilities that are provided?
	Is there a need for the special provision of facilities for vulnerable road users such as children and the elderly?
Cyclists and motorcyclists	Is consideration being given to the needs of cyclists and motorcyclists?
	Are bicycle lanes needed or can shared pedestrian-cycle facilities be implemented?
	Is the roadside forgiving in areas more prone to run off the road accidents by motorcyclists?
Animals Heavy vehicles	Is there a need to make provision for stock or equestrians?
Heavy vehicles	Does the design make provision for the limitations of heavy vehicles (e.g. longer stopping distance, etc.)?
	Does the design consider safe gradients for heavy vehicles?
	If in mountainous terrain, are any arrestor bed facilities required for the design?
	Are they provided or can a modification of the design eliminate the need?
	Should rest areas be provided? If planned, can they be used safely? Are safe heavy vehicle loading facilities provided where required?
	Is provision made for the safe manoeuvring of heavy vehicles where necessary?
Public Transport	Is safe provision made for public transport facilities where needed?
	Is provision made for the safe movement of pedestrians to, at and from the public transport facilities (e.g. Are sufficient space available for passengers alighting from buses)?
Maintenance vehicles and crews	Can maintenance vehicles and crews be safely accommodated after implementation of the project?
Road Traffic Signs and Lighting	
Road signs	Can the project be provided with direction signs in an unambiguous manner?
	Are the road signs adequate to provide for driver needs (guidance, control and warning)
	Will the road signs be visible and readable (review special needs for appropriate night-time reflectivity)?
	Is the amount of reflectivity adequate/ excessive, i.e.

Items for Stage 2	Possible Issue
	blinding the driver?
	Will any of the road signing limit the visibility or sight lines at accesses or intersections?
	Will any of the road signing pose a safety hazard to errant vehicles?
	Was provision made to reduce the severity of such crashes?
	Were road signs placed with due cognisance of road safety?
Road markings	Are the planned road markings adequate in terms of safety?
	Are there any road elements that will require the provision of road studs for visibility at night-time (e.g. raised median islands etc)?
	Is the transition of road markings between the project and the existing adjacent road section/ intersection/ network safe?
Road lighting	Should road lighting be provided for this project? If lit, will safety still be maintained in the case of a break in power supply?
	Are there any special needs created by ambient lighting and will safety be maintained if such special features are not provided?
	Was due cognisance taken of features such as trees, over-bridges, etc. that will affect the installation of road lighting?
	Does the road lighting pose a roadside hazard?
	Is the road user adequately protected from colliding with lighting poles?
	If traffic barriers are used for this purpose, are they properly located or installed to ensure improved safety and will they function as intended?
Traffic Operations and Construction	
Traffic flow	Will the traffic flow of the project have a negative influence on the safety of adjacent road network/ developments?
	Was adequate consideration given to parking control features?
	Can exclusive turning lanes and deceleration lanes be used safely?
	Will the project cause or contribute to the movement of traffic at high speeds through residential areas *(rat-running)?*
Access management	Was adequate consideration given to the possible provision of accesses of future developments in or adjacent to the project?
	Are the existing and proposed accesses in the road project safe to use? Will any up-or downstream effects reduce the safety of an access, particularly those located close to intersections?

Items for Stage 2	Possible Issue
Merging and Overtaking	Are adequate shoulder widths provided during and after lane merges?
	Is adequate overtaking sight distance and stopping distance provided?
	Is advance warning provided for lane merging?
	Is proper sight distance provided for lane merging?
Rest areas and stopping facilities	Are sufficient stopping and rest areas provided?
	Are safe access provided to rest areas and stopping facilities?
	Is the sight distance and access design for accesses to rest areas safe?
Construction	If the project is to be constructed "under traffic," can this be done safely as far as the construction is concerned, as well as the extent to which the general travelling public will be affected?
	Are there any elements of the project that will hamper the safe construction of the project (e.g. construction vehicle routes and interaction with general public traffic)?
	Can safe access be provided for construction vehicles? Are there any features of the project that will require special traffic management during construction, phasing or any period before implementation?
OTHER ISSUES	
Roadside hazard management	Are there any roadside hazards that can be: • Redesigned • Relocated • Protected by traffic barriers? • Made breakaway?
	Are traffic barriers adequate for the design vehicles of the project?
	Are safe end-treatments provided?
Incident management	Can traffic barriers be safely maintained?
	Will they function as was intended?
	Is adequate deflection distance provided for guardrail and cable systems?
	Can traffic be safely accommodated during an incident?
	Is safe access possible for emergency vehicles?
	In the case of fixed medians, does the project provide for the safe stopping and turning of emergency vehicles?
Tourism/ recreation	Are there any safety requirements for the accommodation of tourism or recreation facilities?
	Have all unusual or potentially hazardous conditions associated with special events been considered? If required, can the road be closed in a safe manner?

11.3 Stage 3 Road Safety Audit: Detailed Design - Checklist

Items for Stage 3	Possible Issue
GENERAL	
Changes since previous audit	Do the conditions for which the draft design had been done, still apply (e.g. no changes to the surrounding network, area activities or traffic mix)?
	Has the general form of the project design remained unchanged since the previous audit, (if any)?
Drainage	Will the project drain adequately?
	Has the probability of surface flooding or overflowing of drainage from adjacent drainage features from adjacent roads, intersecting drains or water courses considered?
	Are there any environmental/ vegetation/ other effects that will hamper the functioning of drainage inlets (e.g. sugar cane blocking inlets)?
Climate	Has consideration been given to weather records or local experience that may indicate problems related to adverse weather conditions such as snow, fog, etc. typical in the area?
Landscaping	If landscaping proposals are available, how will they affect the safety of the project (e.g. inter-visibility of drivers and pedestrians, sight lines, shade/ sun interplay on the road and hazards in the clear zones)?
	Will landscaping proposals introduce road side hazards when the vegetation matures?
Services	Does the design adequately deal with buried and overhead services, especially overhead clearances on roads in super-elevation, etc.?
	Has the location of fixed objects or furniture associated with services been checked, including the location of specific poles?
	Do any of the services intrude in the right of way of other road users (e.g. poles located on the sidewalks, etc.)?
Access to property and developments	Can all accesses be used safely?
	Is the design free from any downstream or upstream effects from points of access, particularly near intersections?
	Have truck parking and rest area accesses been checked for adequate sight distance, etc.?
Adjacent land-use	Will the project accommodate the traffic generated by adjacent developments and the adjacent road network safely?
	Is the design reconcilable with driver expectancy from the lighting and traffic signals provided on the adjacent road section/intersection/network?
	Does the design make provision for special road users that are generated by adjacent land-uses and the existing road network?

