Design Manual for Roads and Bridges

Road Layout
Design

# CD 109
# Highway link design

(formerly TD 9/93, TD 70/08)

Revision 1

**Summary**
This document provides requirements and advice for all aspects of highway link design to be used for both new and improved all-purpose and motorway trunk roads including connector roads.

**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 1 | Mar 2020 | Revision 1 (March 2020) Update to references in England National Application Annex only. Revision 0 (November 2019) CD 109 replaces TD 9/93 and TD 70/08. This full document has been re-written to make it compliant with the new Highways England drafting rules. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes TD 9/93 "Highway Link Design" and TD 70/08 "Design of Wide Single 2+1 Roads", which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This document sets out the design requirements and advice to be used when developing the design of a highway / road link.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 5.N] apply to this document.

## Design principles

### General

This document provides requirements and advice 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 geometrical elements of the road design, which together form the three dimensional design of the road.

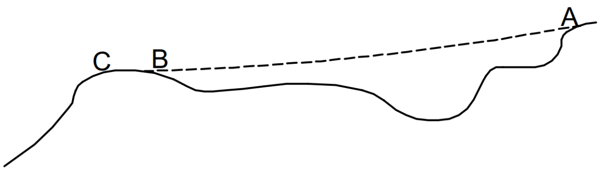
This document provides requirements for maximum and minimum levels of provision for the various design features and also identifies where relaxations from these requirements are permitted.

### Connection to existing roads

Where an improved section of road rejoins an unimproved section of existing road, providing a similar standard of curvature and stopping sight distance as provided for the improvement will create a consistent standard at the interface.

The figure below shows the connection of an improvement to an existing road. The curvature and stopping sight distance at point C is adequate for the approach design speed which has increased due to the improvement between points A and B.

**Connection to existing roads**




### Wide single 2 + 1 roads and climbing lanes

This document includes requirements and advice for the design of wide single 2 + 1 roads and climbing lanes when improving an existing carriageway or in a new build situation.

### Coordinated link design

The various geometrical elements detailed in this document need to be coordinated, together with cross-section ( CD 127 [Ref 1.N]) and junction layouts ( CD 122 [Ref 3.N], CD 123 [Ref 2.N] and roundabouts CD 116 [Ref 4.N]), so the three-dimensional layout as a whole is appropriate in terms of traffic safety, operation and economic / environmental effects. Single carriageway design is given particular emphasis due to the problems of driver understanding and provision for overtaking. A general guide of the layout features, such as edge treatments, access treatments and junction types, that can be appropriate for various types of rural roads is given in Appendix A. 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.

# Abbreviations and symbols

### Abbreviations

| Abbreviation | Definition |
|---|---|
| AADT | Annual average daily traffic |
| C/way | Carriageway |
| D2AP | Dual 2 lane all-purpose |
| D3AP | Dual 3 lane all-purpose |
| D2M | Dual 2 lane motorway |
| D3M | Dual 3 lane motorway |
| D4M | Dual 4 lane motorway |
| FOSD | Full overtaking sight distance |
| Km | Kilometres |
| Kph | Kilometres per hour |
| S2 | Single 2 lane carriageway |
| TSRGD | Traffic Signs Regulations and General Directions |
| VRS | Vehicle Restraint System |
| WS2 | Wide Single 2 lane carriageway |
| WS2+1 | Wide Single 2+1 carriageway |

### Symbols

| Symbol | Definition |
|---|---|
| Ac | Alignment constraint |
| B | Bendiness Degrees / km |
| L | Length of basic transition (metres) |
| Lc | Layout constraint |
| n | Number of observations |
| q | Rate of change of centripetal acceleration (metres / second$^3$) travelling along curve at constant speed V(kph) |
| R | Radius of curve (metres) |
| S | Superelevation % |
| V | Design speed kph |
| VW | Average verge width (averaged for both sides of the road) |
| VISI | Harmonic mean visibility |

# Terms and definitions

**Terms and definitions**

| Term | Definition |
|---|---|
| Adverse camber | A road profile where the carriageway surface slopes away from the inside of a bend, resulting in the carriageway being higher on the inside of the bend than on the outside. |
| Alignment constraint | The degree of constraint imparted by the road alignment. |
| Bendiness | The total change of direction in horizontal alignment in degrees / km measured over a minimum length of 2km. |
| Changeover | A carriageway layout which effects a change in the designated use of the middle lane of a WS2+1 road from one direction of traffic to the opposite direction. |
| Climbing lane | The nearside lane when a lane is added to a single carriageway, dual carriageway or motorway in order to improve capacity and / or safety because of the presence of a steep gradient. |
| Conflicting changeover | A changeover where the vehicles using the middle lane on a WS2+1 road are travelling towards each other. |
| Full overtaking sight distance | The sight distance required for overtaking vehicles using the opposing traffic lane on single carriageway roads. |
| Harmonic mean visibility | The harmonic mean of individual measurements of sight distance. |
| Layout constraint | The degree of constraint imparted by the road cross-section, verge width and frequency of junctions and accesses. |
| Link | A length of road between junctions. |
| Non-conflicting changeover | A changeover where the vehicles using the middle lane on a WS 2+1 road are travelling away from each other. |
| Non-overtaking section | Sections of a 2 lane single carriageway road which are not overtaking sections. |
| Overtaking lane section | A two lane section of a WS2+1 road provided in one direction to facilitate overtaking, with the opposing traffic confined to one lane. |
| Overtaking section | Sections of 2 lane single carriageway road where the combination of horizontal / vertical alignment, visibility, or width provision is such that clear opportunities for overtaking using the opposing lane occur. |
| Single lane section | A single lane section of a WS2+1 road provided in one direction running parallel to an overtaking lane section in the opposite direction. |
| Stopping sight distance | The distance within which drivers need to be able to see ahead to stop from a given speed as required by this document. |
| WS2 carriageway | A wide single carriageway road with one lane in each direction. |
| WS2+1 carriageway | A road with two lanes of travel in one direction and a single lane in the opposite direction as outlined in Section 6 of this document. |
| WS2+1 interface | The interface between a WS2+1 road and a two-lane single carriageway road (S2). |

# 1. Scope

## Aspects covered

1.1 This document provides requirements and advice for all aspects of highway / road link design and shall be used for both new and improved motorway and all-purpose trunk roads.

1.2 This document shall apply to WS2 roads where they are equal to or less than 2km in length.

## Implementation

1.3 This document shall be implemented forthwith on all schemes involving highway / road link design on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 5.N].

## Use of GG 101

1.4 The requirements contained in GG 101 [Ref 5.N] shall be followed in respect of activities covered by this document.

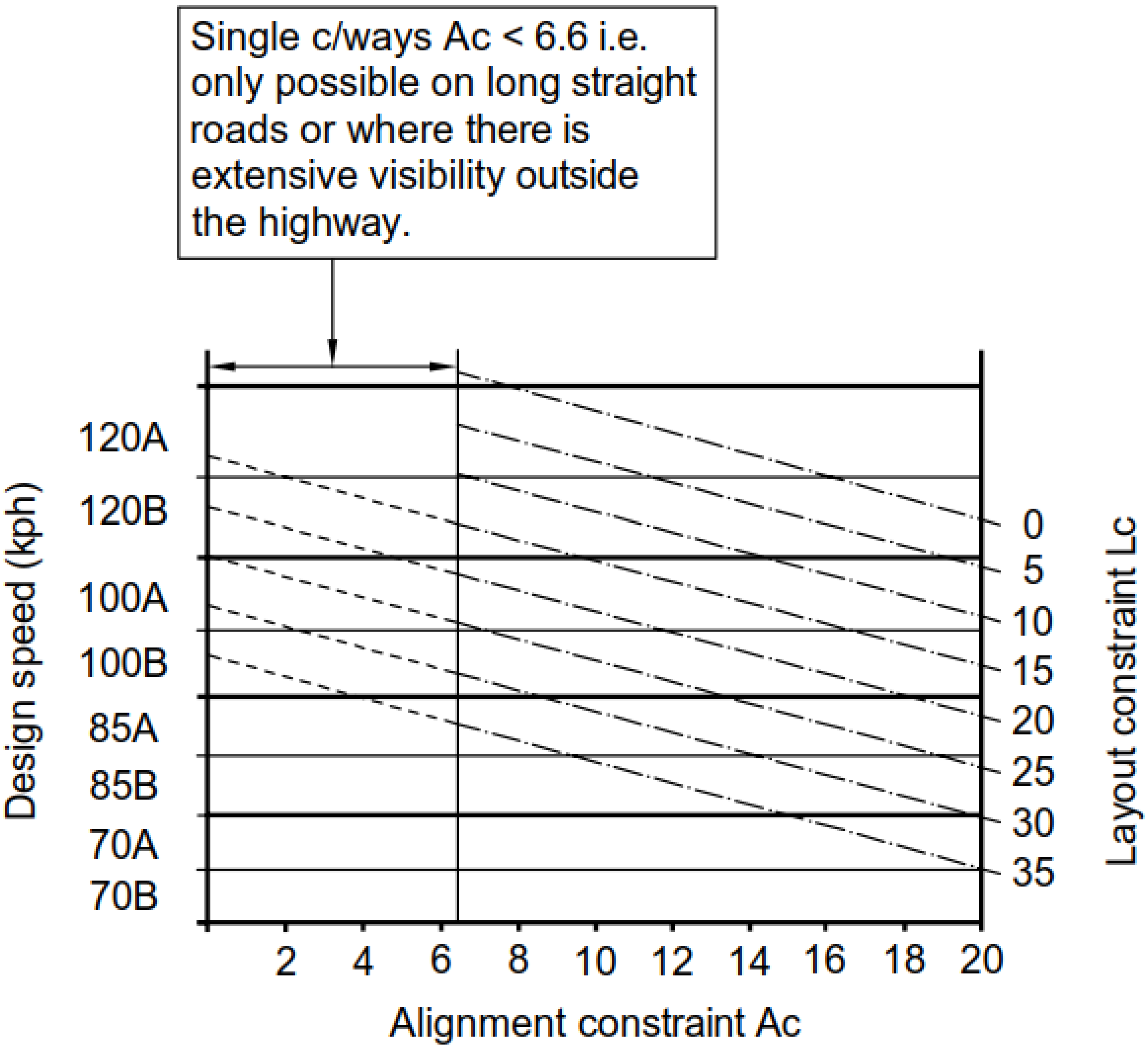
# 2. Design speed

## Selection of design speed

### Rural roads

2.1 For new rural roads, design speed shall be derived from Figure 2.1 using alignment constraint (Ac) and layout constraint (Lc).

**Figure 2.1 Selection of design speed (rural roads)**




*NOTE 1 In Figure 2.1 the design speeds are arranged in bands (i.e. 120kph, 100kph, 85kph, etc). Suffixes A and B indicate the higher and lower categories of each band.*

*NOTE 2 As an example using Figure 2.1 to derive a design speed, an Ac value of 12 and and Lc value of 15 would give a design speed of 100A.*

2.2 Alignment constraint (Ac) shall be calculated using Equation 2.2a and Equation 2.2b for dual carriageways and single carriageways respectively:

**Equation 2.2a Dual carriageways**

$$Ac = 6.6 + \frac{B}{10}$$

**Equation 2.2b Single carriageways**

$$Ac = 12 - \frac{\text{VISI}}{60} + \frac{\text{2B}}{45}$$

where:

B = Bendiness degrees / km.

VISI = Harmonic mean visibility (metres) (see harmonic mean visibility section below).

*NOTE* *Bendiness is calculated by dividing the sum of the change in direction (in degrees) of a road by the length (in km) over which it occurs. For example, a 3km length of road with a total change in direction of 180 degrees would have a bendiness of 60 degrees / km.*

2.3 Layout constraint (Lc) shall be derived using Table 2.3.

**Table 2.3 Layout constraint (Lc)**

| Road type | S2 | | | | WS2 | | WS2+1 | | D2AP | | D3AP | D2M | D3M | D4M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carriageway width (excluding hard strips and hard shoulder) | 6 metres | | 7.3 metres | | 10 metres | | 11.5 metres | | Dual 7.3 metres | | Dual 11 m-etres | Dual 7.3 metres & hard shoulder | Dual 11 metres & hard shoulder | Dual 14.7 metres & hard shoulder |
| Frequency of commercial accesses, lay-bys and junctions | H | M | M | L | M | L | M | L | M | L | L | L | L | L |
| Standard verge width | 29 | 26 | 23 | 21 | 19 | 17 | 19 | 17 | 10 | 9 | 6 | 4 | 0 | 0 |
| 1.5 metre verge | 31 | 28 | 25 | 23 | - | - | - | - | - | - | - | - | - | - |
| 0.5 metre verge | 33 | 30 | - | - | - | - | - | - | - | - | - | - | - | - |
| L = Low number of commercial accesses, lay-bys and junctions, less than or equal to 5 per km | | | | | | | | | | | | | | |
| M = Medium number of commercial accesses, lay-bys and junctions, between 6 to 8 per km | | | | | | | | | | | | | | |
| H = High number of commercial accesses, lay-bys and junctions, greater than or equal to 9 per km | | | | | | | | | | | | | | |

NOTE 1 *Layout constraint (Lc) measures the degree of constraint provided by the road cross-section, verge width, and frequency of junctions, lay-bys and commercial accesses.*

NOTE 2 *Values of Lc are obtained from Table 2.3 by reading along the appropriate verge width rows and down the road type columns corresponding to the appropriate frequency of commercial accesses, lay-bys and junctions. The appropriate value of Lc is denoted by the number read at the intersection of the verge width row and the road type column.*

2.4 For road improvements of up to 2km in length on existing rural roads, the design speed shall be derived using Figure 2.1 with the value of Ac calculated for a minimum road length of 2 km incorporating the section of road improvement.

**Urban roads**

2.5 On urban roads, design speeds shall be selected with reference to the speed limits for the road, as shown in Table 2.5.

**Table 2.5 Urban roads speed limit/design speed relationship**

| Speed limit | | Design speed |
|---|---|---|
| **Mph** | **Kph** | **Kph** |
| 30 | 48 | 60B |
| 40 | 64 | 70A |
| 50 | 80 | 85A |
| 60 | 96 | 100A |

NOTE *Design speeds are higher than the speed limit and therefore permit a small margin for vehicle speeds in excess of the speed limit.*

**Harmonic mean visibility (VISI)**

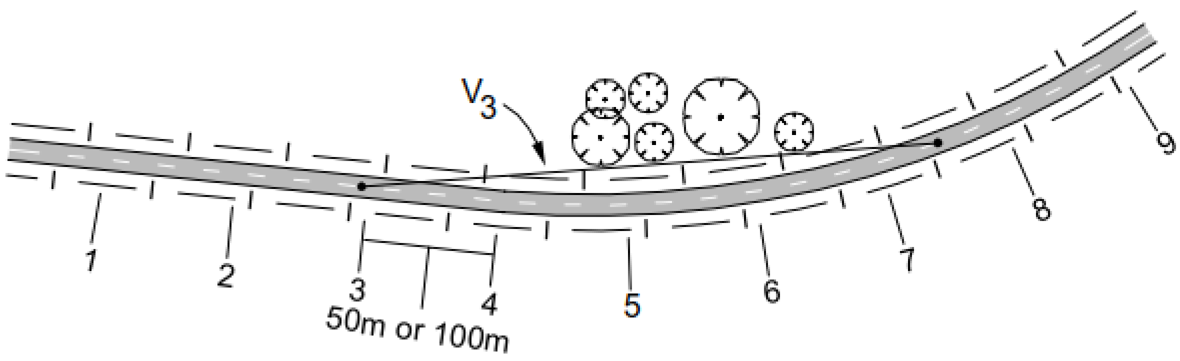
2.6 The harmonic mean visibility (VISI) shall be measured over a minimum length of 2km.

2.6.1 Measurements of sight distance should be taken in both directions at regular intervals (50 metres for sites of restricted visibility, 100 metres for sites with unrestricted visibility).

2.7 Sight distance shall be measured from an eye height of 1.05 metres to an object height of 1.05 metres, with both measurements taken above the centre line of the road surface.

2.8 Sight distance shall be the true sight distance available at any location, including any sight distance available across verges and outside of the highway boundary or across embankment slopes or adjoining land, as shown in Figure 2.8.

**Figure 2.8 Measurement of harmonic mean visibility**




2.8.1 The harmonic mean visibility for new roads should be calculated using Equation 2.8.1.

**Equation 2.8.1 Formula for calculating harmonic mean visibility**

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

where:

| | |
|---|---|
| n = | Number of observations. |
| $V_1$ = | Sight distance at point 1, etc. |

2.8.2 The harmonic mean visibility for existing roads should be calculated using an empirical relationship given in Equation 2.8.2.

**Equation 2.8.2 Empirical relationship**

$$\mathrm{Log}_{10} VISI = 2.46 + \frac{\mathsf{VW}}{25} - \frac{B}{400}$$

where:

| | |
|---|---|
| VW = | Average verge width (averaged for both sides of the road) |
| B= | Bendiness (degree per km - minimum length of 2 km) |

*NOTE 1 Equation 2.8.2 is applicable up to VISI = 720 metres.*

*NOTE 2 On long straight roads, or where sight distance is available outside of the highway boundary, the relationship between the average verge width and bendiness can result in values of harmonic visibility calculated using Equation 2.8.1 being significantly underestimated.*

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

1) VISI = 700 metres for long virtually straight roads, or where the road is predominantly on embankment affording high visibility across embankment slopes or adjoining level land;
2) VISI = 500 metres where a new road is designed with continuous overtaking visibility, with large crest K values and wide verges for visibility;
3) VISI = 300 metres where a new road is designed with frequent overtaking sections, but with stopping sight distance provision at all sharp curves;
4) VISI = 100 - 200 metres where an existing single carriageway contains sharp bends, frequent double white line sections and narrow verges.

*NOTE The empirical relationship provided by Equation 2.8.2 can be used for the preliminary analysis of existing routes if values of bendiness (B) are available.*

## Design speed related parameters and relaxations

2.9 Designs shall provide at least the desirable minimum values for stopping sight distance, horizontal curvature, vertical crest curvature and sag curvature as shown in Table 2.10, except for the following situations:

1) where a relaxation is permitted by sections 2, 3, 4 or 5 of this document;
2) the design of a vertical crest curve on a 2 lane single carriageway road (see Section 9).

2.9.1 Design parameters should meet or exceed desirable minimum values except where particular circumstances relating to 2 lane single carriageways roads exist (see Section 9).

*NOTE Requirements and advice on the application of relaxations below desirable minimum is provided in GG 101 [Ref 5.N].*

2.9.2 Interfaces between sections of road with different design speeds should be designed so as not to suddenly present the driver with low radius horizontal curves, sharp crests or shorter sight distances.

2.10 Minimum geometric parameters for full overtaking sight distance (FOSD) and overtaking crest K values that shall be used for the corresponding design speed are shown in Table 2.10.

**Table 2.10 Design speed related parameters**

| **Design speed kph** | 120 | 100 | 85 | 70 | 60 | 50 | V2/R |
|---|---|---|---|---|---|---|---|
| **Stopping sight distance (metres)** | | | | | | | |
| Desirable minimum | 295 | 215 | 160 | 120 | 90 | 70 | - |
| One step below desirable minimum | 215 | 160 | 120 | 90 | 70 | 50 | - |
| **Horizontal curvature (metres)** | | | | | | | |
| Minimum R* with adverse camber and without transitions | 2880 | 2040 | 1440 | 1020 | 720 | 520 | 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 (superelevation 5%) | 1020 | 720 | 510 | 360 | 255 | 180 | 14.14 |
| One step below desirable Minimum R (superelevation 7%) | 720 | 510 | 360 | 255 | 180 | 127 | 20 |
| Two steps below desirable minimum radius (superelevation 7%) | 510 | 360 | 255 | 180 | 127 | 90 | 28.28 |
| **Vertical curvature** | | | | | | | |
| 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 | - |
| Desirable minimum sag K value | 37 | 26 | 20 | 20 | 13 | 9 | - |
| **Overtaking sight distances** | | | | | | | |
| Full overtaking sight distance FOSD (metres) | - | 580 | 490 | 410 | 345 | 290 | - |
| FOSD overtaking crest K value | - | 400 | 285 | 200 | 142 | 100 | - |
| * Not recommended for use in the design of single carriageways (see Section 9) | | | | | | | |
| The $V^2/R$ values shown above simply represent a convenient means of identifying the relative levels of design parameters, irrespective of design speed. | | | | | | | |

NOTE 1 *The limit for relaxations is defined by a given number of design speed steps below a specific bench mark, 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 permitted relaxations are given in:*

1) *Section 3 for stopping sight distance;*
2) *Section 4 for horizontal alignment; and*
3) *section 5 for vertical alignment.*

NOTE 2 *GG 101 [Ref 5.N] provides requirements and advice on recording the decision process when applying relaxations.*

NOTE 3 *When preparing design options that include relaxations, a number of site specific factors need to be assessed, including, whether the site is:*

1) *isolated from other relaxations;*
2) *isolated from junctions;*
3) *one where drivers have desirable minimum stopping sight distance;*
4) *subject to momentary visibility impairment only;*
5) *subject to low traffic volumes;*
6) *on geometry that is readily understandable to road users;*
7) *on a road with no frontage access;*
8) *one where traffic speeds are reduced locally due to adjacent road geometry (e.g. uphill sections, approaching roundabouts and priority junctions where traffic has to give way or stop, etc), or speed limits.*

NOTE 4 *The safety risk of using a relaxation in the design can be mitigated by providing:*

1) *collision prevention measures;*
2) *specific warning signs and road markings.*

2.11 Values for stopping sight distance, horizontal curvature and vertical curvature shall not be less than those given in Table 2.10 for 50kph design speed regardless of permitted relaxations.

2.12 Except for stopping sight distance relaxations of up to 1 design speed step below desirable minimum coincident with horizontal curvature relaxations of up to 1 design speed step below desirable minimum, relaxations shall not be used in combination.

2.13 The relaxations below desirable minimum in stopping sight distance, desirable minimum vertical curvature for crest curves and sag curves, described in Sections 3 and 5 of this document respectively, shall not be used on the immediate approaches to junctions.

NOTE *For the purposes of this document the immediate approaches to a junction are defined as:*

1) *for minor road approaches at at-grade priority 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 give way line and the stop line or give way line itself;*
2) *for major road approaches at at-grade priority junctions without diverge and merge tapers, 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;*
3) *for at-grade junctions with a diverge taper the length of carriageway from a point 1.5 times the desirable minimum stopping sight distance upstream of the start of the diverge taper to a point level with the minor road centre line;*
4) *for at-grade junctions with a diverge auxiliary lane the length of carriageway from a point 1.5 times the desirable minimum stopping sight distance upstream of the start of the auxiliary lane taper to a point level with the minor road centre line;*

5) *for at-grade junctions with a merge taper the length of carriageway from a point 1.5 times the desirable minimum stopping sight distance upstream of a point level with the minor road centre line to the end of the merge taper;*

6) *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 give way line and the give way line itself;*

7) *for grade separated diverges with a diverge taper, the 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. For diverges without a diverge taper, the length of carriageway 1.5 times the desirable minimum stopping sight distance upstream of a point equivalent to the diverge exit taper length for the appropriate road class (see CD 122 [Ref 3.N]) upstream from the tip of nosing or ghost island head to the back of nosing;*

8) *for grade separated merges with a merge taper, the 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. For merges without a merge taper, the length of carriageway from a point 1.5 times the desirable minimum stopping sight distance upstream of the back of the merge nose to a point equivalent to merge entry taper length downstream of the tip of nosing or ghost island tail (see CD 122 [Ref 3.N]).*

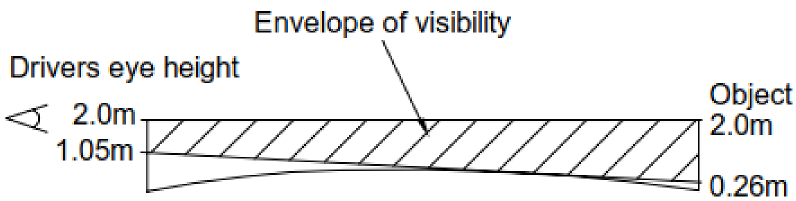
2.13.1 Where the design speed of an alignment changes from a higher to a lower value, permitted relaxations in design standards should be avoided on the length of road with the lower design speed adjacent to its interface with the section of road with the higher design speed.

# 3. Sight distance

## Stopping sight distance

3.1 Stopping sight distance as identified in Table 2.10 shall be measured between driver's eye heights of 1.05 metres and 2.00 metres to object heights of between 0.26 metres and 2.00 metres measured from the road surface, as shown in Figure 3.1.

**Figure 3.1 Measurement of stopping sight distance**

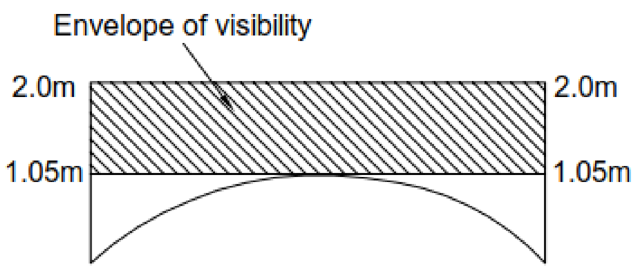



3.2 Desirable minimum stopping sight distance shall be available between any two points in the centre of each lane within the horizontal and vertical extents of the visibility envelope (measured for each carriageway in the case of dual carriageways and motorways).

## Full overtaking sight distance

3.3 Where an overtaking section is provided, at least full overtaking sight distance shall be available between eye heights of 1.05 metres and 2.00 metres to object heights of 1.05 metres and 2.00 metres above the centre of the carriageway as shown in Figure 3.3.

**Figure 3.3 Measurement of full overtaking sight distance**




3.3.1 On 2 lane single carriageway roads, overtaking sections should be provided on as much of the road as practicable, especially where daily traffic flows are expected to approach the maximum design flows.

*NOTE 1 Where an overtaking section is provided on a 2 lane single carriageway road, the full overtaking sight distance to be used is shown in Table 2.10 for the corresponding design speed.*

*NOTE 2 Full overtaking sight distance can normally only be economically provided in flat terrain where the combination of vertical and horizontal alignment permits the design of a level and relatively straight road alignment. It can be more economical to design a single carriageway road to provide clearly identifiable overtaking sections with full overtaking sight distance in relatively level areas, with individual sections of overtaking lane interspersed with non-overtaking sections.*

*NOTE 3 Designs which provide the driver with overtaking sections have been found to have a lower frequency of serious collisions than roads with continuous large radius curves without overtaking sections.*

## Obstructions to sight distance

3.4 The stopping sight visibility envelope shall be free of obstructions by fixed objects with the exception of:

1) a fixed object with a width / length less than or equal to 550mm;
2) a group of fixed objects with a combined width / length of 550mm or less
3) those obstructions covered by the relaxations below.

*NOTE 1 Isolated slim objects less than or equal to 550mm in width / length, such as lighting columns, sign supports, or slim footbridge supports, only result in intermittent obstructions to sight lines.*

*NOTE 2 On horizontal curves where the road is in a cutting, or at bridge crossings, verges and central reserves can be widened or bridge clearances increased to ensure the appropriate stopping sight distance is not obstructed.*

*NOTE 3 Verge and central reserve widening is sometimes required on horizontal curves to provide stopping sight distance in front of VRS.*

3.4.1 Stopping sight distance and FOSD may be measured across opposing lanes or carriageways.

## Relaxations

3.5 Except for the restrictions to relaxations noted in Section 2 (Relaxations) of this document and in the clauses below, relaxations to the desirable minimum stopping sight distance requirements shall be permitted as identified in Table 3.5.

**Table 3.5 Number of steps permitted below desirable minimum - stopping sight distance**

| Road type | Design speed band | Permitted relaxation |
|---|---|---|
| Motorways | Band A | 1 step |
| Motorways | Band B | 2 steps |
| All-purpose | Band A | 2 steps |
| All-purpose | Band B | 3 steps |

3.6 Further relaxations to those shown in Table 3.5 shall be permitted as follows:

1) for all band A roads where the stopping sight distance is reduced by features such as bridge piers, bridge abutments, communications equipment, lighting columns, supports for gantries and traffic signs in the verge or central reserve which form momentary obstructions greater than 550mm in width / length, the scope for relaxations can be extended by 1 design speed step;
2) long bridge parapets or safety fences or safety barriers on horizontal curves can obscure stopping sight distance to the 0.26 metre object height, although the appropriate sight distance to the tops of other vehicles, represented by the 1.05 metre object height, can be obtained above the parapet or safety fence or safety barrier. 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 0.26 metre object height can be extended by 1 design speed step;
3) at or near the top of up gradients on single carriageways steeper than 4% and longer than 1.5 km, the scope for relaxation can be extended by 1 step due to reduced speeds uphill.

3.7 The permitted relaxations identified in Table 3.5 shall be reduced by 1 design speed step:

1) on and immediately following long grades on dual carriageways steeper than 3% and longer than 1.5km;
2) immediately following an overtaking section on single carriageway roads.

# 4. Horizontal alignment

## Road camber and superelevation

4.1 On horizontal curves, with radii less than shown in Table 2.10 (Minimum R with adverse camber and without transitions), (i.e. $V^2/R > 5$) but greater or equal to radii shown in Table 2.10 (Minimum R* with superelevation of 2.5%), 2.5% superelevation falling towards the inside of the curve shall be provided.

4.1.1 On sections of road with radii greater than shown in Table 2.10 (Minimum R with adverse camber and without transitions), (i.e. $V^2/R < 5$), the crossfall or camber should be 2.5% falling from the centre of single carriageways, or the central reserve of dual carriageways, to the outer channels.

*NOTE 1 Document CG 501 [Ref 1.I] provides further advice on the design of crossfall for highway drainage.*

*NOTE 2 It can be necessary to eliminate adverse camber on larger radii for drainage reasons.*

4.2 For curves with radii less than those shown in Table 2.10 (Minimum R with superelevation of 2.5%), (i.e. $V^2/r > 7$) superelevation shall be provided in accordance with Equation 4.2 subject to maximum values for rural and urban roads.

**Equation 4.2 Superelevation**

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

where:

| | |
|---|---|
| V | Design speed (kph) |
| R | Radius (metres) |
| S | Superelevation (%) |

4.3 In rural areas superelevation shall not exceed 7% except on:

1) existing roads, or
2) connector road loops (see CD 122 [Ref 3.N]).

4.4 In urban areas the maximum superelevation shall be 5%.

*NOTE The maximum superelevation in urban areas is influenced by the need to accommodate at-grade junctions and accesses.*

## Relaxations

4.5 Except for the restrictions to relaxations noted in Section 2 (Relaxations) of this document and in the clauses below, relaxations to the desirable minimum horizontal alignment requirements shall be permitted as identified in Table 4.5.

**Table 4.5 Number of steps permitted below desirable minimum - horizontal alignment**

| Road type | Design speed band | Permitted relaxation |
|---|---|---|
| Motorways | Band A | 2 steps |
| Motorways | Band B | 3 steps |
| All-purpose | Band A | 3 steps |
| All-purpose | Band B | 4 steps |

4.6 Further relaxations of 1 design speed step from those shown in Table 4.5 shall be permitted for band B roads at, and immediately before the top of up gradients on single carriageways steeper than 4% and longer than 1.5 km.

NOTE *At locations immediately before the top of gradients the scope for relaxations can be extended due to reduced speeds uphill.*

4.7 The permitted relaxations identified in Table 4.5 shall be reduced by 1 design speed step for band B roads:

1) on, and immediately following long grades on dual carriageways steeper than 3% and longer than 1.5km;
2) immediately following an overtaking section on single carriageway roads.

NOTE *At locations following long grades on dual carriageways and following overtaking sections on single carriageways the scope for relaxations is reduced due to the potential for increased vehicle speeds.*

## Application of superelevation

4.8 Superelevation shall not be introduced, nor adverse camber removed, so gradually as to create large flat areas of carriageway, nor so sharply as to cause road user discomfort due to the change in carriageway profile.

NOTE *Progressive superelevation or removal of adverse camber can be achieved over the length of the transition curve, from the arc end, where transitions are provided.*

4.8.1 The carriageway edge profile should not vary in grade by more than 1% from the line about which the carriageway is pivoted.

4.8.2 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 practicable, i.e. where local drainage conditions permit.

4.8.3 A minimum longitudinal gradient of at least 0.5% should be maintained wherever superelevation is to be applied or reversed.

NOTE 1 *In some locations the application of superelevation can lead to drainage problems, options for mitigating against potential drainage problems can include:*

*1) modifying the horizontal alignment to move the superelevation area,*
*2) increasing the variation in grade of the edge profile, or*
*3) applying a rolling crown.*

NOTE 2 *Situations where the superelevation can lead to drainage problems include locations where the superelevation is applied against the longitudinal gradient.*

4.9 For improvements to existing roads without transitions, between half and two thirds of the superelevation shall be introduced on the approach straight with the remainder provided at the beginning of the curve.

## Widening on curves

4.10 For carriageways of standard width as defined in CD 127 [Ref 1.N], an increase of 0.3 metre per lane shall be provided when the horizontal radius is greater than 90 metres but below 150 metres.

NOTE *Two lane roads of width greater than 7.9 metres require no additional lane widening when the horizontal radius is greater than 90 metres but below 150 metres.*

4.11 For carriageways less than the standard widths as defined in CD 127 [Ref 1.N], widening shall be:

1) 0.6 metres per lane where the radius is greater than 90 metres but below 150 metres subject to maximum carriageway widths of 7.9 metres, 11.9 metres and 15.8 metres (for 2, 3 and 4 lanes carriageways respectively);
2) 0.5 metres per lane where the radius is between 150 metres and 300 metres, subject to a maximum width not being greater than the standard lane widths in CD 127 [Ref 1.N];
3) 0.3 metres per lane, where the radius is between 300 metres and 400 metres subject to a maximum width not greater than the standard lane widths in CD 127 [Ref 1.N].

*NOTE 1* *Widening of curves on links, including where the mainline passes through junctions, need to be provided for carriageways of less than standard width and for low radius curves of standard width.*

*NOTE 2* *Widening on curves is provided to allow for the swept path of long vehicles.*

4.11.1 Where curve widening is applied, the extra lane width should be applied uniformly along the transition curve where a transition curve is provided.

4.11.2 Where curve widening is applied as an improvement to an existing curve, the widening should be applied on the inside of the curve.

## Transitions

4.12 Transition curves shall be provided on curves with radii less than shown in Table 2.10 (minimum R with adverse camber and without transitions).

*NOTE* *The calculation of transition curves is a two-step process where firstly the length of basic transition is calculated using Equation 4.13 then the results of this calculation are compared with a further calculation using √(24R).*

**Length of curve:**

4.13 The length of basic transition curves shall be derived from the formula:

**Equation 4.13 Calculation of basic transition length**

$$L = \frac{V^3}{46.7qR}$$

where:

| | |
|---|---|
| L = | Length of basic transition (metres) |
| V = | Design speed (kph) |
| q = | Rate of increase of centripetal acceleration (metres / sec³) travelling along curve at constant speed V (kph) |
| R = | Radius of curve (metres) |

4.14 The value of q used in the basic transition length calculation shall not exceed 0.6 metres / sec³.

4.14.1 The value of q used in the basic transition length calculation should not exceed 0.3 metres / sec³.

4.15 Where the results of the calculation of basic transition length gives a value less than √(24R) metres, the basic transition length calculated by the formula shall be used.

4.15.1 Where the results of the calculation of basic transition length gives a value greater than √(24R) metres, the √(24R) metres value should be used.

*NOTE 1* *Where a transition length of √(24R) is used this can result in a transition curve with a q value greater than 0.6 metres / sec³.*

*NOTE 2* *The use of transition lengths in excess of √(24R) metres can create flat areas of carriageway resulting in drainage issues.*

4.15.2 Where the basic transition appropriate to the design speed results in insufficient transition length to accommodate superelevation turnover, longer transitions to match the superelevation design should be provided.

# 5. Vertical alignment

## Gradients

5.1 Longitudinal gradients of links shall not exceed the permitted relaxation values given in Table 5.1.

**Table 5.1 Desirable maximum and permitted relaxations to gradients**

| | Desirable maximum | Permitted relaxations |
|---|---|---|
| Motorways | 3% | 4% |
| All-purpose dual carriageways | 4% | 8% |
| All-purpose single carriageways | 6% | 8% |

5.1.1 Wherever practicable desirable maximum values for longitudinal gradients of links should not be exceeded.

*NOTE Climbing lanes (see Sections 7 and 8 of this document) can be appropriate for gradients above 2% on single carriageway and for gradients of 3% and above on dual carriageways.*

### Minimum gradient

5.2 On kerbed roads with a minimum gradient of 0.5% the drainage path shall be provided by false channel paths.

5.2.1 In flatter areas, the vertical alignment should not be manipulated by the introduction of vertical curvature simply to achieve the required surface water drainage gradients.

*NOTE The creation of false channel paths involves providing a drainage path steeper than the adjacent road surface gradient. Methods of achieving this can include providing kerb units with integral drainage channels.*

5.2.2 The desirable minimum gradient for a kerbed road should be 0.5% to enable effective drainage.

5.2.3 Where kerbs are inappropriate, false channel paths may be avoided by using over-edge drainage.

## Vertical curves

### General

5.3 Vertical curves shall be provided at all changes in gradient.

*NOTE The use of permitted vertical curve parameters normally results in compliance with the visibility requirements; however, the horizontal alignment of the road, the presence of crossfall, superelevation or verge treatment and features such as signs, vehicle restraint systems and structures adjacent to the carriageway can affect the interaction between vertical curvature and visibility. Therefore stopping sight distance still needs to be checked.*

### Crest curves

5.4 The lengths of vertical crest curves shall be determined by multiplying the K values shown in Table 2.10 by the algebraic change of gradient expressed as a percentage.

*NOTE 1 As an example, the length of crest curve connecting a gradient of +3% with a gradient of -2% on a road with a design speed of 120kph would be calculated in the following way. The difference between the +3% gradient and the -2% gradient creates a total grade change of 5%. For a design speed of 120 kph, the desirable minimum K value obtained from Table 2.10 is 182. Multiplying the grade change by the K value (5 x 182) gives a vertical crest curve length of 910 metres.*

*NOTE 2 There are two factors that affect the choice of crest curvature: these are visibility and comfort. The crest in the road can restrict forward visibility to the desirable minimum stopping sight distance before driver comfort is affected.*

### Sag curves

5.5 The lengths of vertical sag curves shall be determined by multiplying the K values shown in Table 2.10 by the algebraic change of gradient expressed as a percentage.

*NOTE 1 As an example, the length of sag curve connecting a gradient of +3% with a gradient of -2% on a road with a design speed of 120kph would be calculated in the following way. The difference between the +3% gradient and the-2% gradient creates a total grade change of 5%. For a design speed of 120 kph, the desirable minimum K value obtained from Table 2.10 is 37. Multiplying the grade change by the K value (5 x 37) gives a vertical sag curve length of 185 metres.*

*NOTE 2 The provision of sag curves based on desirable minimum K values does not usually result in obstruction to stopping sight distance (unless overbridges, signs or other features are present). Road user comfort is usually affected before desirable minimum stopping sight distance is impacted.*

## Relaxations

### Crest curves

5.6 Except for the restrictions to relaxations noted in Section 2 (Relaxations) of this document and in the clauses below, relaxations to the desirable minimum crest curve requirements shall be permitted as identified in Table 5.7.

5.7 Further relaxations to those shown in Table 5.7 shall be permitted as follows:

1) on, and immediately following the top of up gradients on single carriageways steeper than 4% and longer than 1.5 km, the scope for relaxations can be extended by 1 step due to reduced speeds uphill;
2) for band A roads when the crest curve is within a straight section the scope for relaxations can be extended by 1 design speed step.

**Table 5.7 Number of steps permitted below desirable minimum - crest curves**

| Road type | Design speed band | Permitted relaxation |
|---|---|---|
| Motorways | Band A | 1 step |
| Motorways | Band B | 2 steps |
| All-purpose | Band A | 2 steps |
| All-purpose | Band B | 3 steps |

5.8 The permitted relaxations identified in Table 5.7 shall be reduced by 1 design speed step immediately following an overtaking section on single carriageway roads.

### Sag curves

5.9 Except for the restrictions to relaxations noted in Section 2 (Relaxations) of this document and in the clauses below, relaxations to the desirable minimum sag curve requirements shall be permitted as identified in Table 5.9.

**Table 5.9 Number of steps permitted below desirable minimum - sag curves**

| Road Type | Permitted relaxation |
|---|---|
| Motorways | None |
| All-purpose 50B, 60B, and 70B | 2 steps |
| All-purpose all others | 1 step |

5.10 The permitted relaxations identified in Table 5.9 shall be extended by 1 design speed step for design speeds of 70kph and less where the road is illuminated.

5.11 The permitted relaxations identified in Table 5.9 shall be reduced by 1 design speed step for roads in design speed bands 50B, 60B and 70B immediately following an overtaking section on single carriageway roads.

# 6. Wide single 2+1 roads

## Design principles

6.1 Wide single 2+1 (WS2+1) roads shall only apply to rural all-purpose single carriageway roads.

6.1.1 WS2+1 roads should only be used for routes with a traffic flow of up to 25,000 vehicles annual average daily traffic (AADT).

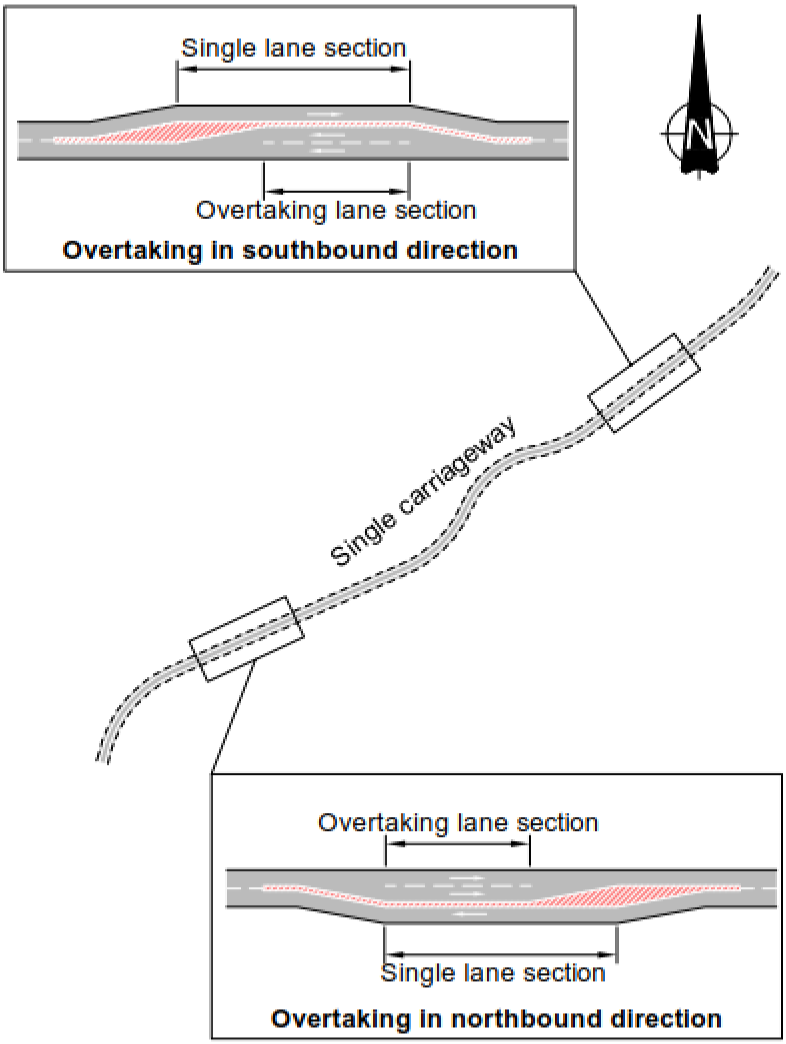
6.1.2 Factors such as the number of accesses, junction spacing, grade separation and gradient can have a significant impact on the design of a WS2+1 road, therefore reference should be made to CD 123 [Ref 2.N] and Section 5 of this document.

6.1.3 Individual sections of WS2+1 road providing overtaking opportunities in one direction (i.e. without changeovers) may be introduced within standard single carriageway roads or wide single roads.

6.1.4 Where individual sections of WS2+1 are provided, overtaking opportunities should also be available in the opposite direction as part of a route strategy, see Section 9 of this document.

*NOTE Overtaking opportunities can be achieved by the provision of additional WS2+1 sections in close proximity, as illustrated in Figure 6.1.4N.*

**Figure 6.1.4N Individual sections of WS2+1 road providing overtaking opportunities in one direction**




6.2 For existing single carriageway roads converted to WS2+1, where desirable minimum stopping sight distance is available, the provision of section C curves shall be permitted.

*NOTE* *The horizontal and vertical alignment design parameters for single carriageway roads, given in this document, apply to the design of WS2+1 roads.*

6.3 Direct interfaces between WS2+1 roads and dual carriageways shall not be permitted unless the interface occurs at a roundabout.

6.4 Where a roundabout does not provide a direct interface between a WS2+1 road and a dual carriageway, a 2km section of single carriageway shall be provided between the WS2+1 layout and the dual carriageway section.

*NOTE 1* *Overtaking lane sections can start directly at the exit from the roundabout.*

*NOTE 2* *Where there is a need to provide overtaking opportunities on a single carriageway road at an isolated uphill gradient of greater than 2% and longer than 500 metres, Section 7 of this document provides requirements and advice for providing climbing lanes.*

## Geometric standards

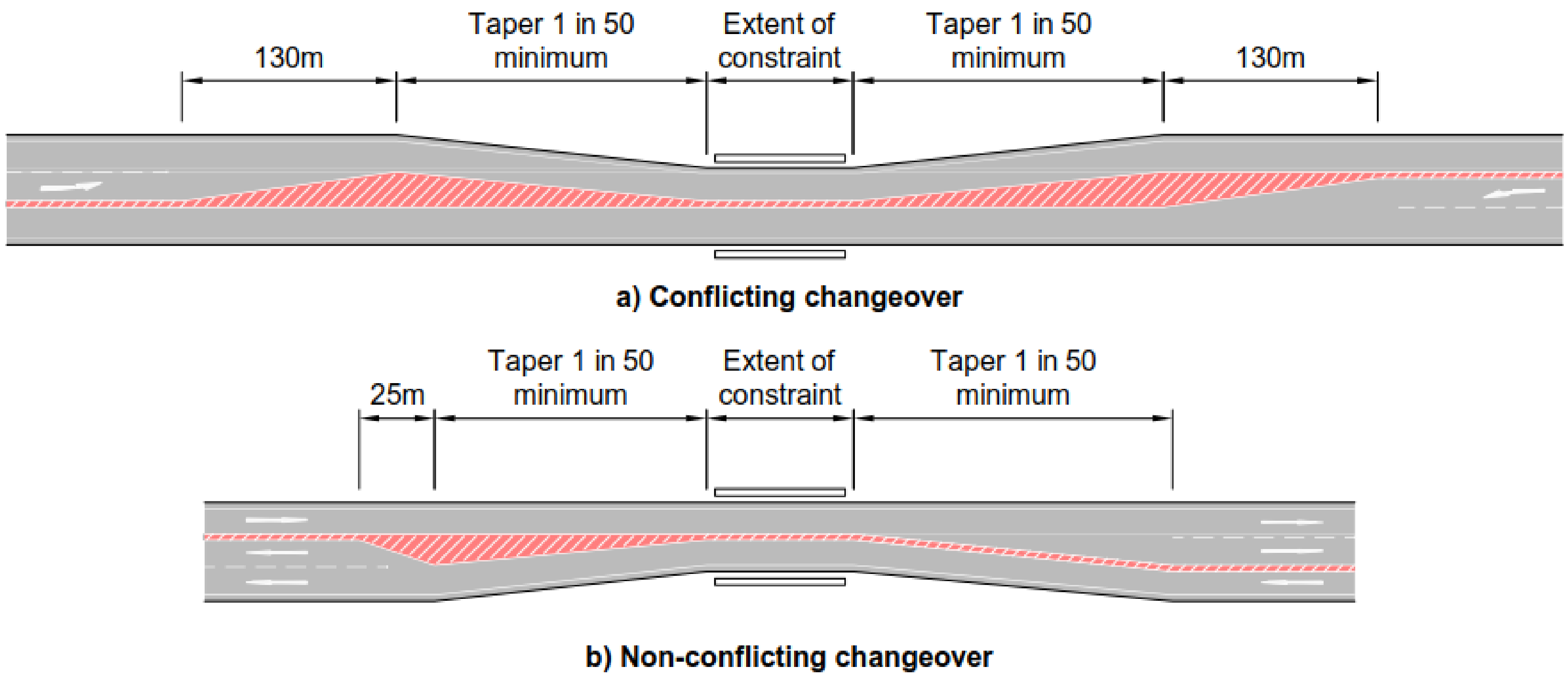
### Cross-section

6.5 On sections of WS2+1 between junctions, the crown of the road shall be located within the double white lines and not within traffic lanes.

*NOTE* *For requirements and advice for cross-sectional elements of WS2+1 roads see CD 127 [Ref 1.N].*

6.5.1 When improving existing roads at restricted locations, the cross-section may be reduced by the use of a changeover to omit the overtaking lane as shown in Figure 6.5.1.

**Figure 6.5.1 Removal of overtaking lanes at restricted locations**



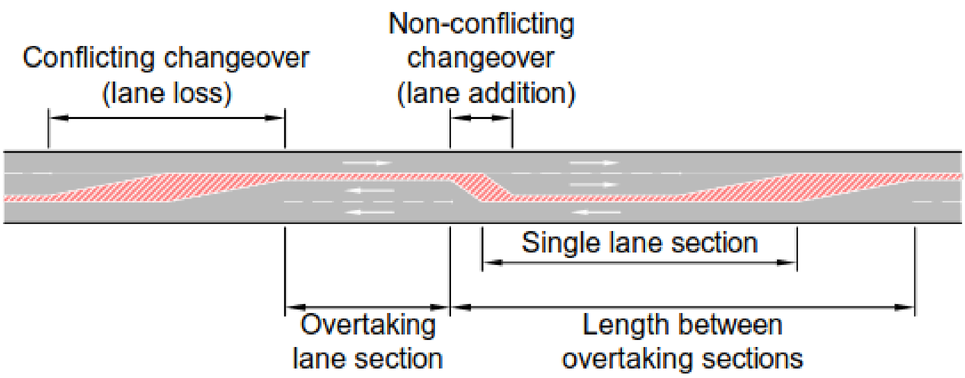
6.5.2 Where a changeover is provided to remove the overtaking lane at a constrained location, the double white line system should be continued through the restricted location as illustrated in Figure 6.5.1.

**Lengths of overtaking lane sections**

6.6 The minimum length of an overtaking lane section shall be 800 metres (see Figure 6.1.4N and Figure 6.7).

6.7 The maximum length of an overtaking lane section shall be 1500 metres.

**Figure 6.7 Typical layout of a WS2+1 road with changeover**

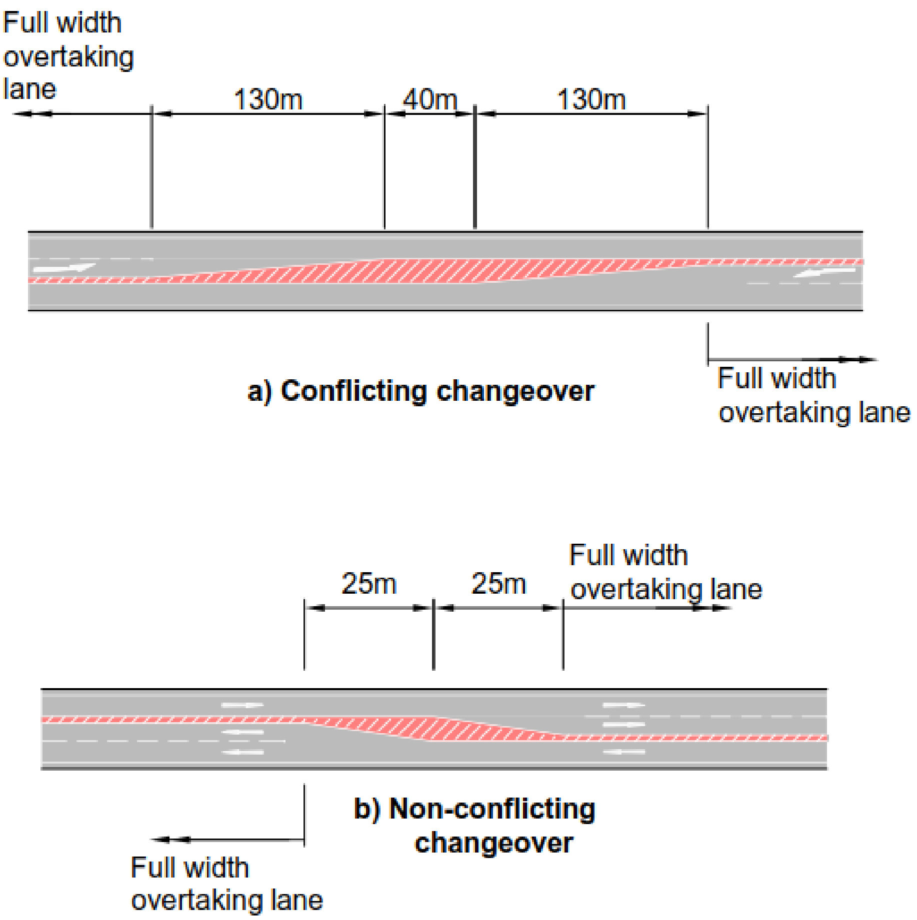



*NOTE* *Overtaking lane sections between 800 metres and 1500 metres in length provide sufficient length to disperse platoons of traffic but are not so long as to cause frustration for drivers in the single lane section.*

**Changeovers**

6.8 Where changeovers are remote from junctions they shall be in accordance with the layouts shown in Figure 6.8.

**Figure 6.8 Dimension of changeovers**




*NOTE* *Details of layouts where junctions are incorporated in changeovers are given in CD 123 [Ref 2.N].*

6.9 Conflicting changeovers shall not be located where the curve radius falls within section C or below of Figure 9.24N2 (see Section 9 of this document).

6.10 At least desirable minimum stopping sight distance shall be provided on the immediate approach to and through all changeovers.

