Design Manual for Roads and Bridges

Prof. Dr.-Ing. Heinrich Semar

July 2003

Summary:

This hand book has been prepared by Prof. Dr. Heinrich Semar for use on national road schemes in Malta. It contains extracts from those Standards contained in the ADT Design Manual for Roads and Bridges (ADT DMRB) that relate to the Geometric Design of Roads.The ADT DMRB is based on the UK Design Manual for Roads and Bridges. The information has been selected to represent the most frequently used sections of the Standards. The user should, therefore, be aware that additional information is available in the full Design Manual.

Published by the Transport Authority, Malta
2003

VOLUME 5 ROAD GEOMETRY
SECTION 0 INTRODUCTION

PART A

ADT INTRODUCTION TO VOLUME 6

Contents

Chapter

1. Standards

2. Advice Notes

3. Enquiries

Appendix A Volume 6 Documents Available for Use in Malta

ADT INTRODUCTION TO

VOLUME 6

ROAD GEOMETRY

The UK Design Manual for Roads and Bridges, Volume 6, is applicable in Malta as outlined in this introduction. Further information on the application of the manual in Malta is given in the General Introduction at the front of Volume 1 (document DMRB 1.0.A).

1. STANDARDS

1.1 In Volume 6 of the UK Design Manual for Roads and Bridges (DMRB), Standards are designated by the letters TD.

1.2 The Standards of Volume 6 of the UK DMRB listed in Table 1 are applicable in Malta as amended by the Addendum to each Standard. All references to the DMRB Standards shall be read as references to the Standards as implemented by the relevai~ ADT Addendum.

UK DMRB Standard			**ADT Addendum**
DMRB Part	**Number**	**Title**	**Dated**
Section 2 : Junctions			
6.2.1	TD 22/92	Layout of Grade Separated Junctions	February 2002
6.2.3	TD 16/93	Geometric Design of Roundabouts	February 2002
6.2.3	TD 50/99	The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts	February 2002
6.2.4	TD 39/94	The Design of Major Interchanges	February 2002
6.2.5	TD 40/94	Layout of Compact Grade Separated Junctions	February 2002
6.2.6	TD 42/95	Geometric Design of Major/Minor Priority Junctions	February 2002
6.2.7	TD 41/95	Vehicular Access to All-Purpose Trunk Roads	February 2002
Section 3 Highway Features			
6.3.1	TD 36/93	Subways for Pedestrians and Pedal Cyclists, Layout and Dimensions	February 2002

Table 1 : UK DMRB Standards Applicable in Malta

1.3 The Standards of Volume 6 listed in Table 2 are replaced for use in Malta by the equivalent ADT documents listed. All references to the DMRB Standards shall be read as references to the equivalent ADT documents.

UK DMRB Standard			**Equivalent ADT Document**		
DMRB Part	**Number**	**Title**	**Number**	**Title**	**Date**
Section 0: ADT Introduction					
-	-	-	6.0.A	ADT Introduction	Oct 2002
Section 1 : Links					
6.1.1	TD 9/93	Highway Link Design	ADT TD 9/02	Road Link Design	Feb 2002
6.1.2	TD 27/96	Cross Sections and Headrooms	ADT TD 27/02	Cross Sections and Headroom	Feb 2002

Table 2 UK DMRB Standards Replaced by Equivalent ADT Documents

1.4 A full list of the Standards relating to Volume~6 of the DMRB which are applicable in Malta is contained in Appendix A.

2. ADVICE NOTES

2.1 In Volume 6 of the UK DMRB, Advice Notes are designated by the letters TA.

2.2 The Advice Notes in Volume 6 have not been adopted formally for application in Malta. However, Advice Notes provide useful background reading to the DMRB Standards. In some instances the advice may be relevant for Maltese roads, but the Advice Notes do not affect or alter any of the information given in the Standards as applied in Malta. Users of the ADT DMRB are, therefore, encouraged to use the Advice Notes as background guidance to the application of the Standards, while taking account of the national differences highlighted in the ADT Addenda and equivalent ADT Standards.

2.3 An additional Advice Note, as noted in Table 3, has been prepared for use in Malta as part of Volume 6.

Additional ADT Document			
ADT DMRB Part	**Number**	**Title**	**Date**
	Section 1 : Links		
6.1.1A	ADT TA 43/00	Guidance on Road Link Design	October 2002

Table 3 Additional Advice Note for Use in Malta

2.4 A full list of the Advice Notes in Volume 6 of the DMRB which may be used as background guidance in Malta is contained in Appendix A.

3. ENQUIRIES

3.1 All technical enquiries or comments on this document or any of the documents of Volume 6 of the DMRB as applied in Malta should be sent in writing to:

Director of the Roads Directorate
Malta Transport Authority
Sa Maison Road
Floriana
Malta

C.Zammit
Director of the Roads Directorate

APPENDIX A

VOLUME 6: ROAD GEOMETRY

DOCUMENTS AVAILABLE FOR USE IN MALTA

Notes:
1. The Standards (TD) of Volume 6 of the DMRB listed below are applicable in Malta when used in conjunction with the relevant ADT Addenda.
2. ADT Standards or other documents are indicated by *. These replace DMRB documents in Malta.
3. With the exception of ADT TA 43/00, Advice Notes (TA) have not been implemented for use in Malta. However, they may be of interest for background reading and, for completeness, are listed here in italics.

Standard or Advice Note			
DMRB Part	**Number**	**Title**	**ADT Addendum or Standard Dated**
Section 0 -	ADT Introduction 6.0.A*	ADT Introduction to Volume 6	October 2002
Section 1: Links			
6.1.1	ADT TD 9/00*	Road Link Design*	October 2002
6.1.1A	ADT TA 43/00*	Guidance on Road Link Design*	October 2002
6.1.2	ADT TD 27/00*	Cross sections and Headroom*	October2002
Section 2: Junctions			
6.2.1	TD 22/92	Layout of Grade Separated Junctions	February 2002
6.2.2	TA 48/92	*Layout of Grade Separated Junctions*	February 2002
6.2.3	TD 16/93	Geometric Design of Roundabouts	February 2002
6.2.3	TA 78/97	*Design of Road Markings at Roundabouts*	February 2002
6.2.3	TD 50/99	The Geometric Layout of Signal-Controlled junctions and Signalised Roundabouts	February 2002
6.2.4	TD 39/94	The Design of Major Interchanges	February 2002
6.2.5	TD 40/94	Layout of Compact Grade Seperated Junctions	February 2002
6.2.6	TD 42/95	Geometric Design of Major/Minor Priority Junctions	February 2002
6.2.7	TD 41/95	Vehicular Access to All-Purpose Trunk Roads	February 2002

Table 4 : Volume 6 Documents Available for Use in Malta (Continued)

Standard or Advice Note			
DMRB Part	**Number**	**Title**	**ADT Addendum or Standard Dated**
Section 3: Highway Features			
6.2	*TA 23/81*	*Junctions and Accesses: Determination of Size of Roundabouts and Major/Minor Junctions*	-
6.3.1	TD 36/93	Subways for Pedestrians and Pedal Cyclists. Layout and Dimensions	Feb 2002
6.3.2	TA 66/95	Police Observation Platforms on Motorways	-
6.3.3	*TA 69/96*	*The Location and Layout of Lay-bys*	-
6.3	*TA 57/87*	*Roadside Features*	-
6.3.4	*TA 81/99*	*Coloured Surfacing of Road Layouts*	-

Table 4 : Volume 6 Documents Available for Use in Malta (Continued)

Volume 6
Section 1
Part 1

ADT TD 9/00

Design Manual for Roads and Bridges

Road Geometry

July 2003

Roads Directorate – Sa Maison Road, Floriana CMR02. Tel: 21 234609 Fax: 21 24375

Summary:

This Standard sets out the elements of design for use in the geometric design of roads. It also sets out the principles for co-ordinating the various design elements so as to ensure that the three dimensional layout as a whole is acceptable. Single carriageway design is given particular emphasis in order to provide clearly identifiable sections for overtaking.

Note:

The layout and format of this Standard are modelled closely on the UK Highways Agency's Standard TD 9/93. Wherever practicable, paragraph and figure numbering follows that of TD 9/93.

Published by the Maltese Transport Authority, Floriana Malta 2002

VOLUME 6 ROAD GEOMETRY
SECTION 1 LINKS

PART 1

ADT TD 9/00

ROAD LINK DESIGN

Contents

Chapter

0. Foreword
1. Design Speed
2. Sight Distance
3. Horizontal Alignment
4. Vertical Alignment
5. Climbing Lanes
6. Introduction to Coordinated Link Design
7. Single 2 Lane Carriageway Roads
8. Dual Carriageways and Motorways
9. References
10. Enquiries

Annexes

Annex A Harmonic Mean Visibility

ELEMENTS OF DESIGN

Chapter		Page
1.	Design Speed	
	General	1/1
	Factors Affecting Speed	1/1
	Rural Roads	1/2
	Urban Roads	1/4
	Selection of Design Speed	1/5
	Design Speed Related Parameters	1/5
	Changeover of Design Speed Standards	1/5
	Connection to Existing Roads	1/5
	Selection of Parameter Values	1/5
	Relaxations	1/5
	Departures	1/7
2.	Sight Distance	
	Stopping Sight Distance	2/1
	Full Overtaking Sight Distance	2/1
	Coordinatied Design of Single Carriageways	2/1
	Obstructons to Sight Distance	2/1
	Relaxations	2/1
3.	Horizontal Alignment	
	Road Camber	3/1
	Superelevation	3/1
	Desirable Minimum Radius	3/2
	Relaxations	3/2
	Appearance and Drainage	3/2
	Application of Superelevation	3/2
	Widening on Curves	3/2
	Lane Width Reductions at Pinch Points	3/3
	Transitions	3/3
	The Effect of Sight Distance at Horizontal Curves	3/3
4.	Vertival Alignment	
	Gradients	4/1
	Vertical Curves	4/1
	Relaxations	4/2
5.	Climbing Lanes	
	Single Carriageways	5/1
	Dual Carriageways & Motorways	5/8

COORDINATED LINK DESIGN

Chapter		Page
6.	Introduction to Coordinated Link	
	General	6/1
	Rural Roads	6/1
	Urban Roads	6/1
7.	Single 2 Lane Carriageway Roads	
	General Principles	7/1
	Overtaking Sections	7/1
	Non-overtaking Sections	7/5
	Obstructions to Overtaking	7/5
	Non-overtaking Crests	7/6
	Overtaking Value	7/7
	Horizontal Curve Design	7/8
	Vertical Curve Design	7/9
	Junction Strategy	7/10
	Changes in Carriageway Width	7/10
	Road Markings	7/13
	Existing Single Carriageway Improvements	7/13
	Staged Construction	7/14
8.	Dual Carriageways and Motorways	
	General Principles	8/1
	All Pupose Dual Carriageways	8/1
	Motorways	8/2

0. FOREWORD

Introduction

0.1 This Standard applies to both single and dual carriageway roads in both urban and rural areas. It shall be used to derive the Design Speed, and the appropriate values of geometric parameters for use in the design of the road alignment. It states the basic principles to be used for coordinating the various elements of the road layout, which together form the three dimensional design of the road.

0.2 An Advice Note **ADT TA** 43 (ADT DMRB 6.1.1A), Guidance on Road Link Design has been prepared to accompany this Standard. It provides background information and explains the general design philosophy of the layout standards.

Definitions

0.3 For the definitions of the general road terms used in this Standard, such as components of the road (central reserve, verge, hard shoulder and hard strip, etc.), see BS 6100: Subsection 2.4.1.

0.4 Particular terms used in this Standard are defined as follows:

All purpose road:- A road for the use of all classes of traffic (e.g. not a motorway).

Central reserve:- The area which separates the carriageways of a dual carriageway road. Note that this includes any offside hard strips.

D2AP or D3AP:- Dual two-lane (or dual three-lane) all-purpose road.

D2M or **D3M:-** Dual two-lane (or dual three-lane) motorway.

S2:- Two-lane single carriageway road with lane widths of up to 3.75m.

Verge:- the part of a road cross-section alongside a carriageway but not including embankment or cutting slopes. Note that this includes hard strips but not hard shoulders.

WS2:- Two-lane wide single carriageway, normally with lane widths of 5.Om.

0.5 and 0.6 (Not used)

0.7 The principal design parameters for the layout of road links are based on “Desirable Minimum” values. Values of parameters below the Desirable Minimum are expressed in terms of the number of Design Speed steps below the Desirable Minimum. However, some other DMRB Standards refer to Absolute Minimum values of parameters in this Standard. Where this occurs, the reference shall be taken to mean one Design Speed step below the Desirable Minimum value.

Implementation

0.8 This Standard shall be used for the design of all new or improved national roads. Unless otherwise agreed with the ADT, it shall also be used on national road schemes for the design of all roads with a Design Speed of 50km/h or more. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the Maltese Transport Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with the Maltese Transport Authority.

0.9 If this Standard is to be used for the design of local road schemes, the Designer should agree with the relevant Road Authority the extent to which the document is appropriate in any particular situation.

Scope

0.10 A major objective of this Standard is to ensure that designs achieve value for money without any significant effect on safety. The design systems that have been developed in relation to both Design Speed and the related geometric parameters will result in greater flexibility to achieve economic design in difficult circumstances. In addition, detailed attention is given to the design of single carriageway roads, where the previous recommendations have been considerably extended to allow greater flexibility for design, with particular emphasis upon the coordination of design elements to improve safety and overtaking conditions. Overall, the greater flexibility for design introduced by this Standard will enable more economic design, reducing both the construction costs and the impact of new roads and road improvements on the environment.

0.11 Throughout this Standard, there are continual references to the use of cost /benefit analyses. These should be used at all stages to test the economic performance of alternative scheme designs.

Interpretation

0.12 The standards contained in this document represent the various criteria and maximum/minimum levels of provision whose incorporation in the road design would achieve a desirable level of performance in average conditions in terms of traffic safety, operation, economic and environmental effects. In most cases, with care, designs can be achieved which do not utilise the lowest levels of design parameters given. At some locations on new roads or major improvements, however, it may not be possible to justify even the lowest levels of design parameters in economic or environmental terms, due to high costs, low traffic levels, and environmental damage etc. In such cases, sufficient advantages might justify either a Relaxation within the standards or, in more constrained locations, a Departure from the standards. The various parameters quoted in this Standard are not, therefore to be regarded as sacrosanct in all circumstances. Relaxations and Departures should be assessed in terms of their effects on the economic worth of the scheme, the environment, and the safety of the road user. Further details on the use of Relaxations are given in Chapters 1 to 4.

0.13 Designers should always have regard to the cost effectiveness of the design provision. However, the implications, particularly in relation to safety may not be quantifiable and the Designer must apply the judgement of experience in proposing a Relaxation or Departure.

0.14 When issued in the United Kingdom in 1981, this Standard introduced the concept of a hierarchy of permitted values for geometric layout parameters (visibility, horizontal curvature and vertical curvature). This hierarchy was based upon Desirable Minimum standards, with lower values being known progressively as Relaxations and Departures. Values equal to or higher than Desirable Minimum give consistently safe alignments and minimise journey times. However, research had shown that in many situations safety was no worse with values lower than the rigid requirements of the previous standards. The hierarchy of values enabled a flexible approach to be applied where the strict application of Desirable Minimum requirements would lead to disproportionately high construction costs or severe environmental impact upon people, properties and landscapes. Successive levels in the hierarchy invoked more stringent consideration in line with the need to consider safety carefully.

0.15 During the years since 1981 there have been many advances in road layout design. The procedures for the assessment of safety and operational aspects have improved. Further research has strengthened the understanding of driver behaviour. Safety audits and other initiatives in the mechanics of assessing and checking scheme layouts have made the design process more rigorous and reliable.

0.16 Since 1981, experience has been gained in the application of this hierarchy of values and this indicates that the environmental and financial benefits gained from increased flexibility can be considerable. Against this background, the scope for Relaxations has been increased to allow Designers to consider alignment parameter values that would generally be approved if they were put to the Maltese Transport Authority as Departure proposals. The Designer is required to consider carefully the benefits and any potential disadvantages of Relaxations. Guidance is included in Chapter 1, describing the approach to be taken to assessing Relaxations. Relaxations are considered to conform to standards.

1. DESIGN SPEED

General

1.1 The road alignment shall be designed so as to ensure that standards of curvature, visibility, superelevation, etc. are provided for a Design Speed which shall be consistent with the anticipated vehicle speeds on the road. A relatively straight alignment in flat country will generate higher speeds, and thus produce a higher Design Speed, than a more sinuous alignment in hilly terrain or amongst dense land use constraints. There is, therefore, always an inherent economic trade-off between the construction and environmental costs of alternative alignments of different Design Speeds, and their user benefits.

Factors Affecting Speed

1.2 Speeds vary according to the impression of constraint that the road alignment and layout impart to the driver. This constraint can be measured by the three factors given in Paragraphs 1.3 to 1.5.

1.3 Alignment Constraint. Ac: This measures the degree of constraint imparted by the road alignment, and is measured by:

Dual Carriageways: Ac = 6.6 + B/10

Single Carriageways:
Ac= 12-VJSII6O+2B/45

where:

B = Bendiness (total angle the road turns through), degrees/kin;

VlSI = Hannonic Mean Visibility, m (see Annex A).

1.4 Layout Constraint, Lc: This measures the degree of constraint imparted by the road cross section, verge width and frequency of junctions and accesses. Table 1 shows the values of Lc relative to cross section features and density of access, expressed as the total number of junctions, laybys and commercial accesses per kin, summed for both sides of the road, where:

L = Low Access numbering 2 to 5 per kin;

M = Medium Access numbering 6 to 8 per kin;

H = High Access numbering 9 to 12 per km.

Road Type	S2						WS2		D2AP				D3AP	D2M		D3M
Carriageway Width (ex. hard strips)	6m		7.0m		7.3m		10m		Dual 7.0m		Dual 7.5m		Dual 10.5m or 11.25m	Dual 7.0m	Dual 7.5m	Dual 10.5m or 11.25m
Degree of Access and Junctions	H	M	M	L	M	L	M	L	M	L	M	L	L	L	L	L
With hard shoulders					21	19	17	15	10	9	8	7	5	5	4	0
Without hard shoulders:																
With 3.0m Verge	(29)	(26)	25	23	(23)	(21)	(19)	(17)	(12)	(11)	(10)	(9)	(6)			
With 1.5m Verge	(31)	(28)	(27)	(25)	(25)	(23)										
With 0.5m Verge	(33)	(30)														

( ) : Non-standard cross-section

There is no research data available for 4 lane Single Carriageway roads between 12 and 15m width (S4). In the limited circumstances for their use described in this document, Design Speed should be estimated assuming a normal D2AP with a Layout Constraint of 15 - 13km/h

Table 1 : Layout Constraint, Lc km/h

1.5 Mandatory Speed Limits: On rural derestricted roads, i.e. with national speed limits of:

	km/h
Motorways Single	80
And Dual Carriageways	80

vehicle speeds are constrained only by the physical impression of the road alignment, as described by Ac and Lc. The use of mandatory speed limits (together with more confined urban cross-sections), however, restricts speeds below those freely achievable, and will act as a further constraint on speed in addition to that indicated by Lc.

Selection of Design Speed

1.6 New Rural Roads: Design Speed shall be derived from Figure 1, which shows the variation in speeds for a given Lc against Ac. The Design Speeds are arranged in bands, i.e. 120, 100, 80km/h etc., within which suffixes A and B indicate the higher and lower categories of each band.

1 .6A An initial alignment to a trial Design Speed should be drawn up, and Ac measured for each section of the route demonstrating significant changes thereof, over a minimum length of 2 km. The Design Speed calculated from the ensuing Ac and Lc should be checked against the initial choice, to identify locations where elements of the initial trial alignment may be relaxed to achieve cost or environmental savings, or conversely where the design should be upgraded, according to the calculated Design Speed. If any changes to road geometry result, then the Design Speed should be recalculated to check that it has not changed.

1.7 Existing Rural Road Improvements (including short diversions or bypasses up to about 2 km in length): Design Speed shall be derived in a similar manner to Paragraphs 1.6 and 1 .6A above, with Ac measured over a minimum length of 2 km incorporating the improvement, provided there are no discontinuities such as roundabouts. The strategy for the contiguous sections of road, however, must be considered when determining Ac and the cross-sectional design. It might be unnecessary to provide a full standard cross-section for a minor re-alignment within a low standard route, unless it represented an initial stage of a realistic improvement strategy.

1.8 Urban Roads: Low speed limits (3040 mph) may be required due to the amount of frontage activity, but also where physical restrictions on the alignment make it impractical to achieve geometry relative to a higher Design Speed. Design Speeds shall be selected with reference to the speed limits envisaged for the road, so as to permit a small margin for speeds in excess of the speed limit, as shown in Table 2.

SPEED LIMIT		DESIGN SPEED
mph	Km/h	Km/h
30	48	60B
40	64	70A
50	80	80A
(60)	(96)	(100A)

Table 2 :.Design Speeds for Mandatory Speeds Limits

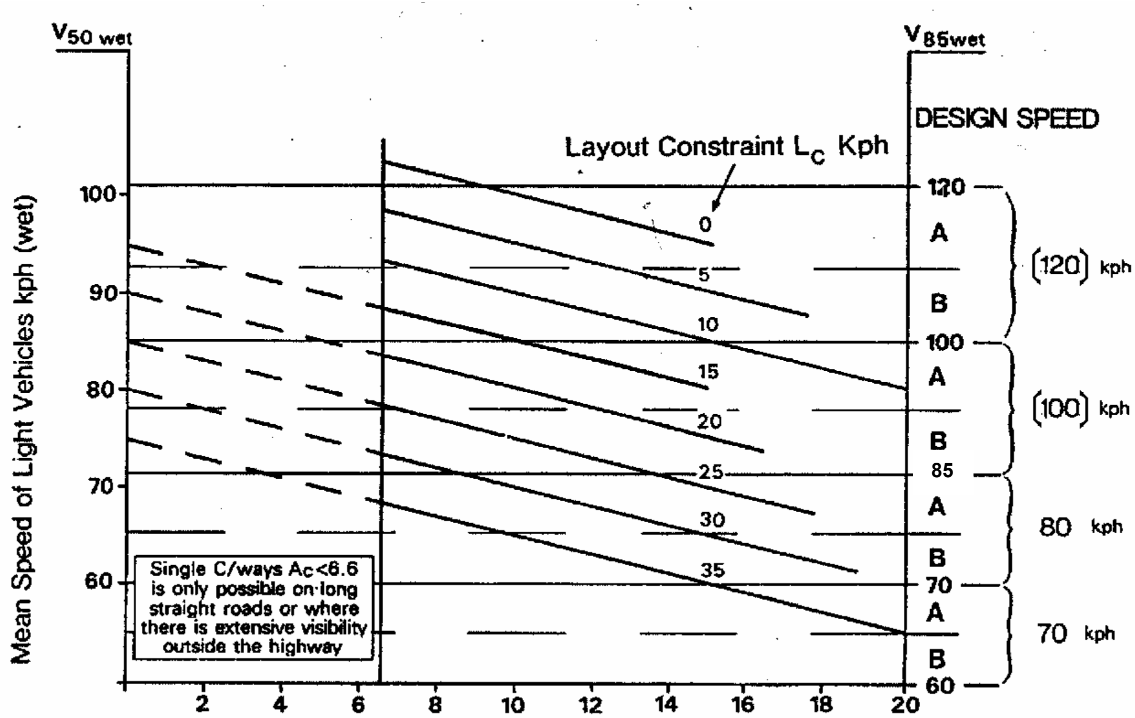


figure 1 : Selection of Design Speed (Rural Roads)

Design Speed Related Parameters

1.9 The Design Speed bands (120), (100), 80 km/h etc dictate the minimum geometric parameters for the design, .according to Table 3, which shows Desirable Minimum values and values for certain Design Speed steps below Desirable Minimum. Desirable Minimum values represent the comfortable values dictated by the Design Speed.

DESIGN SPEED (km/h)	(120)	(100)	80	70	60	50	V^2/R
STOPPING SIGHT DISTANCE m							
Desirable Minimum	295	215	160	120	90	70	
One Step below Desirable Minimum	215	160	120	90	70	50	
Two Steps below Desirable Minimum	160	120	90	70	50	50	
HORIZONTAL CURVATURE m							
Minimum R* without elimination of Adverse Camber and Transitions	2880	2040	1440	1020	720	510	5
Minimum R* with Superelevation of 2.5%	2040	1440	1020	720	510	360	7.07
Minimum R with Superelevation of 3.5%	1440	1020	720	510	360	255	10
Desirable Minimum R with Superelevation of 5%	1020	720	510	360	255	180	14.14
One Step below Desirable Min R with Superelevation of 7%	720	510	360	255	180	127	20
Two Steps below Desirable Min R with Superelevation of 7%	510	360	255	180	127	90	28.28
VERTICAL CURVATURE – CREST							
Desirable Minimum* Crest K Value	182	100	55	30	17	10	
One Step below Desirable Min Crest K Value	100	55	30	17	10	6.5	
Two Steps below Desirable Min Crest K Value	55	30	17	10	6.5	6.5	
VERTICAL CURVATURE – SAG							
Desirable Minimum Sag K Value	53	37	26	20	13	9	
One Step below Desirable Min Sag K Value	37	26	20	13	9	6.5	
Two Steps below Desirable Min Sag K Value	26	20	13	9	6.5	6.5	
OVERTAKING SIGHT DISTANCES							
Full Overtaking Sight Distance FOSD m.	N/A	580	490	410	345	290	
FOSD Overtaking Crest K Value	N/A	400	285	200	142	100	

Notes

* Not to be used in the design of single carriageways (see Paragraphs 7.25 to 7.30)

The V^2/R values simply represent a convenient means of identifying the relative levels of design parameters, irrespective of Design Speed.

K Value = curve length divided by algebraic change of gradient (%). See Paragraph 4.5.

Table 3 : Design Speed Related Parameters

Changeover of Design Speed Standards

1.10 Transitions between sections with different Design Speeds shall be designed carefully so as not to present the driver suddenly with low radius curves, shorter sight distances etc. Where an alignment changes from a higher to a lower Design Speed, Relaxations should be avoided adjacent to the interface on the length of road with the lower Design Speed.

Connection to Existing Road

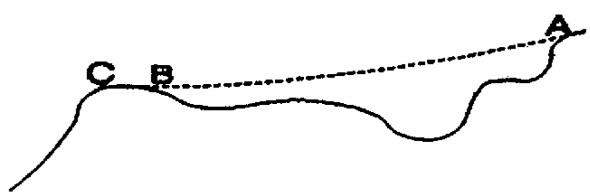


Figure 2

1.11 Care shall be taken where an improved section rejoins an existing road, that the existing standard of curvature and sight distance at the interface shall be subject to the same restrictions as would be relevant for the Design Speed of the improvement. Figure 2 shows the connection of an improvement to an existing road. Care must be taken that the curvature and sight distance at C is adequate for the approach Design Speed which has increased due to the improvement between A and B.

Selection of Parameter Values

1.12 Designers should normally aim to achieve at least Desirable Minimum valued for stopping sight distance, horizontal curvature and vertical curvature. For single carriageways there are certain horizontal and vertical curve values which, although exceeding the Desirable Minimum values, are not recommended: in some cases Departures from Standards would be required. See Paragraphs 7.25 to 7.31 inclusive.

1.13 Numerous accident studies have been carried out and it has always proved difficult to correlate accident rates with causal factors. The reason is that an accident is a rare, random event where people have failed to cope with the situation; often exacerbated by one or more influences from a large selection of contributory factors. Serious injury accidents are rarer still, with the majority being primarily attributable to driver error. It is estimated that road layout is a main contributory factor in only a small proportion of injury accidents, indicating that accident rates are unlikely to be significantly affected by small or even mode`rate reductions in design parameters.

Relaxations

1.15 This Standard defines a sequence of parameter values in the form of a hierarchy of geometric design criteria related to Design Speeds. This three tier hierarchy enables a flexible approach to be applied to a range of situations where the strict application of Desirable Minimum standards would lead to disproportionately high construction costs or severe environmental impact upon people, properties or landscapes. Designs with at least Desirable Minimum standards will produce a high standard of road safety and should be the initial objective. However, the level of service may remain generally satisfactory and a road may not become unsafe where these values are reduced. This second tier of the hierarchy is termed a Relaxation.

1.16 The limit for Relaxations is defined by a given number of Design Speed steps below a specific benchmark, usually the Desirable Minimum. Relaxations vary according to the type of road - motorway or all-purpose - and whether the Design Speed is band A or band B. Details for sight distance are given in Chapter 2, for horizontal alignment in Chapter 3, and for vertical alignment in Chapter 4.

1.17 Relaxations may be introduced at the discretion of the Designer, having regard to the advice given in this document and all the relevant local factors. Careful consideration must be given to layout options incorporating Relaxations, having weighed the benefits and any potential dis Dis-benefits. Particular attention should be given to the safety aspects and the environmental and/or cost benefits which would result from the use of Relaxations. The Design Organisation shall record the fact that a Relaxation has been used and the corresponding reason for its use. The record shall be endorsed by the Design Organisation' s senior engineer responsible for the scheme. The Design Organisation shall report all Relaxations incorporated into the design as part of the project report at the end of each project management phase. The preferred option should be compared against options that would meet Desirable Minimum standards.

1.18 A number of layout options might be feasible for a scheme, with each containing Relaxations. This Standard gives examples of locations where some options can be expected to be safer than others. For example, Desirable Minimum stopping sight distance could be provided to a junction, at the expense of a Relaxation to less than desirable values of horizontal or vertical curvature at a location away from that junction. The Relaxation then becomes isolated in that only one feature is below desirable value on a given length of road, and that length does not contain the complication of a junction. In this manner the accident potential of a constrained alignment has been minimised by applying layout design principles based upon the knowledge currently available.

1.19 A list of principles to follow when preparing options that include Relaxations is as follows. It is equally a list of factors to be taken into account when considering the merits of options.

1.20 The Designer should consider whether, and to what degree, the site of the proposed Relaxation is:

- isolated from other Relaxations;
- isolated from junctions;
- one where drivers have Desirable Minimum stopping sight distance;
- subject to momentary visibility impairment only;

Departures.
1.25 Relaxations are not permitted for either of the overtaking sight distance parameters given in Table 3.
1.26 The Relaxations below Desirable Minimum in stopping sight distance and vertical

- one that would affect only a small proportion of the traffic;
- on straightforward geometry readily understandable to drivers;
- on a road with no frontage access;
- one where traffic speeds would be reduced locally due to adjacent road geometry (eg uphill sections, approaching roundabouts and major/minor junctions where *traffic* has to give way or stop etc), or speed limits.

1.21 The Designer should also consider whether the following should be introduced in conjunction with any Relaxation:

- accident prevention measures (e.g. safety fencing, increased skidding resistance etc.)
- warning signs and road markings to alert the driver to the layout ahead.

1.22 The Designer should have regard to the traffic flows carried by the link. High flows may carry a greater risk of queues & standing traffic approaching junctions in the peak period. Conversely lower flows might encourage higher speeds.

1.23 Values for sight distance, horizontal curvature and vertical curvature shall not be less than those given in Table 3 for each Design Speed and the appropriate number of Design Speed steps.

1.24 only stopping sight distance, horizontal curvature, vertical curvature, superelevation and gradient shall be subject to Relaxations. Stopping sight distance Relaxations of up to 1 Design Speed step below Desirable Minimum may be coincident with horizontal curvature Relaxations of up to 1 Design Speed step below Desirable Minimum. All other combinations of Relaxations are not permitted and shall be treated as curvature for crest curves and more than 1 Design Speed step below Desirable Minimum for sag curves described in Paragraphs 2.8 to 2.13 inclusive and 4.9 to 4.17 inclusive are **NOT** permitted on the immediate approaches to junctions, because the majority of accidents occur in the vicinity of junctions. For the purposes of this Standard the immediate approaches to a junction shall be:

a) For at grade major/minor junctions without diverge and merge tapers, those lengths of carriageway on the minor roads between a point *1.5* times the Desirable Minimum Stopping Sight Distance upstream of the Stop line or Yield line and the Stop line or Yield line itself, and those lengths of carriageway on the mainline between a point *1.5* times the Desirable Minimum stopping sight distance from the centre line of the minor road and the centre line itself.

b) For roundabouts, those lengths of carriageway on the approach to the roundabout between a point *1.5* times the Desirable Minimum stopping sight distance from the Yield line and the Yield line itself.

c) For diverges, that length of carriageway from a point *1.5* times the Desirable Minimum stopping sight distance upstream of the start of the diverge taper to the back of the diverge nose.

d) For merges, that length of carriageway from a point *1.5* times the Desirable Minimum stopping sight distance upstream of the back of the merge nose to the end of the merge taper.

Departures

1.27 In situations of exceptional difficulty which cannot be overcome by Relaxations, it may be possible to overcome them by adoption of Departures, the third tier of the hierarchy. Proposals to adopt Departures from Standard must be submitted to the Maltese Transport Authority for approval before incorporation into a design layout to ensure that safety is not significantly reduced.

2. SIGHT DISTANCE

Stopping Sight Distance

2.1 Table 3 shows the stopping sight distance (SSD) appropriate for each Design Speed.

2.2 Stopping sight distance shall be measured from a minimum driver's eye height of between 1 .05m and 2.00m, to an object height of between 0.26m and 2.00m both above the road surface, as shown in Figure 3. It shall be checked in both the horizontal and vertical planes, between any two points in the centre of the lane on the inside of the curve (for each carriageway in the case of dual carriageways).

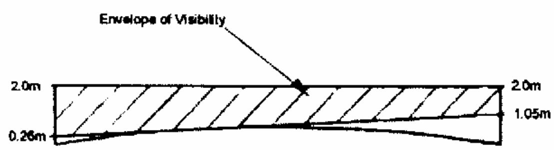


Figure 3 : Measurement of Stopping Sight Distance

Figure 3 Measurement of Stopping Sight Distance

Full Overtaking Sight Distance

2.3 Table 3 shows for each Design Speed the Full Overtaking Sight Distance (FOSD) required for overtaking vehicles using the opposing traffic lane on single carriageway roads. Sufficient visibility for overtaking shall be provided on as much of the road as possible, especially where daily traffic flows are expected to approach the maximum design flows.

2.4 FOSD shall be available between points *1.05m* and 2.OOm above the centre of the carriageway as shown in Figure 4,, and shall be checked in both the horizontal and vertical planes.

2.5 FOSD is considerably greater than stopping sight distance, and can normally only be provided economically in relatively flat terrain where the combination of vertical and horizontal alignments permits the design of a flat and relatively straight road alignment.

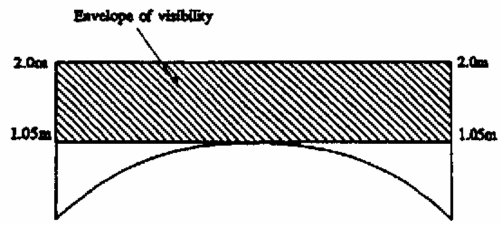


Figure 4 Measurement of FOSD

Coordinated Design of Single Carriageways

2.6 It will frequently be more economic to design a single carriageway road so as to provide clearly identifiable Overtaking Sections with FOSD in relatively level areas, with climbing lanes at hills, interspersed with Non-overtaking Sections where constraints on the alignment would result in high cost or environmental implications. The detailed standards and design considerations regarding the coordinated design of such links are given in Chapters 6 and 7. Designs which provide the driver with obvious lengths for overtaking have been found to reduce the frequency of serious accidents occurring on roads with continuous large radius curves. On the other hand, in some conditions in flat topography speeds may be somewhat reduced. There is therefore always an inherent economic trade-off between the construction and environmental costs of alternative alignments and their user benefits.

Obstructions to Sight Distance

2.7 Care shall be taken to ensure that no substantial fixed obstructions interrupt the sightlines, including road furniture such as traffic signs. However, isolated slim objects such as lamp columns, sign supports, or slim footbridge supports of width *550mm* or under can be ignored. Laybys should, wherever possible, be sited on straights or on the outside of curves, where stopped vehicles will not obstruct sightlines.

Relaxations

2.8 In the circumstances described in Paragraphs 1.15 to 1.26, Relaxations below the

Desirable Minimum stopping sight distance values may be made at the discretion of the Designer. The number of Design Speed steps permitted below the Desirable Minimum are normally as follows:

(motorways band A	1 step)
(motorways band B	2 steps)
all-purpose bands A and B	2 steps

However, in the circumstances listed in Paragraphs 2.9, 2.10, 2.11 and 2.12, the scope for Relaxations shall be extended or reduced as described, provided that the resultant Relaxations do not exceed 2 Design Speed steps.

2.9 For band A roads where the stopping sight distance is reduced by bridge piers, bridge abutments, lighting columns, supports for gantries and traffic signs in the verge or central reserve which form momentary obstructions, the scope for Relaxations may be extended by 1 Design Speed step.

2.10 Long bridge parapets or safety fences or safety barriers on horizontal curves may obscure stopping sight distance to the 0.26m object height, although the appropriate sight distance to the tops of other vehicles, represented by the 1.05m object height, will be obtained above the parapet or safety fence or safety baffler. For band A roads where the appropriate stopping sight distance to the high object is available in this way, the scope for Relaxation of stopping sight distance for sight lines passing in front of the obstruction to the 0.26m object height may be extended by one Design Speed step.

2.11 On or near the bottom of long grades on dual carriageways steeper than 3% and longer than 1.5km the scope for Relaxations shall be reduced by 1 Design Speed step. Conversely, at or near the top of up gradients on single carriageways steeper than 4% and longer than *1.5* kin, the scope for Relaxation may be extended by 1 step due to reduced speeds uphill.

2.12 The scope for Relaxations shall be reduced by 1 Design Speed step immediately following an

Overtaking Section on single carriageway roads (see Paragraphs 7.5 to 7.16).

2.13 Relaxations below Desirable Minimum are not permitted on the immediate approaches to junctions as defined in Paragraph 1.26.

3. HORIZONTAL ALIGNMENT

Road Camber

3.1 On sections of road with radii greater than that shown in Table 3 for Minimum R without elimination of adverse camber & transitions (ie. $V^2 JR < 5$), the crossfall or camber should be *2.5%,* normally from the centre of single carriageways or from the central reserve of dual carriageways to the outer channels. At junctions other than roundabouts, the cross-section of the major road shall be retained across the junction, and the side road graded into the channel line of the major road. On horizontal curves, adverse camber shall be replaced by favourable crossfall of 2.5% when the radius is less than that shown in Table 3 for Minimum R without elimination of adverse camber & transitions (ie. $V^2/R > 5$). However, it will frequently be necessary to eliminate adverse camber on larger radii for aesthetic or drainage reasons.

3.1 A On minor roads where the quality of road pavement laying is unlikely to be high, the minimum crossfall should be 3%.

Superelevation

3.2 On radii less than those shown in Table 3 for Minimum R with superelevation of *2.5%* (ie $V^2/R > 7.07$), superelevation shall be provided, such that:

$$S = \frac{V^2}{2.828 \times R}$$

Where:
V = Design Speed, km/h

R = Radius of Curve, m

S = Superelevation, %.

In rural areas superelevation shall not exceed 7%. In urban areas with at-grade junctions and side accesses, superelevation shall be limited to 5%.

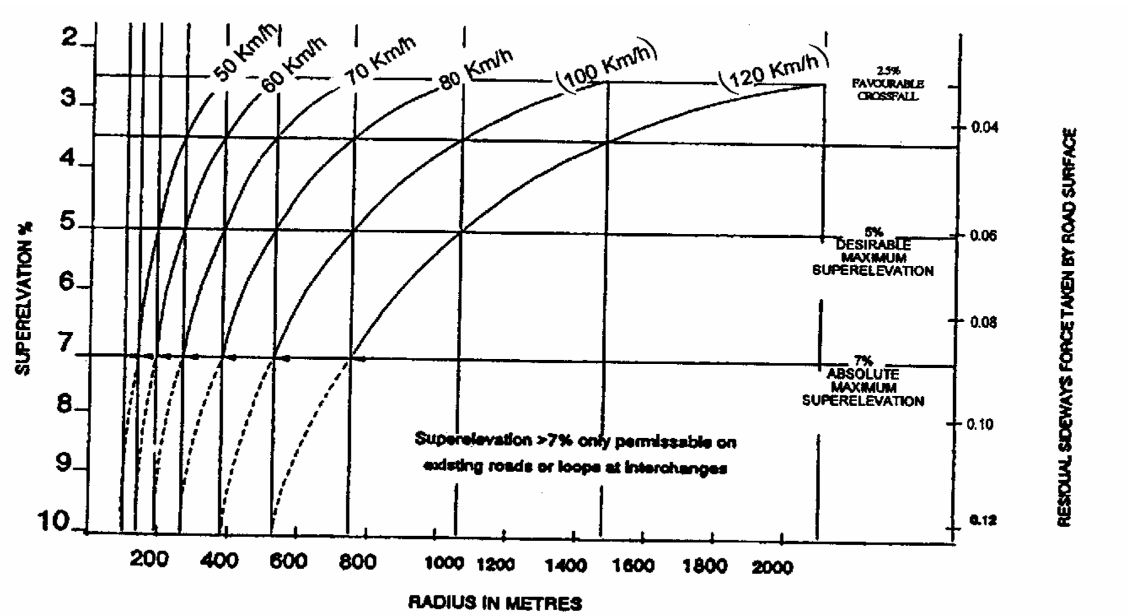


Figure 5 : Superelevation of Curves

Figure 5 shows the appropriate superelevation for the range of Design Speeds. Sharper radii than the Desirable Minimum shown in Table 3 result `in steep crossfalls which should be avoided if possible. It is essential to maintain adequate skidding resistance and good drainage at all superelevations.

Desirable Minimum Radius

3.3 The Desirable Minimum radii, corresponding to a superelevation of 5% (ie. $V^2/R = 14.14$) are shown in Table 3.

Relaxations

3.4 In the circumstances described in Paragraphs 1.16 to 1.26, Relaxations of up to 2 Design Speed steps below the Desirable Minimum values may be made at the discretion of the Designer for all road types. However, for roads in Design Speed band B in the circumstances listed in Paragraphs 3.5 and 3.6, the scope for Relaxations shall be extended or reduced as described, provided that the resultant Relaxations do not exceed 2 Design Speed steps.

3.5 On or near the bottom of long grades on dual carriageways steeper than 3% and longer than 1.5km the scope for Relaxations shall be reduced by 1 Design Speed step. Conversely, at or near the top of up gradients on single carriageways steeper than 4% and longer than 1.5 kin, the scope for Relaxations may be extended by 1 step due to reduced speeds uphill.

3.6 The scope for Relaxations shall be reduced by 1 Design Speed step immediately following an Overtaking Section on single carriageway roads (see Paragraphs 7.5 to 7.16).

Appearance and Drainage

3.7 Superelevation shall not be introduced, nor adverse camber removed, so gradually as to create large almost flat areas of carriageway, nor so sharply as to cause discomfort or to kink the edges of the carriageway. A satisfactory appearance can usually be achieved by ensuring that the carriageway edge profile does not vary in grade by more than about 1% from that of the line about which the carriageway is pivoted, and by ample smoothing of all changes in edge profile. In general on motorways, a smoother edge profile should be provided by reducing the variation in grade of the edge profile to a maximum of *0.5%* where feasible, i.e. where local drainage conditions permit, and care should be taken to ensure that a minimum longitudinal gradient of at least 0.5% is maintained wherever superelevation is to be applied or reversed. However, in some difficult areas even the above requirements can lead to drainage problems, eg. where the superelevation is applied against the longitudinal gradient. It may be necessary to either modify the horizontal alignment to move the superelevation area, increase the variation in grade of the edge profile, or apply a rolling crown. Areas susceptible to such drainage problems should be identified at an early stage in the design process, before the horizontal alignment is fixed.

Application of Superelevation

3.8 Progressive superelevation or removal of adverse camber shall be achieved over or within the length of the transition curve from the arc end. On existing roads without transitions, between ½ and 2 of the cant shall be introduced on the approach straight and the remainder at the beginning of the curve.

Widening on Curves

3.9 Pavement widening at curves on links and on the main line through junctions is required for carriageways of less than standard width and radius curves of standard width to allow for the swept path of long vehicles.

3.10 For carriageways of standard width (with lane widths of 3.5m, 3.65m or 3.75m), each lane shall be widened to 3.95m when the radius is between 90m and 150m.

3.10A For carriageways of standard width, the minimum lane width shall be 3.65m when the radius is between 150m and l000m.

3.11 For carriageways less than the standard widths, widening shall be:

> 0.6m per lane where the radius is between 90m and 150m subject to maximum carriageway widths of 7.9m, 11 .9m and 15.8m (for 2, 3 and 4 lanes respectively).

0.5m per lane where the radius is between

150m and 300m, subject to maximum carriageway widths of 7.9m, 11 .9m and 15.8m (for 2, 3 and 4 lanes respectively).

0.3m per lane, where the radius is between 300m and 400m subject to maximum carriageway widths of 7.9m, 11 .9m and 15.8m (for 2, 3 and 4 lanes respectively).

3.12 Radii less than 90m on the mainline are Departures from standard. For these and all other junction elements, widening should be in accordance with TD 42 (DMRB 6.2.6).

3.13 The extra width should be applied uniformly along the transition curve. In the improvement of existing curves the widening should generally be made on the inside of curves.

Lane Width Reductions at Pinch Points

3.14 At points of particular difficulty on Wide Dual Carriageways, where full lane widths cannot be achieved, a reduction from 3.75m to 3.50m is permitted as a Relaxation provided that the radius of curvature exceeds l000m. Points where such a Relaxation are likely to be most applicable are around the urban fringe, and at sites with difficult topography or in historic or conservation areas. This Relaxation shall not apply on new single carriageway roads.

Transitions

3.15 Transition curves shall be provided on curves the radius of which are less than that shown in Table 3 for Minimum R without elimination of adverse camber & transitions (ie. $V^2/R<5$).

3.16 Length of Curve: The basic transition length shall be derived from the formula:

$$L = \frac{V^3}{46.7 \times q \times R}$$

Where:
L = Length of transition (in)
V = Design Speed (km/h)
q = Rate of increase of centripetal acceleration (mlsec^3) travelling along curve at constant speed V(km/h)
R = Radius of curve (m)

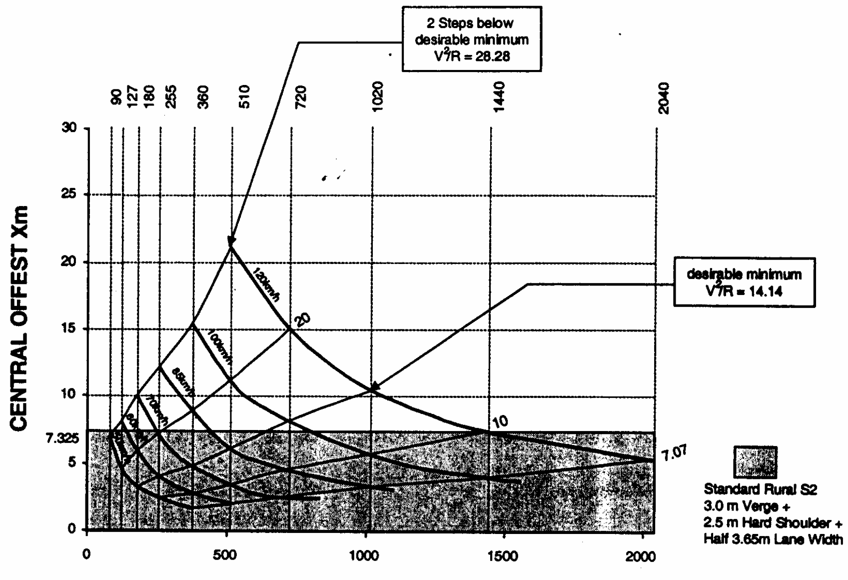
q should normally not exceed 0.3mlsec^3, although in difficult cases, it may be necessary to increase the value of q up to 0.6 rn/sec^3. On curves which are sub-standard for the appropriate Design Speed, the length of transition should normally be limited to ~J(24R) metres.

3.17 Application of Superelevation: Super-elevation or elimination of adverse camber shall generally be applied on or within the length of the transition curve from the arc end. The basic transition appropriate to the Design Speed, however, will often result in insufficient transition length to accommodate superelevation turnover, and in such cases longer transitions should be provided to match the superelevation design.

The Effect of Sight Distance on Horizontal Curves

3.18 Stopping Sight Distance: When the road is in a cutting, or at bridge crossings, it may be necessary tO widen verges or increase bridge clearances to ensure that the appropriate stopping sight distance is not obstructed. Figure 6 shows the maximum central offset required with varying horizontal curvature, in order to maintain the Design Speed related stopping sight distances. It can be seen that extensive widening of verges and structures, or central reserves with safety fence or safety barriers, would be required to maintain Desirable stopping sight distances on horizontal radii below Desirable Minimum. Where a road is on embankment, however, visibility will be available across the embankment slope. However, it must be ensured that the sight distance is not obscured by landscape planting.

3.19 Full Overtaking Sight Distance: Figure 7 shows the maximum central offset required with varying horizontal curvature, in order to maintain the Design Speed related FOSD's. It can be seen that the higher requirements of FOSD result in extensive widening of verges for all but relatively straight sections of road.



The values of X shown are the maxima and apply where SSD < curve length.
Land for visibility should be checked from the plans.

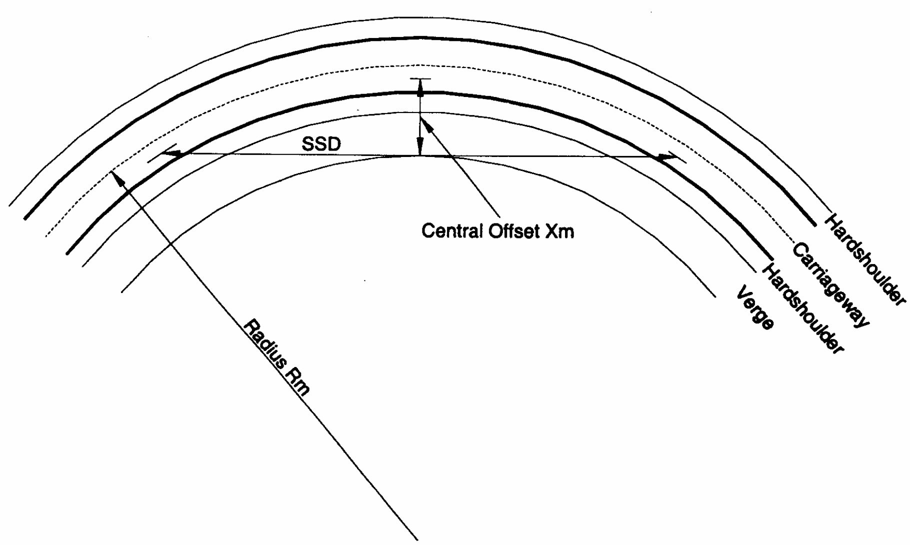
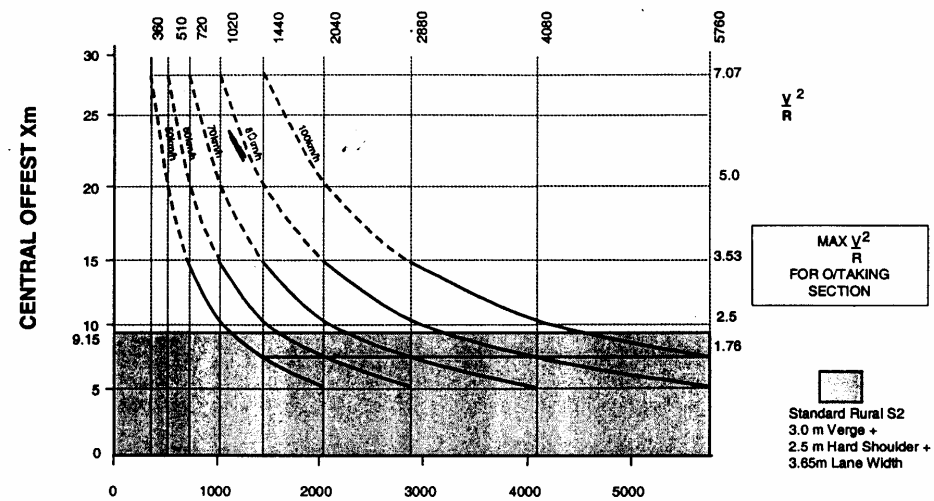


Figure 6 : Verge Widening for Desirable Minimum Stopping Sight Distance



RADIUS Rm

The values of X are the maxima and apply where FOSD < curve length.
Land for visibility should be checked from the plans.

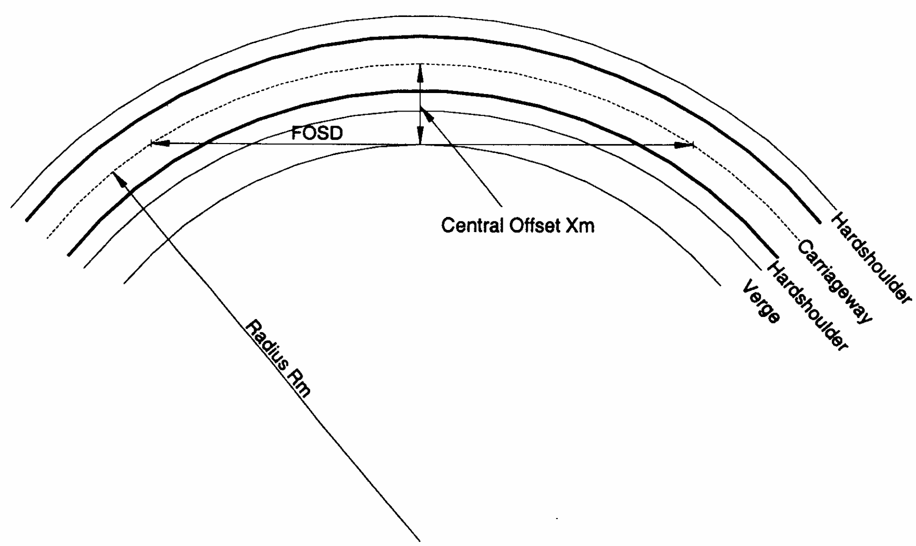


Figure 7 : Verge Widening for Full Overtaking Sight Distance

4. VERTICAL ALIGNMENT

Gradients

4.1 Maximum Gradients: The Desirable Maximum gradient for design shall be:

Desirable

	Max Grade
(Motorways	3%)
AP Dual Carriageways	6%
AP Single Carriageways	8%

However, in hilly terrain steeper gradients, up to 12% will frequently be required, particularly where traffic volumes are at the lower end of the range.

4.2 Effects of Steep Gradients: In hilly terrain the adoption of gradients steeper than Desirable Maximum could make significant savings in construction or environmental costs, but would also result in higher user costs, i.e. by delays, fuel and accidents. Slightly steeper gradients may, therefore, be permitted as Relaxations. There is, however, a progressive decrease in safety with increasingly steeper gradients. Departures from standards will, therefore, be required for any proposals to adopt gradients steeper than the following:

	Max Grade with Relaxation
Motorways	*4%*
AP Dual Carriageways	*8%*
AP Single Carriageways	*12%*

4.3 Minimum Gradients: For effective drainage with kerbed roads a minimum gradient of *0.5%* should be maintained wherever possible. In flatter areas, however, the vertical alignment should not be manipulated by the introduction of vertical curvature simply to achieve adequate surface water drainage gradients. Drainage paths must be provided by false channel profiles with minimum gradients of ***0.5%***. False channels may be avoided by using over-edge drainage (to filter drains or surface channels or ditches) where kerbs are inappropriate, eg. in rural areas.