Items for Stage 3	Possible Issue
	Are there any land-use issues that will have an effect on the safety of the project?
Emergency vehicles and access	Has provision been made for safe access and movement by emergency vehicles (e.g. fire brigade trucks)?
	Does the design and position of medians and vehicle barriers allow emergency vehicles to stop and turn without unnecessarily disrupting traffic or being exposed to danger?
	Will broken down vehicles or stopped emergency vehicle be safe from passing traffic?
	Have median breaks been safely provided on dual carriageway roads (e.g. frequency, visibility, usage constraints, signage)?
Future Planning	If widening is planned: • Are drivers adequately guided by the design? • Are drivers adequately informed by signage?
	Is the possible transition between a single and dual carriageway (both directions) being handled safely?
Project Phasing	If the project is to be constructed/implemented in different phases: • Are the phasing details adequate to ensure safety? • Is the phasing programming safe? • Are there measures to accommodate temporary traffic management between the different phases?
	If the construction is to be split into different contracts, are they arranged safely?
	Do construction plans and programme for staged construction include specific safety measures for temporary arrangements?
Maintenance	Can routine maintenance vehicles be safely located?
Skid Resistance	Has the need for anti-skid surfacing been considered, and provided for, in areas where improved braking and road adhesion is essential?
Design	
Design Standards (General)	Is the design speed and proposed posted speed limits appropriate for the terrain and function of the road? Are they appropriate for the design vehicles and the road users?
	Is the design speed reconcilable with the expected operational speed?
	Has the appropriate design vehicle/s been used? (specifically also for possible constraining turning movements)
Drainage	Does the cross section provide safe drainage parallel and perpendicular to the road (e.g. are the side slopes of the concrete drain such that errant vehicles can recover after entering)?

Items for Stage 3	Possible Issue
	If concrete side drains pose a risk of trapping vehicles, has provision been made for guard rails?
	Are concrete head walls perpendicular to the main road sloped to reduce the impact on an errant vehicle?
	Is the design of grid inlets such that it does not pose a danger to cyclists?
	Are kerb inlets set back from the face of guard rails?
Typical cross-sections	Are the cross-section features such as widths of lanes and shoulders, medians, etc. adequate for the function of the project?
	Do the cross-section features conform to the requirements set for design for safety?
	Are lane and shoulder widths appropriate for: • The alignment? • Road users? • The vehicles that will utilise the project? • The operating speeds? • The combinations of speed and volume?
	Are overtaking/ climbing/ crawler lanes provided if needed?
	Have adequate clear zones been provided?
	Are batter slopes safe for errant vehicles?
	Does the median allow street furniture to be located safely?
	Does the verge design allow the safe installation of ground mounted or overhead structures?
	Has provision been made for side- walks and for the safe handling of pedestrians and cyclists (including full width dropped kerbs at pedestrian crossings)?
Super-elevation	Is the super-elevation consistent with the design speed and type of road?
	Will changes in super-elevation at operating speeds result in the possible shifting of freight on heavy vehicles?
	Are there any curves with adverse cross-fall?
Variations in cross-sections	Are there any variations in cross-section that will influence safety negatively?
	Are the cross-falls safe (particularly where sections of existing roadways are used or accesses accommodated)?
	Are there any unsafe compromises such as sudden narrowing at existing bridges?
Layout of roadway	Do the traffic management features: • Create unsafe conditions? • Provide adequate warning or guidance?
	Do the road signs and markings provide adequate warning and guidance at locations where the alignment is

Items for Stage 3	**Possible Issue**
	substandard or changing (also under night-time or low visibility conditions)? Are overtaking/ climbing/ crawler lanes provided where needed? Are they properly signed and marked at the start and end of these lanes
Shoulders and edge treatment	Are .the following safety aspects of shoulder provision satisfactory • Provision of surfaced or un-surfaced shoulders? • Width and treatment on embankments? • Cross-fall of shoulders(to allow use of shoulder as recovery area)? Are the shoulders likely to be safe when used by slow moving vehicles or cyclists? Are shoulder widths sufficient for stationary vehicles? Are any rest areas or truck parking areas designed safely?
Cut-and-fill	Are there any geological characteristics of the cut-and fill of the project that will endanger road users? Is the stability of slopes safe to ensure that debris or loose material does not collect on the road or that an embankment remains stable?
Deviations from and changes to standard design guidelines and standards	Do typical details used on the project reflect road safety best practices and have they been reviewed for applicability to this particular project? Do any of the deviations from accepted design guidelines or standards reduce the safety performance of the project?
Alignment	
Vertical and horizontal alignment	Does the horizontal and vertical alignment fit together appropriately? Does the vertical and horizontal alignment guide a driver accurately - is it free of visual clues that would cause the driver to misread the road characteristics? Is the vertical and horizontal alignment conducive to consistent operating speed? Is the design free from misleading visual clues?
Visibility and sight distance	Does the vertical and horizontal alignment provide the required sight distance and visibility? Are there any of the following objects or structures present that will obstruct sight lines or reduce sight distance that will have an adverse effect on safety: • Fencing? • Traffic barriers? • Street furniture (including trash bins)? • Services? • Parking facilities?

Items for Stage 3	Possible Issue
	• Signs? • Landscaping/ vegetation? • Bridge abutments?
	Are all hazards such as bridge abutments noticeable?
	Is there any local feature that will obstruct sight lines?
	Are railway crossings, bridges, intersections and other hazards clearly visible under daytime and night time driving?
	Is the design free from overhead obstructions that may restrict sight distance in sag curves or forward sight distance towards overhead mounted road traffic signs?
	Has minimum sight distance been provided at: • Entry and exit ramps? • Gore areas? • Intersections? • Roundabouts? • Other possible conflict points?
Transition between project and existing adjacent road section/ Intersection/ network	Does the transition from existing to new (and opposite) occur well away from any hazardous condition like the following: • Speed differences? • Differences in access provision? • Geometry (e.g. is it on a curve or a crest where the visibility is poor/ where the driver is likely to be distracted)? • Differences in design standards? • Differences in the physical features of the environment (e.g. for example from lit to unlit, rural to urban)? • Differences in the posted speed limit?
	Is adequate advance warning provided where required?
Other:	
Parking	Is on-site parking planned to minimise on-street parking?
	Can on-street parking be provided safely?
	If not, are measures provided to prevent it?
Public Transport	Has the need for public transport facilities been considered and implemented in a manner that would allow safe ingress and egress to possible bus stops?
Intersections	
Readability by drivers	Will the general type, function and broad features be perceived correctly by the drivers?
	Are the approach speeds and likely positions of vehicles as they track through the intersection safe?
	Do successive intersections violate driver expectancy