*NOTE* *For the purposes of this document, the immediate approach to a changeover is the length of carriageway from a point 1.5 times the desirable minimum stopping sight distance upstream of the start of the changeover taper through the changeover to a point where the cross-section returns to the standard WS 2+1 layout (as defined in CD 127 [Ref 1.N]).*

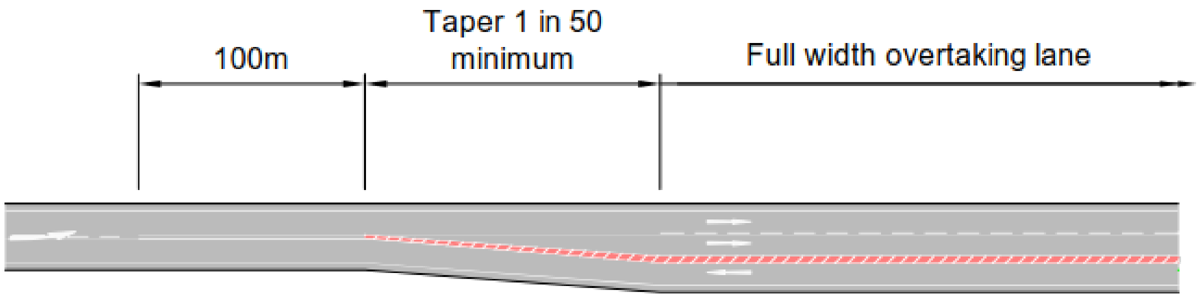
**WS2+1 interfaces**

6.11 WS2+1 interfaces shall not coincide with horizontal curves less than the required desirable minimum radius for the link as identified in Section 2 of this document.

6.11.1 Where a WS2+1 carriageway terminates, the same standards of horizontal and vertical alignment and visibility that apply to the WS2+1 road as defined in Sections 2 to 5 of this document should be applied to the length of two lane single carriageway road within 1.5 times desirable minimum stopping sight distance of the WS2+1 interface.

6.11.2 The layout at the start of a section of WS2+1 road should be designed by widening to the right-hand side (from the perspective of traffic entering the WS 2+1 overtaking section), as shown in Figure 6.11.2.

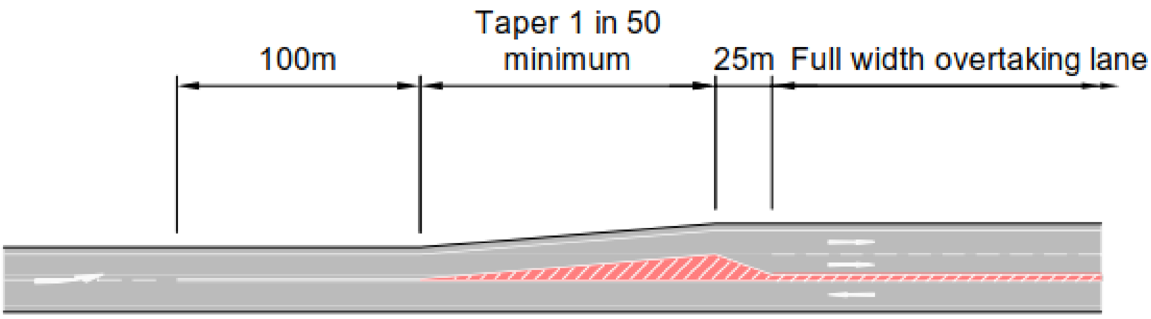
**Figure 6.11.2 WS2+1 start of overtaking lane section with widening on right-hand side**




*NOTE The widening of the nearside channel to the right-hand side encourages drivers to maintain their position on the nearside.*

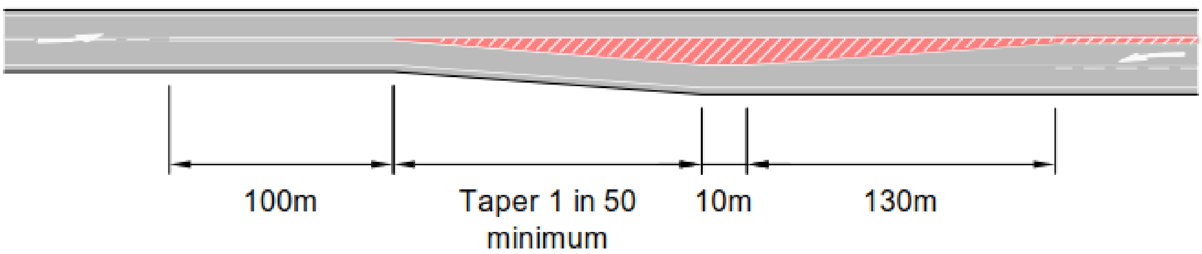
6.11.3 Where physical constraints necessitate widening to the left-hand side (from the perspective of traffic entering the WS 2+1 overtaking section), the layout should guide traffic into the left hand lane, as shown in Figure 6.11.3.

**Figure 6.11.3 WS2+1 start of overtaking lane section with widening on left-hand side**




6.11.4 The layout for a WS2+1 interface where the WS2+1 road ends at a single lane section should be as shown in Figure 6.11.4.

**Figure 6.11.4 WS2+1 end of overtaking lane section**




## Traffic signs and road markings

6.12 Traffic signs to TSRGD 2016 [Ref 6.N] diagram 521 (schedule 2, part 2, item 16), prescribed to indicate the resumption of two-way traffic at the end of a dual carriageway road, shall not be used.

6.12.1 Traffic signs and road markings that should be used on WS2+1 roads are shown in Figure 6.12.1a to 6.12.1d.

**Figure 6.12.1a Traffic signs and road markings at WS2+1 interface (commencing on single lane section)**

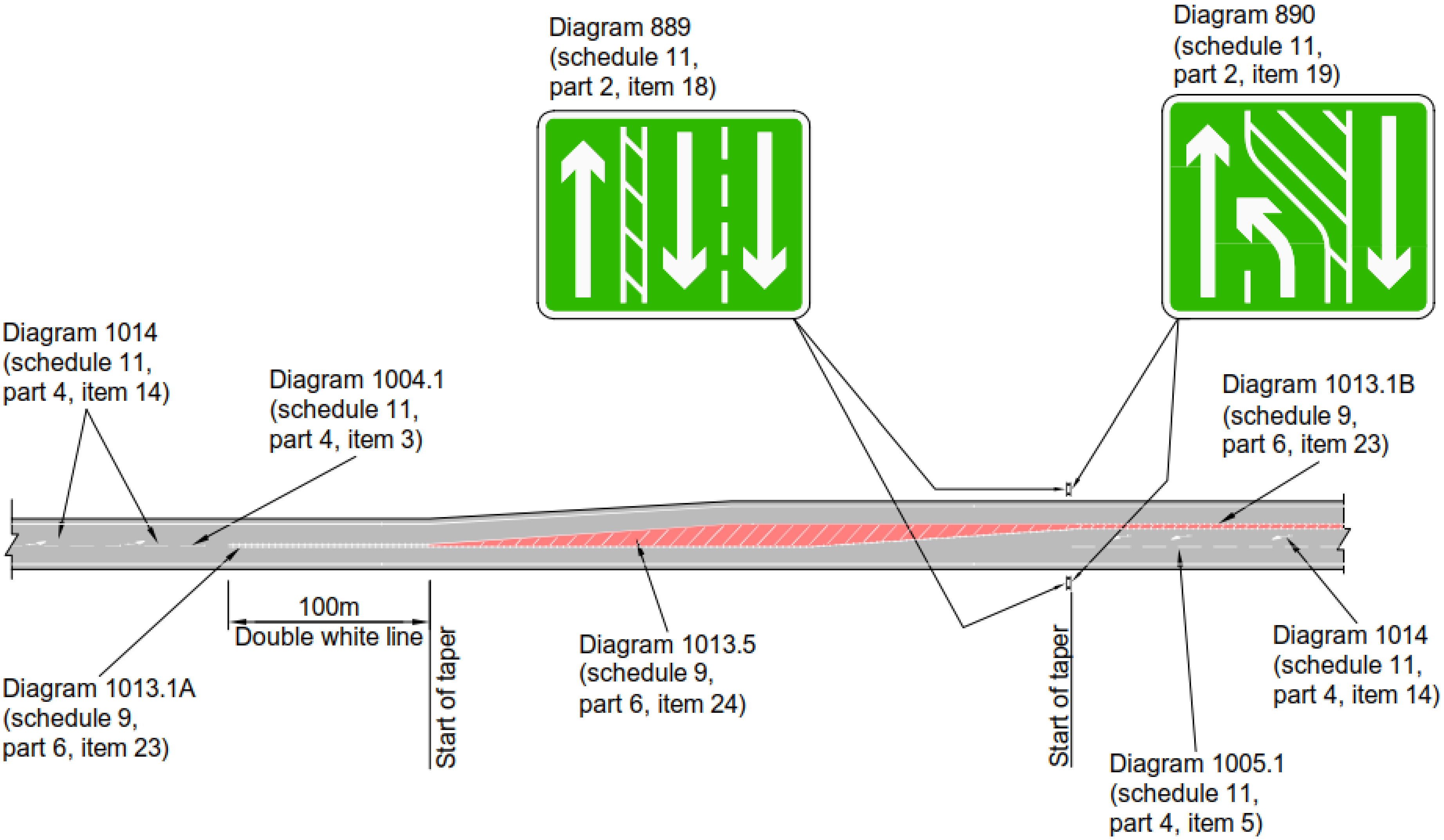


**Figure 6.12.1b Traffic signs and road markings at WS2+1 interface (commencing on overtaking lane section)**

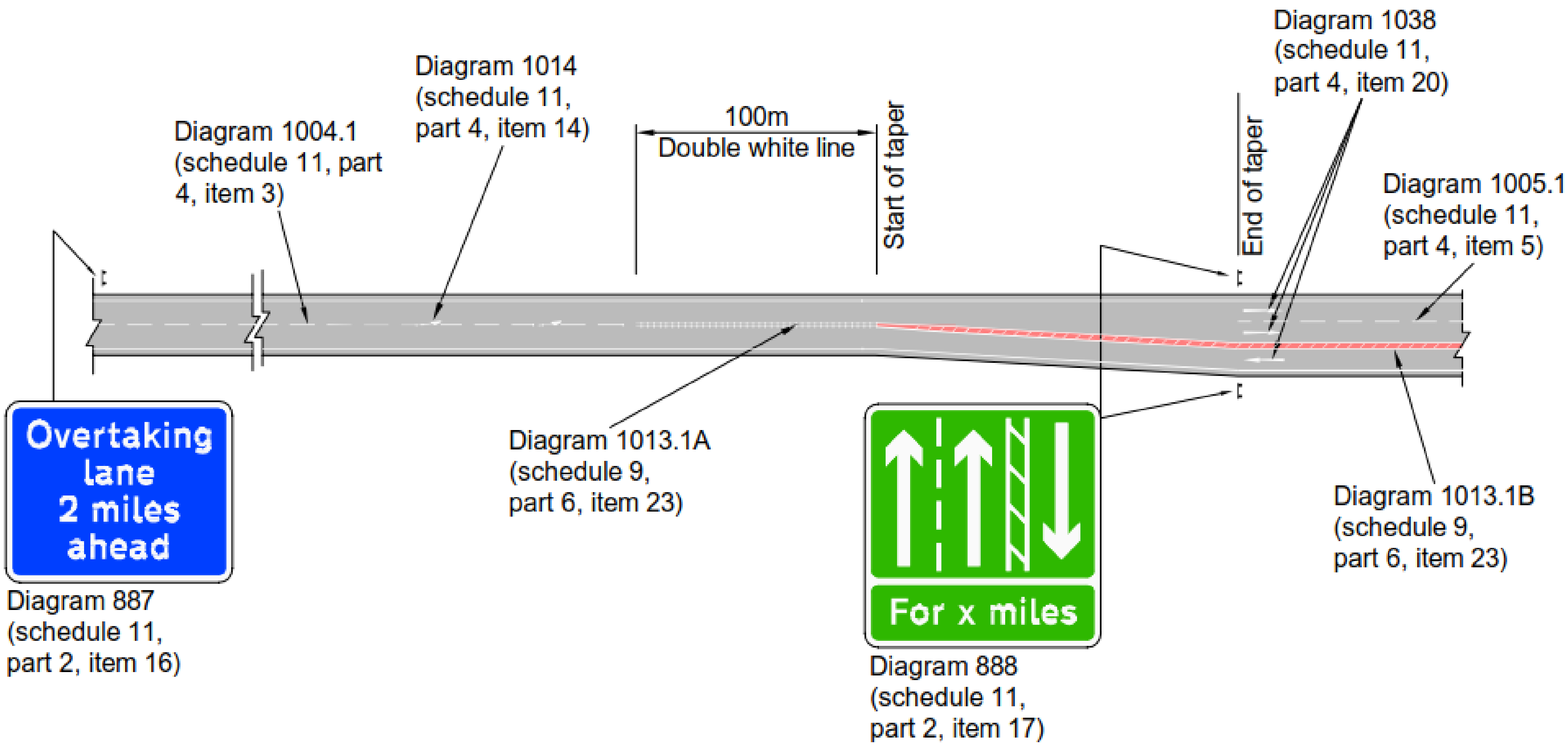


**Figure 6.12.1c Traffic signs and road markings at a conflicting changeover**

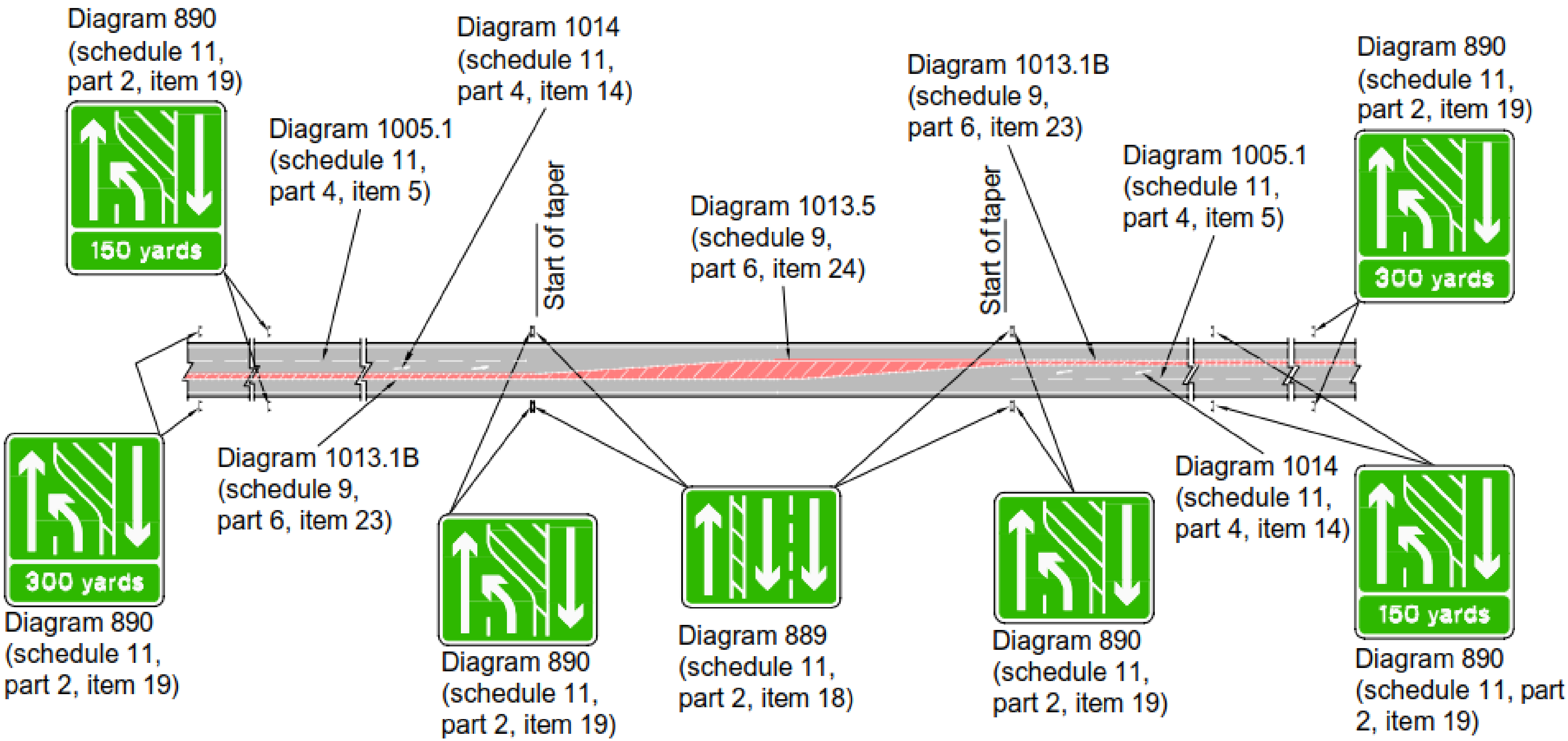
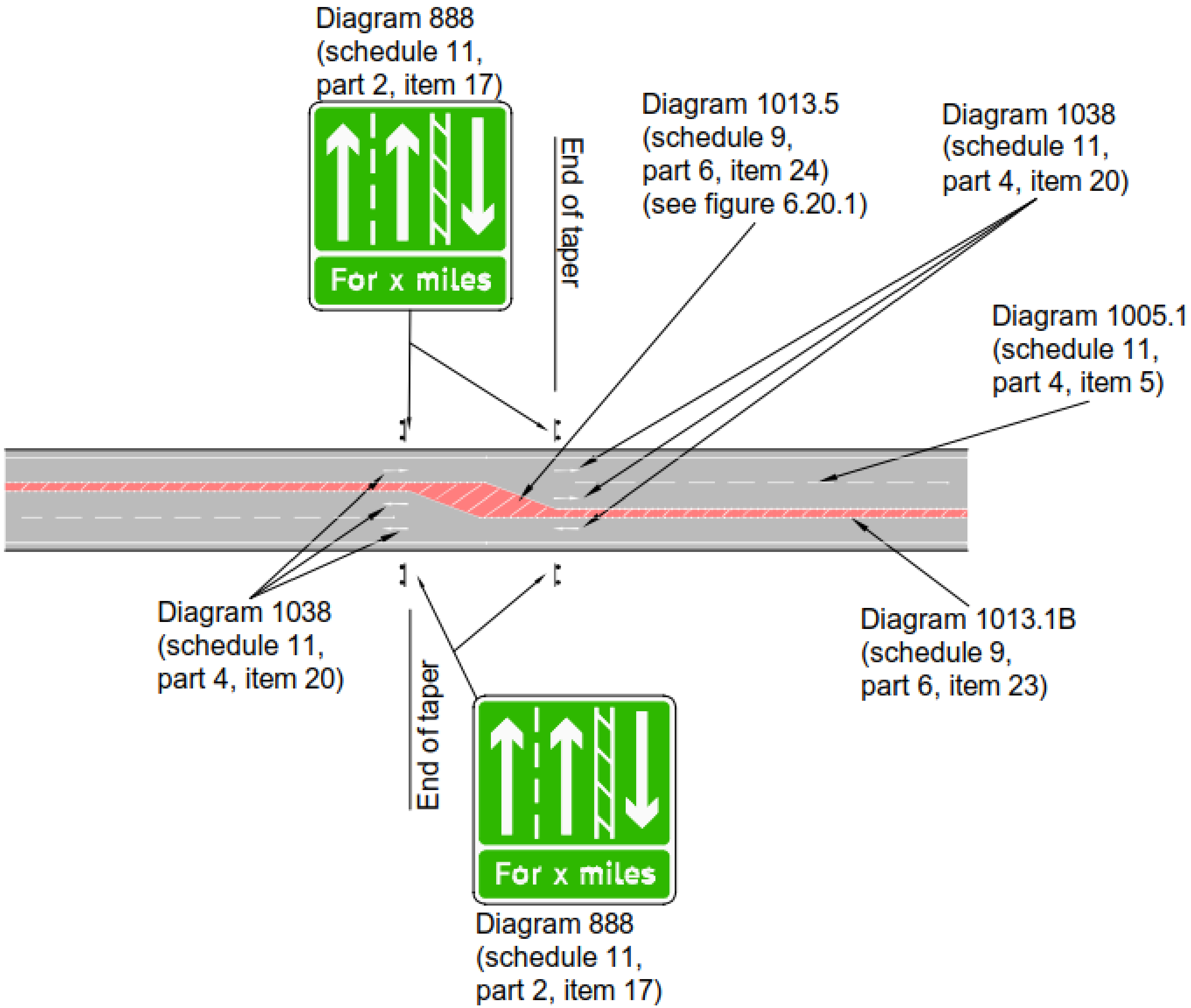


**Figure 6.12.1d Traffic signs and road markings at a non-conflicting changeover**



*NOTE 1 Diagram numbers shown in Figures 6.12.1a to 6.12.1d refer to TSRGD 2016 [Ref 6.N].*

*NOTE 2 Arrow road markings to TSRGD 2016 [Ref 6.N] diagram 1014 (schedule 11, part 4, item 14) are to be place in accordance with the TSM Chapter 5 [Ref 9.N].*

*NOTE 3 Road studs are to be placed in accordance with TSRGD 2016 [Ref 6.N] and TSM Chapter 5 [Ref 9.N].*

*NOTE 4 See TSM Chapter 4 [Ref 8.N] for distance information on informatory traffic signs.*

6.12.2 Advance information up to a distance of two miles prior to the start of the overtaking lane section may be given by the use of the signs shown in Figure 6.12.1b.

*NOTE Traffic signs as shown in Figure 6.12.1b can reduce frustration and encourage drivers to delay overtaking until the overtaking lane section is reached.*

6.12.3 Traffic signs as shown in Figure 6.12.1a should be used at the WS2+1 interface.

*NOTE At priority junctions, traffic signs and road markings are such that drivers do not confuse the right turning lane with the start of an overtaking lane section.*

6.13 The double white line road marking system separating the directions of flow on a WS2+1 road shall be to TSRGD 2016 [Ref 6.N] diagram 1013.1B (schedule 9, part 6, item 23).

6.14 The width of the road marking to TSRGD 2016 [Ref 6.N] diagram 1013.1B (schedule 9, part 6, item 23) shall be 1.0 metre including white lines.

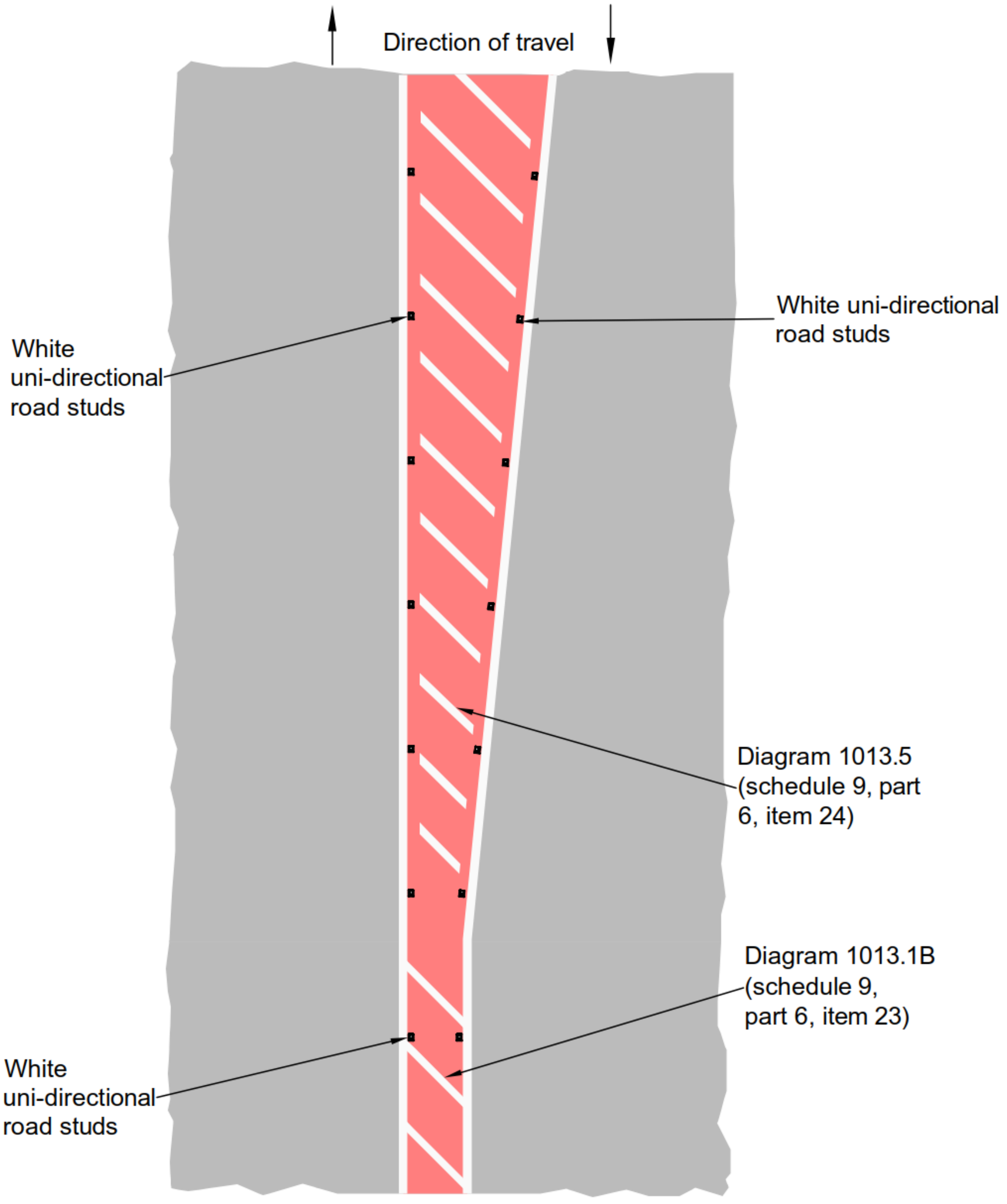
6.15 Road marking to TSRGD 2016 [Ref 6.N] diagram 1013.1B (schedule 9, part 6, item 23) shall incorporate differential coloured surfacing.

6.16 The white line for the TSRGD 2016 [Ref 6.N] diagram 1013.1B (schedule 9, part 6, item 23) shall be 150mm wide.

6.17 At changeovers, interfaces and junctions, the road marking to TSRGD 2016 [Ref 6.N] diagram 1013.1B (schedule 9, part 6, item 23) shall change to the wider road marking to TSRGD 2016 [Ref 6.N] diagram 1013.5 (schedule 9, part 6, item 24) as shown in Figures 6.12.1a to 6.12.1d and 6.17.1.

6.17.1 Road markings to TSRGD 2016 [Ref 6.N] diagram 1013.1B (schedule 9, part 6, item 23) and 1013.5 (schedule 9, part 6, item 24) should be fitted with studs in pairs, within the width of each of the two lines, as shown in Figure 6.17.1 (also see TSM Chapter 5 [Ref 9.N]).

**Figure 6.17.1 Interface between TSRGD diagram 1013.1B (shedule 9, part 6, item 23) and 1013.5 (shedule 9, part 6, item 24)**




*NOTE 1* *Diagram numbers shown in Figure 6.17.1 refer to TSRGD 2016 [Ref 6.N].*

*NOTE 2* *Road studs are to be placed in accordance with TSRGD 2016 [Ref 6.N] and TSM Chapter 5 [Ref 9.N].*

6.17.2 The studs used in the road markings should be uni-directional so that only reflectors on the line of studs adjacent to the road users direction of travel face the road user.

# 7. Climbing lanes - single carriageways

## Introduction

7.1 Where there is a need to provide overtaking opportunities on a single carriageway road at an isolated uphill gradient of greater than 2% and longer than 500 metres, the overtaking section shall be designed as a climbing lane.

7.2 This section shall be used for the design of climbing lanes on single carriageway all-purpose road schemes including improvements to the existing all-purpose trunk road network.

*NOTE 1 For the widths of cross-sectional elements of single carriageway climbing lanes see CD 127 [Ref 1.N].*

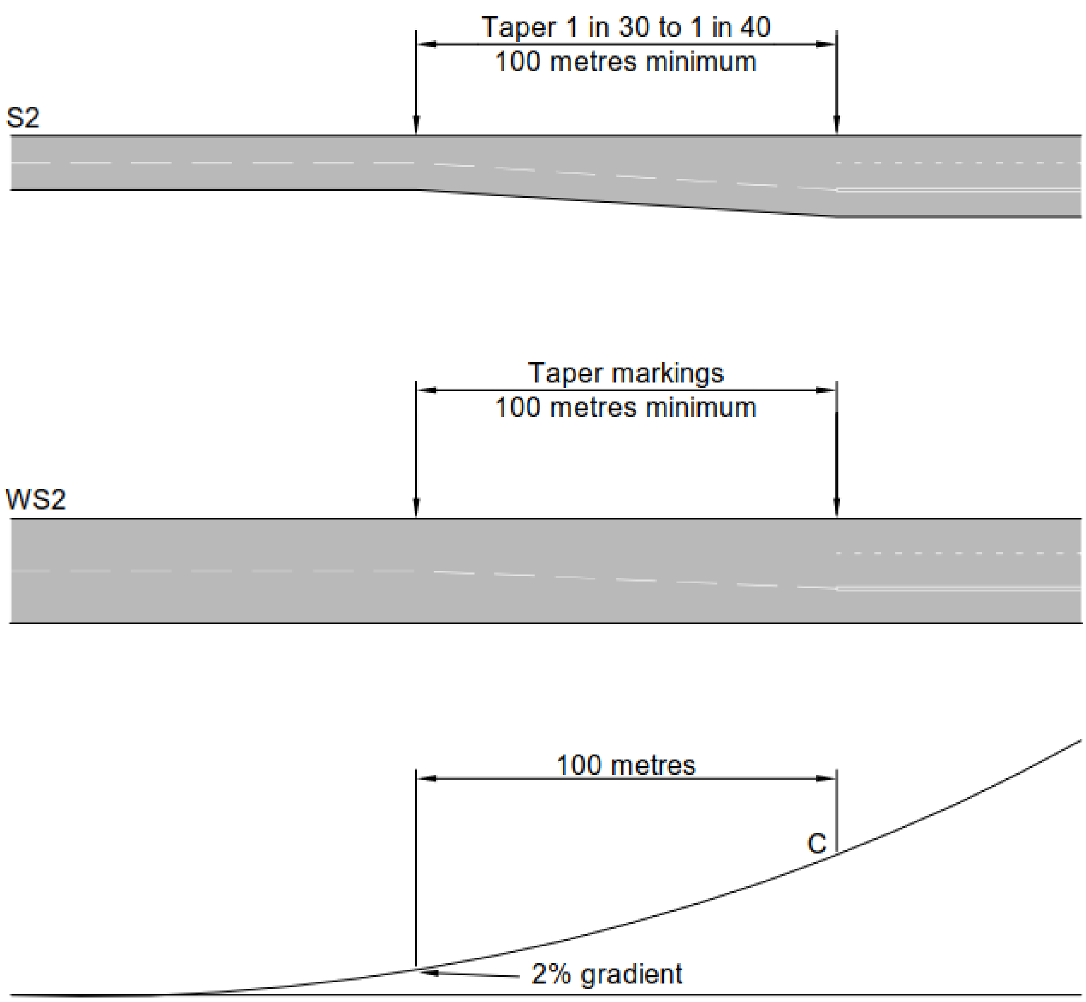
*NOTE 2 For details of the layout of junctions on climbing lanes see CD 123 [Ref 2.N].*

## Layout

### Layout at the start of a climbing lane

7.3 The full width of a climbing lane shall be provided at a point C, 100 metres uphill from the 2% point of sag curve, as shown in Figure 7.3.

**Figure 7.3 Layout at the start of climbing lanes**



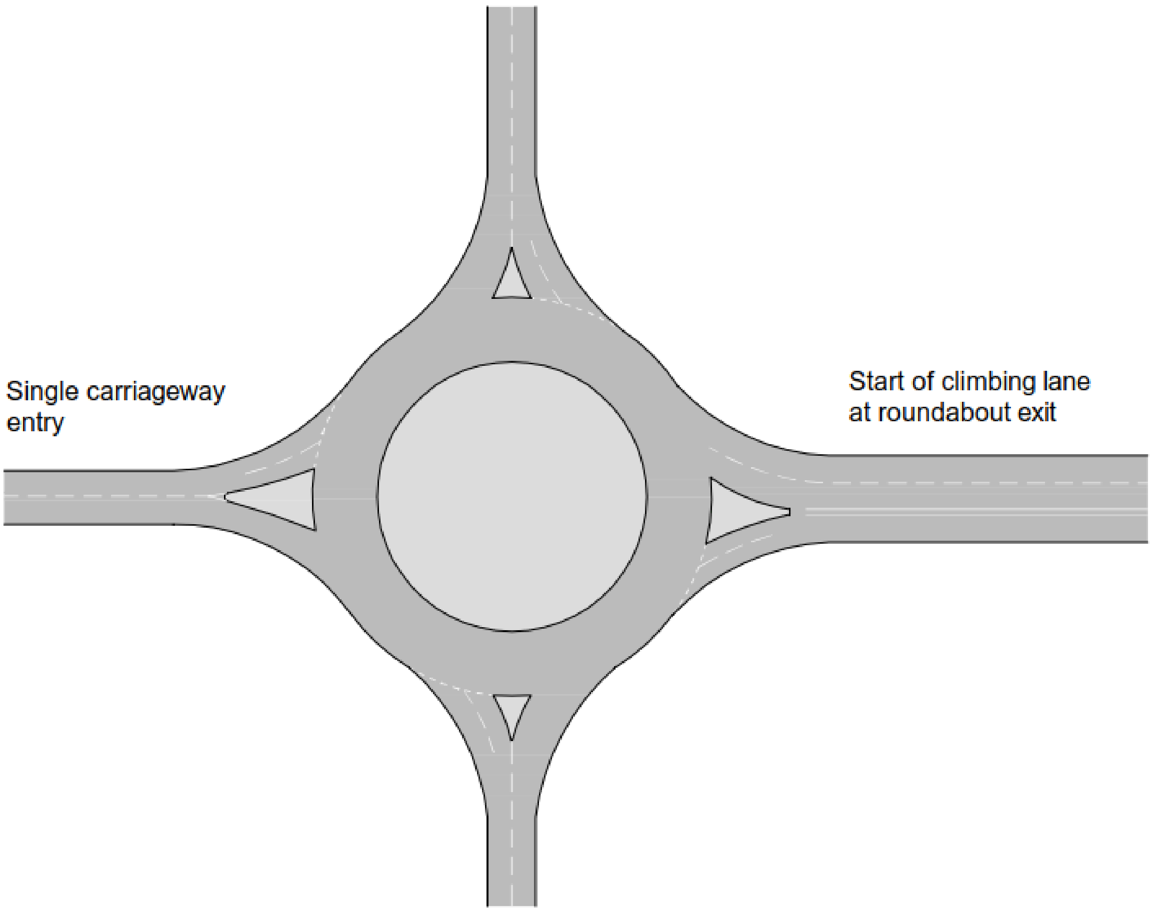
7.4 The full width of the climbing lane shall be preceded by a taper of between 1 in 30 and 1 in 40, as shown in Figure 7.3.

7.4.1 The alignment at the commencement of the climbing lane should encourage drivers to follow the nearside channel unless overtaking.

7.4.2 The taper should provide a smooth transition, by utilising the road curvature to develop the extra width, wherever practicable.

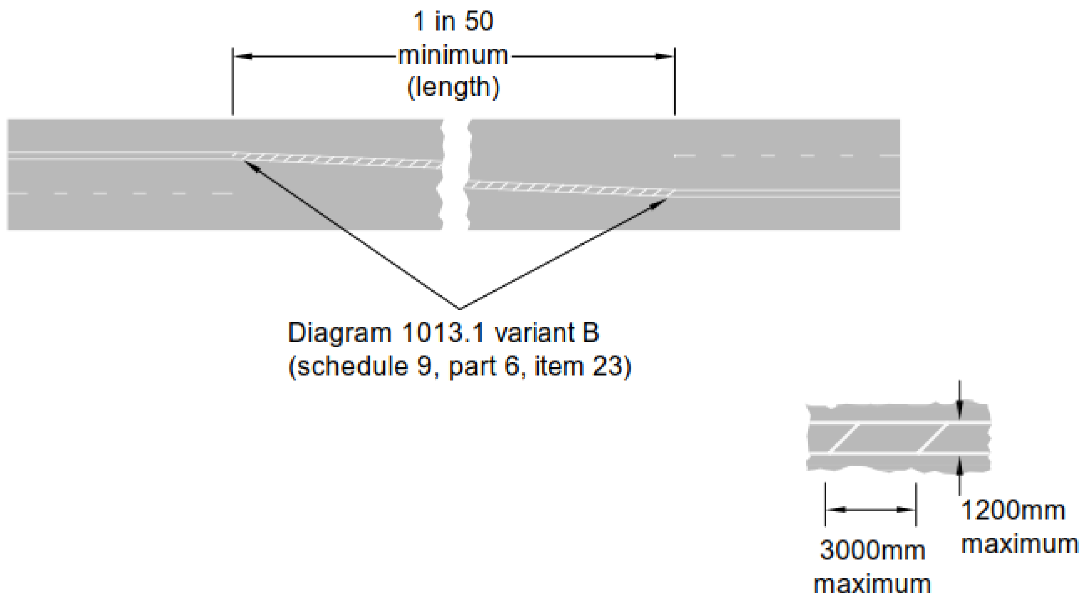
7.4.3 Climbing lanes may also commence directly from the exit lane of a roundabout where the geometry does not allow the use of conventional taper layout, as shown in Figure 7.4.3.

**Figure 7.4.3 Climbing lane starts at roundabout exit - single carriageway**




7.4.4 Where there are climbing lanes at both ends of a sag curve, and conditions can lead to a conventional 2 lane road layout between tapers which is less than 500 metres in length, the intervening carriageway paved width should be maintained at the same width as the climbing lanes section and road markings provided as shown in Figure 7.4.4.

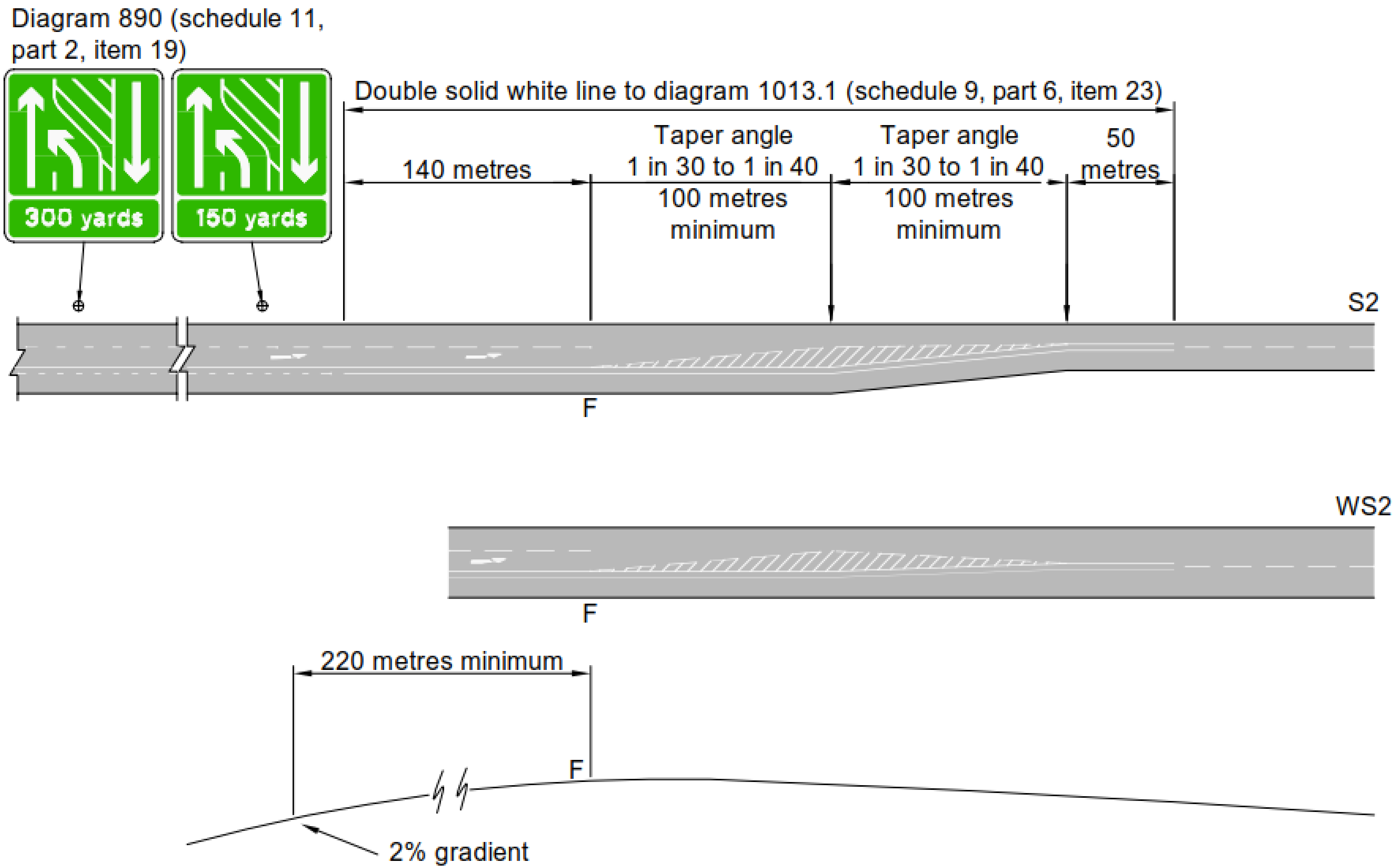
**Figure 7.4.4 Road markings at sags between climbing lanes**




### Layout at the end of climbing lane

7.5 The full width of the climbing lane shall be maintained up or down the gradient to a point F, at least 220 metres beyond the end of the 2% point of the crest curve as shown in Figure 7.5.

**Figure 7.5 Layout at end of climbing lane**



7.5.1 The distance between the 2% point and point F (the end of the full width of the climbing lane), should be extended beyond the minimum value if:

1) an existing junction is in the vicinity of the existing merge taper area and / or where the extension enables traffic to merge more safely;
2) the climbing lane is part of an overall route strategy for overtaking and the climbing lane is extended to maximise overtaking opportunities;
3) a high proportion of HGVs, or slow moving vehicles, currently cause problems or significantly reduce capacity in the merge taper area.

7.6 Commencing from point F, the carriageway shall be narrowed from the offside using a taper of between 1 in 30 and 1 in 40 in order to gradually remove the climbing lane (see Figure 7.5).

*NOTE In situations where the climbing lane termination point is extended greater than 220 metres beyond the 2% point, the taper arrangement at the end of the climbing lane is the same as that of the climbing lane terminating at 220 metres beyond the 2% point.*

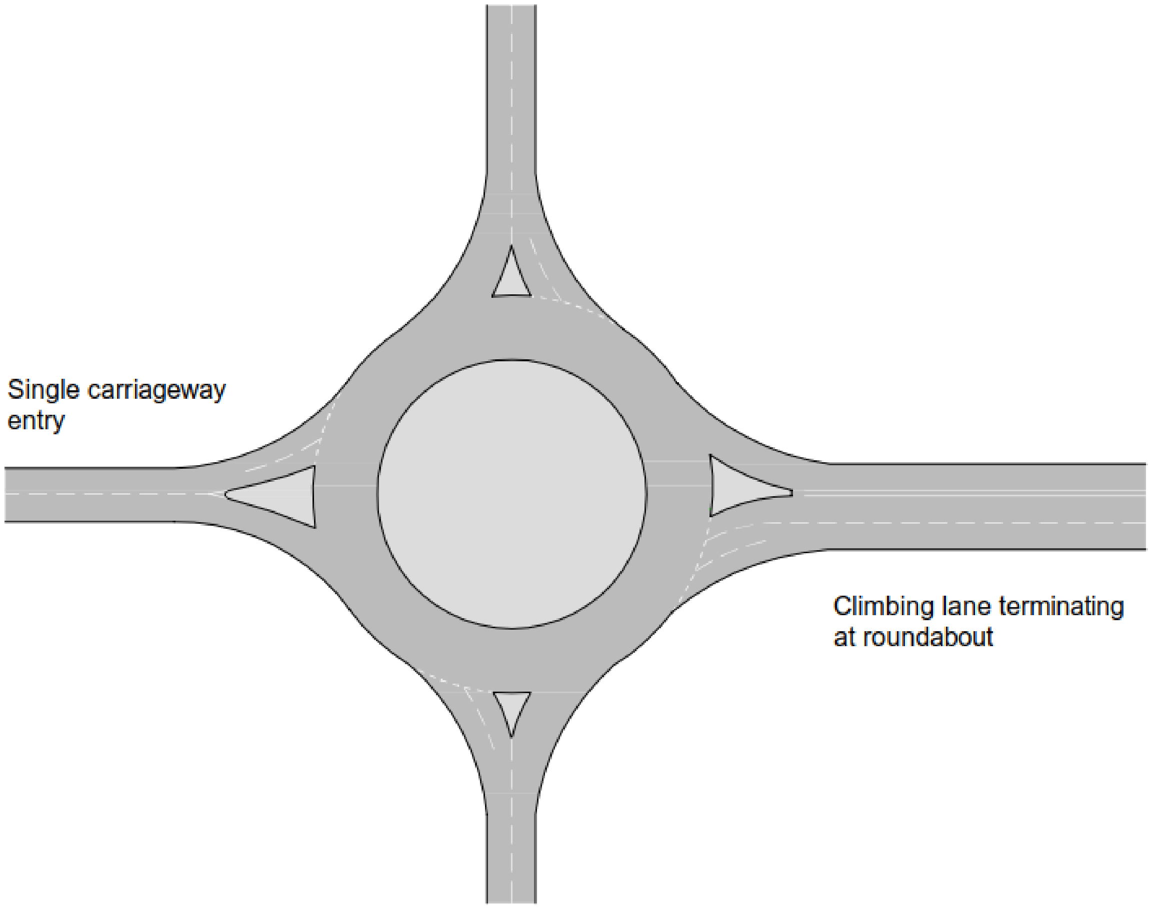
7.7 Where a climbing lane terminates advance warning signs shall be provided in accordance with TSRGD 2016 [Ref 6.N] diagram 890 (schedule 11, part 2 item 19).

*NOTE Clear signing and road markings at the end of a climbing lane is provided to ensure road users are fully aware of potential lane changing movements of other vehicles. This is important both from the point of view of the safety and efficient operation of the climbing lane.*

7.7.1 The transition from a climbing lane to a single lane should not coincide with junctions or curves below desirable minimum radius for the design speed of the road.

7.7.2 The climbing lane may terminate at a roundabout so the overtaking lane becomes the right hand entry lane into the roundabout (see Figure 7.7.2).

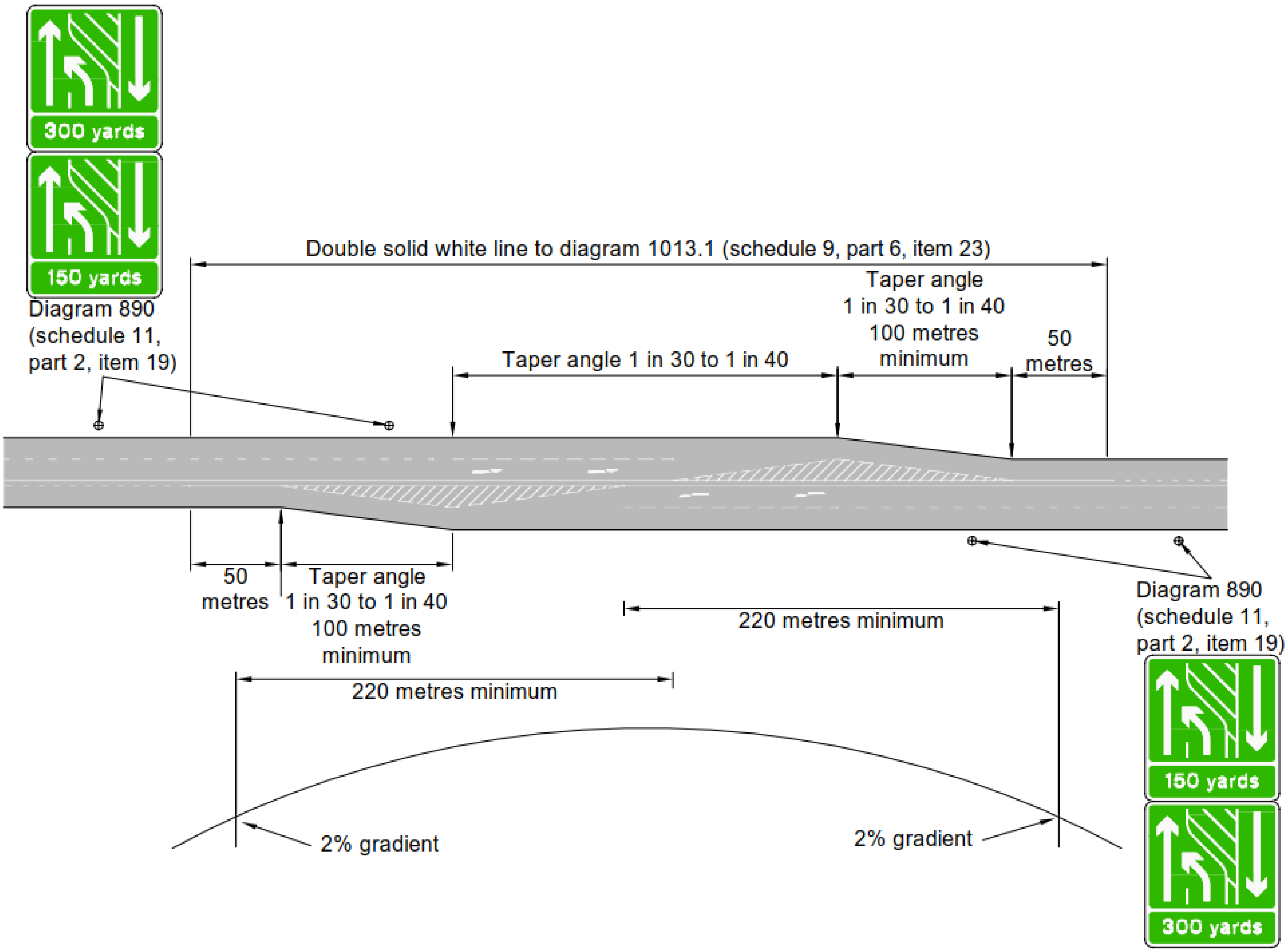
**Figure 7.7.2 Climbing Lane ends at roundabout entry - single carriageway**




7.7.3 Where climbing lanes are provided on both sides of a hill, resulting in a four lane road and the length between tapers is equal to or greater 500 metres, the taper should be terminated as shown in Figure 7.5.

7.7.4 Where climbing lanes are provided on both sides of a hill, resulting in a four lane road and the length between tapers is less than 500 metres, the taper should be terminated as shown in Figure 7.7.4.

**Figure 7.7.4 Crest curve at overlapping climbing lanes**



### Sight distance requirements

7.8 Desirable minimum stopping sight distance appropriate for the design speed of the road (see Table 2.10) shall be provided throughout the length of the climbing lane (including tapers), except in constrained locations where a relaxation of 1 design step below desirable minimum stopping sight distance is permitted.

*NOTE 1 Relaxations in stopping sight distance on climbing lanes can be used where difficult or constrained locations result in provision of desirable minimum stopping sight distance not being practicable.*

*NOTE 2 FOSD need not be provided over the length of a climbing lane.*

7.8.1 For climbing lanes provided as part of a new scheme, crest curves should be designed to just above one step below the desirable minimum K value, with a double white line road marking as in Figure 7.7.4 to clearly establish the climbing lane priority.

*NOTE If vehicles on the crest approaching the downhill section are provided with a high visibility crest curve, there can be a possibility of road users illegally crossing the continuous double white line road marking.*

### Road markings

7.9 On a climbing lane, a double white line road marking shall separate the two uphill lanes from the downhill lane with a continuous line for uphill traffic in all cases.

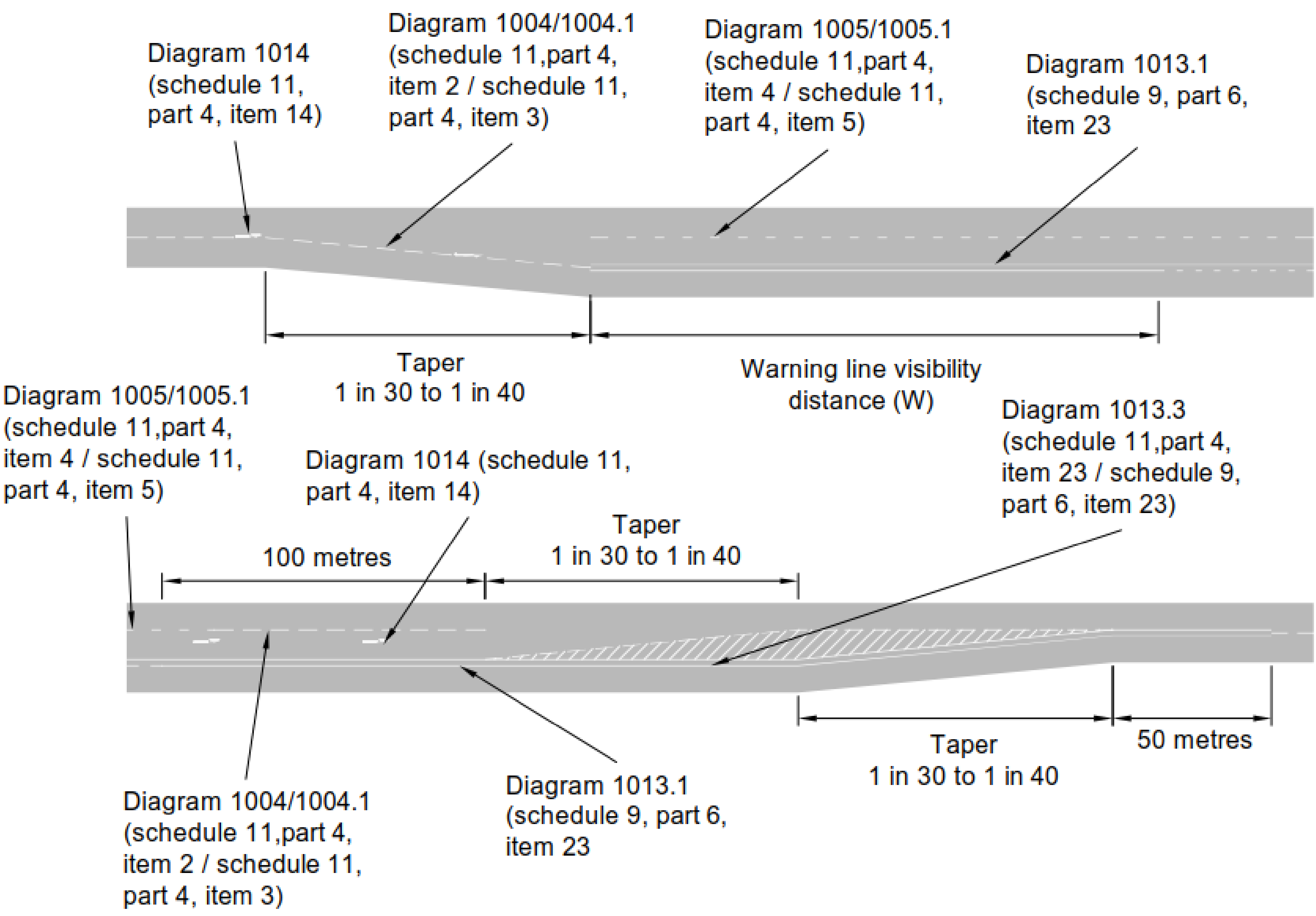
7.9.1 On a climbing lane a continuous line for downhill traffic should be provided except where the criteria for adopting a broken line is satisfied, as identified in TSM Chapter 5 [Ref 9.N].