Vertical Curves

4.4 General: Vertical curves shall be provided at all changes in gradient. The curvature shall be large enough to provide for comfort and, where appropriate, sight distances for safe stopping at Design Speed. The use of the permitted vertical curve parameters will normally meet the requirements of visibility. However stopping sight distance should always be checked because the horizontal alignment of the road, presence of crossfall, superelevation or verge treatment and features such as signs and structures adjacent to the carriageway will affect the interaction between vertical curvature and visibility.

4.5 K Values: Curvature shall be derived from the appropriate K value in Table 3. The minimum curve lengths can be determined by multiplying the K values shown by the algebraic change of gradient expressed as a percentage, ie. +3% grade to -2% grade indicates a grade change of *5%*. Thus for a Design Speed of 120 km/h, the length of a crest curve would be:-

Desirable Mm = *5* x 182 = 910m

One step below Des Mm = *5* x 100 = 500m

4.6 Crest Curves: There are two factors that affect the choice of crest curvature, visibility and comfort. At all Design Speeds in Table 3 the Desirable Minimum crest in the road will restrict forward visibility to the Desirable Minimum stopping sight distance before minimum comfort criteria are approached, and consequently Desirable Minimum crest curves are based upon visibility criteria.

4.6A The use of crest curves in the range from Desirable Minimum up to FOSD Overtaking Crest on single carriageway roads is a Departure from Standards (see Paragraph 7.19).

4.7 Sag Curves: Daytime visibility at sag curves is usually not obstructed unless overbridges, signs or other features are present; this also applies to night-time visibility on roads that are lit. However, sag curvature does affect night-time visibility on unlit roads. The Desirable Minimum sag curves are based on a conservative comfort criterion (0.21 rn/sec^3 maximum rate of vertical acceleration); the resultant sag curves approximate to those using headlamp visibility criteria assuming a 1.50 upward spread of the light beam. The sag curves for 1 Design Speed step below Desirable Minimum are based on the conventional comfort criterion of 0.3 rn/sec^3 maximum rate of vertical acceleration. The adoption of this approach results in the sag curve K values being less than or equal to the equivalent crest curve K values at all the Design Speeds in Table 3.

4.8 Grass Verges: Where, at crests, the sight line crosses the verge, consideration shall be given to the design of a lower verge profile in order to allow for an overall height of grass of 0.5m.

4.9 Crest Curves: In the circumstances described in Paragraphs 1.15 to 1.26, Relaxations below the Desirable Minimum values may be made at the discretion of the Designer. The number of Design Speed steps permitted below the Desirable Minimum are normally as follows:

motorways	band A	1 step
motorways	band B	2 steps
all-purpose roads	bands A and B	2 steps

However, in the circumstances listed in Paragraphs 4.10, 4.11 and 4.12 the scope for Relaxations shall be extended or reduced as described, provided that the resultant Relaxations do not exceed 2 Design Speed steps.

Relaxations

4.10 At or near the top of up gradients on single carriageways steeper than 4% and longer than ***1.5*** km. the scope for Relaxations may be extended by 1 step due to reduced speeds uphill.

4.11 The scope for Relaxations shall be reduced by 1 Design Speed step immediately following an Overtaking Section on single carriageway roads (see Paragraphs 7.5 to 7.16).

4.12 For band A roads when the crest curve is within a straight section the scope for Relaxations may be extended by 1 Design Speed step.

4.13 Relaxations below Desirable Minimum are not permitted on the immediate approaches to junctions as defined in Paragraph 1.26.

4.14 Sag Curves: In the circumstances described in Paragraphs 1.15 to 1.26, Relaxations below the Desirable Minimum values may be made at the discretion of the Designer. The number of Design Speed steps permitted below the Desirable Minimum are normally as follows:

motorways motorways all-purpose roads

(Motorways	band A	1step)
(Motorways	band B	2steps)
All-purpose roads	band A and B	2steps

However, in the circumstances listed in Paragraph 4.16, the scope for Relaxations shall be extended or reduced as described, provided that the resultant Relaxations do not exceed 2 Design Speed steps.

4.15 (Not used.)

4.16 The scope for Relaxations shall be reduced by 1 Design Speed step immediately following an Overtaking Section on single carriageway roads (see Paragraphs 7.5 to 7.16).

4.17 Relaxations below Desirable Minimum are not permitted on the immediate approaches to junctions as defined in Paragraph 1.26.

5. CLIMBING LANES

Single Carriageways

5.1 **General: On single** carriageways climbing lanes are a widening of the road to provide the use of two lanes for uphill traffic whilst the opposing traffic may be partially or fully confined to one lane. They shall be designed so as to encourage their use by all traffic, and not simply as extended laybys.

5.2 **Criteria For Provision**: On single carriageways without hard shoulders, an additional uphill climbing lane shall be provided, if it can be economically or environmentally justified, on hills with gradients (G = 100HIL) greater than 2% and longer than 500m. The solid curves in Figure 8 show~ the height risen, H, of a hill required to justify economically the provision of a climbing lane, according to the design year traffic forecast, based upon a standard cost of provision of a climbing lane in relatively easy terrain. On single carriageways with hard shoulders, the climbing lane should replace the hard shoulder, with little or no additional width (see Paragraph 5.6).As the cost of provision of the climbing lane in such cases will be small, climbing lanes should generally be provided wherever the risen height (H) exceeds 15m. This is shown by the dashed line in Figure 8.

In both cases, the height risen (H) and length (L) shall be calculated between two standard points on the hill as illustrated in Figure 9.

On single carriageways without hard shoulders, where there are high cost elements involved such as heavy earthworks, bridgeworks or environmental effects, (which would invalidate the average cost assumptions of Figure 8), it may be uneconomic or undesirable to make full provision. It may be preferable to adopt a Departure from Standards, by providing the climbing lane partially within the normal verge width/marginal strip to reduce the high cost implications, rather than omit the climbing lane altogether.

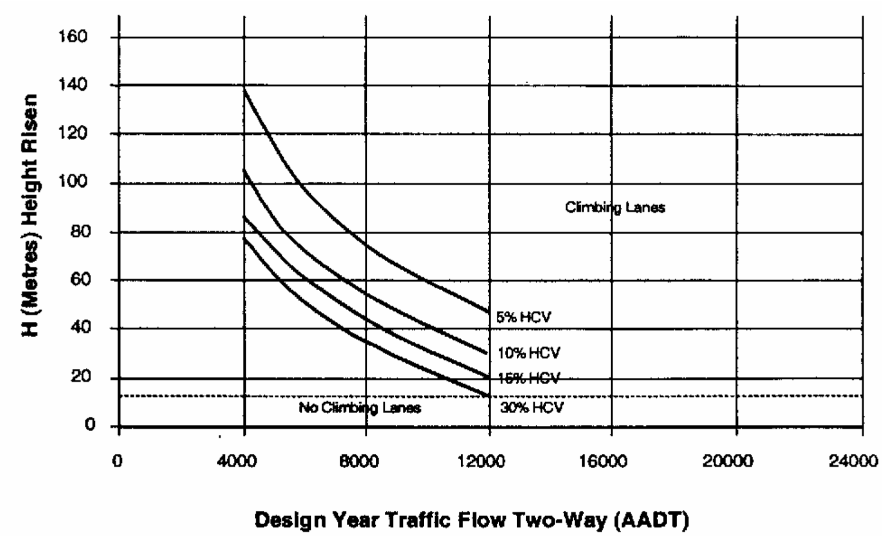


Figure 8 : Single Carriageway Climbing Lanes

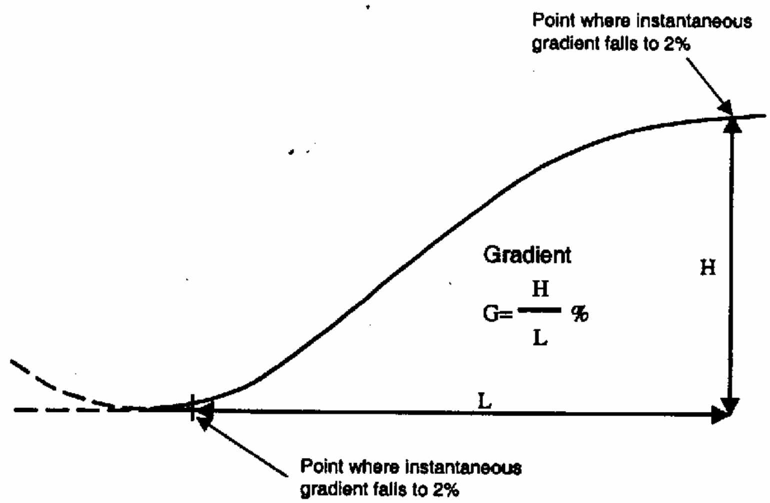


Figure 9 : Layout of Climbing Lanes

5.3 On gradients steeper than 4%, where the economic criteria above are not met, the additional cost of providing the climbing lane, in terms of loss of Net Present Value, should be identified by a simple cost/benefit analysis, and an assessment made, taking all factors into account, including the effect on the road user. Whilst the quantifiable economic benefits of the climbing lane may not be quite sufficient to justify its provision, the resulting loss of Net Present Value may be only minor, and thus a small price to pay for the unquantifiable benefits the climbing lane would provide to traffic, such as relieving the frustration of platoons caused by slow moving heavy goods vehicles (see Paragraph 7.24).

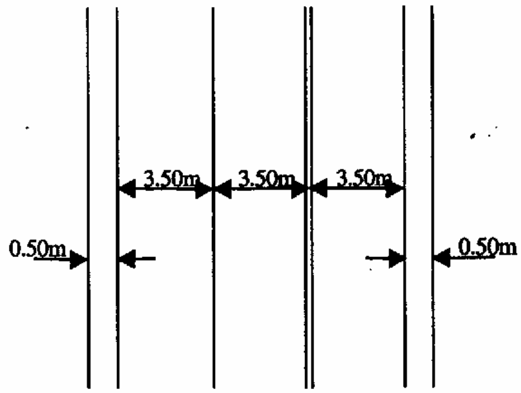
5.4 Climbing Lanes on Wide Single Carriageways: On wide single carriageways (WS2) the normal 2 wide lanes can be reduced, so as to provide an additional climbing lane within the normal cross-section. Whilst the criteria for the provision of climbing lanes at Paragraph 5.2 above serves as a useful guide for the installation of a climbing lane in this way, climbing lanes should be provided wherever their use would be of advantage in permitting slow moving climbing traffic to be overtaken.

(Figure 10 not used.)

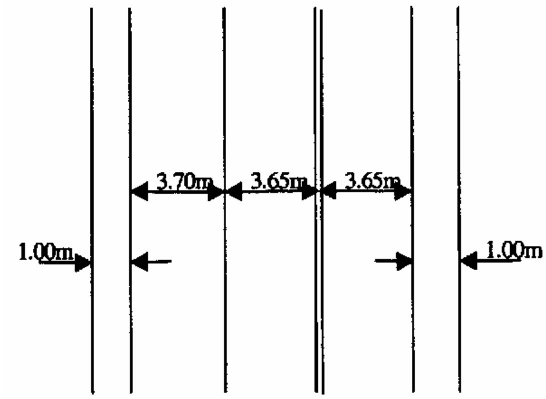
5.5 Length of Climbing Lanes: Climbing lane road markings tend to confine downhill traffic to a single lane, unless there is ample forward visibility unobstructed by slow moving vehicles in the climbing lane. Where the length of a climbing lane exceeds about 3 km therefore, it is important that some sections are provided with a straight or large radius right hand curvature in order to provide an Overtaking Section for downhill traffic (see Paragraph 7.13).

5.6 Lane Widths: The cross-sections of single carriageways including climbing lanes shall be as shown in Figures 11(a), (b) and (c).

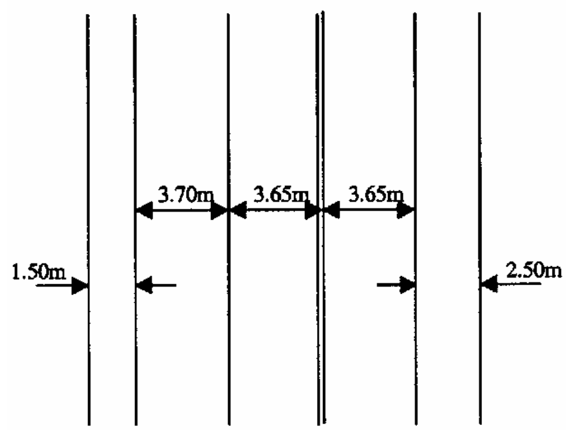
5.7 Layout at Start of Climbing Lane: The full width of the climbing lane shall be provided at a point 5, l00m uphill from the 2% point of sag curve, and preceded by a taper of 1/70, as shown in Figure 12. The length of the taper shall be such that traffic in the lane which is required to experience the greatest lateral shift over the length of the taper does so at 1/70. The alignment at the commencement of the climbing lane shall encourage drivers to follow the nearside channel unless overtaking. The taper shall therefore provide a smooth transition, by utilising the road curvature to develop the extra width, wherever possible. Where the curvature is used in this way, the length of taper may be reduced to 1/40 as a Relaxation. Specific signing of the climbing lane will not be necessary.



(a) : On Reduced Single Carriageway



(b) : On Standard Single Carriageway



(c) : On Wide Single Carriageway

Notes:

1. For standard road cross-sections, see ADT TD 27 (ADT DMRB 6.1.2).

2. The overall width of paved surface in case (c) should be equal to that without a climbing lane but including hard shoulders.

Figure 11:Climbing Lanes on Single Carriageways

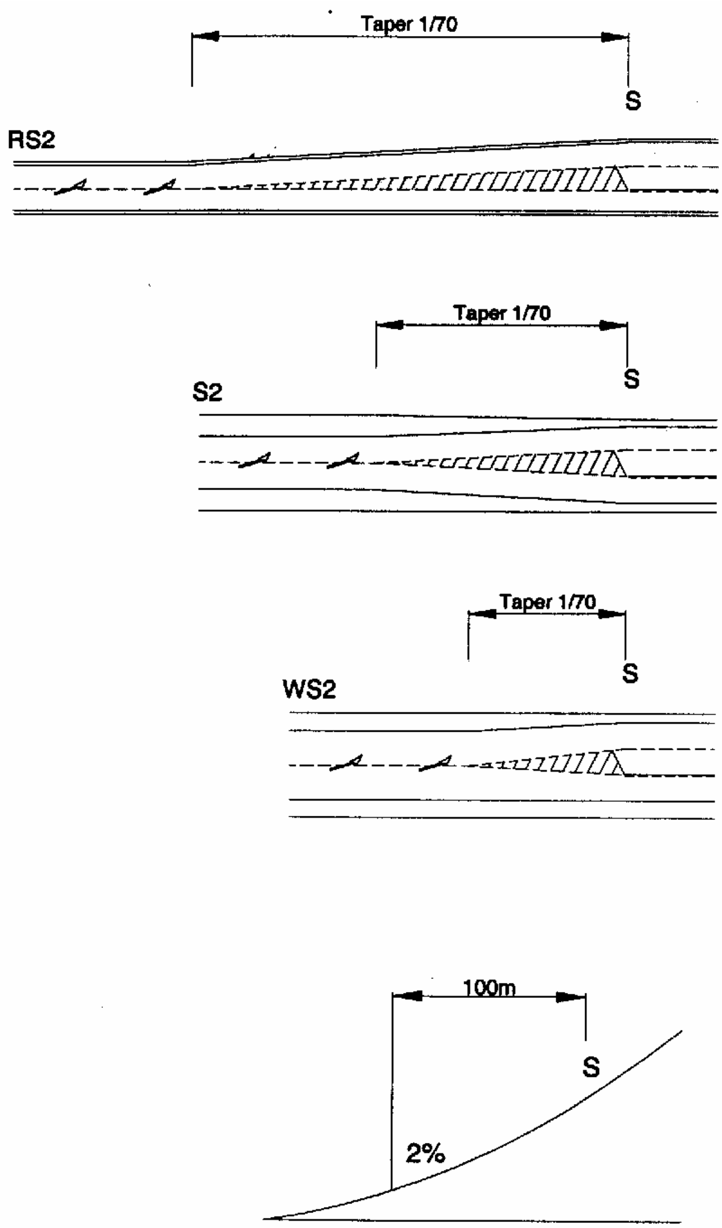


Figure 12 : Start of Climbing Lane

5.8 Layout at end of climbing lane: The carriageway width shall be tapered back to the normal two-lane width at a taper of 1:70 prior to a point F, as shown in Figure 13. The location of point F shall be 400m beyond the 2% point of the crest curve or 200m beyond the summit of the crest curve, whichever gives the shorter length of climbing lane. On a reduced single carriageway, the full width of the paved surface (including hard strips) shall be maintained up to point F. A 200m length of hard shoulder shall be provided on the climbing lane side of a reduced S2, followed by a taper of 1:70 to the normal paved width.

The alignment at the end of the climbing lane shall place the onus on the driver in the climbing lane to rejoin the continuing lane. The taper shall provide a smooth transition in the same manner as that at the start of the climbing lane. Where the road curvature is used to provide a smooth transition, the lengths of tapers may be reduced to ***1:50*** as a Relaxation. Advance warning signs should be provided as shown in Figure 13. Cafe should be taken to ensure that the return to a single lane does not occur where junctions or sharp curves may cause problems.

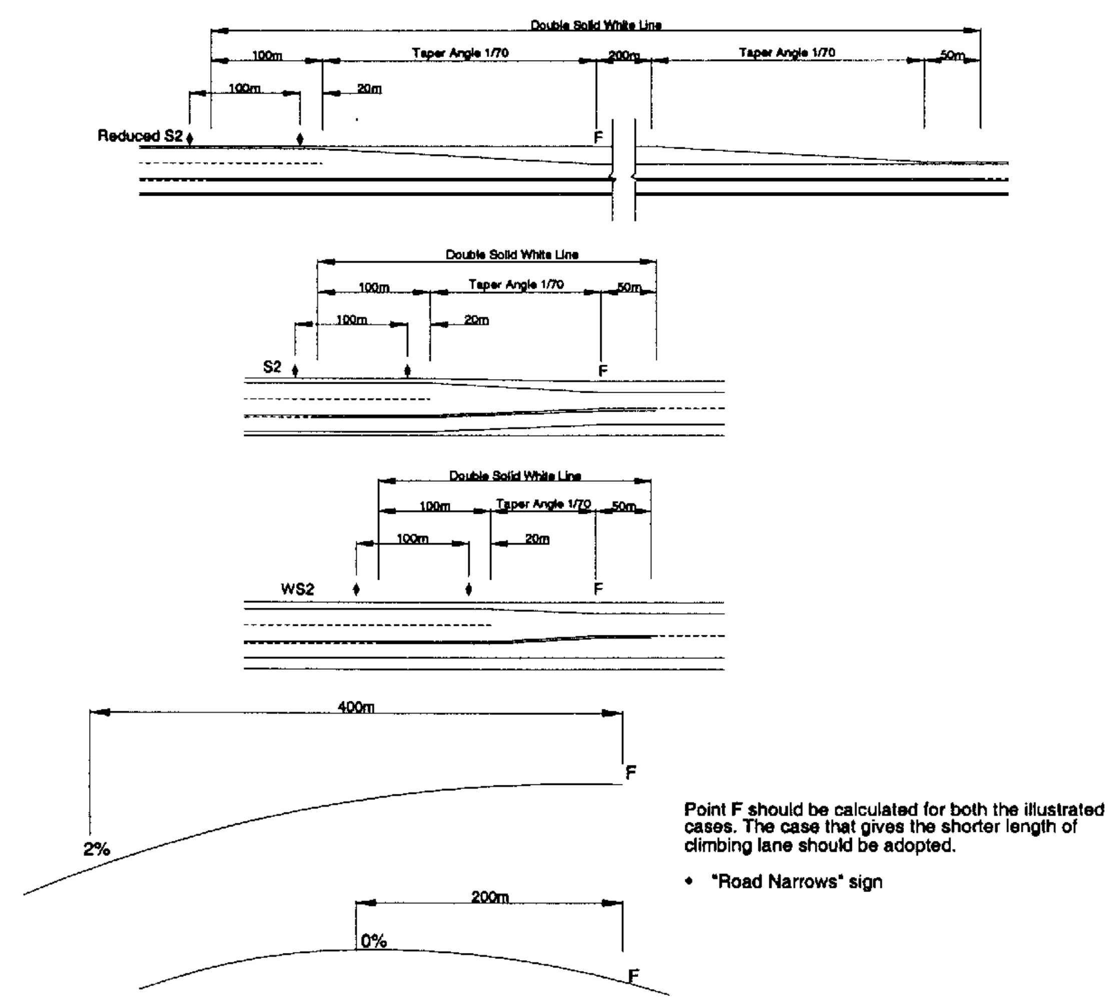


Figure 13 : End of Climbing Lane

5.9 Layout of crests: Where there are climbing lanes on both sides of the hill, and profile conditions would lead to a conventional road layout between ends of tapers of less than 500m in length (see Figure 14a), the climbing lanes shall be extended to provide a length of four lane road at the summit: the detailed layout of a four lane crest is shown in Figure 14b. The treatment of hard shoulders and hard strips should follow Figures 11 and 13 for the appropriate carriageway standard: the overall paved surface width at the summit (which should comprise two "uphill parts" of the relevant Figure 11) including hard shoulders or hard strips should be maintained between points M on Figure 14b.

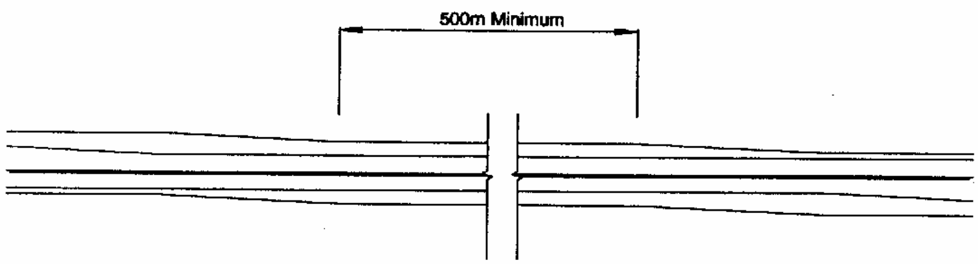


Figure 14a : Crest Curve Between Two Climbing Lanes

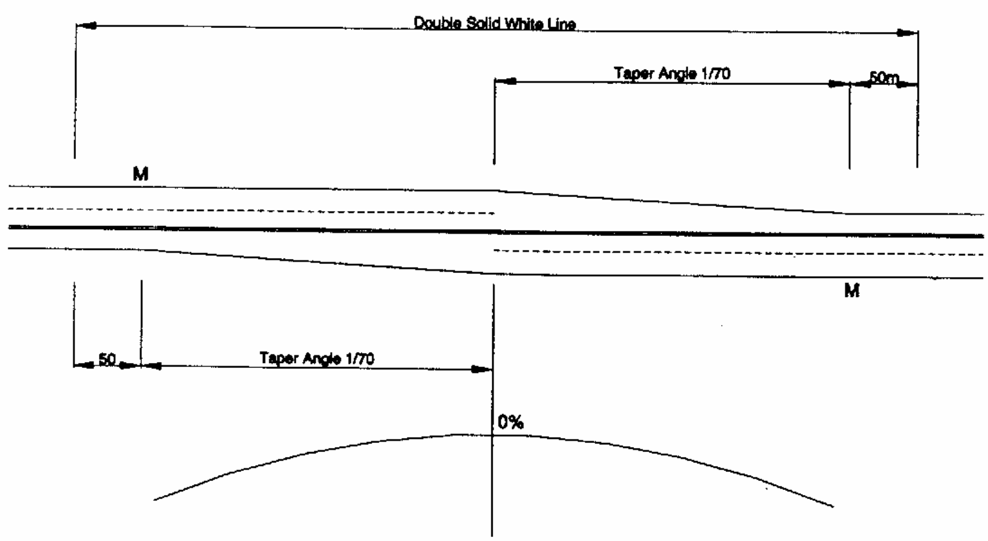


Figure 14b : Crest Curve Between Climbing Lanes

5.10 Layout at Sags: Where there are climbing lanes either side of a sag curve, and profile conditions would lead to a conventional 2 lane road layout between tapers of less than 500m in length, the climbing lanes shall be extended downhill until they meet, with a road marking as illustrated in Figure 15. The treatment of hard shoulders and hard strips should follow Figure 11 for the appropriate carriageway standard: the overall paved surface width of the climbing lane sections (which should comply with the relevant Figure 11) including hard shoulders or hard strips should be maintained between points N on Figure 15.

5.11 Sight Distance requirements with climbing lanes: Climbing lanes do not require FOSD, but a stopping sight distance which is not more than one Design Speed step below Desirable Minimum stopping sight distance shall be provided throughout. Care should be taken, however, in the design of the crest curve. If vehicles on the crest approaching the downhill section are provided with a high visibility crest curve, there is a possibility of subsequent abuse of the priority rule. The crest curve should be designed to a K value of (or slightly more than) one Design Speed step below Desirable Minimum K value. A double continuous line marking should be provided as in Figure 13 to establish clearly the climbing lane priority. If sight distance increases beyond the crest, the marking should then become continuous/broken to permit some overtaking in the downhill direction.

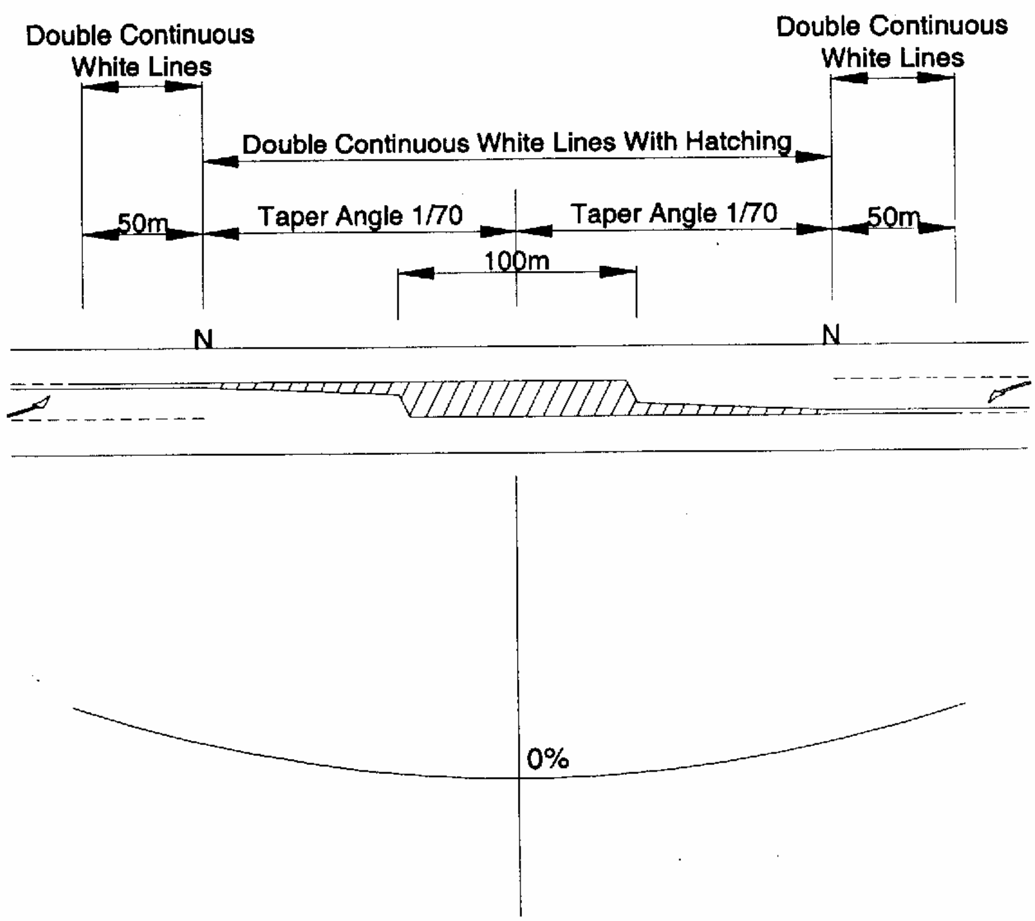


Figure 15 : Sag Between Two Climbing Lanes

Dual Carriageways and Motorways

5.12 General: The provision of an additional lane on an uphill section of a dual carriageway should be expected to provide benefits to travellers by diminishing delays caused by slow moving traffic, and reducing travel time costs. The effect of adding a climbing lane is two-fold; some traffic is able to move over to a faster lane, thereby gaining a significant speed advantage, and the consequent reduced volume in the left hand lanes also enables speeds to increase in these slower lanes. Gradients can be pinch points where congestion starts when traffic flows approach capacity. On roads where design year flows are high the economic benefits can be substantial.

5.13 Criteria for Provision: On motorways, an additional uphill climbing lane shall be provided, if it can be economically or environmentally justified, on hills with gradients (G = 100HJL) greater than 2% and longer than 500m. The hard shoulder shall be continued alongside the climbing lane. The solid curves in Figure 16 show the height risen, H, of a hill required to justify economically the provision of a climbing lane, according to the design year traffic forecast, based upon a standard cost of provision of a climbing lane in relatively easy terrain.
On dual carriageways with hard shoulders at least 2.5m wide, the hard shoulder should be replaced by a 3.5m climbing lane with a 1.Om nearside hard strip. As the cost of provision of the climbing lane in such cases will be small, climbing lanes should generally be provided wherever the risen height (H) exceeds 15m. This is shown by the dashed line in Figure 16.
In both cases, the height risen (H) and length (L) shall be calculated between two standard points on the hill as illustrated in Figure 9.

5.14 Options: Climbing lanes add another optional element to the treatment of vertical alignment. They may allow steeper, shorter, gradients to be considered, which would reduce earthworks, be less intrusive to the local environment, and offset the cost of the wider road. However, from a traffic benefit viewpoint, the option of flattening gradients may often be preferable. The implications of long steep gradient on the downhill carriageway should also be considered.

5.15 (Not used.)

5.16 Lane Widths: In general, an overall additional full lane width shall be provided, although in difficult areas, where structural or environmental costs are high, the cross-section may be reduced by using narrow lanes down to 3.25m, ie. carriageway width of 9.75m (D2), or 13.OOm (D3). Such reductions shall be considered as Departures.

5.17 Layout at Start of Climbing Lane: The full width of the climbing lane shall be provided at a point S in a similar manner to that described for single carriageway roads (Paragraph 5.7), as shown in Figure 17. Wherever possible the additional width should be developed by utilising the road curvature to provide a smooth transition.

5.18 Layout at End of Climbing Lane: The carriageway width shall be tapered back to the normal two lane width at a taper of 1:70 prior to a point F, in a similar manner to that described for single carriageway roads (Paragraph 5.8). A smooth transition should be used wherever possible, as shown on Figure 18.

5.19 Signing of Climbing Lanes: To distinguish the commencement of a climbing lane from a change of carriageway standard, "Slow Lane" signing should be provided in accordance with the Traffic Signs Manual.

5.20 Sight Distance Requirements with Climbing Lanes: As the speeds of vehicles utilising the climbing lane will be considerably less than those on the rest of the carriageway, the climbing lane should be disregarded in respect of provision of stopping sight distance, which shall be checked from the centre of the inside lane of the original carriageway.

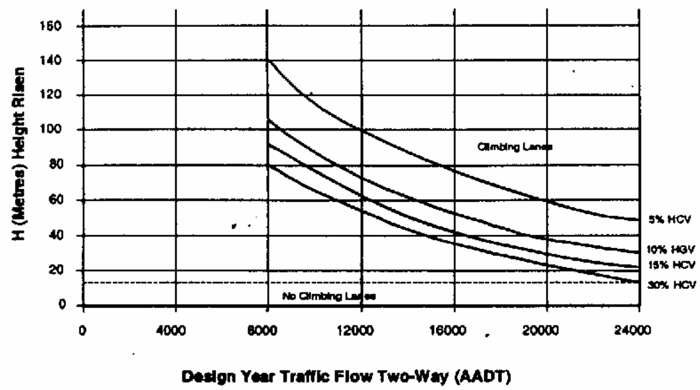


Figure 16 : Dual Carriageway and Motorway Climbing Lanes

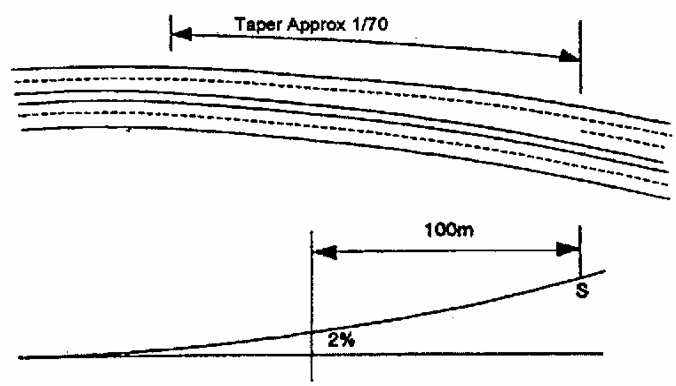


Figure 17 : Start of Dual Carriageway Climbing Lane

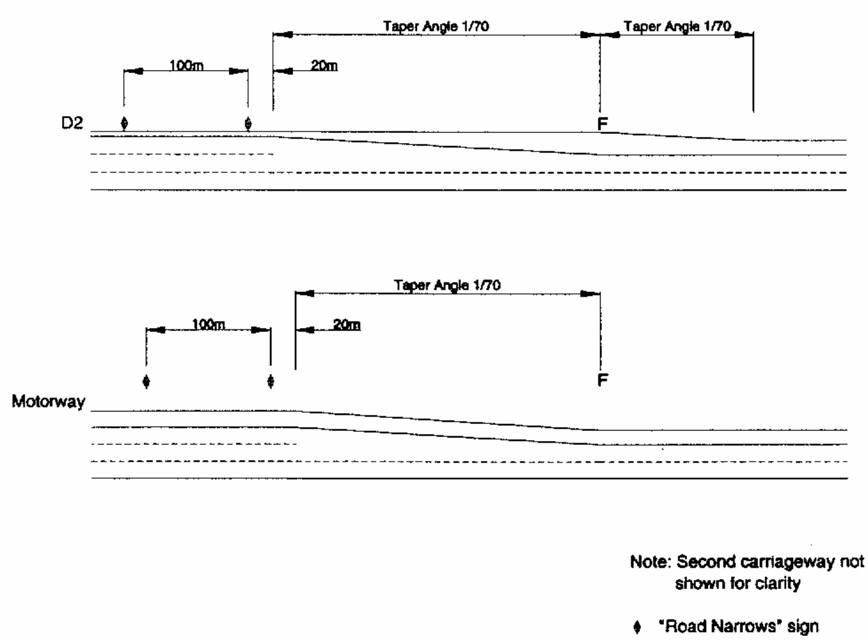


Figure 18 : End of Dual Carriageway Climbing Lane

6. INTRODUCTION TO COORDINATED LINK DESIGN

General

6.1 The various elements detailed in this Standard shall be coordinated, together with cross-section and junction layouts, so as to ensure that the three dimensional layout as a whole is acceptable in terms of traffic safety and operation, and economic/environmental effects. Single carriageway design is given particular emphasis due to the problems of driver understanding and provision for overtaking.

Rural Roads

6.2 A general guide to the layout features appropriate for various types of road is given in Table 4. The table recommends edge treatments, access treatments and junction types that would be suitable in broad terms for each type of road. For details of the standard road cross-sections, see ADT TD 27 (ADT DMRB 6.1.2).

Urban Roads

6.3 It is not possible to tabulate overall layout characteristics for roads in urban areas in the same way as for rural areas, as the constraints of the existing urban fabric will result in designs tailored to meet the site specific requirements. Urban Standards (embracing mandatory speed limits, Design Speeds generally 85km/h and below, and reduced cross-section design), are more conducive to safe conditions where the surrounding development is very much of an urban nature. Urban standards should not normally be used for roads passing through other than short lengths of parklands, recreational areas, non-built up waste land, etc., which present an open aspect.

6.4 In urban areas, there will usually be less scope for coordinating the geometric features than in rural areas, although wherever economically, environmentally practicable every effort should be made to do so. The demands of accommodating the road within the urban fabric will frequently predominate.

6.5 Single two lane carriageway S2 or WS2 urban roads, with no frontage access, no standing vehicles and negligible cross traffic, would normally represent a radial or orbital bypass or new town distributor. The design considerations in respect of Overtaking Sections in Chapter 7 should be applied wherever economically/ environmentally practicable, although the constraints of the urban area will frequently not permit the flexibility of alignment required. In some cases, extra road width (ie. WS2 or even a 4 lane single carriageway) can be used to provide overtaking opportunity if economically feasible.

6.6

6.6 Single two lane carriageways S2 or WS2 with frontage development, side roads, bus stops, etc. with the paramount need to create safe conditions for pedestrians, are likely to be modest projects in an area where comprehensive traffic management has been carried out on the existing network and the new road is required to extend or improve that management. It is unlikely that the coordinated design aspects contained hereafter will be applicable in these cases. Further advise is given in the “Recommendations for Main Roads” ADT Guidelines.

Category	Type of Road [1]	Capacity (AADT) for Level of Service D with Level Terrain	Edge Treatment	Access Treatment	Junction Treatment At Minor Road	Junction Treatment at Major Road
1	Reduced Single (7.0m) Carriageway S2	8,600	0.5m hard strips. Pedestrian footways where required	Minimise number of accesses to avoid standing vehicles and concentrate turning movements	Priority junctions, with ghost islands where necessary	Ghost islands.
2/3A	Standard Single (7.3m) Carriageway S2	11,600	2.5m hard shoulders	As 1	Priority junctions, with ghost islands where necessary.	Ghost islands or roundabouts. [2]
3B/4	Wide Single [3] (10m) Carriageway WS2	13,800	2.5m hard shoulders. Pedestrian usage minimised.	As 1	Ghost islands. Some side roads stopped up. Occasional bridges at higher end of traffic range.	At-grade roundabouts.[2]
5	Standard At Grade Dual 2 Lane (7.0m) Carriageways. All Purpose D2AP	26,500	2.5m hard shoulders	Minimise number of accesses to avoid standing vehicles and concentrate turning movements. No gaps in the central reserve.	Priority junctions. No other gaps in the central reserve.	At-grade roundabouts. Grade separation if economically justified.
5A	Standard Grade Separated Dual 2 Lane (7.0m) Carriageways. All Purpose D2AP	42,000	2.5m hard shoulders	No access.	Left in/left out only. No gaps in the central reserve.	Full grade separation.
6	Wide Dual 2 Lane (7.5m) Carriageways All Purpose D2AP	44,100	3m hard shoulders	Minimisation of access numbers severely enforced. No gaps in the central reserve.	Restricted number of priority junctions. No other gaps in the central reserve.	At grade roundabouts at lower end of range. Otherwise full grade separation.
7A	(Wide) D2AP	44,100	3m hard shoulders	No access.	Left in/left out only. No gaps in the central reserve.	Full grade separation.
7B	Standard Dual 2 Lane (7.0m) Motorway D2M	52,000	2.5m hard shoulders	Motorway Regulations	None	Motorway standards
7C	Wide Dual 2 Lane (7.5m) Motorway D2M	55,500	3m hard shoulders	Motorway Regulations	None	Motorway Standards

Notes:
1. For Details of the standard road cross-sections, see ADT TD 27 (ADT DMRB 6.1.2).
2. Single lane dualling may be appropriate in some situations, but would be regarded as Relaxation (see TD 42, DMRB 6.2.6)
3. The approval of the Maltese Transport Authority is required for schemes which will create more than 2m of Wide Single Carriageway.

Table 4: Recommended Rural Road Layouts

7. SINGLE 2 LANE CARRIAGEWAY ROADS

General Principles

7.1 Single 2 lane carriageways up to 10m wide (running width) shall be designed with the objectives of safety and uncongested flow in mind. This Chapter gives methods of achieving these objectives. Although they are to some extent related, for instance frustrated traffic tends to lead to unsafe conditions, it is important to identify some other aspects which if not taken into account in the design may lead to a higher than average proportion of serious accidents. Amongst these are:

a. Continuous flowing alignments, (Paragraphs 7.25 and 7.28);

b. Treatment of grade separation on single carriageways (Paragraph 7.35);

c. Single carriageway alternating with dual carriageway (Paragraphs 7.16, 7.36, 7.39, 7.40 and 7.41);

d. Staged construction (Paragraphs 7.37, 7.38, 7.47 and 7.48).

7.2 Clearly identifiable Overtaking Sections for either direction of travel are required to be provided frequently throughout the single carriageway, so that vehicles can maintain the Design Speed in off-peak conditions. In peak conditions overtaking opportunities will be rare; nevertheless steady progress will be possible for the majority of vehicles if junctions are carefully designed, and if climbing lanes are provided wherever the forecast traffic demand is sufficient to justify a climbing lane according to Paragraph *5.2*.

7.3 In easy terrain, with relatively straight alignments, it may be economically feasible to provide for continuous overtaking opportunity by means of consistent provision of Full Overtaking Sight Distance (FOSD). Where significant curvature occurs or the terrain becomes increasingly hilly, however, the verge widening and vertical crest requirements implicit in this design philosophy will often generate high cost and/or environmentally undesirable layouts. The alternative philosophy of clearly identifiable Overtaking Sections, including climbing lanes, interspersed with clearly Non-overtaking Sections, will frequently result in a more cost effective design provision. The trade-off between alternative alignments of the construction and user costs, including accidents, should be tested by cost/benefit analyses.

7.4 In the coordination of vertical and horizontal alignments, many of the principles contained in Paragraph 8.7 (Category 5A and 7A dual carriageways) are equally applicable to the design of single carriageway roads. However, the overriding need to design for adequate, overtaking will frequently supersede the general desirability for full coordination of vertical and horizontal alignments, with design concentrating upon the provision of straight Overtaking Sections. At sags and crests, however, designs should still be checked to ensure that the road in perspective does not take on a disjointed appearance.

Overtaking Sections

7.5 Overtaking Sections are sections of road where the combination of horizontal/vertical alignment, visibility, or width provision is such that clear opportunities for overtaking will occur.

Overtaking Sections, which are fully defined in Paragraphs 7.7 to 7.16, comprise:

a) Two-lane Overtaking Sections
b) Climbing Lane Overtaking Sections
c) Downhill Overtaking Sections at Climbing Lanes
d) Dual or S4 Overtaking Sections

It is necessary for the calculation of Overtaking Value (Paragraph 7.19) to define the method by which the lengths of Overtaking Sections are assessed, and the method of measurement for each category of Overtaking Section is described in the following paragraphs. In general, they will commence whenever either FOSD on a straight (or nearly straight) or right hand curve is achieved, or the width provision is sufficient for overtaking without crossing the dividing line between opposing lanes. They will terminate either at a point where sight distance reduces to FOSD/2in when approaching a Non-overtaking Section, or at a distance of FOSD/4m prior to an obstruction to overtaking. (The detailed measurement of single lane downhill sections opposite climbing lanes, however, is described in Paragraph 7.13).

7.6 The method of measurement described in the following paragraphs is based upon curvature/visibility relationships for S2 roads. Whilst the additional road width of a WS2 provides much greater flexibility for overtaking, largely independent of curvature, the following design rules should still be used to achieve an optimal overtaking design.

7.7 Two-lane Overtaking Sections: Two-lane Overtaking Sections are sections of single two lane carriageways, with normal centre of carriageway road markings providing clear opportunities for overtaking. They consist of straight or nearly straight sections affording overtaking in both directions (with horizontal radius of curvature greater than that shown in Table *5)* and right hand curves, the commencement of which are provided with at least FOSD. The section, which is shown in Figure 19, is measured as follows:

7.8 Commencement: At the point on a straight (or nearly straight) or right hand curve where FOSD is achieved, either within or without the road boundary.

7.9 Termination:

a) At a point FOSD/4m prior to the tangent point or centre of transition of a left hand curve

b) The point on a right hand curve where sight distance has reduced to FOSD/2m

c) A point FOSD/4m prior to an obstruction to overtaking (see Paragraph 7.18).

Design Speed km/h	(100)	80	70	60	50
Minimum Radius of straight or nearly Straight sections (m)	8160	5760	4080	2880	2040

Table 5: Minimum Radii for Two-lane Overtaking Sections

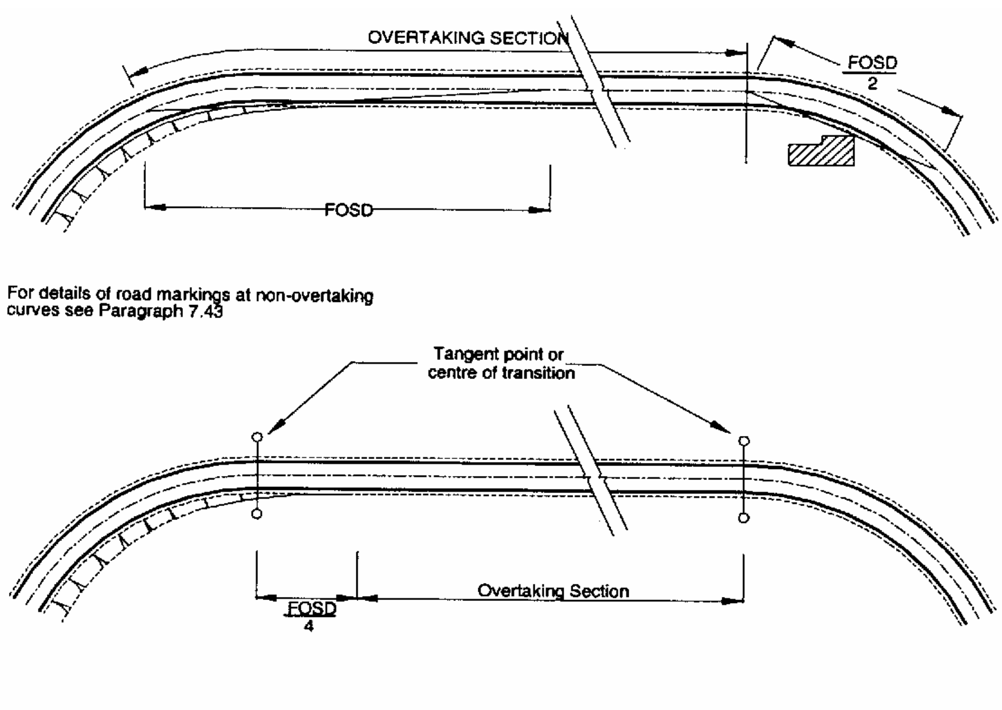


Figure 19 : Two-lane Overtaking Sections

7.10 Climbing Lane Overtaking Sections: Climbing Lane Overtaking Sections are sections where priority uphill overtaking opportunities are provided by means of two uphill lanes, separated from the opposing downhill lane by means of a double line, (either double continuous or continuous/broken). The section, which is shown in Figure 20, is measured as follows:

7.11 Commencement: A point in the centre of the commencing taper.

7.12 Termination: A point FOSD/4m prior to the centre of the finishing taper. However, if the following section is an Overtaking Section, it should be assumed to be contiguous with the climbing lane section.

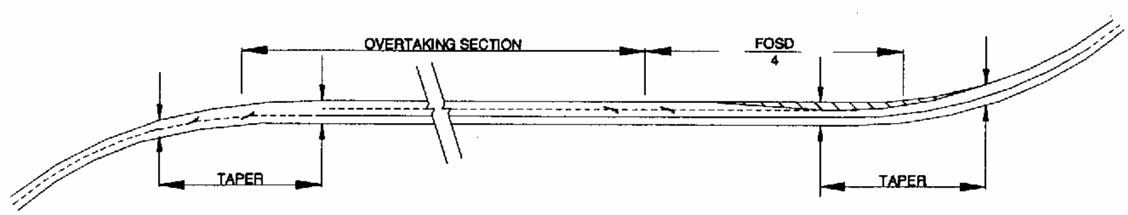


Figure 20 : Climbing Lane Overtaking Sections

7.13 Downhill Overtaking Sections at Climbing Lanes: Downhill Overtaking Sections at Climbing Lanes are sections of a single downhill lane, opposite a climbing lane, constrained by a continuous/broken double line, where the combination of visibility and horizontal curvature provide clear opportunities for overtaking when the opposing traffic permits. They consist of straight or nearly straight sections, and right hand curves with radii greater than those shown in Table 6.

Design Speed Km/h	(100)	85	70	60	50
Minimum Radius(m)	2880	2040	1440	1020	720

Table 6: Minimum Radii of Right Hand Curve Downhill Overtaking Sections at Climbing

The sight distance naturally occurring within the normal road boundaries~ at the radii shown in Table 6 will be sufficient for downhill overtaking, and thus, for Downhill Overtaking Sections at Climbing Lanes, verges shall not be widened to give FOSD. However, these sections should only be considered as Overtaking Sections on straight grades or sag configurations: ie. when the road surface is not obscured by a vertical crest curve within:

FOSD, or

the horizontal sight distance available around the curve.

The section, which is shown in Figure 21, is measured as follows:

7.14 Commencement: The point where the right hand curve radius achieves the requisite value from Table 6.

7.15 Termination: A point FOSD/4m prior to the end of the requisite radius.

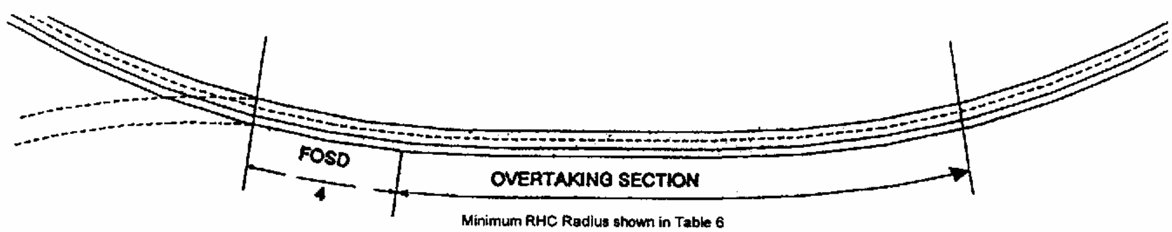


Figure 21 : Downhill Overtaking Sections at Climbing Lanes

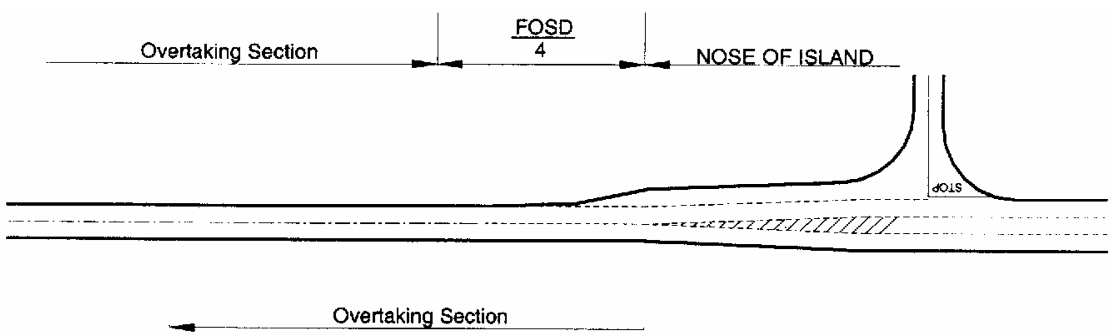
7.16 Dual Overtaking Sections: Dual Overtaking Sections are sections with dual carriageways, which provide overtaking opportunities throughout their length. They should, however, only be provided in cases where the most economic method of improvement of a section of existing single carriageway is to provide a second carriageway alongside the first. Dual Overtaking Sections within otherwise single carriageway roads shall be subject to the same overtaking length criteria as climbing lane sections shown at Paragraph 7.10. S4 Overtaking Sections (where space is limited) should be considered equivalent to Dual Overtaking Sections in terms of assessment of overtaking.

Non-overtaking Sections

7.17 Non-overtaking sections are all left or right hand curves on two-lane sections or single downhill lanes opposite climbing lanes that do not conform with the requirements of Paragraphs 7.7 to 7.16 (see also Non-overtaking crests, Paragraph 7.19)

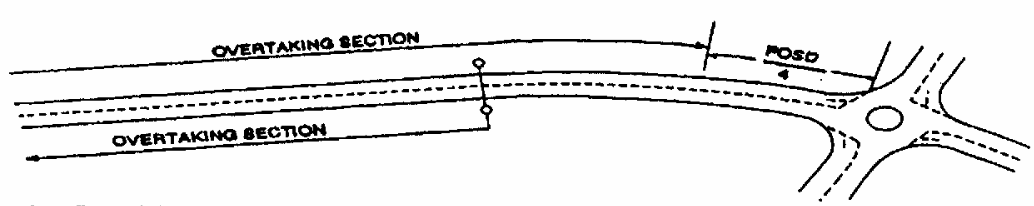
Obstructions to Overtaking

7.18 At Grade Junctions: Major/minor junctions with ghost islands or single lane dualling and roundabouts should be considered as obstructions to overtaking if they are sited within an otherwise Overtaking Section. The Overtaking Section shall terminate at a distance of FOSD/4m prior to the nose of the ghost or physical island, or the roundabout Yield line, as shown in Figure 22. Similarly, the Overtaking Section shall commence at the end of the nose of the ghost or physical island at a priority junction. The commencement at a roundabout shall be in accordance with the requirements for a Two-lane Overtaking Section (see Paragraph 7.8). Simple junctions and accesses, however, with no central ghost or physical islands can be ignored for the purpose of determining Overtaking Sections.



Note: a simple priority junction with no ghost island layout can be ignored for the purposes of determining Overtaking Sections.

a. Approach to Priority Junction (with ghost or solid island).



b. Approach to Roundabout.

Figure 22 : Obstructions to Overtaking

Non-overtaking Crests

7.19 A crest with a K value less than that shown in Table 3 for FOSD Overtaking Crest K Value should be considered as a Non-overtaking Section. The Overtaking Section within which it occurs should be considered to terminate at the point at which sight distance has reduced to FOSD/2, as shown in Figure 23. However, the use of Desirable Minimum crest K values will result in a continuous sight distance only slightly above FOSD/2, and thus, theoretically, the Overtaking Section will be continuous over the crest. The use of crest K values in the range from Desirable Minimum up to FOSD Overtaking Crest is not, therefore, recommended for single carriageway design (see Paragraph 7.30), and is considered to be a Departure from Standards.