Items for Stage 3	Possible Issue
	because of inconsistencies? Does the driver get sufficient time to perceive the upcoming situation, decide upon a course of action, prepare for and execute the necessary actions safely? Does the design provide for erroneous decisions? Is the design free from possible sunrise and sunset problems that may create a hazard? Will the driver experience glare from oncoming vehicles or from road lighting? Is the driver ever exposed to sudden darkness?
Visibility of intersection	Do the horizontal and vertical alignments at the intersection or on the approach to the intersection allow safe forward visibility to the intersection and inter-visibility between the main road and the intersecting road/s? Will drivers be aware of the presence of the intersection and the control thereof (especially approaching on the minor road) and will they be able to react safely to it? Are there any of the following temporary features present that will obstruct sight lines: • Parked vehicles? • Public transport facilities/lay-bys? • Queuing vehicles? • Heavy vehicle loading zones?
Layout and traffic control	Are the following appropriate for the function of the two intersecting roads: Layout (e.g. crossroad, T-junction, roundabout, interchange)? Traffic control type (e.g. signalisation, Stop or Yield control)? Will the layout or traffic control have a negative safety impact on special road users such as: • Pedestrians? • Vulnerable road users? • Cyclists? Heavy vehicles? Does the layout make provision for all design vehicles that will utilise the intersection (e.g. turning radii, swept paths of vehicles, lane widths, etc)? Is the design free from any upstream or down- stream geometric features that could affect safety (e.g. lane merges)? Is there a need for traffic barriers? Will their use result in the reduction of the severity of injuries? Have islands been provided to clarify special movements and to provide refuge for pedestrians? Are the approach speeds on the intersecting roads safe? Are sufficient queue lengths/storage for turning movements available?

Items for Stage 3	Possible Issue
	Will the layout or traffic control affect the safety of the public transport facilities (if planned)?
Roundabouts	Where a roundabout is proposed: • Have cyclist movements been considered? • Have pedestrian movements been considered? • Are the details pertaining to the circulating roadway sufficient? Is adequate deflection provided to reduce approach speeds? If splitter islands are required, are they adequate for sight distance, length, pedestrian storage, etc? Is the central island prominent and does it limit see-through? Can pedestrians be seen early enough by drivers? Can pedestrians determine if vehicles would be turning in conflicting movements? Are direction markings provided in approach lanes where needed? Is lighting at the roundabouts adequate and are the lighting columns in safe locations?
	Are the approach speeds on the intersecting road sections safe?
Geometric design details	Can the layout safely handle unusual traffic mixes or circumstances? Does any median or island safely provide for: • Vehicle alignments and paths? • Future traffic signals? • Pedestrian storage and surface? • Turning path clearance? • Stopping sight distance to the nose? • Mountability by errant vehicles?
Special Road Users	
Pedestrians	Is the design safe for pedestrians? Is there a need for the provision of pedestrian crossings? Are pedestrian crossings provided along desire lines? • Visibility (in each direction)? • Use by the disabled? • Use by the elderly? • Use by children/ schools? Is there a need for paved footpaths? If not planned, where will the pedestrians walk and will it be safe

Items for Stage 3	Possible Issue
	enough?
	Is the carriageway widened to provide for pedestrian movement and can pedestrians utilise this safely?
	Is there a need for pedestrian refuge islands and are they wide enough to ensure safety?
	Is the expected operational speed appropriate for the pedestrian facilities that are provided?
	Has pedestrian fencing been provided on medians or complex intersection layouts to reduce jay-walking?
	Is the surfacing of pedestrian walkways appropriate?
	Has tactile edging been provided at pedestrian crossings to assist the disabled?
Cyclists and motorcyclists	Has consideration being given to the needs of cyclists and motorcyclists?
	Are bicycle lanes needed or can shared pedestrian-cycle facilities be implemented?
	Has the location of devices or objects that could destabilise a motorcyclist on the road surface been avoided?
	Is the road side clear of obstructions where a motorcyclist may lean into curves?
	Is the roadside forgiving in areas more prone to run off the road crashes by motorcyclists?
	Are drainage grids, culverts and bridge expansion joints traversable by a motorcycle?
Heavy vehicles	Does the design make provision for the limitations of heavy vehicles (e.g. longer stopping distance, etc.)?
	Does the design consider safe gradients for heavy vehicles?
	If in mountainous terrain, are any arrestor bed facilities required for the design? Are they provided or can a modification of the design eliminate the need?
	If there are height restrictions, have alternative routes been provided and properly signed for use by such oversize vehicles?
	Should rest areas be provided? If planned, can they be used safely? Are safe heavy vehicle loading facilities provided where required?
	Is provision made for the safe manoeuvring of heavy vehicles where necessary?
Public Transport	Is safe provision made for public transport facilities where needed?
	Is provision made for the safe movement of pedestrians to, and from the public transport facilities (e.g. Are sufficient space available for passengers alighting from buses)?
Maintenance vehicles and crews	Can maintenance vehicles and crews be safely accommodated after implementation of the project?
Animals Heavy vehicles	Is there a need to make provision for stock or equestrians (e.g. animal underpasses)?

Items for Stage 3	Possible Issue
Road Traffic Signs and Lighting	
Road signs	Can the project be provided with direction signs in an unambiguous manner?
	Do signs comply with the standards prescribed in legislation and as set out in the Highway Code and erected in compliance with the Highway Manual?
	Are the road signs adequate to provide for driver needs (guidance, control and warning)? Have the necessary advance warning signs been provided, including advisory speeds for hazardous conditions as well as hazard marker plates?
	Does the design overly rely on signs to be effective (in lieu of appropriate geometric design)?
	Are all physical obstructions properly signed to identify them as hazards?
	Will the road signs be visible and readable with sufficient time for the driver to read, consider options, prepare to manoeuvre and act on the information in a timely and safe manner (review special needs for appropriate night-time reflectivity)?
	Is the amount of reflectivity adequate/ excessive, i.e. blinding the driver?
	Will any of the road signing limit the visibility or sight lines at accesses or intersections?
	Will any of the road signing pose a safety hazard to errant vehicles?
	Was provision made to reduce the severity of such crashes?
	Were road signs placed with due cognisance of road safety?
Road markings	Are the planned road markings adequate in terms of safety?
	Do road markings comply with the legislation, the Highway Code and the Highway Manual?
	Have no overtaking line markings been provided where required?
	Have guideline markings and painted islands been provided to clarify movements in complex layouts?
	Has attention been given to the improvement of wet weather visibility of markings in critical locations?
	Has the need for profiled markings been considered and implemented in the design?
	Are there any road elements that will require the provision of road studs for visibility at night-time (e.g. raised median islands etc)?
	Is the transition of road markings between the project and the existing adjacent road section/ intersection/ network safe?
Traffic Signals	Has the most appropriate signal phasing system been selected for the project? Is the system consistent with