*NOTE 1 The use of a continuous road marking for downhill traffic, even when the visibility criteria for an intermittent road marking line are satisfied, can avoid frequent changes to road markings on long hills.*

*NOTE 2 On a climbing lane the two uphill lanes are separated by road markings in accordance with TSM Chapter 5 [Ref 9.N].*

7.9.2 The road marking at the commencement of the climbing lane should be designed to encourage uphill drivers to keep to the nearside lane unless overtaking (see Figure 7.9.2).

**Figure 7.9.2 Road markings at start / end of a climbing lane**



7.9.3 At the commencement of the climbing lane a length of double continuous line road marking should be provided for a length equal to the warning line visibility distance (W), according to the speed of uphill traffic (see Table 7.9.3).

**Table 7.9.3 Length of double white line to be provided at the commencement of a climbing lane**

| 85 percentile speed (kph) | Warning line visibility distance W (metres) |
|---|---|
| 60 | 145 |
| 70 | 175 |
| 85 | 205 |
| 100 | 245 |
| 120 | 290 |

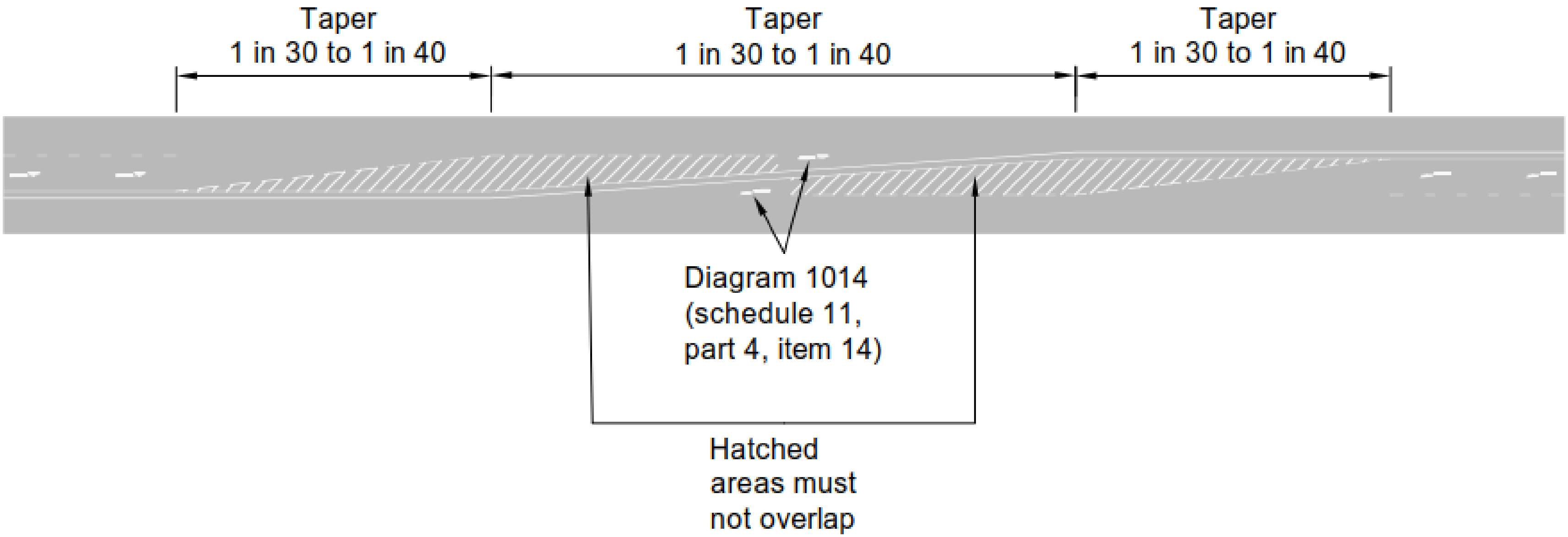
*NOTE 1* *The length of double continuous line at the commencement of the climbing lane can reduce the potential for conflict between uphill and downhill overtaking traffic.*

*NOTE 2* *The length of double continuous line at the commencement of the climbing lane encourages a driver of an overtaking vehicle travelling downhill to return to the nearside lane reducing the potential for conflict with a vehicle travelling uphill.*

7.9.4 The double white line at the commencement of the climbing lane may be extended to divide opposing traffic over the taper in order to discourage overtaking by downhill traffic.

7.9.5 The road marking layout that should be used at overlapping climbing lanes at hill crests is shown in Figures 7.7.4 and 7.9.5 .

**Figure 7.9.5 Road marking at crests - climbing lanes terminate in advance**



7.10 At overlapping climbing lanes, the hatched road markings at the end of opposing lanes must not overlap in accordance with TSRGD 2016 [Ref 6.N].

*NOTE Ensuring the hatched areas of the overlapping climbing lanes do not overlap maintains the differentiation between the opposing lanes.*

7.10.1 Figure 7.7.5 should be applied to situations where conventional exit taper layout would lead to a distance between ends of tapers of less than 500 metres.

7.10.2 Where opposing climbing lanes are provided on a crest and the climbing lane carriageway width is to be retained, Figure 7.9.5 shows the road marking layout that should be used over the crest.

7.10.3 The road marking layout that should be used at adjoining climbing lanes at sag curves is shown in Figure 7.4.4.

7.10.4 At sag curves the taper road marking between opposing traffic streams at adjoining climbing lanes should not be sharper than 1 in 50.

# 8. Climbing lanes - dual carriageways and motorways

## Introduction

8.1 This section shall be used for the design, assessment and construction of climbing lanes on all motorway and dual carriageway trunk road schemes including improvements to the existing trunk road network that result in climbing lanes being introduced on motorways and dual carriageways.

8.1.1 A climbing lane may be provided by means of entry and exit tapers.

8.1.2 Where climbing lanes are provided by means of entry and exit tapers, the climbing lane should be a continuation of the nearside lane and the overtaking traffic merge into the slower moving traffic at the termination point.

*NOTE On dual carriageways, climbing lanes can be justified on gradients of 3% and above over distances of at least 500 metres.*

## Layout

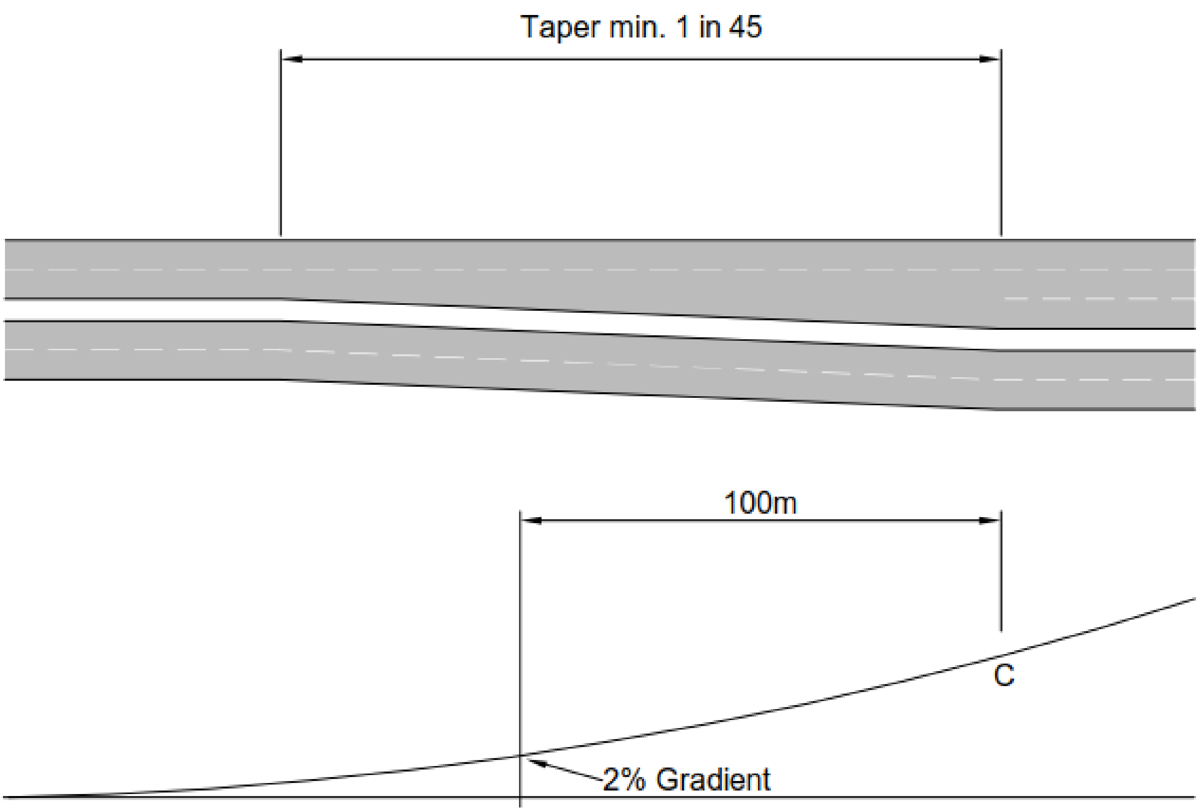
### Lane widths

8.2 The climbing lane shall be 3.65 metres wide.

### Layout at the start of climbing lane

8.3 The full width of the climbing lane shall be provided at a point C, 100 metres uphill from the 2% point of sag curve as shown in Figure 8.3.

**Figure 8.3 Start of dual carriageway climbing lane**




8.4 The full width of the climbing lane shall be preceded by a taper of at least 1 in 45, as shown in Figure 8.3, except for where it is provided at a roundabout exit on a dual carriageway.

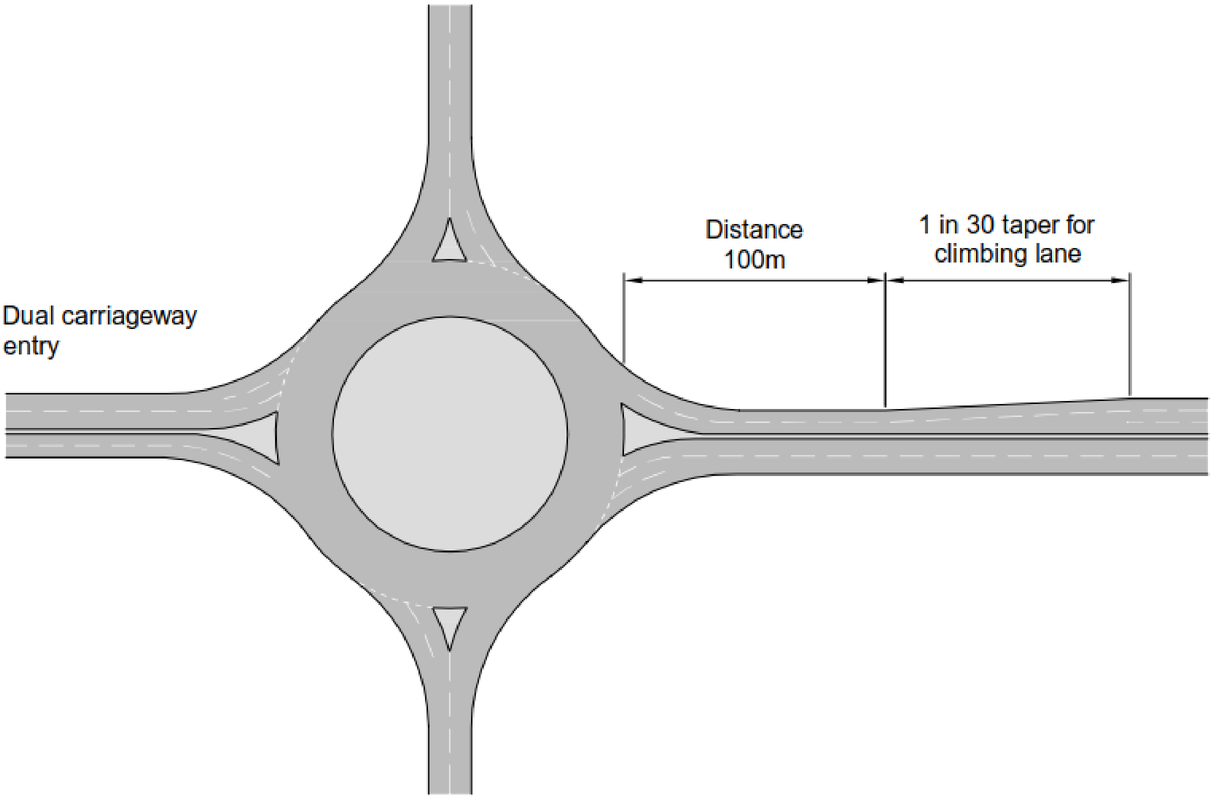
8.4.1 The additional width should be developed by utilising the road curvature to provide a smooth transition.

8.5 Climbing lanes on dual carriageways shall not be provided directly at the exit of a roundabout.

8.5.1 Climbing lanes on dual carriageways located near the exit from a roundabout should allow for a distance of at least 100 metres before the entry taper to avoid conflicting traffic movements on exiting the roundabout.

8.6 The minimum entry taper shall be 1 in 30 where a climbing lane is provided on the exit from a roundabout as shown in Figure 8.6.

**Figure 8.6 Start of climbing lane at roundabout**

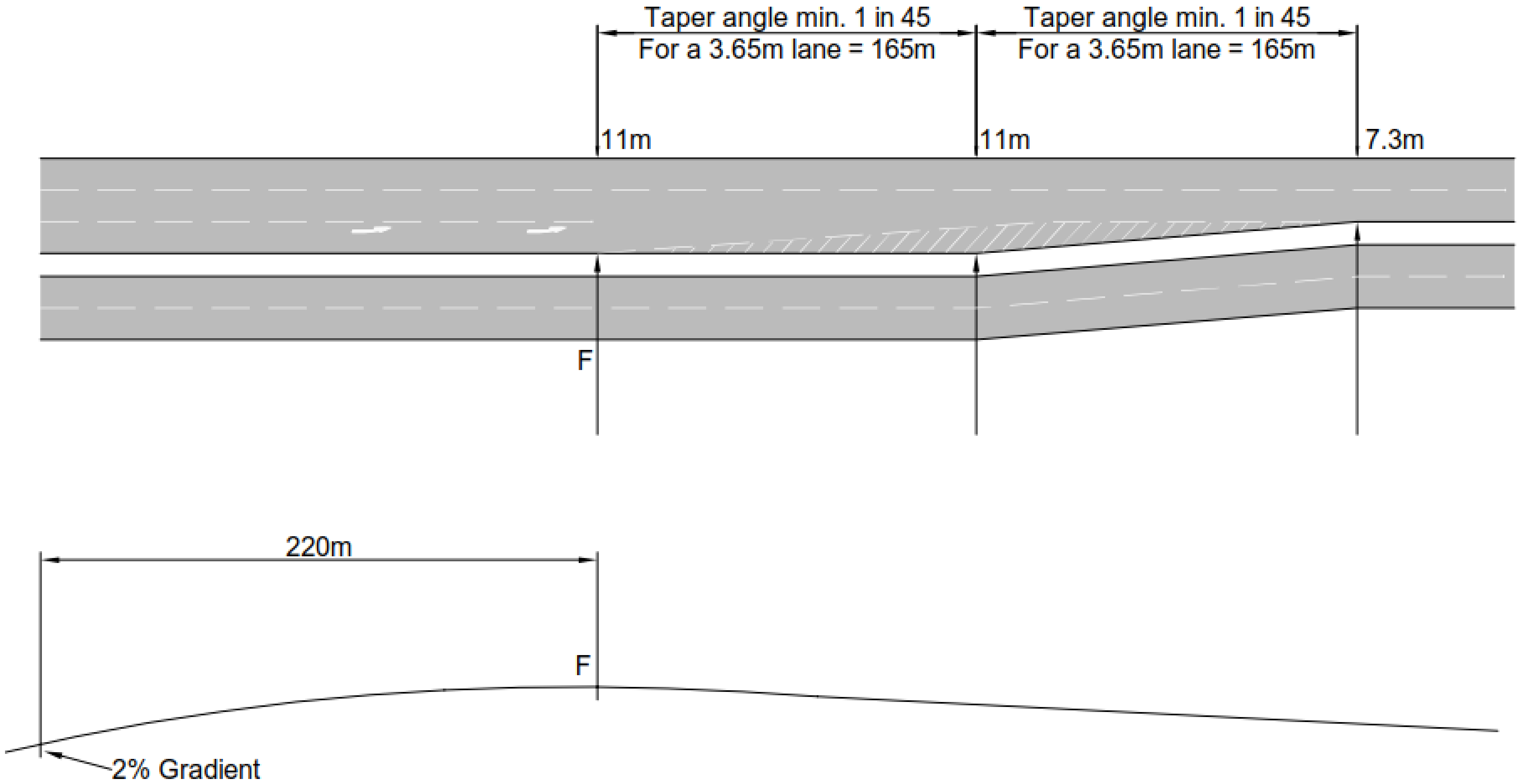



**Layout at the end of climbing lane**

8.7 The full width of the climbing lane shall be maintained up the gradient to point F, which is at least 220 metres beyond the 2% gradient point of the crest curve as shown in Figure 8.7N.

*NOTE* *The distance between the 2% gradient point and point F can be extended if a high proportion of HGVs or other slow moving vehicles currently cause problems or significantly reduce capacity.*

**Figure 8.7N End of dual carriageway climbing lane**



8.8 The taper at the end of the climbing lane shall be at least 1 in 45, as shown in Figure 8.7N.

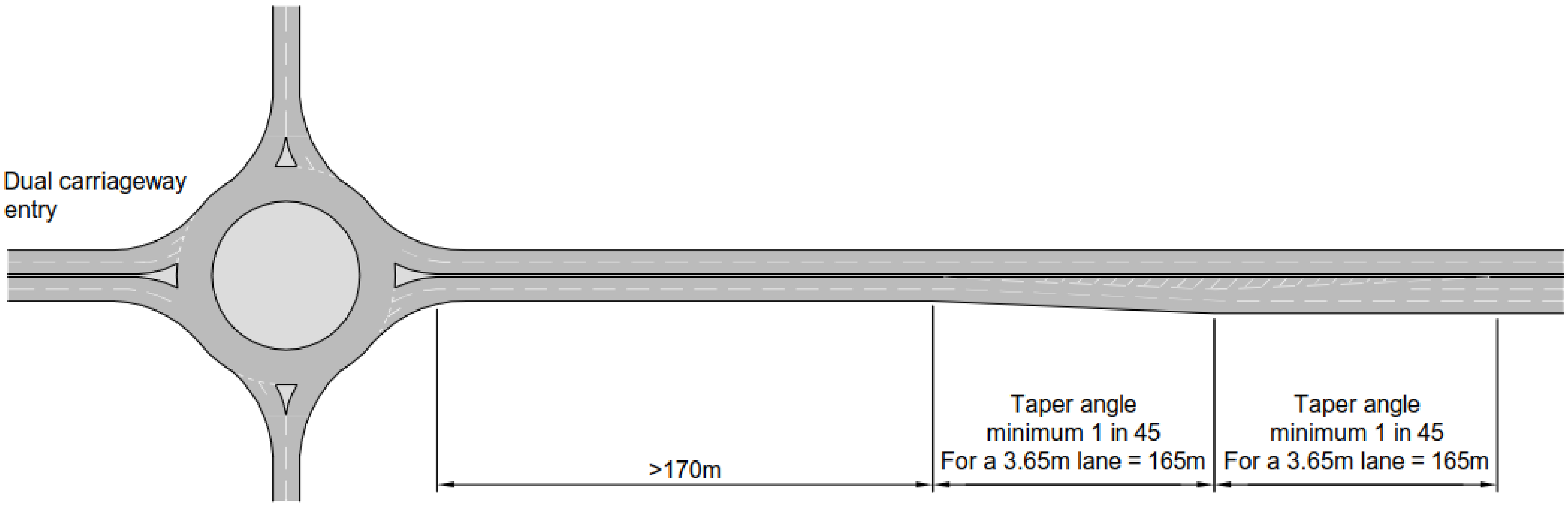
8.8.1 Longer tapers than 1 in 45 should be provided wherever practicable.

8.8.2 A smooth transition should be used wherever possible.

8.8.3 The climbing lane may precede a roundabout so the overtaking lane becomes the right hand entry lane into the roundabout.

8.8.4 Where the climbing lane ends at a distance greater than 500 metres from the roundabout it should be terminated as shown in Figure 8.8.4.

**Figure 8.8.4 Climbing lane end at roundabout entry - dual carriageway**



8.8.5 Where the climbing lane ends within 500 metres of the roundabout, the climbing lane should be extended to the roundabout and hatching at the end of the climbing lane omitted.

# 9. Single carriageway road overtaking sections

## Overtaking sections

9.1 Overtaking sections on single carriageway roads shall comprise of any of the following:

1) level overtaking sections;
2) climbing lane sections;
3) single lane downhill sections at climbing lanes;
4) dual carriageway overtaking sections;
5) wide single 2+1 road overtaking lanes.

*NOTE Dual carriageway overtaking sections are lengths of dual carriageway forming part of a route which is otherwise predominantly single carriageway. The dual sections can be taken into account when calculating the percentage of the route length that provides overtaking sections.*

9.1.1 Clearly identifiable overtaking sections for both directions of travel should be provided throughout a single carriageway so vehicles can maintain the design speed in off-peak conditions therefore minimising the potential for driver frustration.

## Overtaking value

9.2 The minimum overtaking value for rural S2 roads shall be 30%.

*NOTE The overtaking value is the length of overtaking sections expressed as a percentage of the route.*

9.3 The minimum overtaking value for WS2 roads shall be 30%.

9.3.1 The minimum overtaking value for WS2 roads should be 40%.

*NOTE Overtaking values at or above the recommended value of 40% are appropriate for WS2 roads with single lane dualling at junctions with minor roads and at-grade roundabouts at junctions with major roads.*

### Lengths of road over 2km

9.4 The calculation of overtaking value shall apply to new single carriageway roads exceeding 2km in length.

9.5 The total length of overtaking sections for each direction shall be summed and divided by the total length of the new road to obtain the overtaking value in each direction, expressed as a percentage.

9.5.1 Overtaking sections should be distributed along a length of road such that no individual non-overtaking section exceeds 3km in length.

### Lengths of road less than 2 km

9.6 New single carriageway roads less than 2km in length shall be integrated with the contiguous sections of existing road when calculating the overtaking value.

9.6.1 Where contiguous sections afford little or no overtaking opportunities, the overtaking value should only be provided for the length of the new single carriageway road.

*NOTE 1 Where contiguous existing sections of road provide good overtaking opportunities, it can relieve the necessity to provide the required overtaking value for the proposed section of new road.*

*NOTE 2 The minimum overtaking values do not apply to isolated improvements to existing roads such as the treatment of bends, junctions, and narrow sections of road.*

## Level overtaking sections

9.7 Level overtaking sections on 2 lane single carriageway roads shall consist of:

1) straight or nearly straight horizontal alignment with a minimum radius of curvature as shown in Table 9.7 (also see Figure 9.23N2), and/or;
2) right hand curves which provide at least FOSD at their commencement (see Figure 9.23N2).

**Table 9.7 Minimum radius of straight or nearly straight sections at level overtaking sections**

| Design speed (kph) | 100 | 85 | 70 | 60 | 50 |
|---|---|---|---|---|---|
| Minimum radius of straight or nearly straight sections (metres) | 8160 | 5760 | 4080 | 2880 | 2040 |

*NOTE* *Level overtaking sections are lengths of 2 lane single carriageway that provide clear opportunities for overtaking. Lengths of road that form level overtaking sections have central road markings that can be legally crossed.*

**Commencement of level overtaking sections**

9.8 Level overtaking sections shall be measured from the point on a straight, nearly straight or right hand curve where FOSD is achieved either within or outside of the highway / road boundary.

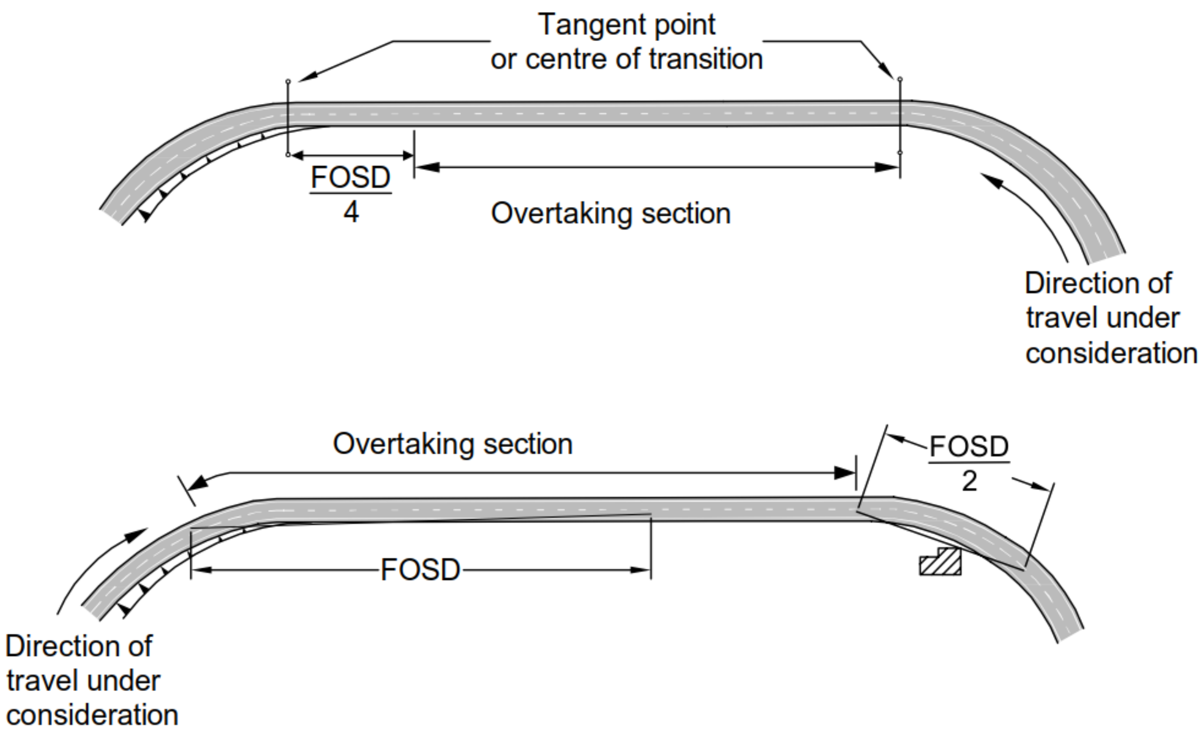
9.9 Where FOSD is measured outside of the highway / road boundary this visibility shall be permanently maintained.

**Termination of level overtaking sections**

9.10 Level overtaking sections shall terminate at one of the following:

1) a point FOSD/4 prior to the tangent point (or centre of transition) of a left hand curve (see Figure 9.10); or
2) the point on a right hand curve where sight distance has reduced to FOSD/2 (see Figure 9.10); or
3) a point FOSD/4 prior to an obstruction to overtaking (see the section on Obstructions to overtaking below).

**Figure 9.10 Commencement and termination of level overtaking sections**



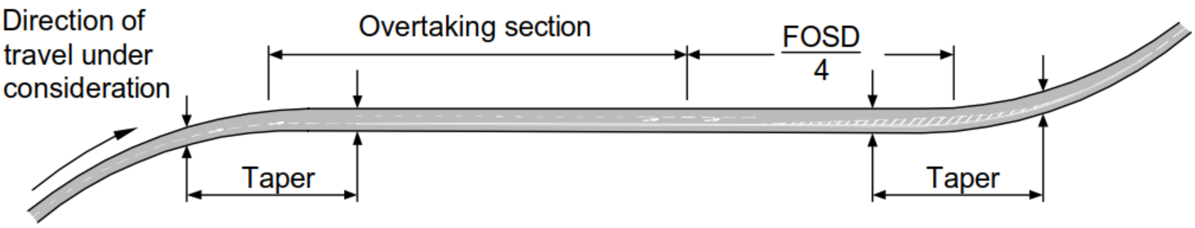
NOTE *Figure 9.10 shows diagrammatically the commencement and termination points of level overtaking sections.*

## Climbing lane sections

### Commencement of climbing lane overtaking sections

9.11 Climbing lane overtaking sections shall be measured from the mid-point of the commencing taper at the start of the two uphill lanes, see Figure 9.11.

**Figure 9.11 Commencement and termintation of climbing lane overtaking sections**




### Termination of climbing lane overtaking sections

9.12 The termination point of a climbing lane overtaking section shall be measured to a point FOSD/4 prior to the mid-point of the finishing taper, see Figure 9.11.

9.12.1 If the section of road following a climbing lane overtaking section is also an overtaking section, it should be treated as being contiguous with the climbing lane section.

## Single lane downhill sections at climbing lanes

9.13 Single lane downhill overtaking sections at climbing lanes shall only consist of straight or nearly straight sections (see Table 9.7 and Figure 9.23N2), or right hand curves with minimum radii as shown in Table 9.13.

**Table 9.13 Minimum right hand curve radii for single lane downhill sections at existing climbing lanes**

| Design speed (kph) | 100 | 85 | 70 | 60 | 50 |
|---|---|---|---|---|---|
| Minimum right hand curve radius of single lane downhill sections (metres) | 2880 | 2040 | 1440 | 1020 | 720 |

NOTE 1 *Single lane downhill overtaking sections are sections of a single downhill lane constrained by a double white line system, with a solid line provided adjacent to the two lane side and a broken line provided adjacent to the single lane, where the combination of visibility and horizontal curvature provide clear opportunities for overtaking when the opposing traffic permits.*

NOTE 2 *Climbing lane road markings 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 3km, it can be beneficial that some sections are provided with a straight or large radius right hand curvature in order to provide an overtaking section for downhill traffic.*

9.14 Verges shall not be widened on single lane downhill lane sections to give FOSD.

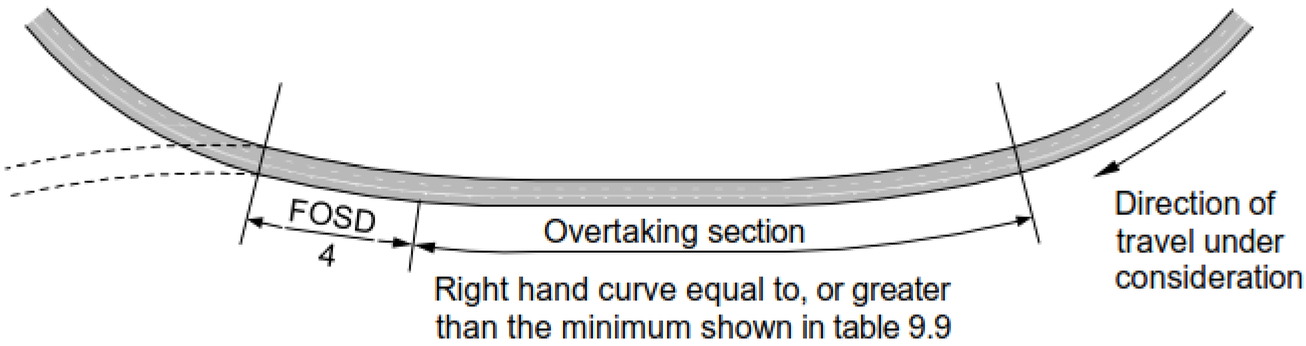
NOTE *On single downhill lane sections the sight distance naturally occurring within the normal highway / road boundaries along straights, near straights and at the radii shown in Table 9.8 for right hand curves is sufficient for downhill overtaking.*

9.14.1 Single lane downhill sections should only be used as overtaking sections on straight grades or sag curves where FOSD is achieved.

**Commencement of single lane downhill overtaking sections at climbing lanes**

9.15 Single lane downhill overtaking sections shall be measured from the point where the right hand curve radius achieves or exceeds the requisite value from Table 9.13, see Figure 9.15.

**Figure 9.15 Commencement and termintation of single lane downhill climbing lane overtaking sections**



**Termination of single lane downhill overtaking sections at climbing lanes**

9.16 The termination point of a single lane downhill overtaking section shall be measured to a point FOSD/4 prior to the end of the straight or nearly straight section or end of radius equal to or greater than shown in Table 9.13, see Figure 9.15.

## Dual carriageway overtaking sections

**Commencement of dual carriageway overtaking sections**

9.17 Dual carriageway overtaking sections shall be measured from the mid-point of the commencing taper where the carriageway widens from 1 to 2 lanes.

**Termination of dual carriageway overtaking sections**

9.18 The termination point of dual carriageway overtaking sections shall be measured to a point FOSD/4 prior to the mid-point of the finishing taper where the carriageway reduces from 2 lanes to 1 lane.

*NOTE Details of the appropriate road marking layout of the finishing taper where the carriageway reduces from 2 lanes to 1 lane are shown in TSM Chapter 5 [Ref 9.N].*

## Wide single 2+1 roads (WS2+1)

**Commencement of WS2+1 overtaking sections**

9.19 WS2+1 overtaking sections shall be measured from a point where the full width overtaking lane commences, see Figures 6.11.2 and 6.11.3.

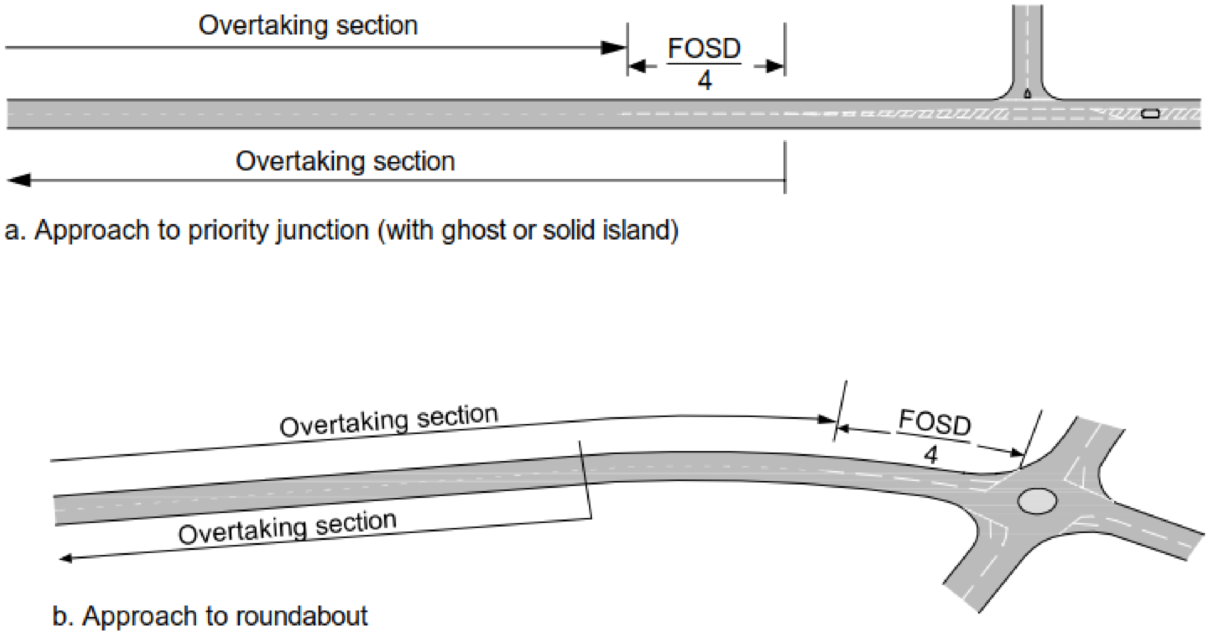
**Termination of WS2+1 overtaking sections**

9.20 The termination point of WS2+1 overtaking sections shall be measured to a point FOSD/4 prior to the mid-point of the 130 metres long taper immediately following the full width overtaking lane see Figure 6.15.

## Obstructions to overtaking

9.21 On 2 lane single carriageway roads the termination point for overtaking sections on the approach to obstructions shall be a distance of FOSD/4 prior to the nose of the ghost island or physical island, or the roundabout give way line, as shown in Figure 9.21.

**Figure 9.21 Termination of overtaking sections at obstructions**




*NOTE 1* *Priority junctions incorporating ghost islands or single lane dualling and roundabouts are defined as obstructions to overtaking when they are located within an, otherwise, overtaking section.*

*NOTE 2* *Simple priority junctions (with no central mainline treatment) are not considered obstructions to overtaking. Direct accesses are not permitted in overtaking sections (refer to CD 123 [Ref 2.N] for details).*

9.22 Following an obstruction to overtaking, an overtaking section shall commence on a straight or nearly straight horizontal alignment with radius of curvature greater than shown in Table 9.7 (also see Figure 9.23N2) providing at least FOSD, or right hand curves which provide at least FOSD at their commencement (see Figure 9.23N2).

9.22.1 When an overtaking section follows a priority junction, the measurement of the overtaking section should commence from the end of the ghost island nose shown in Figure 9.21.

## Horizontal curve design

9.23 Level overtaking sections on single carriageway 2 lane roads shall be provided as straight or nearly straight sections (see section A in Figure 9.23N2 and Table 9.7), thus providing an overtaking section for both directions of travel ($V^2/R < 1.25$).

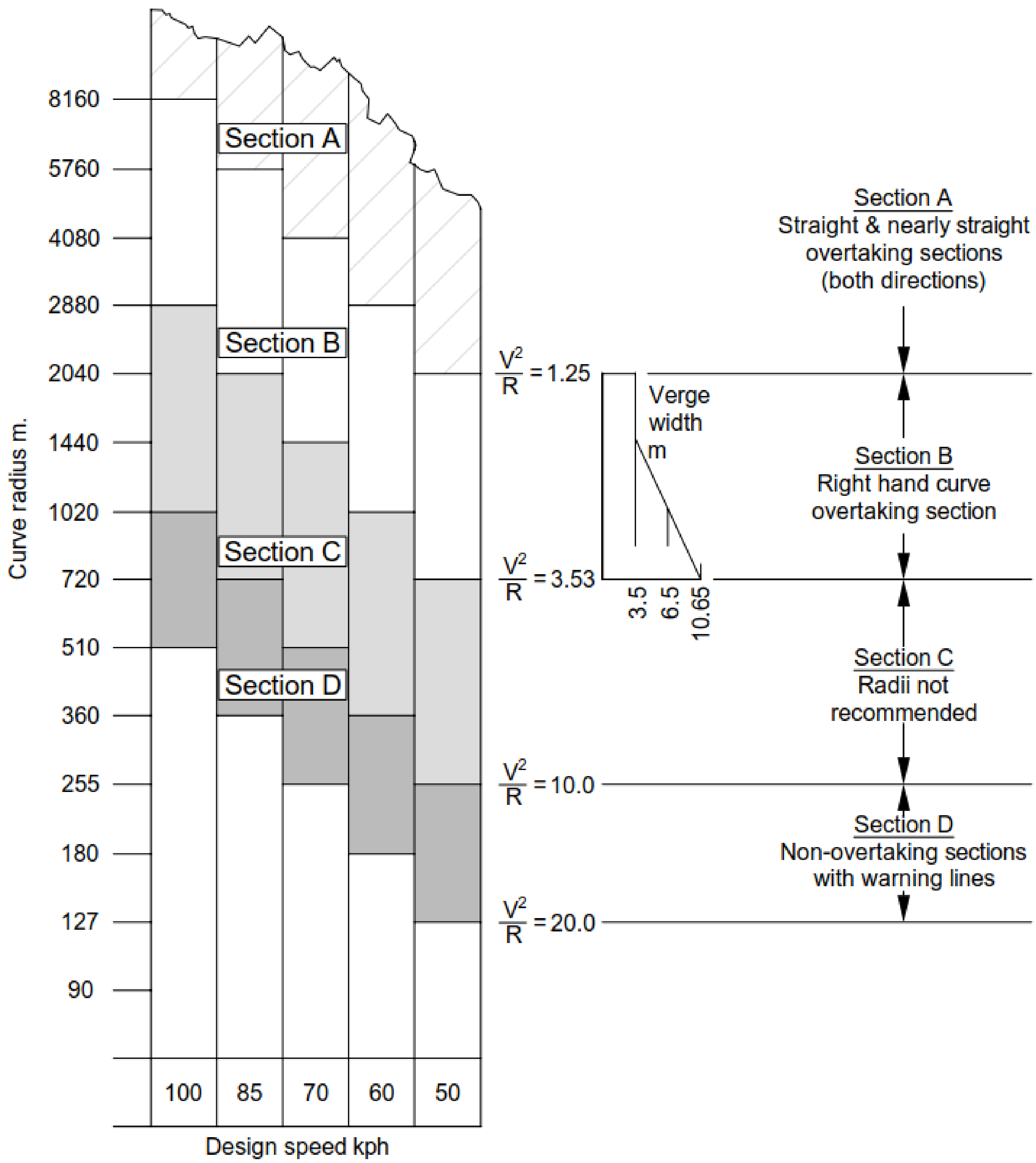
*NOTE 1* *Where straight sections or nearly straight sections are not possible, lower radii results in right hand curve overtaking sections:*

*1) on level sections following the achievement of FOSD; and*

*2) on existing climbing lane single lane downhill sections.*

*NOTE 2* *Figure 9.23N2 shows a curve selection chart for horizontal curves, which illustrates the bands of radii (relative to design speed) and their applicability in the design of 2 lane single carriageway roads.*

**Figure 9.23N2 Horizontal curve design**




9.24 The minimum radii for overtaking sections on single carriageway 2 lane roads shall be the lower limit of section B in Figure 9.24N2 ($V^2/R = 3.53$) and values shown in Table 9.13 for right hand curves.

*NOTE* *At the lower limit of section B, visibility for left hand curve traffic deteriorates significantly, and a verge width of 10.65 metres is needed to maintain FOSD within the highway / road for right hand curve traffic.*

9.24.1 The radii in section C, shown in Figure 9.23N2 ($V^2/R = 3.53$ to $V^2/R = 10$), should not be used in single carriageway design.

*NOTE* *The use of mid to large radius curves inhibits the design of clear overtaking sections for vehicles travelling in the left hand curve direction, and reduces the length of overtaking straight that could otherwise be achieved.*

9.24.2 Non-overtaking sections should be designed using the radii shown in section D ($V^2/R = 10$ to $V^2/R = 20$) in Figure 9.23N2.

9.24.3 Radii of non-overtaking sections should be chosen around the middle of section D ($V^2/R = 14$) in Figure 9.23N2.

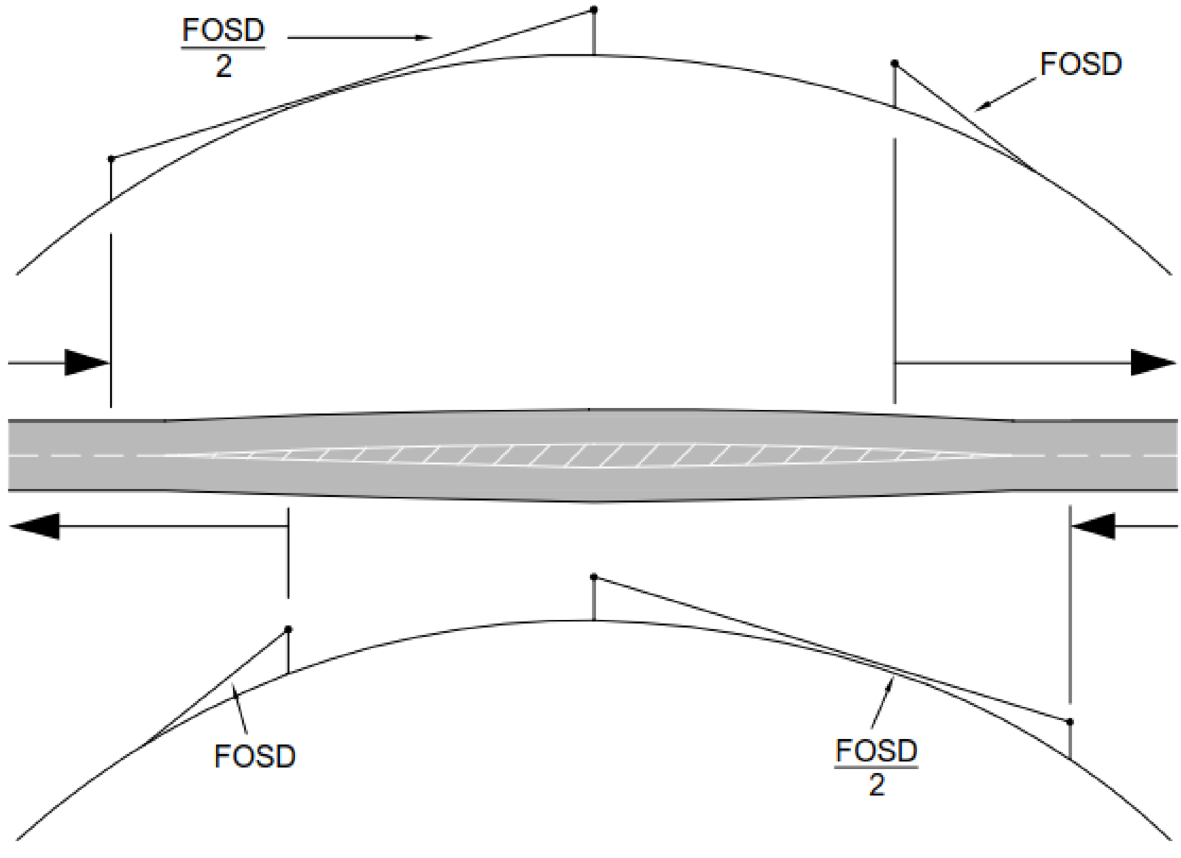
NOTE *Radii around the middle of section D as shown in Figure 9.23N2 strikes a balance between providing clear non-overtaking sections and avoiding steep superelevation.*

### Vertical curve design

9.25 For measurement of overtaking sections, a single carriageway 2 lane road with a crest curve with less than FOSD shown in Table 2.10 shall be a non-overtaking section.

9.25.1 The overtaking section approaching the non-overtaking crest should terminate at the point at which sight distance has reduced to FOSD/2, as shown in Figure 9.25.1.

**Figure 9.25.1 Non-overtaking crest**




9.25.2 The use of desirable minimum crest K values should be avoided for 2 lane single carriageway road design.

NOTE 1 *The use of desirable minimum crest K values results in a continuous sight distance only slightly above FOSD/2, and therefore theoretically, the overtaking section is continuous over the crest (and warning markings are not strictly justified).*

NOTE 2 *Unless a vertical curve can have a large enough K value to provide FOSD (therefore forming an overtaking section) the resulting alignment will provide inadequate visibility for safe overtaking. A K value of one design speed step below desirable minimum results in a clear non-overtaking section and further improvement to K value is counter productive as it increases the length of uncertain crest visibility while not achieving a safe overtaking visibility.*

## Changes in carriageway type

9.26 If lengths of dual carriageway within a generally single carriageway road or vice-versa are provided they shall be at least 2km in length.

# 10. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. CD 127, 'Cross-sections and headrooms' |
| Ref 2.N | Highways England. CD 123, 'Geometric design of at-grade priority and signal-controlled junctions' |
| Ref 3.N | Highways England. CD 122, 'Geometric design of grade separated junctions' |
| Ref 4.N | Highways England. CD 116, 'Geometric design of roundabouts' |
| Ref 5.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 6.N | The Stationery Office. TSRGD 2016, 'The Traffic Signs Regulations and General Directions 2016' |
| Ref 7.N | The Stationery Office. TSM Chapter 3, 'Traffic Signs Manual Chapter 3 - Regulatory Signs' |
| Ref 8.N | The Stationery Office. TSM Chapter 4, 'Traffic Signs Manual Chapter 4 - Warning Signs' |
| Ref 9.N | The Stationery Office. TSM Chapter 5, 'Traffic Signs Manual Chapter 5 - Road Markings' |

# 11. Informative references

The following documents are informative references for this document and provide supporting information.

| | |
|---|---|
| Ref 1.I | Highways England. CG 501, 'Design of highway drainage systems' |

# Appendix A. Coordinated link design

The tables below give guidance on layout features for the various rural road types that can help to provide coordinated link design. The contents of the tables are not exhaustive and not intended to supersede requirements and advice included in the wider Design Manual for Roads and Bridges requirements and advice documents, and the requirements and advice in the appropriate highway design requirements and advice documents take precedence.

**Table A.1 Single carriageway roads**

| Type of road (see CD 127 [Ref 1.N] ) | Sub-category | Edge treatment | Direct access treatment (see CD 123 [Ref 2.N] for a definition of direct access) | Junction treatment at minor road intersection (see CD 123 [Ref 2.N] and CD 116 [Ref 4.N]) | Junction treatment at major road intersection (see CD 123 [Ref 2.N], CD 122 [Ref 3.N] and CD 116 [Ref 4.N]) | Previous category reference used in TD 9 Table 4 (see note 1) |
|---|---|---|---|---|---|---|
| 2 lane single carriageway (S2) - 7. 3 metre carriageway | a | Kerbs and raised verges. Pedestrian footways and cycle tracks. Nearside - hard strip. Offside - hard strip. | Minimise number of direct accesses to avoid standing vehicles and concentrate turning movements. | Simple priority junctions. Ghost island junctions. | Ghost island junctions. | 1 |
| | b | No pedestrian footways or cycle tracks. Nearside - hard strip. Offside - hard strip. | Minimise number of direct accesses to avoid standing vehicles and concentrate turning movements. | Simple priority junctions. Ghost island junctions. | Ghost island junctions. Single lane dualling. Roundabouts. Traffic signals. | 2 |
| | c | No pedestrian footways or cycle tracks. Nearside - hard strip. Offside - hard strip. | Minimise number of direct accesses to avoid standing vehicles and concentrate turning movements. Clearway (see TSM Chapter 3 [Ref 7.N]) | Left-in / left-out priority junctions. Ghost island junctions. | Single lane dualling. Roundabouts. Traffic signals. | 3A |

**Table A.1 Single carriageway roads** (continued)

| **Type of road (see CD 127 [Ref 1.N] )** | **Sub-category** | **Edge treatment** | **Direct access treatment (see CD 123 [Ref 2.N] for a definition of direct access)** | **Junction treatment at minor road intersection (see CD 123 [Ref 2.N] and CD 116 [Ref 4.N])** | **Junction treatment at major road intersection (see CD 123 [Ref 2.N], CD 122 [Ref 3.N] and CD 116 [Ref 4.N])** | **Previous category reference used in TD 9 Table 4 (see note 1)** |
|---|---|---|---|---|---|---|
| Wide single 2 lane carriageway (WS2) - 10 metre carriageway | a | Pedestrian footways and cycle tracks. Nearside - hard strip. Offside - hard strip. | Minimise number of direct accesses to avoid standing vehicles and concentrate turning movements. Clearway (see TSM Chapter 3 [Ref 7.N]) | Left-in / left-out priority junctions. Ghost island junctions. Single lane dualling. | Single lane dualling. Roundabouts. | 3B |
| | b | No pedestrian footways or cycle tracks. Nearside - hard strip. Offside - hard strip. | Minimise number of direct accesses to avoid standing vehicles and concentrate turning movements.Clearway (see TSM Chapter 3 [Ref 7.N]) | Left-in / left-out priority junctions. Single lane dualling. Roundabouts. Some side roads stopped up. | Roundabouts. | 4 |
| Wide single 2+1 roads (WS2+1) - 11.5 metre carriageway | a | Nearside - hard strip. Offside - hard strip. | Not permitted. | Ghost island junctions. | Left-in / left-out compact grade separated junctions. Ghost island junctions. Roundabouts. | Not previously used |

**Table A.2 Dual carriageway roads**

| Type of road (see CD 127 [Ref 1.N] ) | Sub-category | Edge treatment | Direct access treatment (see CD 123 [Ref 2.N] for a definition of direct access) | Junction treatment at minor road intersection (see CD 123 [Ref 2.N] and CD 116 [Ref 4.N]) | Junction treatment at major road intersection (see CD 123 [Ref 2.N], CD 122 [Ref 3.N] and CD 116 [Ref 4.N]) | Previous category reference used in TD 9 Table 4 (see note 1) |
|---|---|---|---|---|---|---|
| Dual 2 lane All-purpose roads (D 2AP) - 7.3 metre carriageway | a | Kerbs and raised verges. Pedestrian footways and cycle tracks. Nearside - hard strip. Offside - hard strip. | Minimise number of direct accesses to avoid standing vehicles and concentrate turning movements. Clearway (see TSM Chapter 3 [Ref 7.N] ) | Left-in / left-out priority junctions. Priority junctions. No other gaps in the central reserve. | Traffic signals. At-grade roundabouts. Compact grade separation. Grade separation if economically justified. | 5 |
| | b | No pedestrian footways or cycle tracks. Nearside - hard strip. Offside - hard strip. | Minimise number of direct accesses to avoid standing vehicles and concentrate turning movements. Clearway (see TSM Chapter 3 [Ref 7.N]) | No minor junctions at-grade. No gaps in the central reserve. | At-grade roundabouts. Full grade separation. | 6 |
| | c | No pedestrian footways or cycle tracks. Nearside - hard strip. Offside - hard strip. | No access except isolated existing access with left turns only. Clearway (see TSM Chapter 3 [Ref 7.N]) | No minor junctions at-grade. No gaps in the central reserve. | Full grade separation. | 7A |
| Dual 3 lane All-purpose roads (D 3AP) - 11 metre carriageway | a | Nearside - hard strip. Offside - hard strip. | Not permitted. Clearway (see TSM Chapter 3 [Ref 7.N]) | No minor junctions at-grade. No gaps in the central reserve. | Full grade separation. | 7C / 8B (See note 2) |

**Table A.2 Dual carriageway roads** (continued)

| Type of road (see CD 127 [Ref 1.N] ) | Sub-category | Edge treatment | Direct access treatment (see CD 123 [Ref 2.N] for a definition of direct access) | Junction treatment at minor road intersection (see CD 123 [Ref 2.N] and CD 116 [Ref 4.N]) | Junction treatment at major road intersection (see CD 123 [Ref 2.N], CD 122 [Ref 3.N] and CD 116 [Ref 4.N]) | Previous category reference used in TD 9 Table 4 (see note 1) |
|---|---|---|---|---|---|---|
| Dual 2 lane motorway (D2M) - 7.3 metre carriageway | a | Nearside - hard shoulder. Offside - hard strip. | Not permitted - Motorway Regulations. | Not permitted - Motorway Regulations. | Full grade separation - motorway standard. | 7B / 8A (See note 3) |
| Dual 3 lane motorway (D3M) - 11 metre carriageway | a | Nearside - hard shoulder. Offside - hard strip. | Not permitted - Motorway Regulations. | Not permitted - Motorway Regulations. | Full grade separation - motorway standard. | 9 |
| Dual 4 lane motorway (D4M) - 14.7 metre carriageway | a | Nearside - hard shoulder. Offside - hard strip. | Not permitted - Motorway Regulations. | Not permitted - Motorway Regulations. | Full grade separation - motorway standard. | 10 |

Note 1: Reference is made to the categorisation system used in TD 9 to allow comparison with schemes that are being progressed to the previous standard or have been completed to the previous standard. It is suggested that for developing schemes the categorisation system introduced in the figures above, based on road type and sub-category, is referenced (for example D2APb).