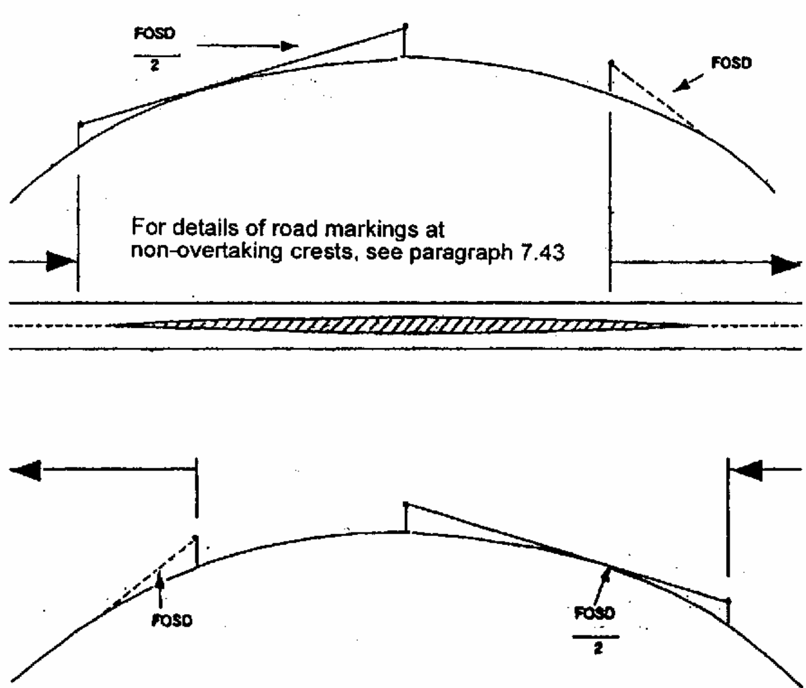


Figure 23 : Non-overtaking Crest

Overtaking Value

7.20 A sight distance analysis shall be carried out for each direction of travel to ensure that there are sufficient and effective Overtaking Sections at frequent intervals along the scheme. The total length of Overtaking Sections for each direction shall be summed and divided by the total length of the road improvement to obtain the 'Overtaking Value" in each direction, expressed as a percentage. The minimum Overtaking Values for the different road types which are thought, to provide a reasonably safe road in most circumstances are given in Table 7.

Road Type (Table 4)	Overtaking Value
Category 1	15%
Categories 2 and 3A	30%
Categories 3B and 4	40%

Table 7 : Overtaking Value

The table applies to new construction and new schemes exceeding 2km. Overtaking sections should be distributed along a length of road such that no Non-overtaking Section exceeds 3km. The results of the sight distance analysis should be plotted on the engineering drawings, with the system of road markings to be adopted along the route included below the plot, see Paragraphs 7.7, 7.10, 7.13, 7.19, 7.29, 7.30 and 7.43. This is to ensure that the significance of the various interacting parameters has been taken account of at an early date. Generally speaking it is an advantage from a safety point of view to provide as much overtaking distance as possible, but the amount of provision above the minimum in each scheme must be a matter of judgment according to the particular circumstances.

7.21 The Overtaking Sections along a scheme, which may comprise combinations of the various types shown in Paragraphs 7.5 to 7.16, should be provided by the most economic means. In some instances it may be suitable to use a few long sections, whilst in other cases more frequent shorter sections, linked with Non-overtaking Sections, would provide the most economic strategy to achieve the appropriate Overtaking Value. Alternative designs should be tested by cost benefit analyses.

7.22 The Overtaking Values shown shall be regarded as a minimum level of provision. Using the principles described in this standard it should be possible in the majority of cases to obtain these values without significant extra expenditure on alignment. Detailed guidance is given in Paragraph 7.24. It must be appreciated, however, that a single carriageway will never provide an equal "level of service" to a dual carriageway. There will always be greater interactions between fast and slow moving vehicles on single carriageways, and overtaking maneuvers will always be hazardous, involving difficult decisions by drivers, whereas dual carriageways permit continuous overtaking without interference with opposing traffic. These implications, however, result in reduced speeds and increased accident rates on single carriageways that are already implicit in the cost/benefit trade-off of alternative standards of design, although the "level of service" or driver-comfort differentials cannot be costed. Provided the requisite Overtaking Values are achieved, therefore, a satisfactory single carriageway design will result. Any additional measures to increase Overtaking Values beyond the requisite levels, such as the provision of additional climbing lanes, straightening route sections, or elimination of junctions, should be justified in economic/environmental terms.

7.23 Schemes Less Than 2km in Length: Schemes less than 2km in length shall be integrated with the contiguous sections of existing road to provide the best overtaking opportunities that can economically be devised. Where contiguous sections afford little or no overtaking opportunity, it is essential that the requisite Overtaking Value be achieved for the scheme. On short bypasses this will result in the need to provide at least one Overtaking Section in either direction. However, where contiguous sections provide good overtaking opportunities, a check on the Overtaking Value for a length of, say, 3km including the bypass may relieve the necessity to provide the requisite Overtaking Value for the bypass.

7.24 Means of Improving Overtaking Value: As well as ensuring sufficient overtaking opportunities, the method also controls the spacing of junctions. If the criteria are not met initially for any alignment it may be necessary to:

a) Modify the junction strategy by stopping up, bridging or diverging some side roads.

b) Adjust the alignment to produce more straight sections.

c) Introduce climbing lanes on hills previously not considered justified because of low traffic flow.

d) Introduce roundabouts at the more heavily trafficked priority junctions to create sharper changes of direction and improve Overtaking Section lengths.

e) Introduce lengths of Standard S2 or WS2 road with hard shoulders at suitable locations. Whilst this will not improve the Overtaking Value according to the formal methods described in Paragraphs *7.5* to 7.16, such sections will nevertheless, by the extra road width, increase flexibility and reduce frustration.

f) Introduce more extensive sections of S4 or dual carriageways.

Alternative means of improving Overtaking Values should be tested by cost/benefit analyses to determine their economic implications. This will take into account any changes in user costs due to increased junction delays, diversion costs, or increased speeds due to increased road width, etc. The minimum overall additional cost of improving Overtaking Values in terms of loss of Net Present Value (NPV) should be identified, and an assessment made taking all factors into account, including the effect on the road user.

The extra cost of provision of extra road width to provide a climbing lane at a hill previously considered unjustified (or a section of wider road cross-section on a constrained level road alignment) may be justified on the total balance of advantage. As the wider road will also provide some improved benefits, the resulting loss of NPV may only be minor and thus a small price to pay for the unquantifiable benefits to traffic of improving the Overtaking Value.

Horizontal Curve Design

7.25 The use of mid-large radius curves is counter productive, inhibiting the design of clear Overtaking Sections. They produce long dubious overtaking conditions for vehicles travelling in the left hand curve direction, and simply reduce the length of overtaking straight that could otherwise be achieved.

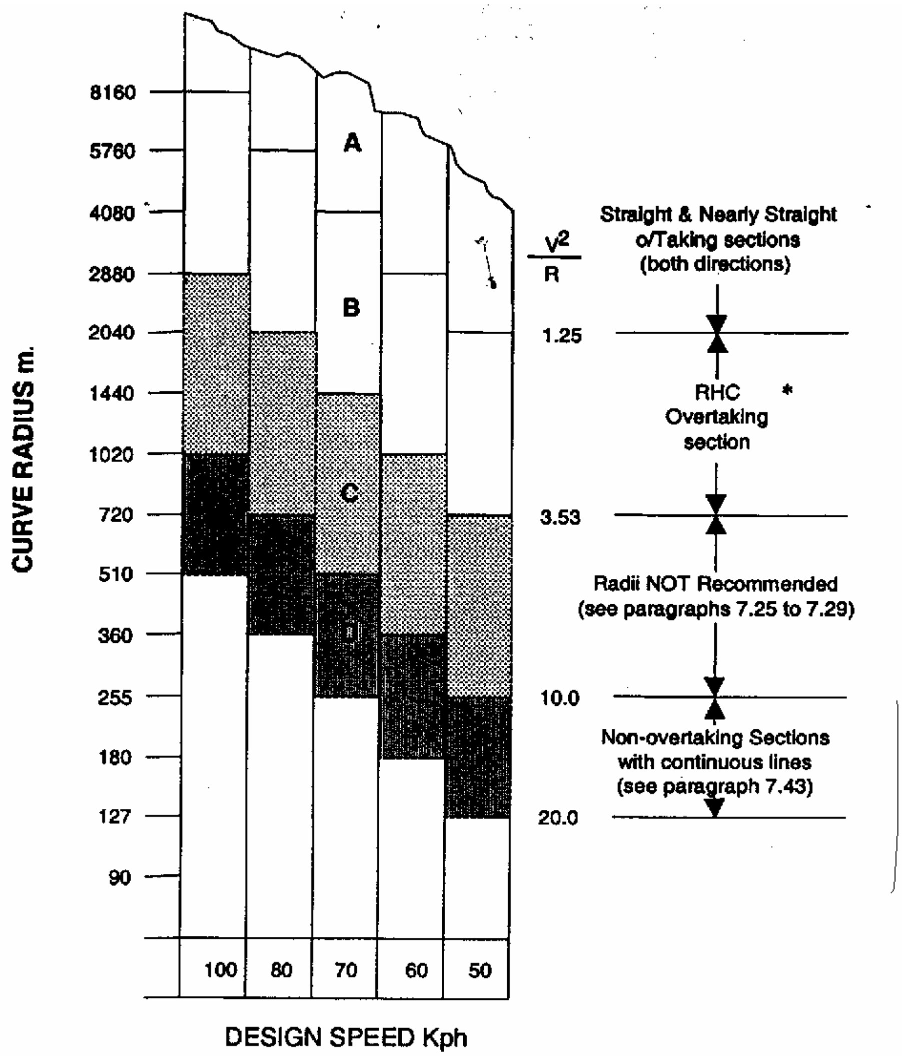
Figure 24 shows a curve selection chart for horizontal curves, which illustrate the bands of radii (relative to Design Speed) and their applicability in the design of single carriageways.

7.26 Wherever possible, level Overtaking Sections and climbing lanes shall be provided as straight or nearly straight sections (Band A), thus providing an Overtaking Section for both directions of travel ($V^2/R < 1.25$).

7.27 Where straight sections are not possible, lower radii will result in right hand curve (RHC) Overtaking Sections:
On two-lane sections following the achievement of FOSD (see Figure 19); and
On single lane downhill sections opposite climbing lanes .(see Figure 21).

The lower limit of Band B ($V^2/R = 3.53$) shown for RHC Overtaking Sections should be considered as the minimum radius for use in designing Overtaking Sections. At this level a maximum verge width of 8.45m (plus the 2.5m hard shoulder) would be required on a Standard Single Carriageway to maintain FOSD within the road cross-section for RHC traffic. Left hand curves with radii in Band B should not be considered to be part of Two-Lane Overtaking Sections or Downhill Overtaking Sections at climbing lanes.

7.28 The use of radii in Band C ($V^2/R =$ **3.53-10)** is not recommended, as they, in common with Band B, provide long sections with dubious overtaking conditions for LHC traffic. Where visibility is constrained within the road cross-section, either excessive verge widening would be required to maintain FOSD for RHC traffic, or the natural visibility without verge widening at these radii would result in dubious overtaking conditions for the RHC traffic also. It is a paramount principle, therefore, that design should concentrate only on Bands A and B for clear non overtaking Sections. The use of radii in Band C is a Departure from Standards (See para. 1.27).
Overtaking Sections, and Band D for clear Non-



*** Note: Verge widening may be necessary. See Paragraph 7.27.**

Figure 24 : Horizontal Curve Design

overtaking Sections. The use of radii in Band C is

7.29 Non-overtaking Sections should be designed using the radii shown in Band D (V^2/R = 10-20), where the radius is sufficiently small to represent a clearly Non-overtaking Section. Radii of Non-overtaking Sections should be chosen around the centre of Band D (V^2/R = 14) to strike a balance between providing clear Non-overtaking Sections and avoiding steep superelevation.

Vertical Curve Design

7.30 The vertical alignment shall be coordinated

a Departure from Standards (see Paragraph 1.27). with the horizontal alignment to ensure the most efficient overtaking provision. On Two-Lane Overtaking Sections, the vertical curvature shall be sufficient to provide for FOSD in accordance with Paragraphs 2.3 to *2.5.* However, for Non-

overtaking Sections and climbing lanes, the use of large crest curves is quite unnecessary and is not recommended. Unless a vertical curve can have a large enough K value to provide FOSD (thus forming an Overtaking Section) a long section of dubious visibility would result (see Paragraph 7.19). Therefore, the K value on a crest on a Non-overtaking Section or a climbing lane should not be greater than that for one Design Speed step below Desirable Minimum Stopping Sight Distance. The use of crest K values in the range from Desirable Minimum up to FOSD Overtaking Crest is not recommended for single Overtaking Sections that could otherwise be achieved.

7.31 Horizontal and vertical visibility shall be carefully coordinated to ensure that sight distance at curves on crests is correlated. For example, it would be unnecessary to acquire additional verge width to provide for Desirable Minimum stopping sight distance in the horizontal sense, when the crest only provides a stopping sight distance of one Design Speed step below Desirable Minimum.

Junction Strategy

7.32 The aim should be to provide drivers with layouts that have consistent standards and are not likely to confuse them. On lengths of inter-urban road, sequences of junctions should not therefore involve many different layout types. For example, a length of route containing roundabouts, single lane dualling, ghost islands, simple priority junctions and grade separation would inevitably create confusion and uncertainty for drivers and cause accidents on that account. The safest road schemes are usually the most straightforward ones that contain no surprises for the driver.

7.33 Major/minor junctions with ghost islands or local single lane dualling and roundabouts represent an obstruction to overtaking. To achieve maximum overtaking efficiency, therefore, straight Overtaking Sections should be located wherever possible between junctions, which can be located in Non-overtaking Sections. Visibility to the junction shall be a minimum of Desirable Minimum Stopping Sight Distance.

7.34 Use of a roundabout will enable a change of alignment at a junction, thus optimising the Overtaking Sections either side. As an alternative to continuing large radius curves into the roundabout with only unidirectional overtaking, it is preferable to utilise a straight section followed by a non-overtaking radius as the final approach, in order to optimise the use of two directional overtaking straights, as shown in Figure 25.

7.35 Designs involving grade separation of single carriageway roads should be treated with carriageways, and is considered to be a Departure from Standards. The use of crest curves in that range would be counter productive, simply increasing costs, increasing the length of dubious crest visibility, and reducing the length of clear caution. Some grade separated crossings will be necessary for undesirable side road connections and for agricultural purposes. Experience has shown that frequent overbridges and the resulting earthworks create the impression of a high speed road, engendering a level of confidence in the road alignment that cannot be justified in single carriageways, where opposing traffic travels on the same carriageway. The provision of regular at grade junctions with ghost islands, local dualling or roundabouts will maintain the impression of a single carriageway road. Where crossing flows are high, or local topographical conditions would suggest the need for a grade separated junction, the single quadrant link with a conventional ghost island junction, as shown in Figure 26, will maintain the impression of a single carriageway road, with conventional single carriageway turning movements and minimise the disruptive right turn movement onto the major road. The link should be located in the quadrant that will ensure the larger turning movements become left turns onto and right turns off the maj or road. With the highest levels of traffic flow, it may be necessary to provide roundabouts at one or both ends of the link road. The use of slip merges can be confusing on single carriageways and create problems with merging into a single lane. They destroy the overall impression of a single carriageway, and shall not be used.

Changes in Carriageway Width

7.36 Changes from dual to single carriageways are a potential hazard situation and the aim in new construction should be to provide continuity of road type, either single or dual carriageway layout, on any major section of a route which carries consistently similar traffic, subject to satisfactory economic and environmental assessments. Exceptions are described below. Where it is not possible to achieve an adequate Overtaking Value by means of Two-lane Overtaking Sections or climbing lanes, the impression of a single carriageway road shall be maintained by utilising Standard S2 or WS2 sections with hard shoulders at suitable locations (see Paragraph 7.24), or short sections of S4, rather than introducing sections of dual carriageway. Where it is appropriate to change from dual to single carriageway, careful consideration should be given to the use of a roundabout as a terminal junction to indicate to drivers the significant change in road standard.

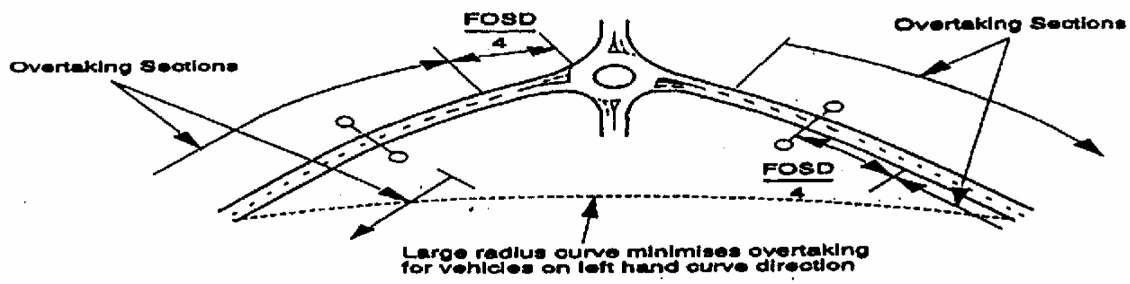


Figure 25 : Use of Roundabout to Change Alignment

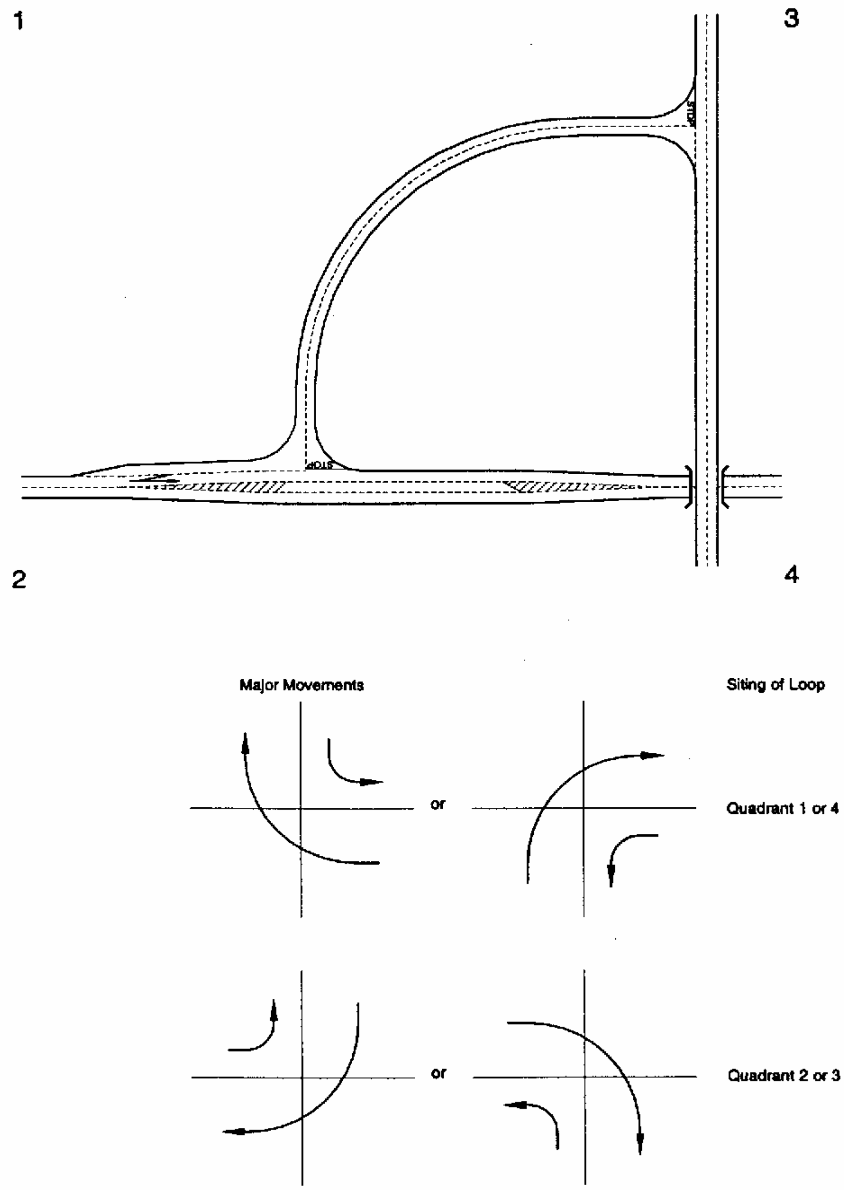


Figure 26 : Single Quadrant Link

7.37 Single carriageways of a type containing wide verges and extensive earthworks prepared for eventual dualling create the illusion of driving on a dual carriageway, which leads to abnormally high serious accident rates. Where staged construction is part of the design or there are safety problems at existing sites, provision shall be made to avoid giving drivers an illusion that they are on a dual carriageway rather than on a single carriageway such as

a) Fencing of a permanent appearance at a verge width (normally 3.Om) from the channel of the constructed carriageway on the side reserved for the future carriageway.

b) Clear signing and marking indicating the existence of two way traffic.

c) Where a changeover occurs at a roundabout, a narrow physical splitter island not less than 50 metres long on the single carriageway side of the roundabout followed by hatching.

7.38 Where there is an overbridge designed for an eventual second carriageway, the illusion of a second running carriageway shall be removed by planting and earth mounds as shown in Figure 27.

Figure 27

7.39 Where a lighter trafficked bypass occurs within an otherwise dual carriageway route, a single carriageway may be acceptable provided the terminal junctions such as roundabouts give a clear indication to drivers of changed Standards (see Figure 28, Paragraph 7.36 and Paragraph 7.37 b and c).

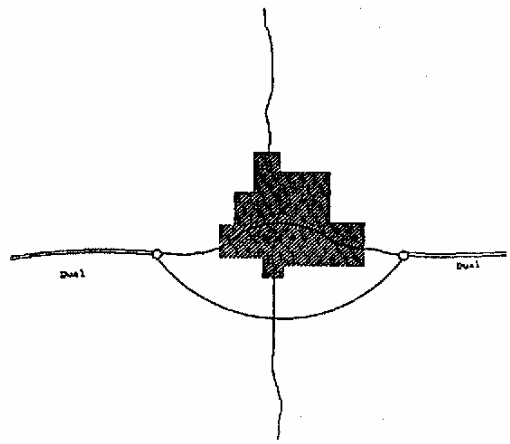


Figure 28

7.40 In circumstances where a length of new carriageway alongside an existing single carriageway provides the most suitable and economic means of achieving a dualled Overtaking Section and where such a dual carriageway returns to single carriageway width or in any other case, the change in width shall be made abundantly clear to drivers by:

a) Signing and marking indicating the existence of the single carriageway

b) Providing a length of central reserve in advance of the taper such that drivers approaching the single carriageway can see across it, to have a clear view of the approaching traffic moving on to the dual carriageway.

7.41 If lengths of dual carriageway within a generally single carriageway road or vice-versa are unavoidable they shall be at least 2km in length and preferably 3km, and major/minor junctions shall be avoided within 1 kilometre of the end of the central reserve on either type of carriageway, see Paragraph 7.39.

Road Markings

7.42 (Not used.)

7.43 At non-overtaking horizontal curves, and crests (see Paragraph 7.30), where double continuous line markings would normally be required, the markings may be strengthened with a hatched marking as shown in Figure 29, especially following Overtaking Sections, in order to make clear to drivers the presence of undesirable overtaking conditions, in accordance with the Traffic Signs Manual.

Existing Single Carriageway Improvements

7.44 The design standards contained in the preceding paragraphs apply generally to lengths of new single carriageway construction, from short bypasses and diversions to extensive new single carriageway routes. When dealing with existing rural roads, the need for improvements will frequently be dictated by evident dangerous bends, junctions, narrow sections, hills, etc. for the improvement of which the standards shown in Chapters 1 to 5, Elements of Design, will be applicable.

7.45 Where, however, the need for improvement arises from congested conditions, or from a restricted alignment providing an unsatisfactory regime of flow, attention should be focused upon the provision of adequate Overtaking Sections, as in Paragraphs 7.20 to 7.24. One of the most economic methods of improving Overtaking Value is the provision of climbing lanes (or a second carriageway added to the first) on hills, where slow moving vehicles create severe congestion and consequent delays, instead of a major realignment to create a Two-Lane Overtaking Section elsewhere.

7.46 On a long length carrying consistently similar traffic which has been defined for more major improvement, it is important to have a comprehensive strategy to maintain an acceptable level of service and safe conditions. Ways of implementing the strategy in stages must be evolved to suit expenditure profiles. The techniques contained throughout Chapters 6 and 7 shall be used when formulating the overall strategy, which, after elimination of dangerous bends, junction improvements, etc., should concentrate upon the provision of adequate Overtaking Sections. Whilst the vertical and horizontal alignments shall be coordinated in accordance with the preceding paragraphs for all newly constructed diversions and bypasses, there will frequently be little necessity for such coordination on the remaining sections which, although not conforming to formal standards, may not demonstrate any operating problems.

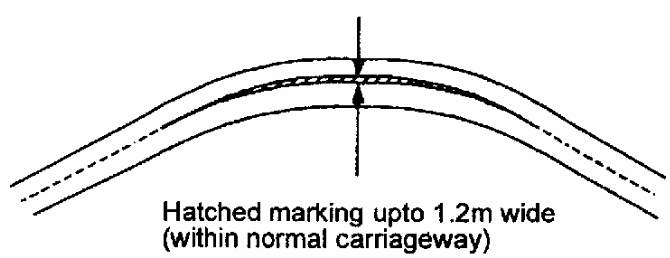


Figure 29 : Hatched Road Marking at Non-overtaking Curves and Crests

7.47 Where a single carriageway is being considered as a first stage of an eventual dual carriageway improvement, the single carriageway shall be designed in accordance with the coordinated design aspects shown in Chapter 7. This will ensure that the impression of an essentially at-grade single carriageway road is maintained. Where it is economic to carry out some earthworks or bridgeworks for the dual carriageway in the first stage, care must be taken to ensure that the wider formation and bridges do •not create the illusion of a dual carriageway. At bridges, such an illusion can be avoided by the methods described in Paragraph 7.38, and generous planting can reduce the overall impression of space.

7.48 The overriding requirements for clear Overtaking Sections in the first stage design will mean that the flowing alignment requirements for dual carriageways (as shown in Paragraph 8.7) will not be possible or desirable. However, first stage designs should be checked to ensure that the horizontal and vertical alignments are phased sufficiently to eliminate any areas where misleading visual effects in perspective might occur, for example, broken back alignments.

8. DUAL CARRIAGEWAYS AND MOTORWAYS

General Principles

8.1 All purpose dual carriageways and motorways shall be designed to permit light vehicles to maintain the Design Speed. Subject to traffic conditions, light vehicles can overtake slower moving vehicles throughout, without conflict with opposing traffic, and drivers are free to travel at a speed controlled only by the constraints described in Chapter 1. Unlike single carriageways, therefore, there is no limitation upon the use of horizontal or vertical curves in excess of the values for one Design Speed Step below Desirable Minimum values, and the coordination of design elements will mainly involve the design and optimisation of aesthetic alignments.

8.2 In the coordination of vertical and horizontal alignments, the principles contained in Paragraph 8.7 (Category 5A and 7A dual carriageways) are generally desirable for all dual carriageway designs. However, for the lower categories of design, with consequently lower traffic flows, a high standard of aesthetic design may frequently not be justifiable, particularly where the dual carriageway represents an alternative to a single carriageway.

All Purpose Dual Carriageways

8.3 <u>Category 5 (Table 4)</u>: This is the lowest category of dual carriageway which will normally represent an alternative layout option to single carriageway types S2 or WS2.

8.4 The vertical alignment should follow the topography closely, with the horizontal alignment phased to match. Junctions should generally be at-grade, with roundabouts at the more heavily trafficked intersections, although where economically! environmentally feasible, grade separated solutions should be provided.

8.5 Major/Minor junctions on dual carriageways are a source of accidents, but collecting together side roads or increased provision of grade separation are costly alternatives that may not be economically justified. Furthermore, where the dual carriageway is being assessed as an alternative option to a single carriageway, the additional costs of higher standards of junction or alignment provision, together with the resulting higher overall earthworks and structural implications, may well cause the dual carriageway option to be so costly as to be uneconomic, in spite of its inherently superior performance in terms of link accidents and user costs. A category 5 dual carriageway, therefore, should be designed essentially as an at-grade alternative to an at-grade single carriageway, and elements of design, such as junctions, should be enhanced only if there is economic or environmental justification for doing so. In this way, dual carriageways will frequently demonstrate superior economic performance to a single carriageway at flows well below the upper limits of single carriageway demand flows.

8.6 <u>Category 6 (Table 4)</u>: In this category, minor side roads shall be stopped up, or collected together to reduce the number of gaps in the central reserve. Major intersection types, which may include roundabouts, will be determined by site conditions, traffic demand, and economic/environmental effect. The combined vertical/horizontal alignments should follow the topography as much as possible, without purposely achieving a “motorway” type of flowing alignment.

8.7 <u>Categories 5A and 7A (Table 4)</u>: These are the highest categories of all-purpose road, where all intersections, both major and minor, should be grade separated. A smooth flowing alignment is required for sustained high speeds. The following are the principles to be followed in securing a satisfactory alignment:

a) Care should be taken to ensure that embankments and cuttings do not make severe breaks in the natural skyline.
b) When negotiating a ridge in cutting or passing through a broad stretch of woodland, the road should be on a curve whenever possible so as to preserve an unbroken background.
c) Short curves and straights should not be used. Adjacent curves should be similar in length.

d) Small changes of direction should not be made, as they give the perspective of the road ahead a disjointed appearance.

e) Curves of the same or opposite sense which are visible from one another should not be connected by a short straight. It is better to introduce a flat curve between curves of the same sense, or to extend the transition curves to a common point between curves of the opposite sense.

e) Changes in horizontal and vertical alignment should be phased to coincide whenever possible. This is very important with horizontal curves sharper than 2,000m radius and vertical curves of less than 15,000m radius.

g) Flowing alignment can most readily be achieved by using large radius curves rather than straights.

h) The profile of the road over bridges must form part of the easy flowing alignment.

i) At the start of horizontal curves superelevation must not create large flat areas on which water would stand.

j) Horizontal and vertical curves should be made as generous as possible at interchanges in order to enhance sight distances.

k) Sharp horizontal curvature shall not be introduced at or near the top of a pronounced crest. This is hazardous especially at night because the driver cannot see the change in horizontal alignment.

1) The view of the road ahead should not appear distorted by sharp horizontal curvature introduced near the low point of a sag curve.

Motorways

8.8 The high standard of motorway design results in high speeds throughout, by complete elimination of access other than at interchanges and service areas, prohibition of usage by pedestrians and certain vehicle types, coupled with the generous flowing alignment. 8.9 The relevant alignment standards are given in Chapters 2 to *5* and the rules in Paragraph 8.7 shall be followed. Additionally:

a) Horizontal and vertical curves should be as generous as possible throughout.

b) To relieve the monotony of driving on a road with such good extensive forward visibility, long sections of the road should be aligned to give a view of some prominent feature ahead.

9. REFERENCES

BS 6100: Subsection 2.4.1, Glossary of Building and Civil Engineering Terms: Highway Engineering. British Standards Institution.

Design Manual for Roads and Bridges (DMRB):

Volume 6 : Road Geometry:

ADT TA 43 (ADT DMRB 6.1.1A) - Guidance on Road Link Design.

ADT TD 27 (ADT DMRB 6.1.2) - Cross-Sections and Headroom.

TD 42 (DMRB 6.2.6) - Geometric Design of Major/Minor Priority Junctions.

“Recommendations for Main Roads ,ADT”

10. ENQUIRIES

10.1 All technical enquiries or comments on this Standard should be sent in writing to:

Roads Directorate
Sa Maison Road
Floriana CMR02

C.Zammit
Director of the Roads Directorate

ANNEX A : HARMONIC MEAN VISIBILITY

Al The Harmonic Mean Visibility VlSI shall be measured over a minimum length of about 2km in the following manner. Measurements of sight distance shall be taken in both directions at regular intervals (50m for sites of uneven visibility, lOOm for sites with good visibility) measured from an eye height of 1 .05m to an object height of 1 *.05m,* both above the centre line of the road surface. Sight distance shall be the true sight distance available at any location, taking into account both horizontal and vertical curvature, including any sight distance available across verges and outside the road boundary wherever sight distance is available across embankment slopes or adjoining land, as shown in Figure Al.

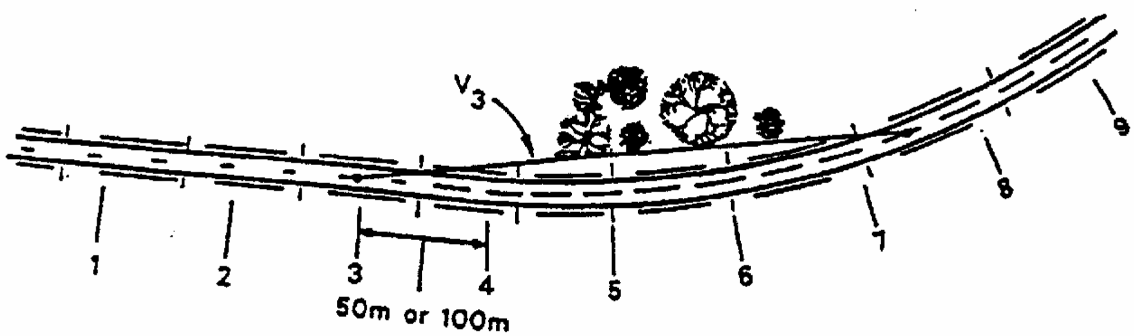


Figure A1 : Measurement of Harmonic Mean Visibility

A2. Harmonic Mean Visibility is the harmonic mean of individual observations, such that:

$$\text{VISI} = \frac{n}{\frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_3} \ldots + \frac{1}{V_n}}$$

where:-

n = number of observations
Vi = sight distance at point 1, etc.

A3. For existing roads, an empirical relationship
has been derived which provides estimates of VlSI given in bendiness and verge width (applicable up to VlSI = 720m) i.e.

$$\text{Log}_{10}\ \text{VlSI} = 2.46 + \text{VW}/25 - \text{B}/400$$

where:

VW = Average width of verge, plus hard shoulder where provided (in, averaged for both sides of the road)

B = Bendiness (Degrees per km, measured over a minimum length of about 2 km)

This relationship is valid for most existing roads. However, on long straight roads, or where sight distance is available outside the highway boundary, significant underestimates of VlSI will result.

A4. For preliminary route analysis, where detailed measurements of sight distance are not available, the following typical values should be used:

a) On long virtually straight roads, or where the road is predominantly on embankment affording high visibility across embankment slopes or adjoining level land:

VlSI= 700m

b) If a new road is designed with continuous overtaking visibility, with large crest K values and wide verges for visibility:

VISI=500m

c) Where a new road is designed with frequent Overtaking Sections, but with stopping sight distance provision at all sharp curves:

VISI=300m

d) Where an existing carriageway contains sharp bends, frequent double continuous line sections, narrow verges etc

VISI=100 to 200m

Although the empirical formula shown in A3 above can be used if Bendiness is avaliable.

an
carriagefr
continuous
line

Volume 6 Section A
Part 1A
ADT TA 43/00

ADT Guidance on Road link Design

JULY 2003

Malta Transport Authority
Roads Directorate
Sa Maison Road

Summary:

This Advice Note gives recommendations for the geometric design of new roads and improvements with regard to traffic operation and safety. It should be read in conjunction with Standard ADT TD 9 – Road link Design.

Published by Malta Transport Authority
2002

VOLUME 6 ROAD GEOMETRY
SECTION 1 LINKS

PART lA

ADT TA 43/00

GUIDANCE ON ROAD LINK

DESIGN

Contents

Chapter

0. Introduction

1. Design Speed

2. Sight Distance

3. Superelevation and Minimum Curvature

4. Vertical Alignment

5. Climbing Lanes

6. Single Carriageways

7. References

8. Enquiries

0. INTRODUCTION

0.1 The Maltese Transport Authority Standard ADT TD 9 “Road Link Design” (ADT DMRB 6.1.1) sets out design standards and a methodology for the geometric layout of national roads. This Advice Note provides the background information to ADT TD 9 and is intended to be used as an aid to the development of well engineered yet economic designs within the general design philosophy of constructing roads on which traffic can travel with minimum hazard and a good level of service. The Advice Note should be read in conjunction with the Standard.

Scope

0.2 The background to ADT TD 9 is given. The rationales of its more important design criteria are discussed in detail in order to assist in the development of effective design layouts that are consistent with its general philosophy.

0.3 This philosophy was developed for the design of major roads on new alignments and for the improvement of existing layouts, but its principles can be applied to •the design of any single or dual carriageway in both rural and urban areas.

Safety and Hierarchy of Standards

0.4 The reasons why accidents occur are seldom easy to identify. In the majority of cases they arise from a combination of factors including driver health or error, but the purpose of geometric design standards is to ensure that the design of the road itself will not present drivers with situations they cannot anticipate as a potential hazard and act accordingly. Drivers are extremely adaptable and are able to deal with the wide variety of road conditions on the existing road network, as the accident records show. It is, therefore, seldom the case that there is a clear dividing line between what is safe and what is not.

0.5 Behavioural studies into the Effects on Safety of Marginal Design Elements (Halcrow Fox, 1981) have indicated that there is a margin below the minimum standards before reduced safety is significantly reflected in the accident records. This is illustrated diagrammatically in Figure 1. The studies showed that the existence of hazards is only gradually reflected in these records, when the geometry is reduced below the minimum and towards a point where the drivers have to brake hard when they perceive the hazard. Such sites are normally identified by hazard warning signs and road markings; they represent high driver stress level situations. Geometry between the minimum prescribed standards and such perceived hazards, therefore, does not produce a sudden increase in accidents. Nevertheless, the level of service provided is inferior in that speed has to be reduced and the potential for accidents rises.

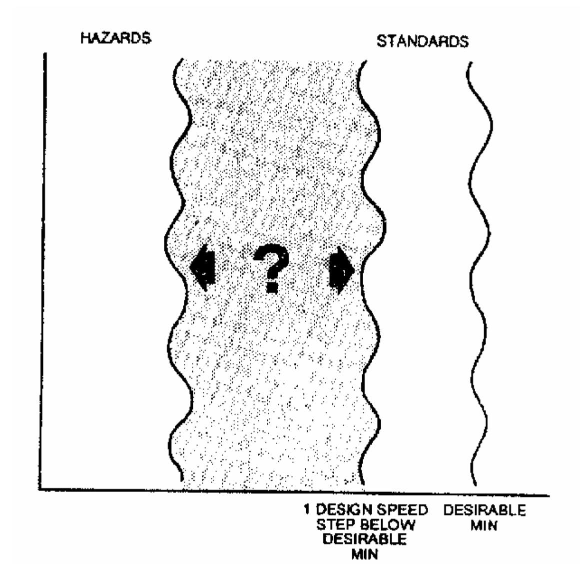


Figure 1 : The Grey Area Between Standards and Hazards

0.6 ADT TD 9 defines a sequence of level of service standards in the form of a hierarchy of geometric design criteria related to Design Speed. This Design Speed is, by definition, the estimate of the speed that traffic will be likely to adopt upon the alignment configuration proposed. The hierarchy is: **Desirable Minimum Standards** (or above), **Relaxations, Departures.** It enables a flexible approach to be applied to a range of situations where the strict application of severe environmental impact upon people, properties and landscapes.

0.7 Design within at least Desirable Minimum Standards will produce a high standard of road safety and should be the initial objective . But level of service will remain generally satisfactory, wherever these standards are infringed in relative isolation. They can, therefore, be relaxed in order to overcome alignment problems where the designer perceives that the advantages gained thereby have sufficient merit to justify the reduction in the level of service, with almost undetectable erosion of safety. This second tier of the hierarchy is termed a Relaxation. These Relaxations can be introduced at the discretion of the designer and must be endorsed by the Design Organisation's senior engineer responsible for the scheme. The Design Organisation shall report all relaxations incorporated into the design as part of the project report at the end of each project management phase. Designs incorporating permitted Relaxations can be said to conform to ADT standards. However, in certain instances, Relaxations are not permitted and there is only a two tier hierarchy of Desirable **Minimum Standards** (or above) and **Departures.**

0.8 In situations of exceptional difficulty which cannot be overcome by the adoption of Relaxations, it may be possible to overcome them by the adoption of the third tier of the hierarchy, termed Departures. Because safety is more significantly reduced by Departures, proposals to adopt a Departure from Standards on national road schemes must be submitted to the Maltese Transport Authority for assessment of the safety implications and approval before incorporation into a layout design.

0.9 The system of Design Speed estimation described hereafter enables a soundly based and consistent approach to be applied to the application of standards, Relaxations and Departures from Standards relevant to rural areas. In many instances its principles will be found to be applicable to urban areas.

0.10 The Roads Directorate has a basic duty of care not to construct roads which are dangerous to traffic. This means that any points of potential hazard, such as Departures from Standards, should either be self evident to the driver or otherwise appropriate precautions should be taken to warn drivers. For example, if a Departure occurs in horizontal curvature, bend or corner signs, "sharp change of direction" chevrons or restrictive road markings may be required, or mandatory speed limits prescribed according to circumstances. Special attention should be made to the maintenance of adequate skid resistance in.these circumstances.

1. DESIGN SPEED

1.1 General

1.1.1 New Roads and Major Improvements. Drivers regulate their speed along a road in accordance with the layout environment in which they are travelling, that is to say the speed characteristics of the length of the road over which they have just driven and their perception of what lies ahead. Factors that influence speed apart from the amount of traffic on the road are, inter alia: visibility, curvature, width, surface conditions, presence of junctions and accesses. The so called 'speed value' of individual curves is no guide to what the actual speeds over a length of road might be, so, in order to define the minimum geometry for a new road (or a major improvement scheme) in a consistent manner over the length of the scheme, it is necessary to estimate the journey speed of vehicles through the scheme, or over sections of it which have approximately the same geometry.

1.1.2 Minor Improvements. For minor improvements to an existing road the best estimate of speed can be achieved by direct measurement. Advice on this is given in TA 22(DMRB 5.1).

1.2 The Structured System of Design Speed and Related Parameters

1.2.1 Speed Distribution. Account needs to be taken of the wide variation of vehicle speeds. Figure 2 shows typical distributions of vehicle speeds obtained from speed studies (TRRL, 1979b, 1980a and 1980b) of three different classes of road. It should be noted that these distributions are of "free" speeds, that is speeds occurring when there is effectively no interference from other traffic. To design for the 99%ile speed would be excessively expensive, whilst design for the 50%ile speed would be unsafe for the fastest drivers (at the 99%ile level); the 85%ile speed is generally regarded as the most appropriate choice for Design Speed, but it must be understood that its primary significance and purpose is to be the identifier of an overall speed distribution. Whilst the 85%ile speed identifies the speed range in question, the dynamic parameters that result from this choice should be such that acceptably safe conditions prevail in the higher part of the speed distribution. For that reason, checks should be made at the 99%ile level to ensure that this is so.

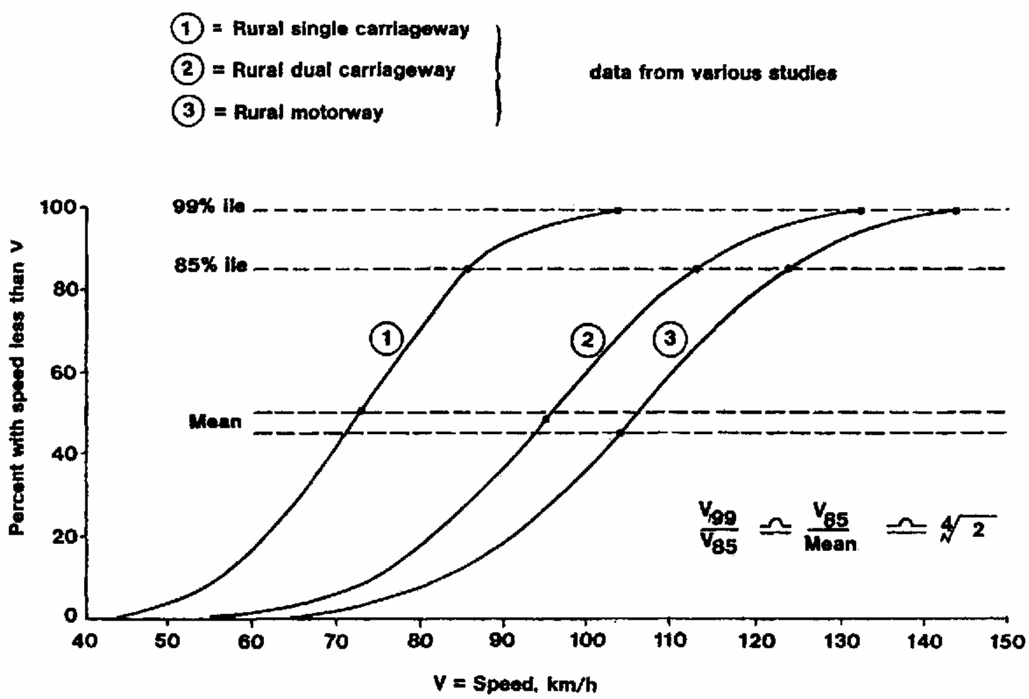


Figure 2 : Distributions of Journey Speeds of Cars 1981

1.2.2 The N2 Relationship. Figure 2 shows the mean, 85%ile and 99%ile speed levels, for rural single carriageways, rural dual carriageways and rural motorways. For practical purposes the following ratios can be assumed constant and equal to N2 = 1.19.

$$\frac{99\%\text{ile speed}}{85\%\text{ile speed}} \qquad \frac{85\%\text{ile speed}}{50\%\text{ile speed}} = {}^{4}J2$$

This constant relationship provides a convenient means of structuring a design system based upon V^2, which is a parameter that occurs throughout the algebra of geometric design.

1.2.3 Design Speed Steps. If a range of Design Speed steps is created using the $^{4}V2$ relationship the progression of speeds given in Table 1 results after slight rounding of the values (the precise values are given in brackets).

Design Speed (km/h)	(145)	(120)	(100)	80	70	60	50
	(142.7)	(120)	(100.9)	(84.8)	(71.3)	(60)	(50.4)

Table 1 : Design Speeds for a Structured System

Because the chosen Design Speed steps are inter-related by the factor $^{4}V2$ and the 99%, *85%* and *50%* levels within a normal distribution are also related in the same way, the stepped speed structure given in Table 2 below can be derived by defining Design Speed as the 85%ile level. (A Design Speed of 100km/h indicates that the 85%ile speed lies anywhere in the range between 85 and 99.9 km/h; thus the mean speed could be as low as about 70 km/h and in other cases the 99%ile speed as high as 119.9 km/h).

50%ile speed km/h	Design Speed (85%ile) km/h	99%ile speed km/h
(100)	(120)	(145)
80	100	120
70	85	100
60	70	85

Table 2: Structural Framework of Speeds Based on $^{4}V2$ Factored Step Progressions

Thus, the effects on vehicles travelling at the 99%ile (or 50%ile) speeds are the same as the effects on the Design Speed vehicle if one Design Speed step above (or below) prevailed. The 85%ile driver on a sub-standard curve of one Design Speed step will experience the same level of risk as the 99%ile driver on a Desirable Minimum standard curve.

1.2.4 The Structural Framework of Standards. A Design Speed is used to determine all geometric design parameters that govern safety: dynamic forces on the vehicle and on the driver, safe stopping distance, safe overtaking distance and soon. A framework for geometric design can therefore be structured around particular Design Speeds appropriate to a route in terms of the Desirable Minimum Standard for the Design Speed and the number of Design Speed Steps below the Design Speed, generally as shown in Table 3.

1.2.5 Scenarios for Departures from Standards. The occasional need for Departures from Standards is discussed at Paragraph 0.8. Such cases need to be examined in relation to their specific geometric parameters. For example, at horizontal curves it would be unwise to select curvature in relation to the limiting sideways force on the 85%ile vehicle. Since all vehicles traverse the curve this would mean that 15% would have to reduce speed in wet weather to maintain control. It is, therefore, more realistic for such horizontal curves to provide limiting conditions for the 99%ile vehicle speed. (See Section 3.3).

1.2.6 On the other hand, less than standard levels of forward visibility at particular locations on an access free link would not represent a significantly higher risk for the 99%ile driver; only in the most rare circumstances might vehicles be required to make an emergency stop. In such a location it is reasonable to provide one Design Speed step below desirable minimum conditions for 85%ile vehicle speeds or, if there is a layout problem, even for 50%ile speeds. On links where junctions or accesses occur, the probability of vehicles having to take emergency action would be very much higher, so forward visibility must be provided to accommodate a greater proportion of the speed distribution than on an access free link. Such conflicting considerations will be taken into account by the Maltese Transport Authority when dealing with proposals for the approval of Departures from Standards.

Parameter	Desirable Minimum Standard	Relaxation – No. of Design Speed Steps Permitted Below the Desirable Minimum	Departure
Visibility	As for Design Speed	Motorways band A 1 Step Motorways band B 2 Steps All Purpose band A 2 Steps All Purpose band B 2 Steps	Subject to Maltese Transport Authority Approval
Horizontal Curvature	As for Design Speed	Motorways band A 2 Steps Motorways band B 2 Steps All Purpose band A 2 Steps All Purpose band B 2 Steps	Subject to Maltese Transport Authority Approval
Vertical Curvature Crest Curves	As for Design Speed	Motorways band A 1 Step Motorways band B 2 Steps All Purpose band A 2 Steps All Purpose band B 2 Steps	Subject to Maltese Transport Authority Approval
Vertical Curvature Sag Curves	As for Design Speed	Motorways band A 1 Step Motorways band B 2 Steps All Purpose band A 2 Steps . All Purpose band B 2 Steps	Subject to Maltese Transport Authority Approval

Note: For an explanation of band A and band B, see Paragraph 1.3.5.

Table 3 Hierarchical Framework of Design Standards

1.3 Speed Models for Rural Roads

1.3.1 Studies into speed/flow relationships during 1977 to 1979 (TRRL, 1979, 1980a and 1980b) involving 620,000 vehicles enabled the free speeds of travel on various road types and widths and under various conditions to be modelled in relation to road type, width, bendiness (sum of angles/kin), and hilliness (sum of intersecting rises and falls/kin). On single carriageways it was also found that visibility, verge widths, junctions, accesses and lay-bys have a significant effect on speed.

1.3.2 Model Relationships. Highly significant between site variation of speed have been derived separately by multiple regression analysis for dual and single carriageways as follows:-

(a) Dual Carriageway mean speed ($\bar{v}$) of light vehicles (km/h):

$$\bar{v} = \text{Base Speed} - \frac{B}{10} + \frac{Hf}{4} - \frac{6 \times Q}{1000} \text{ (km/h)}$$

Base speed (BS) = 108km/h - D3 motorways*
104km/h - D2 motorways*
102km/ - D3 AP Dual Carriageways*
98km/h -D2 AP Dual Carriageways*

*Corrected subsequent to LF780 (TRRL, 1979b)

Using the definitions and assumptions:-

Q = flow	100 vph/lane
Wet weather	deduction 4km/h

Mean Free Speed ($\bar{v}$) light vehicles in wet (km/h)

$$\bar{v} = BS - 4.6 - \frac{B}{10} + \frac{Hf}{4} \text{ (km/h)}$$

(b) Single Carriageway mean speed ($\bar{v}$) of light vehicles (km/h)

$$\bar{v} = 76.5 + (1.1 \times Cw) + \frac{VISI}{60} - 5\left[\frac{2}{Vw+1} + \frac{I}{Cw}\right] - \frac{2B}{45} - \frac{5H}{45} - \frac{2.5Ng}{45} - \frac{22Q}{1200} \text{ (km/h)}$$

Using the definitions and assumptions:

Q = flow...........................100 vph/lane
Wet weather deduction 1 km/h

Mean Free Speed (V) light vehicles in wet (km/h)

V =73.69+(1.1xCw)+\~gI~f,21+ 17]
+ Z5N~] (km/h)

The symbols in (a) and (b) are defined as follows:

I = Number of intersections, lay-bys and non-residential accesses (total for both sides) per kilometre of route;

B = Bendiness.................. degrees per kilometre measured over lengths of not less than 2km;

Q = Total flow.................vehicles per hour per standard lane;

Cw = Carriageway width......... metres (excluding hard strips);

Vw =Width of verge (including hard strips)............metres;

VISI=Harmonic Mean Visibility................. metres measured over lengths of not less than 2km;

Hf = Downgrade Hilliness................... metres per kilometre;

Hr = Upgrade Hilliness....................metres per kilometre;

H = Total Hilliness (Hr + Hf).................metres per kilometre;

Ng = Net gradient (Hr – Hf)..................metres per kilometre.

1.3.3 United Formula. The above formualae have been rationalised to provide the following unified formula for speed of any road type:

V wet = 110 – Lc – Ac. (km/h)

where Lc = the Layout Constraint (km/h)

Ac = the Alignment Constraint (km/h)

“Layout Constraints” are defined as those features which describe road type: width, verge width, frequency of accesses and junctions. The effects of these constraints are given as values in Figure 3 in km/h.

Those features relating to alignment, such as Bendiness and VlSI are described as “Alignment Constraints”, where:

Ac = 6.6 + B/10 for Dual Carriageways

Ac = 12— VlSL’60 + 2B/45 for Single Carriageways.

Hilliness features have been excluded from the initial calculation of Design Speed as adjustments can be applied specifically at hills. Speeds reduce on uphill lengths on single carriageways by *Hr16* km/h, and increase on downhill lengths on dual carriageways by Hf/4 km/h.

1.3.4 The research was undertaken on roads in the United Kingdom and therefore did not include all-purpose roads with hard shoulders. The values of Layout Constraint given in Table 1 of ADT ID 9 (and Figure 3 of this Advice Note) for all-purpose roads with hard shoulders and for a 7.Om carriageway width have, therefore, been interpolated from the research results.

1.3.5 Design Speed Bands. Figure 4 shows plots of mean speeds in wet conditions on existing inter-urban roads. Wet speeds are used because limiting design is based upon tyre/road surface adhesion in the wet. The right hand abscissa gives the equivalent Design Speed (85%ile) by applying the SJ 2 factor. (See Paragraph 1.2.2). Because the Design Speed steps are too large when dealing with some aspects, the speeds have been grouped into the four bands 120, 100, 85, 70 each with an upper range marked A and lower range marked B.