Items for Stage 3	Possible Issue
	that on the adjoining sections of road?
	Are the traffic signal heads visible, i.e. are there any features such as trees, lighting, signage etc. that may prevent drivers approaching the intersection from seeing the signals?
	Are there any signal aspects visible near or within the intersection that may confuse drivers?
	Will the intersection be affected by sunrise/ sunset problems? Is provision made for this in the form of backboards, louvers or high intensity signals?
	Does the vertical alignment on the approaches allow for sufficient stopping distances?
	Is the signal phasing clear to the driver?
	Does the phasing conform to the safety requirements set for the amber and all-red periods?
	Are pedestrians considered in the planned signal phasing?
	If islands are located in the path of the pedestrian, is the size of these sufficient to act as a refuge island?
Road lighting	Should road lighting be provided for this project? If lit, will safety still be maintained in the case of a break in power supply?
	Are there any special needs created by ambient lighting and will safety be maintained if such special features are not provided?
	Was due cognisance taken of features such as trees, over-bridges, etc. that will affect the installation of road lighting?
	Does the road lighting pose a roadside hazard?
	Is the road user adequately protected from colliding with lighting poles?
	If traffic barriers are used for this purpose, are they properly located or installed to ensure improved safety and will they function as intended?
	Has lighting been provided at locations with known crash history?
Roadside Hazard Management	
Roadside hazards	Are there any roadside hazards that can be • Redesigned • Relocated • Protected by traffic barriers? • Made breakaway?
Traffic Barriers/ crash barriers	Are traffic barriers provided where necessary and properly detailed for use at structures, embankments, trees, poles/ posts, drainage channels, bridge piers and gore areas at off ramps?
Traffic barriers/ crash barriers (including wire rope systems)	Are proper deflection distances provided between the traffic barrier and the roadside hazard if flexible traffic

Items for Stage 3	Possible Issue
	barrier systems are used?
	Are all end treatments safe if hit by a vehicle? Will the traffic barrier pose a danger to any of the road users (also pedestrians and motorcyclists)?
	Was the movement of pedestrians considered in the location and placement detail of the traffic barrier systems?
	If guardrail barrier systems are provided, are the design and details safe in terms of: • End-treatment? • Anchorage? • Post spacing? • Block outs? • Post depth? • Soil stability? • Rail overlap?
	Are all traffic barriers necessary (e.g. is what it is shielding a greater hazard than the barrier)?
Bridges and drainage structures	Are bridges and culvert end walls visible and easily recognised?
	Is horizontal clearance to moving traffic adequate?
	Are sight lines through bridge railing sufficient for safety purposes?
	Are end treatments safe?
	Are road traffic signs and markings installed to warn of possible hazards?
	Are the transitions between different traffic barrier system types safe (approach traffic barrier to bridge parapet)?
	Are there differences in the shoulder widths of the approaches and on the bridge?
	Is provision made for the movement of non-vehicular traffic such as pedestrians, horses/ stock over the bridge?
	Does the bridge railing conform to the requirements set for safe traffic barriers in terms of rail height, containment and the fixing detail to the bridge?
	Do traffic barriers adequately protect dangerous culvert structures?
	Are there any headwalls present within the clear zone?
	Are they adequately protected or can the culverts be extended to place the end walls outside the clear zone?
	Is adequate warning sign age and sight distance provided at flood ways/ causeways?
Median barriers	Was the need for median barriers considered and adequately provided for?
	Is the design and median barrier type adequate for the particular application (e.g. design vehicle, median width,

Items for Stage 3	Possible Issue
	maintenance requirements etc.)?
	Are the details for the location and installation of traffic barriers correct?
	Are the end-treatments safe?
Traffic Operations	
Traffic flow	Will the traffic flow of the project have a negative influence on the safety of adjacent road network/ developments?
	Was adequate consideration given to parking control features?
	Can exclusive turning lanes and deceleration lanes be used safely?
	Will the project cause or contribute to the movement of traffic at high speeds through residential areas *(rat-running)?*
Access management	Was adequate consideration given to the possible provision of accesses of future developments in or adjacent to the project?
	Are the existing and proposed accesses in the road project safe to use?
	Will any up-or downstream effects reduce the safety of an access, particularly those located close to intersections?
Merging and Overtaking	Are adequate shoulder widths provided during and after lane merges?
	Is adequate overtaking sight distance and stopping distance provided?
	Is advance warning provided for lane merging?
	Is proper sight distance provided for lane merging?
Rest areas and stopping facilities	Are sufficient stopping and rest areas provided?
	Are safe access provided to rest areas and stopping facilities?
	Is the sight distance and access design for accesses to rest areas safe?
Construction	If the project is to be constructed "under traffic," can this be done safely as far as the construction is concerned, as well as the extent to which the general travelling public will be affected?
	Are there any elements of the project that will hamper the safe construction of the project (e.g. construction vehicle routes and interaction with general public traffic)?
	Can safe access be provided for construction vehicles? Are there any features of the project that will require special traffic management during construction, phasing or any period before implementation?
Accommodation of Traffic	

Items for Stage 3	Possible Issue
Construction	If the project is to be constructed "under traffic," can this be done safely as far as the construction is concerned, as well as the extent to which the general travelling public will be affected? Have innovative or accelerated construction techniques been considered to reduce the exposure of the public to restrictive construction conditions? Have different phasing options been considered? Are there any features of the project that will require special traffic management during construction phases or any period before implementation? Are there any elements of the project that will hamper the safe construction of the project (e.g. construction vehicle routes and interaction with general public traffic)?
Construction program	Have all applicable work zone types been adequately considered to establish the safest construction program? • Work outside of roadway • Full roadway closure • Permanent lane/shoulder/ramp closures • Crossovers/contra-flow • Detour • Intermittent road closures (i.e. 15-minutes, weekend) • Reduced lane widths • Reduced shoulder widths • Lane shifts • Daily lane/shoulder closures
Construction program	Use of shoulder or median One-lane, two-way operation or reversible lanes Use of temporary structures Use of temporary pavement Widening Night work Weekend work
Temporary traffic management planning	Are bypasses or temporary widening needed? Does pedestrian/bicycle traffic access need to be maintained? Are minimum allowable lane widths achievable? Is the reduced work zone speed limit realistic and appropriate? Should certain types of vehicles be prohibited from entering the work zone (over-height, weight restrictions)? Will oversized load permits be affected? Will the work zone be adequate in terms of:

Items for Stage 3	Possible Issue
	• Traffic control devices? • Rail crossings and controls? • Geometries (turning radii, ramp merge/diverge areas, etc.)? • Bridge restrictions and other structures?
Project timing	Can the contractor restrict the roadway during: • Peak hours? • One direction? • Both directions? • Overnight? • Holidays or weekends? • Sporting or other special events? • Other projects in the immediate area?
Protective devices	Are temporary barriers and impact attenuators required? Has extra protection be provided for: • Pedestrians/bicyclists? • School areas and crossings? • Playgrounds and parks? Have areas been designated for the contractor to safely store (where necessary): • Equipment? • Construction materials? • Waste materials?
Detours or deviations	Does the detour planning show that the detours are adequate in terms of: • Weight restrictions? • Height-width constraints and accommodation of abnormal vehicles? • Capacity? • Adequate traffic control devices? • Railway crossing and controls (if needed)? • Geometries (turning radii, etc.)? • Bridge restrictions and other structures? Is there other construction along the detour that might influence traffic? Will all fronting businesses have acceptable ingress and egress? Are alternate routes available to local motorists? Is a public information meeting required?
Work Zone Analysis	Has the work zone traffic analysis been conducted to identify work zone and ramp capacities? Have required number of maintained lanes and allowable lane closure hours been identified?

Items for Stage 3	Possible Issue
	Does the project comply with the guidelines set in the Highway Manual regarding signage and traffic control?
Mobility impacts	Has the work zone traffic analysis identified impacts on any of the following and are measures included to minimise such impact? • Ability to maintain all accesses (business, community, etc.) • Pedestrian, and bicycle facilities public safety (workers and travelling public) • Emergency vehicle access • Construction equipment access and movement through the work zone • Specific user groups (businesses, communities) • Over-height, over-weight vehicles • Public Transport services and bus stops • Traffic operations in and around the work zone (freeway queues, network operations, effect on local roads and detour routes) • Ramp capacity • Intersection traffic control (signal timing, adequate sign age, etc.) • Existing special traffic operations (HOV lanes, etc.) • User Costs (delay)
Temporary traffic control	Are the temporary traffic control signs and markings shown on the drawings or referenced to typical details? Will sign message modifications be required on permanent signs? Have the modifications been shown? Are temporary signals required or will existing signals need to be kept operational? Will the removal of markings be required and has the work zone been set up to minimize removal? Will Portable Changeable Message Signs be required?
Work zone safety management strategies	Have the following work zone safety management strategies been considered? • Speed limit reduction/variable speed limits with portable changeable? • Message signs displaying speed? • Temporary traffic barrier and movable traffic barrier systems? • Temporary transverse rumble strips? • Warning lights? • Temporary roadway lighting? •
Incident management	Is there provision made for a standby towing service,

Items for Stage 3	Possible Issue
	emergency laybys and planned detour routes in case of an incident?
	Have work zone ITS strategies like CCTV monitoring been considered for traffic monitoring/ management?
Other Issues	
Tourism/ recreation	Are there any safety requirements for the accommodation of tourism or recreation facilities?
	Have all unusual or potentially hazardous conditions associated with special events been considered? If required, can the road be closed in a safe manner?

11.4 Stage 4 Road Safety Audit: Construction - Checklist

Items for Stage 4	Possible Issue
Traffic Management During Construction	
Construction	If the project is to be constructed "under traffic", can this be done safely as far as the construction is concerned as well as the extent to which the general travelling public will be affected?
	Have innovative or accelerated construction techniques been considered to reduce the exposure of the public to restrictive construction conditions?
	Have different phasing options been considered? Are there any features of the project that will require special traffic management during construction phases or any period before implementation?
	Are there any elements of the project that will hamper the safe construction of the project (e.g. construction vehicle routes and interaction with general public traffic)?
Construction program	Have all applicable work zone types been adequately considered to establish the safest construction program? • Work outside of roadway • Full roadway closure • Permanent lane/shoulder/ramp closures • Crossovers/contra-flow • Detour • Intermittent road closures *(*i.e. 15-minutes, weekend) • Reduced lane widths • Reduced shoulder widths • Lane shifts • Daily lane/shoulder closures
Construction program	Use of shoulder or median
	One-lane, two-way operation or reversible lanes
	Use of temporary structures
	Use of temporary pavement
	Widening
	Night work
	Weekend work
Temporary traffic management planning	Are bypasses or temporary widening needed?
	Does pedestrian/bicycle traffic access need to be maintained?
	Are minimum allowable lane widths available?
	Is the reduced work zone speed limit realistic and appropriate?
	Should certain types of vehicles be prohibited from

Items for Stage 4	Possible Issue
	entering the work zone (over-height, weight restrictions)? Will oversized load permits be affected? Will the work zone be adequate in terms of: • Traffic control devices? • Rail crossings and controls? • • Geometries (turning radii, ramp merge/diverge areas, etc.)? • Bridge restrictions and other structures?
Project timing	Can the contractor restrict the roadway during: • Peak hours? • One direction? • Both directions? • Overnight? • Holidays or weekends? • Sporting or other special events? • Other projects in the immediate area? Will such restrictions reduce the road safety performance of the construction site?
Protective devices	Are temporary barriers and impact attenuators required? Has extra protection be provided for: • Pedestrians/bicyclists? • School areas and crossings? • Playgrounds and parks? Have areas been designated for the contractor to safely store (where necessary): • Equipment? • Construction materials? • Waste materials?
Work Zone Analysis	Does the proposed traffic management plan meet the capacity analyses done during detailed design? Are the required number of lanes provided within the set time constraints? Do all fronting businesses have acceptable ingress and egress? Does the project comply with the guidelines set in the Highway Manual regarding signage and traffic control?
Mobility impacts	Has the work zone traffic analysis identified impacts on any of the following and are measures included to minimise such impact? • Ability to maintain all accesses (business, community, etc.) • Pedestrian, and bicycle facilities Public safety (workers and travelling public)

Items for Stage 4	Possible Issue
	• Emergency vehicle access • Construction equipment access and movement through the work zone • Specific user groups (businesses, communities) • Over-height, over-weight vehicles • Public Transport services and bus stops • Traffic operations in and around the work zone (freeway queues, network operations, effect on local roads and detour routes) • Ramp capacity • Intersection traffic control (signal timing, adequate sign age, etc.) • Existing special traffic operations (HOV lanes, etc.) • User costs (delay)
Temporary traffic control	Are the temporary traffic control signs and markings shown on the drawings or referenced to typical details? Will sign message modifications be required on permanent signs? Have the modifications been shown? Are temporary signals required or will existing signals need to be kept operational? Will the removal of markings be required and has the work zone been set up to minimize removal? Will Portable Changeable Message Signs be required?
Work zone safety management strategies	Have the following work zone safety management strategies been considered? • Speed limit reduction/variable speed limits with portable changeable? • message signs displaying speed? • Temporary traffic barrier and movable traffic barrier systems? • Temporary transverse rumble strips? • Warning lights? • Temporary roadway lighting?
Incident management and community liaison	Is there provision made for a standby towing service, emergency lay-bys and planned detour routes in case of an incident? Have work zone ITS strategies like CCTV monitoring been considered for traffic monitoring/ management? Has agreement of the Police been received for the proposed traffic management and possible law enforcement in the work zone? Have relevant radio stations been advised of the construction in order for road users to be advised of the

Items for Stage 4	Possible Issue
	need to consider alternative routes? Is a public information meeting required?