Note 2: The previous categories 7C and 8B in TD 9 essentially duplicated each other and these have been rationalised in this document.

Note 3: The previous categories 7B and 8A in TD essentially duplicated each other and these have been rationalised in this document.

Road Layout
Design

# CD 109
# England National Application Annex to CD 109 Highway link design

(formerly IAN 149/17, IAN 161/15 and IAN 198/17)

Revision 1

**Summary**
This National Application Annex sets out the Highways England specific requirements for highway link design on existing roads



**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 1 | Mar 2020 | Revision 1 (March 2020) Update to references only. Revision 0 (November 2019) Highways England National Application Annex to CD 109. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes those parts of IAN 149/17, IAN 161/15 and IAN 198/17 relating to the highway link design which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex (NAA) gives Highways England specific requirements and additional relaxations relating to highway link design for:

1) modifying existing motorways where motorway regulations apply (herein referred to as 'existing motorways');
2) modifying existing all-purpose dual carriageways; and
3) smart motorways.

The additional relaxations included in this NAA allow greater flexibility when dealing with the constraints associated with enhancing elements of existing motorways and all-purpose dual carriageways.

This NAA is to be used in conjunction with CD 109 [Ref 1.N], GD 300 [Ref 3.N] and IAN 161 [Ref 4.N] where appropriate.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| IAN | Interim Advice Note |

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| Expressway | A high speed dual carriageway that has at least two lanes in each direction, grade separated junctions and uses technology to support operational regimes (see GD 300 [Ref 3.N]). |

# E/1. Modifying existing motorways

## Scope

E/1.1 The requirements and advice in Section E/1 shall only be used when modifying existing motorways, with the exception of smart motorway and expressway schemes.

E/1.1.1 The parameters in Section E/1 should only be used where it is not practicable to comply with the requirements of CD 109 [Ref 1.N].

*NOTE 1 IAN 161 [Ref 4.N] provides requirements and advice for the design of smart motorways.*

*NOTE 2 Document GD 300 [Ref 3.N] provides requirements and advice for the design of expressways.*

E/1.2 The parameters in Section E/1 shall not be used for new motorway elements e.g. the construction of a new slip road.

## Geometric parameters

### Design speed (CD 109 clauses 2.1 and 2.4)

E/1.3 Design speed shall be derived in accordance with CD 109 [Ref 1.N] however all design speeds can be classified as band B.

### Combinations (CD 109 clause 2.12)

E/1.4 The relaxations below desirable minimum identified in CD 109 [Ref 1.N] for the following parameters shall be permitted in combination:

1) stopping sight distance;
2) horizontal curvature;
3) vertical crest curves;
4) absolute minimum for sag curves;
5) superelevation.

### Immediate approaches to junctions (CD 109 clause 2.14)

E/1.5 The relaxations below desirable minimum identified in CD 109 [Ref 1.N] for the following parameters shall be permitted on the immediate approaches to junctions:

1) stopping sight distance;
2) vertical crest curves;
3) absolute minimum for sag curves.

### Stopping sight distance (CD 109 clause 3.7)

E/1.6 The relaxations of one design speed step described in CD 109 [Ref 1.N] Section 3 for band A roads shall be permitted for band B roads.

### Road camber and drainage (CD 109 clauses 4.1 to 4.4)

E/1.7 Crossfall shall be measured across the paved surface of a road's cross-section.

*NOTE The paved surface of the cross-section comprises the carriageway, hard shoulder and hard strips.*

E/1.8 Where the total width of the running lanes is to be increased, the existing drainage flow paths shall be assessed to determine their suitability.

E/1.8.1 Where the assessment of suitability identifies a benefit of doing so, crossfall may be increased by 0.5% above the requirements of CD 109 [Ref 1.N] Table 2.9 to mitigate excessive depths of water.

E/1.9 Retention of the existing crossfall (running lanes, hard shoulder, and hard strip) shall be permitted unless:

1) the assessment of drainage flow paths indicates the existing crossfall is not suitable (if an assessment is required);
2) the variation in crossfall for any given cross-section does not meet the criteria given in the following clauses in this sub-section of this document;
3) the review of the existing operational performance as described in this document highlights a collision problem relating to the existing crossfall, e.g. standing water.

E/1.10 The change in gradient of crossfall shall not exceed 5%.

*NOTE For example, a hard shoulder with a 2.5% fall towards the verge adjacent to lane one with a 2.5% fall towards the central reserve, is acceptable as the overall change is 5%.*

E/1.11 Changes in crossfall that create a sag shall only occur within hatched road markings with solid edge lines.

E/1.12 Where a sag creates a low point the associated surface water flow width shall not enter a traffic lane.

E/1.13 Crossfall shall not change within a lane.

E/1.14 Adverse camber shall not be provided on horizontal radii less than 2000 metres.

**Transitions (CD 109 clause 4.14)**

E/1.15 The basic transition length shall be no shorter than the existing transition.

# E/2. Modifying existing all-purpose dual carriageways

## Scope

E/2.1 The requirements and advice in Section E/2 shall only be used when modifying existing all-purpose dual carriageways, with the exception of expressways.

E/2.1.1 The parameters in Section E/2 should only be used where it is not practicable to comply with the requirements of CD 109 [Ref 1.N].

*NOTE Document GD 300 [Ref 3.N] provides requirements and advice for the design of expressways.*

E/2.2 The parameters in Section E/2 shall not be used for new all-purpose dual carriageway elements e.g. the construction of a new slip road.

## Geometric parameters

### Combinations (CD 109 clause 2.12)

E/2.3 The relaxations below desirable minimum identified in CD 109 [Ref 1.N] for the following parameters shall be permitted in combination:

1) stopping sight distance;
2) horizontal curvature;
3) vertical crest curves;
4) absolute minimum for sag curves.

# E/3. Smart motorways

## Scope

E/3.1 The requirements and advice contained in Section E/3 shall only be used to upgrade an existing motorway to a smart motorway.

E/3.2 Where a new junction is proposed as part of a smart motorway, the parameters given in Section E/3 shall not be used to design the new elements of that junction e.g. the slip roads.

## Geometric parameters

### Design speed (CD 109 clauses 2.1 and 2.4)

E/3.3 Design speed shall be derived in accordance with CD 109 [Ref 1.N], however all design speeds can be classified as band B.

### Combinations (CD 109 clauses 2.12 and 2.13)

E/3.4 The relaxations below desirable minimum for the following parameters shall be permitted in combination:

1) stopping sight distance;
2) horizontal curvature;
3) vertical crest curves;
4) absolute minimum for sag curves;
5) superelevation.

### Immediate approaches to junctions (CD 109 clause 2.14)

E/3.5 The relaxations below desirable minimum identified in CD 109 [Ref 1.N] for the following parameters shall be permitted on the immediate approaches to junctions:

1) stopping sight distance;
2) vertical crest curves;
3) absolute minimum for sag curves.

### Stopping sight distance (CD 109 clauses 3.7)

E/3.6 The relaxations of one design speed step described in CD 109 [Ref 1.N] Section 3 for band A roads shall be permitted for band B roads.

### Road camber and drainage (CD 109 clauses 4.1 to 4.4)

E/3.7 Crossfall shall be measured across the paved surface of a road's cross-section.

*NOTE The paved surface of the cross-section comprises the carriageway, hard shoulder and hard strips.*

E/3.8 Where the total width of the running lanes is to be increased, the existing drainage flow paths shall be assessed to determine their suitability.

*NOTE Where the assessment of suitability identifies a benefit of doing so, crossfall can be increased by 0.5% above the requirements of CD 109 [Ref 1.N] to mitigate excessive depths of water.*

E/3.9 Retention of the existing crossfall (running lanes, hard shoulder, and hard strip) shall be permitted unless:

1) the assessment of drainage flow paths indicates the existing crossfall is not suitable (if an assessment is required);

2) the variation in crossfall for any given cross-section does not meet the criteria given in the following clauses in this sub-section of this document;

3) the review of the existing operational performance as described in this document highlights a collision problem relating to the existing crossfall, e.g. standing water.

E/3.10 The change in gradient of crossfall shall not exceed 5%.

*NOTE For example, a hard shoulder with a 2.5% fall towards the verge adjacent to lane one with a 2.5% fall towards the central reserve, is acceptable as the overall change is 5%.*

E/3.11 Changes in crossfall that create a sag shall only occur within hatched road markings with solid edge lines.

E/3.12 Where a sag creates a low point the associated surface water flow width shall not enter a traffic lane.

E/3.13 Crossfall shall not change within a lane.

E/3.14 Adverse camber shall not be provided on horizontal radii less than 2000 metres.

E/3.15 A minimum distance of 3 metres in cross-section shall be provided between changes in crossfall or superelevation within any given cross-section, except for connector road nosings where two changes in crossfall or superelevation are located on either side of the nose.

E/3.15.1 Where pavement works are being carried out (such as resurfacing or strengthening) then the crown line should be relocated to co-locate it with the road marking position, or adverse camber removed.

*NOTE Where an adverse camber is to be retained between the new lane 1 and 2, there is no requirement to move the crown line from its existing position to co-locate it with the road marking position.*

# E/4. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. CD 109, 'Highway link design' |
| Ref 2.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 3.N | Highways England. GD 300, 'Requirements for new and upgraded all-purpose trunk roads (expressways)' |
| Ref 4.N | IAN 161, 'Smart Motorways' |

Road Layout
Design

# CD 109
# Northern Ireland National Application Annex to CD 109 Highway link design

(formerly TD 9/93)

Revision 0

**Summary**
This National Application Annex sets out the Department for Infrastructure, Northern Ireland specific requirements for highway link design.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Nov 2019 | Department for Infrastructure, Northern Ireland National Application Annex to CD 109. |

# Foreword

## Publishing information

This document is published by Highways England on behalf of Department for Infrastructure, Northern Ireland.

This document supersedes those parts of TD 9/93 'Highway link design' which solely relate to roads in Northern Ireland which are withdrawn

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the Department for Infrastructure, Northern Ireland-specific requirements for the design of highway links to CD 109 on the Northern Ireland road network.

This National Application Annex is to be used in conjunction with CD 109.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

# NI/1. Traffic signs and road markings (additional to CD 109)

NI/1.1 All traffic signs and road markings on highway links shall conform to the TSR(NI) 1997 1997 [Ref 2.N].

*NOTE Traffic sign and road marking diagram numbers in TSR(NI) 1997 1997 [Ref 2.N] are generally consistent with TSRGD 2016 2016 [Ref 3.N] but the two sets of regulations can occasionally differ.*

# NI/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 2.N | The Stationery Office (TSO). Department for Infrastructure (DfI). TSR(NI) 1997, 'The Traffic Signs Regulations (Northern Ireland) 1997' , 1997 |
| Ref 3.N | The Stationery Office. TSRGD 2016, 'The Traffic Signs Regulations and General Directions 2016' , 2016 |

Road Layout
Design

# CD 109
# Scotland National Application Annex to CD 109 Highway link design

(formerly TD 9/93)

Revision 0

**Summary**
There are no specific requirements for Transport Scotland supplementary or alternative to those given in CD 109.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

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# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Nov 2019 | Transport Scotland National Application Annex to CD 109. |

Road Layout
Design

# CD 109
# Wales National Application Annex to CD 109 Highway link design

(formerly TD 9/93)

Revision 0

**Summary**
There are no specific requirements for Welsh Government supplementary or alternative to those given in CD 109.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

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# Contents

## Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Nov 2019 | Welsh Government National Application Annex to CD 109. |

Design Manual for Roads and Bridges

Road Layout
Design

# CD 127
# Cross-sections and headrooms

(formerly TD 27/05, TD 70/08)

Version 1.0.1

**Summary**
This document provides requirements for the highway cross-sections and headroom at structures for motorway and all-purpose trunk roads.

**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

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# Contents

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 127 | 1.0.**1** | July 2021 | Core document, Northern Ireland NAA | Incremental change to notes and editorial updates |
| Published due to update of Northern Ireland National Application Annex only. | | | | |

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 127 | 1 | March 2020 | | |
| CD 127 | 0 | November 2019 | | |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes TD 27/05 Cross-sections and Headrooms and the wide single 2+1 road cross-section element from TD 70/08 Design of wide single 2+1 roads, which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This document sets out the design requirements and advice to be followed in selecting highway cross-sections and headrooms on motorways and all-purpose trunk roads.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 18.N] apply to this document.

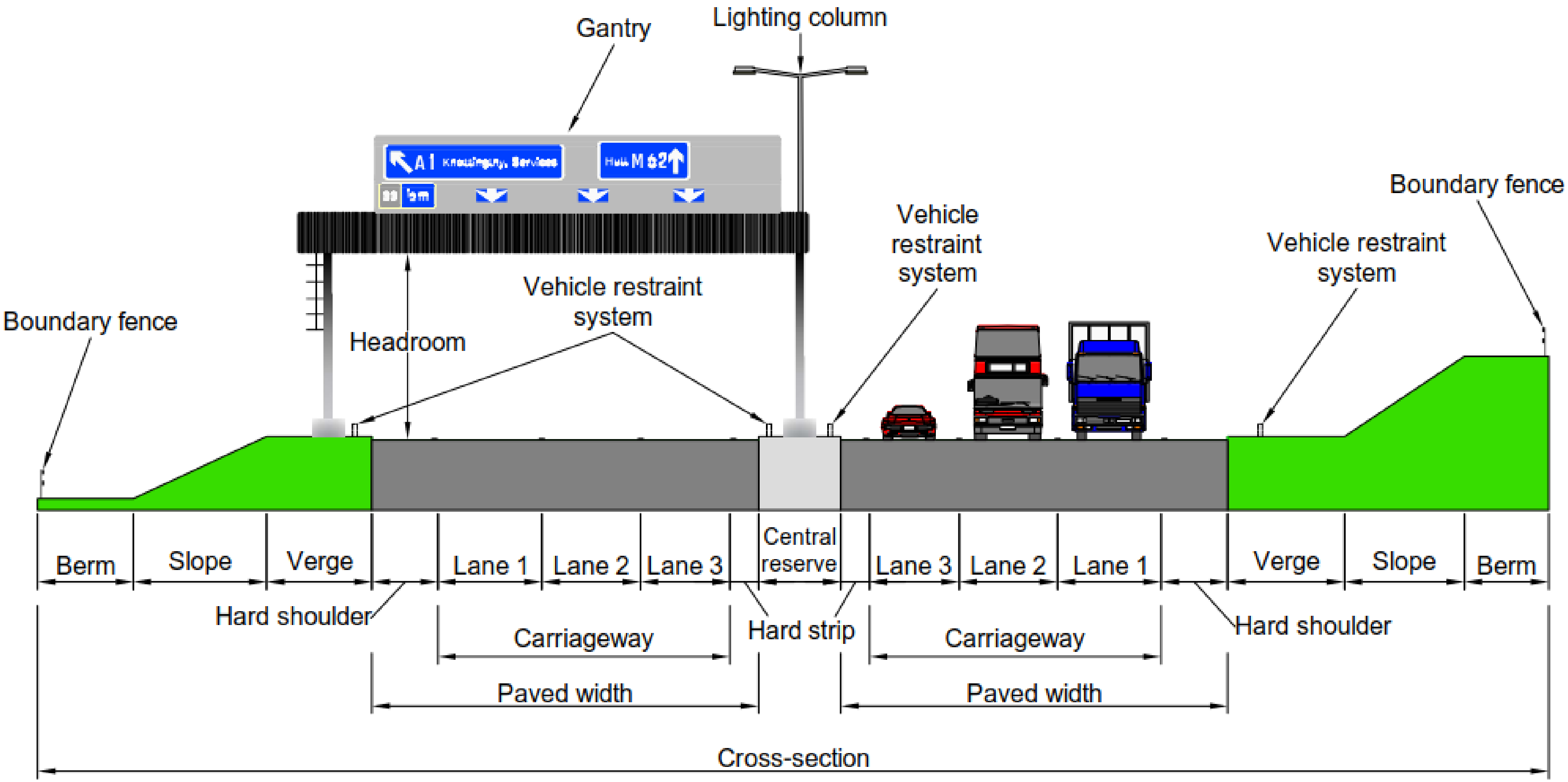
## Cross-section components

### Range of choice

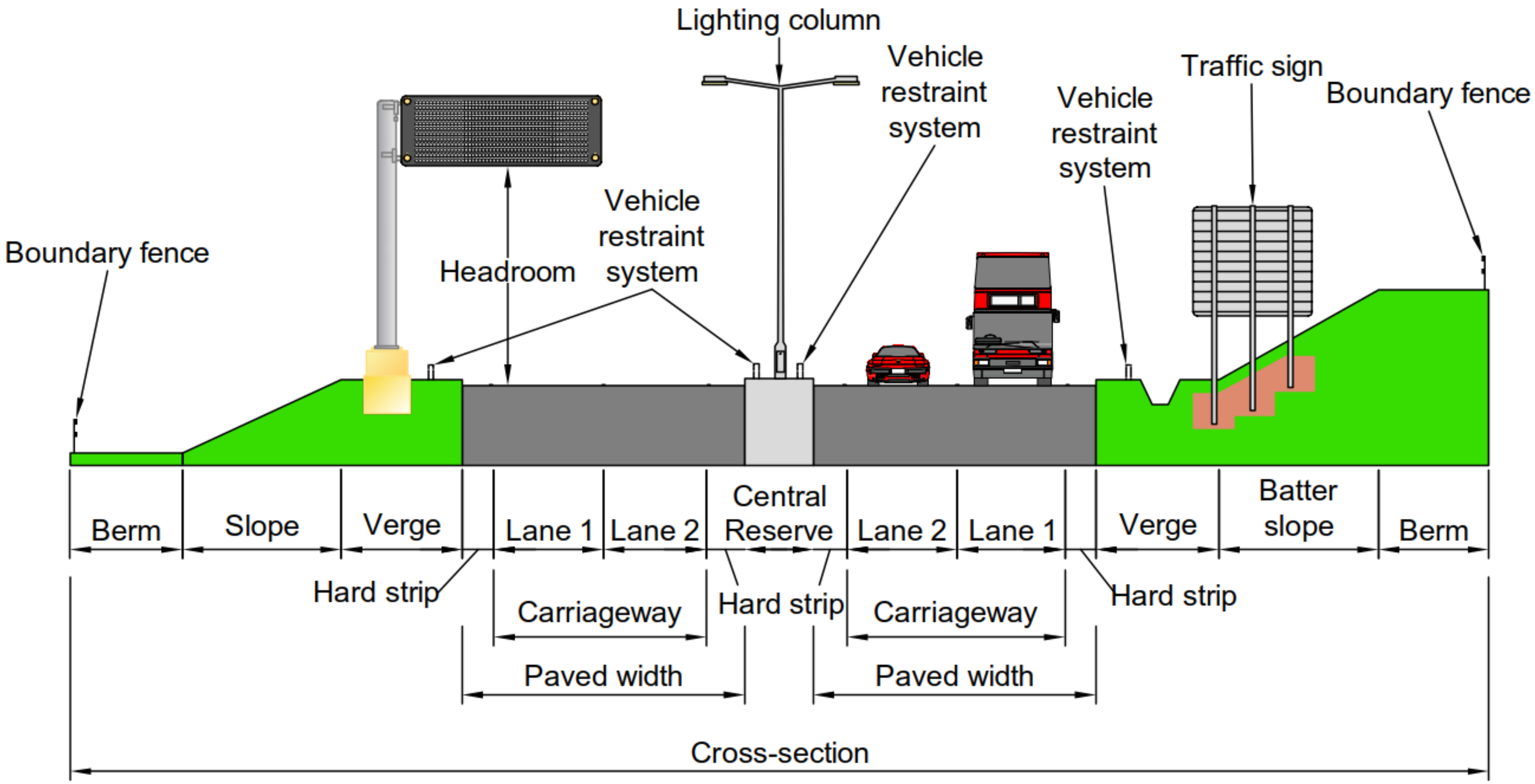
The cross-section is made up from a combination of distinct components that vary depending upon the type of highway and the facilities provided for the various users of the route. The components which make up a typical cross-section are shown in the diagrams below.

Where this document permits options for the dimensions of components, the decision making process needs to assess the impact on safety, environment, cost, buildability, operation, maintenance and other design constraints.

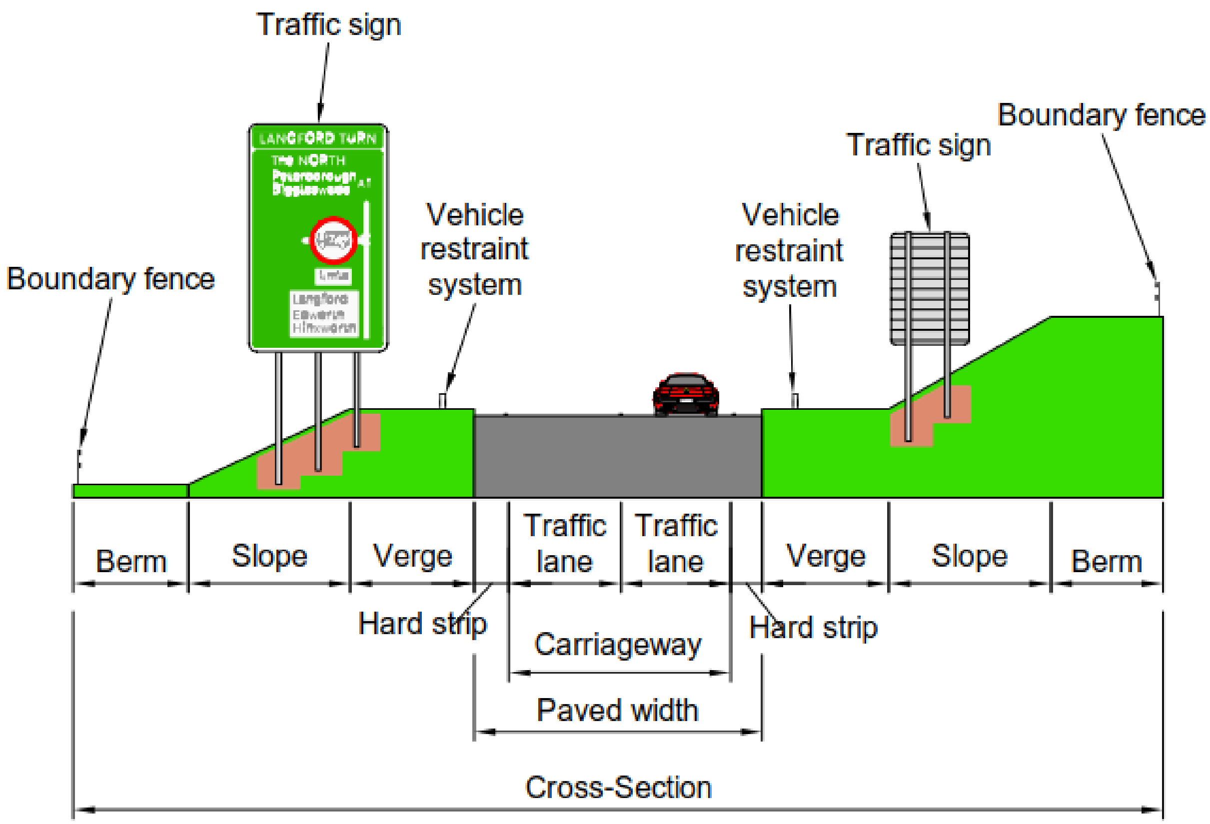
**Typical rural motorway cross-section components**



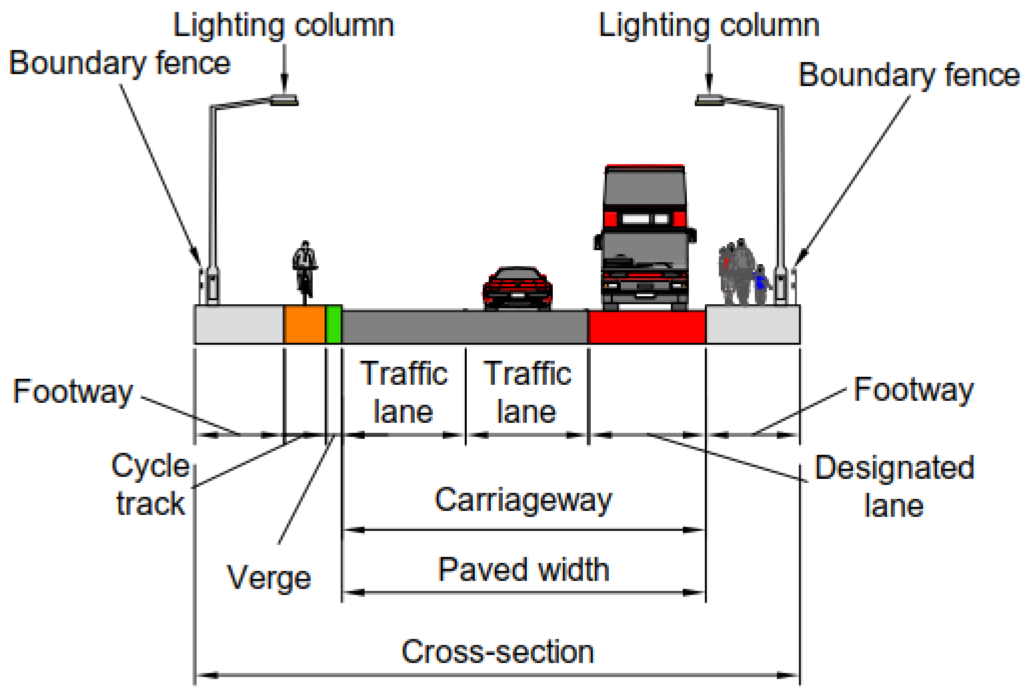
**Typical rural dual carriageway cross-section components**



**Typical rural single carriageway cross-section components**



**Typical urban single carriageway cross-section components**



# Abbreviations and symbols

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| mm | Millimetres |
| mph | Miles per hour |
| SFZ | Structure free zone |
| TSRGD | Traffic Sign Regulations and General Directions |
| VRS | Vehicle restraint system |

**Symbols**

| Symbol | Definition |
|---|---|
| S | Added headroom clearance at sag curves |

# Terms and definitions

**Terms and definitions**

| Term | Definition |
|---|---|
| Bridleway | Highway for use by pedestrians, horse-riders and cyclists (unless specifically prohibited).<br><br>NOTE: Cyclists are expected to give way to other users. |
| Berm | Any nominally flat area between the back of the verge and the highway boundary on a cutting or embankment. |
| Carriageway | The area of the paved width which is trafficked by road users under normal operation.<br><br>NOTE 1: This includes designated lanes such as bus lanes and cycle lanes.<br>NOTE 2: The carriageway excludes hard shoulders and hard strips.<br>NOTE 3: This definition of carriageway can differ from those used in the Highways Act 1980 c66 [Ref 14.N] and the SI 2016 No 362 (TSRGD) 2016 [Ref 23.N]. |
| Central reserve | The area that separates the carriageways of a dual carriageway exclusive of any hard strips. |
| Connector road | A collective term for interchange links, link roads, slip roads and loops designed as part of a full grade separated junction. |
| Cross-section | The assembly of the various components of the highway between the highway boundaries, measured at right angles to the line of the highway.<br><br>NOTE: Cross-section components include:<br>1) carriageways;<br>2) central reserve;<br>3) separator zones;<br>4) hard shoulders;<br>5) hard strips;<br>6) verges including any footway;<br>7) cycle track or bridleway;<br>8) cutting or embankment slopes; and<br>9) berms. |
| Cycle lane | A lane in the carriageway for use by cyclists. |
| Cycle track | A track separate from the main carriageway for use by cyclists. |
| Design organisation | The organisation undertaking the scheme preparation. |
| Designated lanes | A lane exclusively for use by designated vehicles such as bicycles, buses, taxis, large goods vehicles and high occupancy vehicles. |

**Terms and definitions** (continued)

| Term | Definition |
|---|---|
| Headroom | The minimum distance between the surface of the carriageway and a structure (accounting for any deflection due to temporary or permanent attachments) measured at right angles to the surface of the carriageway. |
| Mainline | The major carriageway. At a junction the mainline typically has a higher road classification and / or carries greater traffic volumes. |
| Maintained headroom | The minimum value of headroom to be preserved at all times. |
| Maintaining organisation | The organisation commissioned to undertake the maintenance of an asset. |
| New construction headroom | The value of headroom for new structures that includes an additional allowance for deflection of the structure and future road realignment and resurfacing. |
| Overbridge | A bridge that spans above the road being considered. |
| Paved width | A collective term for the surface of the cross-section that comprises the carriageway, hard shoulder and hard strips (including designated lanes and cycle lanes). |
| Paved width headroom | The value of headroom over the paved width. |
| Rural roads | An all-purpose road or motorway that is generally not subjected to a local speed limit. |
| Separator zone | An area that separates traffic flows on the mainline from an adjacent parallel road, e.g. link road. |
| Slip road | A connector road between a mainline carriageway and another road.<br><br>NOTE: At the end of a slip road, traffic can encounter a priority junction, a roundabout or traffic signals. |
| Standard headroom | Either maintained headroom or new construction headroom, as appropriate. |
| Structure | Any object with the primary purpose of bearing loads.<br><br>NOTE: This includes bridges, footbridges, retaining walls and sign or signal gantries, but excludes more frangible items such as deformable vehicle restraint systems. |
| Structure free zone | A buffer zone beneath a structure located at the central reserve and at the verges adjacent to the paved width, that reduces the risk of errant vehicle impacts by providing an appropriate value of headroom. |
| Subway | Underground passageway or tunnel for use by pedestrians, cyclists, and sometimes equestrians. |
| Underbridge | A bridge that carries the road being considered over another road, railway or watercourse. |
| Urban roads - motorway | A motorway with a speed limit of 60 mph or less within a built-up area. |

**Terms and definitions** (continued)

| Term | Definition |
|---|---|
| Urban roads - all purpose roads | An all-purpose road within a built-up area, either a single carriageway with a speed limit of 40mph or less or a dual-carriageway with a speed limit of 60mph or less. |
| Vehicle restraint system | A safety system installed at the edges of the carriageway to provide vehicle restraint. |
| Verge | Any nominally flat area between the edge of the paved width and either the start of an adjacent side slope or, in the absence of a side slope, the highway boundary or bridge parapet. |
| Wide highway corridor | Any all-purpose dual carriageway with more than 3 mainline lanes or motorway with more than 4 mainline lanes in any one direction. |
| Working width | The distance between the traffic side of the barrier before impact and the maximum dynamic lateral position of the system after impact. |

# 1. Scope

## Aspects covered

1.1 This document provides requirements and advice for the cross-sections and headrooms that shall be used for both new and improved motorways and all-purpose trunk roads including connector roads.

*NOTE 1 This document does not give mandatory requirements for headroom near airports or additional headroom requirements at power lines.*

*NOTE 2 International Civil Aviation Organisation document ICAO Vol 1 [Ref 16.N] provides requirements and advice for headrooms near airports.*

1.2 The distribution network operator shall be contacted to establish whether additional clearance is required beneath overhead power lines.

1.3 The cross-section and headrooms of roads that are not motorways or all-purpose trunk roads and are diverted or improved as part of a trunk road scheme shall be agreed with the highway authority for that road.

1.4 This document shall not be applied to the design of road tunnels or the crossovers at tunnels.

*NOTE For requirements and advice for the design of tunnels refer to CD 352 [Ref 4.N].*

1.5 This document shall not apply to the design of central reserve crossovers used during temporary traffic management situations.

*NOTE For requirements and advice for the design of central reserve crossovers refer to CD 192 [Ref 27.N].*

1.6 This document shall not be applied to the design of pedestrian, cycle and equestrian subways and underpasses.

*NOTE 1 For requirements and advice for the design of subways and underpasses refer to CD 143 [Ref 6.N] and CD 195 [Ref 5.N]. In Scotland, further details are also given in Roads for All Roads for All [Ref 24.N].*

*NOTE 2 Requirements and advice for the design of footbridges is given in CD 353 [Ref 3.N].*

1.7 This document shall not be used for the design of designated lanes for specific vehicle types, e.g. bus lanes or cycle lanes.

*NOTE 1 For advice on the design of bus lanes refer to TSM Chapter 5 ISBN 9780115532085 [Ref 29.N].*

*NOTE 2 For requirements and advice for the design of cycle lanes refer to CD 195 [Ref 5.N].*

## Implementation

1.8 This document shall be implemented forthwith on all schemes involving the design of highway cross-sections and headrooms on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 18.N].

1.9 Proposals to adopt departures from this document shall be submitted in accordance with GG 101 [Ref 18.N].

## Use of GG 101

1.10 The requirements of GG 101 [Ref 18.N] shall be followed in respect of activities covered by this document.

# 2. Highway cross-sections

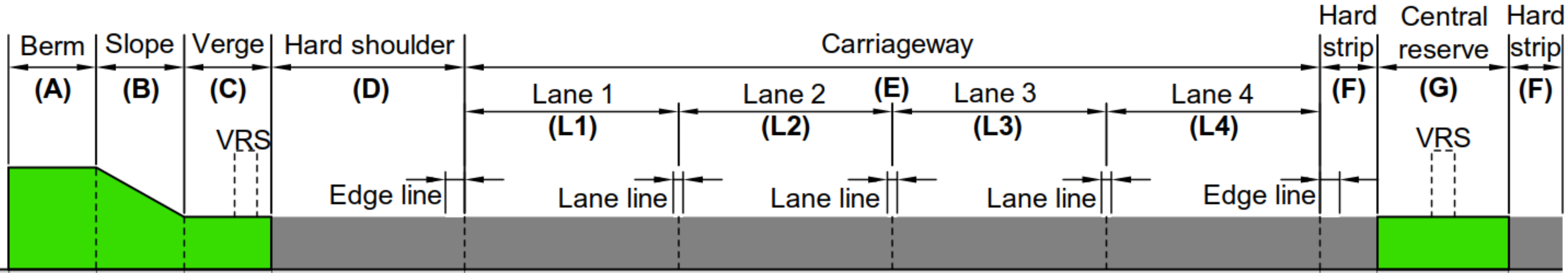
## General

2.1 The requirements in this section shall apply to all cross-sections other than those through or across structures for which the requirements are given in Section 3 of this document.

2.1.1 Numerous changes in the cross-section and its components are not desirable along a route and a consistent width should be provided.

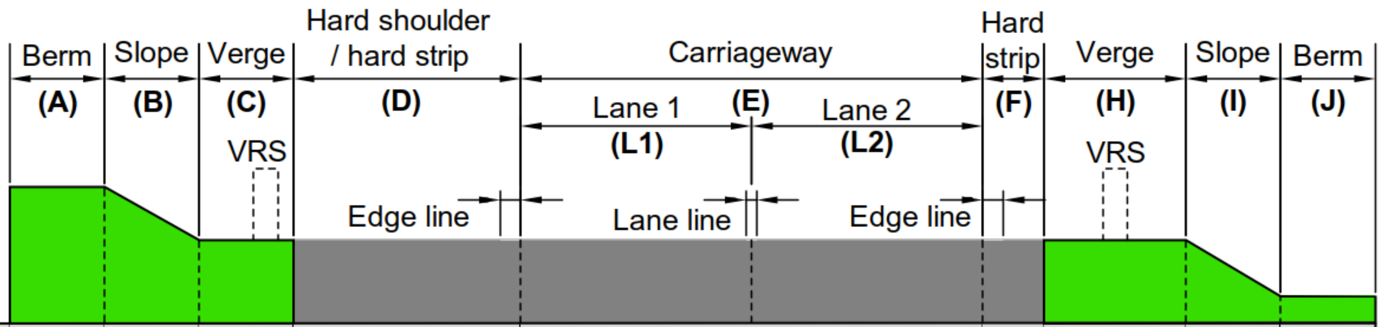
*NOTE 1 Typical cross-sections are provided in Figures 2.1.1N1a to 2.1.1N1h.*

**Figure 2.1.1N1a Dimensions of cross-section components for rural motorway mainline**




| Road type | A | B | C | D | E | | | | F | G | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | L1 | L2 | L3 | L4 | | | |
| Dual 2 lane (D2M) | Varies | Varies | 1.50 | 3.30 | **7.30** | | N/A | | 0.70 | 3.10 | |
| | | | | | 3.65 | 3.65 | | | | | |
| Dual 3 lane (D3M) | Varies | Varies | 1.50 | 3.30 | **11.00** | | | N/A | 0.70 | 3.10 | |
| | | | | | 3.65 | 3.70 | 3.65 | | | | |
| Dual 4 lane (D4M) | Varies | Varies | 1.50 | 3.30 | **14.70** | | | | 0.70 | 3.10 | |
| | | | | | 3.65 | 3.70 | 3.70 | 3.65 | | | |

**Figure 2.1.1N1b Dimensions of cross-section components for rural motorway connector roads**

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<tr><th>hard strip</th><th>hard shoulder</th><th>L1</th><th>L2</th></tr>
<tr><td>Slip roads</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MG1A/DG1A</td><td>Varies</td><td>Varies</td><td>1.50</td><td>N/A</td><td>3.30</td><td>3.70</td><td>N/A</td><td>0.70</td><td>2.30</td><td>Varies</td><td>Varies</td></tr>
<tr><td rowspan="2">DG2A</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">2.50</td><td rowspan="2">1.00</td><td rowspan="2">N/A</td><td colspan="2">7.30</td><td rowspan="2">1.00</td><td rowspan="2">2.00</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td></tr>
<tr><td>3.65</td><td>3.65</td></tr>
<tr><td rowspan="2">MG2C/DG2C</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">1.50</td><td rowspan="2">N/A</td><td rowspan="2">3.30</td><td colspan="2">7.30</td><td rowspan="2">1.00</td><td rowspan="2">2.00</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td></tr>
<tr><td>3.65</td><td>3.65</td></tr>
<tr><td>Interchange links</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>IL1B</td><td>Varies</td><td>Varies</td><td>1.50</td><td>N/A</td><td>3.30</td><td>3.70</td><td>N/A</td><td>0.70</td><td>2.30</td><td>Varies</td><td>Varies</td></tr>
<tr><td rowspan="2">IL2B</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">1.50</td><td rowspan="2">N/A</td><td rowspan="2">3.30</td><td colspan="2">7.30</td><td rowspan="2">1.00</td><td rowspan="2">2.00</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td></tr>
<tr><td>3.65</td><td>3.65</td></tr>
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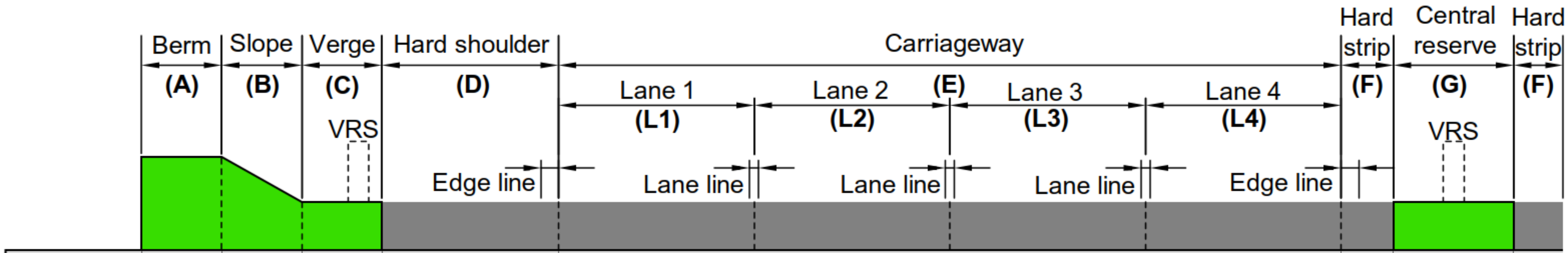
**Figure 2.1.1N1c Dimensions of cross-section components for urban motorway mainline**




<table>
<tr><th rowspan="2">Road type</th><th rowspan="2">A</th><th rowspan="2">B</th><th rowspan="2">C</th><th rowspan="2">D</th><th colspan="4">E</th><th rowspan="2">F</th><th rowspan="2">G</th><th rowspan="2"></th></tr>
<tr><th>L1</th><th>L2</th><th>L3</th><th>L4</th></tr>
<tr><td rowspan="2">Dual 2 lane (D2UM)</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">2.75</td><td colspan="2">7.30</td><td colspan="2" rowspan="2">N/A</td><td rowspan="2">0.70</td><td rowspan="2">1.60</td><td rowspan="2"></td></tr>
<tr><td>3.65</td><td>3.65</td></tr>
<tr><td rowspan="2">Dual 3 lane (D3UM)</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">2.75</td><td colspan="3">11.00</td><td rowspan="2">N/A</td><td rowspan="2">0.70</td><td rowspan="2">2.10</td><td rowspan="2"></td></tr>
<tr><td>3.65</td><td>3.70</td><td>3.65</td></tr>
<tr><td rowspan="2">Dual 4 lane (D4UM)</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">2.75</td><td colspan="4">14.70</td><td rowspan="2">0.70</td><td rowspan="2">2.10</td><td rowspan="2"></td></tr>
<tr><td>3.65</td><td>3.70</td><td>3.70</td><td>3.65</td></tr>
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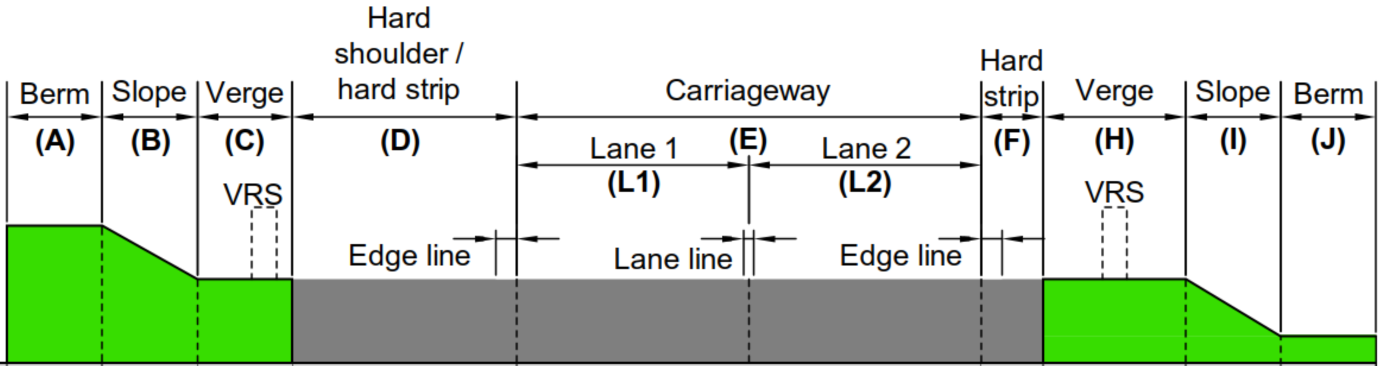
**Figure 2.1.1N1d Dimensions of cross-section components for urban motorway connector roads**

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<tr><th>hard strip</th><th>hard shoulder</th><th>L1</th><th>L2</th></tr>
<tr><td>Slip roads</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MG1B/DG1B</td><td>Varies</td><td>Varies</td><td>Varies</td><td>N/A</td><td>3.30</td><td>3.70</td><td>N/A</td><td>0.30</td><td>Varies</td><td>Varies</td><td>Varies</td></tr>
<tr><td rowspan="2">DG2B</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">1.00</td><td rowspan="2">N/A</td><td colspan="2">7.30</td><td rowspan="2">0.30</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td></tr>
<tr><td>3.65</td><td>3.65</td></tr>
<tr><td rowspan="2">MG2D/DG2D</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">N/A</td><td rowspan="2">2.75</td><td colspan="2">7.30</td><td rowspan="2">0.30</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td></tr>
<tr><td>3.65</td><td>3.65</td></tr>
<tr><td>Interchange links</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>IL1B</td><td>Varies</td><td>Varies</td><td>Varies</td><td>N/A</td><td>3.30</td><td>3.70</td><td>N/A</td><td>0.30</td><td>Varies</td><td>Varies</td><td>Varies</td></tr>
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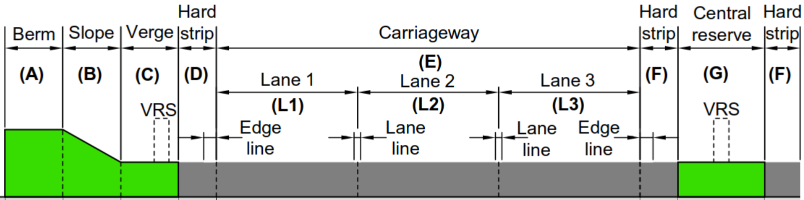
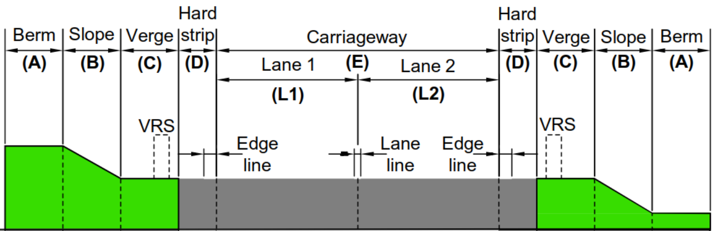
**Figure 2.1.1N1e Dimensions of cross-section components for rural all-purpose roads mainline**



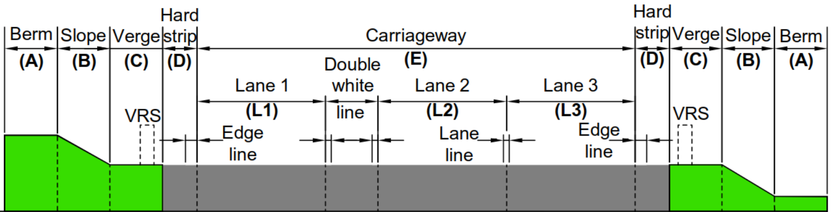

| Road type | A | B | C | D | E | | | F | G | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | L1 | L2 | L3 | | | |
| Dual 2 lane (D2AP) | Varies | Varies | 2.50 | 1.00 | 7.30 | | N/A | 1.00 | 2.50 | |
| | | | | | 3.65 | 3.65 | | | | |
| Dual 3 lane (D3AP) | Varies | Varies | 2.50 | 1.00 | 11.00 | | | 1.00 | 2.50 | |
| | | | | | 3.65 | 3.70 | 3.65 | | | |

**Dual carriageway**



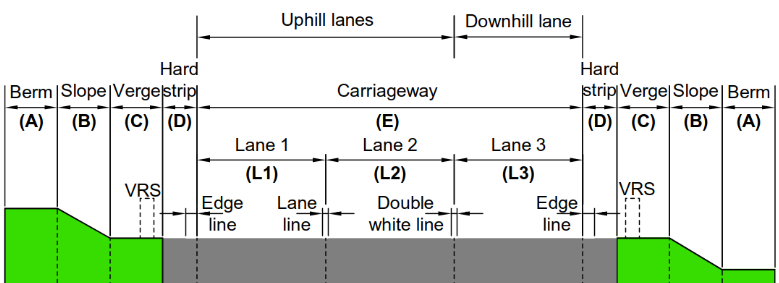

| Road type | A | B | C | D | E | | D | C | B | A |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | L1 | L2 | | | | |
| Single (S2) | Varies | Varies | 2.50 | 1.00 | 7.30 | | 1.00 | 2.50 | Varies | Varies |
| | | | | | 3.65 | 3.65 | | | | |
| Wide single (WS2) | Varies | Varies | 2.50 | 1.00 | 10.00 | | 1.00 | 2.50 | Varies | Varies |
| | | | | | 5.00 | 5.00 | | | | |

**Single carriageway**




| Road type | A | B | C | D | E | | | | D | C | B | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | L1 | M | L2 | L3 | | | | |
| Wide single 2+1 (WS2+1) | Varies | Varies | 2.50 | 1.00 | 11.50 | | | | 1.00 | 2.50 | Varies | Varies |
| | | | | | 3.50 | 1.00 | 3.50 | 3.50 | | | | |

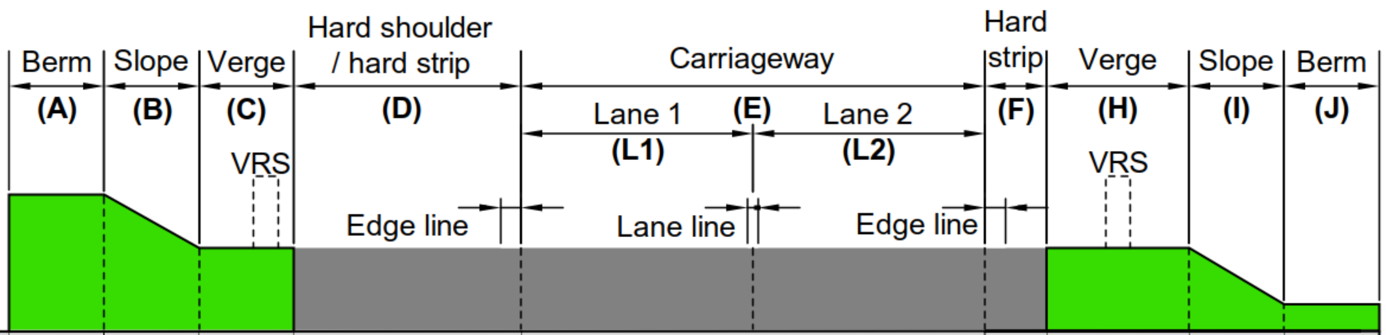
**Wide single 2+1 carriageway**




| Road type | A | B | C | D | E | | | D | C | B | A |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | L1 | L2 | L3 | | | | |
| Wide single (WS2) climbing lane Section | Varies | Varies | 2.50 | 1.00 | 10.50 | | | 1.00 | 2.50 | Varies | Varies |
| | | | | | 3.50 | 3.50 | 3.50 | | | | |

**Wide single (WS2) climbing lane section**

**Figure 2.1.1N1f Dimensions of cross-section components for rural all-purpose connector roads**




<table>
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<tr><th>hard strip</th><th>hard shoulder</th><th>L1</th><th>L2</th></tr>
<tr><td>Slip roads</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MG1C/ DG1C</td><td>Varies</td><td>Varies</td><td>2.00</td><td>N/A</td><td>3.30</td><td>3.70</td><td>N/A</td><td>0.70</td><td>2.80</td><td>Varies</td><td>Varies</td></tr>
<tr><td rowspan="2">MG2E/ DG2E</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">2.50</td><td rowspan="2">1.00</td><td rowspan="2">N/A</td><td colspan="2">7.30</td><td rowspan="2">1.00</td><td rowspan="2">2.50</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td></tr>
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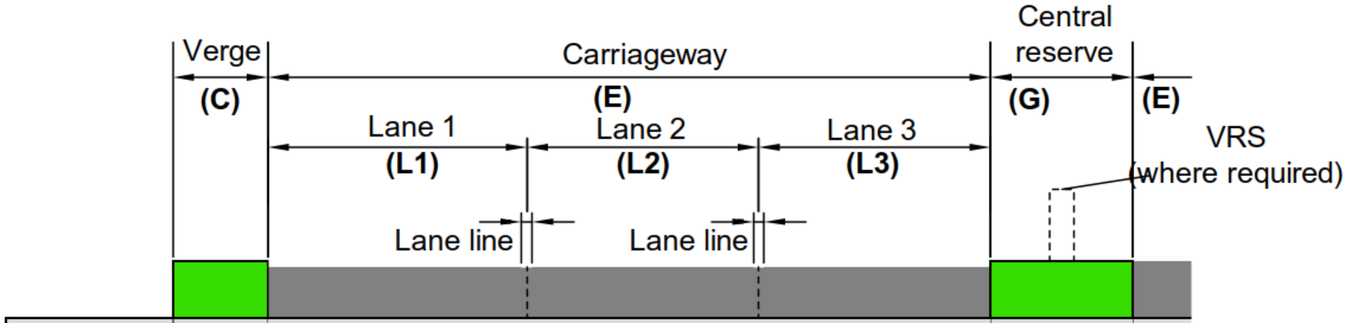
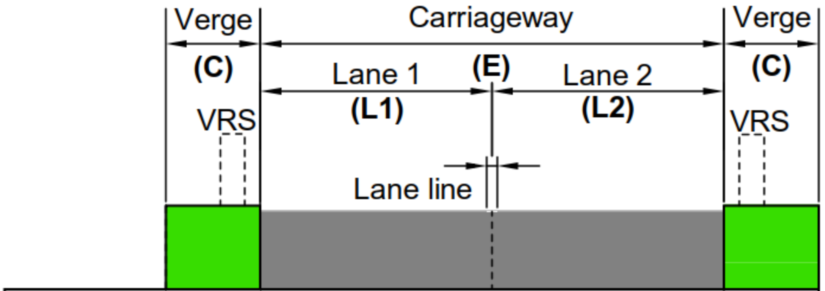
<tr><td>Interchange links</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>IL1C</td><td>Varies</td><td>Varies</td><td>2.00</td><td>N/A</td><td>3.30</td><td>3.70</td><td>N/A</td><td>0.70</td><td>2.80</td><td>Varies</td><td>Varies</td></tr>
<tr><td rowspan="2">IL2C</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td><td rowspan="2">2.50</td><td rowspan="2">1.00</td><td rowspan="2">N/A</td><td colspan="2">7.30</td><td rowspan="2">1.00</td><td rowspan="2">2.50</td><td rowspan="2">Varies</td><td rowspan="2">Varies</td></tr>
<tr><td>3.65</td><td>3.65</td></tr>
</table>

**Figure 2.1.1N1g Dimensions of cross-section components for urban all-purpose roads mainline**




| Road type | C | E | | | G | |
|---|---|---|---|---|---|---|
| | | L1 | L2 | L3 | | |
| Dual 2 lane (D2UAP) | Varies | 7.30 | | N/A | 1.80 | |
| | | 3.65 | 3.65 | | | |
| Dual 3 lane (D3UAP) | Varies | 11.00 | | | 1.80 | |
| | | 3.65 | 3.70 | 3.65 | | |

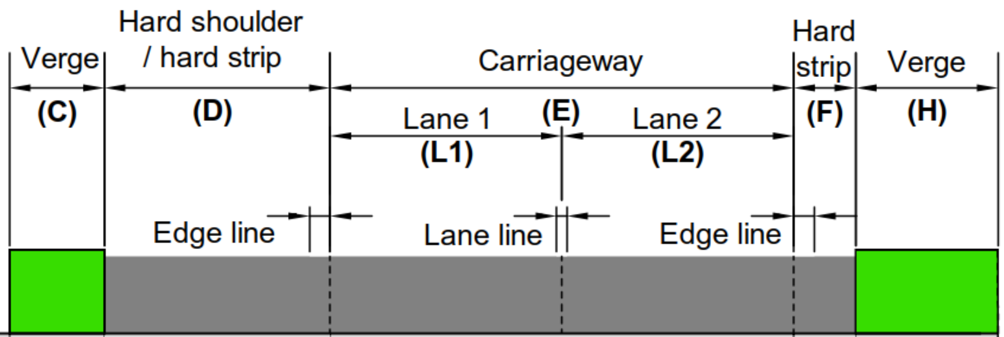
**Dual carriageway**




| Road type | C | E | | C |
|---|---|---|---|---|
| | | L1 | L2 | |
| Single (SU2) | Varies | 7.30 | | Varies |
| | | 3.65 | 3.65 | |

**Single carriageway**

**Figure 2.1.1N1h Dimensions of cross-section components for urban all-purpose connector roads**




<table>
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<tr><th>hard strip</th><th>hard shoulder</th><th>L1</th><th>L2</th></tr>
<tr><td>Slip roads</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>MG1D/ DG1D</td><td>Varies</td><td>N/A</td><td>3.30</td><td>3.70</td><td>N/A</td><td>0.30</td><td>Varies</td></tr>
<tr><td rowspan="2">MG2F/ DG2F</td><td rowspan="2">Varies</td><td rowspan="2">1.00</td><td rowspan="2">N/A</td><td colspan="2">7.30</td><td rowspan="2">0.30</td><td rowspan="2">Varies</td></tr>
<tr><td>3.65</td><td>3.65</td></tr>
<tr><td>Interchange links</td><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>IL1D</td><td>Varies</td><td>N/A</td><td>3.30</td><td>3.70</td><td>N/A</td><td>0.30</td><td>Varies</td></tr>
<tr><td rowspan="2">IL2D</td><td rowspan="2">Varies</td><td rowspan="2">1.00</td><td rowspan="2">N/A</td><td colspan="2">7.30</td><td rowspan="2">0.30</td><td rowspan="2">Varies</td></tr>
<tr><td>3.65</td><td>3.65</td></tr>
</table>

*NOTE 2* *All dimensions in Figures 2.1.1N1a to 2.1.1N1h are in metres.*

*NOTE 3* *Offside lane widths are measured to the trafficked side of the offside edge line (rural) or face of offside kerb (urban).*

*NOTE 4* *Details provided for dual carriageways are applicable for both sides of the road.*

*NOTE 5* *The TSM Chapter 5 ISBN 9780115532085 [Ref 29.N] provides guidance on the widths of road markings.*

### Traffic lane width

2.2 Traffic lane widths for horizontal curvature greater than 400 metres radii shall be in accordance with Figures 2.1.1N1a to 2.1.1N1h.