Road Type	S2						WS2		D2AP				D3AP	D2M		D3M
Carriageway Width (ex. hard strips)	6m		7.0m		7.3m		10m		Dual 7.0m		Dual 7.5m		Dual 10.5m or 11.25m	Dual 7.0m	Dual 7.5m	Dual 10.5m or 11.25m
Degree of Access and Junctions	H	M	M	L	M	L	M	L	M	L	M	L	L	L	L	L
With hard shoulders					21	19	17	15	10	9	8	7	5	5	4	0
Without hard shoulders:																
With 3.0m Verge	(29)	(26)	25	23	(23)	(21)	(19)	(17)	(12)	(11)	(10)	(9)	(6)			
With 1.5m Verge	(31)	(28)	(27)	(25)	(25)	(23)										
With 0.5m Verge	(33)	(30)														

( ) : Non-standard cross-section

There is no research data available for 4 lane Single Carriageway roads between 12 and 15m width (S4). In the limited circumstances for their use described in this document, Design Speed should be estimated assuming a normal D2AP with a Layout Constraint of 15 - 13km/h

Figure 3 : Layout Constraint Lc (km/h)

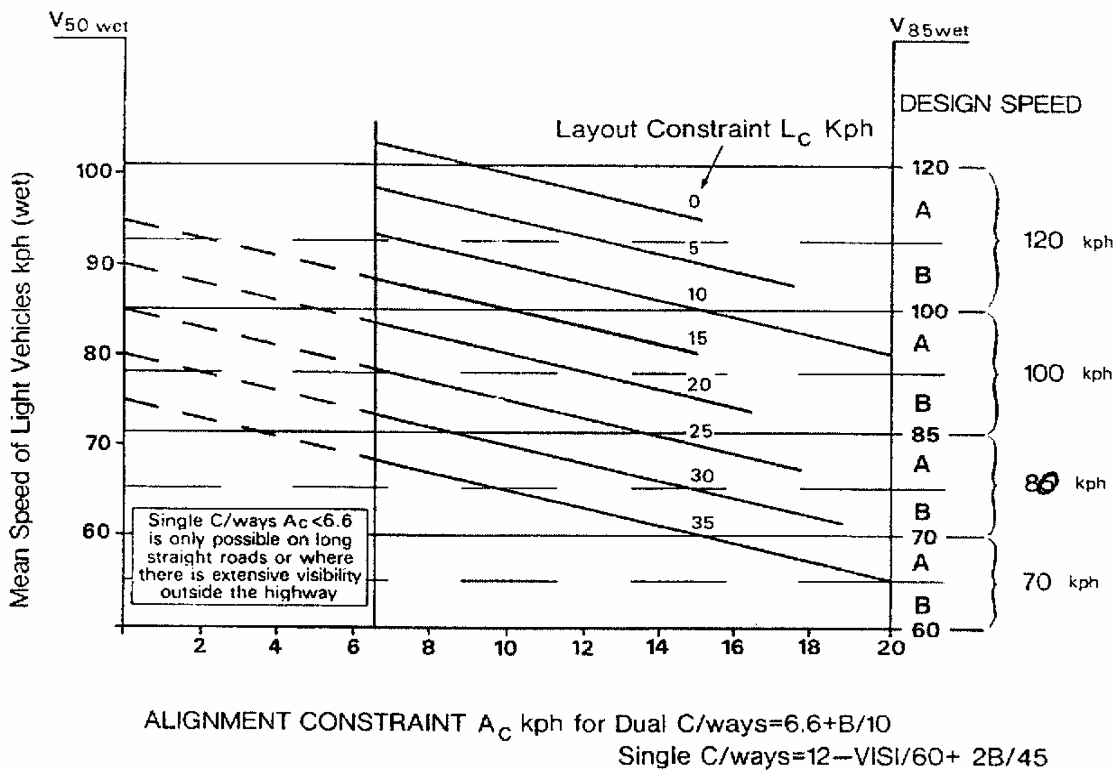


Figure 4 : Selection of Design Speed (Rural Roads)

1.3.6 Bendiness and Departures from Standards. It is important to realise that Design Speed is not dependent on the radius of curvature of individual curves per se but on the total of degrees turned through per km (bendiness) and that Design Speed must be estimated over a length that is not less than 2km long. Figure 5 depicts two different horizontal alignments which both have the same Design Speed. Whereas A conforms to standards requiring the demolition of a church and school, B utilises bends which are Departures from Standards avoiding demolition but necessitating the use of signs to warn the driver of the hazard. This sort of situation is most likely to occur in suburban/urban areas where the surrounding physical constraints are more restrictive. The appropriate warning signs are bend or corner signs, possibly supplemented by "sharp change of direction" chevrons; a mandatory speed limit may also be appropriate. (See Paragraph 0.10).

1.3.7 Dual Carriageway Design Application. Examination of Figures 3 and 4 shows that, except in extreme cases, for any dual carriageway road (as described by its Layout Constraint) only two alternative Design Speed bands apply. For example, a D2AP road with low access will have a Design Speed of 120B where the overall sinuosity of the road is low, i.e. Ac<15, or possibly 100A where the overall alignment is more tortuous, i.e. Ac>15. Thus, as a starter design, an alignment can be drawn with geometry at obvious "hard points" made to conform to 120B. Assessment of the resulting Alignment Constraint (Ac) over minimum lengths of 2km may, however, indicate that the correct estimate of speed over particular sections will be in the 100A band. The starter design may therefore be modified, if the designer perceives a balance of advantage in doing so, to 100A values of geometry at specific points of difficulty though only within sections of minimum length 2km. No further reductions in Design Speed would result from this modification.

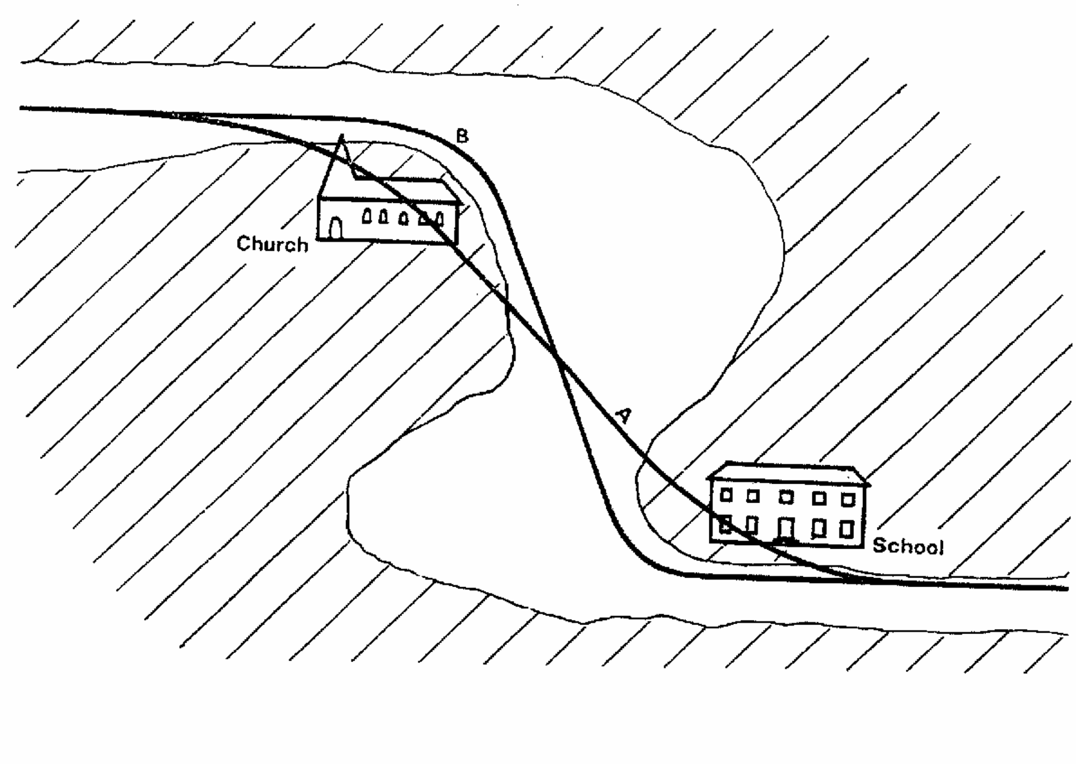


Figure 5 : Horizontal Radii and Departures From Standards

1.3.8 Single Carriageway Design Application. Single carriageways with "standard" cross sections, i.e. those included in Table 4 of ADT TD 9, can have Design Speeds ranging from the 85B to the 120B km/h bands, as indicated in Figure 4, according to respective values of Layout and Alignment constraints (Lc and Ac). But whereas Design Speeds from 85B to 100A are acceptable in relation to their safety characteristics, higher Design Speeds on single carriageways are undesirable and thus the parameters applicable to them are not shown in ADT TD 9. Since a Design Speed of 120B would result from a combination of high VlSI and low bendiness, the essence of satisfactory design is the avoidance of this combination of constraint characteristics. Nevertheless, speed related parameters should be appropriate to the Design Speed. A single carriageway design to a Design Speed of 100A might contain localised Relaxations relevant to 85km/h speed at specific hard points, but the Design Speed would remain as 80A. The resulting design would simply represent a 100A Design Speed, with Relaxations equivalent to "one Design Speed step" at locations where the geometry had been reduced to values relevant to 85km/h speed.

1.4 Roads in Urban Areas

1.4.1 No data are available to model speeds for at-grade roads in urban areas in the same way as for rural roads. Indeed, the wide range of urban network layouts and the frequent breaks in the regime of flow caused by roundabouts, signals, etc. mean that such modelling is not practicable. In these circumstances the Design Speed chosen can only be the designer's judgement of likely vehicle speeds, taking into account any mandatory speed limits that may be relevant. (See Table 2 in ADT TD 9).

1.4.2 It would, for example, be inappropriate to consider a Design Speed of 70km/h on a grade separated urban road not subject to a mandatory speed limit. Additionally, in exercising this judgement, it is not safe to consider the "speed value" of specific geometric elements as the indicators of the appropriate Design Speed. The estimated Design Speed on such a road could be, say, 100A, notwithstanding the presence of "70km/h" elements. Such a design is strictly 100A Design Speed, with Relaxations of "two Design Speed steps" where the 70km/h elements occur.

2 SIGHT DISTANCE

2.1 Stopping Sight Distance

2.1.1 Stopping Sight Distance (SSD) is the theoretical forward sight distance required by a driver in order to stop when faced with an unexpected hazard on the carriageway. It represents the sum of:

(a) The distance travelled from the time when the driver sees the hazard and realises that it is necessary to stop – the perception distance;

(b) The distance travelled during the time taken for the driver to apply the brakes – the reaction distance;

(c) The distance travelled whilst actually slowing down to a stop - the braking distance.

2.1.2 <u>Measurement</u>. Stopping Sight Distance (SSD) should be measured to ensure that there is an envelope of clear visibility (see Chapter 2 of ADT TD 9) such that, at one extreme, drivers of low vehicles are provided with sufficient visibility to see low objects, whilst, at the other extreme, drivers of high vehicles are provided with visibility to a significant portion of other vehicles. The clear visibility envelope will avoid the occurrence of narrow "slits" of visibility, such as might be caused by overhanging trees or bridge soffits at sag curves.

2.1.3 <u>Eye Height</u>. The distribution of eye heights of drivers of private vehicles (TRRL, 1979a) shows that drivers eye heights are as much a result of drivers posture as the types of vehicles being driven; *95%* of drivers eye heights are above 1 .05m, and this value is adopted as the lower extreme of the visibility envelope. The upper bound is assumed to be 2.OOm to represent the eye height of a driver of a large vehicle.

2.1.4 <u>Object Height</u>. For the lower bound of the visibility envelope, an object height of 0.26m will include the rear tail lights of other vehicles, whilst an upper bound of 2.OOm will ensure that a sufficient portion of a vehicle ahead can be seen to identify it as such. A vertical crest curve on a straight alignment designed to provide SSD equivalent to one Design Speed step below Desirable Minimum to the 0.26m object height will automatically provide Desirable SSD to a 1.05m object height. (See Section 4.3).

2.1.5 <u>Perception and Reaction Time</u>. The total elapsed time during perception and reaction (see Paragraph 2.1.1), under test conditions, is generally in the region of 0.4 – 0.7 seconds, However, drivers may be tired and also subject to a variety of conflicting stimuli such as noise and lights, so that in reality their reaction time will be somewhat more. For safe and comfortable design, a reaction time of 2 seconds has been adopted.

2.1.6 <u>Braking Distance</u>. The braking distance must be long enough to allow the required degree of friction to develop between the tyres and the road surface and to avoid excessive discomfort to the driver. Research has shown that the maximum comfortable rate of deceleration is about 0.25g; however, deceleration rates of the order of 0.375g can be achieved in wet conditions on normally textured surfaces without loss of control.

2.1.7 <u>Calculation of SSD</u>. Figure 6 shows the precise stopping sight distance relative to Design Speed for varying values of retardation. Using a Desirable value based on 2 sec + 0.25g, a value of 2 sec + 0.375g will result for a driver travelling one Design Speed step above Design Speed. Thus the Desirable SSD value for a given Design Speed is the same as the one step below Desirable value for one Design Speed step above. This correspondence enables the framework of design to be formulated as in Table 4.

Speed	Desirable Basis	One Step Below Desirable Minimum Basis
99%ile	2sec + 0.375g	O.4sec + 0.375g*
85%ile	2sec + 0.25g	2sec + 0.375g
50%ile	2sec + 0.175g	2sec + O.25g

* <u>Note</u>: With a 2 sec reaction time the deceleration would be 0.62g which would mean a loss of control in wet conditions.

Table 4 Basis for Sight Distance Calculation

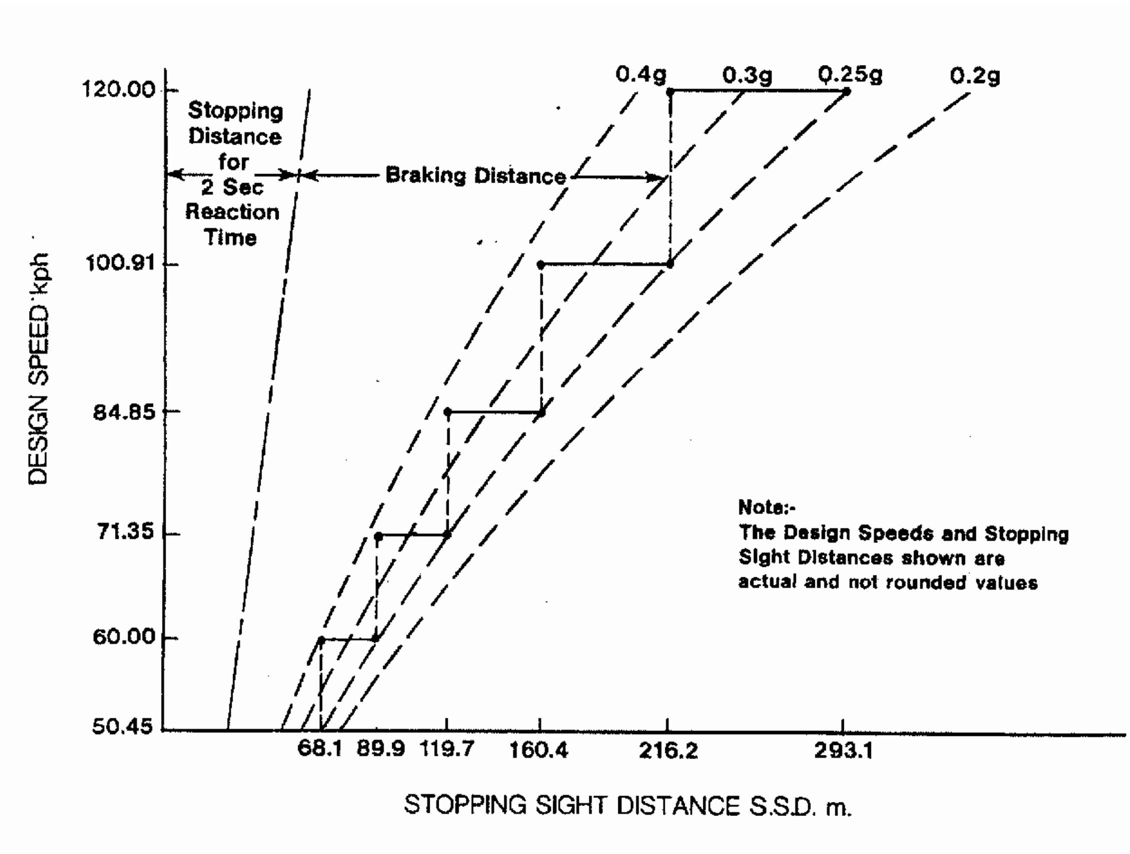


Figure 6 : Stopping Sight Distance v Design Speed

The 99%ile speeds are catered for by a minimum perception/reaction time of 0.4 sec, and a limiting retardation of about 0.375g.

2.1.8 Design Values of SSD. Table *5* below shows the rounded values of SSD for use in design related to the range of Design Speeds when calculated in accordance with Table 4.

DesignSpeed (km/h)	**(120) (100) 80 70 60 50**
Desirable Minimum SSD(m)	**(295) (215) 160 120 90 70**

Table 5 Desirable Minimum Stopping Sight Distance

2.1.9 Reductions in SSD Standards. In dry conditions, higher rates of deceleration can be achieved on all road surfaces regardless of texture. Drivers are not aware of the deceleration forces in an emergency stop - this is generally outside their experience; consequently, they do not limit their speed to deceleration comfort levels for these emergencies. Except in extreme cases, therefore, the provision of sub-standard SSD will not cause any significant reduction in the mean speed of vehicles. Thus, reductions in SSD standards can be expected to be manifest over time as an increase in accidents or accident severity. Studies into the effects of sub-standard SSD on accidents on single carriageways (Halcrow Fox, 1981) have produced the relationship shown in Figure 7 for a sample of rural derestricted roads with Design Speeds of between 75 and 100 kph, i.e. within the 85-lOOkph Design Speed range. Supporting results from another study (Martin and Vorhees, 1981) are shown at Figure 8. It is important to note, however, that no studies have been carried out on motorways. Whilst the model indicates a continuously increasing accident rate with reducing sight distance, the implication of a reduction of SSD by one or, in extreme cases, perhaps two Design Speed steps may be minor. In cases where severe environmental impacts or large increments of expenditure would be involved to maintain the minimum standard values, consideration should be given to a reduction in SSD Standards.

However, this relationship applies only to road lengths without accesses or junctions which would exacerbate the safety implications. A high standard of visibility provision is required where accesses or junctions occur, hence the restrictions on dropping below Desirable Minimum SSD in these locations. (See Paragraph 2.13 of ADT TD 9).

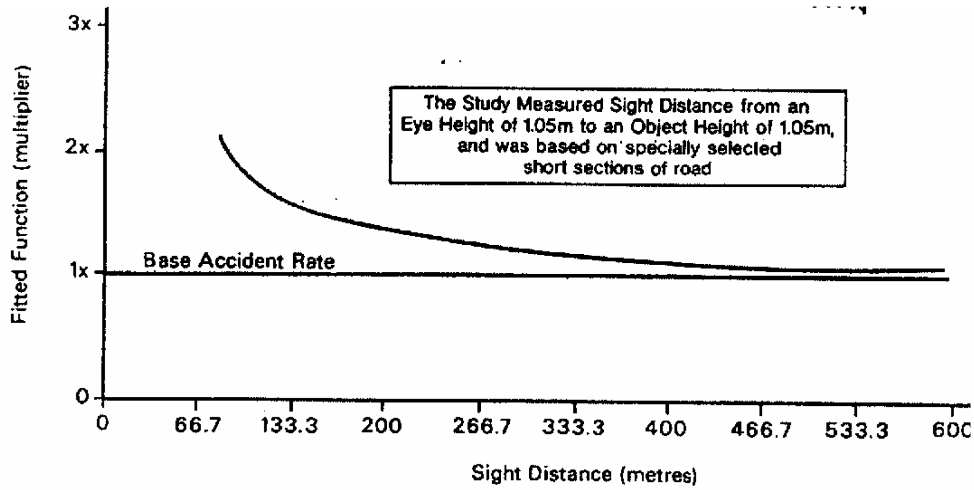


Figure 7 : Accident Rate v Sight Distance 10m Single Carriageway

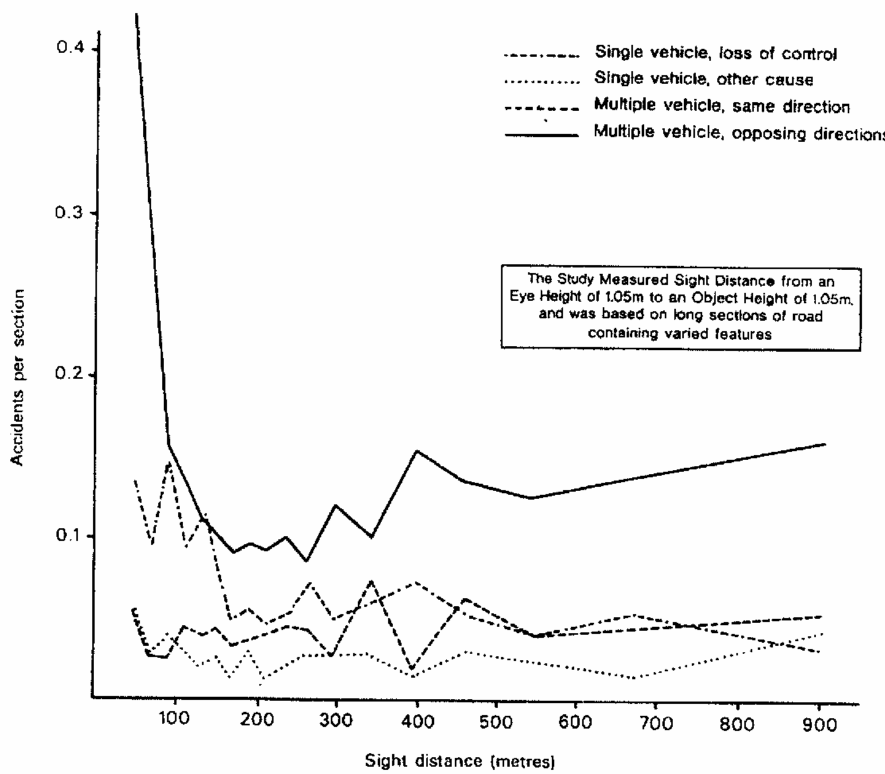


Figure 8 : Accidents per Section v Single Carriageway Sight Distance

2.1.l0 Application in Design. An example of how a compromise solution might sometimes be reached in difficult situations utilising interrelated design elements is illustrated in Figure 9. This shows diagrammatically the various options available for the design of a crest curve on a 120B Design Speed dual-carriageway in cutting, approaching an at grade priority junction. To obtain Desirable Minimum SSD of 295m to the junction, the first approach is to use a Desirable Minimum Crest K value of 182. This would result in heavy earthworks with considerable environmental impact. However, an alternative design using a more pronounced crest curve (K value 30), with associated steeper approach gradients, would reduce the earthworks to a minimum. This alternative is potentially three Design Speed steps below Desirable Minimum SSD Standards over the crest but would provide the required visibility of over 295m to the junction which is the most important provision. Cases of this nature should be considered on their merits and reductions in SSD Standards considered if this seems appropriate to the circumstances. Wherever reduced SSD Standards are adopted, it is important that wet weather skid resistance is maintained at a level commensurate with the speed of traffic and the prevailing risk.

2.2 Overtaking Sight Distance

2.2.1 On the sections of single carriageway expressly designed for safe overtaking, sight distance should always be at least sufficient to permit drivers to complete a normal overtaking manoeuvre in the face of an oncoming vehicle. However, overtaking manoeuvres vary widely from driver to driver, vehicle to vehicle and the speed of the vehicle being overtaken, so it is difficult to be precise about what a normal overtaking manoeuvre is. Limited studies (TRRL, 1978) into overtaking practice, involving the recording of about 200 overtaking manoeuvres, have shown that the time taken for vehicles to complete an overtaking manoeuvre will vary from about 4 seconds to more than 15 seconds, and to be largely independent of vehicle speed. Figure 10 shows the observed distribution of overtaking duration. It can, therefore, be assumed for practical purposes that:

50% of overtaking manoeuvres take less than 7 seconds;

85% of overtaking manoeuvres take less than 10 seconds;

99% of overtaking manoeuvres take less than 14 seconds;

It follows from this that any single criterion selected for overtaking sight distance is an over-simplification. It is clear, however, that the longer the sight distance, the greater the proportion of the vehicle population that will be able to make overtaking manoeuvres, and that long sight distances are therefore very desirable.

2.2.2 Calculation of Full Overtaking Sight Distance. For design, Full Overtaking Sight Distance (FOSD) and Abort Overtaking Sight Distance (ASD see Section 6.2) are calculated as shown in Figure 11, on the basis of an overtaking driver completing a manoeuvre if an opposing vehicle appears at X the moment the manoeuvre commences. It is assumed that the overtaking driver A commences the manoeuvre two Design Speed steps below the Design Speed V and accelerates to Design Speed, whilst the approaching vehicle B travels in the opposite direction at the Design Speed. The overtaking durations in Paragraph 2.2.1 are assumed in the calculation of the overtaking sight distances for 50, 85 and 99%ile drivers. Thus, if T is the time to complete an overtake, and V' is Design Speed (m/s):

$$D1 = T \times \tfrac{1}{2}\left(\frac{V'}{\sqrt[4]{2} \times \sqrt[4]{2}} + V'\right) = 0.85 \times T \times V'$$

and assuming $D3 = \frac{D2}{5}$

FOSD = 2.05 x T x V' (metres)

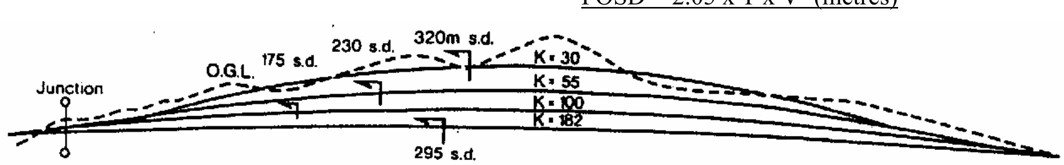


Figure 9 : Options for Design of a Crest Near a Junction on a Dual Carriageway

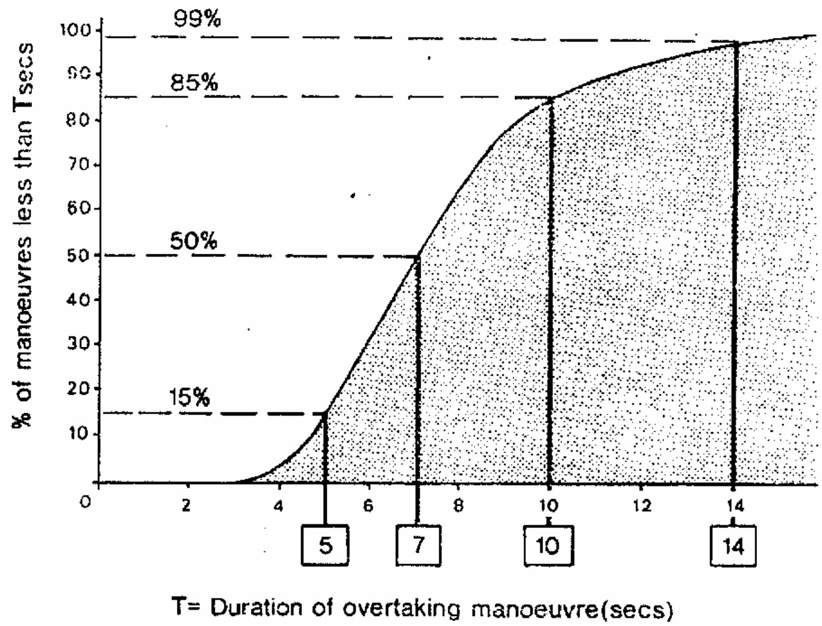


Figure 10 : Distribution of Overtaking Duration

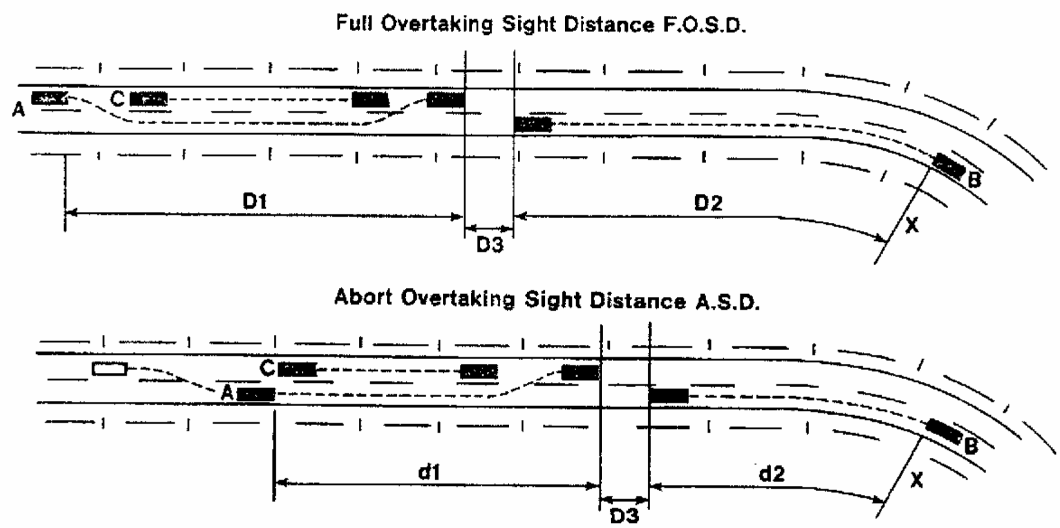


Figure 11 : Definitions of Overtaking Sight Distance

2.2.3 Design Values of FOSD. The complete range of rounded Design Speed related FOSD values based on these assumptions is given in Table 6.

2.2.4 Application in Design. It can be seen that the values of FOSD required by the 85%ile driver are two Design Speed steps more than those required by the 50%ile driver and, similarly, FOSD for the 99%ile driver is two steps more than that for the 85%ile driver. This feature is useful for the measurement system for single carriageway design shown in Chapter 6. It is important to note, however, that the single FOSD standard does not represent a "safe" overtaking visibility for all manoeuvres, but the visibility that will provide a reasonable degree of safe overtaking for 85% of traffic, though not in peak hours and when heavy traffic prevails.

2.3 Obstructions to Sight Distances

2.3.1 The low object height of 0.26m means that safety fences, bridge parapets, or even uncut grass, may become obstructions to SSD on horizontal curves, although ample sight distance will be obtained above these obstructions. With the exception of grass, which should be maintained so as not to interfere with SSD, the following points apply to obstructions.

2.3.2 Safety Fences. Where central reserve safety fences are provided on dual carriageways, the aim should be to provide Desirable SSD in front of the safety fence, but the additional central reserve widening needed to achieve this may be regarded as excessive when curvature is more severe than Desirable Minimum Radius. In such circumstances a one Design Speed step Relaxation may be adopted for the SSD to a 0.26m object in front of the safety fence provided that Desirable Minimum SSD is available over the top to a 1 .05m object representing other vehicles (see Paragraph 2.10 of ADT TD 9). This latter sightline may encroach onto the other carriageway (see Figure 12). It should be noted that on some right hand curves in combination with a sag curve it may be possible to see a low (0.26m) object over the top of a safety fence, provided the sightline is of adequate length and does not encroach into the opposing carriageway. However, if a Relaxation such as that shown in Figure 12 is being considered where there is a combination of vertical crest and right hand horizontal curvature, a "shadow" zone of seriously restricted visibility can occur: whilst the safety fence immediately adjacent to the 1.05m eye and object heights will not obstruct the full 295m visibility chord, forward visibility to a vehicle between 2 15m and 295m away is likely to be impeded by the safety fence, whose height will be exacerbated by the crest curve. These "intermediate" visibility distances should be evaluated and such Relaxations carefully considered accordingly.

2.3.3 Future Provision for Safety Fences. Where a new dual carriageway is to be provided without central reserve safety fencing because initial traffic levels do not justify the expenditure, it is important to have regard to the likelihood of safety fences being needed in later years as traffic grows. This will not be a safe provision if the available width of the central reserve is inadequate.

Design Speed (km/h)		(120)	(100)	80	70	60	50
FOSD required at Various Driving Speeds (m)	99% ile	(960)	(820)	690	580	490	410
	85% ile	(690)	(580)	490	410	345	290
	50%ile	(490)	(410)	345	290	245	205

Table 6 Full Overtaking Sight Distances – FOSD

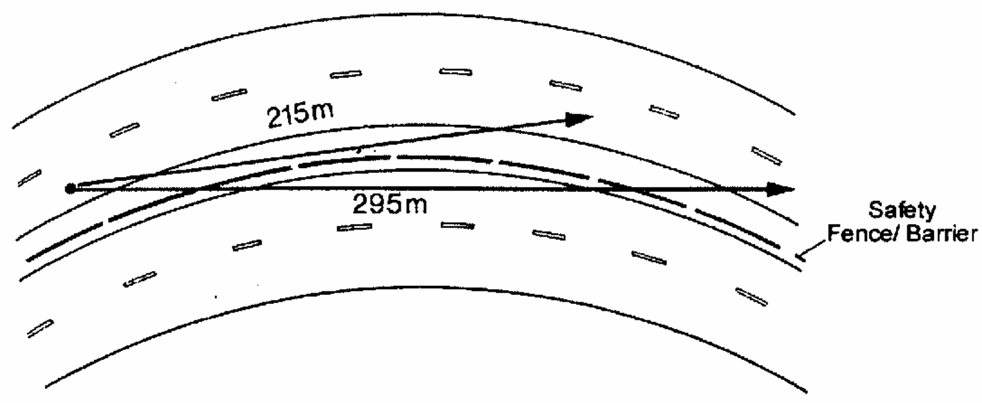


Figure 12 : Dual Carriageway Stopping Sight Distance Requirements

2.3.4 Urban Roads. On dual carriageways in urban areas where central reserve lighting columns are protected by safety fences, similar design requirements would be required relative to the Design Speed (normally determined by a speed limit, see Section 1.4). However, the implications of the visibility requirements to low objects in these areas might well involve very high costs and severe environmental impacts within tightly constrained conditions, for example on elevated structures, and Relaxations and even Departures from Standards will, necessarily, be commonplace.

2.3.5 Departures from Standards. A rigid interpretation of the requirements of SSD, particularly regarding low objects, would result in widened central reserves, setting back of safety fences on widened embankments, or a limitation in the use of horizontal curvature to maintain SSD in front of the safety fence. These effects give added weight to the desirability of attempting to maintain Desirable Minimum Radius wherever economically possible in dual carriageway design. Above this radius, the implications of SSD are generally modest. Safety studies on non motorway dual carriageways have shown that the rate of increase in accident risk associated with reductions in sight distance to low objects is relatively small, particularly where ample forward visibility to vehicles is available over the top of safety fences. There is no justification for committing inordinately large increments of expenditure to maintain full

standards, if it is found that Relaxations from the Standards, or in rare cases, Departures will overcome much of the difficulty associated with severely constrained route locations.

3. SUPERELEVATION AND MINIMUM CURVATURE

3.1 General

3.1.1 As a vehicle moves round a curve, it is subject to an outward centrifugal force which causes it to drift outwards. This has to be counteracted by the driver steering into the curve. The centrifugal force acting through the centre of gravity of the vehicle is resisted by the friction force developed between the road surface and the tyres; the two forces create an overturning moment which is counteracted by the vehicle weight also acting through its centre of gravity. When the centre of gravity is high, the overturning moment is increased and with it the danger of overturning. The steering effort and the overturning moment can both be reduced within limits, by superelevating the outer side of the road around its curves.

3.2 Forces Acting on a Vehicle

3.2.1 Figure 13 shows the forces acting on a vehicle of unit weight as it travels on a superelevated curve of radius R. By resolving these forces the following relationship is obtained:

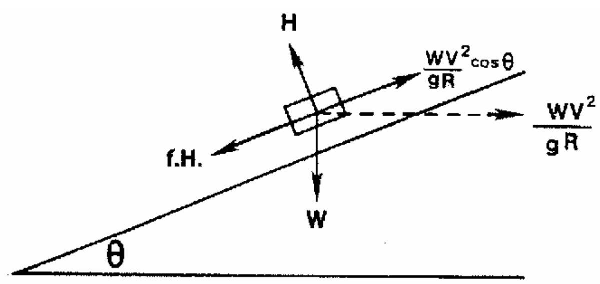
$$\frac{V^2}{127R} = f+s$$

Where V = speed of travel (km/h)
s = % of lateral acceleration counteracted by superelevation

f = Lateral coefficient of friction
R = Curve radius (metres)

To minimise discomfort to drivers it is necessary to place limits on the magnitudes of s and f. The rationale for this is described below.

[Note: The side friction ratio referred to here must not be confused with the Sideways Force Coefficient (SFC) as measured by machines such as SCR1M (TRRL, 1976). At the present time there is no established relationship between these two expressions of tyre/road surface friction].



$\frac{WV^2}{gR}\cos\theta$ = Force applied to vehicle parallel to road

R = radius of curve

V = speed

W = weight of vehicle

$\bar{H}$ = reaction with road = W cos θ

f = side friction factor

θ = angle of superelevation

S = superelevation % $\approx$ 100 θ (θ in rads)

Figure 13 : Forces Acting on a Vehicle as it travels on a Superelevated Curve of Radius R.

3.3 Superelevation at one Design Speed Step Below Desirable Minimum Radius

3.3.1 Design Criteria. The coefficient of friction between an icy. road and a tyre tread is about 0.1 which means that a stationary or slow moving vehicle would tend to slide towards the curve centre at superelevation above 10%. Superelevation, therefore, has been arbitrarily limited to a maximum of 7%, although it is better practice to design within the desirable value of *5%.* The fundamental assumption is that at a radius of one Design Speed step below desirable minimum, the 99%ile vehicle should not experience more than the maximum level of centrifugal acceleration acceptable for comfort and safety. This level was established as about 0.22g by researchers in the 1920's and 1930's and has not been changed since. Therefore substituting in the formula in Paragraph 3.2.1, the 99%ile vehicle on any bend, assuming no reduction in speed, will experience a theoretical gross lateral acceleration of:

$$\frac{(Vx^{4}V\ 2)2}{127R} = 0.22g$$

i.e. $$\frac{V2V2}{127R} = 0.22g$$

where V = Design Speed (km/h)
and g = Acceleration due to gravity.

3.3.2 Lateral Acceleration Contributions. The respective contributions by the superelevation and tyre/road surface interface to balance these gross lateral accelerations at one Design Speed step below desirable minimum Radius are shown in Table 7.

3.3.3 It will be noted from Table 7 that at the Design Speed (85%ile) the superelevation contribution is *45%,* and that the "hands off" speed where the nett lateral acceleration is zero approximates to the 15%ile speed. As Paragraph 1.2.3 herein shows, on a road with a Design Speed of V kph the mean speed of some vehicles may be as low as V/2; therefore where the upper limit of superelevation is used, the slowest vehicles on the slowest roads in a Design Speed category may actually experience "negative" centrifugal acceleration.

Speed	Gross Lateral	Reduction in Lateral Acceleration from Max Superelevation%(0.7g)	Nett Lateral Acceleration
99%ile	0.22g	32%	0.15g (68%)
85%ile	0.16g	45%	0.09g *(55%)*
50%ile	0.llg	63%	0.04g (37%)
15%ile App.	0.07g	100%	(0%)

Table 7 Distribution of Lateral Acceleration at One Design Speed Step Below Desirable Minimum Radius

3.4 Superelevation at Radii larger than one Design Speed step below Desirable Minimum Radius

3.4.1 In providing the change between normal crossfall and maximum superelevation of 7%, the superelevation contributions in Table 7 should be maintained constant for radii greater than one Design Speed step below desirable minimum. At the Design Speed (85%ile) the superelevation contribution is *45%,* thus:

Design Super'n S% $\frac{0.45 V^2 \times 100}{127R} = \frac{V^2}{2.82R}$

It is convenient to write this as: S =
242R

3.4.2 For curves designed in accordance with this system, one Design Speed step below desirable minimum radius (with 7% superelevation) occurs at $V^2/R = 20$, Desirable Minimum Radius (with *5%* superelevation) occurs at $V^2/R = 14.14$, and Minimum Radius with 2.5% normal crossfall (in the same sense) occurs at $V^2/R = 7.07$. Figure 14 illustrates this graphically, utilising a y axis log scale. It will be seen that the V^2/R ratio enables the normal family of curves relationships (see Figure *5* of ADT TD 9) to be replaced by a single straight line and is therefore a convenient way of describing a curve radius at a Design Speed using one number. It should be noted that the definition of Desirable Minimum Radius is when the gross lateral acceleration at the Design Speed (85 %ile) is 0.11g, half the threshold of discomfort 0.22g.

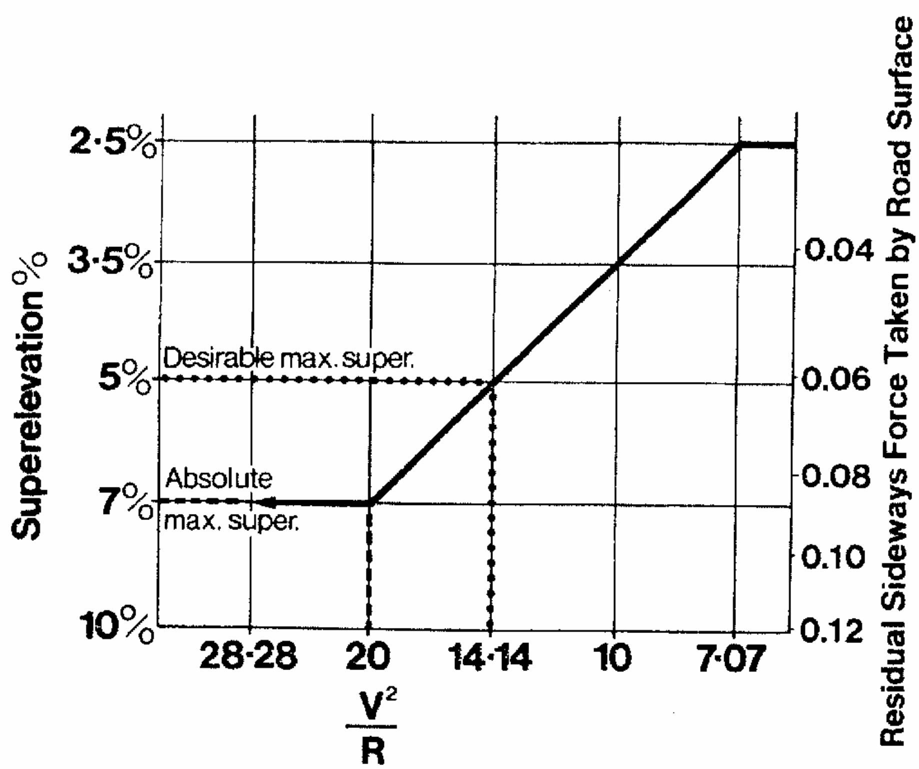


Figure 14 : Superelevation of Curves

3.5 Framework for Design

3.5.1 The stepped hierarchy of standard Design Speeds is based upon a ^{4}V2 relationship. Consequently a hierarchy of radii can be derived based upon N2 relationship steps. Table 8 illustrates this hierarchy appropriate to the standard Design Speeds, in which relevant V^2/R values are related by SI2 factors, and gives the theoretical gross lateral acceleration applicable to each; it is assumed speed is maintained at the Design Speed through the curve.

V^2/R Value	Design Speed (km/h)					Theoretical Gross Lat Acc'n
	(120)	(100)	(80)	70	60	
	Radius – Metres					
14.14	1020	720	510	360	255	0.11g
20.0	720	510	360	255	180	0.16g
28.28	510	360	255	180	127	0.22g
40.0	360	255	180	127	90	0.31g

Table 8: Hierarchy of Radii

3.5.2 It will be noted that the above table includes values for up to 3 Design Speed steps below Desirable Minimum. Special considerations apply to these radii as discussed in Paragraph 3.7 but it is necessary first to examine driver behaviour travelling around a curve or bend.

3.6 The Effect of Curves on Speeds

3.6.1 It has been shown (Southampton University, 1982) that drivers tend to reduce speed when traversing curves of lower radii. This is based on measurements made on a sample of 52 single carriageway and 20 dual carriageway sites in the United Kingdom, mainly in dry weather, representing a total of over 10,000 speed observations covering a wide variety of site conditions and approach speeds. This speed reduction is illustrated in Figure 15 which shows the relationships that have been established between mid curve speed and radius for various approach speeds (or Design Speed). The studies showed that there is a very strong correlation between approach speed A, and speed round curve B~, as follows:-

B, (85%ile level) = $\underline{A_s}$ $\quad$ 1- $\frac{As^2}{400R}$

where A_s=Approach Speed (85%ile value)(km/h).

R = Radius of curve (metres).

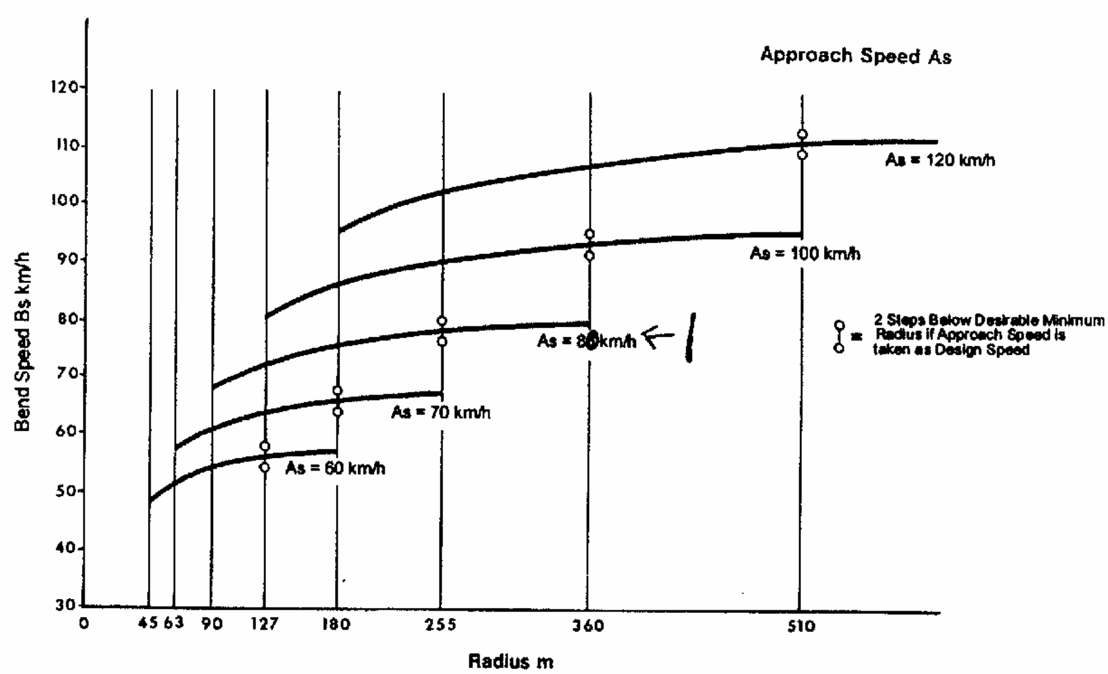


Figure 15 : Speed Curvature Relations

3.6.2 Measured Speed Reductions. The effects of superelevation, sight distance and length of curve were not found to affect the observed speeds significantly, even when wet conditions were observed. However, exceptionally wet conditions were not encountered during the studies, but a further study by TRRL in 1983 suggested no more• than trivial wet weather speed reduction. It appears that speeds drop significantly only when the intensity of rainfall reduces visibility. As the Design Speed adopted in TD 9 is the estimated 85%ile speed of vehicles, the 85%ile approach speed A, can be taken as the Design Speed for curve design. This model derived from the 10,000 measurements shows that drivers approaching a curve will moderate their speed relative to the approach speed in a consistent pattern, according to the V^2/R value of the curve. Values for light vehicles are shown in Table 9:-

Horizontal Curve	V JR Value	Speed Reduction %		
		From 50%ile Speed	From 85%ile Speed	From 99%ile Speed
Desirable Minimum Radius	14	2.5	3.5	5
One Step below Desirable Mm	20	3.5	5	7
Two Steps below Desirable Mm	28	5	7	10
Three Steps below Desirable Mm	40	7	10	14
Four Steps below Desirable Mm	56	10	14	20
Five Steps below Desirable Mm	80	14	20	28

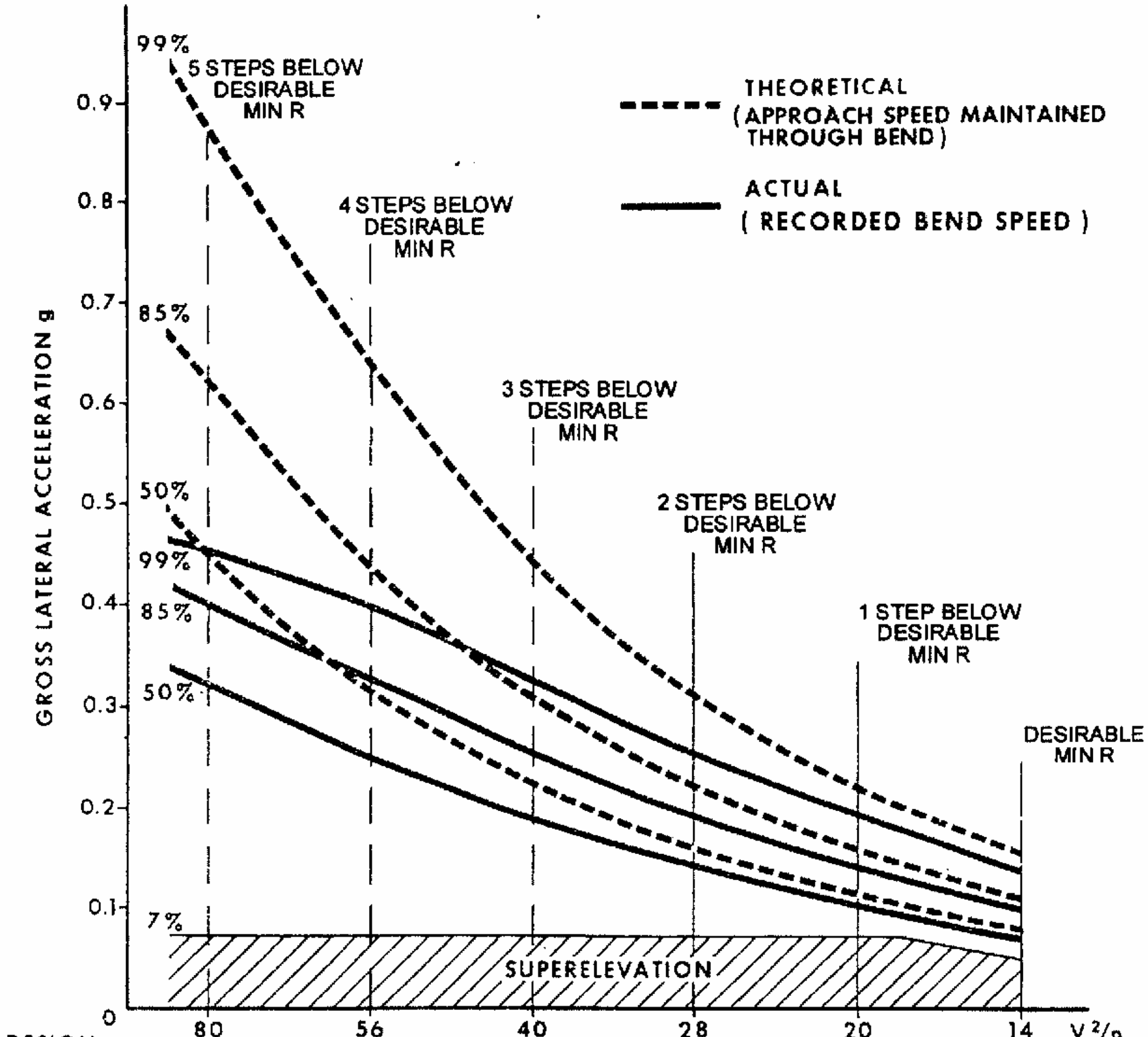
Table 9: Speed Reductions observed to occur in practice

The effect of these speed reductions on light vehicle gross lateral accelerations for the 50, 85 and 99%ile driver is shown in Figure 16 as solid lines, in comparison with the gross lateral acceleration that would result if speed were maintained at approach speed (Design Speed), as shown by broken lines. For goods vehicles, however, the gross lateral accelerations are 75% of the light vehicle value on single carriageways and 70% of the light vehicle value on dual carriageways. It can be seen that, in dry or not excessively wet conditions, drivers accept continually increasing values of lateral acceleration, more so at higher values of V^2/R, well above the comfort level of 0.22g. The study provides a clear demonstration that, within the normal distribution of speeds, drivers adapt readily to road layout configuration. However, considerably more driver intervention is necessary with the higher V^2/R values, involving reducing speed and increased steering effort.

3.6.3 Application in Design. In comparing the net lateral theoretical accelerations shown in Table 7 with those actually adopted by drivers in Figure 16, it is clear that the former are extremely modest. Furthermore the actual amount of superelevation appears to have no direct effect upon driver behaviour, implying that superelevation, though obviously a desirable contribution to driver comfort and safety, need not be considered too exactingly. Thus, for example, if local circumstances should present problems in the application of, say, 7% superelevation, 5% would have no significant effect on behaviour. The latter adjustment however is only recommended for cases where radius is not less than one Design Speed step below desirable minimum.

3.7 Superelevation – Radii equal to and tighter than 2 Design Speed steps below desirable minimum

3.7.1 Standard ADT TD 9 permits relaxations of up to 2 Design Speed steps below Desirable Minimum radius at sites of particular difficulty, depending upon road type and the Design Speed band, but with superelevation not increased beyond the maximum 7%. This is the only case within Standards where account is taken formally of the speed reductions shown in Table 9, the reason being that the gap between theoretical and observed values at this level has become too great to ignore. The approximate contributions that are assumed are to be made by the superelevation and tyre/road surface interface to balance actual gross lateral acceleration for cases of two steps below Desirable Minimum radius are shown in Table10.



DESIGN SPEED	RADIUS m					
(120 km/h)	180	255	360	510	720	1020
(100 km/h)	127	180	255	360	510	720
80 km/h	90	127	180	255	360	510
70 km/h	63	90	127	180	255	360
60 km/h	45	63	90	127	180	255

	ACTUAL SPEED REDUCTION %					
50% ile	14%	10%	7%	5%	3.5%	2.5%
85% ile	20%	14%	10%	7%	5%	3.5%
99% ile	28%	20%	14%	10%	7%	5%

Figure 16 : Lateral Acceleration Values

Speed	Gross Lat Acc'n	Reduction in Lat Acc'n from Max Super'n	Nett Lat Acc'n
99%ile	0.26g	.07g	0.19g
85%ile	0.19g	.07g	0.12g
50%ile	0.14g	.07g	0.07g

3.7.2 Additionally, when considering Departures from curvature Standard at sites of particular difficulty, as described in Paragraphs 0.12 to 0.16 of ADT TD 9, account should be taken of the further speed reductions shown in Table 9 depending on the V^2/R value. It is worth repeating that the known speed drop is taken into account when dealing with radii equal to and tighter than 2 Design Speed steps below Desirable Minimum but ignored when dealing with lower V^2/R values.

3.8 Departures from Standards

3.8.1 Drivers perceive the curve ahead and reduce speed in a remarkably consistent manner, depending on the curve radius, provided it is clearly visible and not of decreasing radius (prolonged spiral). For any particular case, the sideways force generated by the 99%ile vehicle can be calculated. Full calculation for emergency situations needs also to take account of the forces simultaneously generated by braking in the likely case of a desirable minimum stop (deceleration 0.25g) or in the less likely case of a one Design Speed step below desirable minimum stop (deceleration *0.375g)*. Where gradients are present adjustments will be required in the calculation. (TRRL, 1979b and 1980b).