11.5 Stage 5 Road Safety Audit: Pre-opening- Checklist

Items for Stage 5	Possible Issue
General Topics	
Changes since Stage 3: Detailed Design Road Safety Audit	Were there any changes since the Stage 3Audit?
	Was the translation of the design into the project satisfactory in terms of safety?
Adjacent land use	Was the effect/ influence of adjacent land uses catered for?
	Are all accesses safe and adequate as far as design, location and visibility are concerned?
Drainage	Is the drainage of the road and the surrounds adequate?
Climatic condition	Is adequate provision made for adverse weather conditions?
Environmental features	Are there any environmental features such as a rock, bank or trees that will pose a danger to traffic in terms of its visibility and presence?
Landscaping	Is the actual landscaping on site appropriate from a safety point of view?
	Is the roadside hazard of the landscaping limited?
	Is the visibility through or along the vegetation satisfactory, especially for pedestrians? Will this remain when the vegetation matures?
Services	Do traffic barriers protect all services that are not located in safe locations and is the protection adequate?
Shoulders and road edges	Can the constructed shoulders and road edges act as a safe recovery area?
Surfaces and skid resistance	Are there any of the following features that will cause low skid resistance: • Joints in surfacing that are bleeding excessively? • Loose material (e.g. gravel etc) on any of the trafficked areas?
Treatment of batters	Will the treatment of batters prevent debris from falling on the roadway?
Alignment	
Visibility and sight distance	Are the sight lines provided sufficient and free of obstructions?
	Is the visibility of the elements of the project adequate?
Readability by drivers	Is the form and function of the road and its traffic management easily recognised under likely operating conditions (e.g. heavy traffic, minimal traffic, poor visibility or adverse weather conditions)?
Transition between project and existing adjacent road section/ intersection/ network	Is there a need for additional signage or markings to ensure safe transition?

Items for Stage 5	Possible Issue
Bridges and culverts	Are all the sign age and markings adequate and visible?
Intersections	
Visibility to and at the intersections	Are the drivers aware of the existence of the intersections and the control type? Is visibility satisfactory at the intersection?
Readability by drivers	Is the function of the intersections clear to drivers?
	Is the stop line for all the approaches (if necessary) clear to an approaching driver (This should prevent a vehicle from protruding into the conflicting traffic)?
Traffic signals	Is the alignment of the traffic signal heads and the general installation thereof correct?
	Are all the respective aspects visible from an appropriate distance on each approach?
	Is the signal phasing (for both vehicles and pedestrians) as programmed safe and functioning as intended?
	Are all the road signs, markings, lighting and signals combining effectively to guide/ warn road users?
Roundabouts and approach islands	Are the roundabout and islands fully visible and recognisable from all approaches?
	Are all signs, markings and lighting correctly in place?
Driver Perception	
	Has the design been implemented in such a manner that it takes due cognisance of the following limitations of a driver as a human being: • Adequate input for the driving tasks: navigation, guidance and vehicle control • Overloading of the driver by the design features and elements • Provision for erroneous decisions • Driver expectancy of dangerous elements or changes in design standards • Adequate reaction time • The visual field of the driver -for example, if a driver should see something outside of the visual field of the driver, is there a cue for him to seek the object (for example: a driver travelling at 100 km/h has a 40 degree visual field)? • Is the driver ever exposed to sudden darkness? • Will the driver experience glare from oncoming vehicles or from road lighting?
	Is the approach speed to the project safe?
	Does the driver easily perceive the function of the project and the traffic management (also check for poor visibility or heavy traffic conditions)?
	Is the transition between the new project and the existing road constructed in such a way that it ensures that there

Items for Stage 5	Possible Issue
	can be no uncertainty or ambiguity for the driver?
Special Road Users	
Adjacent land use	Are the measures to prevent pedestrians and animals from crossing a highway or rural road (e.g. fencing) effective?
Pedestrians	Are the following key features satisfactory at all pedestrian crossings and facilities? • Visibility -Can pedestrians see and be seen? • Road signs? • Surfacing Lighting and other hardware? • Disabled pedestrians?
Cyclists	Are the following key features satisfactory for the cycling facilities? Visibility -Can cyclists see and be seen? Road signs? Surfacing? Lighting and other hardware?
Animals	Are the following key features satisfactory for stock and equestrians? Visibility? Road signs? Other special features?
Road Signs, Markings and Lighting	
General	Is the transition between the road signs and markings of the project and the adjacent road network safe? Does the existing signage on the adjoining road network tie in with those on the project? Are guide posts or any other delineation devices correctly installed? Are retro reflective crash barrier delineators properly installed, as far as colour/ spacing and alignment are concerned?
Road signs	Are all the road traffic signs and markings provided as designed? Do the road traffic signs and markings clearly convey the intended message to drivers? Are the road traffic signs and markings visible as intended -for night-time and adverse weather conditions? Was all old and construction signage removed that may cause confusion? Are the following safe -both at day and night time conditions:

Items for Stage 5	Possible Issue
	• Visibility? • Message? • Legibility? • Location? • Reflectivity/ illumination? • Frequency (Is there a need for fewer or additional signage?) Are there any road signs that can easily be overgrown by close-by vegetation? Can it be moved without loss of effectiveness? Is any variable message sign age operating satisfactorily?
Road markings	Are all road markings: • Located correctly? • Marked correctly (size, colour etc)? • Visible to the road users as intended (also during night-time and adverse weather conditions)? Is the transition between the road markings of the existing adjoining road and the new project safe, continuous and appropriate? Are the road markings clear from any debris? Have road studs been installed in accordance with the correct colour convention and at all locations where hazardous conditions may exist?
Road lighting	Is the lighting safe in terms of operation and efficiency? Where located in a clear zone, is the lighting adequately protected by means of traffic barriers?
Roadside Hazard Management	
Fixed objects/ roadside hazards	Are all poles and breakaway poles installed correctly? Are all poles and supports appropriately located? Are there any roadside hazards within the clear zone that are not: • Properly marked • Properly signed • Protected by a traffic barrier system
Traffic barriers	Do all the traffic barrier systems conform to the standards and guidelines to ensure safe operation? Especially in terms of: • Location (do they create a hazard in themselves)? • Lengths? • End-treatments? • Installation detail?