*NOTE 1* *Traffic lane widths for carriageways with horizontal curve radii of greater than 90 metres but below 400 metres are given in CD 109 [Ref 13.N].*

*NOTE 2* *Traffic lane widths at junctions where the horizontal curve radii are 90 metres or less are given in CD 123 [Ref 11.N].*

2.3 Traffic lane widths shall be measured between the trafficked side of carriageway edge lines and the centre of lane lines.

### Hard strips

2.4 Nearside hard strips shall be provided as shown in Figures 2.1.1N1a to 2.1.1N1h.

2.5 The minimum width of offside hard strips (dimension F) shall be as shown in Figures 2.1.1N1a to 2.1.1N1h.

2.6 The maximum width of offside hard strips (dimension F) shall be 1.00 metre.

*NOTE 1* *Offside hard strip widths up to 1.00 metre can be appropriate where the road falls to the offside and additional drainage surface area is required.*

*NOTE 2* *A hard strip provides a surfaced strip that abuts the carriageway. The key reasons for the provision of hard strips include:*

1) *pavement integrity/stability;*
2) *partial provision for stopped vehicles;*
3) *snow and water collection;*
4) *overrun facility for driver error or evasive action;*
5) *improved level of service and driver comfort;*
6) *supports edge lines;*
7) *reduces the risk of vegetation encroachment over edge lines; and*
8) *allows for the placement of road studs outside vehicle wheel paths, where appropriate.*

### Hard shoulders

2.7 Nearside hard shoulders shall be provided as shown in Figures 2.1.1N1a to 2.1.1N1h.

*NOTE* *The hard shoulder is provided adjacent to the nearside of the carriageway to offer a place to stop in emergencies, clear of mainline traffic. It also provides access for emergency vehicles and additional road space during temporary traffic management.*

2.8 Offside hard shoulders shall not be permitted.

### Central reserves

2.9 Minimum central reserve widths shall be as shown in Figures 2.1.1N1a to Figure 2.1.1N1h except where the offside hard strip has been widened for drainage.

NOTE *Where the offside hard strip has been widened for drainage, the central reserve can be reduced by up to the same value as the increase in the offside hard strip.*

2.9.1 The central reserve may be widened in order to:

1) provide the requisite stopping sight distances in accordance with CD 109 [Ref 13.N];
2) accommodate any street furniture, utility, drainage features or equipment;
3) meet the requirements for vehicle restraint systems (VRS);
4) accommodate any permanent signs required with particular attention to the provision of the required working width and set-back for VRSs relative to the complete sign assembly;
5) accommodate significant difference in levels of adjacent carriageways;
6) accommodate temporary traffic management layouts for the envisaged maintenance regime;
7) accommodate matrix signs and signals;
8) accommodate any parts of structures or complete structures;
9) provide sufficient space for maintenance operations;
10) fulfil landscape and environmental objectives; and
11) accommodate walking, cycling and horse-riding routes.

NOTE *Requirements and advice for the widening of central reserves at priority junctions are given in CD 123 [Ref 11.N].*

2.9.2 The central reserve should be hardened or have low growth species of grass to minimise the need for maintenance.

2.9.3 When deciding whether to harden central reserves, the design should:

1) check the adequacy of the surface water drainage system to accommodate any additional surface water run-off;
2) make an assessment of environmental factors, such as the landscape character of the setting and location of the road, the environmental consequences of weed control and the function of the central reserve as potential habitat;
3) determine the area to be hardened, based on what areas of vegetation can be left uncut without affecting visibility or sign conspicuity; and
4) take account of whole-life costs and safety considerations.

2.9.4 Away from crossovers, any hardening of the central reserve should be designed to be capable of withstanding vehicle over-run and prevent vegetation growth.

NOTE *For further requirements and advice on landscape design see LA 101 [Ref 17.N], LA 102 [Ref 26.N], LA 103 [Ref 25.N], LA 104 [Ref 8.N], LA 107 [Ref 19.N] and LD 117 [Ref 20.N].*

2.9.5 Where the hardened area could be misused by road users, contrasting coloured surfacing may be used in the central reserve, although this is only likely to be necessary where the VRS set-back is 1.50 metres or greater.

NOTE 1 *In some situations it can be appropriate to continue the coloured surface across the whole central reserve.*

NOTE 2 *In other situations, for reasons of cost or aesthetics, the width of the coloured surfacing can be limited to the traffic side of the VRS.*

### Verges

2.10 Minimum verge widths shall be as shown in Figures 2.1.1.N1a to 2.1.1.N1h, except where:

1) there is a need for increased width to accommodate communication ducts and chambers;
2) the offside hard strip is being widened for drainage; or

3) the nearside verge on a single lane rural all-purpose connector road is located immediately adjacent to the highway boundary.

2.11 Where the offside hard strip has been widened for drainage, the reduction of the offside verge shall be no more than the increase in the offside hard strip.

2.11.1 Thin strips of grass or other vegetation within the highway cross-section should be avoided as they can result in safety issues related to maintenance.

*NOTE 1 The verge offers an important component in highway drainage systems, including the storage of snow displaced from the carriageway. It offers an area to support utility plant and to house highway equipment. Congested verges with insufficient room for necessary roadside components present both safety and engineering difficulties.*

*NOTE 2 Documents CD 143 [Ref 6.N] and CD 195 [Ref 5.N] provide requirements and advice on the appropriate widths of facilities for walking, cycling and horse-riding and the horizontal separation (verge) from the carriageway.*

2.12 Where the nearside verge on a single lane rural all-purpose connector road is located immediately adjacent to the highway boundary, the verge shall be increased by a minimum of 0.50 metres over the values given in Figure 2.1.1.N1f.

2.13 Where Figures 2.1.1.N1a to 2.1.1.N1h indicate the verge width "varies" and it is necessary to accommodate communications ducting and chambers, a minimum verge width of 2.00 metres shall be provided.

2.13.1 Where Figures 2.1.1.N1a to 2.1.1.N1h indicate verge width "varies" or where the verge width needs to be increased over the minimum value, the verge should be designed where applicable to:

1) accommodate the requisite stopping sight distances in accordance with CD 109 [Ref 13.N];
2) accommodate any street furniture, utility, drainage features or equipment;
3) meet the requirements for VRS ( CD 377 [Ref 22.N]);
4) accommodate any permanent signs required with particular attention to the provision of the required working width and set-back for VRSs relative to the complete sign assembly;
5) accommodate significant level differences;
6) accommodate temporary traffic management layouts for the envisaged maintenance regime;
7) accommodate matrix signs and signals;
8) accommodate any parts of structures or complete structures;
9) provide sufficient space for maintenance operations;
10) fulfil landscape and environmental objectives including environmental fencing;
11) accommodate walking, cycling and horse-riding routes; and/or
12) provide for access to emergency telephones or provide a safe location for stranded motorists.

## Wide carriageways

### Mainline lane provision

2.14 All-purpose dual carriageways shall not have more than three mainline lanes in one direction.

2.15 Motorways shall not have more than four mainline lanes in one direction.

*NOTE Auxiliary lanes are not included when determining the number of mainline lanes on all-purpose dual carriageways and motorways.*

### Auxiliary lane provision

2.16 Where auxiliary lanes are provided, the width of the auxiliary lane(s) shall be equal to the width of the adjacent nearside mainline lane.

2.17 The provision of either a hard shoulder or a hard strip adjacent to an auxiliary lane shall be consistent with the provision on the mainline.

### Connector road lane provision

2.18 Where a junction capacity assessment has identified additional connector road lanes are required at the junction at the end of the slip road, the lane width requirements for additional lanes shall be:

1) where the additional lane(s) is 100 metres or less in length, the lane width is derived from the junction document ( CD 122 [Ref 12.N] or CD 123 [Ref 11.N]) for the type of junction at the end of the slip road, see Figure 2.18a;
2) where the additional lane(s) is greater than 100 metres in length, the lane width is 3.65 metres wide plus any allowance for widening at tight radii, see Figures 2.18b and 2.19 (see section on "Traffic lane width").

**Figure 2.18a Partial additional lane(s) slip road provision - additional lane 100m or less in length**

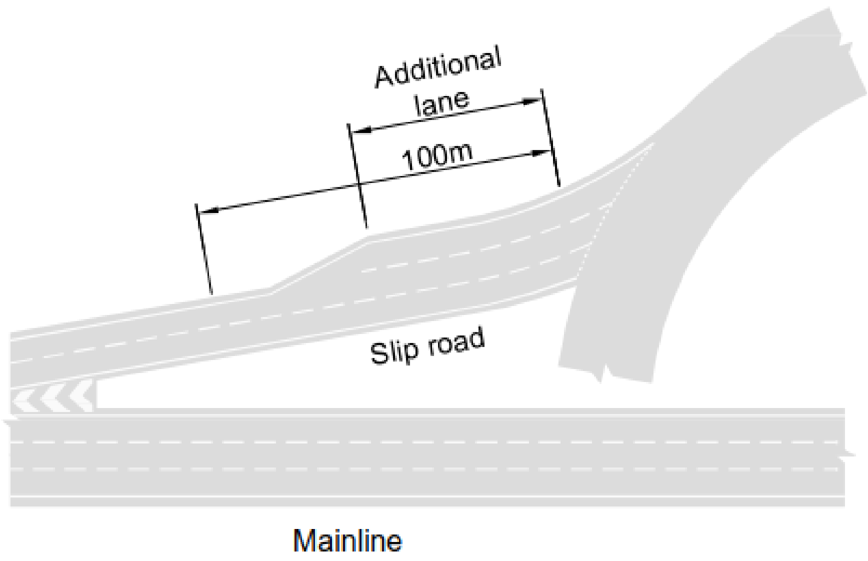
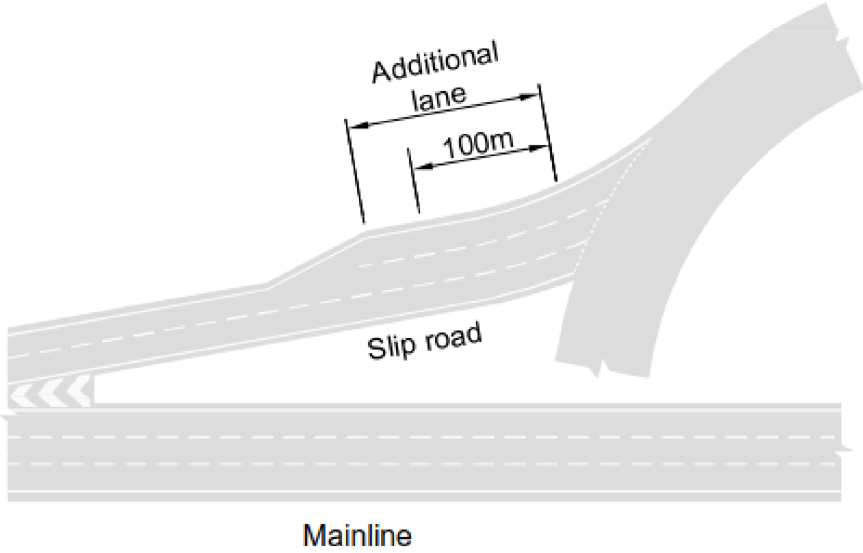
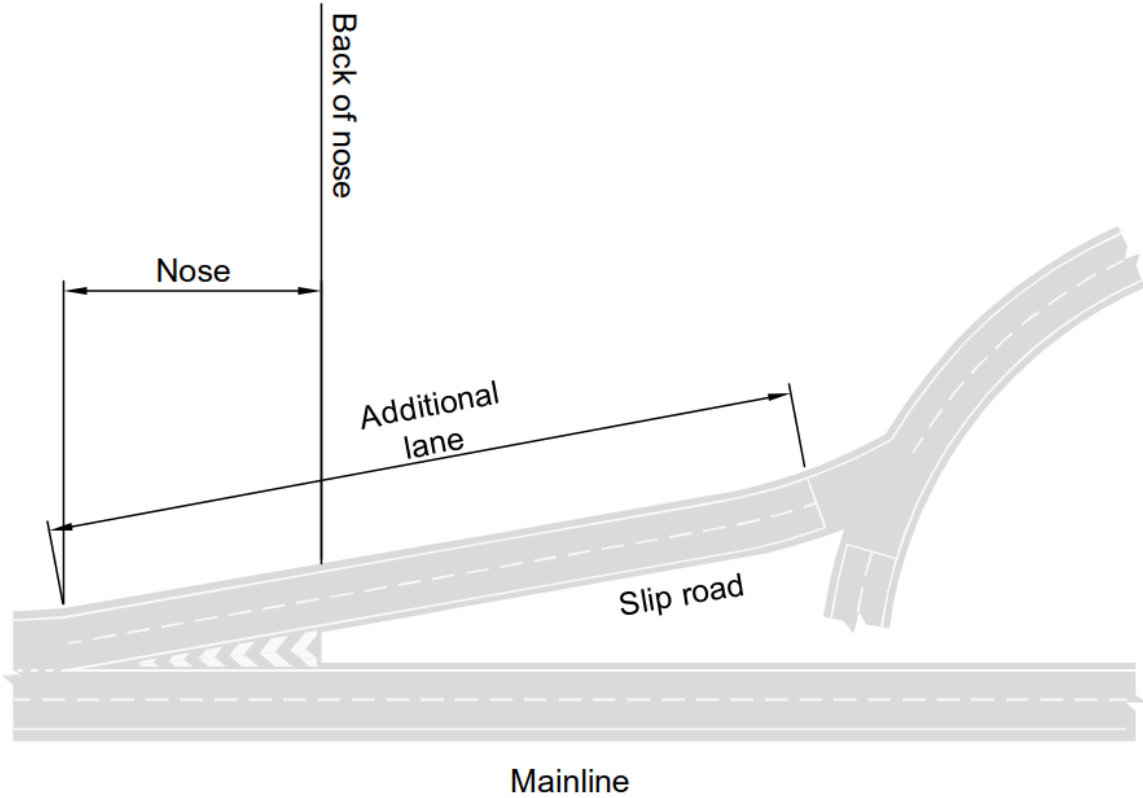


**Figure 2.18b Partial additional lanes(s) slip road provision - additional lane greater than 100m in length**



2.19 Where the additional lane(s) extend upstream beyond a point level with the back of diverge nose the additional lane(s) provided shall extend at least as far upstream as the tip of the diverge nose (see Figure 2.19).

**Figure 2.19 Partial additional lane(s) slip road provision - additional lane extends upstream beyond a point level with the back of diverge nose**



2.20 Hard shoulder and hard strip widths adjacent to the additional connector road lanes shall be consistent with the upstream connector road provision.

*NOTE 1 For further requirements and advice on determining the required number of lanes, hard shoulder and hard strip provision on connector roads, see CD 122 [Ref 12.N].*

*NOTE 2 Compliant widths of single lane connector roads allow routine maintenance activities to be undertaken. Full resurfacing within such widths is unlikely to be possible without closing the connector road.*

*NOTE 3 Compliant widths of two lane connector roads allow all maintenance activities to be undertaken, including full resurfacing, without having to close the connector road.*

2.21 For connector roads that carry two-way traffic for some of their length, the minimum width of central reserve shall be as shown in Figure 2.1.1N1a, Figure 2.1.1N1c, Figure 2.1.1N1e and Figure 2.1.1N1g.

### Separator zones

2.22 Headlight glare from any lane of a parallel road that runs counter to the mainline traffic flow shall not affect main line traffic.

*NOTE Headlight glare can be managed through the use of a separator zone.*

2.22.1 Where a separator zone is used to manage headlight glare from a parallel road, it should be wide enough to accommodate the following features (where applicable):

1) the requisite stopping sight distances in accordance with CD 109 [Ref 13.N];
2) any street furniture, utility or drainage features and equipment;
3) the working width and set-back requirements for VRS;
4) any permanent signs required with particular attention to the provision of the required working width and set-back for VRSs relative to the complete sign assembly;
5) any difference in levels of adjacent carriageways;
6) temporary traffic management layouts for the envisaged maintenance regime;
7) matrix signs and signals;
8) any parts of structures or complete structures;
9) space for maintenance operations;
10) landscaping and environmental provision;
11) walking, cycling and horse-riding routes; and
12) the occupants of broken down vehicles.

2.22.2 Methods to eliminate headlight glare may include:

1) designing the alignments of the roads to provide level differences;
2) screening fences or earthbunds;
3) soft planting that provides foliage all year round at the correct heights; and
4) a VRS system that is designed to cut off glare where a VRS system is to be installed.

### Raised rib edge lines

2.23 Nearside and offside edge line road markings on motorway mainline and connector roads shall have raised ribs in accordance with diagram 1012.2 (schedule 11, part 4, item 12) of the SI 2016 No 362 (TSRGD) 2016 [Ref 23.N].

*NOTE Raised rib road markings can be used on all-purpose trunk roads in accordance with diagram 1012.3 (schedule 11, Part 4, item 13) of the SI 2016 No 362 (TSRGD) 2016 [Ref 23.N].*

### VRS set-back

2.24 The minimum dimensions for VRS set-back shall be as shown in Table 2.24 and are illustrated in Figures 2.25a to 2.25d.

**Table 2.24 Set-back**

| Location | Desirable minimum set-back value (mm) | Available relaxations described in notes |
|---|---|---|
| In verges with no adjacent hard strip or hard shoulder | 1200 | Notes 1) and 2) |
| In verges with an adjacent hard strip or hard shoulder | 600 | Note (3) |
| Central reserves | 1200 | Notes 1) and 2) |

Notes:
Relaxations to set-back are permitted as follows:

1) Relaxation to 600mm for roads of speed limit 50mph or less (including temporary mandatory speed limits).
2) Relaxation to 1000mm at existing roads with physical constraints (e.g. a structure) where it could be difficult to provide the desirable value.
3) Relaxation to 450mm where it is considered necessary to position the VRS away from the edge of an existing embankment in order to provide support to the foundation.

2.25 The set-back shall be the lateral distance between the traffic face of a safety barrier and:

1) nearside: the back of the nearside hard strip or hard shoulder;
2) nearside: the kerb face for roads without a nearside hard strip or hard shoulder;
3) offside: the trafficked edge of the edge line;
4) offside: the kerb face where there is no edge line.

**Figure 2.25a Nearside - no hard shoulder or hard strip**

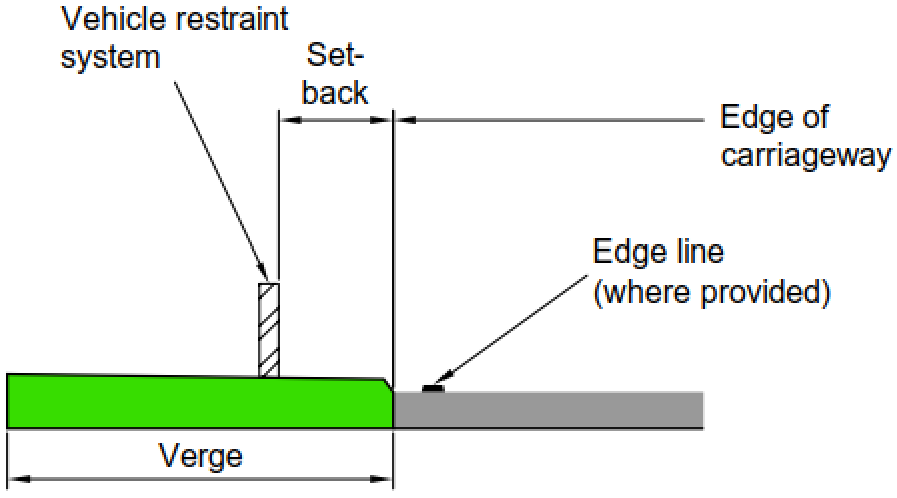


Figure 2.25b Nearside - with hard shoulder or hard strip

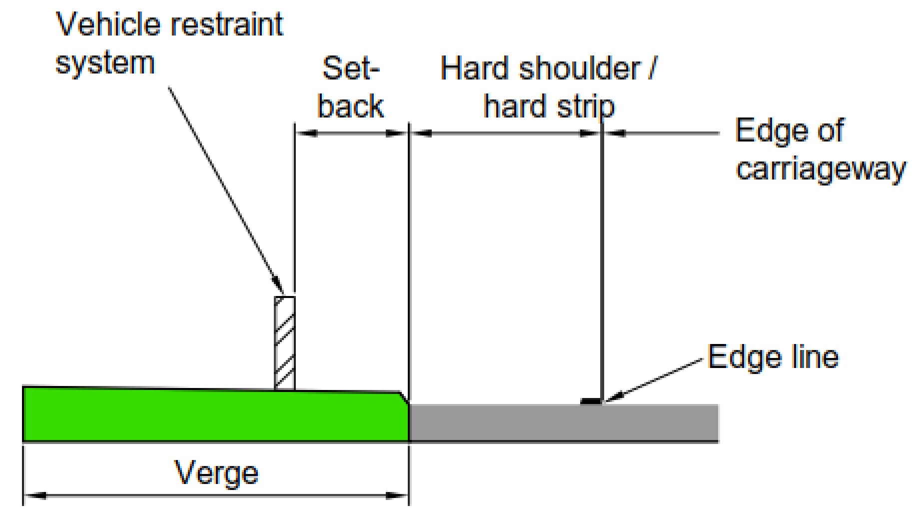



Figure 2.25c Offside - with hard strip

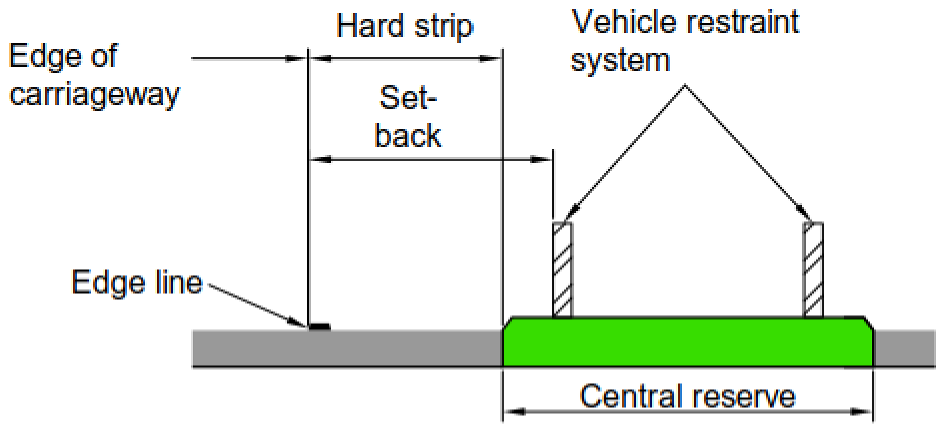
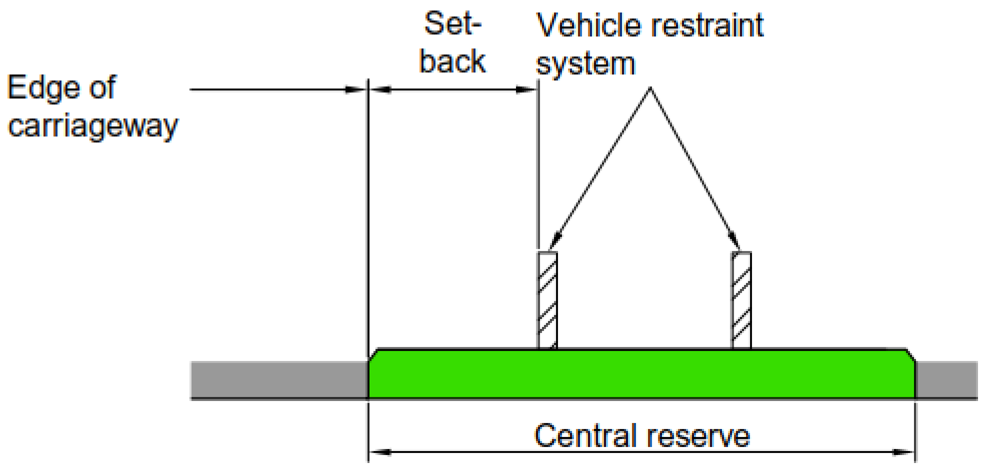



Figure 2.25d Offside - no hard strip




*NOTE 1 For further VRS design requirements see CD 377 [Ref 22.N].*

*NOTE 2 The following factors can influence the decision to use a relaxation in Table 2.24:*

*1) in central reserves: the effects on vehicle positioning within traffic lanes, particularly where* *non-standard lane widths are proposed;*

2) *in verges with a hard strip or hard shoulder: the effects on the ability of occupants of parked vehicles to leave via the nearside doors and the possibility of increased risk due to parking closer to live traffic;*
3) *in verges without a hard strip or hard shoulder: the effects on vehicle positioning within traffic lanes, particularly where non-standard lane widths are proposed; and*
4) *in all cases: the effects on future temporary traffic management systems, e.g. a reduced set-back, can limit the width available for temporary traffic management.*

*NOTE 3 Physical objects such as VRS immediately adjacent to the edge of the carriageway can result in drivers reducing speed and positioning their vehicles away from the obstruction. The purpose of the set-back is to provide a lateral distance between the VRS and the carriageway which reduces the effect of the safety barrier on driver behaviour.*

2.25.1 Set-back greater than the minimum values should be provided in the following circumstances:

1) at verges for roads where continuous or near continuous VRS is proposed to prevent a driver from mounting the verge in an emergency;
2) where use of the minimum set-back in central reserves can result in the paved width being closer than 600mm to the VRS; and
3) to achieve a smooth alignment with a parapet.

2.26 On central reserves where there are no obstructions and there is only one double sided deformable safety barrier between carriageways, the minimum set-back on both sides of the safety barrier shall be as stipulated in Table 2.24 but also no less than the working width of the safety barrier minus the actual width of the safety barrier.

### Kerbs (away from bridge decks)

2.27 Kerbs shall be specified in accordance with BS EN 1340 [Ref 2.N]: Concrete Kerb Units - Requirements and Test Methods and the minimum requirements of Series 1100.

*NOTE 1 Kerbs are used to:*

1) *provide physical or visual delineation and minor restraint, particularly between surfaces intended for different users such as footways and carriageways; and/or*
2) *create drainage channels.*

*NOTE 2 Further requirements and advice relating to the use of kerbs as a drainage feature are given in CD 524 [Ref 7.N].*

2.27.1 In urban areas where footways are present adjacent to the carriageway, bullnose or half battered kerbs with an upstand of at least 100mm should be provided.

2.27.2 In rural areas where a footway is less than 1.30 metres from the carriageway edge, half battered kerbs with an upstand of 100mm should be provided.

*NOTE Half battered or bullnose kerbs with an upstand of 100mm or more can act as a form of minor restraint to light traffic, thereby reducing the risk of vehicles overrunning the edge of the carriageway. This is particularly important at junctions where vehicles are undertaking sharper turns.*

2.27.3 In rural areas where a footway is more than 1.30 metres from the carriageway edge, full battered kerbs with an upstand of 75mm should be provided.

*NOTE Full battered kerbs with an upstand of 75mm are used in rural areas where it is considered safer for an errant vehicle travelling at high speed to be able to mount the kerb with a reduced risk of overturning e.g. at features such as traffic islands and roundabouts.*

2.27.4 Where there are no adjacent footways, kerbs should not be provided except where they are necessary for drainage purposes or to act as a minor restraint, e.g. at traffic islands and in structures or tunnels.

NOTE *At rural junctions with corner radii of 10 metres or less and where there is no adjacent footway, upstand kerbs can be provided to reduce the risk of vehicles overrunning the verge.*

2.27.5 Where it is necessary to lower kerbs they should be laid flush with the carriageway or with a maximum upstand of 6mm using bullnose kerbs for the purpose of retaining water where the carriageway falls towards the kerb.

NOTE 1 *It can be necessary to lower kerbs at private accesses, pedestrian crossings and the start / end of cycle tracks.*

NOTE 2 *For requirements and advice for kerbs at bridge decks see Section 3 of this document.*

## Rate of change of cross-section width

2.28 The minimum transition tapers for the rate of change in the cross-section width of mainline lanes, connector road lanes and hard shoulder width shall be in accordance with Table 2.28.

**Table 2.28 Mainline and connector road rate of change in lane width**

| Design speed (km/h) | Minimum transition taper |
|---|---|
| 50 | 1:25 |
| 60 | 1:30 |
| 70 | 1:35 |
| 85 | 1:45 |
| 100 | 1:50 |
| 120 | 1:55 |

NOTE *The values in Table 2.28 are not applicable to the widening of central reserves, for example around bridge piers. In such cases, a smooth alignment of the carriageway edge lines is to be maintained.*

2.29 Where a transition taper is used to change cross-section between two adjoining links with differing design speeds, the higher design speed of the two links shall be used.

NOTE *For requirements and advice on the layout of grade separated junction merges and diverges see CD 122 [Ref 12.N].*

2.30 Transitions between hard shoulders and hard strips shall be undertaken over the length of the nose, as shown in Figures 2.30a and 2.30b.

**Figure 2.30a Hard shoulder / hard strip transitions for motorways**

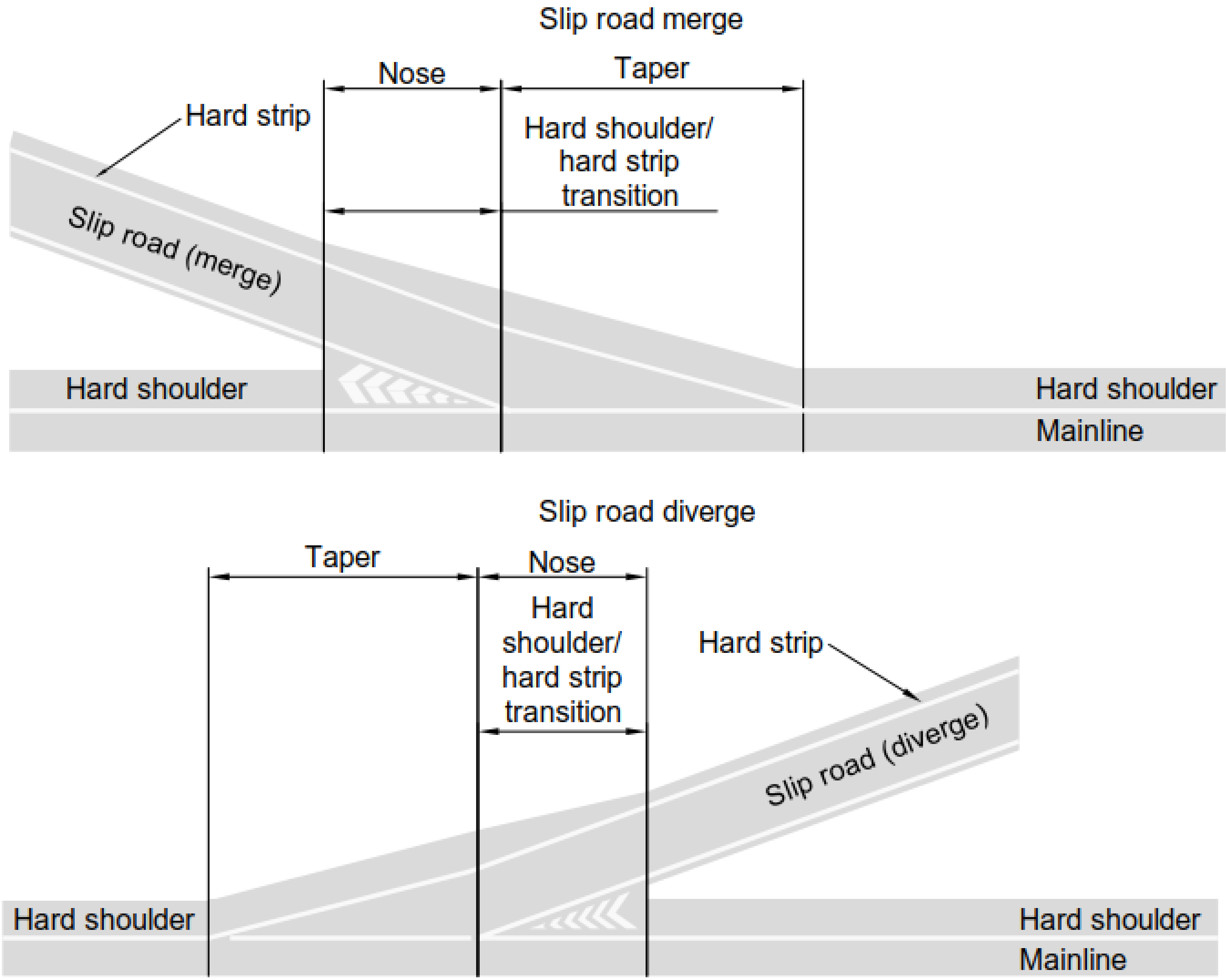
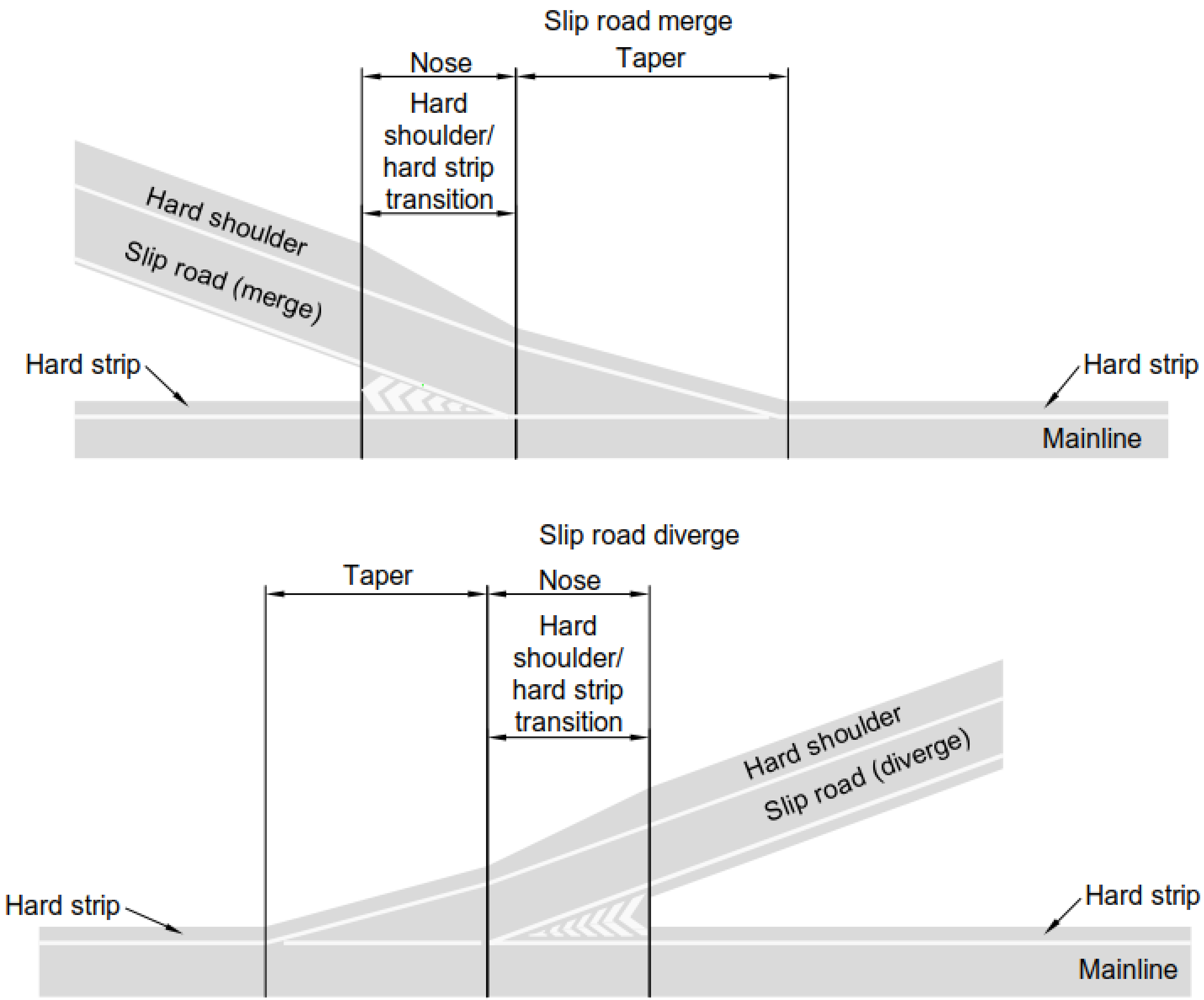


**Figure 2.30b Hard shoulder / hard strip transitions for all-purpose roads**



2.30.1 Gain and loss of the offside hard strip on connector roads with superelevation should be as shown in Figure 2.30.1

**Figure 2.30.1 Offside hard strip width changes**

*NOTE 1* *For further information on determining transitions in the number of mainline lanes see CD 109 [Ref 13.N] , CD 122 [Ref 12.N] and MCHW HCD Drawings [specify] [Ref 21.N] .*

*NOTE 2* *For further information on determining transitions in the number of connector road lanes see CD 122 [Ref 12.N] and TSM [SPECIFY CHAPTER] [Ref 28.N].*

*NOTE 3* *For further information on transitions from dual carriageway to single carriageway see CD 109 [Ref 13.N] and TSM Chapter 5 ISBN 9780115532085 [Ref 29.N].*

# 3. Highway cross-sections at structures

## General

3.1 The paved widths as determined by Section 2 of this document shall be continued through the structure.

3.1.1 The design should include an assessment of the need to provide additional widening at structures to allow for future widening of the cross-section.

*NOTE Additional information on the cross-section components that are found at structures are detailed below in Figures 3.1.1Na to 3.1.1Ne.*

**Figure 3.1.1Na Cross-section components for rural and urban motorways at structures**

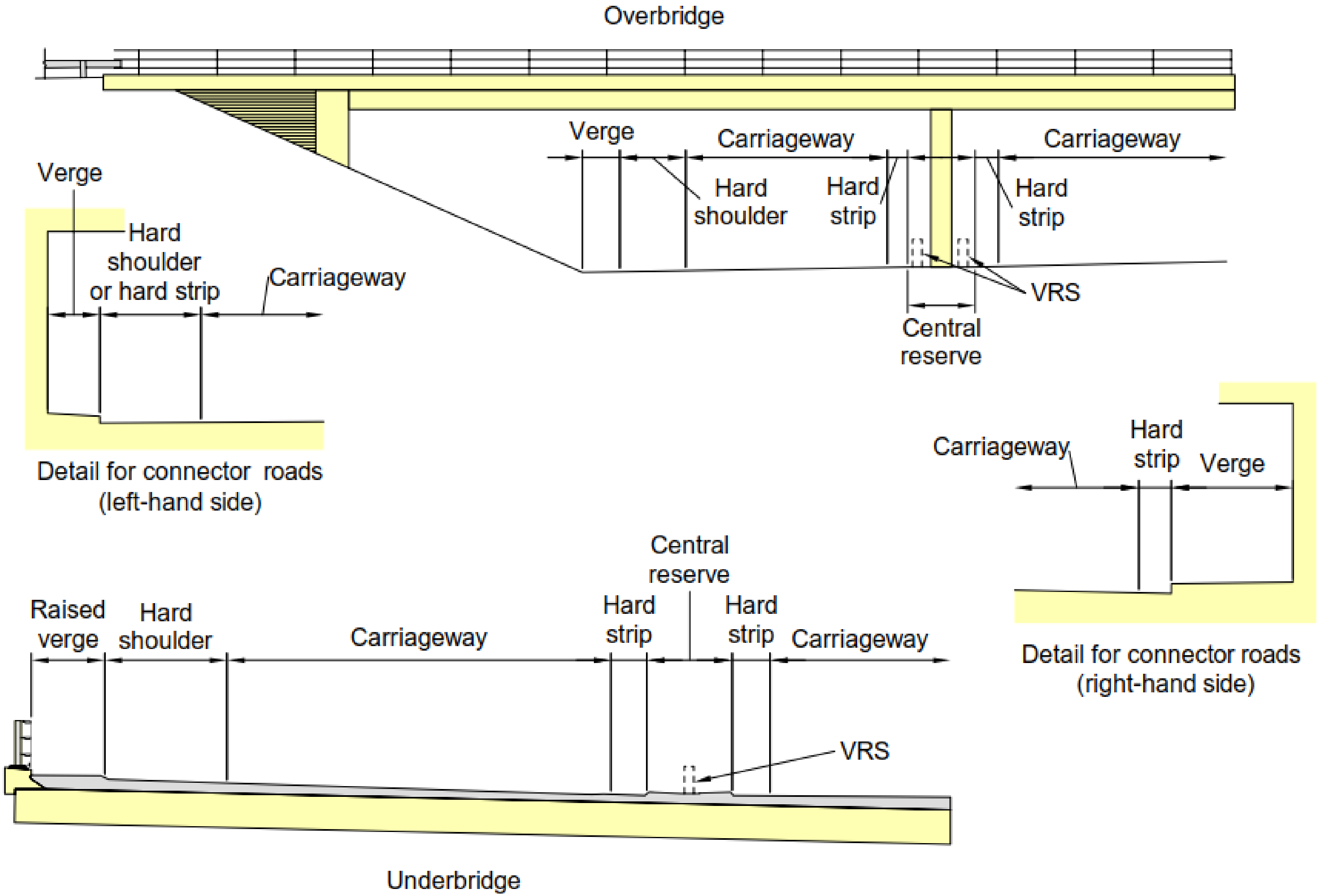


**Figure 3.1.1Nb Cross-section components for rural all-purpose dual carriageway roads at structures**

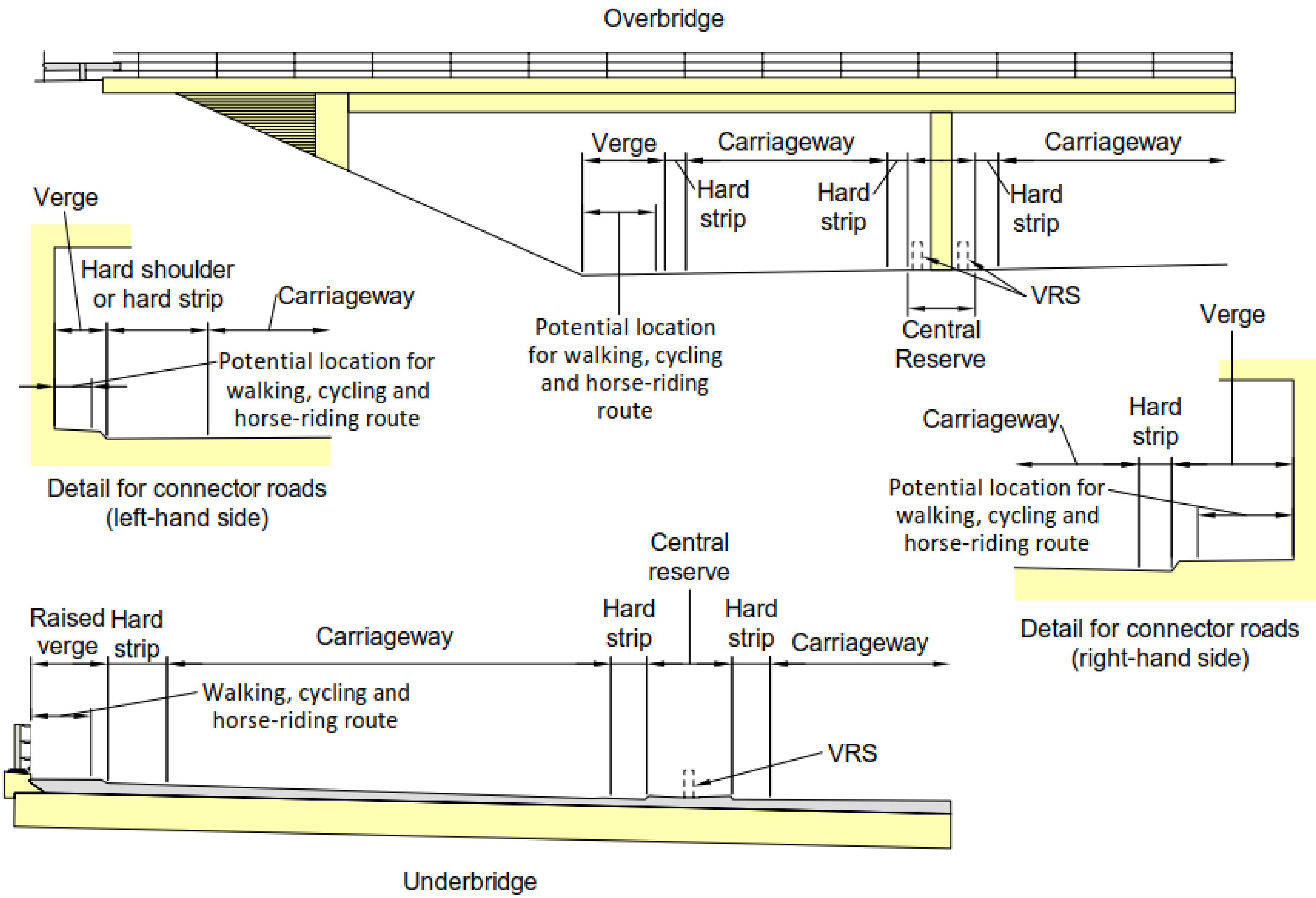


**Figure 3.1.1Nc Cross-section components for rural all-purpose single carriageway roads at structures**

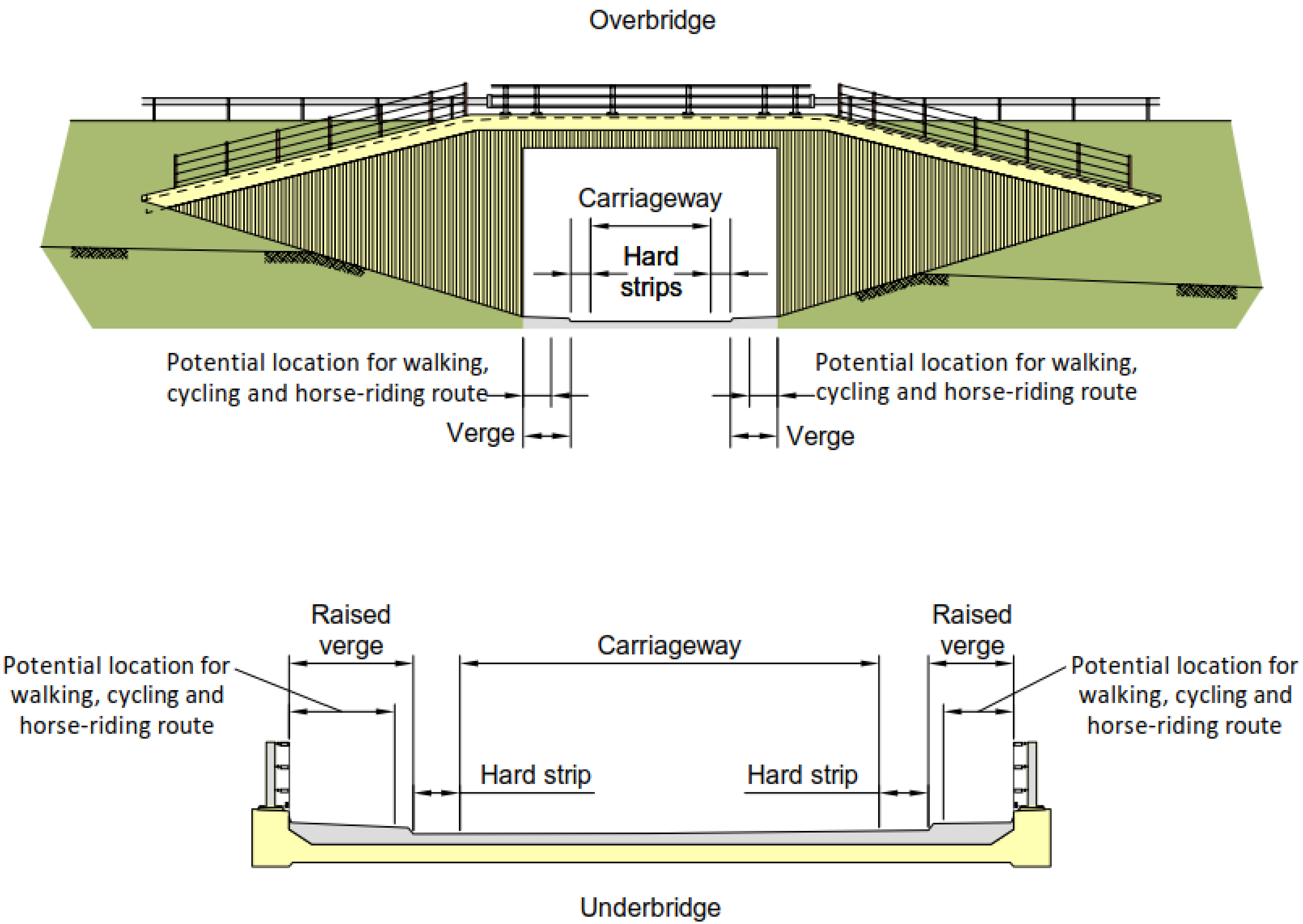


**Figure 3.1.1Nd Cross-section components for urban all-purpose dual carriageway roads at structure**

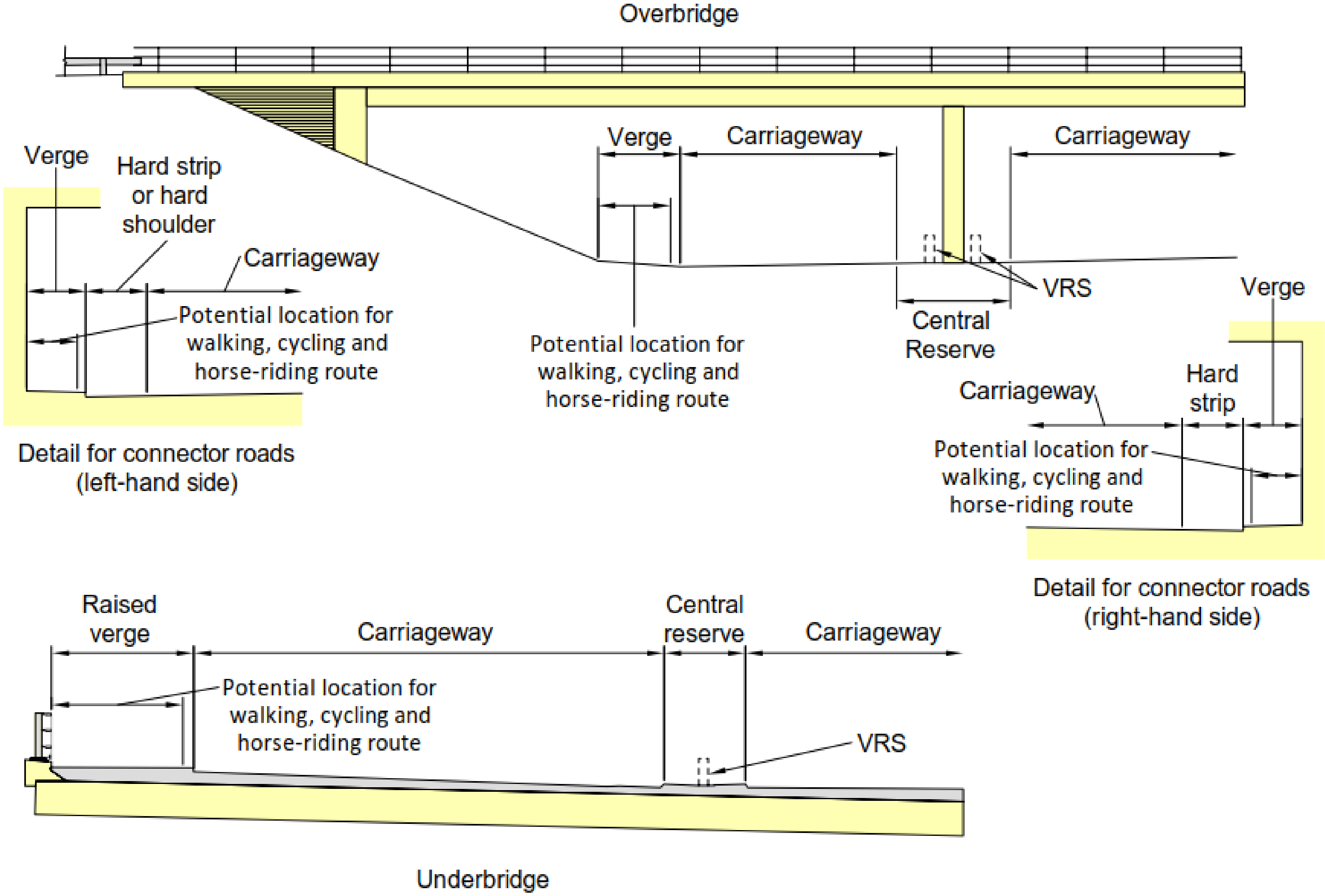
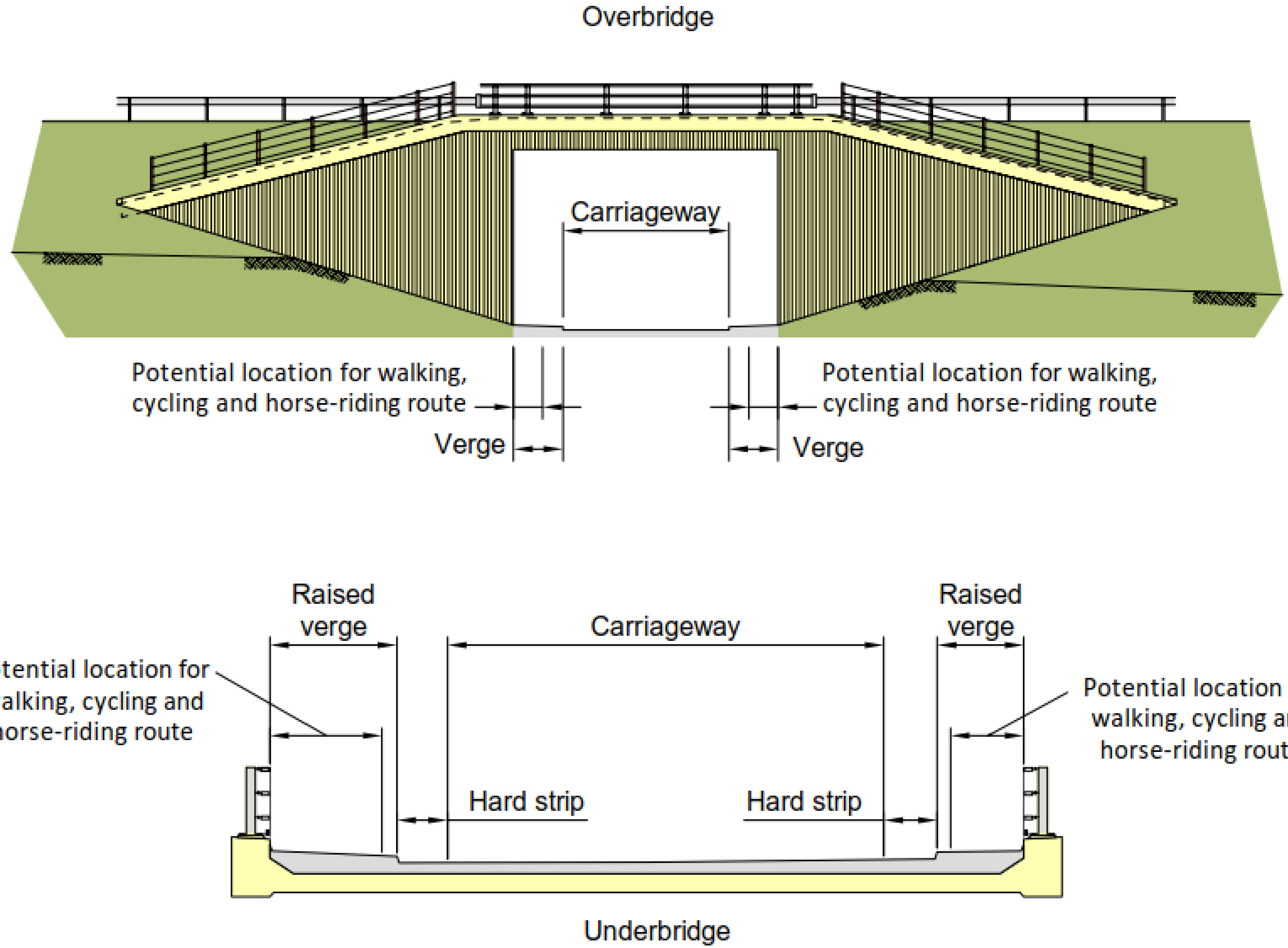
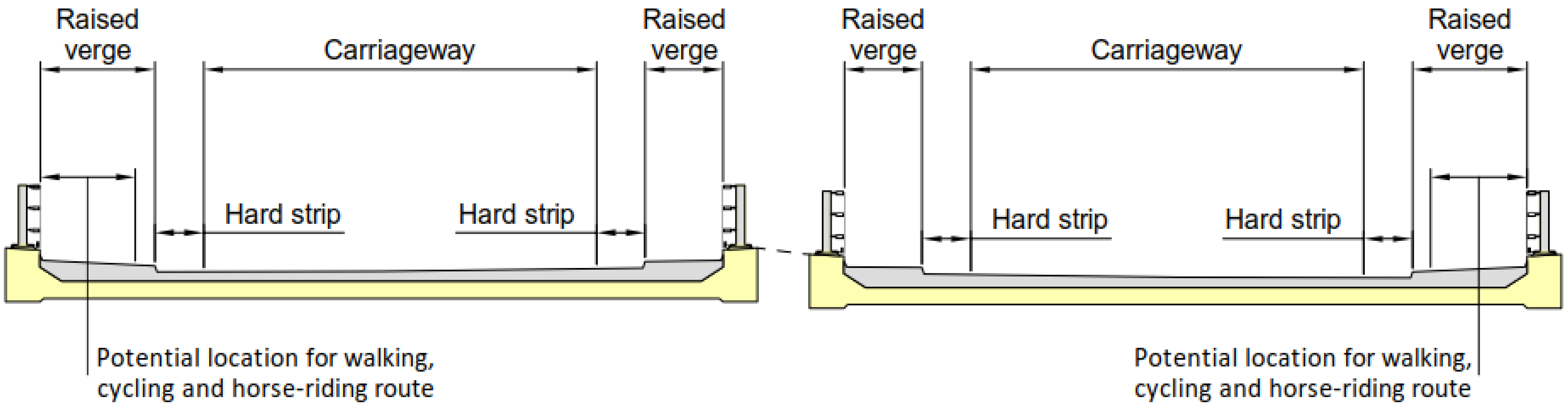


**Figure 3.1.1Ne Cross-section components for urban all-purpose single carriageway roads at structures**



3.1.2 Where it is necessary to divide lanes of a single carriageway at divided structures (see Figure 3.1.2), the carriageway dimensions should be in accordance with those identified for single-lane dualling on single carriageway roads in CD 123 [Ref 11.N].