3.8.2 Safety. The fitted functions for estimating the effects on safety at low radius curves are shown at Figure 17. The model indicates a continually increasing accident rate with reducing radius. However, curve length might be considered as a factor since lower radius curves are shorter in length for the same angle turned. In practice their overall effect on accidents might not be as great as curves of larger radius although this argument will not apply to long curves. Figure 18 illustrates this in that, at a given site, the use of a 255m radius curve will result in a 400m long curve (with a higher accident rate), compared with a *510* in radius curve 800m long (with a more moderate accident rate). It is not desirable, nor statistically sound, to codify a method for comparative analysis of the various geometric forms, but the general interpretation is that reductions from desirable minimum Standards by one or, in rare cases, 2 Design Speed steps would have little effect on the overall accidents at some sites and be insufficient to justify any inordinately large increments of expenditure to maintain full standards.

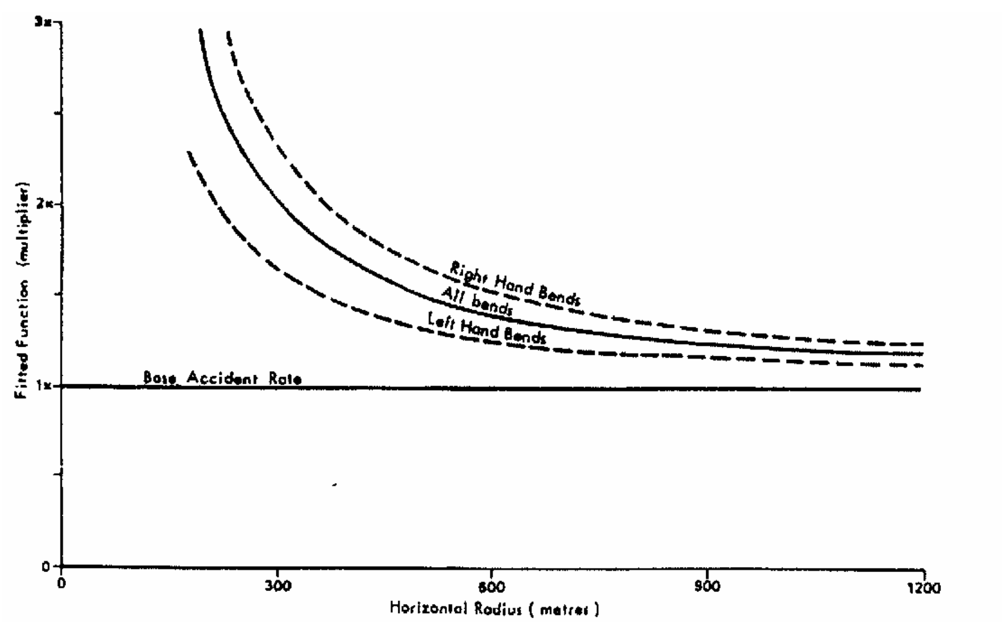


Figure 17 : Accident Rate v Horizontal Radius 10m Single Carriageway

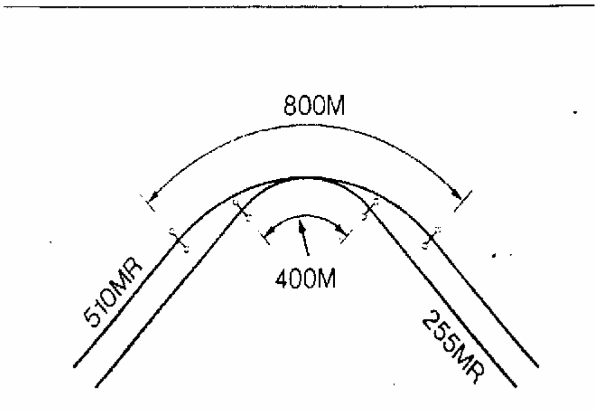


Figure 18 : Alternative Alignment Options

3.8.3 Junction Implications. The two studies carried out (Halcrow Fox, 1981, and Southampton University, 1982) were made on non motorway road sections but without the interference of frontage development, accesses or junctions, the presence of which would undoubtedly exacerbate the accident implications considerably. A high standard of visibility provision is required where accesses or junctions occur, hence the restrictions on Relaxations in these locations. Where Relaxations or Departures from curvature standards are adopted it is important that skidding resistance appropriate to the circumstances and traffic speeds is provided.

3.9 Interrelation with Stopping Sight Distance

3.9.1 In normal circumstances SSD limitations will be encountered well in advance of the need to consider Relaxations or Departures from horizontal curvature Standards. For example, for rural roads at radius of one Design Speed step below Desirable Minimum, considerable verge widening is required to meet SSD Standards. In some cases, Relaxations from SSD Standards will reduce considerably the impact or cost of the road in very difficult situations, and curvature Standards can be maintained. In severely constrained sections of route, however, it may also be necessary to adopt Relaxations or Departures from the horizontal curvature Standards. The accident relationships at Figure 17 are multiplicative with those for SSD at Figure 7, thus increasing the accident potential. The accident implication of combined curvature/SSD Relaxations or Departures within one or perhaps 2 Design Speed steps may not be sufficiently increased to justify inordinately large increments of expenditure to maintain the Standards. The feasibility of suitable warning signs should always be determined and it is important that appropriate skidding resistance is provided for the prevailing risk. (See Paragraph 3.8.3).

On dual carriageways there is no sign to warn drivers explicitly of reduced sight distance; mandatory speed limits are the only devices available to indicate what is safe.

3.10 Elimination of Adverse Camber

3.10.1 A vehicle travelling on a straight section of road with normal *2.5%* camber to the outside channel is subject to a lateral acceleration of 0.025g by virtue of the camber. To counteract this, drivers have to steer slightly towards the centre of the road. With progressive curvature against the camber, the resulting sideways force to be balanced by tyre-road surface friction will increase rapidly. Adverse camber should therefore be changed to the opposite, favourable sense when curvature is sufficient to render driving conditions uncomfortable.

3.10.2 Limiting Value of V^2/R: The forces in Figure 13 become additive in the case of adverse camber, resolving to the following relationship:

$$\frac{V^2}{127R} = f - s$$

The magnitude of the sideways force that must be resisted by the tyre/road surface friction increases with increasing values of V^2/R. Assuming a normal *2.5%* adverse camber, this should be eliminated when $V^2/R = 5$ to limit the maximum net lateral acceleration resisted by the tyre/road surfaces to:

0.064g at 85%ile (Design Speed)
and 0.081g at 99%ile Speed

This recommendation is a compromise between avoiding high net lateral accelerations and introducing a high “hands off speed” by the favourable camber which could cause large numbers of drivers of slower vehicles to steer to the opposite sense of the curve. (See Paragraph 3.3.2). The forces, however, are not high and the use of transitional design to make a smooth transfer of steering requirements should eliminate any danger of instability.

3.10.3. Safety: No evidence is available to show whether adverse camber has any adverse effect upon safety, but this is thought to be unlikely. There would appear to be no grounds for adhering rigidly to this arbitrary $V^2/R = 5$ value for eliminating adverse camber whilst at the same time incorporating curves around the $V^2/R = 3.53$ to 7.07 range. Such a policy would result in the use of continuous or nearly continuous curves on either side of the cut-off with essentially similar appearance to drivers, but one requiring positive steering into the curve, whilst the other requires negative steering. The V^2/R limit of *5* should therefore be treated as a guide point only, with the maintenance of consistent steering requirements on contiguous or near contiguous sections of road the more important design consideration.

4. VERTICAL ALIGNMENT

4.1 Gradients

4.1.1 Maximum Gradients. ADT TD 9 incorporates a Desirable Maximum Gradient for the design of:

	Desirable Max Gradient
Motorways	3%
AP Dual Carriageways	6%
AP Single Carriageways	8%

These values are intended as a general guide to the maximum gradients below which the economic effects on user costs and construction costs will not be significant. They are found to suit the majority of design situations and profiles can be developed within them to produce economical earthworks designs. However, in hilly terrain where the cost/environmental implications of working to Desirable Maximum Gradients are severe, the trade off between construction/environmental costs and user costs can be assessed.

4.1.2 Effect of Gradient on Accidents. Studies in the United Kingdom into the effect of gradients on accidents (Halcrow Fox, 1981) have shown that accident rate can be expected to increase with steeper gradients. The fitted functions of accident rate against gradient are shown in Figure 20. It can be seen that there is a negligible increase in accidents in the uphill direction, but a significant increase is indicated in the downhill direction. This result is also supported by studies in other countries. However, the accident rates shown are calculated as accidents per vehicle kilometre and, on that basis, short steep gradients will be subject to higher accident rates for shorter lengths of gradient. (See Figure 19). This suggests that the total effect of the adoption of a steeper gradient is relatively minor, though this may be an oversimplification of causal factors. It should be noted that the studies referred to were made on road sections without accesses or junctions which would be likely to exacerbate the accident risks of steep gradients.

4.1.3 Departures from Standards. The data for steep gradients is valid for gradients up to 8% on single and all-purpose dual carriageways. Gradients steeper than 4% on motorways, *6%* on all-purpose dual carriageways and 8% on all-purpose single carriageways are Departures from Standards which may require the provision of additional safety measures.

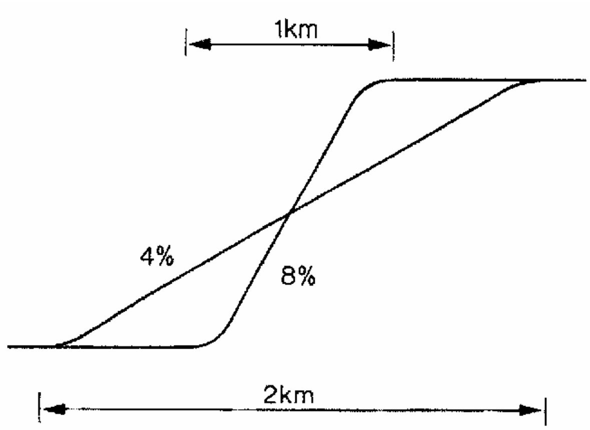


Figure 19 : Alternative Gradient Options

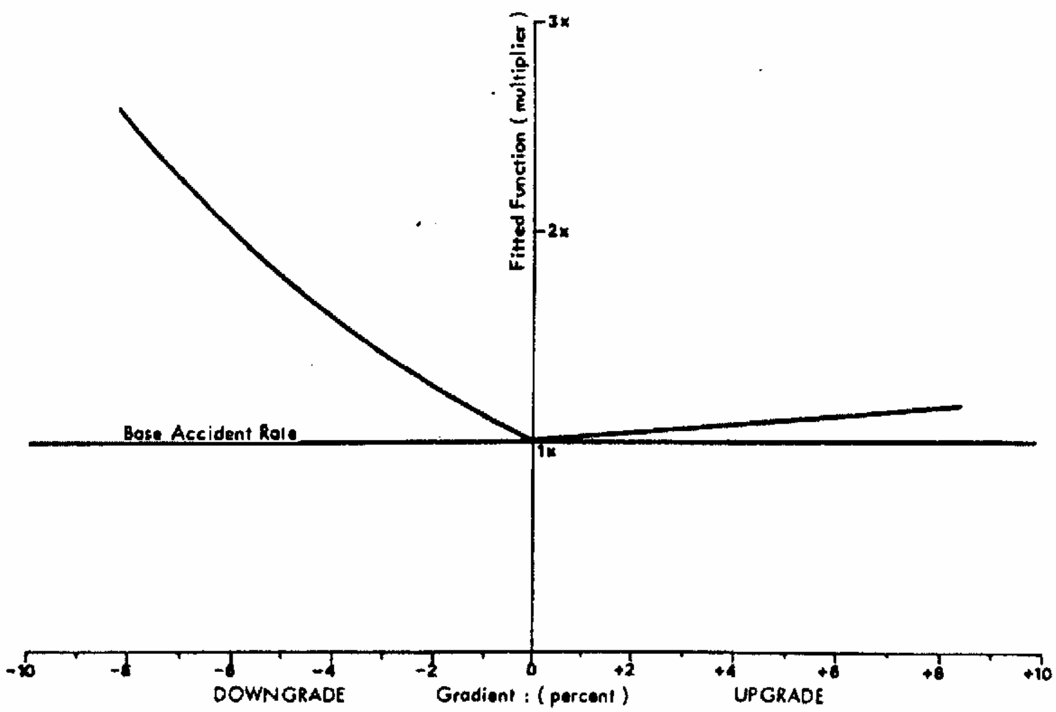


Figure 20 : Accident Rate v Gradient 10m Single Carriageway

4.2 Vertical Curves

4.2.1 Considerations of visibility and driver discomfort require that the vertical rate of change of grade should be kept within tolerable limits. For the higher ranges of Design Speed, the discomfort aspect is not critical because, in order to satisfy the SSD criteria, crest curves have large radii, affording a very gradual rate of change of grade with negligible discomfort to vehicle occupants. On the other hand, sag curves, with their inherent better visibility, can often be designed to the limit of comfort.

4.2.2 Type of Curve. Vertical curves can be circular or parabolic. The latter is preferred in highway design because it provides a constant rate of change of curvature. It closely approximates to a circular curve and is simple to apply to the relatively flat grades of highway profiles where the assumption of a vertical axis introduces no practical error.

4.2.3 K Values. It is convenient to express the length of a vertical sag or crest curve by K value, to facilitate the provision of parabolic vertical curves, where:

L = KA (metres)

In this way, the length of the vertical curve L is obtained from the relevant Design Speed related K value and the algebraic difference in grade A%. Thus K values will approximate to Curve Radius R/100 for the.equivalent circular curve.

4.3 Crest Curves

4.3.1 Figure 21 illustrates the effect of vertical curvature on visibility. There are two design conditions to consider when determining the length of crest curves:

(a) The SSD is less than the length of the vertical curve;

(b) SSD is greater than the length of the vertical curve.

However, at high Design Speeds, situation (b) only occurs where the changes in grade are minor; in these circumstances the difference in effects of the two approaches is not significant. At low Design Speeds where, because of the low SSD's, larger changes of grade do not obstruct visibility, the difference between (a) and (b) would become significant, but comfort criteria will override. In these latter cases, a maximum vertical acceleration of $0.3 m/s^2$ is taken as the limit for comfortable design.

4.3.2 Design Criteria. For practical purposes therefore, situation (b) above can be ignored and the formulae for vertical crest curve length can be resolved to:

Visibility Criterion $$L = \frac{S^2A}{200\,(a+b+2\sqrt{ab})}$$

Comfort Criterion $$L = \frac{V^2A}{389}$$

where:

L = Curve length (in)
S = SSD at the Design Speed (in)
A = Algebraic difference in grades *(%)*
a = Eye height above road surface **(in)**
b = Object height above road surface (in)
V= Design Speed (km/h)

4.3.3 Interrelation with SSD. The lower boundary of the visibility envelope for SSD (Paragraph 2.1.2) represents visibility between an eye height of 1 *.05m* and an object height of 0.26m. Figure 22 shows the object height visible from a 1 *.05m* eye height at the SSD with varying vertical crest radii. The SSD's derived in Paragraph 2.1.8 each bear a constant relationship to each other. Thus, if at a given radius an object of 0.26m height can be seen at the Desirable SSD for the Design Speed, an object of 1 .05m height can be seen at an SSD one step below the Desirable value providing there is no horizontal interference to the visibility envelope. This object height of 0.26m includes the stop/indicator lamps of a vehicle, probably the most important criterion, and also significant low objects on the carriageway.

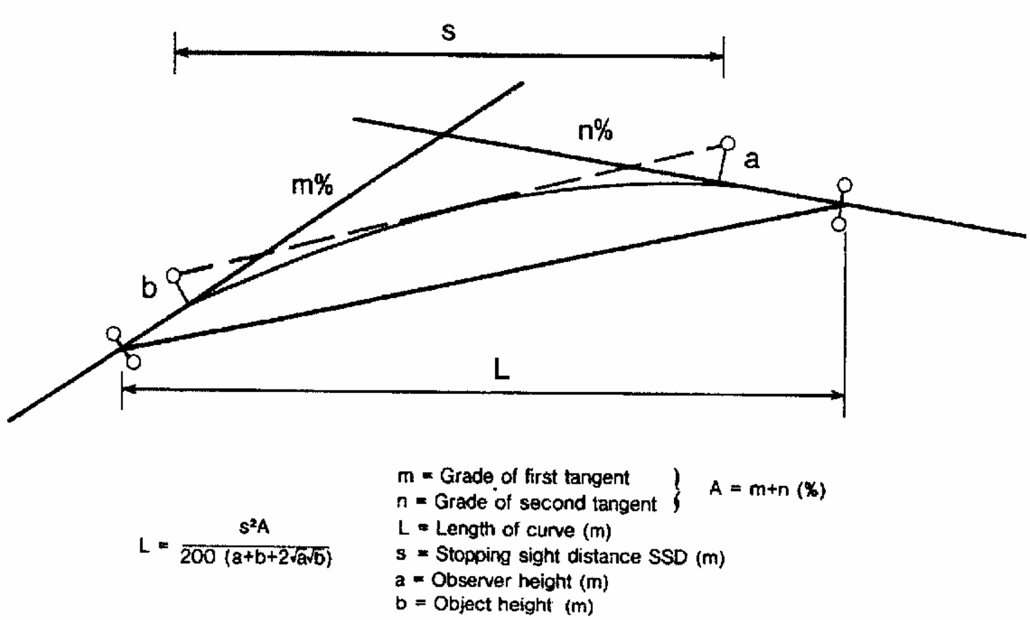


Figure 21 : Relationship between Vertical Curvature and Visibility

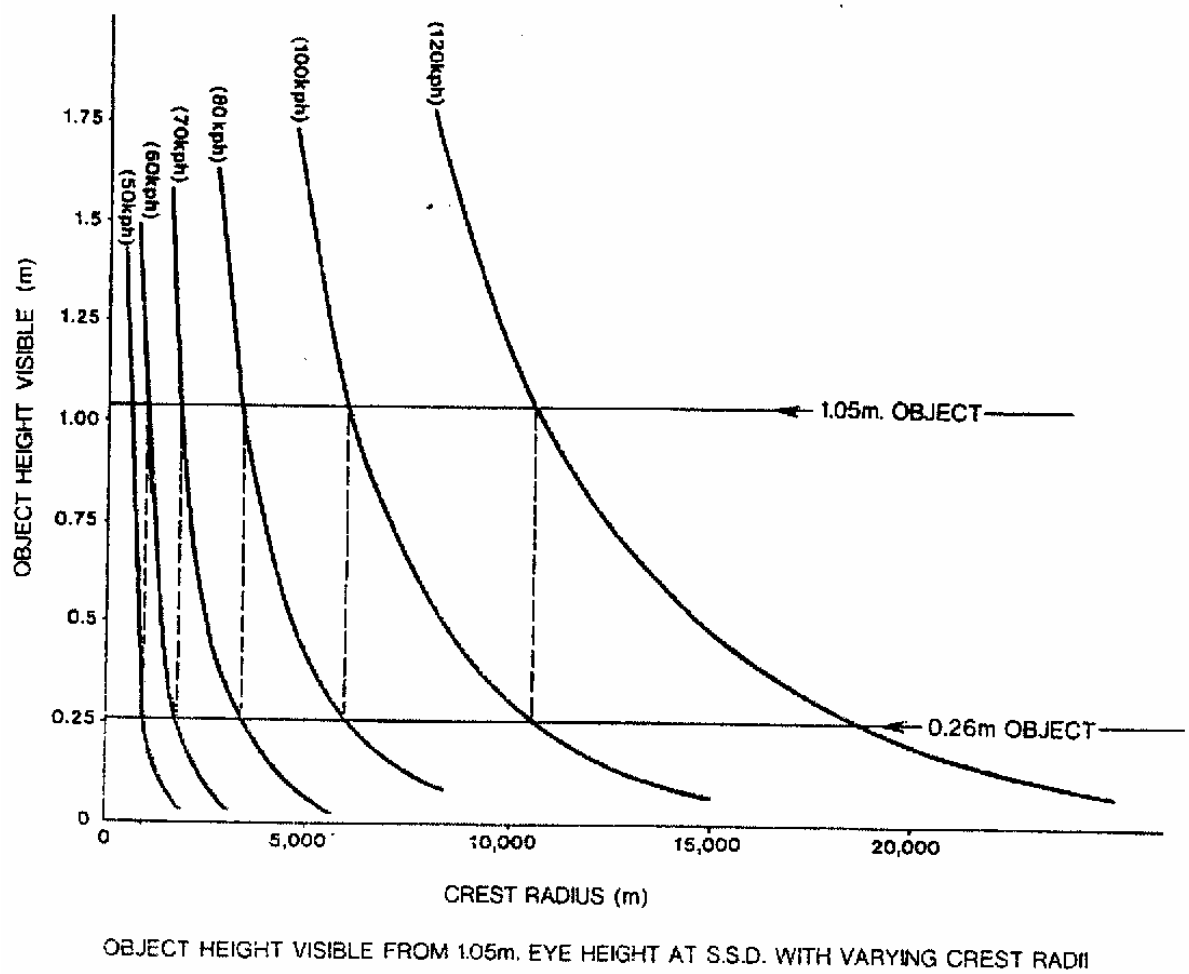


Figure 22 : Crest Curves

4.3.4 Design Formula. The Desirable Minimum SSD crest curve provides Desirable SSD to an object of 0.26m height. The crest curve for one Design Speed Step below Desirable Minimum provides an SSD of one Design Speed step below Desirable Minimum to an object height of 0.26m and this is equivalent to Desirable SSD to an object height of *1.05* in. By substituting an eye and object height of 1.05m and 0.26m respectively the equation for stopping visibility crest length becomes:

$$L=\frac{S^2A}{471}$$

or for Design Speeds below 6okph, where SSD is unaffected by the crest curve, the comfort criteria will override, i.e.:

$$L=\frac{V^2A}{389}$$

4.3.5 Design Values. Table 11 shows the relevant K values for Design Speed related minimum crest curves. It can be seen that at Design Speeds of 60km/h and above, the visibility criterion will take precedence over the comfort criterion, whilst for 50km/h (and below) comfort criteria will override. For minor changes of grade, however, visibility will not be obstructed and comfort criteria will be the minimum requirement. The Design K values for crest curvature for general use are therefore as in Table 12.

Design Speed (1cm/h)	(120)	(100)	80	70	60	50
Visibility Criteria Desirable Minimum K	(182.4)	(99.2)	54.6	30.4	17.2	9.8
One Design Speed Step Below Desirable Minimum K	(99.2)	(54.6)	30.4	17.2	9.8	5.7
Comfort Criteria Minimum K	(37.0)	(26.2)	18.5	13.1	9.3	6.5

Table 11 : K Values for Different Criteria in the Design of Crest Curves

Design Speed (km/h)	120	100	80	70	60	50
Desirable Minimum K	(182)	(100)	55	30	17	10
One Design Speed Step Below Desirable Minimum K	(100)	(55)	30	17	10	6.5

Table 12 : K Values for the Design of Crest Curves

4.3.6 Dual Carriageways. The cost implications of providing Desirable Minimum SSD crest curvature, which produces Desirable SSD to a 0.26m object, are minimal where the terrain is easy and where grade changes are relatively minor.

On dual carriageways where grade changes exceed about 4% it will rarely be feasible to consider the use of Desirable Minimum SSD crest curvature and relaxations should be considered in appropriate cases. Relaxations below Desirable Minimum are not permitted where junctions or accesses are sited beyond the crest, (but see Paragraph 2.1.10).

4.3.7 Single Carriageways. On single carriageway roads, the need for clear identification of non-overtaking sections will override, (see Paragraphs 6.4.2 and 6.5.2) and Desirable Minimum K value should be avoided with lesser values being used.

4.4 Sag Curves

4.4.1 Design of sag curves has, in the past, been based upon considerations of headlamp visibility whereby a headlamp, 0.6m above the surface of the road with an upward spread of the light beam of 1 degree, would illuminate the road surface for a distance ahead equivalent to the Design Speed related SSD. The following formula can be derived for length of curve in situations when S <

$$\frac{S^2A}{200S + 120}$$

where:
L = Length of sag curve (in)
S = SSD at Design Speed (in)
A = Algebraic difference in grades *(%)*
a = Angle of upward spread of light beam (radians)

4.4.2 New Criteria. In applying this formula, four aspects need to be appreciated:

(a) The formula is extremely sensitive to the assumption of a 1 degree upward spread of the light beam;

(b) The philosophy assumed that headlamps are
capable of illuminating objects up to 300m distance, which is considerably beyond the reach of headlamps;

(c) Many drivers drive on dipped headlamps which considerably reduces the effect of the beam;

(d) On horizontal curves the headlamp beam does not illuminate the road surface at even shorter distances ahead.

Whilst, in relatively flat terrain, relaxations of the SSD related values would have no significant effect, in difficult topography, with gradients of more than about 4%, the minimum sag curve derived from the above formula can have a very severe effect on cost and environmental impact, eg. height of embankment or viaduct. Reliance upon the tenuous headlamp beam parameters in these situations, therefore, cannot be sustained and it is more realistic at the higher Design Speeds to design in relation to the effects of the sag curve on comfort.

4.4.3 Design Values. Data from international practice suggests that the maximum desirable vertical acceleration for comfort is 0.3ni/sec^2 for which:

$$L = \frac{V^2 A}{389} \text{ or K value } = \frac{V^2}{389}$$

where: L = Length of curve (in)
V = Design Speed (km/h)
A = Algebraic difference in grades *(%)*

Table 13 shows the relevant K values for Design Speed related sag curves.

4.4.4 Practice is to use comfort criteria for high Design Speeds (more than 70km/h), but the lower of the two headlamp visibility criteria for low Design Speeds (less than 70km/h) in unlit areas. In lit areas, it is considered acceptable to use comfort criteria for all Design Speeds. All values are considered to be 1 Design Speed step below Desirable Minimum.

4.4.5 A result of this practice is that, at low Design Speeds in unlit areas, minimum crest curve K values are smaller than minimum sag curve K values. A framework of sag curve K values has therefore been developed which both overcomes this anomaly and provides Desirable Minimum values; these are shown in Table 14.

Design Speed (km/h)	(120)	(100)	80	70	6	50
Headlamp Visibility K to provide Desirable SSD	(75.0)	(53.3)	37.8	26.6	18.6	12.9
K to provide 1 step below Desirable SSD	(53.3)	(37.8)	26.6	18.6	12.9	8.9
Comfort K	(37.0)	(26.2)	18.5	13.1	9.3	6.5

Table 13: K Values for Different Criteria in the Design of Sag Curves

Design Speed (km/h)	(120)	(100)	80	70	60	50
DesMinSagKValue	(53)	(37)	26	20	13	9
One Design Speed Step Below Des Mm K Value	(37)	26	20	13	9	6.5

Table 14 : Minimum K Values to be Used for Sag Curves

4.4.6 The Desirable Minimum sag curves are based on a conservative comfort criterion (0.21m/sec^2 maximum rate of vertical acceleration); the resultant sag curves approximate to those which would provide Desirable Minimum SSD using headlamp visibility criteria assuming a 1.50 upward spread of the light beam.

4.4.7 The sag curves 1 step below Desirable Minimum are based on the conventional comfort criterion of 0.3m/sec^2 maximum rate of vertical acceleration. The adoption of this approach results in the sag curve K values being less than or equal to the equivalent crest K values at all the Design Speeds in Table 3 of ADT TD 9.

4.5 Vertical Curvature Relaxations and Departures from Standards

4.5.1 Crest Curves. Whilst the values quoted are suitable for general design conditions, limited evidence has indicated that the accident implications resulting from Relaxations from the crest curvature standards are only minor for road lengths without accesses and junctions. There is evidence to indicate that junctions or accesses sited at or just beyond sharp hill crests do create accident zones thus the full standard of crest curve should always be maintained at such locations.

4.5.2 Sag Curves. There is little evidence to suggest that Relaxations from the sag curvature Standards have any appreciable effect upon accidents or, indeed comfort. Large increments of expenditure would not be justified simply to achieve the recommended design values. Designers may need to consider Relaxations or Departures at a few difficult locations in relation to cost or environmental impact, although perspectives should always be checked to avoid an unacceptably kinked appearance.

5. CLIMBING LANES

5.1 Justification

5.1.1 Gradients cause a significant drop in the speed of heavy goods vehicles, whilst following light vehicles are much less affected by the gradient itself, thus creating operational problems which can be overcome by the provision of an additional climbing lane; but at extra cost. A climbing lane is economically justified when the combination of severity of the hill and the traffic volumes and composition are such that the additional cost of providing it can be justified by the operational benefits achieved.

5.1.2 Design Chart. Detailed data from climbing lane studies (Martin and Vorhees, 1976), QUADRO (DMRB Volume 14) and accident records were used in producing the solid curves in the design chart shown in Figure 8 of ADT TD 9. The chart shows the combination of height risen or gradient, traffic flow and composition that would create disbenefits sufficient to economically justify the provision of a climbing lane in average conditions, for example, where the terrain is relatively easy and there are no especially high costs or adverse environmental impacts associated with the climbing lane provision.

5.1.3 Cost Implications. The chart gives only a generalised economic analysis for climbing lane provision, but does not indicate when a gradient will cause significant operational problems if a climbing lane is not provided. If, therefore, one is shown to be justified by the chart but would result in disproportionately high cost implications, such as extensive extra cutting, embankment, or property demolition, or entail significant extra structural work, the average cost assumptions inherent in the chart obviously do not apply. In these circumstances consideration should be given to alternative, less costly means of providing an overtaking facility. It may be preferable to adopt a Departure from Standards by providing the climbing lane partially within the normal verge/marginal strip.

5.1.4 Justification when Cost is Small. The cost of the provision of a climbing lane on all purpose roads with hard shoulders will be small or negligible and climbing lanes should generally be provided wherever the risen height (H) exceeds 15m. The figure of 15m has been derived from RT 186 and is the lowest value that can be derived from RT 186 Table 1 (for 6% over 250m).

5.1.5 Dual Carriageways. Figure 16 of ADT TD 9 has been derived from Figure 8 of ADT TD 9 using double the traffic flow on each curve; this doubling follows the practice of RT 186 which suggested that the volume warrant would be doubled in the case of dual carriageways.

5. Measurement of Climbing Lanes

5.2.1 No British studies are available which have expressly examined the performance of heavy goods vehicles in relation to the decline in speed at the start of a gradient, or the recovery of speed beyond the top. Nevertheless, studies from other countries available (US Highways Research Record, 1971) which have been used to derive a rational determination of where a climbing lane should start and terminate. Whilst conditions will vary widely according to the dimensions of the sag and crest curves it has generally been found sufficient to relate the start and finish of the climbing lane to measured distances from the points on the gradient where the gradient reaches or drops to 2% as shown in Figure 9 of ADT TD 9. The start point shown in Figure 12 of ADT TD 9 relates to a point where the heavy goods vehicles can be expected to reduce speed by 15%.

5.2.2 The finish points shown in Figure 13 of ADT TD 9 are designed to enable heavy goods vehicles to regain the majority of their speed and thus to facilitate their rejoining the continuing lane. The two alternative ways to determine the location of point F have been provided because:

- the dimension of 200m from the summit of the crest curve does not cover the case where the road continues upwards at a gradient of less than 2%

- on sharp crests, it would be excessive to continue the climbing lane for a distance of 400m from the 2% point.

6 SINGLE CARRIAGEWAYS

6.1 General

6.1.1 Chapter 7 of the Maltese Transport Authority Standard ADT TD 9 gives a considerable amount of explanation in its text. In this section, the Advice Note deals with the system developed to introduce a complete design methodology for single carriageways and provides explanations necessary for further understanding of Chapter 7 of the Standard.

6.2 Overtaking Sections

6.2.1 General. The provision of an alignment that provides adequate safe overtaking possibilities to ensure a reasonable degree of freedom for faster vehicles to maintain their desired speed is one of the main principles of single carriageway design. ADT TD 9 adopts a measurement system in order to assess the overtaking value of an alignment, but as described in Paragraph 2.2.1 of this ADT TA 43, it is not possible to precisely define overtaking possibilities. Guidelines that represent good possibilities for overtaking for one driver may be prohibitive for another driver. Thus the measurement system is of necessity an oversimplication but the objective is to develop a practice of designs that optimises good overtaking opportunities for as many drivers as possible. This practice should be seen as a rational system that will achieve a consistency within schemes and between schemes that is important in itself as contributing to safety. It is not intended that designs should be considered as comprising sections that are designated as either “safe” or “unsafe”.

6.2.2 Measurement Criteria. Measurement of a length formally considered viable under the system commences when FOSD is available. Examples are Figure 19 of ADT TD 9 and Figure 23 herein. FOSD is the distance within which 85% of drivers can overtake in the face of oncoming vehicles. The termination of a length is assumed to occur when only FOSD/2 is available. This distance, within which 50% of drivers can overtake, is called the Abort Sight Distance (ASD) and is the distance required for the overtaking vehicle to complete a manoeuvre (either by completing overtaking or by pulling back) in the face of oncoming vehicles from the stage when it has drawn alongside the vehicle it is overtaking. (See Figure 11).

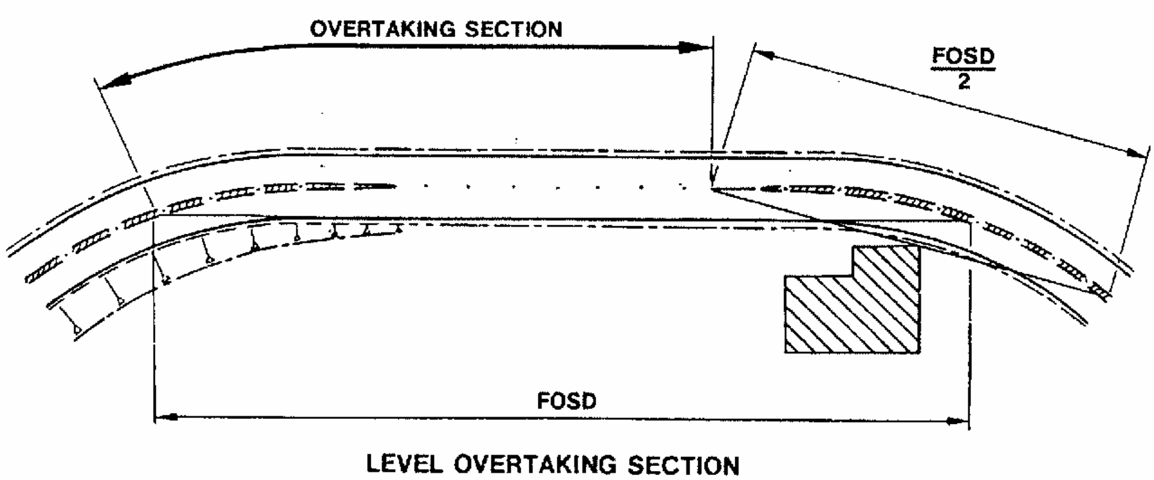


Figure 23 : Overtaking Section less than FOSD in Length

6.2.3 Left Hand Curve Sections. Figure 19 of ADT TD 9 shows FOSD/4 as the termination of the overtaking section for the left hand curve situation. For left hand curves sight distance for overtaking deteriorates immediately beyond the tangent point. For very sharp curves deterioration is immediate, for larger radius curves it is gradual and depending on the lateral position of the overtaking vehicle, it might be nearly FOSD/2 just beyond the point. For practical purposes, since this is only a measurement system having no impact on safety beyond what is perceived by the actual road user, the average between 0 and FOSD/2, i.e. FOSD/4 (beyond the tangent point) is taken. Thus, coupled with FOSD/4 before the tangent point, the same value (i.e. FOSD/2) is arrived at as for the right hand curve case.

6.2.4 Application in Design. Table 5 of ADT TD 9 details the radii above which there are clear opportunities for overtaking. The other category is for right hand curves and includes radii above those in Table 6 of ADT TD 9 where visibility is within the road boundary fencelines. The system is based on the attainment of at least FOSD because this provides a reasonable overtaking opportunity for the 85%ile driver. However, where a link between roundabouts is less than 1 Km the appropriate Design Speed FOSD should be one Design Speed step lower than that of the higher Design speed of the approach sections, with a minimum value of 80A kph. In some cases the opportunity will occur only for design of straight or nearly straight sections with less than FOSD initially available. If no better alternative alignment is possible these should be included as they will afford overtaking opportunity for perhaps the 80, 60 and 40%ile drivers. Although the assessment system only summates good lengths (i.e. over FOSD initially, see Paragraph 7.20 of ADT TD 9), the sub FOSD sections do contribute to traffic relief in practice because the faster drivers will nevertheless overtake without undue difficulty. A route alignment is superior, however, if it comprises mostly straight or nearly straight sections exceeding FOSD rather than many sub-FOSD sections. The "Overtaking Value" is intended to be a control on this.

6.2.5 Climbing Lane Overtaking Sections. The measurement points of commencement and termination of climbing lane overtaking sections are described in ADT TD 9. The rationale for the point of termination is based on that described in Paragraphs 6.2.2 and 6.2.3. The length of climbing lanes (between centres of tapers) does not have to be at least FOSD. Quite short climbing lanes afford valuable relief to some traffic, though no minimum value can be given as circumstances vary widely. Therefore within the summation of the Overtaking Value, any length of climbing lane overtaking section or single lane downhill overtaking section should be counted.

6.2.6 Straight or Nearly Straight Sections. ADT TD 9 encourages optimisation of overtaking potential especially in flattish areas by the adoption of Band A designs (Figure 24 of ADT TD 9). Operational drawbacks of such straight or nearly straight sections are sometimes cited as:

(a) Headlamp dazzle at night;

(b) Low or rising/setting sun effect;

(c) Monotony;

(d) Difficulty in assessing speed of oncoming vehicles.

Counter arguments to these are:

(a.a) The range of full headlamps is well below 300m so dazzle is a short period, transitory problem;

(b.b) Low or rising/setting sun is a nuisance on certain straight roads necessitating caution by drivers but there is no available evidence that it is an accident hazard; only a few hours of the year are affected at any one location at peak flow periods;

(c.c) Lengths of straight road in Malta are unlikely to be long enough to create monotonous driving conditions, bearing in mind the land use and the need to minimise environmental impact.

(d.d) It is more difficult to assess the speed of an oncoming vehicle on straight rather than curvilinear alignments, but the design methodology does not preclude flowing alignments provided they utilise curves in the "nearly straight" category. This enhances the awareness of the presence of oncoming vehicles and contributes to safe overtaking.

6.3 Overtaking Value

6.3.1 Attention is particularly drawn to the final sub-paragraph of Paragraph 7.24 in ADT TD 9, where the minimum Overtaking Value cannot be reached. This is of particular relevance in short by pass situations and often the best solution will be to widen as described in Paragraph 7.24e. Departures from "Overtaking Value" standard and/or carriageway width standard will be considered on either "level" roads or in climbing lane situations.

6.4 Horizontal Curve Design

6.4.1 The objective should be to evolve a design using Band A, Figure 24 of ADT TD 9, with the upper range of Band B where it cannot be avoided, keeping verge widening minimal. Where this is not possible Band D radii have to be used but not the non recommended Band C.

6.4.2 Non-Overtaking Radii Design – Considerations. Non-overtaking curves in Band D should be utilised only when constraints make this unavoidable. There are both advantages and disadvantages in their use. Radii towards the lower end of this non-overtaking band shorten the length of a curve thereby increasing the amount of overtaking alignment available; they also enhance driver perception of what is a non-overtaking curve. These radii have relatively less sight distance available within the road boundary; Paragraph 7.43 of ADT TD 9 describes the use of hatched markings which are recommended. On the other hand, lower Band D radii will lead to higher sideways forces on vehicles and less than Desirable Minimum Stopping Sight Distance (DMSSD) unless there is excessive verge widening. These effects are illustrated in Table 15 by comparing the difference between the situation for a single 7.3m carriageway at Desirable and one Design Speed Step Below Desirable Minimum Radius (Figure 24) for Design Speeds of 100 km/h or less.

6.4.3 Recommended Radii. There is no unique answer to the conflicting questions posed in Table 15 and in any case too much precision would be spurious in view of two further factors:

(a) The Design Speed is not in itself an exact assessment, and on lengths of road having Band A curvature/straight characteristics which exceed 2 kilometres in length the design of the first Band D curve should be considered very carefully with safety in mind;

(b) There may be a tendency for speeds to continue to increase with the passage of time.

It is better to err on the side of safety when making decisions and as a general guide, to keep near Desirable values of Radius and Sight Distance for all Design Speeds.

Aspect of Design	Desirable Minimum Radius (DMRB) $V^2/R = 14$	One Design Speed Step below Desirable Minimum Radius $V^2/R = 20$
Amount of adjacent overtaking section used up	Mid-way between maximum and minimum	Superior to DMR
Driver perception of what is a non-overtaking curve	Good, well away from Bands B&C the zone of dubious overtaking	High, superior to DMR
Sideways Force (Design Vehicle)	0.11g half the threshhold of discomfort	0.16, inferior to DMR
Is Visibility DMSSD?	Yes, 0.7m of verge widening would be required on a Standard (7.3m) Single Carriageway to obtain DMSSD for a Design Speed of 100 km/h	Yes, 4.01m of verge widening would be required on a standard (7.3m) Single Carriageway to obtain DMSSD for a Design Speed of 100 km/h

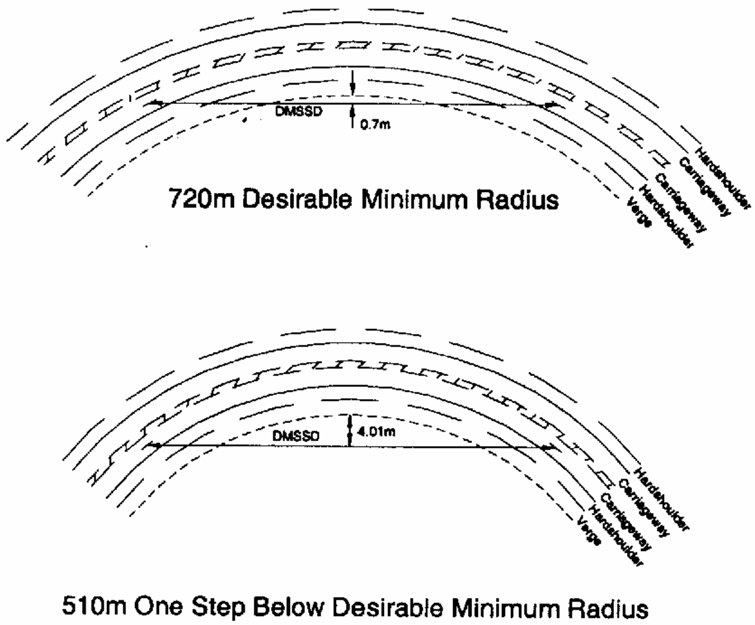


Figure 24 : Horizontal Curve Verge Widening for a 100 km/h Design Speed

6.4.4 Application in Design. When designing 000horizontal curves consideration should be given to all the factors contained in Paragraphs 6.4.2 and
6.4.3 and any other factors which may be relevant such as length and importance of route being considered. Full attention must be paid to these considerations, including the road markings, at the earliest stage of design. At the later stages unsatisfactory compromises almost always have to be made and poor designs result.

6.5 Vertical **Curve Design**

6.5.1 The objective should be to co-ordinate the design of vertical curves with the horizontal alignment to provide the maximum overtaking provision. To illustrate principles, the vertical non-overtaking crest curve on a straight alignment is considered.

6.5.2 Non-Overtaking Radii Design Considerations. Non-overtaking crest curves should be utilised whenever the provision of a FOSD or greater curve creates heavy earthworks and inordinately high cost. Sharper crest curvesserve to minimise loss of some overtaking section, maximise driver perception of what is a non-overtaking curve and reduce the length of road given over to prohibitory continuous road markings. On the other hand such curves will lead to the provision of less than Desirable Minimum Stopping Sight Distance (DMSSD). However, if the vertical curve is on a straight, Stopping Sight Distance appropriate to one Design Speed step below Desirable Minimum to a low object (0.26m) gives DMSSD to a 1.05m object. (See Paragraph 4.3.3). Comparing this with the horizontal curve case where SSD for one Design Speed step below Desirable Minimum to the low object does not always give DMSSD to the 1.05m object, it is clear that on crests there is relatively greater sight distance at one Design Speed step below Desirable Minimum when the road is straight or nearly straight compared with one Design Speed step below Desirable Minimum on purely horizontal curves. In Table 16, three conceivable alternatives for a non-overtaking crest curve are examined to illustrate the above points (Figure *25)*.

6.5.3 Recommended Radii. Desirable Minimum crests are unsatisfactory for single carriageway non-overtaking crests on the straight for the reasons given in Table 16. They also usually result in much heavier earthworks. A crest curve 2 Design Speed steps below Desirable Minimum is also totally unsatisfactory, except in rare and exceptional circumstances, due to the excessively high rate of deceleration required for an emergency stop and particularly since Figures 7 and 8 herein indicate that the threshold of higher accident rates is reached.

The recommended crest curve on a straight is therefore that for one Design Speed step below Desirable Minimum, particularly if DMSSD is available to the 1 .05m high object. Its advantages as the most appropriate non-overtaking crest are fully summarised below:

(a) Desirable SSD should be still available to the *1.05m* object;

(b) Maximum rate of deceleration is kept within acceptable limits of tyre/surface interface, *0.375g;*

(c) Earthworks and cost can be reduced;

(d) The length of non-overtaking is minimised;

(e) Rate of curvature does not exceed the comfort value of 0.3 m/sec^2;

6.5.4 FOSD Curve. Figure 26 herein also shows the effect of incorporating a steady FOSD curve in hilly terrain. In this example, a curve of length 4km results and significant earthworks are required which is clearly unacceptable. Generally speaking, to be successful, overtaking crest curves need to provide a good deal more than FOSD and this is only likely to be cost effective if the natural ground levels are favourable. This is because, whilst a FOSD crest would enable a driver to see an approaching vehicle FOSD away, in the absence of any approaching vehicles, the driver can see nothing beyond the road surface FOSD/2 away and thus finds it difficult to judge whether or not FOSD is available.

Aspect of Design	Desirable Minimum Crest	One Design Speed Step below Desirable Minimum Crest	Two Design Speed Steps below Desirable Minimum Crest
Amount of adjacent overtaking section used up	On the boundary of over-taking/non-overtaking, see ADT TD 9 para 7.19 as DMSSD to 0.26m object is FOSD/2 to 1 .05m object	Acceptable as it isbetween maximum and minimum	Minimal
Driver perception of what is non-overtaking curve	None - very ambiguous	Good	High
Theoretical 85%ile rate of deceleration required for emergency stop to a0.26m object(Design Vehicle)	0.25g (maximum comfortable rate)	0.375g (requires maximum tyre/road surface interface friction deemed necessary in the wet)	0.62g (far in excess of guidelines - see Section2.1)
Are double continuous lines recommended	No, only normal centre of carriageway marking, but see ADT TD 9 para 7.43	No, although visibility available is only marginally greater than the limit without double continuous lines	Double continuous line system justified

Table 16: Design Considerations for Non-Overtaking Vertical Curves

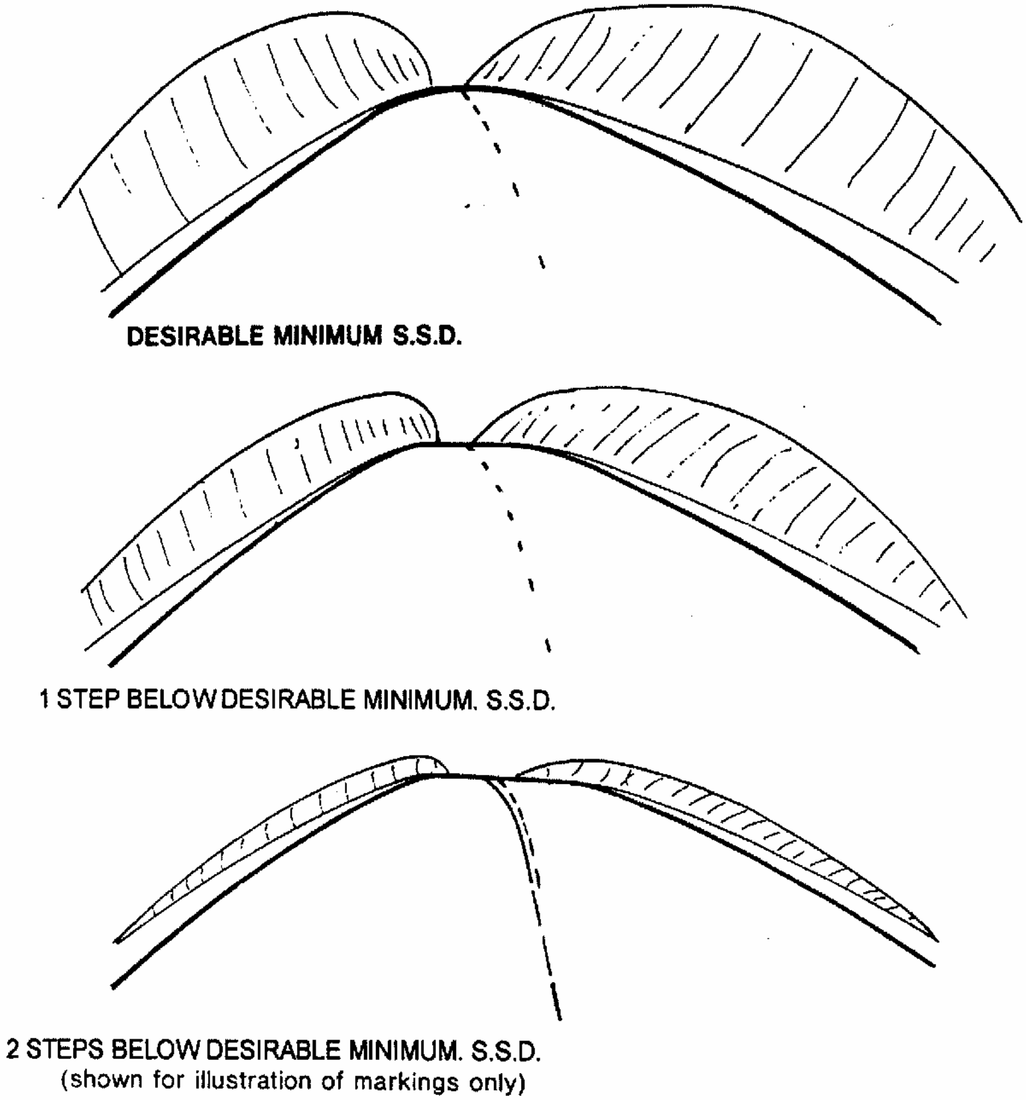


Figure 25 : Road Markings at Vertical Curves

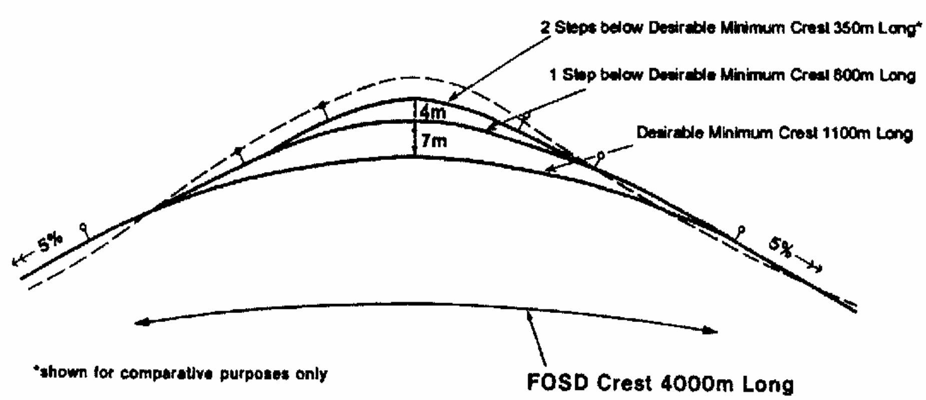


Figure 26 : Types of Crest Curve (Connecting Two 5% Grades)

6.5.5 Application in Design. Examples are shown in Figures 27a, 27b and 27c of various crest curve treatments for a broken back crest. Figure 27a indicates that a FOSD crest curve is unacceptable on earthworks and cost grounds, whereas the overlapping climbing lanes with a tighter crest curve in Figure 27b create sounder overtaking opportunities and reduce earthworks. If the conditions permit, Figure 27c is the preferred solution as it optimises earthworks, cost and overtaking.

Figure 27a : Incorrect Treatment of Broken Back Crest

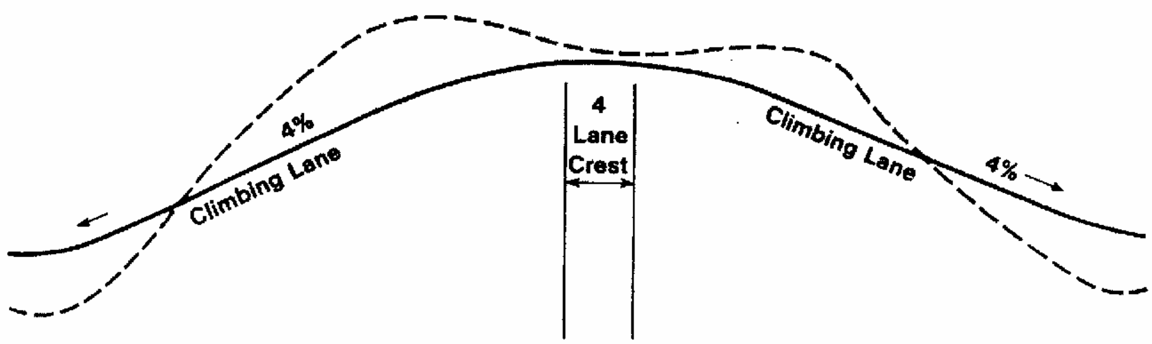


Figure 27b : Possible Treatment of Broken Back Crest

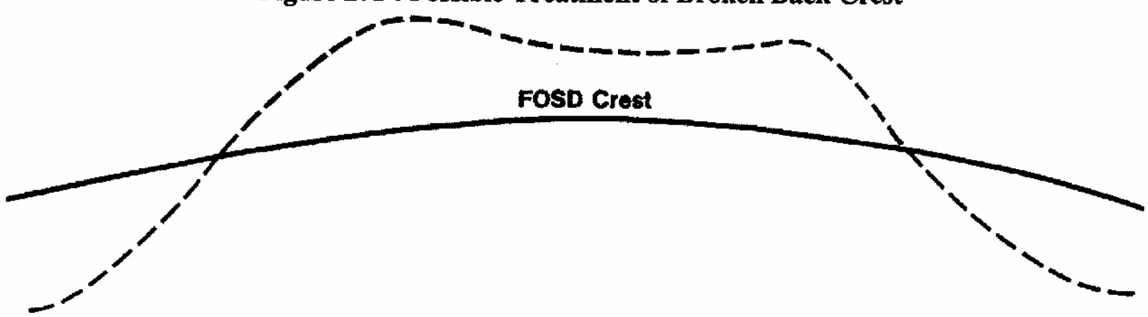
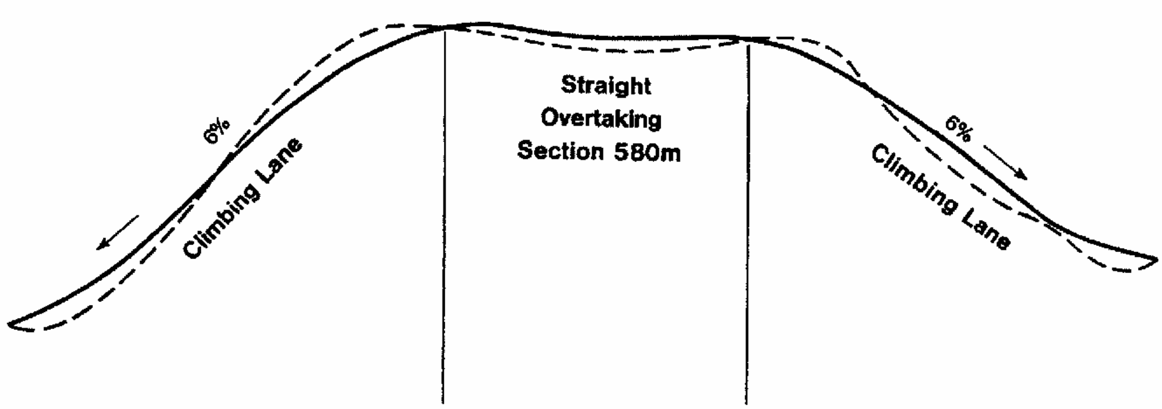


Figure 27a : Incorrect Treatment of Broken Back Crest
Figure 27b : Possible Treatment of Broken Back Crest



6.6 Junction Strategy

6.6.1 The best location for major/minor junctions is on non-overtaking sections in the horizontal sense always subject to visibility requirements being met. The siting of junctions on crest curves is not recommended. (See TD 42 (DMRB 6.2.6) Paragraph 3.6 and Chapter 7, and ADT TD 9 Paragraphs 7.32 to *7.35).*

6.7 Road Markings

6.7.1 The provision of road markings on climbing lanes requires careful consideration. Figure 28, which is looking downhill, shows a section of route marked with a climbing lane which affords excellent visibility for downhill traffic and the continuous/broken line marking as shown is justified. On the other hand Figure 29, which is also looking downhill, should preferably be marked with a double continuous line as soon as FOSD is not available even if DMSSD is, to prevent dangerous downhill overtaking in the left hand bend situation.