Items for Stage 5	Possible Issue
	• Anchorage? • Post spacing? • Proper deflection distance? • Soil stability? • Height of installation? • Intended function -design vehicle?
Median barriers	Are all the median barriers installed to the exact specified details and is the installation safe and properly delineated where required? Are all median barriers located in such a way that they: • Do not limit visibility or • Constitute a hazard?
Traffic Management AND Operation	
Operation	Are all operating features installed correctly and easily accessible?
Traffic management	Are all traffic management devices functioning satisfactorily (e.g. clarity of messages, readability from moving vehicles etc.)?
Access management	Are the design, location and visibility at the accesses safe for the intended purpose?
Speed management	Is the speed limit appropriate?
Emergency vehicles	Can emergency vehicles access the project safely and stop safely?
Temporary traffic management	Are all temporary construction sign age, markings etc. removed from the project?
OTHER	
	Are there any other safety issues that were identified during the site visits? Did the site visits cover day-time conditions, sunrise and sunset and night time?

11.6 Road Safety Audit: Appraisal of Existing Roads

Items for Appraisal of Existing Roads	Possible Issue
General Topics	
Landscaping and natural vegetation	Does the existing landscaping have any negative safety effects (e.g. clearances, sight distance)? Will the clearances and sight distances be reduced by further plant growth?
Headlight glare	Is there a problem with headlight glare?
Parking	Are the parking provisions safe in terms of operation and sight lines?
Temporary works	Is there any construction or maintenance equipment, material or signage although no construction or maintenance is being done?
Cross-section and Alignment	
Visibility and sight distances	Is the sight distance adequate for the 85^{th} percentile operating speed? Is the sight distance for pedestrian crossings adequate?
Design speed and 85th percentile operating speed	Is the horizontal and vertical alignment appropriate for the 85^{th} percentile operating speed? If not: • Are adequate warning signs provided? • Are advisory speed signs provided? Is the posted speed limit or advisory speed limits (if provided) appropriate for the curves?
Overtaking	Are adequate and safe overtaking facilities provided?
Readability by drivers	Can any of the road sections cause confusion in terms of: • Roadway alignment not clearly defined? • Disused pavement that was not removed or treated? • Old pavement markings that were not removed properly? • The alignment of lighting and/ or trees not conforming to the road alignment? Are there any curves (vertical or horizontal) or combinations of curves that: • Can be misleading in guiding the driver to the approaching alignment of the road? • Provide no guidance to the driver on the approaching alignment of the road?
Widths	Are the widths of the following adequate? • Traffic lanes • Shoulders • Carriageways Bridges

Items for Appraisal of Existing Roads	Possible Issue
Shoulders	Are shoulder widths appropriate (e.g. for emergency vehicles, broken-down vehicles or as a recovery area for errant vehicles)?
	Are all shoulders traversable by vehicles?
	Does the cross-fall of the shoulders ensure proper drainage? Is the transition between the traffic lane and the shoulders safe?
Batter slopes	Are the batter slopes and table drains a safe recovery area for run-off-the-road vehicles?
Drainage	Are all drainage structures within the clear zone safe for vehicles to traverse?
Auxiliary Lanes and Exclusive Turning Lanes	
Visibility and sight distance	Is adequate stopping sight distance provided up to the end of the queue of turning vehicles?
	Is adequate stopping sight distance provided for entering and leaving vehicles?
Tapers	Is the start and finish tapers located and aligned correctly?
	Is the sight distance to the end of the auxiliary lane sufficient?
Shoulders	Are the shoulder widths appropriate at merges?
Signs	Are the signage and road markings adequate to guide, control and warn drivers of the auxiliary and exclusive turning lanes?
Exclusive turning lanes	Is advance warning provided for the approaching exclusive right turning lane?
Intersections	
Visibility and sight distance	Are the sight distances provided adequate for all road users?
Location	Are all intersections located safely in terms of the horizontal and vertical alignment?
Layout	Is the alignment of the medians, kerbing and traffic islands safe?
	Is the function and layout of the intersection clear to all road users?
	Are the tapers and turning radii appropriate?
	Does the layout address all potential conflict points between turning vehicles in a safe way?
	Are there any capacity problems that may influence safety negatively?
Traffic control Warning	Is the traffic control provided by the road signs and markings satisfactory? Are there adequate warning on the approaches of intersections that have high approach speeds (e.g. at approaches to towns)?
Special Road Users	

Items for Appraisal of Existing Roads	Possible Issue
Pedestrians	Is the speed limit appropriate for the pedestrian activities in the area? Note particularly pedestrian-sensitive areas.
	Is adequate signage and delineation provided in pedestrian sensitive areas?
	Are crossing facilities provided at safe locations and at the pedestrian desire lines?
	Are paved footways provided? Note particularly where a discontinuation takes place or where the sidewalk is not "walkable."
	Is provision made for the movement of pedestrians on bridges (i.e. in terms of adequate width and protection)?
	Is sufficient lighting provided along pedestrian walkways and at pedestrian crossings?
	Is adequate pedestrian facilities provided at and on the approach to public transport facilities?
	Is adequate provision made for the elderly, disabled and baby carriages (e.g. ramps, kerbs and median crossings)?
	Is the distance between the stopping line and the pedestrian crossing of signalised intersections enough to ensure the visibility of pedestrians (for example for a driver of a heavy vehicle)?
	Is the signal length sufficient in terms of: • Cycle length • Pedestrian clearance times
	Are all pedestrian buttons working on traffic lights?
	Are there any particular areas where traffic barriers are necessary to separate vehicular traffic and pedestrians?
Cyclists	Has appropriate consideration been given to the needs of cyclists? Also note whether bicycle paths are continuous?
Public transport	Is adequate provision made for safe public transport facilities (e.g. sight distance, stopping areas, pedestrian facilities, etc.)?
	Are the public transport facilities adequately signed and marked?
Road Signs, Markings, Delineation and Lighting	
Road signs	Are all signage: directional, warning and regulatory, visible and adequately located?
	Are all the sign sizes and letter sizes adequate?
	Is there any signage that is obscuring one another?
	Is there any need for the adding or the removal of signage?
	Is there any signage that can be confusing to drivers?
	Is all signage properly installed in terms of lateral clearance and height?
	Is the sign age provided adequate for the intended message?