**Figure 3.1.2 Cross-section components for dual one lane all-purpose roads at divided structures**



*NOTE* *Occasionally it is necessary to provide a single lane in each direction separated by a central reserve. For instance, certain landmark bridges featuring a central cable stay with a single traffic lane either side.*

### Walking, cycling and horse-riding provision at structures

3.2 The provision for walking, cycling and horse-riding, including horizontal separation from the carriageway, at a structure shall be at least equivalent to any provision immediately upstream and downstream of the structure.

### Central reserves

3.3 Minimum central reserve widths derived from Section 2 of this document shall be continued through or across the structure.

*NOTE* *Central reserve widening can be necessary through a structure where a central pier is located in the central reserve.*

### Verges

3.4 For overbridges and underbridges the verge width derived from Section 2 of this document shall be continued through the structure.

### Raised verges and central reserves on bridge decks

3.5 The maximum kerb height of raised central reserves shall be 75mm.

3.6 For cross-sections above bridge decks where the VRS is a parapet, a raised verge of 600mm minimum width and with a maximum kerb height of 75mm shall be provided between the paved width and adjacent parapets, and this applies to both the nearside or offside.

*NOTE* *Limiting the height of the kerb upstand to 75mm minimises the risk of an errant vehicle being projected upwards upon impact.*

### Accommodation bridges

3.7 Any discussions with landowners with respect to accommodation bridges and the resulting agreed provision shall be recorded in a formal agreement.

3.7.1 When deriving the widths of accommodation bridges the following criteria should be assessed:

1) the agreed reasonable needs of the respective private landowner;
2) the size of vehicles, particularly agricultural vehicles, that can reasonably be expected to use the bridge;
3) maintenance requirements; and
4) the needs of walkers, cyclists and horse-riders in locations where they have legal right of way.

# 4. Headrooms at structures

## General

4.1 Bridges and highway structures shall be designed, constructed, and maintained to provide a minimum standard headroom above the paved width, verges and central reserve in accordance with Table 4.1 and Table 4.3.

**Table 4.1 Minimum standard headroom at structures**

| Type of structure | New construction headroom (metres) | Maintained headroom (metres) |
|---|---|---|
| Overbridges | 5.30 + $S$ | 5.03 + $S$ |
| Footbridges, sign and signal gantries, and other structures vulnerable to vehicular impact | 5.70 + $S$ | 5.41 + $S$ |
| Free-standing temporary structures | N/A | 5.41 + $S$ |
| All permanent structures over high load routes (not applicable in NI) | 6.45 + $S$ | 6.18 + $S$ |
| Where $S$ is the additional clearance in accordance with Table 4.3 | | |

4.2 The headroom after the maximum deflection of the superstructure at the serviceability limit state shall be greater than the minimum standard headroom given in Table 4.1 as shown in Figures 4.6N1, 4.8a, 4.8b, and 4.8c.

*NOTE 1 For new bridges, provision for any additional self-weight due to waterproofing, surfacing, and other coatings are in accordance with BS EN 1991-1-1 [Ref 9.N] and NA to BS EN 1991 [Ref 30.N].*

*NOTE 2 For existing bridges, the provision for any additional self-weight due to waterproofing, surfacing, and other coatings is made in accordance with CS 454 [Ref 1.N].*

*NOTE 3 Where required, bridges and highway structures are designed to withstand vehicular impact in accordance with BS EN 1991-1-7 [Ref 10.N] and NA to BS EN 1991 [Ref 30.N].*

## Sag curve compensation

4.3 Where the road passing under the superstructure is on a sag curve, the minimum standard headroom given in Table 4.1 shall be increased by the additional clearance $S$ in accordance with Table 4.3:

**Table 4.3 Sag curve compensation**

| Sag radius (metres) | Additional clearance $S$ (mm) |
|---|---|
| $\leq$ 1000 | 80 |
| 1200 | 70 |
| 1500 | 55 |
| 2000 | 45 |
| 3000 | 25 |
| 6000 | 15 |
| $>$ 6000 | 0 |

4.4 Sag curve radius shall be measured along the carriageway over a 25 metres chord.

## Structure free zones (SFZ)

4.5 SFZs shall include central reserves and verges adjacent to the carriageway.

*NOTE 1* *SFZs can reduce the risk of a vehicular impact at the superstructure during an accidental situation where an errant vehicle could leave the paved width.*

*NOTE 2* *SFZs can be used in the future to increase the width of the pavement either permanently or temporarily.*

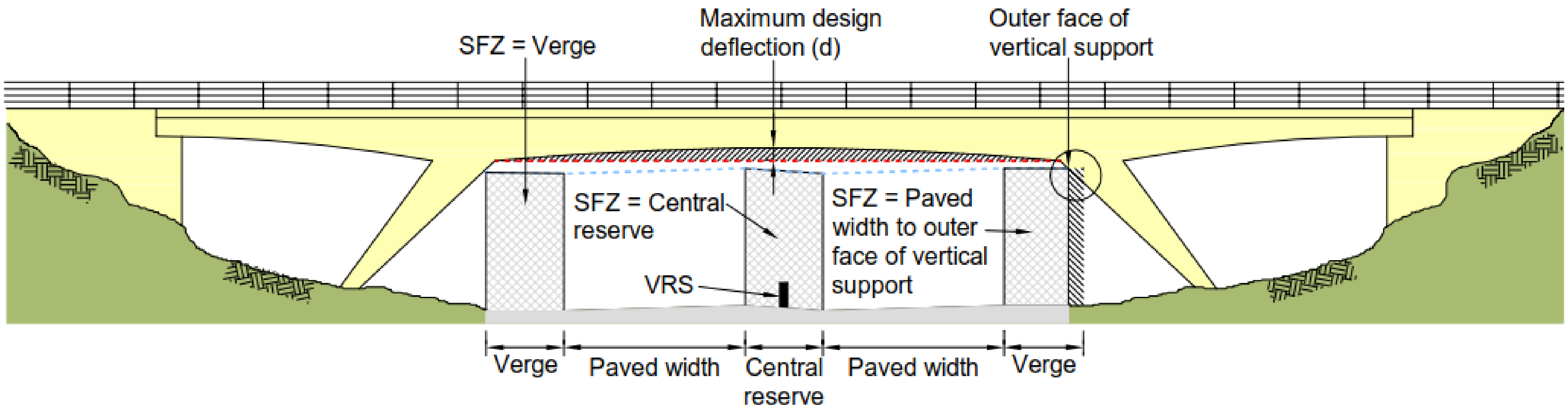
4.6 Minimum width of the SFZ for all new structures shall be the lesser of either:

1) the full verge width or the central reserve width (including any slopes shallower than 1:4 (vertical:horizontal);
2) the width from the edge of the paved width to the outermost face of any vertical support.

*NOTE 1* *Vertical supports can include:*

*1) vertical or inclined columns or piers as shown in Figure 4.6N1;*
*2) columns or piers with a varying cross-section;*
*3) columns or piers with or without crossheads.*

**Figure 4.6N1 Minimum width of the SFZ**



NOTE 2 *The lowest point of the slope adjacent to the verges can be used as a reference point to measure the inclination of the slopes.*

4.7 Where the existing headroom within the SFZ is found to be less than the minimum maintained headroom, the maintaining organisation shall:

1) carry out a risk assessment;
2) manage the structure in accordance with the output of the risk assessment.

NOTE *The installation of a VRS at the interface between the paved width and the verge can reduce the risk of a vehicular impact at the superstructure within the SFZ.*

## Design and as-built drawings

4.8 In the design and as-built drawings the following information shall be included in a similar manner as shown in Figures 4.8a, 4.8b, 4.8c:

1) the SFZ;
2) the paved width headroom;
3) the maximum deflection of the superstructure in the serviceability limit state obtained from the structural analysis;
4) the sag curve (where applicable).

**Figure 4.8a Headroom and SFZ for a single carriageway road with footways**

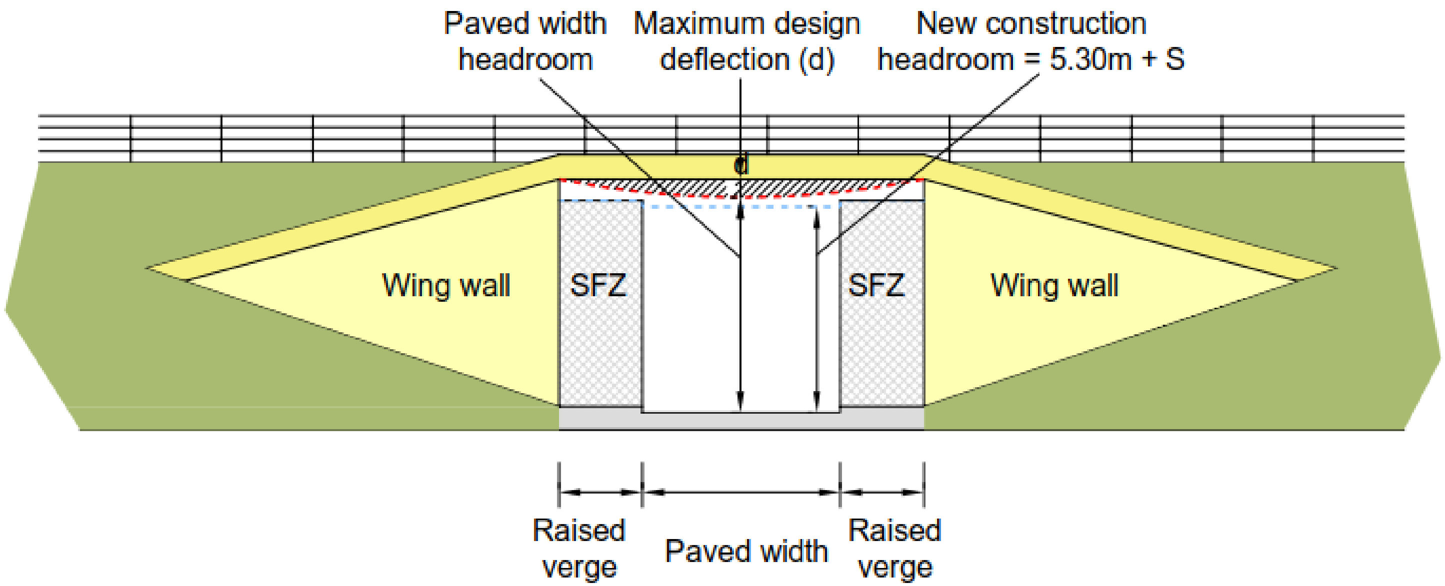


**Figure 4.8b Headroom and SFZ for a 2 No. span structure crossing a dual carriagway**

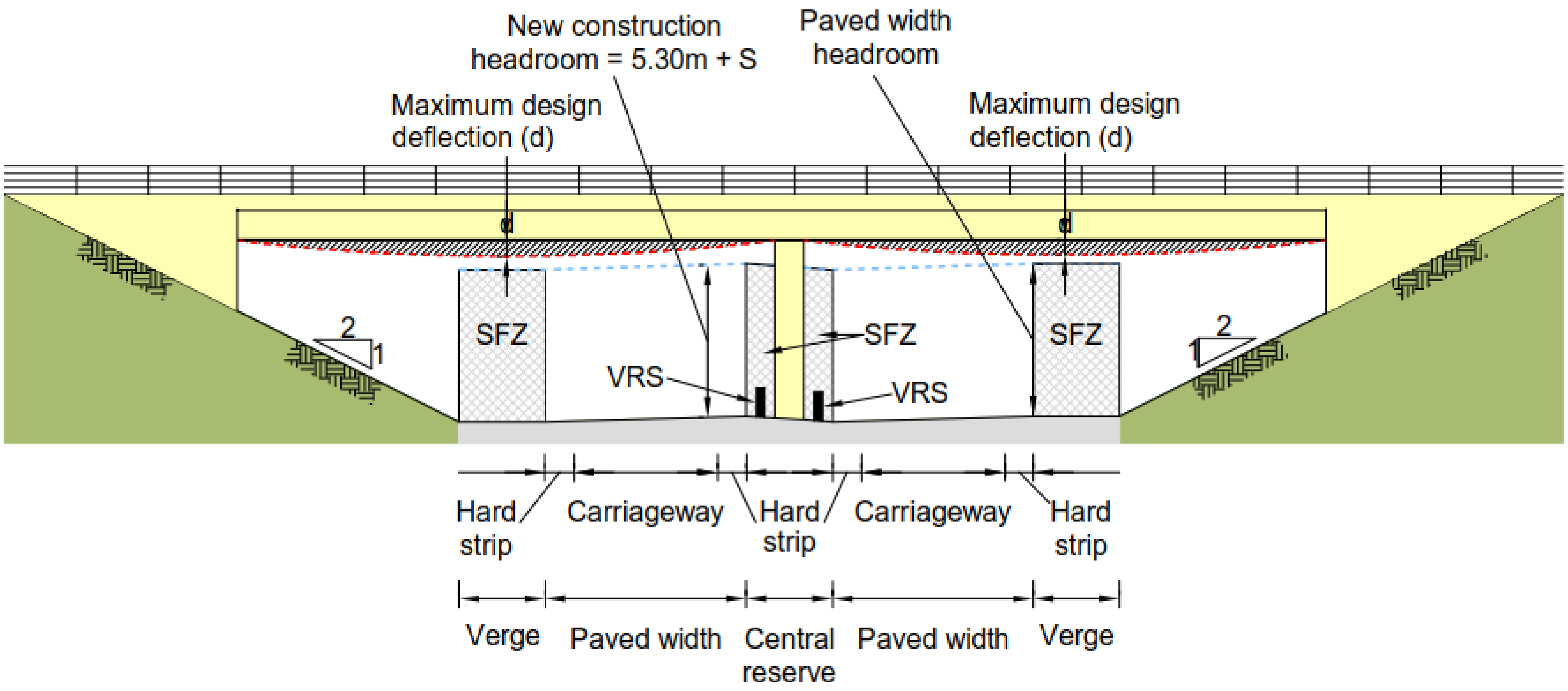
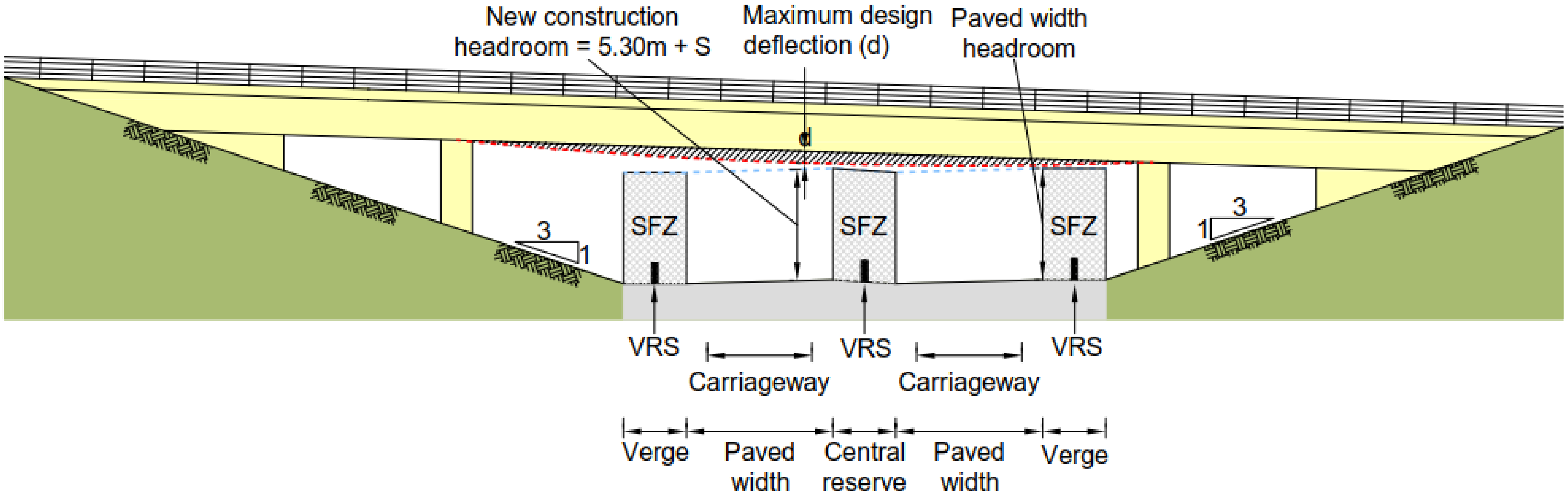


**Figure 4.8c Headroom and SFZ for a 3 No. span structure crossing a dual carriageway**



### New structures

4.9 New bridges and highway structures shall be designed to have a minimum new construction headroom and a minimum paved width headroom equal to or greater than the new construction headroom given in Table 4.1.

*NOTE Paved width includes the width of the carriageway plus any hard shoulders and hard strips.*

4.9.1 Headroom should be greater than the minimum given in Table 4.1 where:

1) the location presents a high risk of vehicle impact based on previous records;
2) forward visibility is affected due to sags (comfort criteria for sag curves can be obtained from CD 109 [Ref 13.N];
3) forward visibility is affected due to overhead signs and signals;
4) future maintenance of the bridge and pavement can result in a reduction of the headroom;
5) it is economical with regards to the whole life costs of the structure and pavement;
6) accommodation of services or apparatus is required;
7) there are other site specific constraints (such as access limitations);
8) lightweight structures (such as footbridges) are passing above the road;
9) it is environmentally sustainable.

4.9.2 Where the headroom of existing structures on a route is greater than the new construction headroom given in Table 4.1, and where an increase of the new construction headroom for new structures does not have a significant impact to the overall construction cost, new structures should have the same headroom as the existing structures.

*NOTE 1 Providing headroom uniformity along an existing route can reduce the probability of vehicular impact.*

*NOTE 2 Existing robust structures along a route with a greater headroom than the new construction headroom, can provide protection to new lightweight structures (such as footbridges) against vehicular impacts, only if the new structures have an equal or greater headroom than the headroom of the existing robust structures.*

4.10 Where a trunk road passes over other authorities infrastructure or third party land, the headroom provision shall be agreed with the relevant authority or landowner.

4.10.1 Where a trunk road passes over other authorities infrastructure or third party land, the minimum headroom at under-bridges should be subject to the minimums quoted in this document.

*NOTE Infrastructure can include rail and navigable canals.*

### Existing structures

4.11 Existing bridges and highway structures shall have a minimum maintained headroom and a minimum paved width headroom preserved at all times in accordance with Table 4.1.

*NOTE Re-surfacing of the paved width can result to an increase of the pavement's level which can lead to a reduction of the headroom.*

4.11.1 Where structural strengthening is required beneath a superstructure, the adopted strengthening techniques should have a minimum impact on headroom.

4.12 The design organisation shall inform the Overseeing Organisation of any change of the headroom.

*NOTE Up to date bridge records for the maintained headroom can facilitate the implementation of accurate planning systems for the movement of high loads on a route.*

4.13 Where a headroom is found to be less than the minimum maintained headroom over the paved width in accordance with Table 4.1, the maintaining organisation shall:

1) immediately notify the Overseeing Organisation;

2) carry out a risk assessment and manage the structure in accordance with the outcome of the risk assessment.

4.14 Where as-built records of the structure are available, verification of the headroom on site shall be made after a review of the available information.

*NOTE 1 A review of the available information and as-built records can:*

*1) reduce the risk of a measurement error;*

*2) contribute towards identifying health and safety risks and hazards and implementing the appropriate health and safety measures during the site visit.*

*NOTE 2 Vertical measurements to verify and record the minimum headroom are made in accordance with CS 450 [Ref 15.N].*

4.14.1 Vertical measurements should be taken at different locations along the paved width area and within the SFZ such as:

1) from the top of the raised verges and central reserve;
2) where a sag curve is present, from the outermost point of the curve;
3) below both edges of the superstructure in the transverse direction to assess the minimum headroom against any cross-sectional deck inclination.

### Utilities companies and other authorities apparatus

4.15 Where utility companies or other authorities (such as rail or legislative bodies) require greater headroom, any such increase shall be agreed with the Overseeing Organisation.

*NOTE Utility companies or other authorities can require an increased headroom to achieve sufficient vertical clearance to pass their services above the pavement.*

### Accommodation underbridges

4.16 Headroom for accommodation underbridges shall be agreed with the landowners and expected users of the structure and recorded in a legally enforceable agreement.

4.16.1 The headroom at accommodation bridges should be derived from the following criteria:

1) the likely methods of farming in the area;
2) the size of the agricultural and maintenance vehicles expected to use the bridge;
3) the use of the bridge by walking, cycling, and horse-riding users;
4) the use of the bridge for animal access.

*NOTE The maximum height of an agricultural vehicle can be up to 4.65 metres except those transporting agricultural baled produce (i.e. hay, silage straw, or animal fodder) which have no height limit.*

### Walking, cycling, and horse-riding users

4.17 For new structures the minimum headroom given in CD 143 [Ref 6.N] shall be increased by 300mm where there is a risk for a reduction of the headroom.

*NOTE 1 A future overlay of the road pavement can result in a reduction of the subway's headroom.*

*NOTE 2 Minimum headroom for subways and structures that are used by walkers, cyclists and horse-riders is in accordance with the requirements of CD 143 [Ref 6.N].*

4.18 Headrooms for structures outside the scope of CD 143 [Ref 6.N] shall adopt the headroom requirements in CD 143 [Ref 6.N] where facilities for walking, cycling or horse-riding are provided.

4.18.1 Where more than one headroom is quoted in CD 143 [Ref 6.N] due to different widths along the length of the structure, the maximum headroom should be adopted.

# 5. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. CS 454, 'Assessment of highway bridges and structures' |
| Ref 2.N | BSI. BS EN 1340, 'Concrete kerb units. Requirements and test methods.' |
| Ref 3.N | Highways England. CD 353, 'Design criteria for footbridges' |
| Ref 4.N | Highways England. CD 352, 'Design of road tunnels' |
| Ref 5.N | Highways England. CD 195, 'Designing for cycle traffic' |
| Ref 6.N | Highways England. CD 143, 'Designing for walking, cycling and horse riding (vulnerable users)' |
| Ref 7.N | Highways England. CD 524, 'Edge of pavement details' |
| Ref 8.N | Highways England. LA 104, 'Environmental assessment and monitoring' |
| Ref 9.N | BSI. BS EN 1991-1-1, 'Eurocode 1 - Actions on Structures - Part 1-1: General actions- Densities, self weight, imposed loads for buildings' |
| Ref 10.N | BSI. BS EN 1991-1-7, 'Eurocode 1 - Actions on structures - Part 1-7 General actions - Accidental actions' |
| Ref 11.N | Highways England. CD 123, 'Geometric design of at-grade priority and signal-controlled junctions' |
| Ref 12.N | Highways England. CD 122, 'Geometric design of grade separated junctions' |
| Ref 13.N | Highways England. CD 109, 'Highway link design' |
| Ref 14.N | The National Archives. legislation.co.uk. Highways Act 1980 c66, 'Highways Act 1980 [General Act 1980 c66]' |
| Ref 15.N | Highways England. CS 450, 'Inspection of highway structures' |
| Ref 16.N | International Civil Aviation Organization. ICAO Vol 1, 'International Standards and Recommended Practices, Annex 14 to the Convention on International Civil Aviation, Volume 1 Aerodrome Design and Operations' |
| Ref 17.N | Highways England. LA 101, 'Introduction to environmental assessment' |
| Ref 18.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 19.N | Highways England. LA 107, 'Landscape and visual effects' |
| Ref 20.N | Highways England. LD 117, 'Landscape design' |
| Ref 21.N | Highways England. MCHW HCD Drawings [specify], 'Manual of Contract Documents for Highway Works Volume 3: Highway Construction Details' |
| Ref 22.N | Highways England. CD 377, 'Requirements for road restraint systems' |
| Ref 23.N | The National Archives. legislation.gov.uk. SI 2016 No 362 (TSRGD), 'ROAD TRAFFIC - The Traffic Signs Regulations and General Directions 2016' , 2016 |
| Ref 24.N | Transport Scotland. Roads for All, 'Roads for All - Good Practice Guide for Roads' |
| Ref 25.N | Highways England. LA 103, 'Scoping projects for environmental assessment' |
| Ref 26.N | Highways England. LA 102, 'Screening projects for Environmental Impact Assessment' |

| | |
|---|---|
| Ref 27.N | Highways England. CD 192, 'The design of crossovers and changeovers' |
| Ref 28.N | TSO. Department for Transport. TSM [SPECIFY CHAPTER], 'Traffic Signs Manual' |
| Ref 29.N | TSO. Department for Transport. TSM Chapter 5 ISBN 9780115532085, 'Traffic Signs Manual Chapter 5 - Road Markings' |
| Ref 30.N | BSI. NA to BS EN 1991, 'UK National Annex for Eurocode 1: Actions on structures' |

Road Layout
Design

# CD 127
# England National Application Annex to CD 127 Cross-sections and headrooms

(formerly IAN 149/17, IAN 161/15 and IAN 198/17)

Revision 1

**Summary**
This National Application Annex sets out the Highways England specific requirements for highway cross-sections and headrooms on existing roads.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 1 | Mar 2020 | Revision 1 (March 2020) Update to references only. Revision 0 (November 2019) Highways England National Application Annex to CD 127. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes those parts of IAN 149/17, IAN 161/15 and IAN 198/17 relating to the geometric design of highway cross-section and headrooms which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex (NAA) gives the Highways England specific requirements and additional relaxations relating to cross sections and headrooms for:

1) modifying existing motorways where motorway regulations apply (herein referred to as 'existing motorways');
2) modifying existing all-purpose dual carriageways; and
3) smart motorways

The additional relaxations included in this NAA allow greater flexibility when dealing with the constraints associated with enhancing elements of existing motorways and all-purpose trunk roads.

This NAA is to be used in conjunction with CD 127 [Ref 1.N], GD 300 [Ref 6.N] and IAN 161 [Ref 9.N] where appropriate.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 5.N] apply to this document.

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| ALR | All lane running |
| IAN | Interim Advice Note |
| m | Metres |
| SCRG | Safety Control Review Group |
| VRS | Vehicle restraint system |

# Terms and definitions

**Terms and definitions**

| Term | Definition |
|---|---|
| All lane running | A smart motorway scheme with the permanent conversion of the hard shoulder to a running lane. |
| Expressway | A high speed dual carriageway that has at least two lanes in each direction, grade separated junctions and uses technology to support operational regimes (see GD 300 [Ref 6.N]). |
| Maintaining organisation | The organisation commissioned to undertake the maintenance of a structure. |

# E/1. Modifying existing motorways

## Scope

E/1.1 The requirements and advice in Section E/1 shall only be used when modifying existing motorways, with the exception of smart motorway and expressway schemes.

E/1.1.1 The parameters in Section E/1 should only be used where it is not practicable to comply with the requirements of CD 127 [Ref 1.N].

*NOTE 1 Document IAN 161 [Ref 9.N] provides requirements and advice for the design of smart motorways.*

*NOTE 2 Document GD 300 [Ref 6.N] provides requirements and advice for the design of expressways.*

E/1.2 The parameters in Section E/1 shall not be used for new motorway elements e.g. the construction of a new slip road.

## Geometric parameters

### Highway cross-section (CD 127 clauses 2.1, 2.2, 2.4, 2.5, 2.7, 2.8, 2.9, 2.12, 2.23, 2.26, 3.3 and 3.4)

E/1.3 Where the cross-section component dimensions specified in CD 127 [Ref 1.N] cannot be achieved for mainline carriageways, the appropriate cross-section component dimensions shall be derived from Table E/1.4.

E/1.4 Any relaxations applied to the motorway mainline cross-sections as shown in Figure E/1.4 shall follow the hierarchy shown in Table E/1.4 and be applied in sequence starting at 'priority 1', with the exception that priority 3 can be used before priority 2 over lengths of less than 100 metres.

**Figure E/1.4 Layout of the components detailed in Table E/1.4**

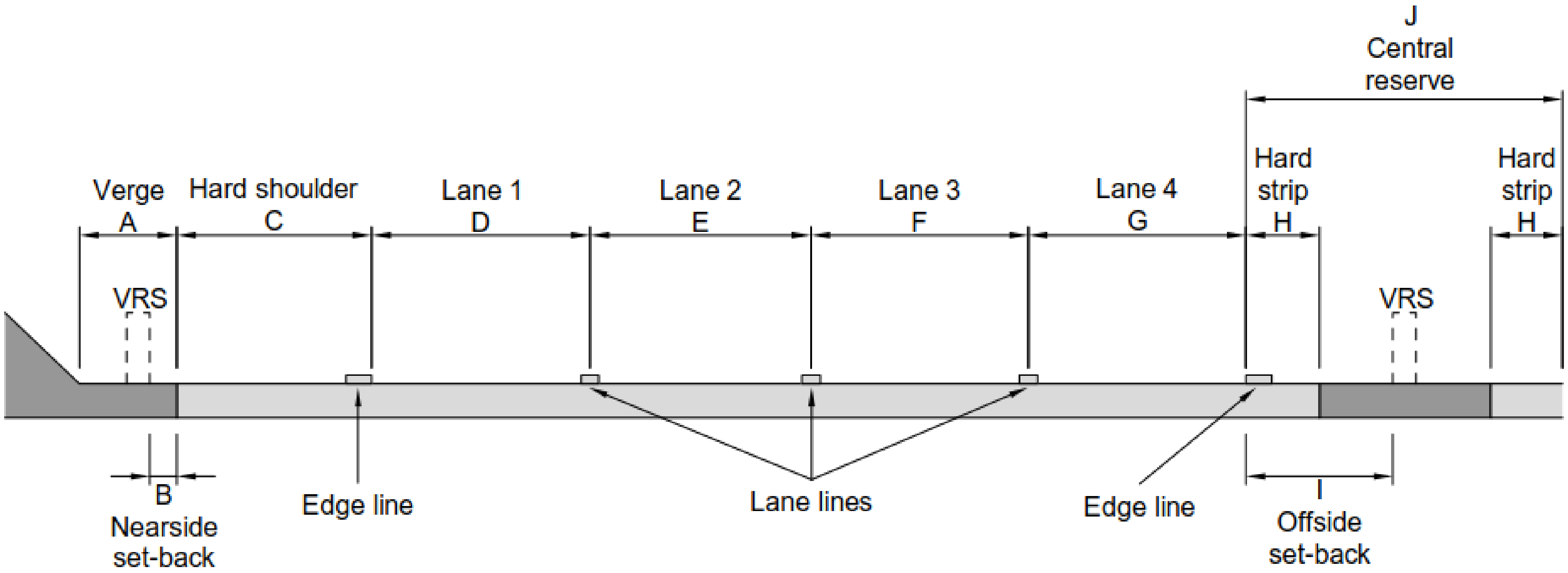


**Table E/1.4 Reduced cross-sections hierarchy for widening on existing motorway mainline carriageways**

| | | | | | Lane widths (metres) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | D2M | | D3M | | | D4M | | | | | | |
| Reference to Figure E/1.4 | | A | B | C | D | E | D | E | F | D | E | F | G | H | I | J |
| Priority order | Reduced element | Nearside verge (m) | Nearside set-back (m) | Hard shoulder/ emergency access width (m) | Lan-e 1 | Lan-e 2 | Lan-e 1 | Lan-e 2 | Lan-e 3 | Lan e1 | Lan-e 2 | Lan e3 | Lan e4 | Off-side hard strip (m) | Off-side se-t-back (m) | Central reserve inc. hard strip (m) |
| 1 | Nearside verge (metres) | See note 1 | 0.60 | 3.30 | 3.65 | 3.65 | 3.65 | 3.70 | 3.65 | 3.65 | 3.70 | 3.70 | 3.65 | 0.70 | 1.20 | 4.50 |
| 2 | Central reserve | See note 1 | 0.60 | 3.30 | 3.65 | 3.65 | 3.65 | 3.70 | 3.65 | 3.65 | 3.70 | 3.70 | 3.65 | 0.70 | 1.00 | 3.40 |
| 3 | Set-back to nearside VRS | See note 1 | 0.00 | 3.30 | 3.65 | 3.65 | 3.65 | 3.70 | 3.65 | 3.65 | 3.70 | 3.70 | 3.65 | 0.70 | 1.00 | 3.40 |
| 4 | Lane widths | See note 1 | 0.00 | 3.30 | 3.65 | 3.55 | 3.65 | 3.55 | 3.30 | 3.65 | 3.60 | 3.40 | 3.30 | 0.70 | 1.00 | 3.40 |
| 5 | Lane widths and central reserve | See note 1 | 0.00 | 3.30 | 3.65 | 3.55 | 3.65 | 3.55 | 3.30 | 3.65 | 3.60 | 3.40 | 3.30 | 0.70 | 1.00 | 3.00 |
| 6 | Hard shoulder | See note 1 | 0.00 | 3.00 | 3.65 | 3.55 | 3.65 | 3.55 | 3.30 | 3.65 | 3.60 | 3.40 | 3.30 | 0.70 | 1.00 | 3.00 |
| 7 | Central reserve | See note 1 | 0.00 | 3.00 | 3.65 | 3.55 | 3.65 | 3.55 | 3.30 | 3.65 | 3.60 | 3.40 | 3.30 | 0.70 | 1.00 | 2.60 |
| 8 | Emergency access | See note 1 | 0.00 | 2.50 | 3.65 | 3.55 | 3.65 | 3.55 | 3.30 | 3.65 | 3.60 | 3.40 | 3.30 | 0.70 | 1.00 | 2.60 |
| 9 | Emergency access | See note 1 | 0.00 | 2.00 | 3.65 | 3.55 | 3.65 | 3.55 | 3.30 | 3.65 | 3.60 | 3.40 | 3.30 | 0.70 | 1.00 | 2.60 |

*NOTE 1 The width of the nearside verge can be reduced as required as long as the resultant width can accommodate both underground and over-ground equipment, including emergency roadside telephones.*

*NOTE 2 Document TD 131 [Ref 8.N] provides further requirements and advice for situations where the verge width is reduced in accordance with Table E/1.4 and emergency roadside telephones are provided.*

E/1.5 Where a 600mm raised verge is provided on an underbridge, the raised verge width shall be excluded from the measurement of the hard shoulder.

E/1.5.1 The 600mm raised verge provided on an underbridge may be included in the measurement of an emergency access width.

E/1.6 Where it is proposed to reduce the central reserve (including hard strips) to 3.40 metres or less, the Overseeing Organisation shall be consulted to ensure that any implications on maintenance activities have been considered and any potential issues resolved.

E/1.7 Where resultant wheel tracks from altered lane widths are within 100mm of existing pavement joints, the maintaining organisation shall be consulted to ensure that any implications on maintenance have been considered and any potential issues resolved.

E/1.8 Where it is proposed to reduce the hard shoulder below 3.00 metres the emergency services shall be consulted to ensure that any implications on their activities have been considered and any potential issues resolved.

E/1.9 Where verge widths at structures are reduced to zero the maintaining organisation and emergency services shall be consulted to ensure that any implications on maintenance activities and the potential impact on the occupants of stricken vehicles have been considered and any potential issues resolved.

E/1.10 When applying the cross-section relaxations identified in Table E/1.4, no lane lines shall taper at gradients steeper than 1:100 when transitioning from one cross-section to another.

E/1.11 The central reserve width as identified in Table E/1.4 shall accommodate the working widths of the vehicle restraint system (VRS) and any equipment that is present or proposed.

E/1.12 Where the hard shoulder width is reduced to 3.00 metres or less for a distance of over 100 metres, a safety risk assessment shall be undertaken in accordance with GG 104 [Ref 7.N] 'Requirements for safety risk assessment', to determine if mitigation such as CCTV or an alternative monitoring / verification system is required.

E/1.13 Where lengths of hard shoulder less than 3.00 metres wide are proposed in accordance with Table E/1.4 these shall be limited to 30% of the overall length of a link.

E/1.14 Hard shoulders shall be at least 3.00 metres wide for a distance of 300 metres downstream from the merge datum points.

E/1.15 Where hard shoulders less than 3.00 metres wide are proposed these shall be hatched out as illustrated in Figure E/1.15.

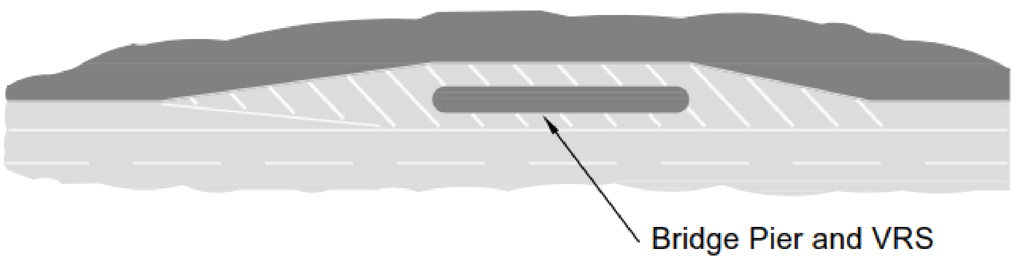
**Figure E/1.15 Layout of hatching for hard shoulders less than 3.00 metres wide**

E/1.16 The taper at the start of the hatching in a hard shoulder less that 3.00 metres wide shall have a ratio of 1:15.

E/1.17 Where an access route for emergency vehicles is to be provided behind a bridge pier, the dimensions shall be derived from a swept path analysis using the largest emergency vehicle likely to use the link.

E/1.18 Where an access route for emergency vehicles is to be provided behind a bridge pier the hard shoulder shall be hatched out as illustrated in Figure E/1.18.

**Figure E/1.18 Layout of hatching at an emergency access route behind a bridge pier**




E/1.19 The taper at the start of the hatching in the hard shoulder where an emergency access route is provided behind a bridge pier shall have a ratio of 1:15.

# E/2. Modifying existing all-purpose dual carriageways

## Scope

E/2.1 The requirements and advice in Section E/2 shall only be used when modifying existing all-purpose dual carriageways, with the exception of expressways.

E/2.1.1 The parameters in Section E/2 should only be used where it is not practicable to comply with the requirements of CD 127 [Ref 1.N].

*NOTE Document GD 300 [Ref 6.N] provides requirements and advice for the design of expressways.*

E/2.2 The parameters in Section E/2 shall not be used for new all-purpose dual carriageway elements e.g. the construction of a new slip road.

## Geometric parameters

### Highway cross-section (CD 127 clauses 2.1, 2.4, 2.5, 2.6, 2.16 and 2.23)

E/2.3 Where hard strips with the dimensions specified in CD 127 [Ref 1.N] cannot be achieved, hard strips with dimensions equivalent to or greater than the existing hard strip provision shall be retained.

E/2.4 Where the VRS set-back dimensions specified in CD 127 [Ref 1.N] cannot be achieved, VRS set-back equivalent to or greater than the existing VRS set-back on the mainline carriageway at overbridges shall be retained.

E/2.5 Where the paved width dimensions of a slip road specified in CD 127 [Ref 1.N] cannot be achieved, paved width dimensions (including lane widths and hard strip widths) equivalent or greater than the existing paved width dimensions shall be retained when the slip road meets the requirements for the design flow ranges and connector road type as required by CD 122 [Ref 3.N].

# E/3. Smart motorways

## Scope

E/3.1 The requirements and advice contained in Section E/3 shall only be used to upgrade an existing motorway to a smart motorway.

E/3.2 Where a new junction is proposed as part of a smart motorway, the parameters given in Section E/3 shall not be used to design the new elements of that junction e.g. the slip roads.

## Geometric parameters

**Verges, edge detail and omission of hard shoulder (CD 127 clauses 2.1, 2.2, 2.4, 2.5, 2.7, 2.8, and 2.23)**

E/3.3 Where there is no nearside edge restraint, such as a kerb or drainage channel, nearside hard strips shall be provided in accordance with Table E/3.3.

**Table E/3.3 Minimum hard strip width provision**

| | Minimum hard strip width | Minimum hard strip width when endorsed by the safety control review group (SCRG). |
|---|---|---|
| Minimum hard strip width | 500mm | 300mm |

E/3.4 Where there is no offside edge restraint, such as a kerb or drainage channel, an offside hard strip with a width of at least 300mm shall be provided.

*NOTE Where an edge restraint is provided, such as a kerb or drainage channel for example, there is no requirement for a nearside or offside hard strip.*

E/3.5 If a drainage channel is provided adjacent to a concrete carriageway the drainage channel shall be tied to the carriageway pavement.

E/3.5.1 Any additional pavement width available should be allocated to the provision of a nearside hard strip (where it is sub-standard or where one is not provided) rather than increasing the all lane running (ALR) lane widths above the dimensions given in Table E/3.10.

E/3.5.2 Mainline hard shoulders may be omitted on smart motorways.

E/3.5.3 The design should avoid paved areas in the verge that encourage road users to stop illegally.

E/3.5.4 Where the proposed emergency access / hard strip adjacent to the mainline carriageway is greater than 1.50 metres and less than 3.00 metres wide it should be marked with a hatched road marking.

E/3.6 Hatched road markings in the emergency access / hard strip shall only be used when endorsed by the SCRG.

*NOTE Where ALR is utilised, the requirement to hatch an emergency access width / hard strip does not apply where a hard shoulder has been converted into a running lane and a hard strip is also provided due to the available cross section.*

E/3.7 Where a hard shoulder is present on a merge connector road, this shall be hatched where the width drops below 3.00 metres.

E/3.7.1 The hatching on hard shoulders below 3.00 metres wide on merge connector roads should terminate at the entry datum point in accordance with CD 122 [Ref 3.N].

E/3.8 Where a hard shoulder is present on a diverge connector road, the hard shoulder shall be hatched where the width drops below 3.00 metres.

E/3.8.1 On diverge connector roads the hatching in hard shoulders below 3.00 metres wide should commence at the exit datum point in accordance with CD 122 [Ref 3.N].

E/3.9 There shall be no loose stone, or filter drain material within 1.00 metre of the trafficked edge of the carriageway edge line.

*NOTE For requirements and advice on the stabilisation of filter drain material at the edge of the carriageway see CD 525 [Ref 2.N] .*

**Traffic lane widths**

E/3.10 The minimum dimensions for smart motorway traffic lane widths shall be as shown in Table E/3.10.

**Table E/3.10 Minimum dimensions for smart motroway traffic lane widths**

| Lane 1 (metres) | Lane 2 (metres) | Lane 3 (metres) | Lane 4 (metres) |
|---|---|---|---|
| 3.65 | 3.50 | 3.40 | 3.20 |

*NOTE The dimensions given in Table E/3.10 are for converting a 3 lane motorway with a hard shoulder to a 4 lane ALR motorway and lanes are to be measured in accordance with CD 127 [Ref 1.N].*

E/3.11 Where compliant hard strips are provided in accordance with CD 127 [Ref 1.N], the hierarchy for increasing lane widths above the dimensions shown in Table E/3.10 shall be to allocate additional width to lane 2, then lane 3 and finally lane 4.

E/3.11.1 The impact on the joints in both the surface and the binder course from the movement of wheel tracks should be addressed in the design.

*NOTE 1 Relocating the lane lines (without carriageway resurfacing) can result in the proposed wheel tracks moving over the existing longitudinal joints in the final solution.*

*NOTE 2 When considering the impact of wheel tracks on longitudinal joints for lane widths below 3.65 metres, wheel track zones can be assumed to be 600mm wide at 2050mm centres, centred in the lane.*

**Central reserves**

E/3.12 Where it is proposed to reduce the central reserve (including hard strips) to 3.40 metres or less, the maintaining organisation shall be consulted to ensure that any implications on maintenance activities have been considered and any potential issues resolved.

E/3.13 Central reserve widths shall be wide enough to accommodate any relevant equipment, the working widths for the VRS and be no less that 2.60 metres wide including hard strips.

E/3.14 The use of unbound materials in the central reserve shall only be proposed when it has been endorsed by the SCRG.

E/3.14.1 Where works are undertaken in the central reserve, the use of unbound material as the surface treatment should be avoided.

E/3.14.2 Where unbound material is used in the central reserve, the material should be stabilised in accordance with CD 525 [Ref 2.N].

**Vehicle restraint system set back**

E/3.15 The set-back to a VRS shall be measured as the lateral distance between the traffic face of a safety barrier and:

1) nearside:
   a) the back of the nearside hard strip (when it is greater than 600mm) or hard shoulder;
   b) the kerb face for roads without a nearside hard strip (or hard strip less than 600mm) or without hard shoulder;
   c) the trafficked edge of the edge line for roads without a hard strip (or hard strip less than 600mm), or without hard shoulder or kerb;
2) offside:

a) the trafficked edge of the edge line or the kerb face where there is no edge line.

E/3.16 The minimum set-back dimensions that shall be used for smart motorways are as given in Table E/3.16.

**Table E/3.16 Smart motorway set-back**

| Location | Minimum set-back value (mm) | Available relaxations at sites described in footnotes |
|---|---|---|
| In verges with no adjacent hard strip or hard shoulder (i.e. <than 600mm width hard strip) | 1200 | Notes 1, 2, 4 |
| In verges with an adjacent hard strip or hard shoulder (i.e. ≥ 600mm width hard strip) | 600 | Note 3 |
| Central reserves | 1200 | Notes 1, 2, 4 |
| Note 1. Relaxation to 600mm for roads of speed limit 50mph or less (including temporary mandatory speed limits).<br>Note 2. Relaxation to 600mm at existing roads with physical constraints (e.g. a structure) where it could be difficult to provide the minimum set-back value.<br>Note 3. Relaxation to 450mm is permitted where it is considered necessary to position the VRS away from the edge of an existing embankment in order to provide support to the foundation.<br>Note 4. Relaxation to 1.00 metre is permitted where space is limited for extended lengths. | | |

E/3.16.1 Set-back dimensions greater than the minimum values given in Table E/3.16 should be provided wherever practicable on smart motorways.

E/3.17 The relaxations in set-back identified in Table E/3.16 shall not be applied if they create non-compliant stopping sight distance in accordance with CD 109 [Ref 4.N].

E/3.18 For the purposes of measurement of set-back, an emergency area shall be treated as a hard shoulder.

# E/4. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. CD 127, 'Cross-sections and headrooms' |
| Ref 2.N | Highways England. CD 525, 'Design of combined surface and sub-surface drains and management of stone scatter' |
| Ref 3.N | Highways England. CD 122, 'Geometric design of grade separated junctions' |
| Ref 4.N | Highways England. CD 109, 'Highway link design' |
| Ref 5.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 6.N | Highways England. GD 300, 'Requirements for new and upgraded all-purpose trunk roads (expressways)' |
| Ref 7.N | Highways England. GG 104, 'Requirements for safety risk assessment' |
| Ref 8.N | Highways England. TD 131, 'Roadside technology and communications' |
| Ref 9.N | IAN 161, 'Smart Motorways' |

Road Layout
Design

# CD 127
# Northern Ireland National Application Annex to CD 127 Cross-sections and headrooms

(formerly TD 27/05)

Version 0.1.0

**Summary**
This National Application Annex sets out the Department for Infrastructure, Northern Ireland specific requirements for highway cross-sections and headrooms.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

# Contents

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 127 | 0.**1**.0 | July 2021 | Northern Ireland NAA | Incremental change to requirements |
| Word 'rural' deleted from clause NI/1.1. NI/2.1 corrected to a 'must' clause for legislation. | | | | |

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 127 | 0 | November 2019 | | |

# Foreword

## Publishing information

This document is published by Highways England on behalf of Department for Infrastructure, Northern Ireland.

This document supersedes those parts of TD 27/05 'Cross-sections and headrooms' which solely relate to roads in Northern Ireland which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the Department for Infrastructure, Northern Ireland-specific requirements for the design of cross-sections and headrooms to CD 127 [Ref 1.N] on the Northern Ireland road network.

This National Application Annex is to be used in conjunction with CD 127 [Ref 1.N].

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 3.N] apply to this document.

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| AADT | Annual average daily traffic |
| TSRGD | Traffic Sign Regulations and General Directions |
| TSRNI | Traffic Sign Regulations (Northern Ireland) |

# NI/1. Highway cross-sections

## Paved width

NI/1.1 A reduced mainline carriageway with a minimum carriageway width of 6.00 metres shall be permitted for all-purpose single carriageway (S2) roads with design year flows of 5000 AADT or less.

NI/1.1.1 For the purposes of widening on curves, where a reduced mainline carriageway width is applied, it should be treated as a "carriageway of less than the standard width" in accordance with Section 4 of CD 109 [Ref 2.N] "Widening on curves".

*NOTE Section 2 of CD 127 [Ref 1.N] provides information on cross-section widths for other roads.*

# NI/2. Traffic signs and road markings (additional to CD 127)

NI/2.1 All traffic signs and road markings on highway links must conform to the NISR 1997 No. 386 [Ref 4.N].