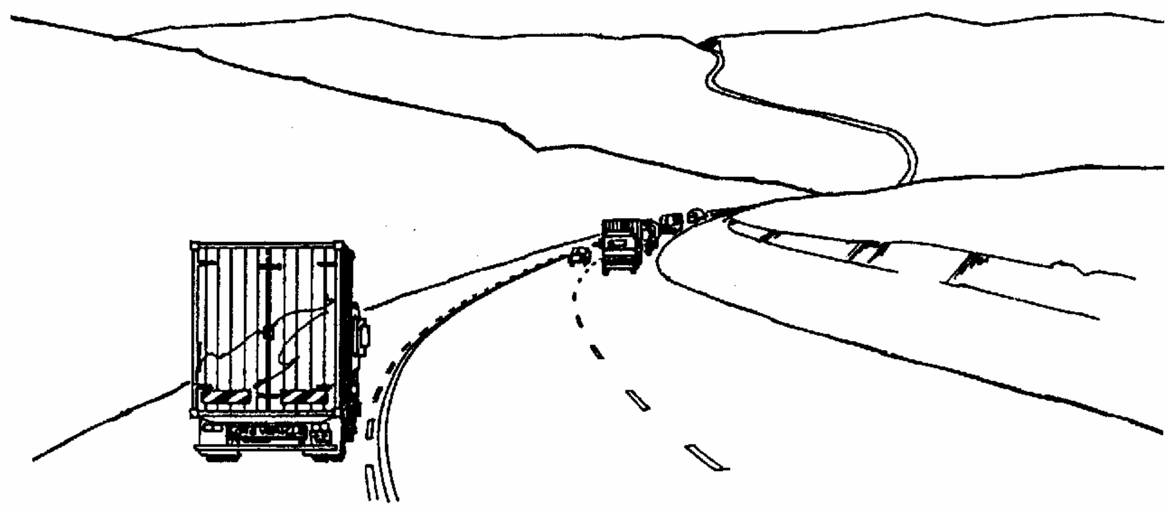


Figure 28 : Climbing Lane with Right Hand Bend Downhill

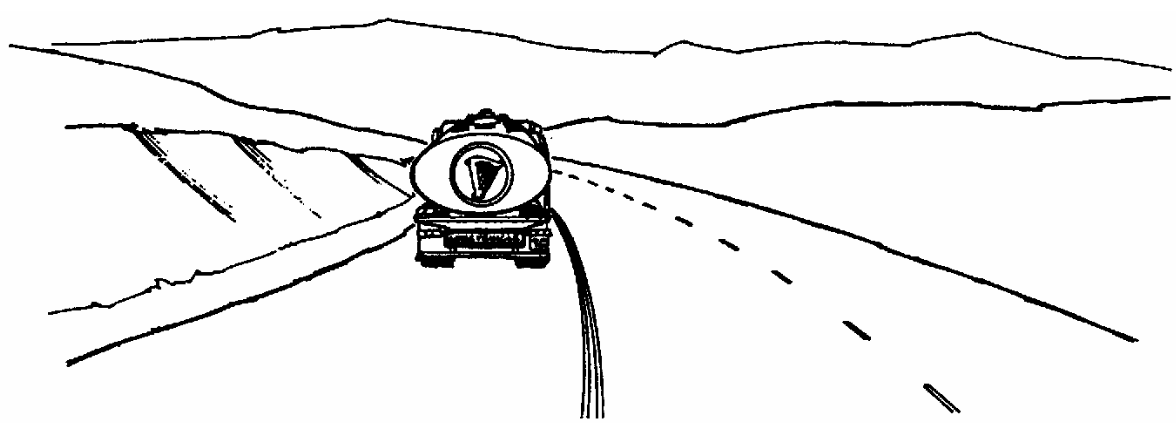


Figure 29 : Climbing Lane with Left Hand Bend Downhill

6.7.2 Figure 30 illustrates another typical danger to be avoided in the use of sections of route marked with climbing lanes, that of an SSD section within a gradient. Given apparently suitable traffic conditions a driver of a vehicle moving downhill and overtaking using the ccntre lane could be in a dangerous situation where an uphill overtaking manoeuvre is simultaneously taking place beyond the crest. The dangerous length should preferably be marked with a double solid white line even with SSD available, and in new design such situations should not be introduced.

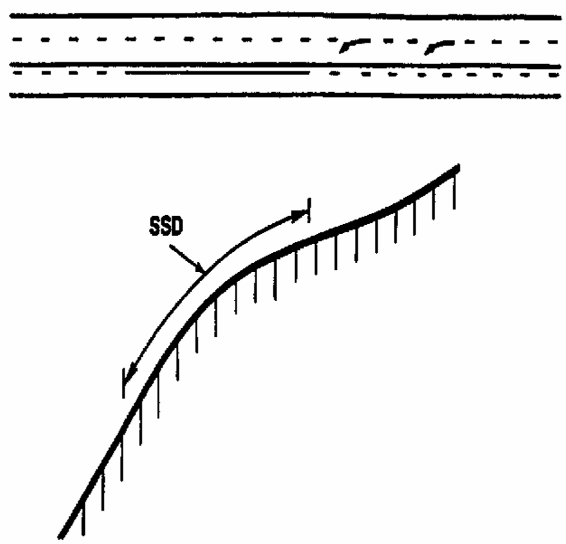


Figure 30 : Climbing Lane Visibility Problem overcome by use of Double Continuous Lines

7. REFERENCES

Design Manual for Roads and Bridges (DMRB):

Volume *5* Assessment and Preparation of Road Schemes
TA22 Vehicle Speed Measurement on All-Purpose Roads (DMRB 5.1.4)

Volume 6 Road Geometry
ADT TD9 Road Link Design (ADT DMRB 6.1.3)
TD 42 Geometric Design of Major/Minor Priority Junctions (DMRB 6.2.6).

Volume 14 Economic Assessment of Road Maintenance.

Halcrow Fox, Effects on Safety of Marginal Design Elements (1981).

Martin and Vorhees, Crawler Lane Study (1976).

Martin and Vorhees, A Study for the Development of an Accident Model for Minor Highway Improvements (1981).

Southampton University, The Effect of Road Curvature on Vehicle/Driver Behaviour (1982).

Transport Research Laboratory Report LR226, TheEffect of Road and Traffic Conditions on Fuel Consumption (1968).

Transport Research Laboratory Report Measurement of Skidding Resistance Guide to the Use of SCRIM (1976).

Transport Research Laboratory (unpublished), A Study of Overtaking on Trunk Road (1978).

Transport Research Laboratory Report SR494, Measurement of the Eye Height of British Car Drivers Above the Road Surface (1979a).

Transport Research Laboratory Reports LF779 and LF780, Speed/Flow Relationships on Rural Motorway and All-Purpose Dual Carriageways (1979b).

Transport Research Laboratory Report LF923 and LF924, Speed/Flow Relationships on Rural Single Carriageways (1980a)

Transport Research Laboratory Report LF925, Changes in Speeds on Rural Roads (1980b).

US highway Research Record 371, Critical Review of Climbing Lane Practices (1971).

8. ENQUIRIES

1.1 All technical enquiries or comments on this Advice Note should be sent in writing to:

Roads Directorate
Sa Maison Road
Floriana
CMR 02

C. Zammit
Director of the Roads Directorate

Volume 6 Cross-Sections and Headroom

Section

Part 2

ADT TD 27/00

ADT Cross-Sections and Headroom

JULY 2003

Malta Transport Authority, Sa Maison Road, Floriana. Tel: 21 248041 Fax: 21 247553

Summary:

This Standard sets out the dimensional requirements for road cross-sections for national roads including motorways. It covers the requirements on the open road and at structures, but not in tunnels. It also gives requirements for headroom at structures.

Note:

The layout and format of this Standard are modelled closely on the UK Highways Agency's Standard TD 27/96. Wherever practicable, paragraph and figure numbering follows that of TD 27/96.

Published by Malta Transport Authority, Floriana 2002

VOLUME 6 ROAD GEOMETRY
SECTION 1 LINKS

PART 2

ADT TD 27/00

CROSS-SECTIONS AND HEADROOM

Contents

Chapter

1. Introduction
2. Design Principle
3. Cross-Sections on Open Roads
4. Cross-Sections at Structures
5. Headroom at Structures
6. References
7. Enquiries

Annex A Cross-Sections for Non-National Roads

1. INTRODUCTION

General

1.1 This Standard outlines the design principles and factors which should be considered by designers in selecting road cross-sections and headroom. The process of design is described together with an approach to developing options.

1.2 (Not used).

Scope

1.3 This Standard gives details of the cross-sections and headroom clearances to be used for national roads, including motorways, both on open roads and at structures.

1.4 This Standard is not applicable to road tunnels.

1.5 For details of pedestrian and cycle subway dimensions see TD 36 (DMRB 6.3.1), for footbridges see BD 29 (DMRB 2.2). Advice on equestrian subways and for agricultural crossings is given in TA 57 (DMRB 6.3).

Implementation

1.5A This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the ADT, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with the Malta Transport Authority.

1.5B For the application of this Standard to side roads which are improved or diverted as part of a national road scheme, see Paragraphs 3.2 and 4.4.

1.6 If this Standard is to be used for the design of local road schemes (non-national roads), the Designer should agree with the relevant Road Authority the extent to which the document is appropriate in any particular situation.

Definitions

1.7 For the definitions of the general road terms used in this Standard such as components of the road (central reserve, verge, hard shoulder, and hard strip, etc.) see BS 6100: Subsection 2.4.1.

1.8 Particular terms used in this Standard are defined as follows:

All-purpose road: - A road for the use of all classes of traffic (e.g. not a motorway).

Bridge Length: - is the length of bridge parapet. Long underbridges are those exceeding l00m.

Bridleway: - Road (surfaced or unsurfaced) for use on foot or horseback.

Central reserve: - The area which separates the carriageways of a dual carriageway road. Note that this <u>includes</u> any offside hard strips.

Connector Road: - A collective term for slip roads, interchange links and loop roads.

Cross-section: -The road cross-section incorporates all elements between the boundaries including carriageways, the central reserve, separation zones, hard shoulders, hard strips, verges including any footway, cycle track or bridleway, cutting or embankment slopes, berms and work space. All dimensions are measured square to the line of the road (see Figures 5 to 7 and Tables 2 to *5).*

Cycle Lane: - A separate part of the carriageway for use by pedal cycles.

Cycle Track: - A separate part of a road for use only by pedal cycles and by pedestrians where permitted.

D2AP: - Dual two-lane all-purpose road (i.e. a dual carriageway with two traffic lanes in each direction).

D2M: - Dual two-lane motorway.

Interchange: - A grade separated junction that provides free flow of traffic from one mainline carriageway to another.

Interchange Link: - Refer to TD 22 (DMRB

6.2.1).

Loops: - Refer to TD 22 (DMRB 6.2.1).

Mainline: - The carriageway carrying the main flow of traffic (generally traffic passing straight though a junction or interchange).

Maintained Headroom: - The minimum headroom which shall be preserved at all times.

New Construction Headroom: - The headroom which includes an allowance for resurfacing.

Overbridge: - A bridge that spans the road under consideration.

Pedestrian Access Provision: - That part of the verge on all-purpose roads provided to enable pedestrian movement though or over a structure.

Road Tunnel: - A road tunnel enclosed for a length of 150m or more. A shorter enclosed length is an overbridge.

Roads: Urban and Rural: - An Urban Road is a road which is in a built-up area and has either a single carriageway with a speed limit of 40mph or less, or has a dual carriageway (including motorways) with a speed limit of 50mph or less. All other roads are Rural Roads.

S2: - Two-lane single carriageway road with lane widths of up to about 3.65m (i.e. a Standard Single Carriageway or a Reduced Single Carriageway).

Slip Road: - Refer to TD 22 (DMRB 6.2.1).

Subway: - Underground passageway or tunnel for use by pedestrians, cyclists and sometimes equestrians.

Underbridge: - A bridge that carries the road under consideration.

Verge: - The part of a road cross-section alongside a carriageway but not including embankment or cutting slopes. Note that this includes any hard strips but <u>not</u> hard shoulders.

Work Space: -The strip of land between the top of cutting or toe of embankment and the road boundary.

WS2: - Two-lane wide single carriageway road, normally with lane widths of 5.Om (i.e. Wide Single Carriageway).

Mandatory Sections

1.9 Sections of this document which form part of the standards the Malta Transport Authority expects in design are highlighted by being contained in boxes. These are the sections with which the Design Organisation must comply or must have agreed a suitable Departure from Standard with the Malta Transport Authority. The remainder of the document contains advice and enlargement which is commended to designers for their consideration.

Relaxations within Standard

1.10 In difficult circumstances, the Designer may relax a standard set out in this document to that relating to the next lowest design speed step. Refer to ADT TD 9 (ADT DMRB 6.1.1). The Designer shall record the fact that a Relaxation has been used in the design and the corresponding reasons for its use. The record shall be endorsed by the Design Organisation's senior engineer responsible for the scheme. The Design Organisation shall report all Relaxations incorporated into the design as part of the project report at the end of each project management phase.

Departures from Standards

1.11 In exceptional situations, the Malta Transport Authority may be prepared to agree to a Departure from Standard where the standard, including permitted Relaxations, is not realistically achievable. Design Organisations faced by such situations and wishing to consider pursuing this course shall discuss any such option at an early stage in design with the Malta Transport Authority. Proposals to adopt Departures from Standard must be submitted by the Design Organisation to the Malta Transport Authority and formal approval received BEFORE incorporation into a design layout.

2. DESIGN PRINCIPLES

General

2.1 This section describes the principles to be followed when designing road cross-sections for new and improved all-purpose national roads and motorways. The underlying principle is that designers are given the maximum choice, so that there is flexibility to develop layout options that will meet the Malta Transport Authority's objectives.

2.2 Designers should balance considerations of safety, environmental impact, cost, buildability of the road elements, operation and maintenance. Where there are options for heights or widths, the selection process should include due consideration of these factors and any other design constraints.

Range of Choice

2.3 The widths of paved elements of the cross-section, i.e. running lanes, hard shoulders and hard strips, vary between different types of road. Dimensions have been selected on the basis of research, experience in Malta, Ireland and the United Kingdom, and comparison with other countries' standards, in order to give new and improved roads that maximise safety and are operationally efficient and cost effective. The designer is not given choices over the widths of running lanes, hard shoulders and hard strips for a particular type of road.

2.4 The designer does, however, have some flexibility over the width of work space, berms, side slopes, verges and central reserves, although a reduction of verge or central reserve width below desirable minimum will require a Relaxation.

2.5 The verge width on either side of the paved area may be a factor affecting the severity of accidents where vehicles run off the carriageway. Research has indicated that only a small proportion of injury accidents, perhaps 2% or 3% in open country, would be avoided if verges were to be doubled in width. Consequently, safety aspects will not normally be a factor when choosing a verge width greater than the desirable width, provided visibility requirements are met. Details of when to provide safety fences or safety barriers in verges and central reserves to protect against collisions between vehicles and roadside objects or features are given in TD 19 (ADT DMRB 2.2).

2.6 The width between the back of the verge and the road boundary will depend on the terrain, the need to accommodate environmental mitigation measures, the engineering or geotechnical measures used to accommodate changes in ground levels, and any need to include differing types and widths of drain and other services in the work space.

Environmental Aspects

2.7 Environmental aspects may affect elements of the cross-section.

Design Process

2.8 For the purposes of developing initial layouts, the designer's objective should be to determine the appropriate width for the road cross-section, and any variation in width required. Features included in the cross-section can affect the choice of width. To assist the designer Table 1 lists features that commonly occur within the road. The table also lists the Standards, Advice Notes and other documents that contain further details. Some features, safety fences for example, can have a significant effect on the cross-section width whilst other features, road signs for example, are usually accommodated within the side slopes and work space.

2.9 The preferred locations for features in verges and the central reserve may often coincide or overlap, and the designer should be aware of the potential for such conflicts. Generally, there is far more below the surface of verges and central reserves than is apparent on the surface, and some underground features must be readily accessible for routine maintenance purposes. Engineering solutions can usually be designed to overcome conflicts where space is limited, but these may increase costs. The sizes and extents of features above and below ground in the verge and central reserve of rural roads can vary widely. Therefore, details are best designed individually for each situation.

Other Features Within the Road Cross-section

2. 10 In addition to the features listed in Table 1, there are other items that frequently occur within the road. A checklist of the most common of these is as follows:

Bridleways
Cycle Tracks
Culverts
Fencing
Footways
Foundations
Geotechnical Monitoring Equipment
Geotextiles
Hardstandings
Landscaping
Communications Equipment
Overbridges
Apparatus of Utility Companies and other Authorities
Subways
Tracks for Equestrians
Underbridges
Weather Monitoring Equipment.

Visibility

2.11 On curved alignments and approaches to junctions, it may be necessary to widen the cross-section, particularly verges and central reserves, to ensure that drivers and other road users can see the appropriate distances, and that the layout meets the visibility requirements. Refer to ADT TD 9 (ADT DMRB 6.1.1).

(Note: Figures 1 to 4 not used).

FEATURE	**STANDARD, ADVICE OR GUIDANCE**	**TITLE**
Agricultural Cattle/Horse Crossings	*TA 56 (DMRB 8.2)*	*Hazardous Cattle Crossings, Use of Flashing Amber Lights*
	TA 57 (DMRB 6.3)	*Roadside Features*
Animal Tunnels		
	HA 59 (DMRB 10.1.5)	*Nature Conservation*
Anti-Dazzle Fences		
	TA 57 (DMRB 6.3)	*Roadside Features*
Arrester Beds		
		Roadside Features
	(RCD)	Road Construction Details (Volume 4 of ADT Manual of Contract Documents for Road Works)
Drains		
	HD33 DMRB 4.2.3	Surface and Sub-surface Drainage Systems for Highways
	HA 37 (DMRB 4.2)	*Hydraulic Design of Road Edge Surface Water Channels*
Footbridges	*BD 29 (DMRB 2.2)*	Design Criteria for Footbridges
Sign/Signal Gantries	*BD 51 (DMRB 2.2.4)*	Design Criteria for Portal and Cantilever Sign/Signal Gantries
Kerbing	(RCD)	Road Construction Details (Volume 4 of ADT Manual of Contract Documents for Road Works)
	TA 57 (DMRB 6.3)	*Roadside Features*
Lay-bys	*TA 69 (DMRB 2.2.1)*	*Location and Layout of Lay-Bys*
Lighting Columns	*BS 5489 Part 1*	Road Lighting: Guide to General Principles
	BD 26 (DMRB 2.2.1)	Design of Lighting Columns
	TD 30 (DMRB 8.3)	Design of Road Lighting for All-Purpose Trunk Roads
	BS5649 / ISEN4O	Lighting Columns
	TD 34 (DMRB 8.3)	Design of Road Lighting for Motorway Trunk Roads

(Continuted)

Table 1 : Features Commonly Occurring in the Road Cross-section

FEATURE	STANDARD, ADVICE OR GUIDANCE	TITLE
Loop Detectors	HD 20 (DMRB 9.3.1)	Loop Detectors for Motorways Road Construction Details
Traffic Control and Communications	(RCD)	Road Construction Details
Delineator Posts	(TSM)	Traffic Signs Manual
Parapets	BS 6779 Parts 1, 2 & 3	Highway parapets for bridges and other structures
	BD 52 (DMRB 2.3.3)	The Design of Highway Bridge Parapets
Pedestrian Guardrails	BS 7818	Specification for Pedestrian Restraint Systems in Metal
	TA 57 (DMRB 6.3)	*Roadside Features*
	BA 48 (DMRB 2.2.2)	*Pedestrian Protection at Headwalls, Wing Walls and Retaining Walls*
Garda Observation Platforms	*TA 66 (DMRB 6.3.2)*	*Police Observation Platforms on Motorways*
Services	(RCD)	Road Construction Details (Volume 4 of ADT Manual of Contract Documents for Road Works)
Signs	(TSM)	Traffic Signs Manual
Slope Strengthening	*HA 44 (DMRB 4.1.1)*	*Earthworks: Design and Preparation of Contract Documents*
Traffic Signals	TD 50 (DMRB 6.2)	The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts
Vehicle Safety Fences/ Safety Barriers	TD 19 (DMRB 2.2)	Safety Fences and Barriers

Table 1 : Features Commonly Occurring in the Road Cross-section (Continued)

3. CROSS-SECTIONS ON OPEN ROADS

General

3.1 Figures 5 to 12 show the locations of the elements within the road cross-section and Tables 2 to 5 give detailed dimensions for each element. The information covers most types of national road, including rural motorways, rural all-purpose roads, urban motorways and urban all-purpose dual carriageway roads, together with associated interchange links, loops and on and off slip roads.

3.1A Wide Dual Carriageway and Wide Motorway cross-sections will normally be used only where adjacent lengths of road are of equivalent cross-section. The use of these cross-sections shall be agreed with the Maltese Transport Authority in each case.

3.2 The cross-section of a side road, which is not a national road and is diverted or improved on-line as part of a national road scheme, should be agreed with the Maltese Transport Authority and the relevant Road Authority. A suggested cross-section is illustrated in Annex A.

Pavement Width

3.3 The width of the paved elements of the cross-section, i.e. carriageways, hard shoulders and hard strips, shall normally be in accordance with the requirements of this Standard. Any reduction or increase in the width of these elements is a Departure from Standard, unless the increase results from the requirements of Paragraph 3.6.

Traffic Lane Widths

3.4 Traffic lane widths shall be as detailed in Figures 5 to 7.

3.5 Information on the start and finish of climbing lanes incorporated into single and dual carriageway roads can be found in ADT TD 9 (ADT DMRB 6.1.1).

3.6 Traffic lanes shall be widened on curves of low radius to allow for the swept path of long vehicles. See ADT TD 9 (ADT DMRB 6.1.1) and TD 42 (DMRB 6.2.6).

Changes of Carriageway Edge Treatment

3.7 Where slip roads, interchange links and loop roads join or leave main carriageways, the edge detail may change from hard shoulder to hard strip or carriageway edge.

3.8 Transitions between different edge details should take place over the length of the taper.

3.9 (Not used).

3.10 See TD 22 (DMRB 6.2.1) for layouts of merges and diverges.

Work Space, Side Slope, Verge and Central Reserve Widths

3.11 Work space and side slope widths should be chosen to match the local situation. For verges and central reserves, however, the widths given in Tables 2 to 5 should be the first option considered, although other dimensions may be used in circumstances where this would be preferable. These circumstances might range from a need to minimise land take to a requirement to accommodate a large amount of equipment and features in a location where land is not so limited.

3.12 The use of a verge or central reserve width greater than the desirable width is not a Relaxation or Departure. Reference should be made to TD 42 (DMRB 6.2.6) for guidance on widening the central reserve at major/minor junctions on dual carriageway all-purpose roads.

3.13 There may be benefits in using dimensions less than the desirable widths for verges or central reserves, and these cases shall be regarded as Relaxations. The requirements of other Standards may limit the scope for width reductions. For example, space may be needed for roadside features and the safety fences to protect them.

3.14 Variations of verge and central reserve widths in close succession should be avoided. The designer should consider how the scheme will integrate with adjacent highway sections and the route as a whole.

3.15 Provision for pedestrians and cyclists should be made were a local need has been identified. The width and location of such provision should have the agreement of both the local Road Authority and the Maltese Transport Authority.

Urban Areas

3.16 All purpose roads in urban areas should be provided with raised verges and footways with the widths given in Table 1A.

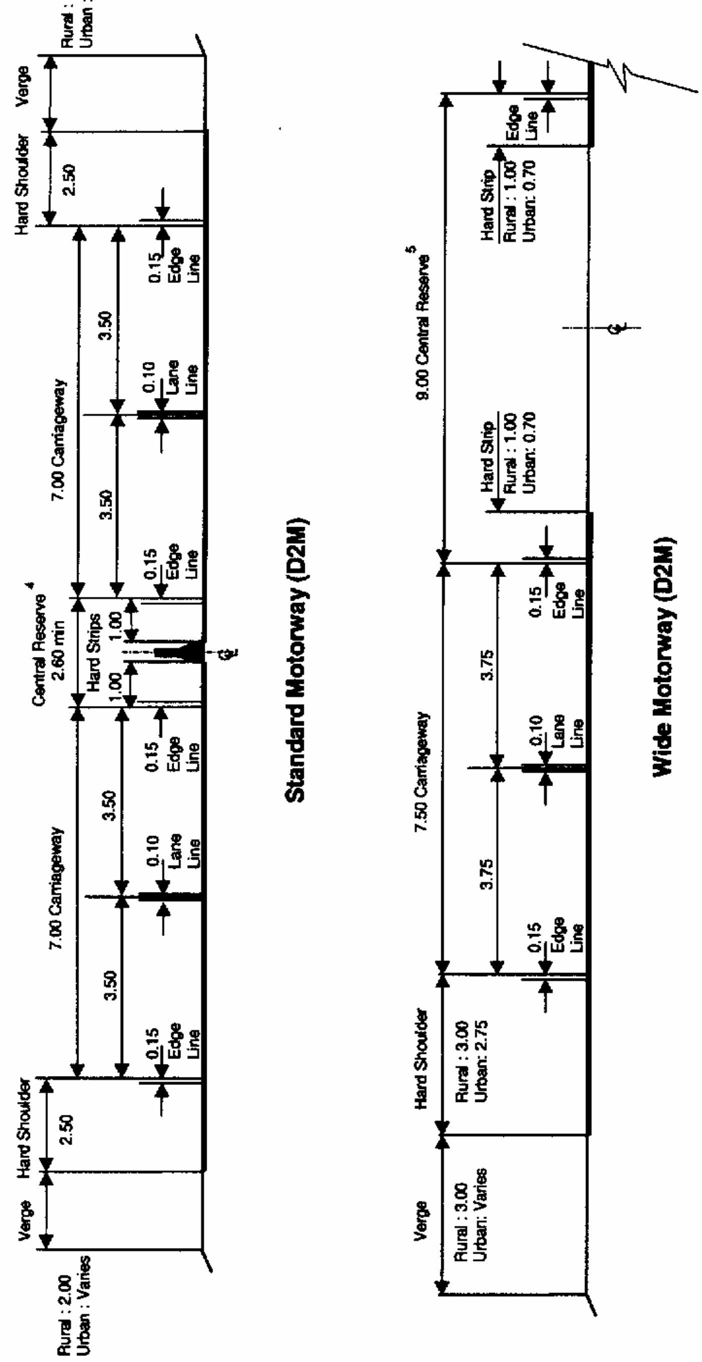
3.17 In urban areas there may be numerous items of street furniture within the highway cross-section.

3.18 See ADT TD 9 (ADT DMRB 6.1.1) and Roads and Traffic in Urban Areas for further advice on designing urban single and dual carriageway roads.

Pedestrian Usage	Overall Verge Width	Footway Width
Regular Occasional	3.00m min 2.50m min	1.30m min 1.50m min

Note: Regular Usage occurs where there is a clearly defined local need with a predicted maximum flow 25 or more pedestrians per hour, or footways are provided on contiguous sections.

Table 1A : Verge and Footway Widths on Urban Roads

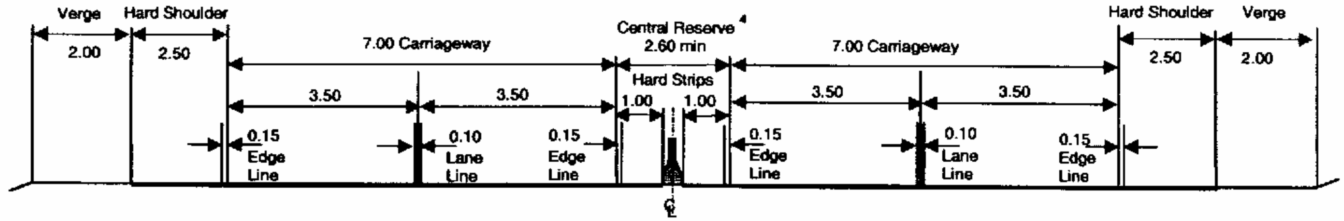


Notes

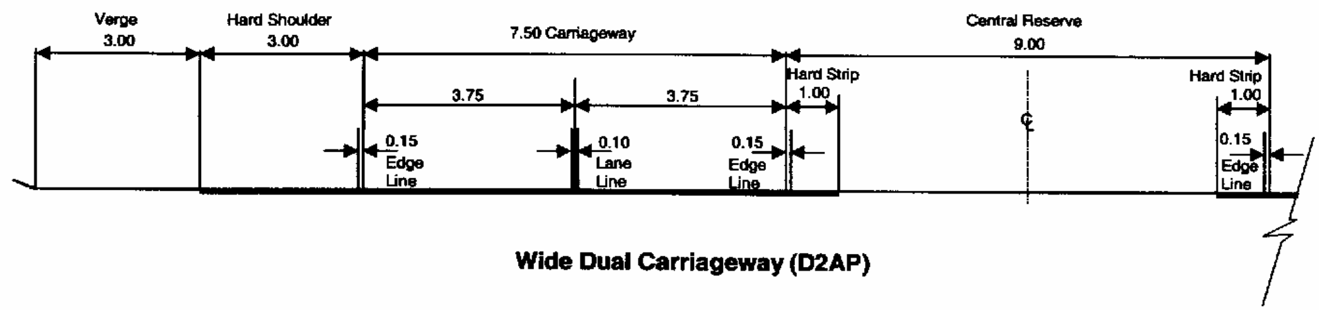
1. All dimensions are in metres.
2. See Tables 2 and 4 for dimensions of cross-section elements.
3. For details of road markings see the Traffic Signs Manual.
4. Width of central reserve for a Standard Motorway is determined by the type of safety fence or barrier: see TD 19 (DMRB 2.2). It is suggested that a width of 3.00m be assumed for preliminary designs.
5. Central reserve for a wide Motorway is 16.00m wide where provision is made for future widening to dual three lanes.

FIGURE 5

LANE WIDTHS AND CARRIAGEWAY MARKINGS: RURAL AND URBAN MOTORWAYS (MAINLINE)



Standard Dual Carriageway (D2AP)



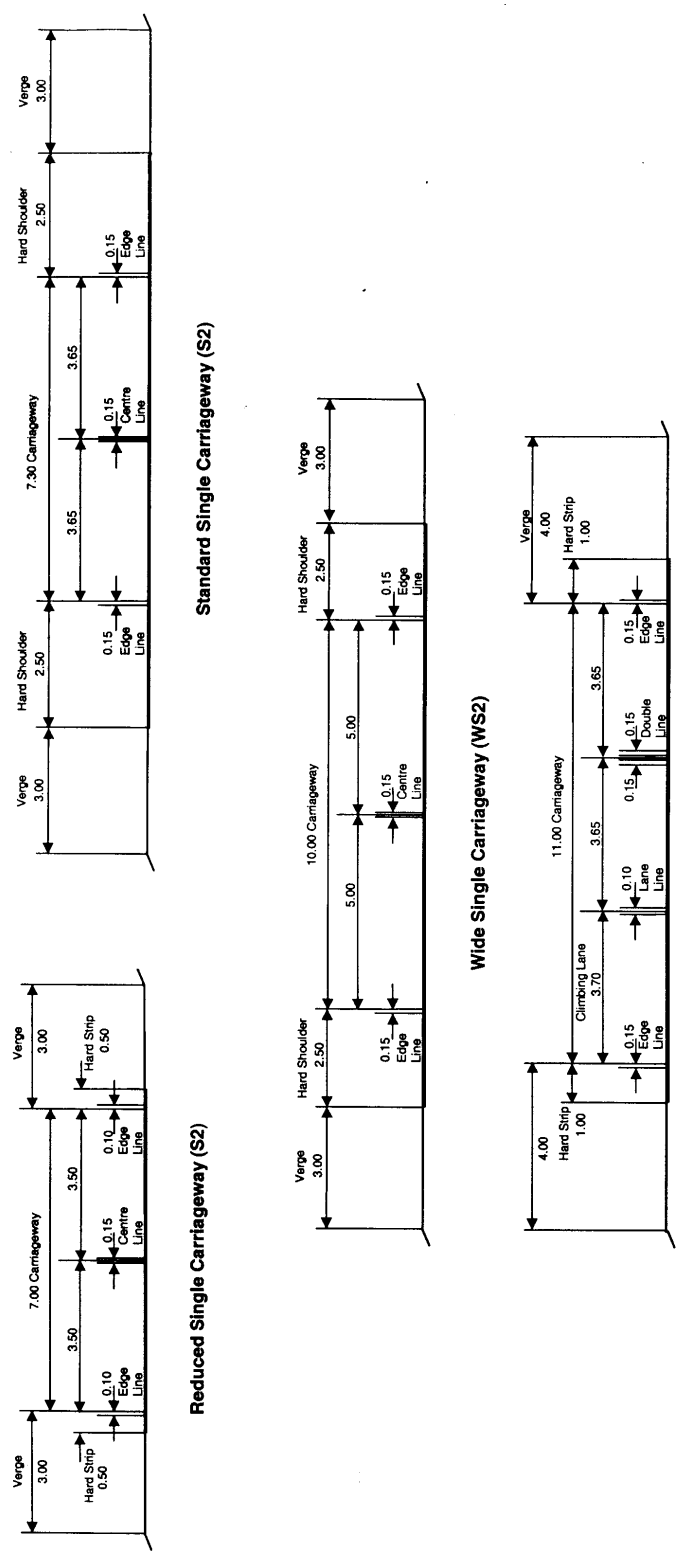
Wide Dual Carriageway (D2AP)

Notes

1. All dimensions are in metres.
2. See Table 3 for dimensions of cross-section elements
3. For details of road markings see the Traffic Signs Manual.
4. Width of central reserve for a Standard Dual Carriageway is determined by the type of safety fence or barrier: see TD 19 (DMRB 2.2). It is suggested that a width of 3.00m be assumed for preliminary designs.

FIGURE 6

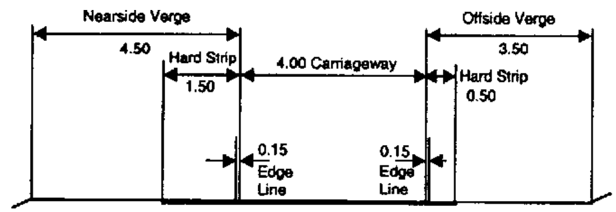
LANE WIDTHS AND CARRIAGEWAY MARKINGS: RURAL ALL-PURPOSE ROADS (MAINLINE)



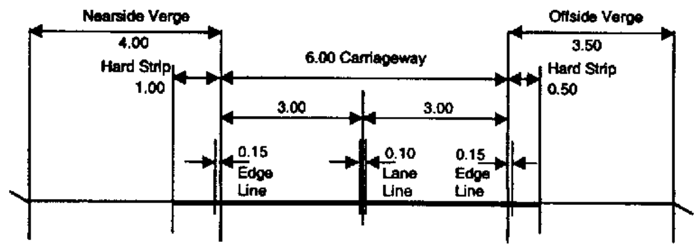
Notes

1. All dimensions are in metres.
2. See Table 3 for dimensions of cross-section elements
3. For details of road markings see the Traffic Signs Manual.
4. For lane widths of climbing lane sections on WS2 and reduced S2 see MTA TD9 (MTA DMRB 6.1.1).

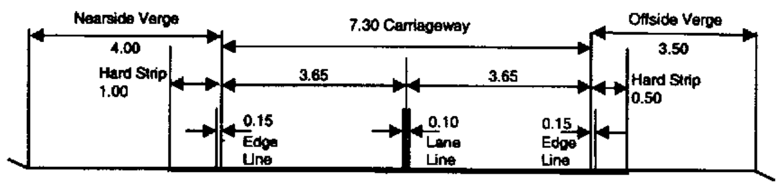
FIGURE 6A
LANE WIDTHS AND CARRIAGEWAY MARKINGS:
RURAL ALL-PURPOSE ROADS (MAINLINE)



Slip Roads, Interchange Links and Loops : 1 Lane



Diverge Slip Roads Only : 2 Lane



Slip Roads, Interchange Links And Loops : 2 Lane

FIGURE 7

LANE WIDTHS AND CARRIAGEWAY MARKINGS: RURAL MOTORWAY AND ALL-PURPOSE SLIP ROADS, INTERCHANGE LINKS AND LOOPS

Notes

1. All dimensions are in metres.
2. See Tables 2 and 3 for dimensions of cross-section elements.
3. For details of road markings see the Traffic Signs Manual.

Table 2
Dimensions of Cross-Section Elements for
Rural Motorways
Including Slip Roads, Interchange Links and Loops

	Nearside				Offside		
	Verge [1,4]	**Hard Strip** [2]	**Hard Shoulder**[2]	**Carriageway**[2]	**Hard Strip**[2]	**Verge**[1,4]	**Central Reserve**[1,4]
MAINLINES							
Standard Motorway (D2M)	2.00		2.50	7.00	1.00	-	2.60 min[5]
Wide Motorway (D2M)	3.00	-	3.00	7.50	1.00	-[3]	9.00
Wide Motorway (D2M) (with provision for extra lane)	3.00	-	3.00	7.50	1.00	-[3]	16.00
SLIP ROADS, INTERCHANGE LINKS AND LOOPS: MERGES AND DIVERGES							
1 Lane	4.50	1.50	-	4.00	0.50	3.50	-
2 Lane	4.00	1.00	-	7.30	0.50	3.50	-
SLIP ROADS: DIVERGE ONLY							
2 Lane	4.00	1.00	-	6.00	0.50	3.50	-

Notes:

1. Verge and central reserve dimensions are desirable values: any reduction is a Relaxation.
2. Carriageway, hard shoulder and hard strip dimensions are fixed values: any alternative is a Departure.
3. For details of offside verges at divided structures, see Paragraph 4.12 and Table 6.
4. Where a hard strip is present, the corresponding verge or central reserve dimension <u>includes</u> the hard strip. However, where a hard shoulder is present, the corresponding verge dimension <u>does not</u> include the hard shoulder.
5. Width of central reserve on Standard Motorway is determined by the type of safety fence or barrier. See TD 19 (DMRB 2.2). It is suggested that a width of 3.00m be assumed for preliminary designs.
6. For guidance on selection of slip roads and interchange link and loop roads, see TD 22 (DMRB 6.2.1).
7. All dimensions are in metres.

Table 3
Dimensions of Cross-Section Elements for
Rural All-Purpose Roads
Including Slip Roads, Interchange Links and Loops

	Nearside				Offside		
	Verge [1,4]	**Hard Strip [2]**	**Hard Shoulder[2]**	**Carriageway[2]**	**Hard Strip[2]**	**Verge[1,4]**	**Central Reserve[1,4]**
MAINLINES							
Reduced Single (S2)	3.00	0.50	-	7.00	-	-	-
Standard Single (S2)	3.00	-	2.50	7.30	-	-	-
Wide Single (WS2)	3.00	-	2.50	10.00	-	-	-
Standard Dual Carriageway (D2AP)	2.00	-	2.50	7.00	1.00	-[3]	2.60 min[5]
Wide Dual Carriageway (D2AP)	3.00	-	3.00	7.50	1.00	-[3]	9.00
SLIP ROADS, INTERCHANGE LINKS AND LOOPS: MERGES AND DIVERGES							
1 Lane	4.50	1.50	-	4.00	0.50	3.50	-
2 Lane	4.00	1.00	-	7.30	0.50	3.50	-
SLIP ROADS: DIVERGE ONLY							
2 Lane	4.00	1.00	-	6.00	0.50	3.50	-

Notes:

1. Verge and central reserve dimensions are desirable values: any reduction is a Relaxation.
2. Carriageway, hard shoulder and hard strip dimensions are fixed values: any alternative is a Departure.
3. For details of offside verges at divided structures, see Paragraph 4.12 and Table 6.
4. Where a hard strip is present, the corresponding verge or central reserve dimension includes the hard strip. However, where a hard shoulder is present, the corresponding verge dimension does not include the hard shoulder.
5. Width of central reserve on Standard Dual Carriageway is determined by the type of safety fence or barrier. See TD 19 (DMRB 2.2). It is suggested that a width of 3.00m be assumed for preliminary designs.
6. For guidance on selection of slip roads and interchange link and loop roads, see TD 22 (DMRB 6.2.1).
7. All dimensions are in metres.

Table 4
Dimensions of Cross-Section Elements for
Urban Motorways
Including Slip Roads, Interchange Links and Loops

	Nearside				Offside		
Motorways up to 80km/h Design Speed	**Verge**	**Hard Strip** [2]	**Hard Shoulder** [2]	**Carriageway** [2]	**Hard Strip** [2]	**Verge**	**Central Reserve** [1,4]
MAINLINES Standard Motorway (D2UM)	Varies	-	2.50 [3]	7.00	1.00	- [6]	2.60 min [5]
SLIP ROADS, INTERCHANGE LINKS AND LOOPS: MERGES AND DIVERGES							
1 Lane	Varies	1.50	-	4.00	0.50	Varies	-
2 Lane	Varies	1.00	-	7.30	0.50	Varies	-
SLIP ROADS: DIVERGE ONLY							
2 Lane	Varies	1.00	-	6.00	0.50	Varies	-

Notes:

1. Central reserve dimensions are desirable values: any reduction is a Relaxation.
2. Carriageway and hard strip dimensions are fixed values: any alternative is a Departure.
3. In difficult and restricted areas, where due consideration has been given to the maintenance requirements, the hard shoulder width may exceptionally be Relaxed to 2.0m. Any other changes of width are a Departure.
4. The central reserve dimension includes the offside hard strip.
5. Width of central reserve is determined by the type of safety fence or barrier. See TD 19 (DMRB 2.2). It is suggested that a width of 3.00m be assumed for preliminary designs.
6. For details of offside verges at divided structures, see Paragraph 4.12 and Table 6.
7. For guidance on selection of slip roads and interchange link and loop roads, see TD 22 (DMRB 6.2.1).
8. All dimensions are in metres.

Table 5
Dimensions of Cross-Section Elements for
Urban All-Purpose Dual Carriageway Roads
Including Slip Roads, Interchange Links and Loops

	Nearside				Offside		
All-Purpose Roads Up to 80km/h	**Verge[3]**	**Hard Strip[2]**	**Hard Shoulder[2]**	**Carriageway[2]**	**Hard Strip[2]**	**Verge[3]**	**Central Reserve[1]**
MAINLINES							
Dual 2 Lane (D2AP)							
With CR Lighting Cols	Varies	-	-	7.50	-	-[4]	2.60
No CR Lighting Cols	Varies	-	-	7.50	-	-[4]	1.80
Dual 3 Lane (D3AP)							
With CR Lighting Cols	Varies	-	-	11.25	-	-[4]	2.60
No CR Lighting Cols	Varies	-	-	11.25	-	-[4]	1.80
SLIP ROADS, INTERCHANGE LINKS AND LOOPS: MERGES AND DIVERGES							
1 Lane	Varies	1.50	-	4.00	0.50	Varies	-
2 Lane	Varies	1.00	-	7.30	-	Varies	-
SLIP ROADS: DIVERGE ONLY							
2 Lane	Varies	1.00	-	6.00	-	Varies	-

Notes:
1. Central reserve dimensions are desirable values: any reduction is a Relaxation.
2. Carriageway, hard shoulder and hard strip dimensions are fixed values: any alternative is a Departure.
3. Verge width shall be determined to take account of the uses and clearances required. See also Table 1A.
4. For details of offside verges at divided structures, see Paragraph 4.12 and Table 6.
5. For guidance on selection of slip roads and interchange link and loop roads, see TD 22 (DMRB 6.2.1).
6. All dimensions are in metres.

4. CROSS-SECTIONS AT STRUCTURES

General

4.1 The cross-sections detailed in Figures 8 to 12 and Table 6 assume a straight horizontal alignment of the carriageway. If this is not the case the verges and central reserve may require widening to give the stopping sight distances required in accordance with ADT TD 9 (ADT DMRB 6.1.1).

4.2 Variations of cross-section provision at bridges in close succession shall be avoided except where sight distance requirements dictate otherwise. The verge and central reserve widths appropriate for the longest structure shall be used. Individual cases shall be treated on their merits.

4.3 The requirements of this Standard are not applicable to road tunnels.

Non-National Side Roads

4.4 The cross-section at a structure of a side road, which is not a national road and is diverted or improved on-line as part of a national road scheme, should .be agreed with the Maltese Transport Authority and the relevant Road Authority. See Annex A for general guidance.

Traffic Lane Widths

4.5 Lane widths shall be maintained though or over a structures.

4.6 (Not used).

Hard Shoulders and Hard Strips

4.7 Where hard shoulders or hard strips are provided adjacent to the edges of the carriageway they shall be continued at the same width though or over the structure.

Central Reserves

4.8 The width of central reserve applicable to the adjacent open road section should be continued though or over the structure, except in the case of long underbridges, where the width may be reduced to a minimum of 2.6m.

Verges at Underbridges and Overbridges

4.9 In planning the overall width required, consideration should be given to the space necessary for structural elements of the bridge, including: foundations, items such as bridge joints, drainage runs, electrical equipment and services, and safety fences or safety barriers. Consideration should also be given to maintenance operation needs.

4.10 On all-purpose road overbridges, underbridges, elevated roads and viaducts, the nearside verge will need to provide a clear width for pedestrian access. The width can be varied depending upon the overall length of the structure and the likely pedestrian flows as indicated in Paragraphs 4.1OA to 4.13C. Provision may also need to be made for pedal cyclists.

4. 10A **Regular** pedestrian usage on an all-purpose road occurs where there is a clearly defined local need with a predicted maximum flow of more than 25 pedestrians per hour and/or footways are provided, or are to be provided, on contiguous sections of road. Occasional pedestrian usage occurs at other locations.

4.11 Verge widths may need to be increased to allow adequate visibility, particularly where a bridge is located on a horizontal curve.

Verges at Underbridges

4.12 On underbridges the part of the verge adjacent to the bridge parapet shall be raised with a maximum kerb height of *75mm.* The widths given in Table 6 for the raised verge should be the first option considered. Any reduction in width shall be regarded as a Relaxation.

Road Type	Location	Pedestrian Usage (see Paragraph 4.10A)	Bridge Length M	Raised Verge Width m
Motorway	Nearside Offside	- -	All All	0.60 0.60
All-Purpose Road	Nearside	Regular Regular Occasional	<100 >100 All	2.00 1.50 1.50
	Offside	All		0.6

Table 6 : Verge Widths at Underbridges

Verges at Overbridges

4.13 At overbridges the verge width shall be not less than 2.Om and shall also comply with the following arrangements where applicable.

4.13A At overbridges where an abutment is adjacent to the carriageway:

a) the distance from the edge of road pavement to the face of the abutment shall be not less than 4.50m.

b) where there is regular pedestrian usage, a paved footway of 1.65m minimum clear width shall be provided on the nearside verge behind any safety fence.

4.13B At overbridges where a pier is adjacent to the carriageway:

a) the distance from the edge of road pavement to the face of the pier shall be determined to suit the safety fence setback and working width. Working width is the distance from the traffic face of the safety fence to the maximum dynamic deflected position of the fence after impact.

b) where there is regular pedestrian usage, a paved footway of b.65m minimum clear width shall be provided on the nearside though the span away from the main carriageway. In cuttings it may be necessary to introduce a small retaining wall alongside the footway, to avoid the need to widen the cutting.

4.13C Provision may also be needed for pedal cyclists, in which case this should normally be located alongside the footway.

Safety Fences, Safety Barriers and Bridge Parapets

4.14 Safety fences, safety barriers and bridge parapets shall be positioned in accordance with the requirements of TD 19 (DMRB 2.2) and BD 52 (DMRB 2.3.3).

(Table 7 not used).

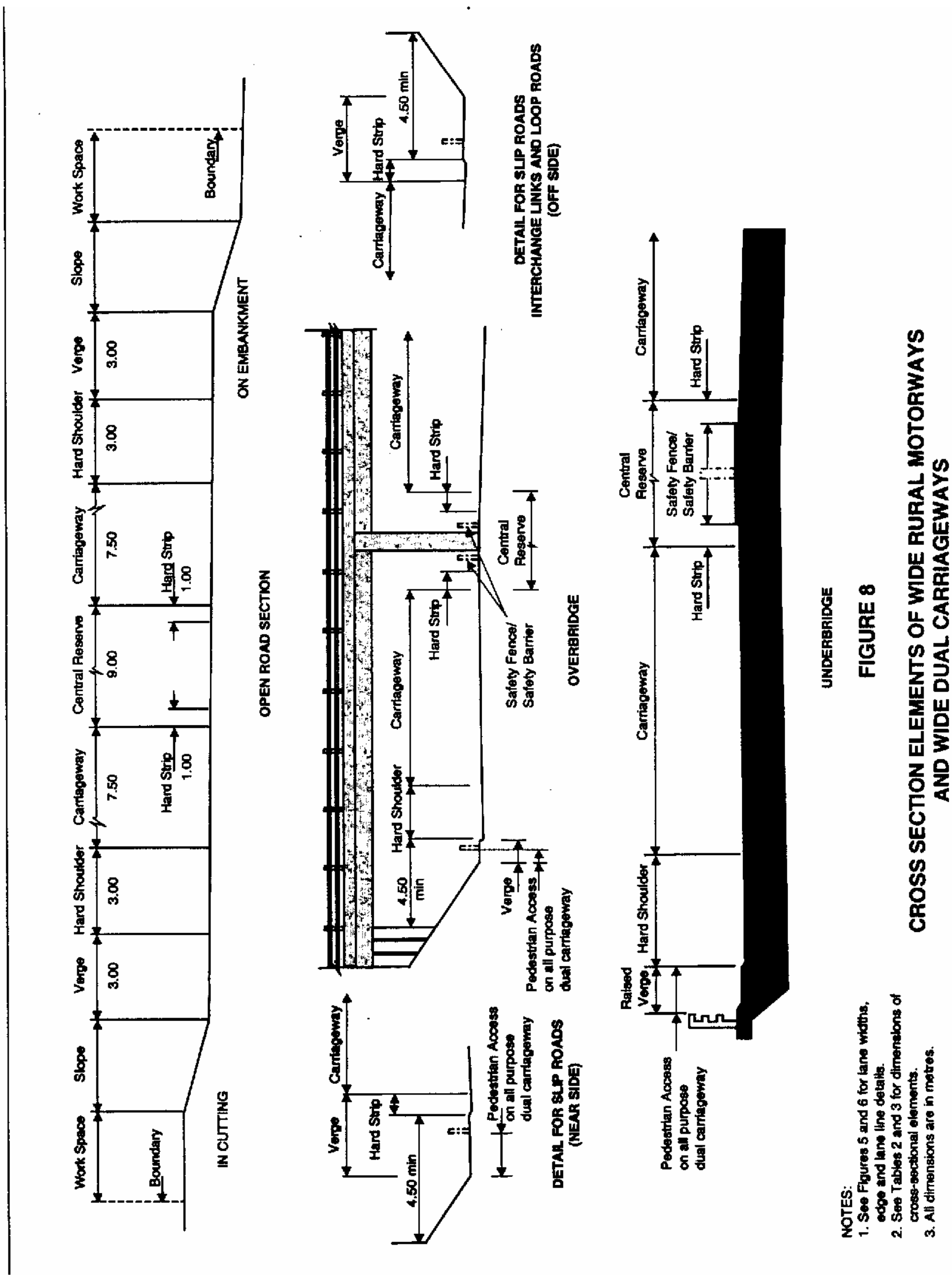


FIGURE 8

CROSS SECTION ELEMENTS OF WIDE RURAL MOTORWAYS AND WIDE DUAL CARRIAGEWAYS

NOTES:
1. See Figures 5 and 6 for lane widths, edge and lane line details.
2. See Tables 2 and 3 for dimensions of cross-sectional elements.
3. All dimensions are in metres.