Items for Appraisal of Existing Roads	Possible Issue
	Are there any signs that restrict sight distance (e.g. for turning vehicles, blocking the view to pedestrians)?
	Is all signage clearly visible during all likely conditions (e.g. adverse weather conditions, sunrise, sunset, night-time, poor lighting)?
	Does any of the signage supports present a danger to a run-off-the-mad vehicle?
Road markings and delineation	Are all road markings clearly visible and reflective during all likely conditions?
	Is there a need for road studs? If provided, is their condition satisfactory?
	Are all line markings (edge, centre and traversable) clearly visible and effective during all likely conditions (e.g. adverse weather conditions, sunrise, sunset, night-time, poor lighting, oncoming headlights)?
	Is adequate delineation provided along curves?
	Are the chevron posts visible, adequately spaced and continuous?
	Are all reflective areas appropriate for the driver eye height (also check for heavy vehicle drivers)?
	Are guidelines provided for vehicular paths through intersections where necessary?
	Is there a need for additional road markings e.g. advisory lane directional arrows at the exiting approach of an intersection, to improve guidance to drivers?
	Warning signs and advisory speed limits: • Are curve warning signs and advisory speed limits provided and located appropriately? • Are the advisory speed limits along the route consistent?
	Does the placing of the warning signs and advisory speed limits provide for adequate reaction time?
Road lighting	Is appropriate lighting installed at intersections, pedestrian crossings and refuges?
	Is all lighting operating satisfactorily?
	Are all lighting posts that are located within the clear zone protected by traffic barriers?
	Is any of the lighting causing visual conflict with traffic signals and signage?
	Is appropriate lighting provided for overhead sign age where necessary?

Traffic Signals

Visibility	Are all traffic signals clearly visible to approaching drivers?
	Is adequate stopping sight distance provided to the end of queuing vehicles?
	Will the intersection be affected by sunrise/ sunset problems?
	Is provision made for this in the form of backboards or high intensity signals?
	Are the signal displays shielded so as to ensure that they are only visible to the motorists for whom they are intended?
	Is adequate warning provided where signals are not visible from an adequate distance?
	Are there any features in the environment, such as trees, signs, lighting etc, that obscure signal heads?
Operation	Are all traffic signals operating satisfactorily and correctly?
	Are the location and number of signal displays adequate?
	Where necessary, is provision made for the elderly and disabled pedestrians (e.g. extended green phase)?
	Is the controller located at a safe position?
	Are there any signal aspects visible near or within the intersection that may confuse drivers?
	Is the signal phasing clear to the driver?
	Does the phasing conform to the safety requirements set for the amber and all red periods?
	Pedestrians: • Are pedestrians considered in the signal phasing? • If islands are located in the path of the pedestrian, is the size thereof sufficient to act as a refuge island? • Can drivers see the pedestrian crossing(s) and the pedestrians that are crossing?
	Is the signal phasing appropriate for: • The traffic movements • The accommodation of all vehicles utilising the intersection • The geometry of the intersection • The geometry of the approaches

Roadside Hazard Management

Clear zone and roadside hazards	Is a clear zone provided?
	Are all roadside hazards within the clear zone appropriately protected?
Traffic barriers	Are traffic barriers installed at hazardous locations?
	Are the traffic barrier systems suitable for the purpose?
	Does the traffic barrier system meet its intended function for the design vehicle on the road?

Driver Perception

Does the road environment take due cognisance of the following limitations of a driver as a human being:

- Adequate input for the driving tasks of navigation, guidance and vehicle control?
- Overloading of the driver by the design features and elements?
- Provision for erroneous decisions?
- Driver expectancy of dangerous elements or changes in design standards?
- Adequate reaction time?
- The visual field of the driver?
- The rate at which the eye can gather information from the environment?

Is there any exposure of the driver to sudden darkness?

Will the driver experience glare from oncoming vehicles or from road lighting?

Can the driver easily perceive the function of the road and the traffic management (also check for poor visibility or heavy traffic conditions)?

Pavement

Loose gravel	Are there any loose screenings that can cause vehicles to lose control/ not brake properly?
Pavement defects	Are there any pavement defects that can cause safety problems like loss of control (e.g. Excessive roughness, Rutting, Potholes, etc.)?
Skid resistance	Is adequate skid resistance provided on curves, steep grades and intersection approaches?
Ponding	Are there any areas where ponding or sheet flow of water occur that can result in safety problems?

12 References

"An informational Guide on Fencing Controlled Access Highways", American Association of State Highway Official.

"*An Informational Guide for Roadway Lighting*", American Association of State Highway Officials.

"*Layout of Roads in Rural Areas*", Ministry of Transport, Scottish Development Department.

---

[i] "*Road Safety Audit Manual, 2nd Edition"*, May 2012, Road Traffic Management Corporation, South Africa.

This document references the following additional references

Austroads, 2008, Guide to Road Safety -Part 6: Road Safety Audit, (Publication No AGRS06/09), Sydney, Australia.

Belcher, M., S. Proctor and P. Cook, 2008, Practical Road Safety Auditing, 2nd edition

Department of Transport, Abu Dhabi, 2009, Road Safety Audit Guidelines for Abu Dhabi, (Transport Research Laboratory, Report 11110401/01; Unpublished) (Author: Stefan Lotter).

FHWA, 2006, Road Safety Audit Guidelines, Publication No FHWA-SA-06-06, Washington DC, USA: Federal Highway Administration, US Department of Transportation.

Highways Agency, 2003, HD19/03 Road Safety Audit (Design Manual for Roads and Bridges, Vol.5 Assessment and Preparation of Road Schemes, Section 2: Preparation and Implementation, Part 2).

IHT, 2008, Road Safety Audit, London UK: Institution of Highways and Transportation.

Jordan P.W. & E.V. Barton, 1992, Road safety audit: What is it and why do we need it?, Proceedings of the 16th Australian Road Research Board Conference, in: SARSM (1999).

Municipality of Abu Dhabi City, 2009, Road Safety Audit Procedures for Abu Dhabi City Internal Roads.

National Department of Transport, 1999, South African Road Safety Manual, (Final Draft).

National Roads Authority, Ireland, 2004, Road Safety Audit Guidelines, Advice note NRA HA 42/04, Ogden K., 1996, Safer Roads: A Guide to Road Safety Engineering.

Organisation for Economic Co-operation and Development, 1990, Integrated traffic safety management in urban areas, Paris, France.

PIARC, 2003, Road Safety Manual, Grande Arche de la Defence, France: PIARC Technical Committee on Road Safety.

Sabey B.E., 1993, Safety audit procedures and practice, Traffex '93, Planning and Transportation Research and Computation, London UK, in SARSM 1999.

SANRAL, 2003, Geometric Design Guidelines, Pretoria, South Africa: South African National Roads Agency Limited.

Treat, J.R., N.S. Tumbas, S.T. McDonald, et ai., 1979, Tri-level study of the cause of accidents, Indiana, US: Indiana University, in: PIARC (2003).

Transit New Zealand, 1993, Safety Audit Policy and Procedures.

World Health Organisation, 2004, World Report on Road Traffic Injury Prevention, Geneva.