*NOTE Traffic sign and road marking diagram numbers in NISR 1997 No. 386 [Ref 4.N] are generally consistent with SI 2016 No 362 (TSRGD) 2016 [Ref 1.I] but the two sets of regulations can occasionally differ.*

# NI/3. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. CD 127, 'Cross-sections and headrooms' |
| Ref 2.N | Highways England. CD 109, 'Highway link design' |
| Ref 3.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 4.N | The National Archives. legislation.gov.uk. NISR 1997 No. 386, 'Traffic Signs Regulations (Northern Ireland) 1997' |

# NI/4. Informative references

The following documents are informative references for this document and provide supporting information.

| | |
|---|---|
| Ref 1.I | The National Archives. legislation.gov.uk. SI 2016 No 362 (TSRGD), 'ROAD TRAFFIC - The Traffic Signs Regulations and General Directions 2016' , 2016 |

Road Layout
Design

# CD 127
# Scotland National Application Annex to CD 127 Cross-sections and headrooms

(formerly TD 27/05)

Revision 0

**Summary**
This National Application Annex sets out the Transport Scotland specific requirements for highway cross-sections and headrooms.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

**This is a controlled document.**

# Contents

## Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Nov 2019 | Transport Scotland National Application Annex to CD 127. |

# Foreword

## Publishing information

This document is published by Highways England on behalf of Transport Scotland.

This document supersedes those parts of TD 27/05 'Cross-sections and headrooms' which solely relate to roads in Scotland which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the Transport Scotland-specific requirements for the design of cross-sections and headrooms to CD 127 [Ref 1.N] on the Scottish trunk road network.

This National Application Annex is to be used in conjunction with CD 127 [Ref 1.N].

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 3.N] apply to this document.

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| AADT | Annual average daily traffic |

# S/1. Highway cross-sections

## Paved width

S/1.1 A reduced mainline carriageway with a minimum carriageway width of 6.00 metres shall be permitted for rural all-purpose single carriageway (S2) roads with design year flows of 5000 AADT or less.

S/1.1.1 For the purposes of widening on curves, where a reduced mainline carriageway width is applied, it should be treated as a "carriageway of less than the standard width" in accordance with Section 4 of CD 109 [Ref 2.N] "Widening on curves".

*NOTE Section 2 of CD 127 [Ref 1.N] provides information on cross-section widths for other roads.*

# S/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. CD 127, 'Cross-sections and headrooms' |
| Ref 2.N | Highways England. CD 109, 'Highway link design' |
| Ref 3.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |

Road Layout
Design

# CD 127
# Wales National Application Annex to CD 127 Cross-sections and headrooms

(formerly TD 27/05)

Revision 0

**Summary**
There are no specific requirements for Welsh Government supplementary or alternative to those given in CD 127.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Nov 2019 | Welsh Government National Application Annex to CD 127. |

Design Manual for Roads and Bridges

Pavement
Design

# CD 224
# Traffic assessment

(formerly HD 24/06)

Revision 0

**Summary**
This document sets out the method for calculating traffic loading for the design of road pavements.

**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Mar 2020 | CD 224 replaces HD 24/06. This full document has been re-written to make it compliant with Highways England drafting rules and has also been updated and simplified. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes HD 24/06, which is withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This document covers the calculation of design traffic (commercial vehicle pavement loading over the design period) for new trunk roads, including motorway schemes and for the maintenance of existing trunk roads, including motorways.

In the UK, pavement designs for particular materials are intrinsically related to the road pavement structural wear resulting from traffic (i.e. fatigue cracking within the bound pavement layers and/or excessive sub-grade deformation). Pavement designs for flexible and rigid pavements are presented in CD 226 [Ref 2.N].

Road pavement structural wear in the UK is calculated using wear factors based on axle loads. Wear factors have been calculated using loads measured using weigh-in-motion (WIM) sensors installed on the road network.

The background to the method is given in TRL Report ( TRL PPR 066 [Ref 1.I])

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 4.N] apply to this document.

# Abbreviations and symbols

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| AADF | Annual average daily flow (1-way traffic) |
| AADT | Annual average daily traffic (2-way traffic) |
| COBA | COst benefit analysis [program] |
| cv | Commercial vehicles (over 3.5 tonnes maximum gross vehicle weight) |
| msa | Million standard axles |
| OGV | Other goods vehicle (over 3.5 tonnes maximum gross vehicle weight). Where no other data are available, it can be assumed that vehicles over 6.6m long are OGVs. |
| OGV1 | Other goods vehicle 1 (2 and 3-axle rigid vehicles) |
| OGV2 | Other goods vehicle 2 (4-axle rigid vehicles and articulated vehicles with any number of axles) |
| PSV | Public service vehicle |
| WebTAG | Web-based transport analysis guidance |

**Symbols**

| Symbol | Definition |
|---|---|
| F | Commercial vehicle flow |
| $F_i$ | Traffic flow after i years |
| G | Growth factor |
| P | Percentage of vehicles in the heaviest loaded lane |
| R | Annual growth rate |
| T | Design traffic |
| Tc | Weighted annual traffic for vehicle category c |
| W | Wear factor |
| $W_M$ | Wear factor for maintenance |
| $W_N$ | Wear factors for new road schemes |
| Y | Design period |

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| Design traffic | The commercial vehicle loading over the design period of a pavement. It is expressed as the number of equivalent 80kN standard axles. |
| New road schemes | Road construction schemes, including road widening, where there is greater uncertainty about traffic flows. |
| Standard axle | An axle exerting or applying a force of 80kN. The structural wear associated with each vehicle increases with increasing axle load. Although alternative methods are available, structural wear for pavement design in the UK is taken as being proportional to the 4th power of the axle load. The number of standard axles is the estimated structural wear factor for the vehicle class. |

# 1. Scope

## Aspects covered

1.1 This document defines the method that shall be used to calculate traffic loading for the design of road pavements.

## Implementation

1.2 This document shall be implemented forthwith on all schemes involving the construction, improvement and maintenance of pavements on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 4.N].

## Use of GG 101

1.3 The requirements contained in GG 101 [Ref 4.N] shall be followed in respect of activities covered by this document.

# 2. Calculation of design traffic

2.1 The following factors shall be used to calculate the design traffic (T):

1) commercial vehicle flow (F);
2) design period (Y);
3) growth factor (G);
4) wear factor (W); and
5) percentage of vehicles in the heaviest loaded lane (P).

## Commercial vehicle flow

2.2 The annual average daily flow (AADF) of commercial vehicles, at scheme opening (or for existing road schemes, the current flow) shall be used to calculate the commercial vehicle flow (F), for the different vehicle classes.

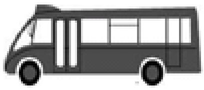
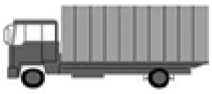
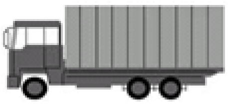
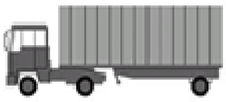
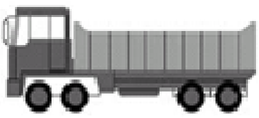
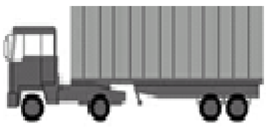
*NOTE The AADF is the flow measured in one direction (1-way flow).*

2.3 Annual average daily traffic (AADT) shall be converted into AADF assuming a 50:50 directional split, unless traffic counts or studies show a directional bias.

*NOTE The AADT is the traffic measured in both directions.*

2.4 Table 2.4 shows the commercial vehicle classes and categories that shall be used in the calculation of design traffic DVSA Simplified Guide [Ref 1.N].

**Table 2.4 Commercial vehicle classes and categories**

| Commercial vehicle (cv) | cv class* | cv category |
|---|---|---|
|  | Buses and coaches | PSV |
|  | 2-axle rigid | OGV1 |
|  | 3-axle rigid | |
|  | 3-axle articulated | OGV2 |
|  | 4-axle rigid | |
|  | 4-axle articulated | |
|  | 5-axle articulated | |
|  | 6 (or more) axle articulated | |

*classed by axles in contact with the road
PSV = Public service vehicle
OGV = Other goods vehicle

**New road schemes**

2.5 For new road schemes, the commercial vehicle flows by class / category shall be determined from traffic transport analysis using the principles described in the Department for Transport's WebTAG Unit M3.1 [Ref 3.N].

2.6 The flow of other goods vehicle 2 (OGV2) vehicles as a percentage of all commercial vehicles shall be obtained by calculation or modelling.

2.7 The resulting percentage of OGV2 vehicles shall not be less than 70 per cent.

**Existing road schemes (maintenance design or re-alignment)**

2.8 Where there are existing AADF data for the scheme, they shall be used to determine the commercial vehicle flow.

2.9 Where there are no existing AADF data, a classified count shall be carried out and converted to AADF using the principles given in the COBA Manual ( COBA [Ref 5.N]).

## Design period

2.10 For new road schemes, the design period (Y) is the number of years over which traffic is to be assessed, and shall be defined according to the design life given in CD 226 [Ref 2.N].

2.11 For existing road schemes, where past traffic is used, the design period (Y) shall be the number of years since opening or the last major structural maintenance of the carriageway.

## Growth factor

### Future traffic

2.12 The growth factors for future traffic shown in Table 2.12 shall be used.

**Table 2.12 Growth factors (G) for future traffic**

| Design period (years) | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
|---|---|---|---|---|---|---|---|---|
| OGV1 + PSV | 1.02 | 1.05 | 1.08 | 1.11 | 1.14 | 1.17 | 1.21 | 1.24 |
| OGV2 | 1.04 | 1.10 | 1.16 | 1.23 | 1.30 | 1.37 | 1.46 | 1.54 |
| All commercial vehicles | n/a | | | | | | | 1.45 |

*NOTE 1 The growth factor (G) represents the difference between the average annual vehicle flow over the design period and the present flow (or flow at opening).*

*NOTE 2 The growth factors (G) are based on scenario 5 of the road traffic forecasts 2015 ( RTF 2015 [Ref 2.I]). The equivalent annual growth rates (R) are 1.07% for OGV1, 2.10% for OGV2 and 1.54% for all commercial vehicles.*

2.13 Where no information on commercial vehicle classes and categories is available, a 40 year design period (Y) and a growth factor (G) of 1.45 shall be used.

2.14 Where there is a requirement to calculate the traffic flow (F) after i years (for example, when calculating an appropriate polished stone or aggregate abrasion value), the annual growth rate (R) shall be used as in Equation 2.14.

**Equation 2.14 Traffic flow**

$$F_i = F \times \left((1+R)^i\right)$$

*NOTE For example, after 10 years the OGV2 flow (R = 2.10%) becomes $1.021^{10}$ = 1.23 times the current flow (F). This is larger than the equivalent growth factor (G) for a 10 year design period (1.10 - see Table 2.12) as it is the flow in year 10 rather than the average across the 10 years.*

### Past traffic

2.15 Where classified local traffic counts are available, they shall be used to calculate traffic flows for each class / category and year.

2.16 Where classified local traffic counts are not available, national traffic statistics shall be used.

2.17 A growth factor of 1.0 shall be used for calculations of past traffic.

## Wear factor

2.18 The wear factors given in Table 2.18 shall be used.

**Table 2.18 Wear factors for commercial vehicle classes and categories**

| | Maintenance $W_M$ | New $W_N$ |
|---|---|---|
| Buses and coaches | 2.6 | 3.9 |
| 2-axle rigid | 0.4 | 0.6 |
| 3-axle rigid | 2.3 | 3.4 |
| 4-axle rigid | 3.0 | 4.6 |
| 3 and 4-axle articulated | 1.7 | 2.5 |
| 5-axle articulated | 2.9 | 4.4 |
| 6-axle articulated | 3.7 | 5.6 |
| OGV1 + PSV | 1.3 | 1.9 |
| OGV2 | 3.2 | 4.9 |
| All commercial vehicles (70% OGV2) | 2.7 | 4.0 |

2.19 The wear factors for maintenance, $W_M$, shall be used to calculate design traffic for all maintenance schemes including re-alignment.

2.20 The wear factors for new road schemes, $W_N$, shall be used to calculate design traffic for all new road construction schemes including road widening.

2.20.1 For motorway schemes requiring widening and re-alignment, the use of $W_N$ and $W_M$ may be applicable.

## Percentage of commercial vehicles in the heaviest loaded lane

2.21 For carriageways with 2 or more lanes in one direction, the proportion of vehicles in the most heavily loaded lane (P) shall be calculated using Table 2.21.

**Table 2.21 Assumed proportion of commercial vehicles in the heaviest loaded lane**

| Number of lanes (in one direction) | Flow (F) (cv/day) | P (%) |
|---|---|---|
| 2 or 3 | Up to 5,000 | P = 100 - (0.0036 x F) |
| | Over 5,000 up to 25,000 | P = 89 - (0.0014 x F) |
| | Over 25,000 | P = 54 |
| 4 or more | Up to 10,500 | P = 100 - (0.0036 x F) |
| | Over 10,500 up to 25,000 | P = 75 - (0.0012 x F) |
| | Over 25,000 | P = 45 |

### Percentage of commercial vehicles in other lanes

2.22 Where required for maintenance purposes, the traffic in the other lanes shall be based on the assumptions in Table 2.22.

**Table 2.22 Assumed distribution of commercial vehicles in other lanes**

| | |
|---|---|
| 2-lanes | All traffic not in the heaviest loaded lane is in the other lane. |
| 3-lanes | All commercial vehicle traffic is in lanes 1 and 2 - traffic not in the heaviest loaded lane is in the other lane. |
| 4 or more lanes | Classified traffic count data are needed to confirm the distribution of traffic across each lane. No commercial vehicle traffic is in the right hand lane. |

## Design traffic

2.23 The future cumulative design traffic, in terms of million standard axles (msa), for commercial vehicle class or category c shall be calculated according to Equation 2.23a and 2.23b.

**Equation 2.23a Weighted annual traffic**

$$T_c = 365 \times F \times G \times W \times 10^{-6} msa$$

**Equation 2.23b Design traffic (T)**

$$T = \sum T_c \times Y \times P$$

where:

| | |
|---|---|
| $T_c$ | Weighted annual traffic for commercial vehicle category c |
| F | Commercial vehicle flow (AADF) |
| G | Growth factor |
| W | Wear factor ($W_M$ for maintenance or $W_N$ for new design) |
| Y | Design period (years) |
| P | Percentage of commercial vehicles in the heaviest loaded lane |
| T | Design traffic |

2.23.1 Design traffic calculations may be made using the proforma given in Table 2.23.1.

**Table 2.23.1 Table for the calculation of design traffic**

| **Commercial vehicle class or category** | **AADF (F)** | **Growth factor (G)** | **Wear factor (W)** | **Weighted annual traffic ($T_c$)** |
|---|---|---|---|---|
| | | | **$W_M$ or $W_N$** | |
| Either by class<br>buses and coaches (PSV) | | | | |
| OGV1<br>2 axle rigid<br>3 axle rigid | | | | |
| OGV2<br>4 axle rigid<br>3 and 4 axle articulated<br>5 axle articulated<br>6 axle articulated | | | | |
| Or by category<br><br>OGV1 + PSV<br>OGV2 | | | | |
| **Total daily flow (cv/day)** | | **Total weighted annual traffic** $(\sum T_c)$ | | |
| | | **Percentage of vehicles in heaviest loaded lane (P)** | | |
| | | **Design period (Y)** | | |
| | | **Design traffic (T)** | | |

NOTE 1 *An example calculation for maintenance schemes (by class) is given in Table 2.23.1N1.*

**Table 2.23.1N1 Design traffic calculation example for maintenance schemes**

| **Commercial vehicle class** | **AADF (F)** | **Growth factor (G) (20 years)** | **Wear factor (W)** | **Weighted annual traffic ($T_c$)** |
|---|---|---|---|---|
| | | | **$W_M$** | |
| Buses and coaches (PSV) | 77 | 1.11 | 2.6 | 0.08 |
| OGV1<br>2 axle rigid<br>3 axle rigid | <br>914<br>59 | <br>1.11<br>1.11 | <br>0.4<br>2.3 | <br>0.15<br>0.05 |
| OGV2<br>4 axle rigid<br>3 and 4 axle articulated<br>5 axle articulated<br>6 axle articulated | <br>53<br>302<br>1,021<br>574 | <br>1.23<br>1.23<br>1.23<br>1.23 | <br>3.0<br>1.7<br>2.9<br>3.7 | <br>0.07<br>0.23<br>1.33<br>0.93 |
| **Total daily flow (cv/day)** | 3,000 | **Total weighted annual traffic** $(\sum T_c)$ | | 2.87 msa |
| | | **Percentage of vehicles in heaviest loaded lane (P)** | | 89.2% |
| | | **Design period (Y)** | | 20 years |
| | | **Design traffic (T)** | | 51 msa |

NOTE 2 *An example calculation for new road schemes where minimum 70% OGV2 applies (by category) is given in Table 2.23.1N2.*

**Table 2.23.1N2 Traffic calculation example for road schemes (minimum 70% OGV2 applied)**

| **Commercial vehicle category** | **AADF (F)** | **Growth factor (G) (40 years)** | **Wear factor (W)** <br> **$W_N$** | **Weighted annual traffic ($T_c$)** |
|---|---|---|---|---|
| OGV1 + PSV | 360 | 1.24 | 1.9 | 0.31 |
| OGV2 | 840 | 1.54 | 4.9 | 2.31 |
| **Total daily flow (cv/day)** | 1,200 | **Total weighted annual traffic** $(\sum T_c)$ | | 2.62 msa |
| | | **Percentage of vehicles in heaviest loaded lane (P)** | | 95.7% |
| | | **Design period (Y)** | | 40 years |
| | | **Design traffic (T)** | | 100 msa |

NOTE 3 *An example calculation for new road schemes where there is no information on commercial vehicle categories is given in Table 2.23.1N3.*

**Table 2.23.1N3 Traffic calculation example for new road schemes where there is no information on vehicle categories**

| **Commercial vehicle category** | **AADF (F)** | **Growth factor (G)** | **Wear factor (W)** <br> **$W_N$** | **Weighted annual traffic ($T_c$)** |
|---|---|---|---|---|
| **Total daily flow (cv/day)** | 2,000 | 1.45 | 4.0 | 4.23 msa |
| | | **Percentage of vehicles in heaviest loaded lane (P)** | | 92.8% |
| | | **Design period (Y)** | | 40 years |
| | | **Design traffic (T)** | | 157 msa |

# 3. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Driver and Vehicle Standards Agency. Department for Transport. DVSA Simplified Guide, 'A Simplified Guide to Lorry Types and Weights' |
| Ref 2.N | Highways England. CD 226, 'Design for new pavement construction' |
| Ref 3.N | Department for Transport (UK). WebTAG Unit M3.1, 'Highway Assignment Modelling' |
| Ref 4.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 5.N | Mott MacDonald. COBA, 'The COBA User Manual' |

# 4. Informative references

The following documents are informative references for this document and provide supporting information.

| | |
|---|---|
| Ref 1.I | Transport Research Laboratory. VM Atkinson, D Merrill and N Thom. TRL PPR 066, 'Pavement wear factors' |
| Ref 2.I | Department for Transport. RTF 2015, 'Road Traffic Forecasts 2015' |

Design Manual for Roads and Bridges

Pavement
Design

# CD 225
# Design for new pavement foundations

(formerly IAN 73/06 revision 1 (2009), HD 25/94)

Revision 1

**Summary**
This document sets out the design procedure for pavement foundations in terms of the ability of the foundation to resist loads applied both during construction and the service life of the pavement.

**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 1 | Apr 2020 | Revision 1 (April 2020): Clarification of typo in Equation 2.4; function tables relaid for all equations (2.4, and C.1 to C.5). Revision 0 (March 2020) CD 225 replaces IAN 73/06 Revision 1 (2009) and HD 25/94. This full document has been rewritten to make it compliant with the new Highways England drafting rules and extensively restructured, with corresponding updates to the MCHW Volume 1 Series 800 and MCHW Volume 2, Series 700 and Series 800. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes IAN 73/06 Revision 1 (2009) and HD 25/94 which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

The main function of a pavement foundation is to distribute the applied vehicle loads to the underlying subgrade, without causing distress in the foundation layers or in the overlying layers. This is required both during construction and during the service life of the pavement.

Pavement foundations are designed on the basis of practical minimum layer thicknesses for construction, protection of the subgrade during construction and long term provision of support to the overlying pavement layer. Other considerations include drainage and durability.

In the short-term during pavement construction, the stresses in the foundation are relatively high. It is expected that loads are going to be applied to the foundation by delivery vehicles, pavers and other construction plant. At any level where such loading is applied, the stiffness and material thickness of the layer has to be sufficient to withstand the load without damage occurring that might adversely influence, to any significant extent, the long-term performance.

In the longer-term during the in-service life of a pavement, the stresses in the foundation are expected to be lower than during construction; although the foundation is going to experience repeated loads from traffic. It is essential that the assumed support of the foundation to the pavement is maintained, otherwise, deterioration of the upper pavement layers is going to occur more rapidly than anticipated.

This document sets out the permitted approaches that can be taken when designing a new pavement foundation. A variety of materials can be utilised in the foundation in the capping and subbase layers. The designer can take advantage of improved foundation materials by using them to construct stronger and stiffer foundations that require a reduced thickness of overlying pavement construction (refer to CD 226 [Ref 1.N]).

Three foundation design approaches are presented:

1) A restricted design approach that offers assurance of performance of the foundation through use of a limited palette of well understood materials.
2) A performance design approach that gives flexibility to the designer in terms of the materials that can be used in the foundation conjunction with top of foundation testing to confirm performance requirements have been met.
3) A widening design approach that utilises a restricted or performance design approach to assure the performance of the foundation whilst considering the additional requirements to provide sub-surface drainage continuity between the existing pavement and the widening.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 3.N] apply to this document.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a "British Standard" or other technical specification, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 3.N].

# Abbreviations and symbols

### Abbreviations

| Abbreviation | Definition |
|---|---|
| CBR | California bearing ratio |
| msa | Million standard axles |
| NINS | Non-intercellular neoprene foam sheet |

### Symbols

| Symbol | Definition |
|---|---|
| A | Cross sectional area of the permeameter |
| c | Temperature correction factor $\mu_T/\mu_{20}$, obtained from a standard chart |
| $d_{50}$ | Median grain (particle) size |
| $d_{100}$ | Maximum particle size |
| E | Estimated subgrade surface modulus |
| $G_{sa}$ | Apparent relative particle density |
| $\Delta H$ | Head difference across specimen |
| Hg | Mercury (as used in pressure measurement) |
| i | Hydraulic gradient |
| k | Coefficient of permeability |
| $k_{20}$ | Coefficient of permeability at standard laboratory temperature of 20°C |
| L, W, D | Length, width and depth of the specimen |
| M | Total mass of aggregate in permeameter |
| MPa | MegaPascal |
| $M_w$ | Mass of water |
| n | Porosity |
| q | Steady state flow rate |
| $q_{20}/A$ | Flow rate per unit area standardised to 20°C |
| $R_c$ | Compressive strength |
| Sr | Degree of saturation |
| T | Temperature |
| V | Volume of sample |
| $\mu$ | Dynamic viscosity of water |
| $\mu_T$ | Dynamic viscosity of water at ambient temperature |
| $\mu_{20}$ | Dynamic viscosity of water at standard laboratory temperature of 20°C |
| $\rho_s$ | Dry density of sample |
| $\omega$ | Water content |

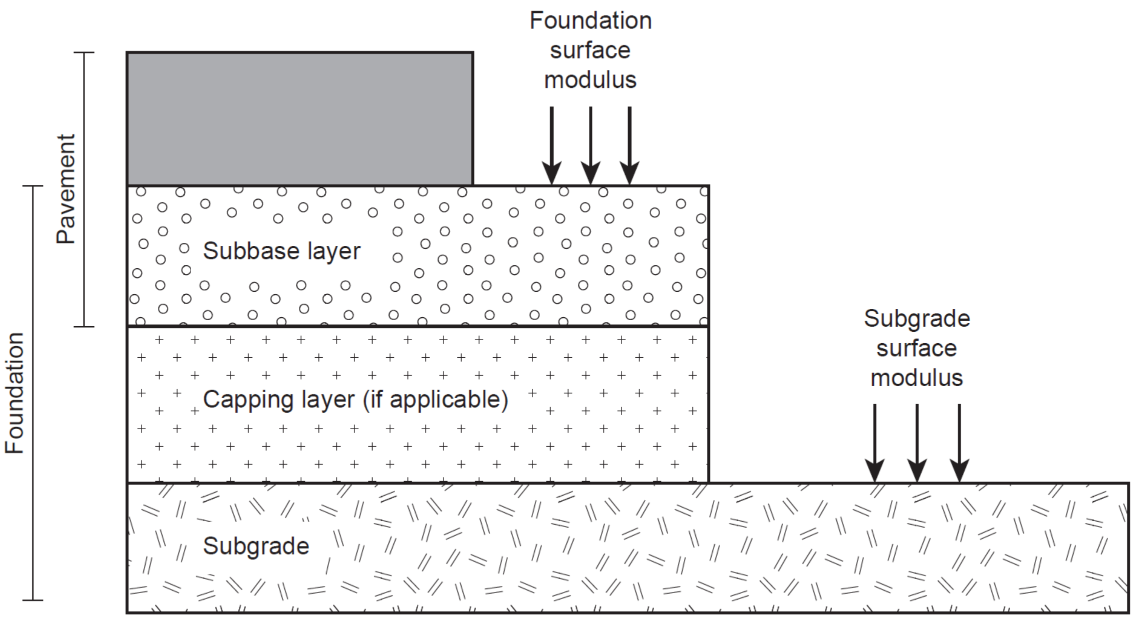
# Terms and definitions

| Term | Definition |
|---|---|
| Apparent relative particle density | Ratio obtained by dividing the oven-dried mass of an aggregate sample by the volume it occupies in water including the volume of any internal sealed voids but excluding the volume of water in any water accessible voids (apparent relative density synonymous with apparent specific gravity $G_{sa}$). |
| Capping | An improvement layer on top of the subgrade, protecting the subgrade from damage and/or increasing the stiffness at formation level. |
| Coefficient of permeability | The mean discharge velocity of flow of water in a soil under the action of a unit hydraulic gradient. |
| Construction subgrade surface modulus | A value of stiffness modulus of the subgrade measured during construction. |
| Design subgrade surface modulus | An estimated value of stiffness modulus for the subgrade used for foundation design. It is the lower of the short-term and long-term subgrade surface modulus. |
| Formation | Level upon which subbase is placed. |
| Foundation | All materials up to and including subbase. |
| Foundation surface modulus | A stiffness modulus based on the application of a known load at the top of the foundation; it is a composite value representing all of the foundation layers under the completed pavement. A design value for the confined foundation under a pavement. |
| Foundation surface modulus class | The design class of the foundation, based upon the long-term foundation surface modulus. |
| Horizontal permeability | The ability of a material to allow the passage of a fluid in the horizontal plane. |
| Hydraulically bound mixture | A mixture which sets and hardens by hydraulic reaction. |
| Hydraulic gradient | The ratio of the difference in total head of water on either side of a layer of material or soil, to the thickness of the layer measured in the direction of flow. |
| Layer stiffness | The stiffness modulus assigned to a given layer that accounts for in-service conditions and degradation. |
| Long-term subgrade surface modulus | An estimated value of stiffness modulus for the subgrade when a state of equilibrium is reached under the pavement. |
| Loose bulk density | The quotient obtained when the mass of dry aggregate filling a specified container without compaction is divided by the capacity of that container. |
| Pavement | All layers above formation. |
| Short-term subgrade surface modulus | An estimated value of stiffness modulus for the subgrade during construction. |

(continued)

| Term | Definition |
|---|---|
| Standard axle | An axle exerting or applying a force of 80 kN. The structural wear associated with each vehicle increases significantly with increasing axle load. Although alternative methods are available, structural wear for pavement design in the UK is taken as being proportional to the 4th power of the axle load. The number of standard axles is the estimated structural wear factor for the vehicle class. |
| Steady-state flow | In which flow into a system is equal to flow out of the system. |
| Stiffness modulus | The ratio of applied stress to induced strain. |
| Subbase | A platform layer upon which the main structure of a pavement is constructed. The subbase is both part of the foundation and pavement. |
| Sub-formation | Level upon which capping is placed. |
| Subgrade | Soil or fill underlying a pavement. |
| Surface modulus | A stiffness modulus based on the application of a known load at the top of a layer. |

**The following figure provides a diagrammatic representation to illustrate some of the key definitions above.**



# 1. Scope

## Aspects covered

1.1 This document provides details of the requirements that shall be used to design pavement foundations.

## Implementation

1.2 This document shall be implemented forthwith on all schemes involving the construction, improvement and maintenance of pavements on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 3.N].

## Use of GG 101

1.3 The requirements contained in GG 101 [Ref 3.N] shall be followed in respect of activities covered by this document.

# 2. Subgrade assessment and requirements

2.1 The design subgrade surface modulus shall be used in the pavement foundation design (Section 3).

2.2 The pavement foundation shall be divided into characteristic sections of subgrade, each having a single design subgrade surface modulus value.

2.2.1 The characteristic sections should be based on the type of subgrade material and its condition.

2.3 The short-term subgrade surface modulus and long-term subgrade surface modulus shall be determined for each characteristic section of subgrade.

2.3.1 The process outlined in LR1132 [Ref 13.I] may be used to review soil properties and construction assumptions when estimating the short-term subgrade surface modulus and/or long-term subgrade surface modulus.

*NOTE The presence of a high or perched water table (300 mm or less below formation level) can reduce subgrade stiffness, culminating in low subgrade surface modulus values at the time of construction. Guidance on determining subgrade surface modulus values in the presence of a high or perched water table is given in LR1132 [Ref 13.I].*

2.3.2 For widening schemes, where the subgrade is consistent across the width of the existing carriageway and the proposed widening, use of the in situ long-term subgrade surface modulus of the subgrade below the existing carriageway may be used for design purposes.

2.4 Equation 2.4 shall be used where California bearing ratio (CBR) is used in the estimation of short-term and/or long-term subgrade surface modulus:

**Equation 2.4 CBR to subgrade surface modulus conversion**

$$E = 17.6(CBR)^{0.64}$$

where:

| | |
|---|---|
| E | is the estimated subgrade surface modulus (MPa) |
| CBR | is the California bearing ratio (CBR) of the subgrade |

*NOTE Equation 2.4 is valid for CBR values in the range 2 to 12 per cent.*

2.5 The design subgrade surface modulus shall be determined as being equal to the lower of the short-term subgrade surface modulus and the long-term subgrade surface modulus values.

2.5.1 For widening schemes, the depth at which the design subgrade surface modulus is determined may be dependent on any requirements to maintain drainage continuity between the existing carriageway and the proposed widening.

2.6 For each characteristic section of subgrade, the following shall be detailed:

1) start and end chainage;
2) short-term subgrade surface modulus (MPa);
3) long-term subgrade surface modulus (MPa); and,
4) design subgrade surface modulus (MPa).

2.7 Where the design subgrade surface modulus is lower than 30 MPa, improvement of the subgrade shall be undertaken.

*NOTE 1 Subgrades with a design subgrade surface modulus value lower than 30 MPa are unsuitable to support the construction of a pavement foundation.*

NOTE 2 *Options for improvement of the subgrade include excavation and replacing between 500 to 1000 mm of the soft subgrade with granular fill, mechanical stabilisation (geogrids and/or geotextiles) and soil stabilisation.*

2.8 The upper limit on design surface modulus for areas of improvement of the subgrade shall be 50 MPa.

2.9 A testing regime, specified in accordance with the MCHW [Ref 4.N], shall be detailed to establish the construction subgrade surface modulus.

2.10 Where the construction subgrade surface modulus is found to be lower than the design subgrade surface modulus, then action shall be taken by either effecting improvement of the subgrade (see clause 2.8) or by reviewing the design subgrade surface modulus with a view to redesign using the lower value (see clause 2.5).

# 3. Foundation designs

## Applicability for restricted, performance and widening foundations

3.1 Subgrade characteristic sections shall be divided into one or more foundation areas.

3.2 Each foundation area shall have a single design approach.

3.3 The design approach for each foundation area shall be one of the following:

1) restricted;
2) performance; or,
3) widening (restricted or performance).

*NOTE Restricted and performance design approaches can be implemented on the same scheme where different design approaches are appropriate depending on the requirements of specific areas within the scheme e.g. slip roads versus mainline.*

3.4 The design approach shall be determined based on the scheme type, the availability of materials and economics.

*NOTE 1 The restricted foundation design options are based on a limited selection of materials linked to an assumed performance which does not require verification via performance testing of the foundation.*

*NOTE 2 Performance foundation designs can offer economic benefits through innovation and/or the use of materials not permitted within restricted foundation designs. Assurance of material performance is provided by the performance related specification outlined within the MCHW [Ref 4.N].*

*NOTE 3 Foundation designs for carriageway widening can follow either a restricted or performance foundation design approach with additional measures to ensure drainage paths are not impeded by the widening of the carriageway.*

## General requirements

3.5 For each foundation area, the design approach shall be detailed, i.e. restricted or performance, and whether it is widening.

3.6 Details of foundation designs shall be recorded as required in CD 226 [Ref 1.N] Section 6.

*NOTE See Clauses 2.6, 3.5, 3.11, 3.24 that define the foundation design details to be recorded.*

3.7 The design for all foundation areas shall be based on achieving a foundation class selected from Table 3.7.

**Table 3.7 Foundation classes**

| Foundation class | Assumed long-term confined foundation surface modulus (MPa) |
|---|---|
| 1 | ≥ 50 |
| 2 | ≥ 100 |
| 3 | ≥ 200 |
| 4 | ≥ 400 |

*NOTE Foundation class 4 is not available for the restricted foundation design approach due to a lack of performance data sets generated since the inclusion of this foundation class in 2006. Therefore, foundation class 4 is only permitted as a performance foundation.*

3.8 The foundation class shall be used in the pavement design within CD 226 [Ref 1.N].

3.9 The design subgrade surface modulus (see Section 2) for each characteristic section shall be used in the foundation design.

3.10 Design layer thicknesses in this section assume the foundation carries up to 1000 standard axles during construction. Where higher levels of construction traffic are anticipated (e.g. for a haul road), the design layer thickness shall be assessed for suitability versus the limiting requirement on vertical strain the subgrade (see Section 4).

3.10.1 LR1132 [Ref 13.I] may be used to establish the subbase thickness required for different levels of cumulative construction traffic.

3.10.2 Additional subbase thickness may be required for other reasons such as at interfaces, regulation or for drainage continuity.

## Restricted foundation designs

### General requirements

3.11 For each foundation area and for each layer to be constructed, the following shall be detailed:

1) start and end chainage;
2) foundation class;
3) materials to be used; and,
4) nominal layer thicknesses to be constructed.

### Options and restrictions

3.12 Where the short-term subgrade surface modulus is 50 MPa or lower, the foundation design shall consist of subbase and capping.

*NOTE 1 Foundations built on a construction subgrade surface modulus of 50 MPa or less have a relatively high risk of structural rutting during construction. This can be prevented through subgrade improvement and/or the use of a capping layer.*

*NOTE 2 Following subgrade improvement, a capping layer is not necessarily required, dependent on the estimated short-term subgrade surface modulus value.*

3.13 The materials used in the foundation shall be limited to those detailed in the MCHW clauses referenced in Figure 3.17 to Figure 3.23.

*NOTE The feasibility of using site won materials (particularly soils containing organics, sulphates and/or sulphides) within the bound capping and/or subbase mixtures is dependent on designing a durable mixture. Historic lessons are that initial feasibility is best done at the design stage.*

3.14 Foundation class 1 shall not be used where the pavement is designed for traffic loading greater than 20 msa.

3.15 Unbound subbase to Clause 804 (Type 2) of the MCHW [Ref 4.N] shall not be used where pavements are designed for traffic loading greater than 5 msa.

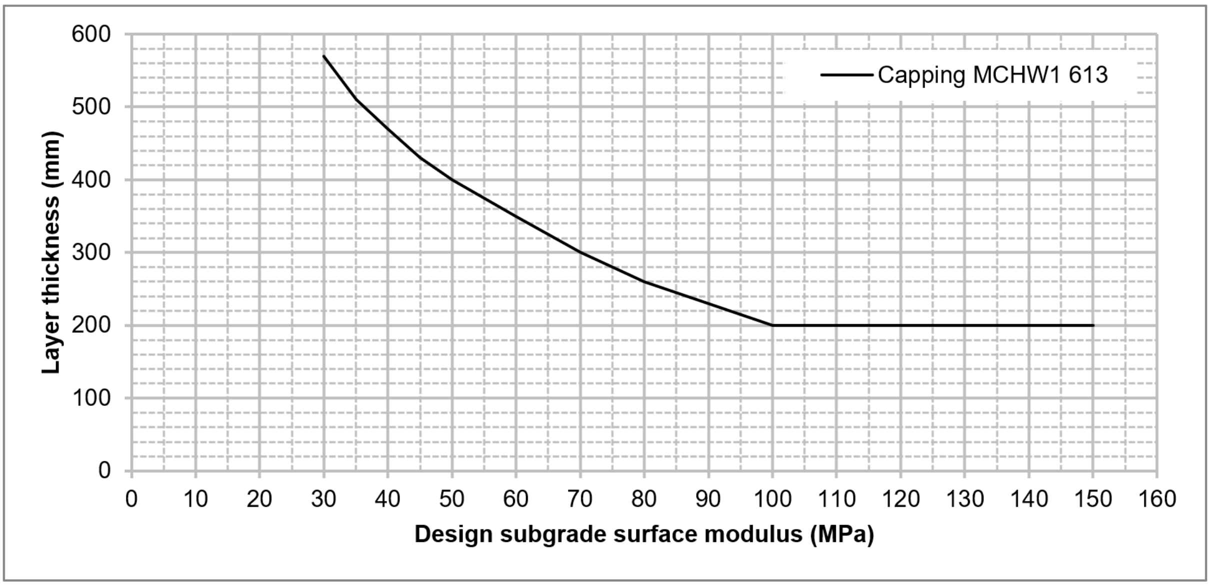
### Thickness charts

3.16 Design nominal thicknesses for each layer shall be rounded up to the nearest 10 mm.

*NOTE For worked examples demonstrating use of the thickness charts, see Appendix B.*

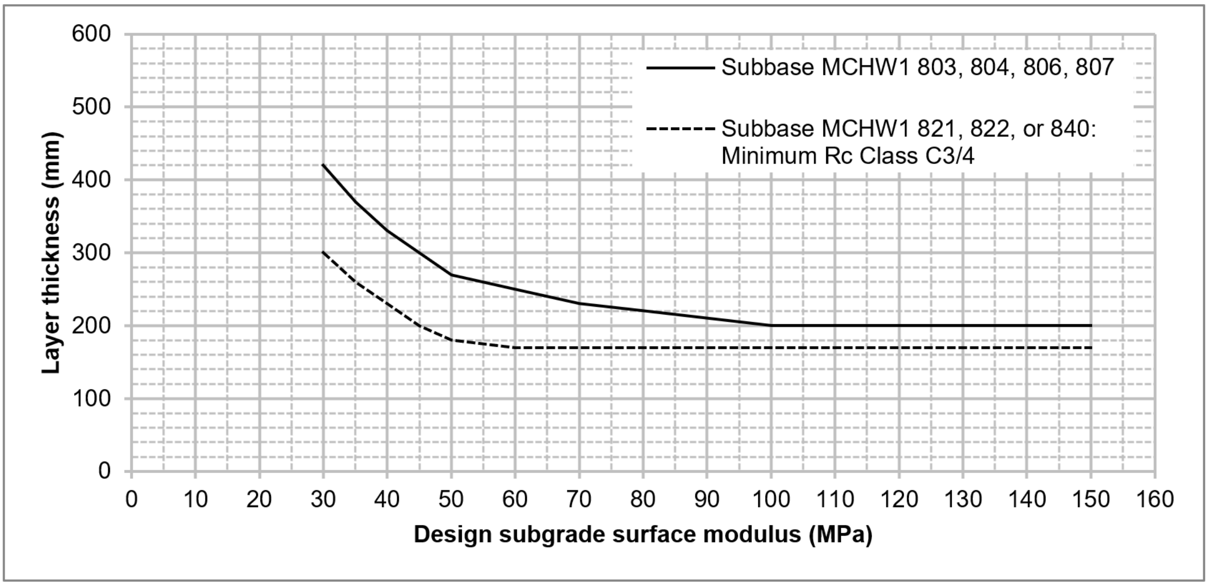
3.17 The design thickness for foundation class 1 designs shall be obtained from Figure 3.17.

Figure 3.17 Restricted design options - class 1 capping only



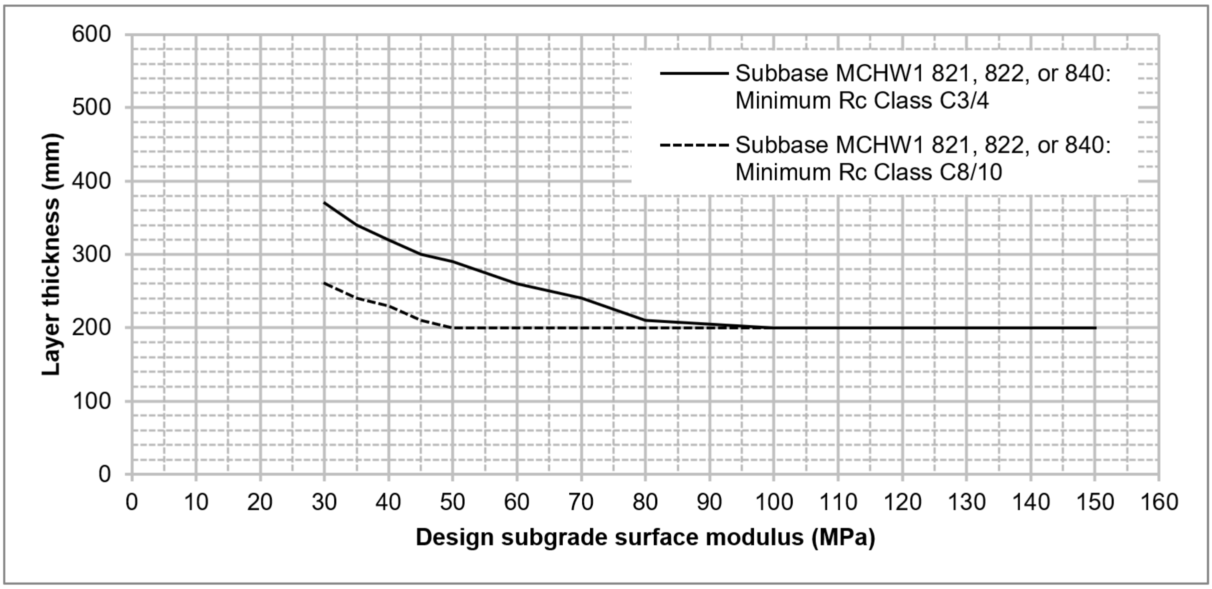

3.18 The design thickness for subbase only foundation class 2 designs shall be obtained from Figure 3.18.

Figure 3.18 Restricted design options - class 2 subbase only



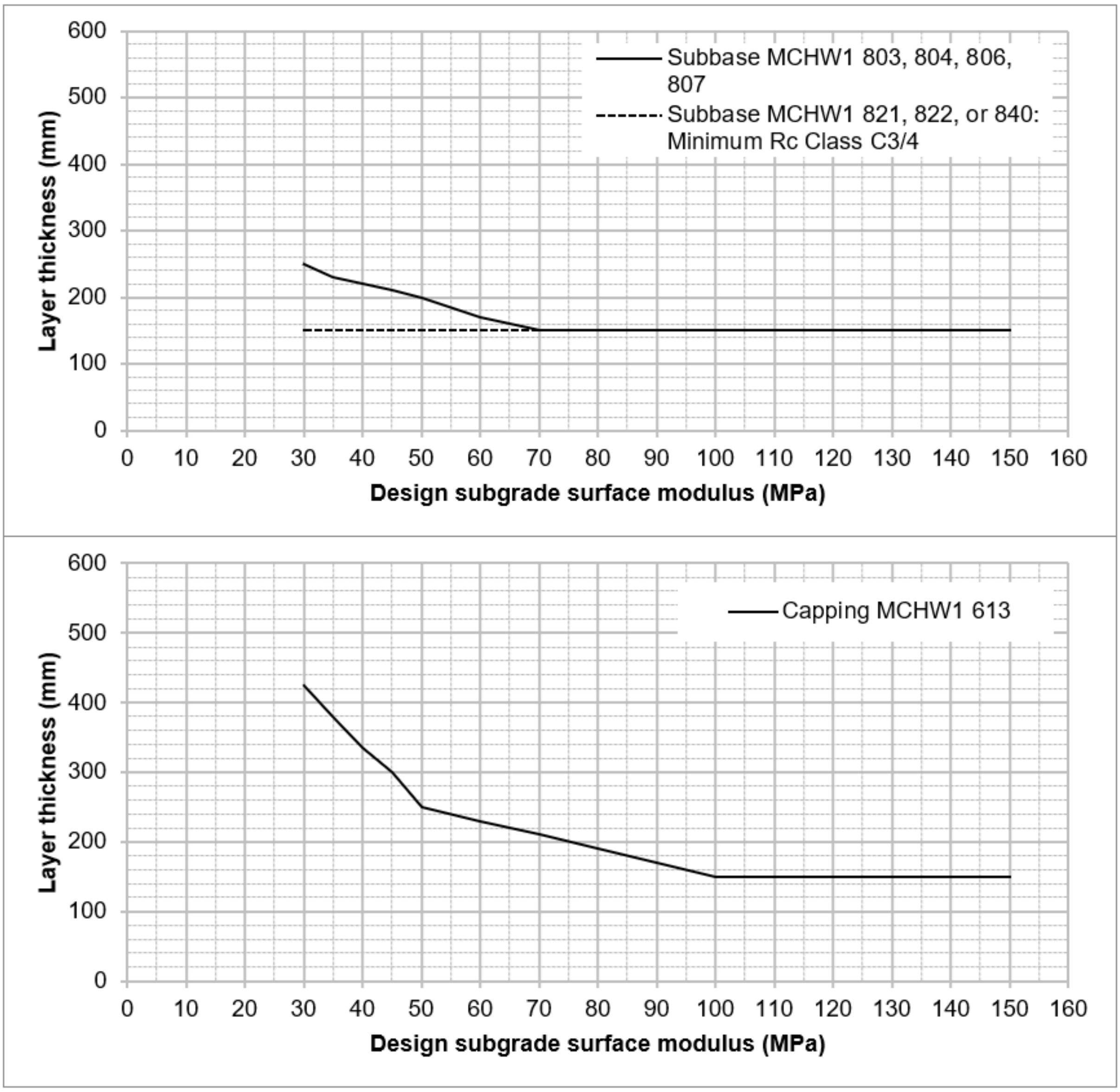

3.19 The design thickness for subbase only foundation class 3 designs shall be obtained from Figure 3.19.

**Figure 3.19 Restricted design options - class 3 subbase only**



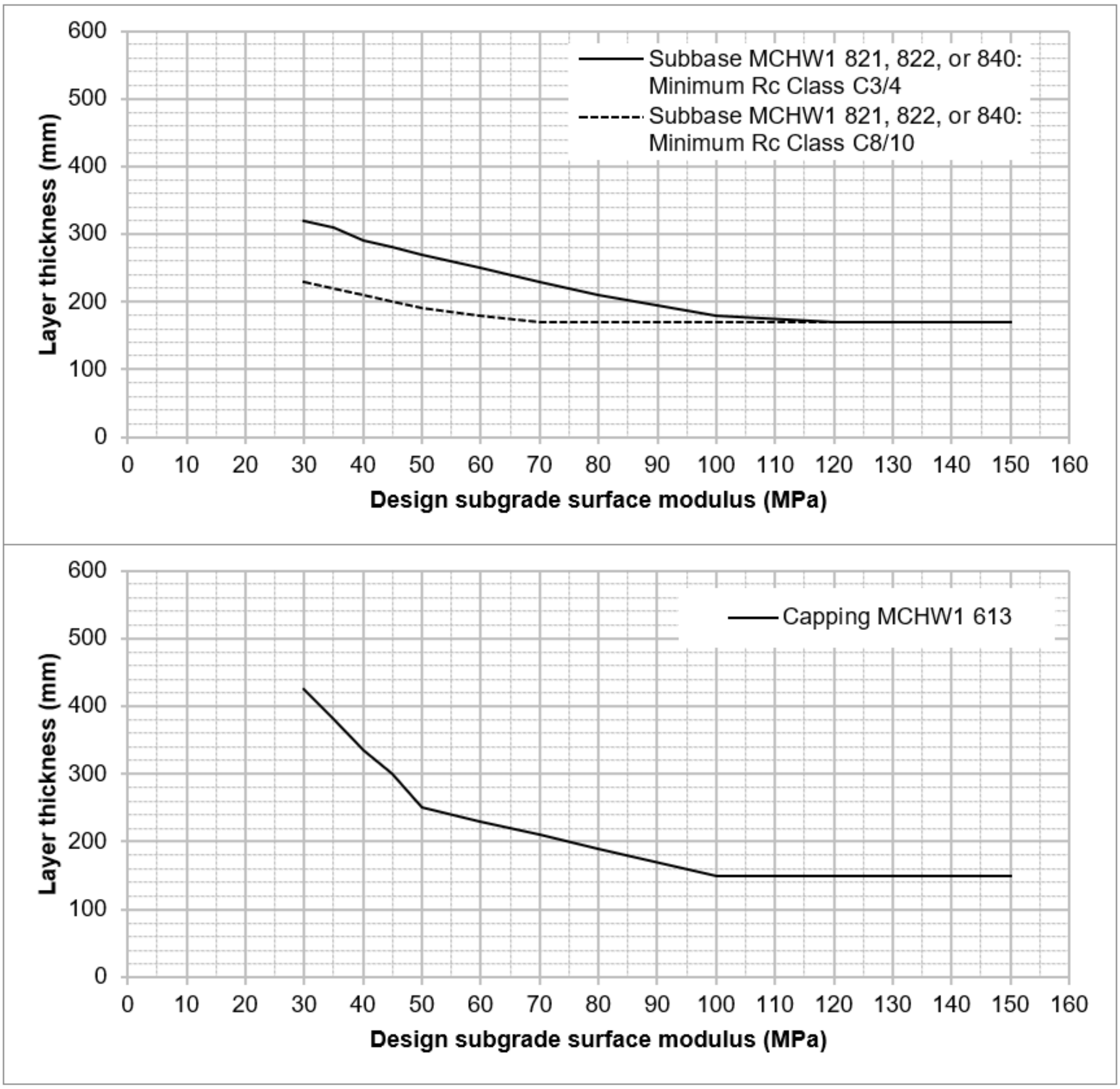

3.20 The design thicknesses for subbase on capping for foundation class 2 restricted designs shall be obtained from Figure 3.20.

**Figure 3.20 Restricted design options - class 2 subbase on capping**



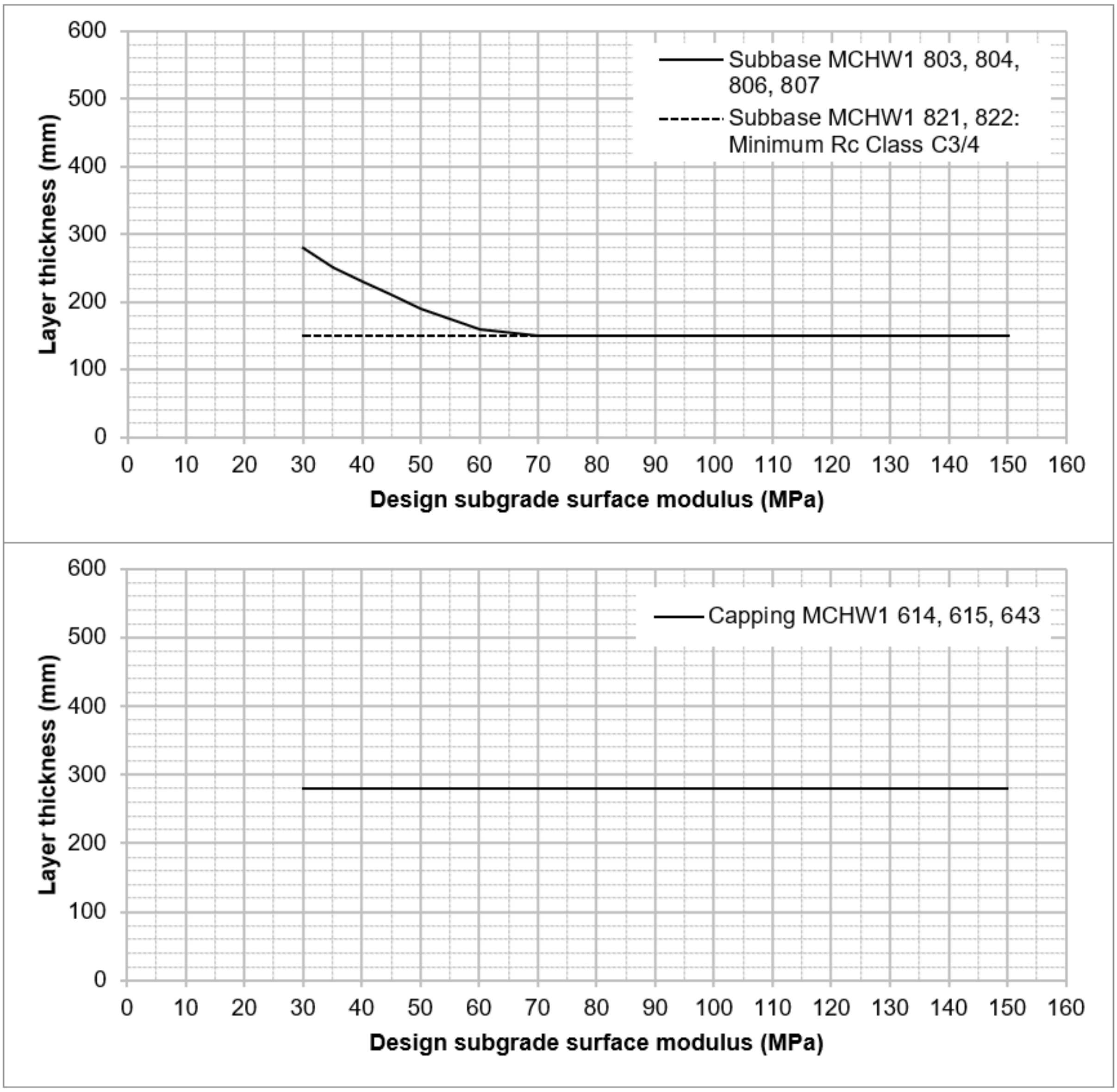

3.21 The design thicknesses for subbase on capping for foundation class 3 restricted designs shall be obtained from Figure 3.21.