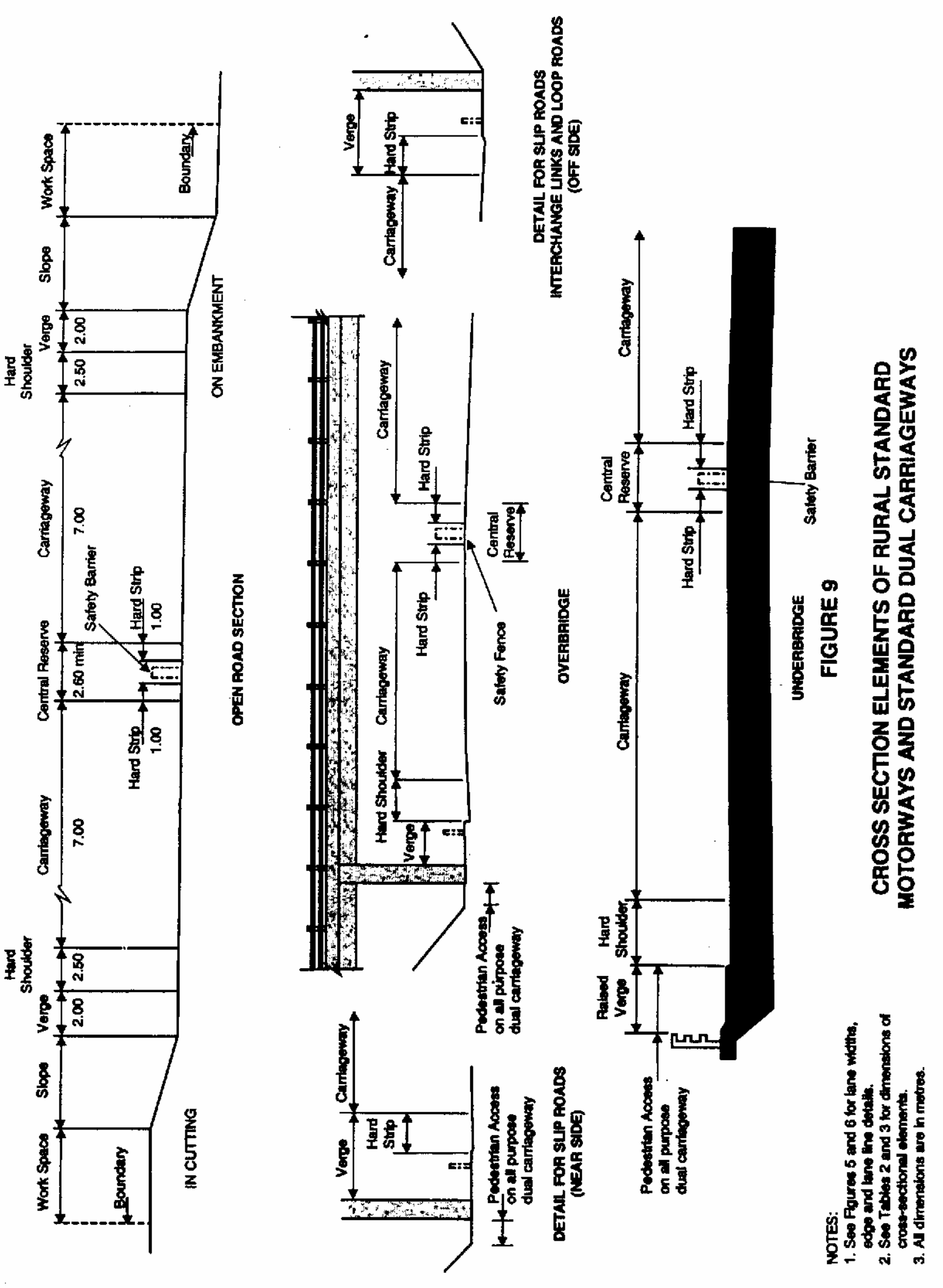


FIGURE 9

CROSS SECTION ELEMENTS OF RURAL STANDARD MOTORWAYS AND STANDARD DUAL CARRIAGEWAYS

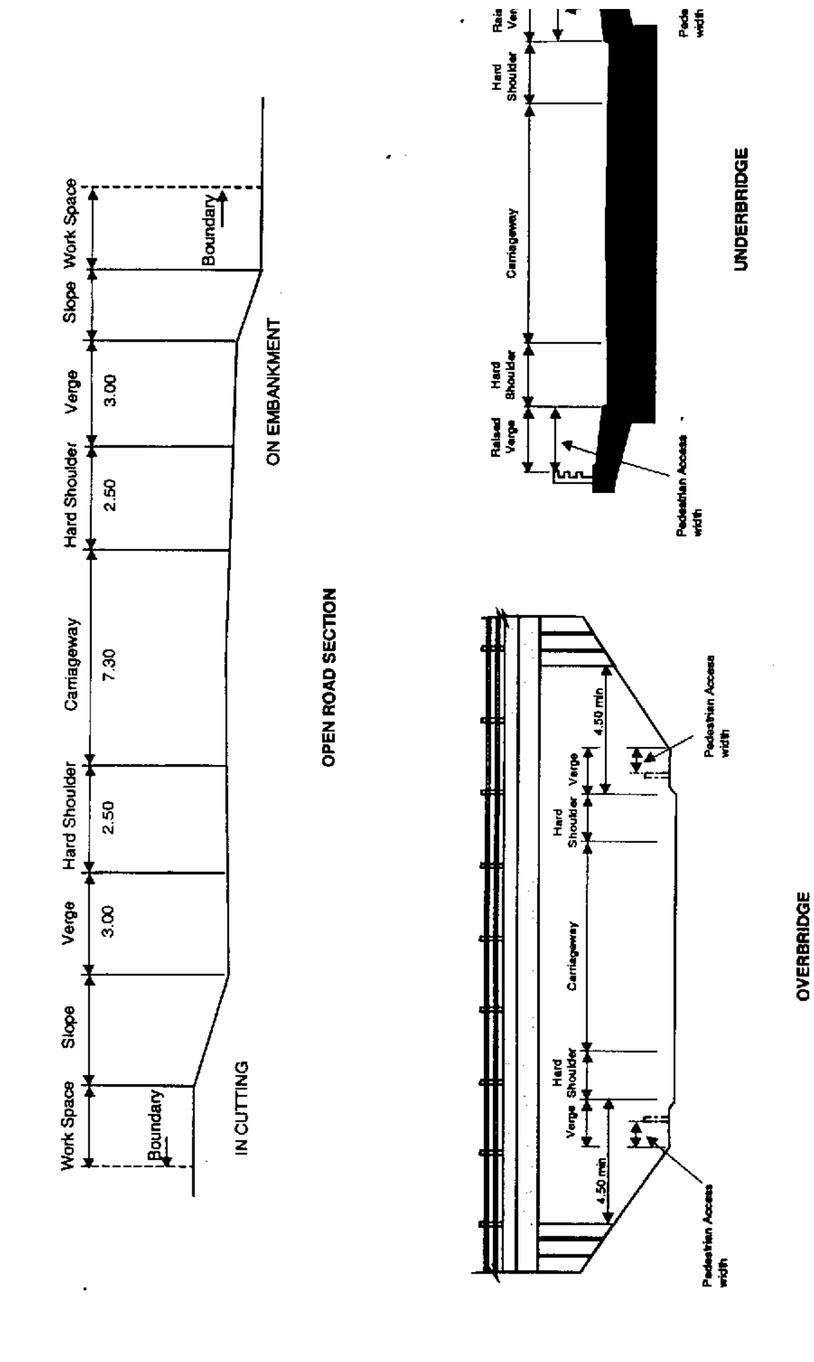
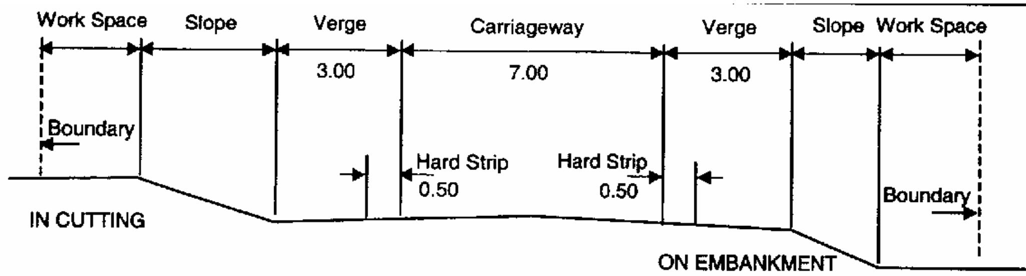


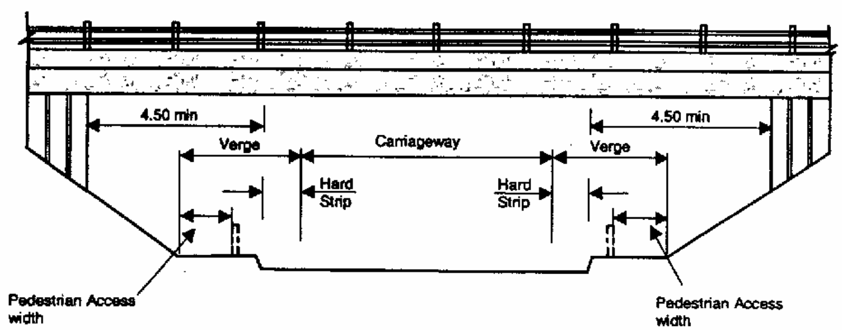
FIGURE 10

CROSS SECTION ELEMENTS OF RURAL STANDARD SINGLE CARRIAGEWAY ROADS

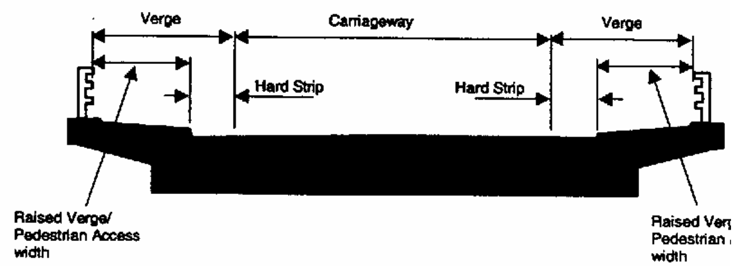
NOTES:
1. See Figure 6A for lane widths, edge and lane line details.
2. See Table 3 for dimensions of cross-sectional elements.
3. All dimensions are in metres.



OPEN ROAD SECTION



OVERBRIDGE



UNDERBRIDGE

NOTES:
1. See Figure 6A for lane widths, edge and lane line details.
2. See Table 3 for dimensions of cross-sectional elements.
3. All dimensions are in metres.

FIGURE 10A

CROSS SECTION ELEMENTS OF RURAL REDUCED SINGLE CARRIAGEWAY ROADS

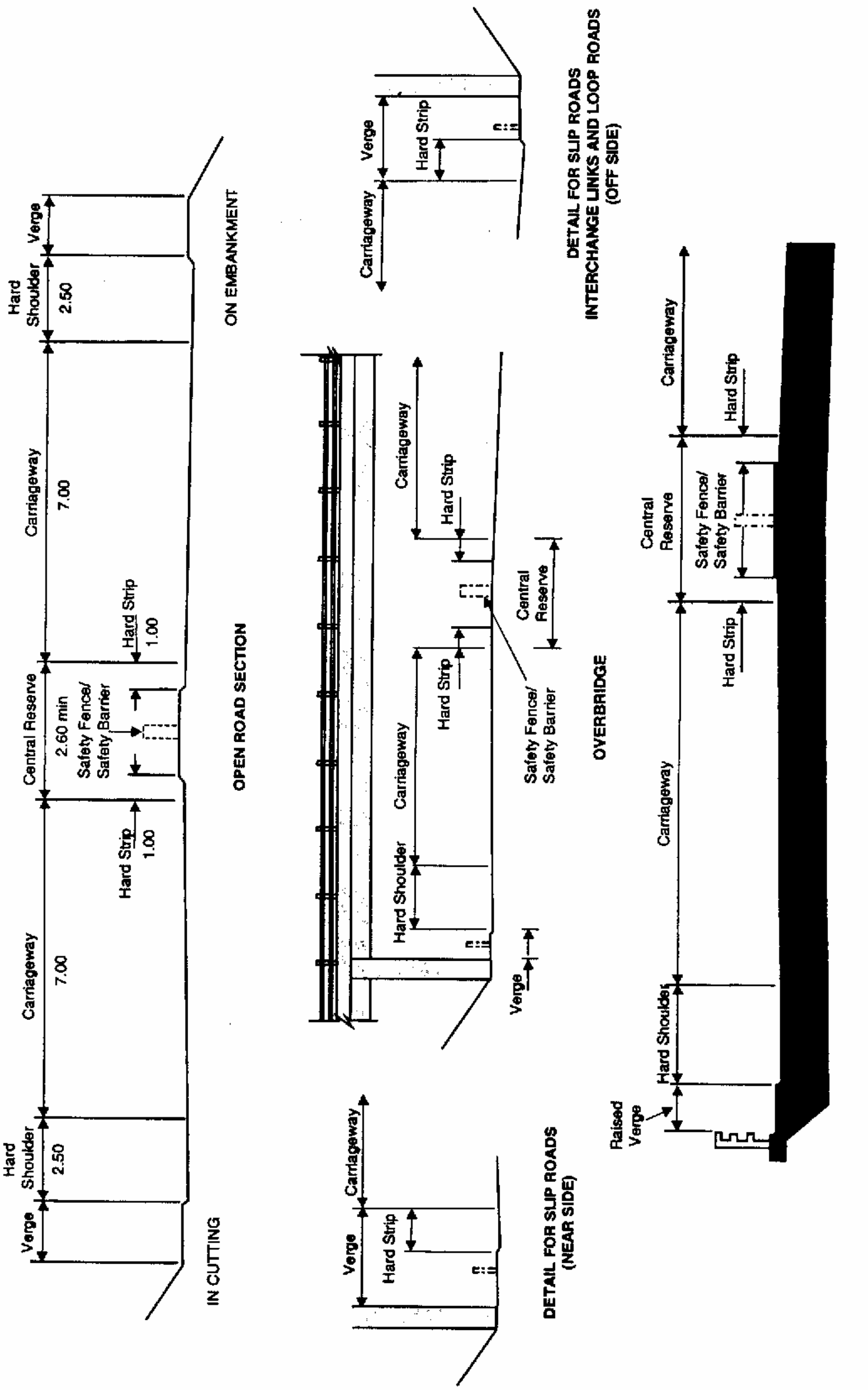


FIGURE 11

CROSS SECTION ELEMENTS OF URBAN MOTORWAYS
(Up to 80kph Design Speed)

NOTES:
1. See Figure 5 for lane widths, edge and lane line details.
2. See Table 4 for dimensions of cross-sectional elements.
3. All dimensions are in metres.

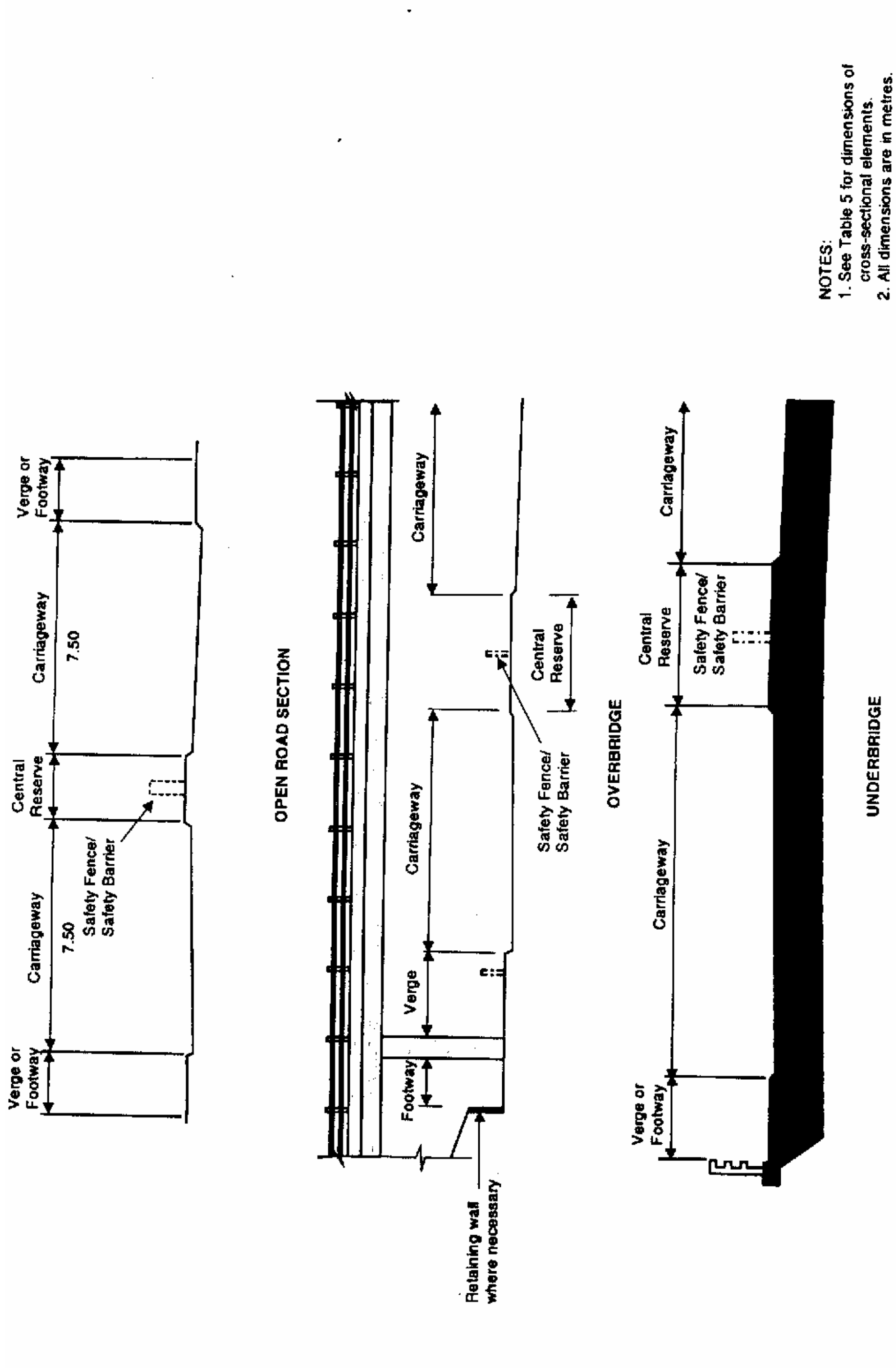


FIGURE 12

CROSS SECTION ELEMENTS OF URBAN ALL-PURPOSE DUAL CARRIAGEWAY ROADS

5. HEADROOM AT STRUCTURES

General

5.1 Dimensional standards are given in Table 8 for "new construction headroom"and "maintained headroom" at overbridges and at other structures over a road.

Type of Structure	New construction headroom (m)	Maintained Headroom (m)
Overbridges	5.30	5.03
Footbridges and Sign/Signal Gantries	5.70	5.41
Free Standing Temporary Structures	N/A	5.41
All Permanent Structures over High Load Routes	6.45	6.18

Table 8: Standard Headroom At Structures

5.2 The headroom provision at underbridges shall be agreed with the relevant Road, or Water Authority.

5.3 The headrooms given are the minimum; where it is economical and/or environmentally acceptable, greater headroom should be provided.

5.4 The requirements of this standard are not applicable to road tunnels.

Dimensional Requirements

5.5 Headroom shall be measured at right-angles to the surfaces of the carriageway, hard shoulder, hard strip, verge or central reserve, at the point where it is a minimum.

5.6 The relevant standard headroom in Table 8 shall be provided:

(a) Over the paved carriageway, hard shoulder or hard strip;

(b) Over the full verge width, except where (e) applies;

(c) Over the central reserve of a dual carriageway, except where (e) applies;

(d) Between the carriageway and the pier or abutment face where such a support is located within *4.5m* of the edge of the road pavement, except where (e) applies;

(e) Up to the back of the working width of a safety fence, when installed (see Figure 13). The working width is the distance from the traffic face of the safety fence to the maximum deflected position of the fence after impact.

5.7 The headroom to be provided at a structure on a "high load route" shall be as given in Table 8.

5.8 The headroom standards for pedestrian subways and combined pedestrian/cycle subways are contained in TD 36 (DMRB 6.3.1). Guidance on the headroom requirement for equestrian usage is contained in TA 57 (DMRB 6.3).

5.9 (Not used.)

Compensation for Vertical Sag Curvature and Deflection

5.10 Where the road passing underneath a structure is on a sag curve, the headrooms in Table 8 shall be increased in accordance with Table 9. The sag radius is measured along the carriageway over a 25m chord.

Sag Radius (m)	Additional Clearance (mm)
1000	80
1200	70
1500	55
2000	45
3000	25
6000	25
> 6000	nil

Table 9:
Sag Radius Compensation

5.11 Allowances shall be made for the deflection of structures. The minimum headroom shall be maintained for the serviceability limit state under the action of load combination 1 specified in BD 37
(DMRB 1.3).

Utilities Companies' and Other Authorities' Apparatus

5.12 Greater headroom than that determined from Paragraphs 5.1 to 5.11 may be required by a Utility Company or other Authority. Any increase in the headroom dimension shall be agreed with the Malta Transport Authority.

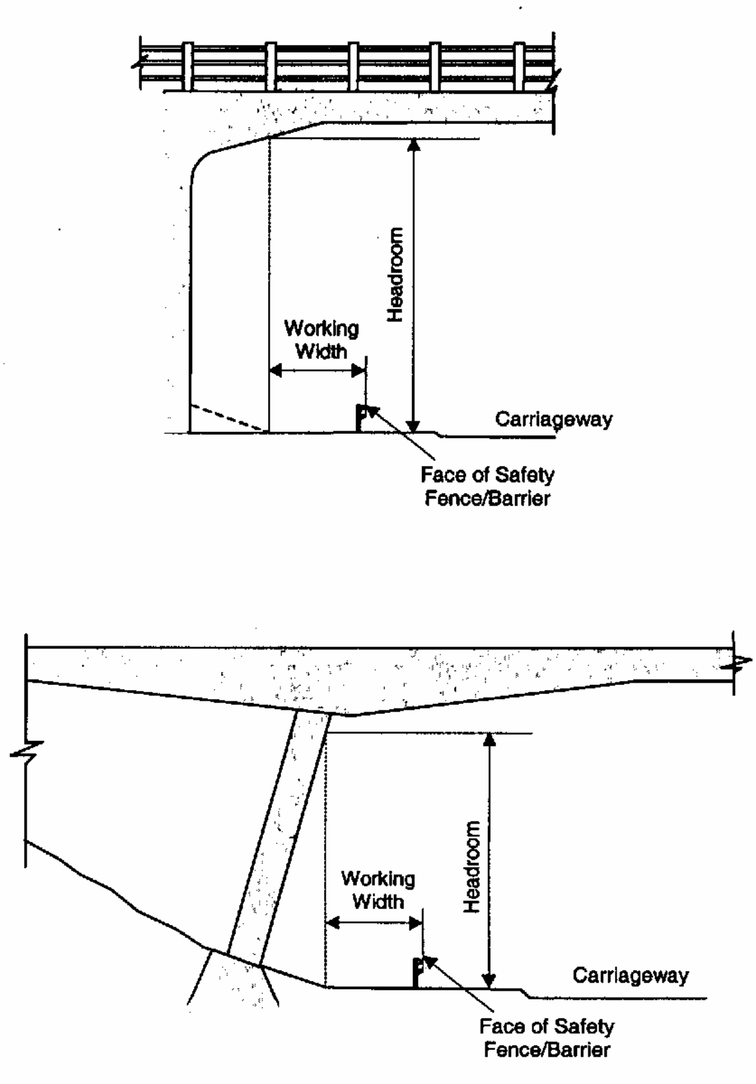


FIGURE 13

HEADROOM AT STRUCTURES

6. REFERENCES

6.1 Design Manual for Roads and Bridges (DMRB):

Volume 1 Highway Structures : Approval Procedures and General Design:

BD 37 (DMRB 1.3) – Loads for Highway Bridges.

Volume 2 : Highway Structures : Design (Substructures and Special Structures) Materials:

BD 26 (DMRB 2.2.1) – Design of Lighting Columns.

BA 48 (DMRB 2.2.2) – Pedestrian Protection at Head Walls, Wing Walls and Retaining Walls.

BD 51 (DMRB 2.2.4) – Design Criteria for Portal and Cantilever Sign/Signal Gantries.

BD 29 (DMRB 2.2) - Design Criteria for Footbridges.

TD 19 (DMRB 2.2) - Safety Fences and Barriers.

BD 52 (DMRB 2.3.3) – The Design of Highway Bridge Parapets.

Volume 4: Geotechnics and Drainage:

HA 44 (DMRB 4.1.1) – Earthworks : Design and Preparation of Contract Documents.

HID 33 (DMRB 4.2.3) – Surface and Sub-surface Drainage Systems for Highways.

HA 37 (DMRB 4.2) – Hydraulic Design of Road Edge Surface Water Channels.

Volume 6 : Road Geometry:

ADT TD9 (ADT DMRB 6.1.1) - Road Link Design.

TD 22 (DMRB 6.2.1) – Layout of Grade Separated Junctions.

TD 50 (DMRB 6.2.3) – The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts.

TD 42 (DMRB 6.2.6) – Geometric Design of Major/Minor Priority Junctions.

TD 36 (DMRB 6.3.1) – Subways for Pedestrians and Pedal Cyclists. Layout and Dimensions.

TA 66 (DMRB 6.3.2) – Police Observation Platforms on Motorways.

TA 69 (DMRB 6.3.3) – The Location and Layout of Lay-bys.

TA 57 (DMRB 6.3) —Roadside Features.

Volume 8 :Traffic Signs and Lighting:

TA 56 (DMRB 8.2) – Hazardous Cattle Crossings : Use of Flashing Amber Lamps.

TD 30 (DMRB 8.3) – Design of Road Lighting for All-Purpose Trunk Roads.

TD 34 (DMRB 8.3) – Design of Road Lighting for Motorway Trunk Roads.

Volume 9 : Network - Traffic Control and Communications:

HD 20 (DMRB 9.3.1) – Loop Detectors for Motorways.

Volume 10 : Environmental Design: HA 59 (DMRB 10.1.5) Nature Conservation.

6.2 Other References

BS 5489 : Part 1, Road Lighting: Guide to the General Principles. British Standards Institution.

BS 5649 : Parts 1 – 7, Lighting Columns. British Standards Institution.

BS 6100: Subsection 2.4.1, Glossary of Building and Civil Engineering Terms: Highway Engineering. British Standards Institution.

BS 6779 : Parts 1 – 3, Highway Parapets for Bridges and Other Structures. British Standards Institution.

BS 7818, Specification for Pedestrian Restraint Systems in Metal. British Standards Institution.

IS EN 40, Lighting Columns. National Standards Authority of Ireland.

7. ENQUIRIES

7.1 All technical enquiries or comments on this Standard should be sent in writing to:

Head of Project Management and Engineering
Malta Transport Authority
Sa Maison Road
Floriana

C. Zammit
Director of the Roads Directorate

ANNEX A : CROSS-SECTIONS FOR NON-NATIONAL ROADS ROAD SCHEME (AS PART OF A NATIONAL ROAD SCHEME)

Al Figure Al illustrates a suggested range of cross-sections for use on rural non-national roads which are diverted or improved on-line as part of a national road scheme. The use of these cross-sections should be agreed with the relevant Road Authority and the Maltese Transport Authority in each case.

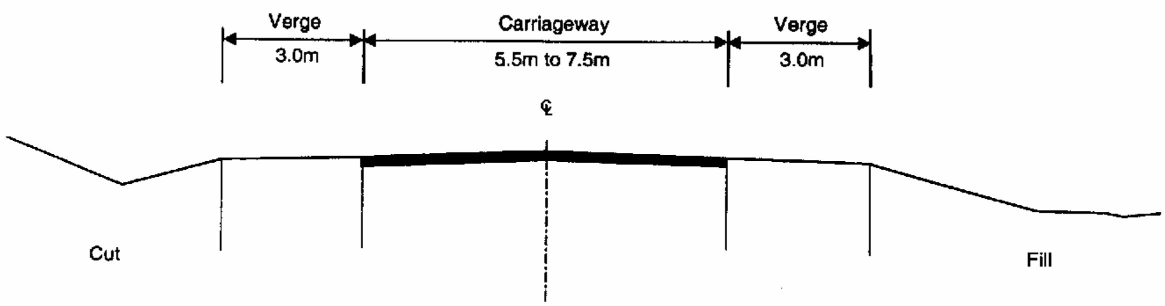


FIGURE A1

RURAL REGIONAL OR LOCAL ROAD

Verge Widths at Structures

A2 A raised verge should normally be provided adjacent to the parapet at an underbridge or adjacent to the abutment or pier at an overbridge. It is recommended that the raised verge have a minimum width of 0.60m. Provision may also be needed on one or both verges for pedestrians and/or pedal cyclists.

A3 The recommended minimum width of clear pedestrian access is 2.Om (included within the verge), except where the predicted two-way traffic flow is less than 2,500 vehicles Annual Average Daily Traffic and Occasional pedestrian usage is anticipated, when a width of 1 .5m is recommended. Occasional pedestrian usage is defined in Paragraph 4. 10A.

ADT ADDENDUM TO

TD 22/92

LAYOUT OF GRADE SEPARATED JUNCTIONS

Standard TD amendments: 22/92. – Layout of Grade Separated Junctions – is applicable in Malta with the following

GENERAL

At several locations:

For: “HGV” Read: “HCV”;

For: “highway” Read: “road”;

For: “TD 9 (DMRB 6.1)”
Read: “ADT TD 9 (ADT DMRB 6.1.1)”.

SPECIFIC

Chapter 1, Introduction

1.1 Page 1/1, Paragraph 1.3, line *5:*
For: "Overseeing Departments will each"
Read: "The Maltese Transport Authority will".

1.2 Page 1/1, Paragraph *1.5,* line 8:
For: "TA 43 (DMRB 6.1) (Sections A3 and B1 refer: and Table B3 in TD 9 (DMRB 6.1))." Read: "ADT TD 9 (ADT DMRB 6.1.1)."

1.3 Page 1/1, Paragraph *1.5,* line 12:
For: "For weaving lengths,"
Read: "For weaving lengths on rural roads,"

1.4 Page 1/1, Paragraph 1.6, line 4:
For: "trunk roads"
Read: "national roads".

1.5 Page 1/1, Paragraph 1.7:
Delete Paragraph 1.7 and replace with:

"1.7. This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the Maltese Transport Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with the Maltese Transport Authority."

1.6 Page 1/2, Paragraph 1.18, line 2:
For: "merge or taper"
Read: "merge taper".

1.7 Page 1/2, Paragraph 1.20, line 1:
Delete: "as defined in **TD** 20 (DMRB *5.1),* namely that"

Chapter 2, Design Procedure

2.1 Page 2/1, Paragraph 2.6, line 4:
Delete: "(The **Traffic Appraisal Manual** (STEAM) refers)." and replace with:
"(The traffic appraisal method shall be agreed with the Malta Transport Authority)."

2.2 Page 2/1, Paragraph 2.6, line 11:
For: **"TD** 20 (DMRB *5.1)"*
Read: "ADT TD 9 (DMRB 6.1.1)".

2.4 Page 2/2, Figure 2/1:
For: "TD 20" Read: "ADT TD 9".

2.5 Page 2/3, Figure 2/2 For: ‘‘possibly to next merge~~ Read: "possibly to next diverge".

2.6 Page 2/3, Paragraph 2.13, line 4:
For: "a length of auxiliary lane" Read: "a length of extended auxiliary lane".

2.7 Page 2/4, Paragraph 2.22:
After Paragraph 2.22 insert new Paragraph 2.22A:
"2.22A. The single lane taper merge (Layout A) will not normally be used."

2.8 Page 2/4, Paragraph 2.23:
At end of Paragraph 2.23 insert:
"Layout B should be used in place of Layout A at locations where the volume of flow or the design of the junction may lead to significant queuing traffic on the diverge slip road."

2.9 Page 2/6, Figure 2/3:
Delete Figure 2/3 and replace with the new Figure 2/3 enclosed.

2.10 Page 2/7, Figure 2/4:
For: "lane width 3.7m" (thee locations)
Read: "lane width *3.65m"*.

2.11 Page 2/8, Figure *2/5:*
Delete Figure *2/5* and replace with the new Figure 2/5 enclosed.

2.12 Page 2/9, Figure *216C:*
For: "Highway Construction Details"
Read: "Traffic Signs Manual".

2.13 Page 2/10, Paragraph 2.24, line 2:
For: “paras 4.21 to 4.2.3”
Read: “paras 4.21 to 4.24”.

2.14 Page 2/10, Paragraph 2.26, line 11:
For: ‘‘D = Maximum mainline flow~~
Read: “D Maximum mainline capacity”.

2.15 **Page** 2/10, Paragraph 2.26, line 15:
For: “paras 4.21 to 4.23”
Read: “paras 4.21 to 4.24”.

Chapter 3, Flow Standards

3.1 Page 3/1, Paragraph 3.1, line 1:

Delete first two sentences “Hourly Design Flows ... highest hourly flow.” and replace with:

“3.1 Hourly Design Flows shall be calculated using an appraisal method agreed with the Maltese Transport Authority. For roads of the Main Urban Type, junction and weaving area design shall be based on the 30~ highest hourly flow.”

3.2 Page 3/1, Table 3/1:
Delete Table 3/1 and replace with the new Table 3/1 below:

<table>
<tr><th></th><th colspan="2">For Mainline Road Class</th><th colspan="3">Connector Road Cross-Sections for:</th></tr>
<tr><th rowspan="2"></th><th rowspan="2">All-Purpose</th><th rowspan="2">Motorway</th><th colspan="2">Slip Road</th><th>Interchange Limk/Loop</th></tr>
<tr><th>Merge</th><th>Diverge</th><th>Merge/Diverge</th></tr>
<tr><td rowspan="7">Peak Corrected Design Flow on Connector Road:

Vehicles Per hour</td><td rowspan="2">0-800</td><td rowspan="2">0-900</td><td colspan="2">Single Lane 4.00m</td><td rowspan="4">Single Lane 4.00m</td></tr>
<tr><td rowspan="2">Single Lane 4.00m</td><td rowspan="4">Two 3.00m Lanes</td></tr>
<tr><td>800-1200</td><td>900-1350</td></tr>
<tr><td rowspan="2">1200-2400</td><td rowspan="2">1350-2700</td><td rowspan="4">Two 3.65m Lanes</td></tr>
<tr><td rowspan="3">Two 3.65m Lanes</td></tr>
<tr><td rowspan="2">2400-3200</td><td rowspan="2">2700-3600</td><td rowspan="2">Two 3.65m Lanes</td></tr>
<tr></tr>
</table>

Note: Standards for hard strips and hard shoulders are shown in Table 4/1.

Table 3/1 : Connector Road Cross-Sections for Design Flows

3.3 Page 3/2, Table 3/2, title:
For: “Heavy Goods Vehicles”
Read: “Heavy Commercial Vehicles”

Chapter 4, Geometric Standards

4.1 Page 4/1, Paragraph 4.1:

Delete Paragraph 4.1 and replace with:
"4.1 For the purpose of designing junctions and interchanges, cross-sections for the mainline and typical connector roads are given in ADT TD 27 (ADT DMRB 6.1.2) and in the ADT Road Construction Details. The complete range of available cross-sections for connector roads is shown in Table 4/1 and Figures 4/1 and 4/3. The design flow ranges corresponding with these cross-sections are shown in Table 3/1."

4.2 Page 4/1, Table 4/1:
Delete Table 4/1 and replace with the new Table 4/1 below:

	Motorway Or All-Purpose	Rural Or Urban	Nearside Hard Strip Width	Carriageway Provision and Width	Offside Hard Strip Width
Slip roads					
Merges and Diverges:	M/AP	R/U	1.50m	1 lane 4.00m	0.50m
	M/AP	R	1.00m	2 lane 7.30m	0.50m
	M	U	1.00m	2 lane 7.30m	0.50m
	AP	U	1.00m	2 lane 7.30m	-
Diverge Only:	M/AP	R	1.00m	2 lane 6.00m	0.50m
	M/AP	U	1.00m	2 lane 6.00m	-
Interchange Links and Loops Merges and Diverges:	**M/AP**	**R/U**	1.50m	1 lane 4.00m	0.50m
	M/AP	**R**	1.00m	2 lane 7.30m	0.50m
	M	**U**	1.00m	2 lane 7.30m	0.50m
	AP	**U**	1.00m	2 lane 7.30m	-

Table 4/1 : Summary of Cross-Sections for Connector Roads

4.3 Page 4/2, Figure 4/1:

Delete Figure 4/1 and replace with the new Figure 4/1 enclosed.

4.4 Page 4/3, Figure 4/2:
Delete Figure 4/2.

4.5 Page 4/4, Figure 4/3:
Delete Figure 4/3 and replace with the new Figure 4/3 enclosed.

4.6 Page 4/5, Figure 4/4:
Delete Figure 4/4.

4.7 Page 4/6, Paragraph 4.7, line 2:
For: "accordance with paragraphs B3.7 of **TD** 9 (DMRB **6.1)** and 8.13 of **TA** 20 **(DMRB 6.1)."**
Read: "accordance with ADT TD 9 (ADT DMRB 6.1.1) and TD 42 (DMRB 6.2.6)."

4.8 Page 4/6, Paragraph 4.8, line 9:

For: “in paragraphs B3.2 and B3.4 of **TD 9** (DMRB **6.1).”**
Read: “in ADT TD 9 (ADT DMRB 6.1.1).”

4.9 Page 4/6, Paragraph 4.8, line 16:
For “in paragraph B3.5 of **TD** 9 (DMRB **6.1).** Widening on loops shall be as set out in para 8.13 of **TA 20 (DMRB 6.1).”**
Read: “in ADT TD 9 (ADT DMRB 6.1.1). Widening on loops shall be as set out in TD 42 6.2.6).”

4.10 Page 4/7, Paragraph 4.9, line 4:
For: “in section B2 of **TD 9** (DMRB **6.1).”**
Read: “inADTTD9 (ADT DMRB 6.1.1).”

4.11 Page 4/7, Paragraph 4.10, line 3:
For: ‘‘This will apply along to the back of the merge nose.~~
Read: “This will apply until the driver reaches the Stopping Sight Distance from the back of the merge nose.~~

4.12 Page 4/7, Paragraph 4.11, line 2:
For: “shall be maintained into the diverge as far as the back of the diverge nose.”
Read: “shall be maintained until the driver reaches the back of the diverge nose.”

4.13 Page 4/7, Paragraph 4.12, line 4:
For: “limiting radius shown in Part B Table 3 of **TD 9** (DMRB 6.1).”
Read: “two Design Speed steps below Desirable Minimum radius in accordance with ADT TD 9 (ADT DMRB 6.1.1).”

4.14 Page 4/7, Paragraph 4.13, line 3:
For: **“TA** 20 (DMRB **6.1)”**
Read: “TD 42 (DMRB 6.2.6)”.

4.15 Page 4/7, Paragraph 4.14, line 3:
For: “in accordance with Drawing A7 of “Highway Construction Details” (MCHW3. 1).” Read: “over the length of the merge or diverge taper.”

4.16 Page 4/7, Paragraph 4.14
For: “in accordance with Figures 5 and 6 of **TA 42** (DMRB 6.2).”
Read: “in accordance with TD 16 (DMRB 6.2.3).”

4.17 Page 4/8, Table 4/4:
Delete Table 4/4 and replace with the new Table 4/4 below:

Road Class	Length of entry taper (m) (1)		Taper for min angle at nose (2)	Nose length (m) (3)	Minimum auxiliary lane length (m) (4)	Length of aux lane taper (m) (5)	Ghost island length (m) (6)
	4m lane	3.65m lane					
Rural Motorway	220	205	1:40	115	230	75	180
Rural Dual Carriageway Design Speed 120 km/h	160	150	1:30	85	190	55	150
100A km/h or less	140	130	1:25	75	160	55	150
Urban Road Speed Limit 60 mph	100	95	1:15	50	125	40	n/a
50 mph or less	80	75	1:12	40	100	40	n/a

Note: To be read in conjunction with Figure 2/4.

Table 4/4 : Geometric Design Parameters for Merging Lanes

4.18 Page 4/9, Figure 4/6:
For: "lane width 3.7m"
Read: "lane width 3.65m".

4.19 Page 4/9, Paragraph 4.18, line 2:
For: **"parallel merges and diverges,** (Layout B),"
Read: "4m wide parallel merges and diverges (similar to Layout B),".

4.20 Page 4/10, Paragraph 4.22, line 4:
Delete: "(Table 2 of **TD** 20 **(DMRB** *5.1)"*

4.21 Page 4/12, Figure 4/12:
For: "D is the hourly flow"
Read: "D is the lane capacity in vehicles/hour/lane"

Chapter *5,* References

5.1 Page 5/1, 1. Introduction, reference (b):
Delete reference (b) and replace with:
"(b) ADT **TD** 9—Road Link Design (ADT DMRB 6.1.1)."

5.2 Page 5/1, 2. Design Procedure, reference (d):
Delete reference (d) and replace with:
"(d) ADT **TD9,** as Chapter 1."

5.3 Page 5/1, 2. Design Procedure:
Add reference (i):
(i) **Traffic Signs Manual,** DOELG.

5.4 Page *5/1,* 4. Geometric Standards, references (a) to (C):
Delete references (a) to (c) and replace with:
"(a) ADT Manual of Contract Documents for Road Works, Volume 4: **Road Construction Details**

(b) **ADT TD 9,** as Chapter 1.

(c) **TD 42** – Geometric Design of Major/Minor Priority Junctions (DMRB 6.2.6)."

5.5 Page *5/1,* 4. Geometric Standards, reference (e):
Delete reference (e) and replace with:
"(e) ADT **TD27** – Cross-Sections and Headroom (ADT DMRB 6.1.2)."

5.6 Page 5/1, 4. Geometric Standards, reference (g):
Delete reference (g).

Chapter 6, Enquiries

6.1 Page 6/1, Section 6:
Delete text and replace with:
"6.1. All technical enquiries or comments on this Standard should be sent in writing to:

Roads Directorate
Sa Maison Road
Floriana
CMR02

C. Zammit
Director of the Roads Directorate

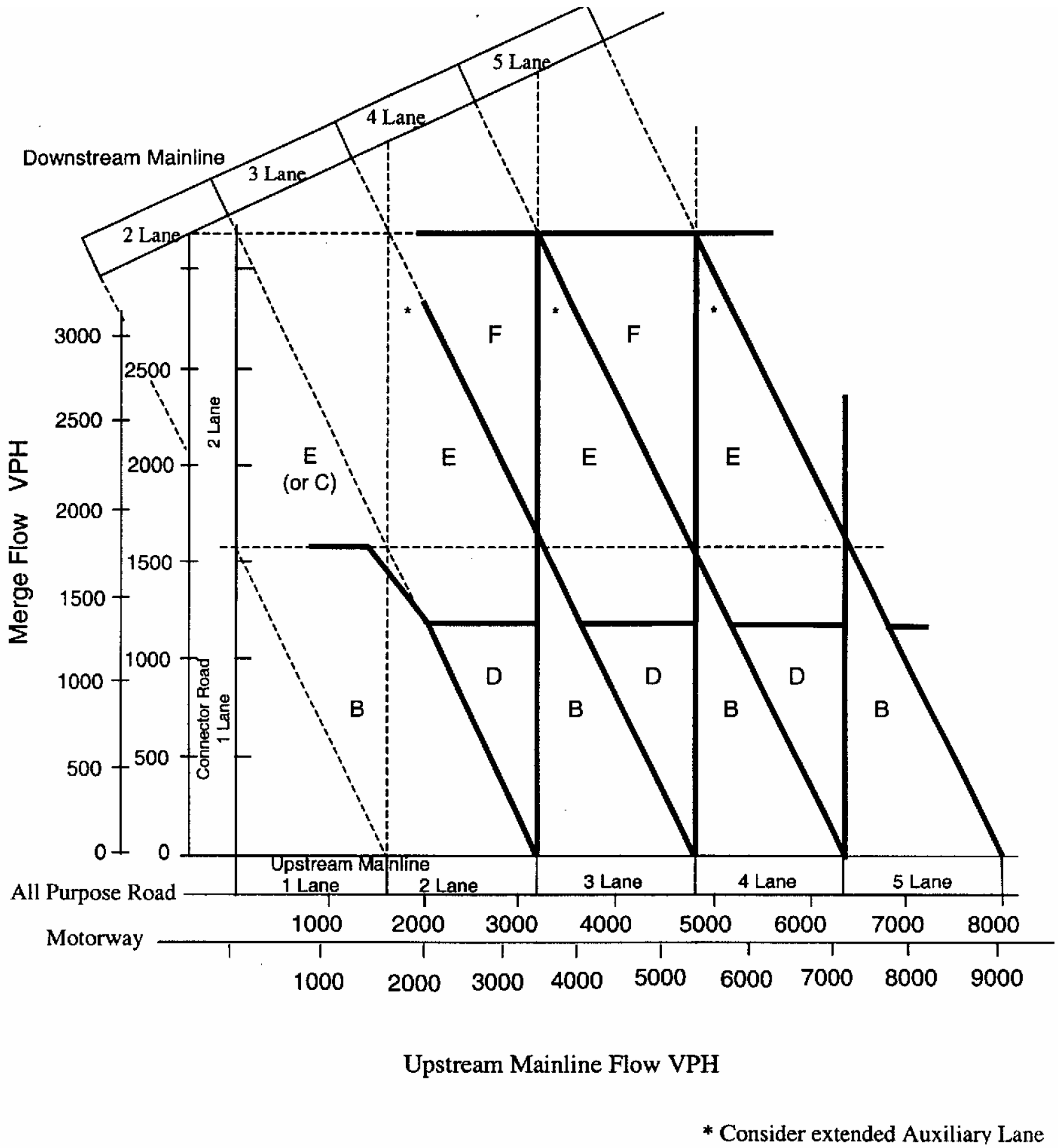


Figure 2/3 : Merging Diagram

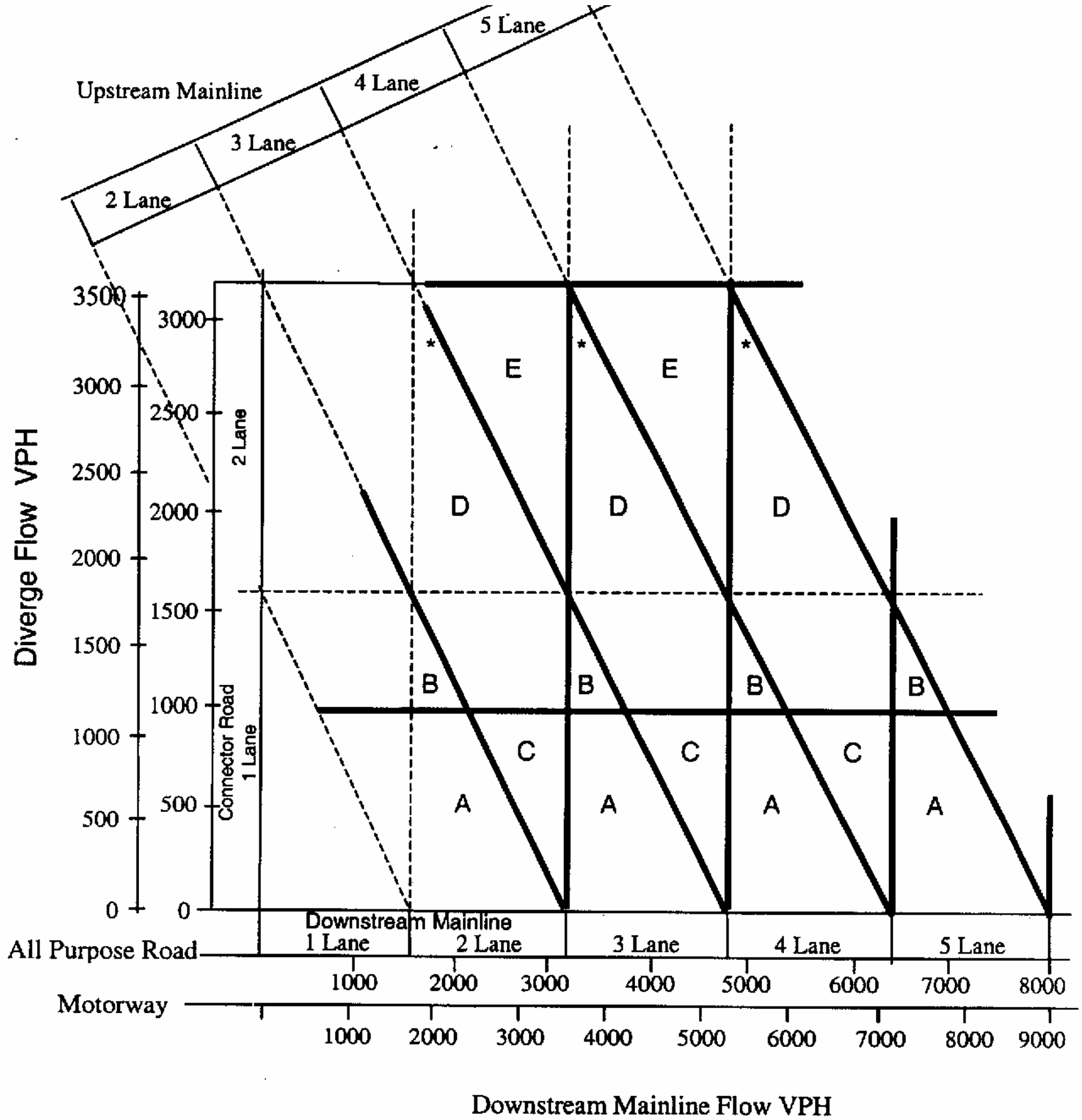
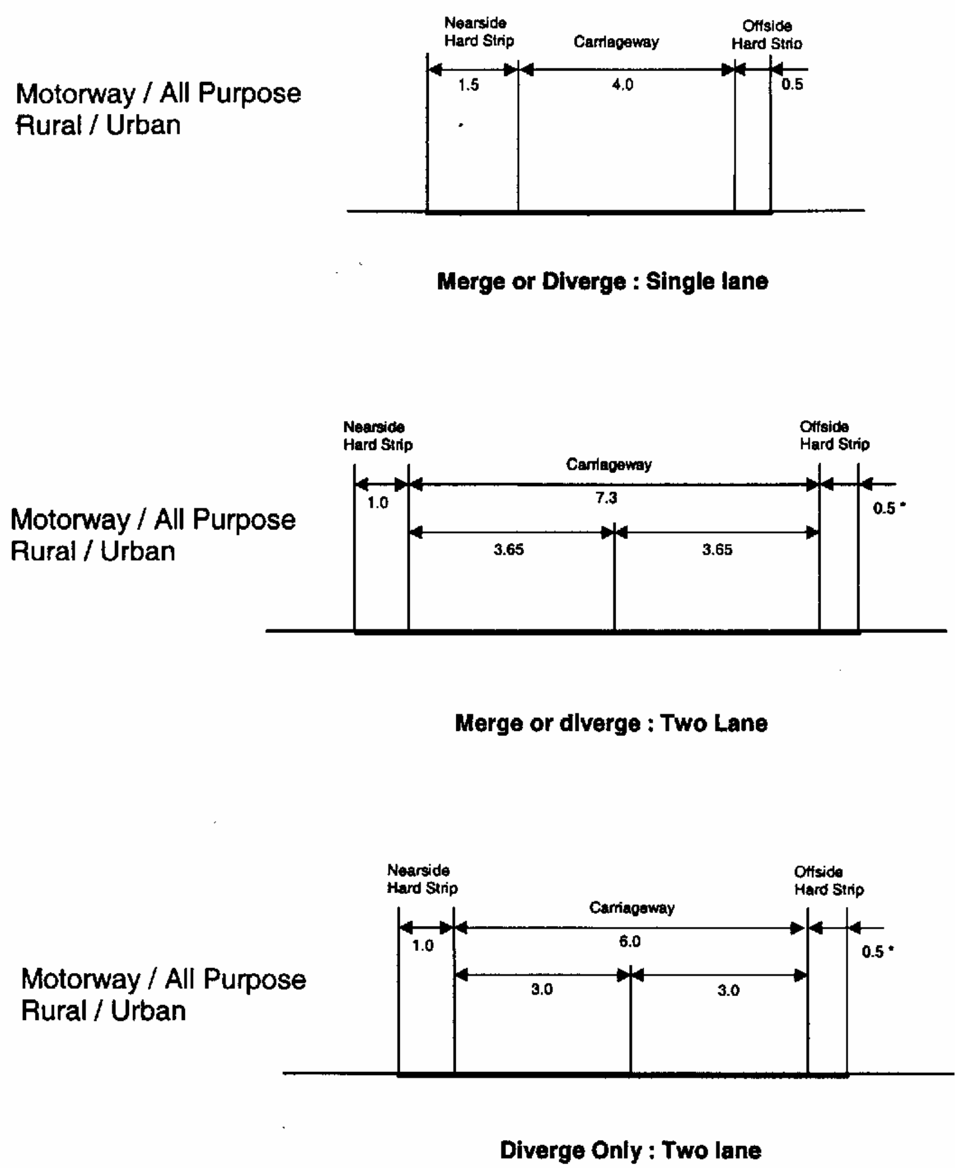


Figure 2/5 : Diverging Diagram

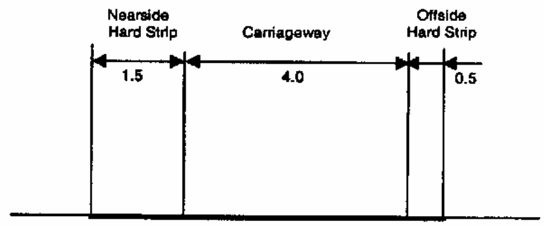


Note: * No offside hard strip on two-lane urban all-purpose slip roads.

Figure 4/1 : Cross-Sections for Slip Roads

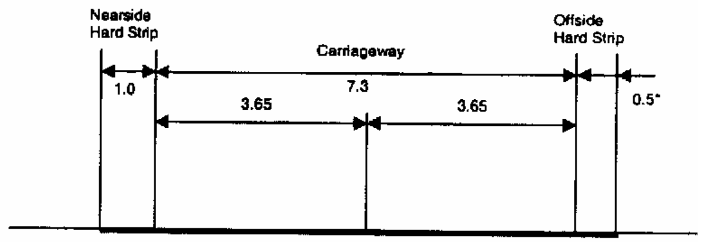
(Note: Figure 4/2 not used)

Motorway / All Purpose
Rural / Urban



Single Lane

Motorway / All Purpose
Rural / Urban



Two lanes

Note: * No offside hard strip on two-lane urban all-purpose interchange links and loops.

Figure 4/3 : Cross-Sections for Interchange Links and Loops

(Note: Figure 4/4 not used)

ADT ADDENDUM TO

TD 16/93

GEOMETRIC DESIGN OF ROUNDAB OUTS

Standard TD 16/93 - Geometric Design of Roundabouts - is applicable in Malta with the following amendments:

GENERAL

1. At several locations:

For: "Give Way line"
Read: "Yield line";

For: "large goods vehicle"
Read: "heavy commercial vehicle";

For: "Overseeing Department"
Read: "Maltese Transport Authority";

For: "TD 9 (DMRB 6.1)"
Read: "ADT TD 9 (ADT DMRB 6.1.1)";

For: "trunk road"
Read: "national road".

SPECIFIC

1. TD 1 *6/93*

1.1 Page 1/1, Paragraph 1.10:
Delete Paragraph 1.10 and replace with:

"1.10. This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the Maltese Transport Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with the Maltese Transport Authority."

1.2 Page *2/5,* Paragraph 2.21, line 9:
For: "(see DMRB 8.1)"
Read: "(see TD 50 (DMRB 6.2.3) and DMRB 8.1)."

1.3 Page 4/1, Paragraph *4.5b,* line 2:
Delete: ".(TD 6 DMRB 8.2)".

1.4 Page 4/2, Paragraph *4.5c,* line 18:
For: "Standard HID 21 (DMRB 7.2.1) and Advice Note HA *45* (DMRB 7.2.2)."
Read: "HID 36 (DMRB *7.5.1)."*

1.5 Page 4/2, Paragraph 4.9, line *5:*
For: "Class A roads"
Read: "main roads".

1.6 Page *5/1,* Paragraph *5.3,* line *5:*
Delete last sentence: "Further details ... Advisory Unit."

1.7 Page *5/1,* Paragraph *5.5,* line 8:
For: "(para 7.64)."
Read: "(para 7.69)."

1.8 Page 6/1, Paragraph 6.6, line 7:
Delete second sentence: "The chevron ... being explored."

1.9 Page *7/5,* Paragraph 7.24, lines 2, 4, *5,* 10 and 13:
For: "hardstrip" (five locations)
Read: "hard strip or hard shoulder".

1.10 Page 7/10, Figure 7/15, note b:
For: "D2"
Read: "D2L (dual 2-lane)"

1.11 Page 7/11, Paragraph 7/34, line 9:
For: "the Traffic Signs Regulations and General Directions."
Read: "the Road Traffic (Signs) Regulations."

1.12 Page 7/13, Figure 7/19, top (7.3m Dual Carriageway):

For: "7.3m" (two locations)
Read: "*7.5m* or 7.Om".

1.13 Page 7/13, Figure 7/19, bottom (7.3m Single Carriageway):
For: "7.3m" (two locations)
Read: "*7.5m* or narrowe,r".

1.14 Page 7/14, Table 7/1, second column:
For: "Fig 7/20a"
Read: "Figures 7/20, 7/21 and 7/22".

1.15 Page 7/15, Figure 7/20b:
Insert dimension a on circulatory carriageway in the same location as in Figure 7/20a.

1.16 Page 7/16, Figure 7/21, notes and Figure 7/22, notes:
For: "a. Distance related to circulatory speed" (two locations)
Read: "a. Stopping sight distance for circulatory traffic."

1.17 Page 7/18, Paragraph *7.56,* line 8:
For: ‘‘Vehicle Construction and Use Regulations,~~
Read: "Road Traffic (Construction, Equipment and Use of Vehicles) Regulations,".

1.18 Page 7/19, Paragraph 7.58, line 6:
For: "TA 20 (DMRB 6.2)."
Read: "ID 42 (DMRB 6.2.6)."

1.19 Page 7/20, Paragraph 7.61:
At end of Paragraph 7.61 insert:
"Where there is a hard shoulder or hard strip on the exit road, the hard shoulder or hard strip should not start before the end of the exit widening.~~

1.20 Page 7/24, Paragraph 7.72, line 19:
For: "IA 20 (DMRB 6.2)."
Read: "ID 42 (DMRB 6.2.6)."

1.21 Page 8/1, 2. Types of Roundabout, reference a):
For: "Section 1.,,
Read: "Section 1, Traffic Signals and Control Equipment."

1.22 Page 8/1, 3. The Siting of Roundabouts, reference b):
Delete reference b) and replace with:
"b) ADT ID 9, Road Link Design (ADT DMRB 6.1.1)."

1.23 Page 8/1, 4. Safety, reference 1):
Delete reference f) and replace with:
"f) HID 36, Surfacing Materials for New and Maintenance Construction (DMRB 7.5.1)."

1.24 Page 8/2, 6. Landscaping, reference b):
Delete reference b) and replace with:
"b) Road Traffic (Signs) Regulations 1997."

1.25 Page 8/2, 7. Geometric Design Features:
Delete sub-section 7 and replace with:
"7. Geometric Design Features:

a) ADT ID 9, Road Link Design (ADT DMRB 6.1.1).

b) ID 42, Geometric Design of Major/Minor Priority Junctions (DMRB 6.2.6).

c) Road Traffic (Signs) Regulations 1997.

d) Road Traffic (Construction, Equipment and Use of Vehicles) Regulations 1963 to 1997."

1.26 Page 9/1, Section 9:
Delete text and replace with:
"9.1. All technical enquiries or comments on this Standard should be sent in writing to:

Maltese Transport Authority
Sa Maison Road
Floriana
CMR02

2. Annex

2.1 Page A 1/4, Paragraph 4, line 6:
For: "(see TAM)."
Read: "(obtained, in this example, from the UK Traffic Appraisal Manual (TAM), Volume 12 of the DMRB)."

2.2 Page A 1/7, Paragraph 7, line 4:
After: ''in this case~~
Insert: which is based on UK lane widths."

2.3 Page A1/9, Paragraph 9, line 3:
For: "COBA 9."
Read: "COBA (Volume 13 of the DMRB) for this UK example. In Ireland advice on cost benefit analyses should be sought from the Maltese Transport Authority."

2.4 Page Al/il, Paragraph 4, line 8:
For: "(see TAM)."
Read: "(see TAM for this UK example)."

2.5 Page A/12, Paragraph 6, line 3:
For: "COBA 9."
Read: "COBA for this UK example."

C. Zammit
Director of the Roads Directorate

ADT ADDENDUM TO

TD 50/99

THE GEOMETRIC LAYOUT OF SIGNAL-CONTROLLED JUNCTIONS AND SIGNALISED ROUNDABOUTS

Standard TD 50/99 – The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts – is applicable in Malta with the following amendments:

GENERAL

At several locations:

For: "Overseeing Organisation"
Read: "Maltese Transport Authority";

For: "large goods vehicle"
Read: "heavy commercial vehicle";

For: "LGV"
Read: "HCV";

For: "TD 9 (DMRB 6.1.1)"
Read: "ADT ID 9 (ADT DMRB 6.1.1)".

SPECIFIC

1. **TD** *50/99*

1.1 Page 1/2, Paragraph 1.10:
Delete Paragraph 1.10 and replace with:

"1.10. This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the Maltese Transport Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with the Maltese Transport Authority."

1.2 Page 2/11, Paragraph 2.56:
Delete Paragraph 2.56 and replace with:

"2.56 Traffic signs and road markings (including yellow box markings) are specified in the Traffic Signs Manual and the Road Traffic (Signs) Regulations. Advice on the provision of road markings to indicate non-hooking turns is given in
TA 8 (DMRB 8.1.1)."

1.3 Page 3/2, Paragraph 3/12n:
Delete item n and replace with:

"n. is the junction on a route with particular
requirements for abnormal loads."

1.4 Page 4/1, Paragraph 4.2:
Delete Paragraph 4.2 and replace with:

"4.2 Provisions for pedestrians, cyclists, equestrians and buses may require additional signing in accordance with the Road Traffic (Signs) Regulations and may require special authorisation by the Minister for the Environment."

1.5 Page 4/1, Paragraph 4.3, line 10:
For: "a **Toucan** crossing"
Read: "a combined crossing".

1.6 Page 4/2, Paragraph 4.15, line 1:
Delete the first two sentences "The crossing … is 2.4m." and replace with:

"4.15 The crossing place should be indicated by two rows of studs or marks as indicated in the Road Traffic (Signs) Regulations and the Traffic Signs Manual. The crossing place should be a minimum of 2.4m wide."

1.7 Page 4/2, Paragraph 4.15, line 9:
For: **"Toucan** crossings"
Read: "combined pedestrian/cyclist crossings"

1.8 Page 4/3, Paragraph 4.21, line 1:
For: "Toucan crossings"
Read: "combined pedestrian/cyclist crossings"

1.9 Page 4/5, Figure 4/4, title:
For: **"Combined Toucan and Equestrian** Crossing"
Read: "Combined Crossing for Pedestrians, Cyclists **and Equestrians".**

1.10 Page 7/1, 1. DESIGN MANUAL FOR ROADS AND BRIDGES, reference c:
Delete reference c and replace with:
"c. ADT TD 9, Road Link Design (ADT DMRB 6.1.1)."

1.11 Page 7/2, 2.TRAFFIC SIGNS REGULATIONS:
Delete Section 2 and replace with:

"2. **TRAFFIC** SIGNS REGULATIONS

a. Road Traffic (Signs) Regulations 1997.

b. Traffic Signs Manual, Department of the Environment and Local Government.

1.12 Page 8/1, Section 8:
Delete text and replace with:
"8.1. All technical enquiries or comments on this Standard should be sent in writing to:

Maltese Transport Authority
Sa Maison Road
Floriana
CMR02

2. **Annex 1**

2.1 Page Al/i, Paragraph Al.1, line 4:
For: "TR Ol4lB"
Read: "TR 0141C"

2.2 Page Al/i, Paragraph A 1.2, line 2:
For: "TRO141B"
Read: "TRO141C"

2.3 Page Al/i, Paragraph Ai/3, line 2
For: "Traffic Signs and General Directions, 1994, Traffic Signs Regulations (Northern freland) 1997 (TSR[NI])"
Read: "the Road Traffic (Signs) Regulations 1997."

2.4 Page Ai/2, Paragraph Ai.4:
Delete paragraph A 1.4 and replace with:

"A 1.4 Details of the equipment relevant to pedestrian facilities are contained in TA 15 (DMRB 8.1.1)."

C. Zammit
Head of Project Management and Engineering

ADT ADDENDUM TO

TD 39/94

THE DESIGN OF MAJOR INTERCHANGES

Standard TD3 9/94 -The Design of Major Interchanges – is applicable in Malta with the following amendments:

GENERAL

At several locations:

For: “highway”
Read: “road”;

For: “Large Goods Vehicle”
Read: “Heavy Commercial Vehicle”;

For: “Overseeing Organisation”
Read: “Maltese Transport Authority”;

For: “trunk road”
Read: “national road”.

SPECIFIC

1. Page 1/2, Paragraph 1.12:
   Delete Paragraph 1.12 and replace with:

   "1.12 This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the Maltese Transport Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with the Maltese Transport Authority."

2. Page *2/5,* Paragraph 2.21:
   Delete Paragraph 2.21 and replace with:

   "2.21 Derive low and high growth design year traffic flows for each section of mainline and connector road using a traffic appraisal method agreed with the Maltese Transport Authority."

3. Page *2/5,* Paragraph 2.24, line 2:
   For: **"TD 9** (DMRB **6.1.1)"**
   Read: "ADT TD 9 (ADT DMRB 6.1.1)"

4. Page *2/5,* Paragraph 2.29:
   Delete Paragraph 2.29 and replace with:

5. Page 4/1, Paragraph 4.6, line 9:
   After "QUADRO" insert:
   "(see DMRB Volume 14)."

6. Page 4/2, Paragraph 4.12, line 11:
   For: "reduced in accordance with Drawing No. D6 of the Highway Construction Details (MCHW3). This is illustrated as Layout (b), Figure 4/1."
   Read: "reduced as illustrated in Layout (b) of Figure 4/1."

7. Page 4/2, Figure 4/1(a):
   For: "lane widths 3.7m".
   Read: "lane widths 3.65m".

8. Page 4/2, Figure 4/1, Notes:
   For: "reduced according to Drawing D6 in MCHW3"
   Read: "reduced as illustrated in Layout (b)."

9. Page 4/3, Figure 4/2 (a) and (b)
For: "lane widths 3.7m" (two locations)
Read: "lane widths *3.65m"*.

10. Page 4/4, Paragraph 4.15, line 12:
Delete: "which should be undertaken in accordance with Drawing No. D6 of the Highway **Construction Details (MCHW3)."**

11. Page 4/7, Figure 4/5(a):
For: "Highway Construction Details"
Read: "Traffic Signs Manual".

12. Page 6/1, Paragraph 6.1, line 4:
For: "DOT"
Read: "UK Department of Transport"

13. Page 7/1, 2 Design Procedure, reference (f):
For: "(f) **TD 9 (DMRB 6.1.1)** - Road Layout and Geometry: Highway Link Design"
Read: "(f) ADT **TD** *9* (ADT DMRB 6.1.1). - Road Link Design."

14. Page 7/1, 2 Design Procedure:
Insert new reference:
"ADT."

15. Page 7/1, 3 General Layout Advice:
Insert new reference:
"(d) **TA 44** (DMRB **5.1.1)** – Capabilities, Queues,
Delays and Accidents at Road Junctions -
Computer Programs ARCADY/3 and PICADY/3 (TRRL)."

16. Page 7/1, 4 Design Standard, references (b) and (c):
Delete references (b) and (c) and replace with:
"(b) Design Manual for Roads and Bridges (DMRB),
Volume 14, Economic Assessment of Road Maintenance.

(c) Traffic Signs Manual, DOELG."

17. Page 8/1, Section 8:
Delete text and replace with:
"8.1. All technical enquiries or comments on this Standard should be sent in writing to:

Maltese Transport Authority
Sa Maison Road
Floriana
CMR02

C. Zammit
Director of the Roads Directorate

ADT ADDENDUM TO

TD 40/94

LAYOUT OF COMPACT

GRADE SEPARATED JUNCTIONS

Standard TD 40/94 – Layout of Compact Grade Separated Junctions – is applicable in Malta with the following amendments:

GENERAL

1. In several locations:
   For: "Overseeing Organisation" Read: "Maltese Transport Authority";

   For: "TA2O (DMRB 6.2)" Read: "TD42 (DMRB 6.2.6)";

   For: "TD9 (DMRB 6.1.1)" Read: "ADT TD9 (ADT DMRB 6.1.1)".

SPECIFIC

1. Page 1/1, Figure 1/1, title:
   For: "Examples **of the range of Grade Separations"**
   Read: **"Examples of Different Standards of Grade Separation".**

2. Page 1/2, Paragraph 1.11:
   Delete Paragraph 1.11 and replace with:

   "1.11. This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the Maltese Transport Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard• to particular schemes with the Maltese Transport Authority."

3. Page 2/4, Paragraph 2.22, line 2:
   After: "use of **COBA"**
   Insert: "(DMRB Volume 13, as used for the economic assessment of UK Highways Agency schemes)".

4. Page 2/4, Paragraph 2.26, line 2:
   After: **"(The Casualty Report)"** insert:
   ''and similar publications,''

5. Page *2/5,* Paragraph 2.27c, line 3:
   For: "M **Factor and value of time (VOT)** obtained from **COBA** (NESA in Scotland)."
   Read: "M Factor and value of time (VOT). Guidance on the appropriate factor and value of time should be sought from the Maltese Transport Authority."

6. Page *2/5,* Paragraph 2.30:
   At end of Paragraph 2.30 add:
   "Guidance on the relevant discount rate should be sought from the Maltese Transport Authority."

7. Page 3/1, Paragraph 3.4, line 10:
   For: "in **Table 3/1."**
   Read: "in Table 3(1 from UK accident statistics."

8. Page 3/1, Table 3/1:
Revise first column to read:

"Classification of Road (in the UK)
A (major roads including trunk roads)
B (roads of medium significance)
C (minor roads)
Unclassified (minor roads)"

9. Page 3/2, Paragraph 3.10, line 1:
For: "Where full curve widening"
Read: "Where normal curve widening".

11. Page *5/1,* Paragraph *5.2,* line 3:
For: "Categories 3A, 3B, 4, *5* and 6 of roads as defined in Table 4 of **TD9** (DMRB **6.1.1)."** Read: "Categories 3A to 6 of roads as defined in Table 4 of ADT TD 9 (ADT DMRB 6.1.1)."

12. Page *5/1,* Paragraph *5.7,* line 7:
For: **"Figure 7/8."**
Read: "Figure 7/9."

13. Page 6/3, Paragraph 6.19:
Delete Paragraph 6.19 and replace with:
"6.19 For the purpose of designing junctions and interchanges, cross-sections for the mainline and typical connector roads are given in ADT TD 9 (ADT DMRB 6.1.1) and TD 22 (DMRB 6.2.1). Different lane marking details and widths of construction for connector roads are specified in this Standard."

14. Page 7/1, Paragraph 7.2, line *5:*
For: **"Figure 7/4 to 7/8."**
Read: "Figure *7/5* to 7/8."

15. Page 7/1, Figure 7/3, line 3:
For: "forming a loop."
Read: "forming a single connection over the mainline."

16. Page 8/1, 1. DMRB, references b and d:
Delete references b. and d. and replace with:
"b. **TD 42** (DMRB 6.2.6) – Geometric Design of Major/Minor Priority Junctions.

d. ADT **TD 9 (DMRB 6.1.1)** – Road Link Design."

17. Page 8/1, 1. DMRB:
Insert new reference g:
"g. **TA48 (DMRB** 6.2.2) – Layout of Grade Separated Junctions."

18. Page 8/1, 6. Economic Assessment, reference a:
Delete reference a and replace with:
"a. **DMRB Volume 13-** Economic Appraisal of Road Schemes."

19. Page 8/1, 7. Miscellaneous, reference a:
Delete reference a and replace with:
"a. Road Traffic (Signs) Regulations 1997."

20. Page 8/1, 7. Miscellaneous:
Insert new reference f:
"f. **Traffic** Signs **Manual,** DOELG."

21. Page 9/1, Section 9:
Delete text and replace with:
"9.1. All technical enquiries or comments on this Standard should be sent in writing to:

Maltese Transport Authority
Sa Maison Road
Floriana
CMR02

C.ZAMMIT
Director of The Roads Directorate

ADT **ADDENDUM TO**

TD 42/95

GEOMETRIC DESIGN OF

MAJOR/MINOR PRIORITY JUNCTIONS

Standard TD 42/95 – Geometric Design of Major/Minor Priority Junctions – is applicable in Malta with the following amendments:

GENERAL

1. National road schemes require major/minor junctions to be designed with "Stop" signs and road markings, however the figures contained in TD 42/95 assume that "Yield" ("Give Way") signs and road markings are used. "Yield" road markings shown in these figures shall be interpreted as meaning "Stop" signs and road markings.

2. At several locations:

   For: "trunk road"
   Read: "national road";

   For: "Overseeing Organisation"
   Read: "Maltese Transport Authority";

   For: "TD 9 (DMRB 6.1.1)"
   Read: "ADT TD 9 (ADT DMRB 6.1.1)";

   For: "large goods vehicle"
   Read: "heavy commercial vehicle".

3. At several locations, unless otherwise indicated:

   For: "Give Way"
   Read: "Stop".

SPECIFIC

TD *42/95*

1.1 Page 1/1, Paragraph 1.1, line 3:
For: "Department of Transport"
Read: "UK Department of Transport".

1.2 Page 1/1, Paragraph 1.10:
Delete Paragraph 1.10 and replace with:

"1.10. This Standard should be used forthwith for all schemes for, the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the Maltese Transport Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with the Maltese Transport Authority."

1.3 Page 1/4, Paragraph 1.23, line 15:
Delete final sentence and replace with:

"The record shall be endorsed by the Design Organisation' s senior engineer responsible for the scheme. The Design Organisation shall report all Relaxations incorporated into the design as part of the project report at the end of each project management phase."

1.4 Page 2/1, Paragraph 2.1:
Delete Paragraph 2.1 and replace with:

"2.1 Major/minor priority junctions are the most common form of junction control. Traditionally, these junctions have been controlled by "Yield" signs and road markings, with the traffic on the minor road giving way to the traffic on the major road. However, for future national road schemes, these junctions shall be designed with "Stop" signs and road markings in place of the "Yield" signs."

1.5 Page 2/2, Figure 2/1:
For: "(TA 18)"
Read: "(TD *50)".*

1.6 Page 2/3, Table 2/1:
Delete Table 2/1 and replace with the new Table 2/1 below:

Carriageway Type		**Junction Type**								
		Simple			**Ghost Island**			**Dualling**		
Standard	Location	T-Junction	Staggered Junction	Crossroads	T-Junction	Staggered Junction	Crossroads	T-Junction	Staggered Junction	Crossroads
S2	Urban	Yes	Yes	Maybe	Yes	Yes	No	Yes (D1)	Yes (D1)	No
	Rural	Yes	Yes	Maybe	Yes	Yes	No	Maybe* (D1)	Maybe* (D1)	No
WS2	Urban	No	No	No	Yes	Yes	Yes	Yes (D1)	Yes (D1)	No
	Rural	No	No	No	Yes	Yes	No	Maybe* (D1)	Maybe* (D1)	No
D2		No	No	No	No	No	No	Yes (D2)	Yes (D2)	No
D3		No	No	No	No	No	No	No	No	No

T-Junction Staggered Junction Crossroads

* The use of single lane dualling is not normally recommended and will be regarded as a Relaxation (see Paragraph 2.23).

Table 2/1 : Possible Junction Types for Different Major Road Carriageway Types

1.7 Page 2/4, Figure 2/2, title, line 3:
For: “(paras 2.2, 2.14)”
Read: **“(paras** 2.12, **2.14)”.**

1.8 Page 2/6, Paragraph 2.22, line 7:
For: “highway”
Read: “road”.

1.9 Page 2/7, Figure 2/5, title:
For: **“(para** *2.25)”*
Read: **“(para** 2.27)”.

1.10 Page 2/4, Figure 2/2:
After “Single Lane Dualling” add “*”. Below the figure add:
“* The use of single lane dualling is not normally recommended and will be regarded as a Relaxation (see Paragraph 2.23).”

1.11 Page 2/6, Paragraph 2.23:
Delete Paragraph 2.23 and replace with:
"2.23 The use of single lane dualling on rural lengths of national road schemes is not normally recommended and will be regarded as a Relaxation (see ADT TD 9, ADT DMRB 6.1.1).

2.23A Single lane dualling may be appropriate on rural single carriageway roads that have good overtaking opportunities on adjacent links. It may also be appropriate on such roads as an alternative to ghost islands where overtaking opportunities on adjacent links are restricted and where traffic turning right out of the minor road would need to make the manoeuvre in two stages. Single lane dualling may also be appropriate on schemes where the alternative would be a series of roundabouts at relatively close spacing."

1.12 Page 3/1, Paragraph 3.2a, line 2:
For: "the metre strips"
Read: "the hard strips".

1.13 Page 3/1, Figure 3.1, title
For: **"Metre Strips"**
Read: **"Hard Strips".**

1.14 Page 4/1, Paragraph 4.3d, line 1:
For: "metre strips"
Read: "hard strips".

1.15 Page 5/2, Paragraph 5.13, line 3:
For: "shall"
Read: "should".

1.16 Page *5/2,* Paragraph *5.13,* line 6:
For: **"TD** 28, **TA 52** (DMRB *8.5)"* Read: "TA 68 (DMRB 8.5.1)".

1.17 Page 6/1, Paragraph 6.1, line 2:
For: "highway"
Read: "road".

1.18 Page 7/4, Paragraph 7.15, line 6:
For: "Vehicle Construction and Use Regulations"
Read: "Road Traffic (Construction, Equipment and Use of Vehicles) Regulations".

1.19 Page 7/4, Paragraph 7.16, line *5:*
For: "Great Britain"
Read: "Malta"

1.20 Page 7/7, Paragraph 7.23, line2:
For: "7.3m"
Read: "7.5m or less".

1.21 Page 7/7, Figure 7/7, note a:
For: "7.3m"
Read: "7.5m or less".

1.22 Page 7/13, Paragraph 7.52, line 1:
Delete first two sentences "Nearside … or above." and replace with:
"7.52 Except on roads with hard shoulders, nearside diverging tapers shall not be provided at simple junctions (Paragraph 1.14). They shall be provided at junctions between national roads and national or regional roads where the design speed for the major road is 85km/h or above."

1.23 Page 7/13, Paragraph 7.52, last paragraph:
For: "7,000 – 8,000"
Read: "4,000 – 5,000".

1.24 Page 7/13, Paragraph 7.54, lines 7 and 12:
For: "Give Way" (two locations)
Read: *"Yield".*

1.25 Page 7/14, Paragraph 7.55, line 4:
Delete second sentence "Where there are … 35m long." and replace with:
"Where there are severe site constraints and the design speed is 85km/h, the length may be reduced to a minimum of 35m as a Relaxation."

1.26 Page 7/14, Paragraph 7.56, line 1:
For: "7,000 – 8,000"
Read: "4,000 – 5,000".

1.27 Page *7/15,* Paragraph 7.57:
After Paragraph 7.57, insert new Paragraph 7.57A:
"7.57A On roads with hard shoulders, diverging tapers should be provided in accordance with the requirements of Paragraphs 7.80 to 7.84."

1.28 Page 7/15, Paragraph 7.59, line 3:
For: "where a "B" road joins an "A" dual carriageway road"
Read: "where a national or regional road joins a national dual carriageway road".

1.29 Page 7/22, Paragraph 7.79:
After Paragraph 7.79 insert additional Paragraphs 7.80 to 7.93 and additional Figures 7/20 to 7/24. See enclosed pages 9 to 15.

1.30 Page 9/1, Section 9, Design Manual for Roads and Bridges, references c), g) and h):
Delete references c), g) and h) and replace with:
"c) ADT TD 9, Road Link Design (ADT
DMRB 6.1.1).

g) ADT TA 43, Guidance on Road Link Design (ADT DMRB 6.1.1A).

h) TA 68, The Assessment and Design of Pedestrian Crossings (DMRB 8.5.1)."

1.31 Page 9/1, Section 9, Design Manual for Roads and Bridges:
Insert new references:
"j) TA 44 (DMRB 5.1.1) – Capabilities,
Queues, Delays and Accidents at Road
Junctions – **Computer Programs**
ARCADY/3 and PICARDY/3 (TRRL).

k) **TD** 22, Layout of Grade Separated Junctions (DMRB 6.2.1).

I) TD 40, Layout of Compact Grade Separated Junctions (DMRB 6.2.5).

m) TD 50, The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts.

n) Volume 12, Traffic Appraisal of Road Schemes.

o) Volume 13, Economic Assessment of Road Schemes."

1.34 Page 10/1, Section 10:
Delete text and replace with:
"10.1 All technical enquiries or comments on this Standard should be sent in writing to:

Maltese Transport Authority
Sa Maison Road
Floriana
CMR02

C. Zammit
Director of the Roads Directorate

Roads With Hard Shoulders

7.80 Where hard shoulders are provided on roads with major/minor priority junctions, particular care should be taken to ensure safe designs for the junctions. The layouts should be in accordance with the geometric requirements described in the preceding paragraphs of this Chapter and in Chapter 8, together with the following additional requirements.

Approach to a **Junction**

7.81 On the major road approach to a junction on the left, a direct taper diverging lane should generally be provided within the paved width of the hard shoulder, as shown in Figure 7/20. Where the traffic flow warrants (see Paragraph 7.56) an auxiliary diverging lane 3.Om wide should be provided as shown in Figures 7.21 and in accordance with the requirements of Paragraph *7.57.* In both cases the desirable length of the diverging taper shall be that of the relevant deceleration length given in Tables 7/5a and *7/Sb.* Where there are severe site constraints, this length may be reduced by half as a Relaxation subject to a minimum length of 25m for design speeds of 70km/h or less and 35m for higher design speeds.

7.82 The hard shoulder shall be tapered by means of hatched road markings prior to the junction. The taper angle shall be 1:30, reducing the hard shoulder to form a hard strip 0.6m wide. At a simple junction or a dual carriageway junction, the taper shall terminate at least 15m before the start of the diverging taper (see Figures 7/20 and 7/24). At a ghost island junction or single lane dualling, the taper shall terminate at the start of the central island road markings or 1 Sm before the start of the nearside diverging taper, whichever is the earlier (see Figure 7/22). The full paved width should generally be continued through the junction; otherwise a 0.6m wide hard strip shall be provided up to the junction.

7.83 At junctions where one of the traffic flow criteria of Paragraph 7.52 are satisfied, the layout of the diverging lane shall be in accordance with the requirements of Paragraphs 7.49 to 7.57.

7.84 At junctions where none of the traffic flow criteria of Paragraph 7.52 are satisfied, nearside diverging tapers may be omitted as a Relaxation. At such locations the hard shoulder shall be tapered by means of hatched road markings prior to the junction. The taper angle shall be 1:30, reducing the hard shoulder to form a hard strip 0.6m wide. At a simple junction the taper shall terminate at least 15m before the start of the corner radius. At a ghost island junction or single lane dualling the taper shall terminate at the start of the central island road markings, and at a dual carriageway junction it shall terminate at least 50m before the start of the corner radius (see Figure 7/23). After the hatched taper, a 06m wide hard strip shall be provided up to the junction.

Departure from a Junction

7.85 On the major road departure from a simple junction on the left, the hard shoulder shall start **not** less than 20m beyond the end of the corner radius, as illustrated in Figure 7/20. The full paved width should be continued through the junction, with the paved area behind the edge of carriageway or 0.6m wide hard strip hatched until the start of the hard shoulder.

7.86 On the major road departure from a ghost island junction or single lane dualling, the hard shoulder may be introduced oyer the length of the taper of the central island road markings as illustrated in Figure 7/22.

7.87 **On a dual** carriageway **departure from a** junction on the left, the hard shoulder shall start not less than 50m beyond the end of the corner radius, as illustrated in Figure 7/23, or be introduced over the length of the merging taper, as illustrated in Figure 7/24. Merging tapers shall be provided where the traffic flow criteria of Paragraph 7.59 are satisfied. The layout of a merging taper shall be in accordance with the requirements of Paragraphs 7.58 to 7.62.

Opposite a Junction

7.88 On the side of the major road opposite a simple T junction, the hard shoulder shall be maintained through the junction.

7.89 On the side of the major road opposite a ghost island junction or single lane dualling, the hard shoulder shall be tapered to form a 0.9m hard strip as illustrated in Figure 7/22. On the approach side the taper shall be at an angle of 1:30 and shall be introduced by means of hatched road markings. This taper shall terminate at the start of the central island road markings. On the departure side, the hard shoulder may be reintroduced over the length of the central island taper. Opposite a ghost island junction on a Wide Single Carriageway, the hard shoulder may, as an alternative, be continued through the junction. Where the required paved width is less than the full paved width away from the junction, the full paved width should be continued through the junction, with any excess area hatched.

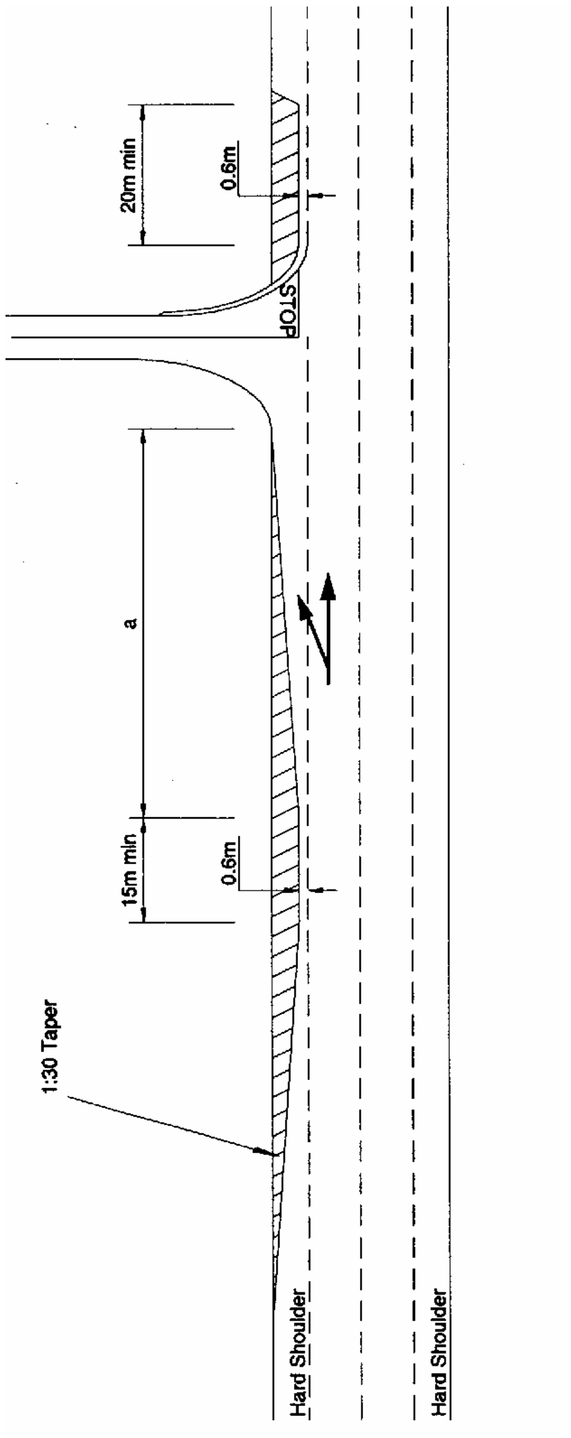
7.90 On the side of a dual carriageway opposite a junction, the hard shoulder shall be continued through the junction.

Hard Shoulders on the Minor Road

7.91 Where the minor road approach to a junction has a hard shoulder, the hard shoulder should be terminated by tapering to a width of 1 .Om to form a hard strip. The taper angle should be 1:30 and the taper should terminate not less than 15m before the start of the entry widening.

7.92 Where the minor road departure from a junction has a hard shoulder, the hard shoulder should not start before the end of the exit widening.

7.93 Tn accordance with the Traffic Signs Manual, the Stop line on the minor road shall be set 0.6m back from the edge of major road carriageway.



a = Deceleration Length (Refer to Table 7/5a)

Not to Scale

Figure 7/20 : Treatment of Hard Shoulders at Simple Junction with Direct Diverging Taper

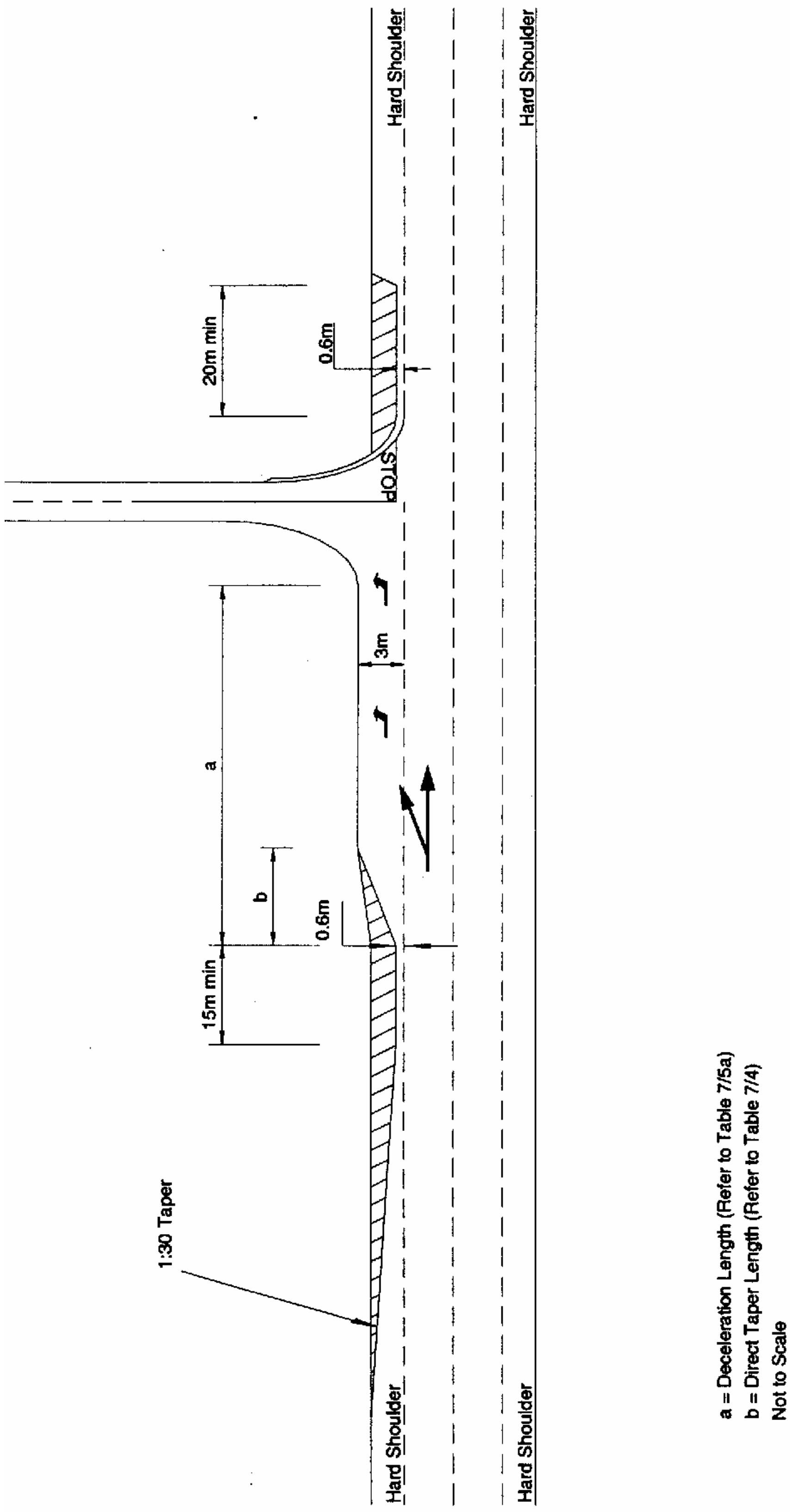
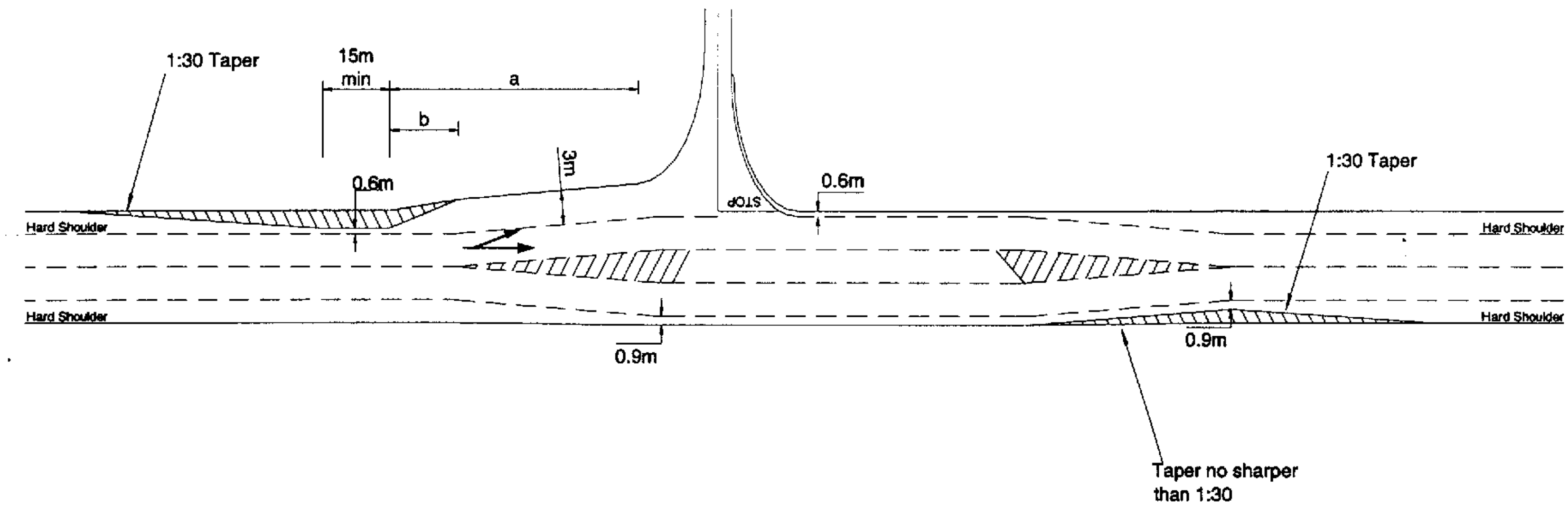


Figure 7/21 : Treatment of Hard Shoulders at Simple Junction with Auxiliary Deceleration Lane



a = Deceleration Length (Refer to Table 7/5a)
b = Direct Taper Length (Refer to Table 7/4)
For treatment of additional widths at a Wide Single Carriageway. see Paragraph 7.89.
Not to Scale

Figure 7/22 : Treatment of Hard Shoulders at Ghost Island Junction

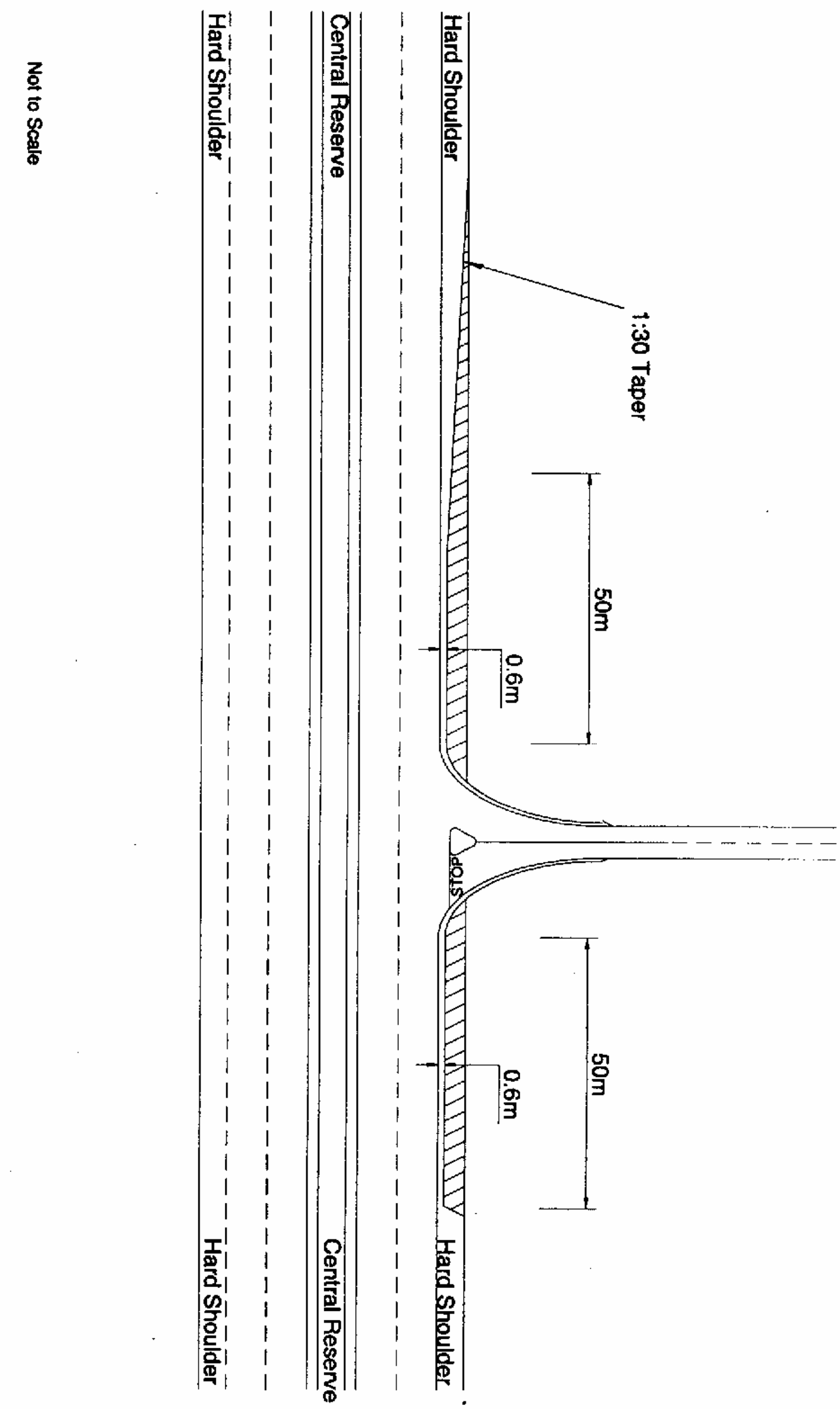
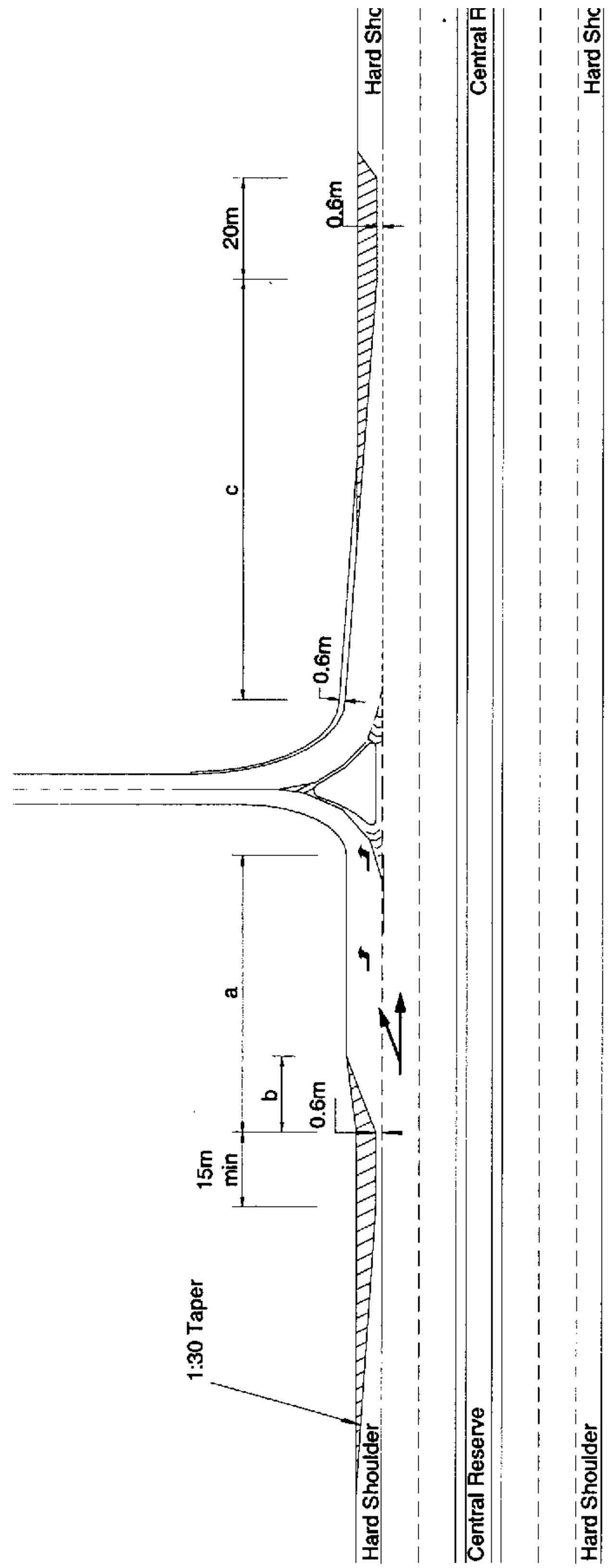


Figure 7/23 Treatment of Hard Shoulders at Dual Carriageway Junction - Without Tapers



a = Deceleration Length (Refer to Table 7/5b)
b = Direct Taper Length (Refer to Table 7/4)
c = MergingTaper (Refer to Table 7/6)
Not to Scale

Figure 7/24 Treatment of Hard Shoulders at Dual Carriageway Junction - With Tapers

ADT ADDENDUM TO

TD 41/95

VEHICULAR ACCESS TO ALL-PURPOSE

TRUNK ROADS

Standard TD 41/95 – Vehicular Access to All-Purpose Trunk Roads – is applicable in Malta with the following amendments:

GENERAL

Note: National road schemes require direct accesses to be designed with “Stop” signs and road markings, however the figures contained in TD 4 1/95 assume that “Yield” (“Give Way”) signs and road markings are used. “Yield” signs and road markings shown in these figures shall be interpreted as meaning “Stop” signs and road markings.

2. At several locations:

For: “trunk road” (except in Annex 2)
Read: “national road”;

For: “Overseeing Organisation”
Read: “Maltese Transport Authority”;

For: “TD 9 (DMRB 6.1.1)”
Read: “ADT TD 9 (ADT DMRB 6.1.1)”;

For: “Large Goods Vehicles”
Read: “Heavy Commercial Vehicles”;

For: “LGV”
Read: “HCV”;

For: “highway”
Read: “road”.

3. At several locations, unless otherwise indicated:

For: ‘‘Give Way”
Read: “Stop”.

SPECIFIC

1. TD41195

1.1 Page 1/1, Paragraph 1.4, line 3:
For: "this country"
Read: "Great Britain".

1.2 Page 1/1, Paragraph 1.5. line 4:
For: "a road designated as unclassified and"
Read: "a minor road".

1.3 Page 1/1, Paragraph ***1.5,*** line 12:
For: **"(TA 18** DMRB 6.2)"
Read: "(TD 50 DMRB 6.2.3)".

1.4 Page 1/1, Paragraph *1.5,* line 19:
For: "para 1.11"
Read: "para 1.12".

1.5 Page 1/1, Paragraph 1.8, line 1:
For: "It has been accepted"
Read: "In Great Britain, it has been accepted".

1.6 Page 1/2, Paragraph 1.9, line 1:
For: "Accident records"
Read: "In Great Britain, accident records".

1.7 Page 1/2, Paragraph 1.10:
Delete Paragraph 1.10 and replace with:

"1.10. This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the Maltese Transport Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with the Maltese Transport Authority."

1.8 Page 1/2, Paragraph 1.12, Minor Junction, line 1:
For: "an unclassified road or a classified unnumbered road"
Read: "a minor road".

1.9 Page 1/2, Paragraph 1.12, Roads: Urban and Rural, line 1:
Delete paragraph and replace with:

"**Roads: Urban and Rural: An** Urban Road is a road which is in a built-up area and has either a single carriageway with a speed limit of 50mph or less, or has a dual carriageway (including motorways) with a speed limit of 80mph or less. All other roads are Rural Roads."

1.10 Page 1/3, Paragraph 1.14, line 14:
Delete final sentence "On. Organisation." and replace with:

"The record shall be endorsed by the Design Organisation' s senior engineer responsible for the scheme. The Design Organisation shall report all Relaxations incorporated into the design as part of the project report at the end of each project management phase."

1.11 Page 2/1, Paragraphs *2.5* and 2.6:
Delete paragraphs and replace with the following:

"2.5 Where an existing direct access is likely to cause, or has caused, danger to road users, then the Road Authority shall endeavour to provide alternative, improved means of access.

2.6 Where alternative means of access cannot be provided, the owners of these existing accesses are expected to use them safely. However the Road Authority shall endeavour to see that improvements are made to these accesses, in order to increase safety."

1.12 Page 2/1, Paragraph 2.7, line 2:
For: "highway"
Read: "road boundary".

1.13 Page 2/2, Paragraph 2.11, line 9:
For: "Direct Accesses shall also not be sited"
Read: "Wherever practicable, Direct Accesses should not be sited".

1.14 Page 2/2, Paragraph 2.12, line 17:
For: "para 1.11"
Read: "para 1.12".

1.15 Page 2/2, Paragraph 2.14, line 5:
For: "are in the bottom half of the range set out in **TD 20** (DMRB 5.1),"
Read: "are less than 60% of the capacity given in Table 4 of ADT TD 9 (ADT DMRB 6.1.1),".

1.16 Page 2/4, Paragraph 2.20, line 5:
For: **"lm** hardstrip"
Read: "hard strip".

1.17 Page 2/4, Paragraph 2.20, line 6:
After first sentence insert:
"Where a hard shoulder on the major road continues across the line of the Direct Access (see Paragraph 2.39), the "X" distance shall be measured from the back of the hard shoulder."

1.18 Page *2/5,* Paragraph 2.29, line *25:*
At end of Paragraph 2.29 insert:
"The layout diagrams indicate the paved width required; adequate visibility shall be provided in accordance with Paragraphs 2.15 to 2.26."

1.20 Page 2/7, Paragraph 2.30, line 31:
At end of Paragraph 2.30 insert:
"Further advice is given in Recommendations for Main Roads

1.21 Page 2/7, Paragraph 2.32, line 6:
For: ‘‘give way~~
Read: "yield".

1.23 Page 2/8, Paragraph 2.38:
After Paragraph 2.38 insert new Paragraphs 2.39 to 2.41:

"Roads with Hard Shoulders

2.39 On roads with hard shoulders, accesses with Layouts 1, 2, 3 (without hard strip), 4, 5, 6, 7 and 8 shall be positioned at the back of the hard shoulder rather than at the edge of carriageway. Alternatively, the hard shoulder adjacent to the access shall be hatched as described in TD 42 (DMRB 6.2.6) for a junction, and the access positioned at the edge of carriageway.

2.40 On roads with hard shoulders, accesses with Layout *5* (ghost island) shall be designed in accordance with TD 42 (DMRB 6.2.6).

2.41 Where diverge or merge tapers are required for accesses on roads with hard shoulders, as Layouts 9 and 10, the taper shall be accommodated within the hard shoulder width and the hard shoulder adjacent to the access shall be hatched as described in TD 42 (DMRB 6.2.6) for junctions."

1.24 Page 2/9, Layout 1:
For: “3.5m mm”
Read: “4m mm”.

1.25 Page 2/9, Layout 2:
For: “lm” (four locations)
Read: “2m”.

1.26 Page 2/10, Layout 3:
For: “lm hardstrip” or “lm strip” (four locations) Read: “hard strip”.

1.27 Page 2/11, Layout 4 and Page 2/12, Layout 7:
For: “lm hardstrip”
Read: “Hard strip”

1.28 Page 3/1, Paragraph 3.7, line 5:
For: “shall be consulted which gives advice”
Read: “may be consulted for advice”.

1.29 Page 4/1, Paragraph 4.1, line 3:
Delete second sentence: “Where an access followed.”

1.30 Page 5/1, Section 5, 1. Design Manual for Roads and Bridges:
Delete references a, g and i, and replace with:
“a. ADT **TD** *9* (DMRB **6.1.1),** Road Link Design.

g. **TD 50** (DMRB 6.2.3), The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts.

i. **Volume 10,** Environmental Design.

j. **Volume** 11, Environmental Assessment.”

1.31 Page 5/1, Section *5,* 2. British Standards:
Insert new reference:
“b. **BS** *5837:* Guide for Trees in Relation to Construction”.

1.33 5/2, Section 5, 6. Other Government Publications:
Insert new reference:
“n. Guidelines for Recommendations for Main Roads

1.34 Page 6/1, Section 6:
Delete text and replace with:
“6.1 All technical enquiries or comments on this Standard should be sent in writing to:

Maltese Transport Authority
Sa Maison Road
Floriana
CMR02

2. **Annex 1**

2.1 Page Al/i, Paragraph A1.5, line 1:
For: **"Overseeing Organisations"**
Read: "Local Authorities"

2.2 Page Al/i, Paragraph A 1.9., line 2:
For: "para **1.4"**
Read: **"para** 1.5".

2.3 Page Al/3, Paragraph Al.13., lineS:
For: "para 1.8"
Read: "para **1.9".**

2.4 Page Al/4, Tables Al/i and *A112,* titles:
Add: "in Great Britain" at the end of each title.

3. Annex 2

3.1 Page A2/l, Paragraph A2.l, line 2:
For: "the trunk road Network"

C.Zammit
Director of the Roads Directorate

ADT ADDENDUM TO

TD 36/93

SUBWAYS FOR PEDESTRIANS AND PEDAL CYCLISTS LAYOUT AND DIMENSIONS

Standard TD 36/93 – Subways for Pedestrians and Pedal Cyclists: Layout and Dimensions – is applicable in Malta with the following amendments:

1. Page 1/1, Paragraph ***1.5,*** line 3:
   For: "trunk roads"
   Read: "national roads".

2. Page 1/1, Paragraph 1.5:
   Delete Paragraph 1.5 and replace with:

   "1.5. This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the Maltese Transport Authority, application would result in significant additional expense or delay progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with the Maltese Transport Authority."

3. Page 2/1, Paragraph 2.3, line 3:
   For: "highway"
   Read: "road".

4. Page 7/1, Reference 14:
   Delete Reference 14 and replace with:
   "14. Traffic Signs Manual, Directorate of Traffic Management."

5. Page 8/1, Section 8:
   Delete text and replace with:
   "8.1. All technical enquiries or comments on this Standard should be sent in writing to:

   Maltese Transport Authority
   Sa Maison Road
   Floriana
   CMR02

C.ZAMMIT
Director of the Roads Directorate, Malta