**Figure 3.21 Restricted design options - class 3 subbase on capping**




3.22 The design thickness for subbase on a constant thickness of bound capping (in-situ stabilised soil as per Series 600 of the MCHW [Ref 4.N]) for foundation class 2 shall be obtained from Figure 3.22.

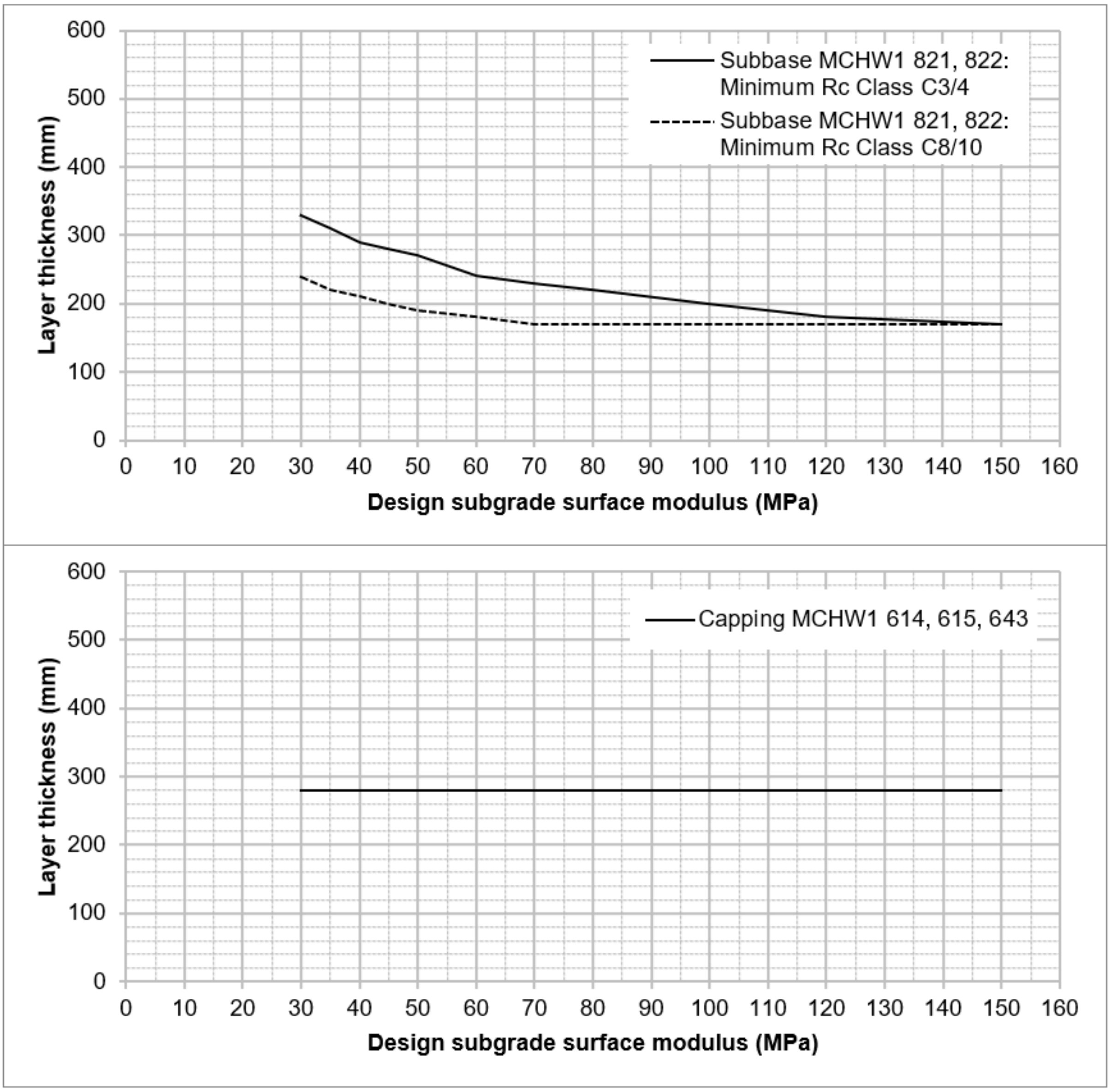
**Figure 3.22 Restricted design options - class 2 subbase on bound capping**




*NOTE* *Other constant nominal thicknesses of capping can be used via the performance foundation design approach.*

3.23 The design thickness for subbase on a constant thickness of bound capping (in-situ stabilised soil as per Series 600 of the MCHW [Ref 4.N]) for foundation class 3 shall be obtained from Figure 3.23.

**Figure 3.23 Restricted design options - class 3 subbase on bound capping**




## Performance foundation designs

### General requirements

3.24 For each foundation area and for each layer to be constructed, the following shall be detailed:

1) start and end chainage;
2) foundation class;
3) the layer stiffness; and,
4) minimum layer thicknesses.

3.25 Performance foundation designs shall be subject to performance testing in accordance with Series 800 of the MCHW [Ref 4.N].

3.26 A demonstration area to meet the requirements of the MCHW [Ref 4.N] shall confirm the performance of the foundation design.

3.27 Where the demonstration area fails to meet the requirements of the MCHW [Ref 4.N] for that foundation class, then the materials shall be modified or the foundation redesigned.

3.27.1 The foundation redesign may involve increasing foundation thickness and/or changing the materials used.

3.28 For the main works, a testing regime shall be detailed to confirm that the performance requirements of the MCHW [Ref 4.N] have been achieved.

3.29 The foundation surface modulus shall be equal to or higher than that specified in the MCHW [Ref 4.N] for the designed foundation class.

*NOTE The foundation surface modulus measured in accordance with the MCHW [Ref 4.N] is for a partially confined foundation and is not to be confused with the long-term confined foundation surface modulus values within Table 3.6.*

3.30 Where the foundation surface modulus is lower than that specified in the MCHW [Ref 4.N] for the designed foundation class, action shall be taken to either undertake improvement or review the foundation design.

*NOTE The approach for improvement is dependent on the scale of the issue and the practical options available on site.*

3.31 Where a foundation area within the main works fails to comply with the surface modulus performance measurement requirements, and the foundation is to be redesigned, the suitability of the redesigned foundation shall be confirmed with a demonstration area, specified in accordance with the MCHW [Ref 4.N].

**Layer stiffness requirements**

3.32 Capping layers shall be assigned a layer stiffness for use in the foundation design.

3.33 Subbase layers shall be assigned a layer stiffness for use in the foundation design.

3.34 The layer stiffness assigned to hydraulically bound mixtures for use in the foundation design shall be no more than 20% of the mixture's mean modulus of elasticity in compression when tested in accordance with the MCHW [Ref 4.N].

**Thickness design requirements**

3.35 The design thickness shall be derived using the layer stiffness values assigned to each layer and the procedure outlined in Section 4.

3.35.1 When the subgrade surface modulus is expected to be low at the time of construction, a capping layer should be added to provide a working platform for construction of the subsequent layers.

*NOTE Foundations built on a construction subgrade surface modulus of 50 MPa or less have a relatively high risk of structural rutting during construction if the foundation does not incorporate a capping layer.*

3.36 The design thickness derived shall either be subject to zero negative tolerance; or, to ensure that the design thickness is applied throughout the scheme, an additional thickness may be applied to the derived thickness.

3.36.1 Any additional thickness required may be limited by the capacity of the construction equipment to deliver the required design thickness consistently.

3.37 The minimum foundation thickness for class 1 and 2 foundations shall be 150 mm.

3.38 The minimum foundation thickness for class 3 foundations shall be 180 mm.

3.39 The minimum foundation thickness for class 4 foundations shall be 200 mm.

## Widening of pavement foundations

3.40 For widening, the pavement and the foundation of the existing adjacent carriageway shall be assessed to establish the material type, condition and the thickness of each layer.

*NOTE 1 The type, condition, construction thicknesses and levels of the layers in the adjacent pavement and foundation are key to the design of the widened pavement and foundation.*

*NOTE 2 This section only details the requirements for the pavement foundations.*

3.41 For widening, the design for each foundation area shall follow either a restricted or performance foundation design approach.

3.42 The foundation design for widening shall provide continuity of drainage.

*NOTE The requirement for drainage continuity can result in a thicker subbase layer than required by the foundation design.*

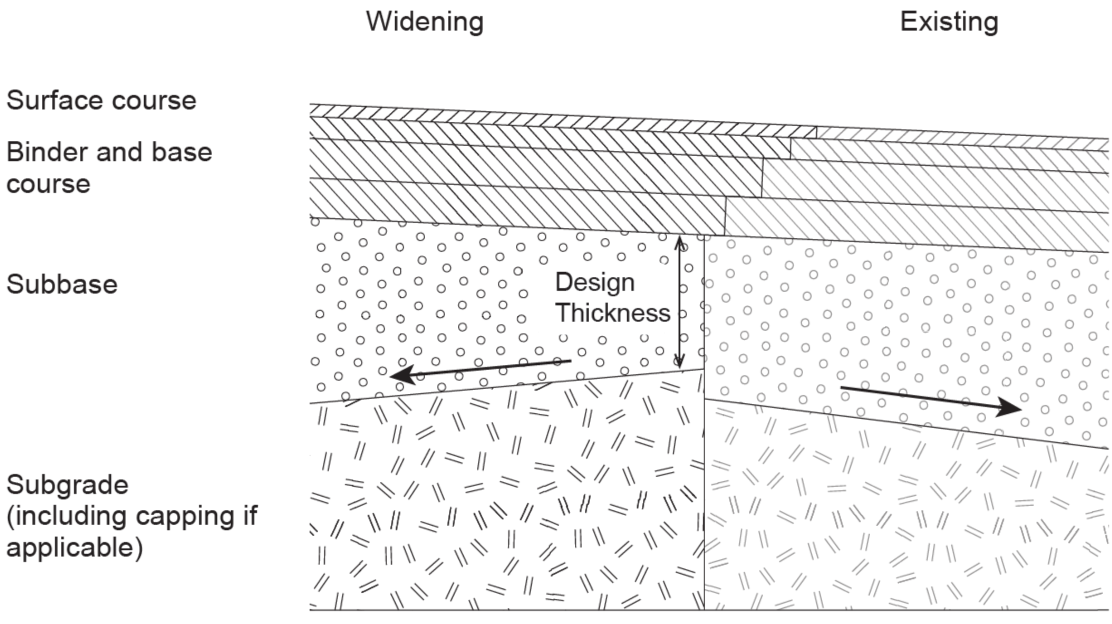
3.42.1 Continuity of drainage may be achieved by selecting appropriate:

1) materials that do not inhibit the flow of subsurface drainage through the foundation;
2) layer thicknesses;
3) crossfalls.

3.43 Edge of pavement drains shall be as detailed in pavement drainage design guidance CD 524 [Ref 2.N].

3.44 Where the existing subsurface drainage falls towards the existing pavement, the formation level within the widening shall fall in the opposite direction, away from the existing pavement, to avoid additional water contributing to the existing drainage paths (see Figure 3.44).

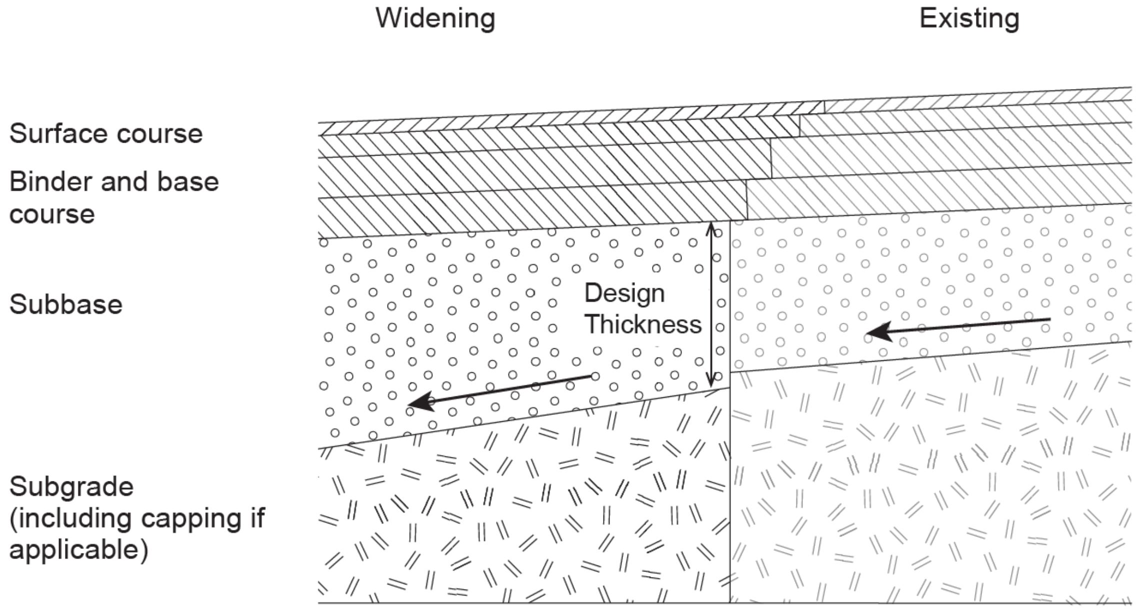
**Figure 3.44 Pavement falls towards existing carriageway**




*NOTE Additional thickness of subbase to match the existing formation level in this scenario is not required. However, there can be practical construction benefits to doing so.*

3.45 Where the existing subsurface drainage falls towards the widening, the formation level within the widening shall either match or be lower than the existing formation level (refer to Figure 3.45, for example).

**Figure 3.45 Pavement falls away from existing carriageway**



# 4. Procedure for performance foundation designs

4.1 Performance foundation design thicknesses shall be derived analytically using multi-layer linear elastic analysis.

4.1.1 Design charts for a range of layer stiffness and foundation class scenarios are contained within Appendix A and may be used to establish a performance foundation design thickness.

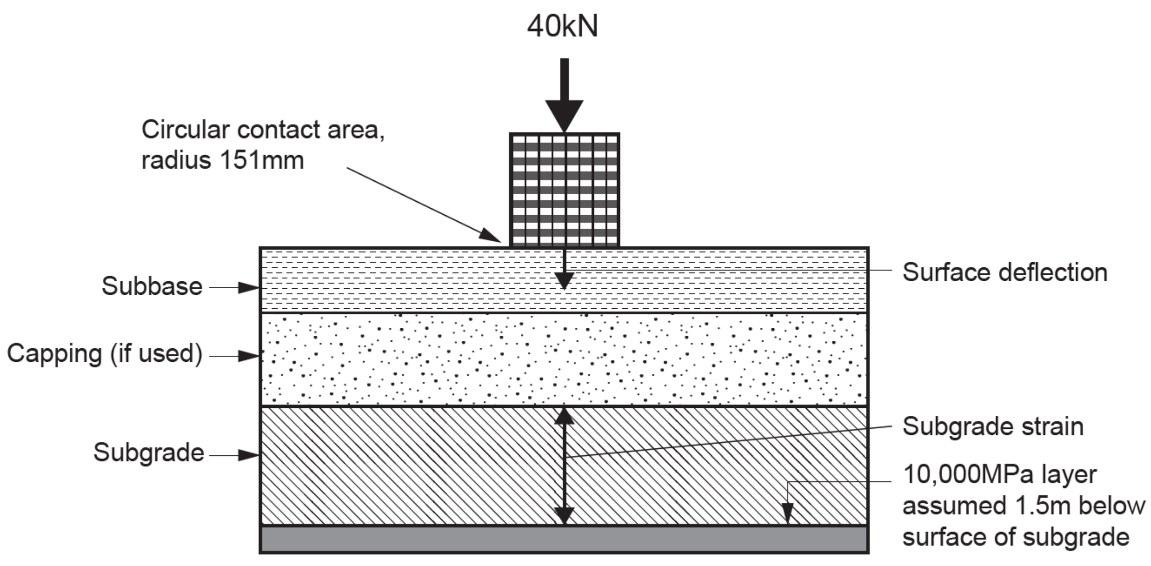
4.2 Performance design criteria of subgrade strain and surface deflection shall be as detailed in this section.

*NOTE 1 Protection of the subgrade during construction (short-term) is based on the vertical compressive strain in the top of the subgrade. The structural response is limited so that excessive deformation does not occur.*

*NOTE 2 Support for the pavement during its design life is defined by calculating the deflection of the foundation under the action of a wheel load at the top of foundation level, shown in Figure 4.3. The deflection under a given load can be equated to a surface modulus for the foundation as a whole.*

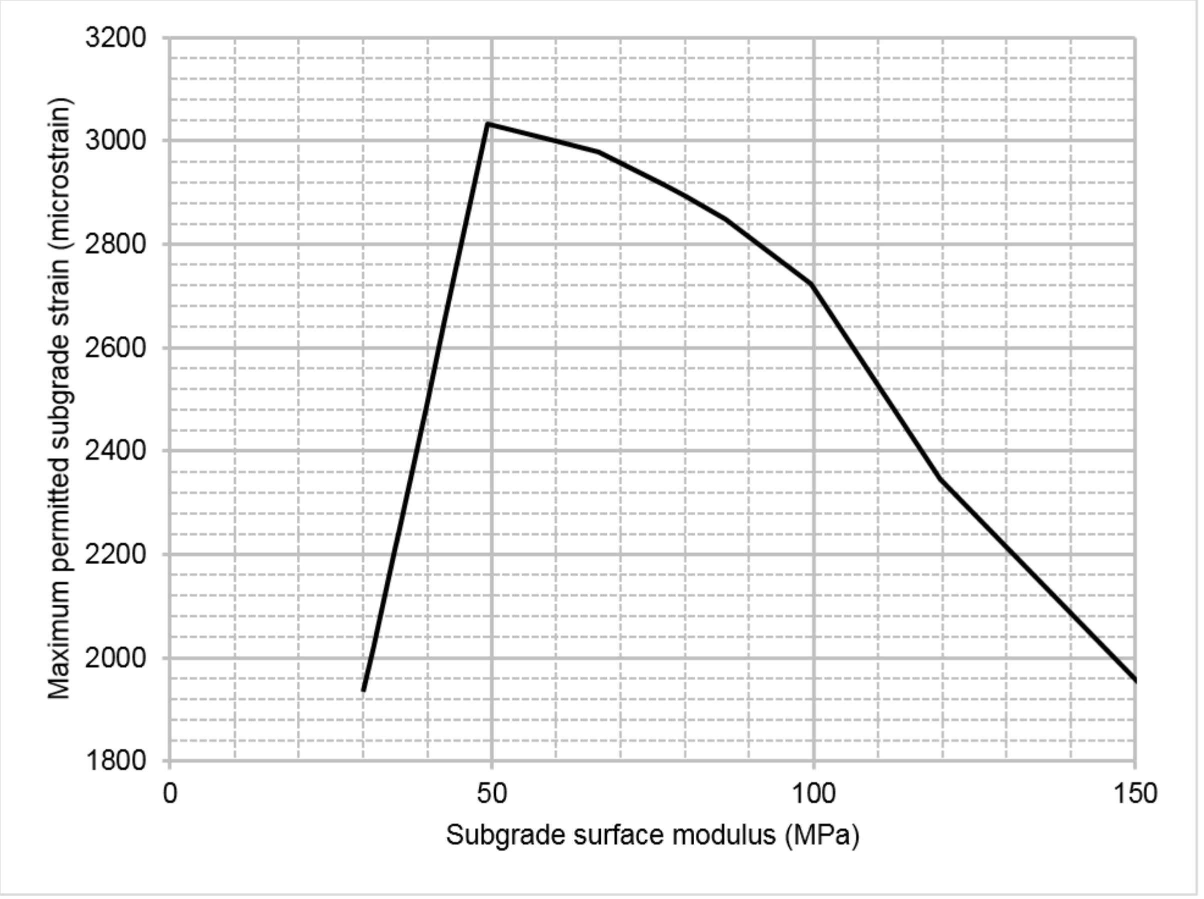
4.3 The vertical strain in the subgrade shall be calculated under the action of a standard 40 kN wheel load travelling at the top of foundation level, refer to Figure 4.3.

**Figure 4.3 Input parameters for performance foundation designs**




4.4 The vertical strain in the subgrade for the corresponding subgrade surface modulus value shall not exceed the limits as shown in Figure 4.4.

**Figure 4.4 Subgrade strain limits for performance foundation designs**




NOTE *Based on the principles presented by LR1132 [Ref 13.I], these limits assume that the foundation carries up to 1000 standard axles of traffic with no more than 40 mm deformation at the top of subbase.*

4.4.1 Trafficking at lower levels may be permitted provided the deformation limits given in the performance specification are not exceeded.

4.5 The deflection of the foundation shall be calculated under the action of a standard wheel load (40 kN load over a 151 mm radius loaded area).

4.6 The maximum deflection of the foundation for each foundation class under a standard wheel load (40 kN load over a 151 mm radius loaded area) shall be:

1) Foundation class 1 - 2.96 mm;
2) Foundation class 2 - 1.48 mm;
3) Foundation class 3 - 0.74 mm;
4) Foundation class 4 - 0.37 mm.

NOTE *These limits are based primarily on the criteria used in LR1132 [Ref 13.I] but adjusted for reasons given in PPR 127 [Ref 6.I].*

4.7 The Poisson's Ratio value used in the design for subbase materials shall be 0.35.

4.8 The Poisson's Ratio value used in the design for subgrade materials including capping and the 10,000 MPa layer assumed 1.5 m below the surface of the subgrade shall be 0.45.

# 5. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. CD 226, 'Design for new pavement construction' |
| Ref 2.N | Highways England. CD 524, 'Edge of pavement details' |
| Ref 3.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 4.N | Highways England. MCHW, 'Manual of Contract Documents for Highway Works' |

# 6. Informative references

The following documents are informative references for this document and provide supporting information.


| | |
|---|---|
| Ref 1.I | BSI. BS EN ISO 4787, 'Laboratory glassware. Volumetric instruments. Methods for testing of capacity and for use' |
| Ref 2.I | BSI. BS 1377-5, 'Methods of test for soils for civil engineering purposes. Compressibility, permeability and durability tests' |
| Ref 3.I | BSI. BS 1377-6, 'Methods of test for soils for civil engineering purposes. Consolidation and permeability tests in hydraulic cells and with pore pressure measurement' |
| Ref 4.I | BSI. BS 1377-4, 'Methods of test for soils for civil engineering purposes. Part 4. Compaction related tests' |
| Ref 5.I | BSI. BS 5835-1, 'Recommendations for testing of aggregates. Compactibility test for graded aggregates' |
| Ref 6.I | TRL Ltd. Chaddock, B & Roberts, C. PPR 127, 'Road foundation design for major UK highways' |
| Ref 7.I | National Physical Laboratory. Kaye GWC & Laby TH. Kaye & Laby , 'Tables of physical and chemical constants and some mathematical functions' |
| Ref 8.I | BSI. BS EN 932-6, 'Tests for general properties of aggregates. Definitions of repeatability and reproducibility' |
| Ref 9.I | BSI. BS EN 932-1, 'Tests for general properties of aggregates. Methods for sampling' |
| Ref 10.I | BSI. BS EN 1097-3, 'Tests for mechanical and physical properties of aggregates. Determination of loose bulk density and voids' |
| Ref 11.I | BSI. BS EN 1097-6, 'Tests for mechanical and physical properties of aggregates. Determination of particle density and water absorption' |
| Ref 12.I | BSI. BS EN 1097-5, 'Tests for mechanical and physical properties of aggregates. Determination of the water content by drying in a ventilated oven' |
| Ref 13.I | TRL. Powell, WD, Potter, JF, Mayhew, HC & Nunn, ME. LR1132, 'The structural design of bituminous roads' |
| Ref 14.I | ASCE Journal of the Hydraulics Division, Vol 93, pp 137-148. Dudgeon, CR. ASCE Proc Paper 5433, 'Wall effects in permeameters' |

# Appendix A. Example performance foundation design charts

Design thicknesses using the procedure in Section 4 have been generated at 5 MPa increments between 30 MPa and 50 MPa and at 10 mm increments between 50 MPa and 150 MPa and have been rounded up to the nearest 10 mm.

**Table A.1 Performance related design curves**

| Figure | Foundation class | Construction type | Layer stiffness (MPa) |
|---|---|---|---|
| A.1 | 1 | Single layer | 50, 75 |
| A.2 | 2 | Single layer | 120, 150, 350 |
| A.3 | 3 | Single layer | 350, 500, 1000 |
| A.4 | 4 | Single layer | 1000, 2000, 4000 |
| A.5 | 2 | Subbase on capping | Capping – 75<br>Subbase – 120, 150, 350 |
| A.6 | 3 | Subbase on capping | Capping – 75<br>Subbase – 350, 500, 1000 |
| A.7 | 4 | Subbase on capping | Capping – 75<br>Subbase – 1000, 2000, 4000 |

**Figure A.1 Performance design options - class 1 single foundation layer**

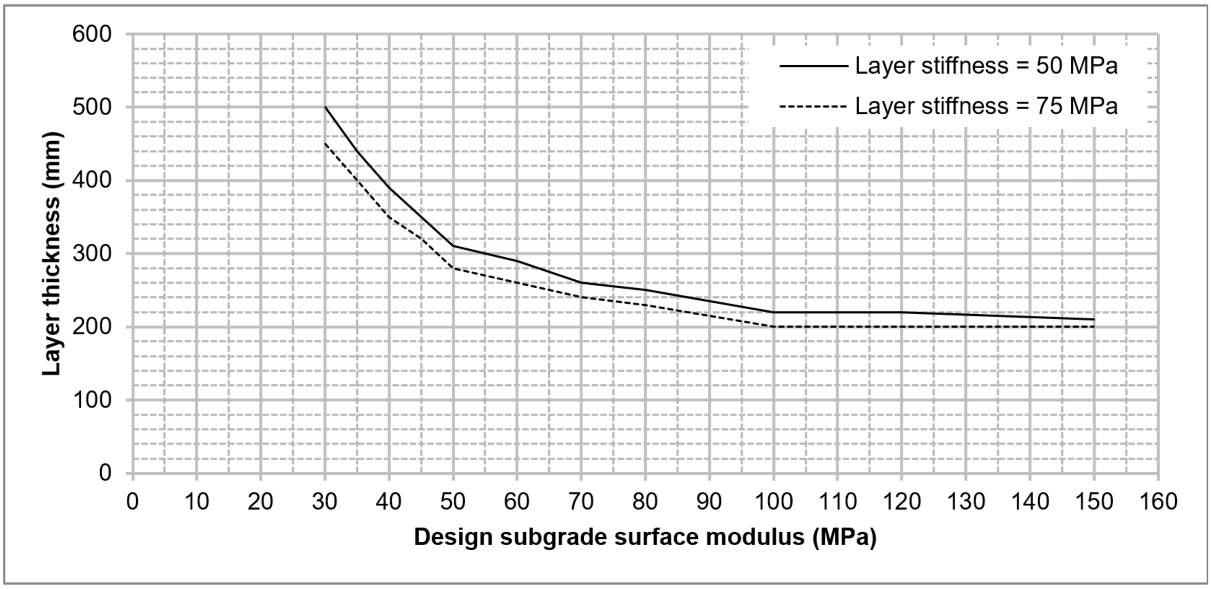


**Figure A.2 Performance design options - class 2 single foundation layer**

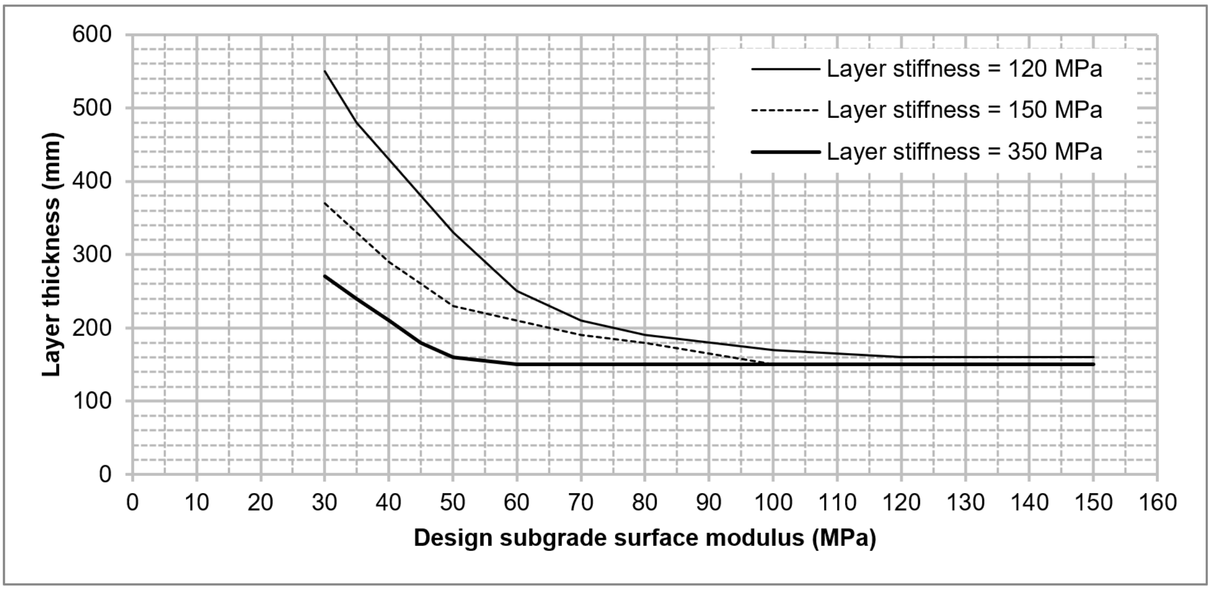



**Figure A.3 Performance design options - class 3 single foundation layer**

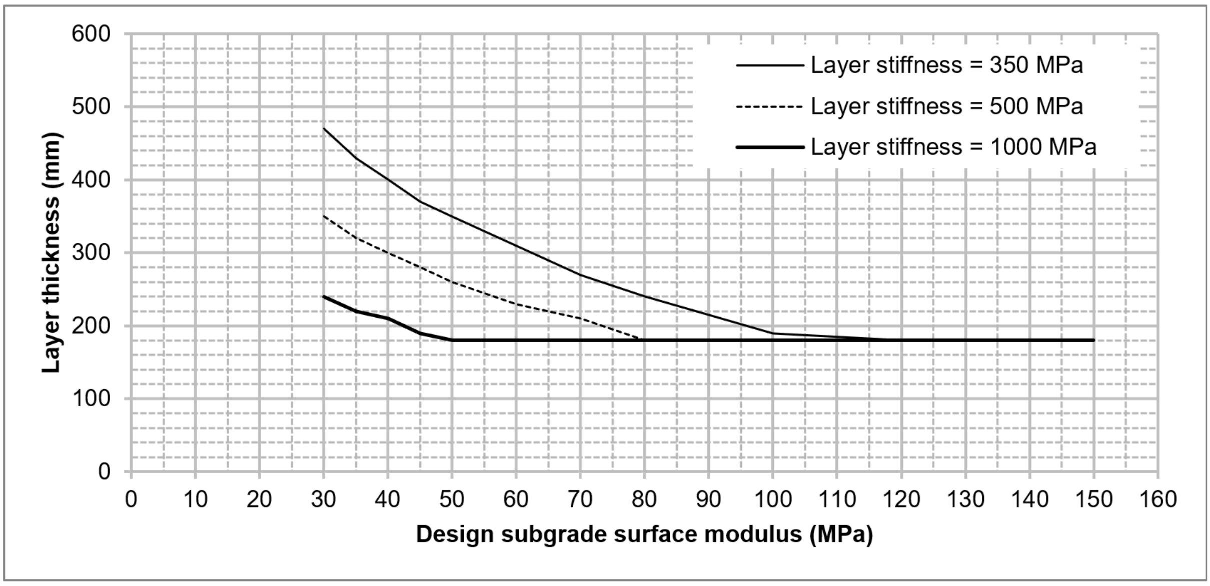


**Figure A.4 Performance design options - class 4 single foundation layer**

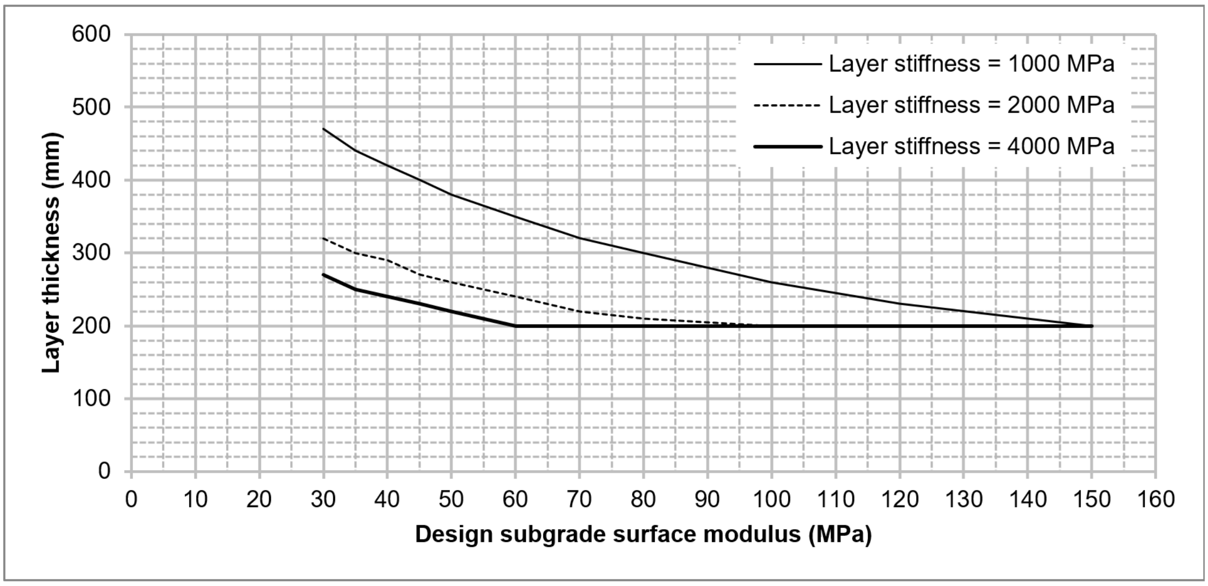


**Figure A.5 Performance design options - class 2 subbase on capping**

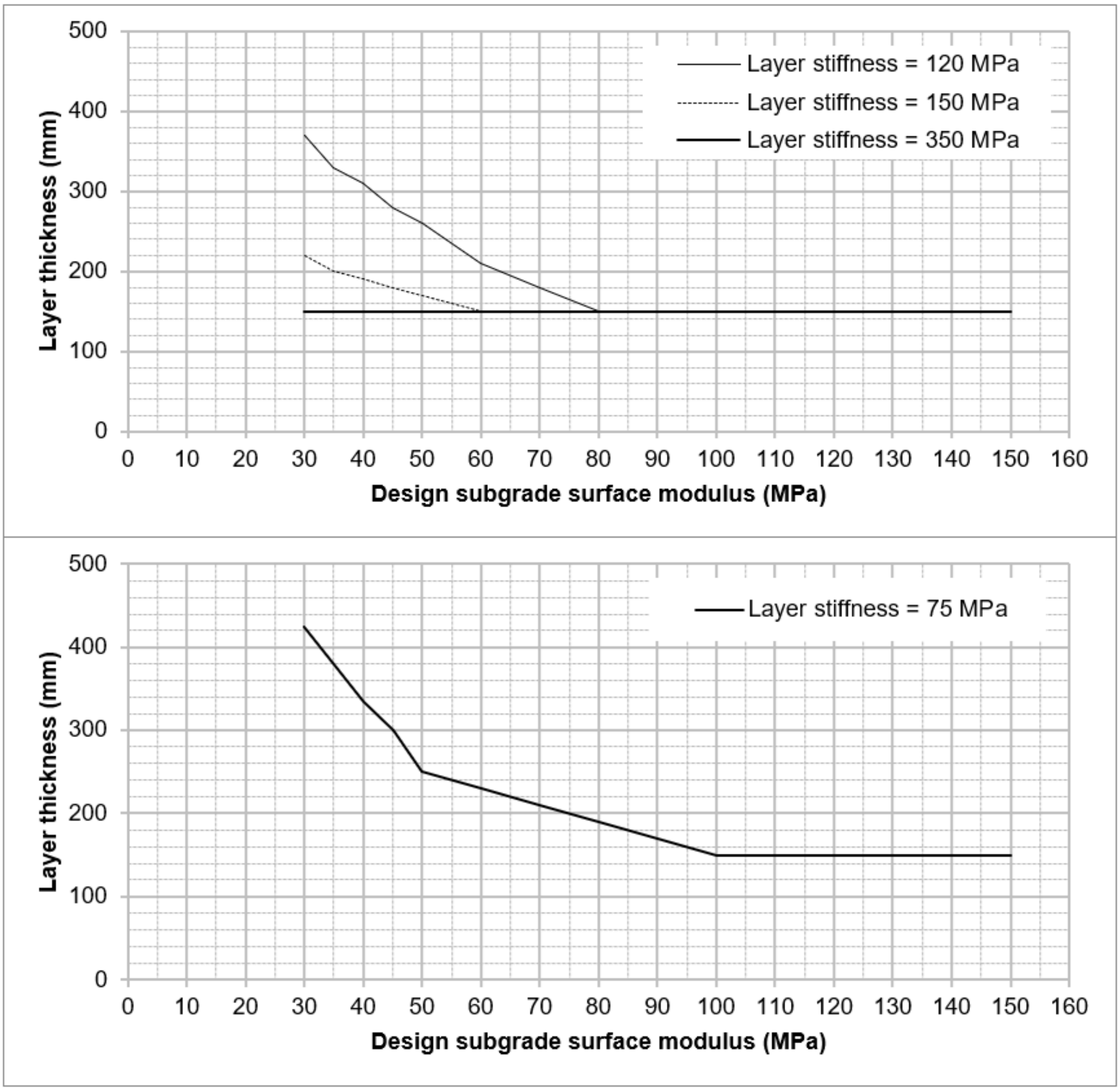


**Figure A.6 Performance design options - class 3 subbase on capping**

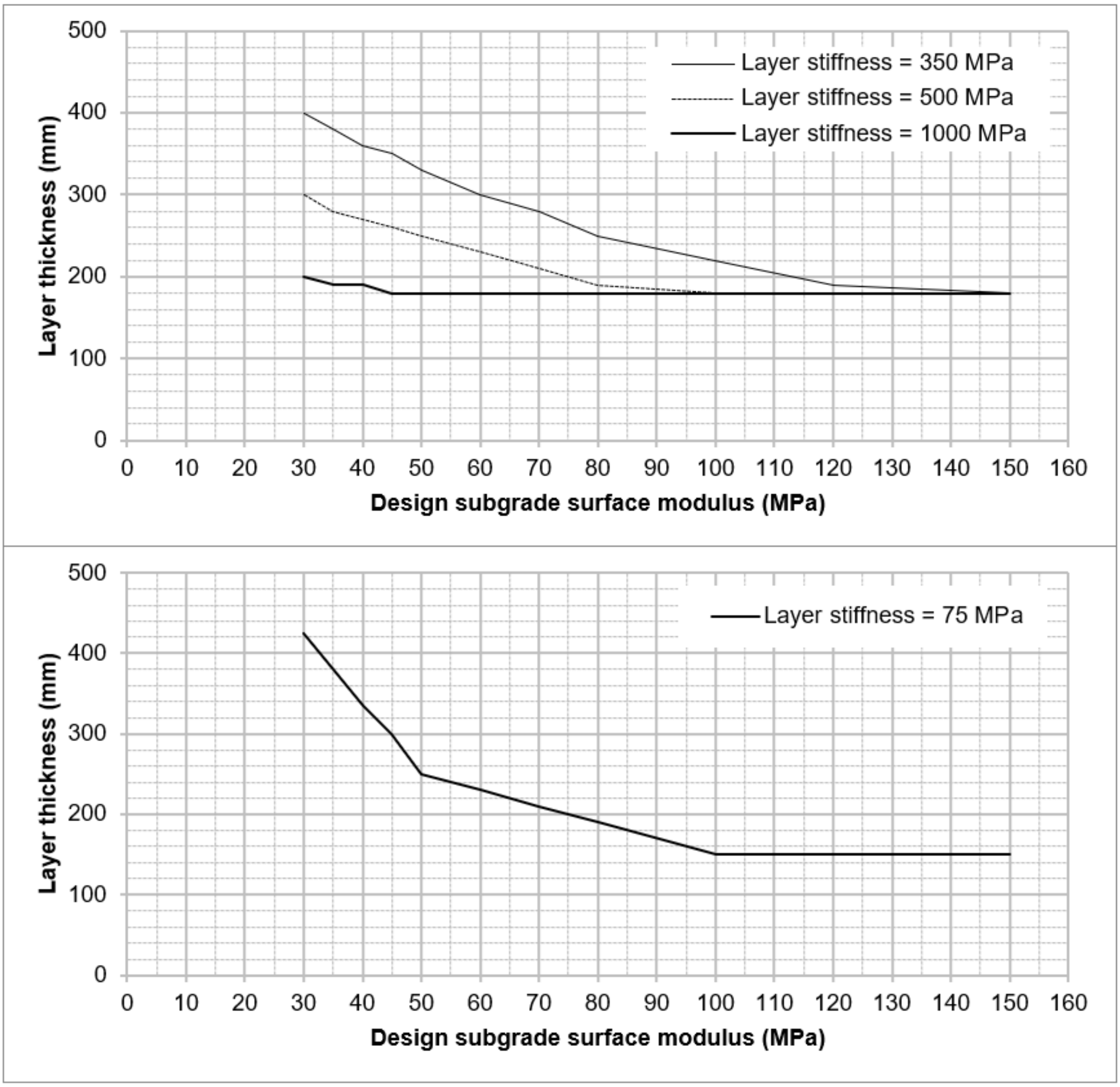
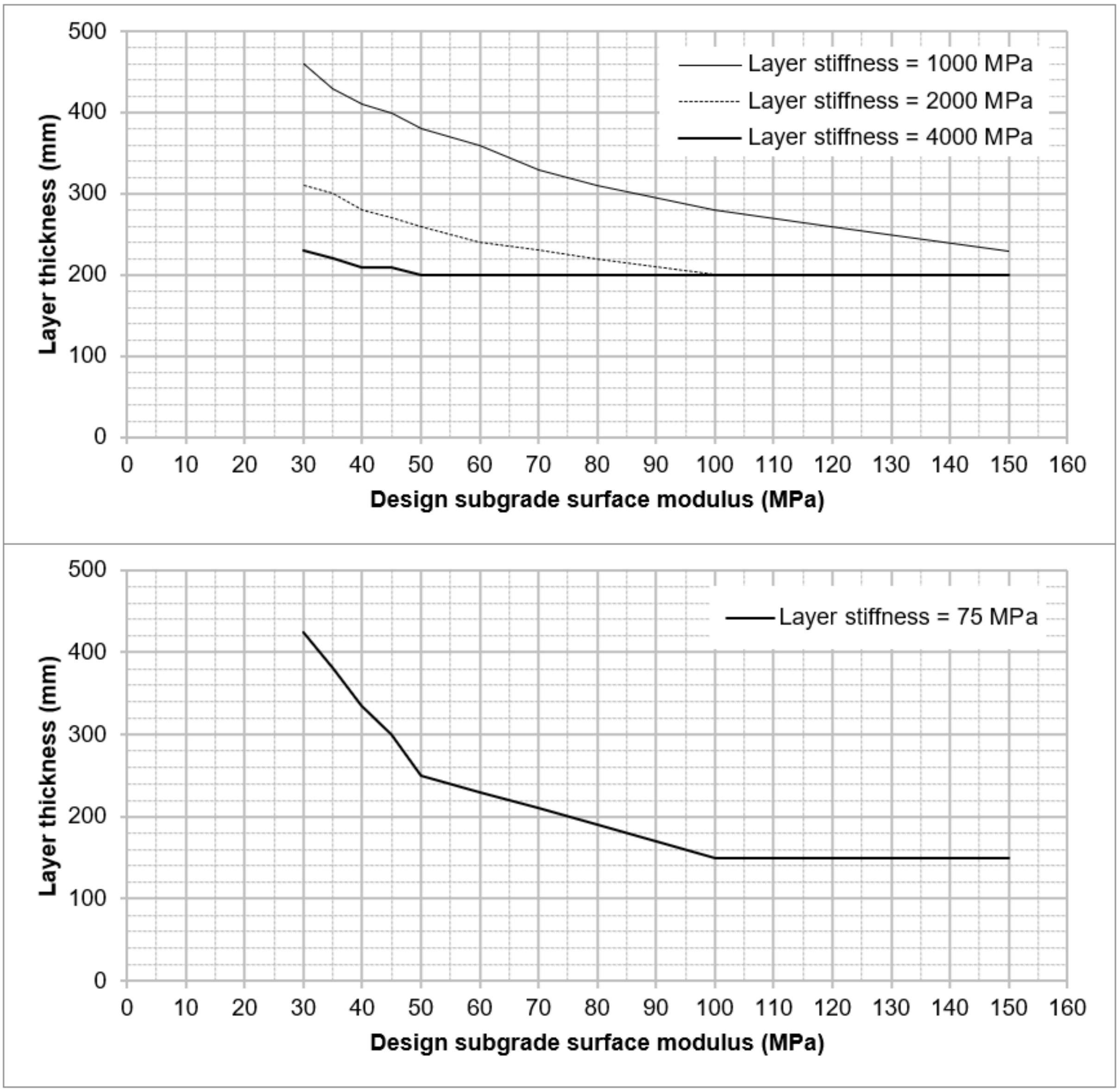


**Figure A.7 Performance design options - class 4 subbase on capping**



# Appendix B. Worked examples

## B1 Example 1 – Restricted foundation design procedure

Design factors:

1) long-term subgrade surface modulus = 35 MPa; and,
2) short-term subgrade surface modulus = 60 MPa.

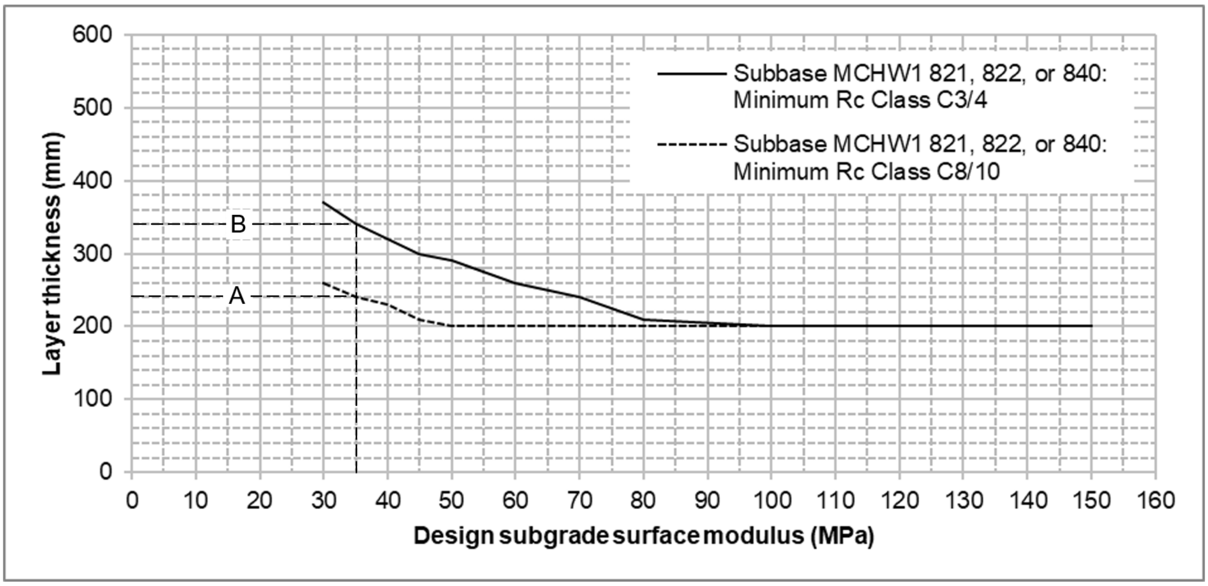
Design subgrade surface modulus = 35 MPa.

Using Figure B.1 (replica of Figure 3.19) to design a class 3 restricted subbase only foundation:

A) 240 mm MCHW 821, 822 or 840 $R_c$ Class 8/10; or,

B) 340 mm MCHW 821, 822 or 840 $R_c$ Class 3/4.

**Figure B.1 Example 1**




## B2 Example 2 – Performance foundation design procedure

Design factors:

1) long-term subgrade surface modulus = 35 MPa;
2) short-term subgrade surface modulus = 60 MPa; and,
3) mean modulus of elasticity in compression ($E_c$) of material = 3500 MPa.

Design subgrade surface modulus = 35 MPa.

For layer stiffness take 20% $E_c$ of material, therefore layer stiffness = 700 MPa.

Using the procedure in Section 4 to design a class 3 performance single layer foundation:

260 mm of 700 MPa subbase

## B3 Example 3 – Restricted foundation design procedure for widening

Design factors:

1) long-term subgrade surface modulus = 40 MPa;

2) short-term subgrade surface modulus = 30 MPa;
3) existing adjacent pavement unbound;
4) existing pavement falls towards proposed widening;
5) existing asphalt approximately 380 mm thick, widening to match this thickness; and,
6) existing subbase approximately 160 mm thick.

Design subgrade surface modulus = 30 MPa.

Short-term subgrade surface modulus <50 MPa, capping layer required.

Formation level to match or be lower than formation under existing adjacent pavement.

Unbound materials required to ensure drainage is not inhibited.

Using Figure B.2 (replica of Figure 3.20) to design a class 2 restricted capping and subbase foundation:

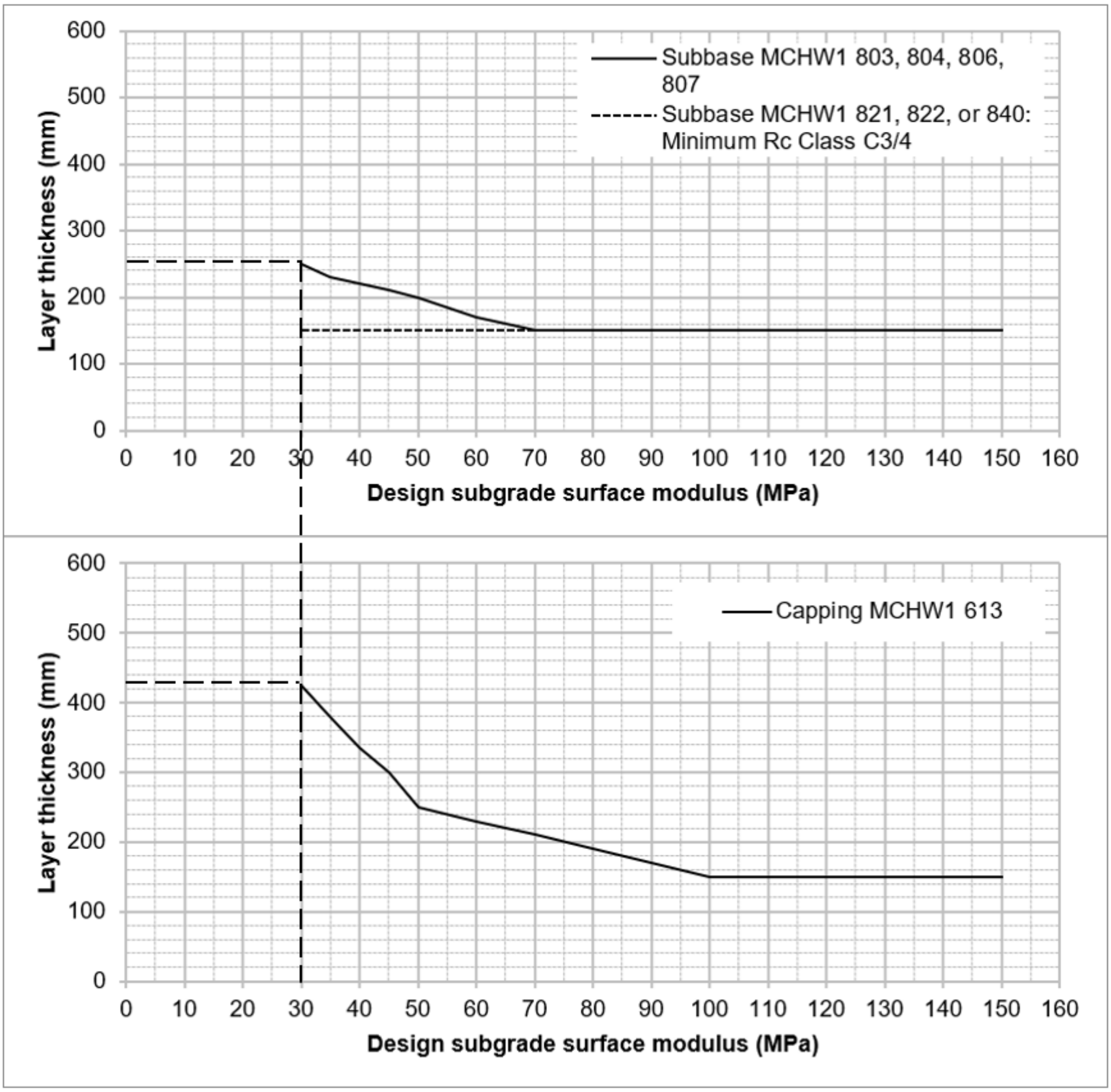
250 mm MCHW1 803, 804, 806 807 subbase

On

430 mm MCHW 613 capping

Formation level of widening lower than adjacent pavement formation so additional thickness not required.

**Figure B.2 Example 3**




## B4 Example 4 – Performance foundation design procedure

Design factors:

1) long-term subgrade surface modulus = 40 MPa; and,
2) short-term subgrade surface modulus = 30 MPa.

Design subgrade surface modulus = 30 MPa.

Short-term subgrade surface modulus <50 MPa, capping layer specified.

Using the procedure in Section 4 and 75 MPa layer stiffness for capping and 150 MPa layer stiffness for subbase, to design a class 2 performance multi-layer foundation:

214 mm of 150 MPa subbase

on

430 mm of 75 MPa capping

# Appendix C. A permeameter for road drainage layers

## C1 Overview

### C1.1 Introduction

Appendix C describes a box-type permeameter that can be used for testing the horizontal permeability of road drainage layers.

It describes the apparatus and sets out the test procedure.

### C1.2 Scope

The test can be used to determine the horizontal permeability of embankment drainage layers, capping materials and subbases and can be used to supplement the information required by Clause 640 of the MCHW [Ref 4.N].

It is used where, subject to limitations set out below, particle sizes within the granular specimens exceed those that can be tested using methods described in BS 1377-5 [Ref 2.I] and BS 1377-6 [Ref 3.I].

Whilst the apparatus and test methods are currently the best available, as with any test procedure, there are limitations on reproducibility and repeatability. The test can only be applied to conditions of laminar flow and not to situations where high hydraulic gradients and turbulent flow might occur in practice.

### C1.3 Background

Granular layers can be used to provide drainage of pavement layers beneath roads and for the relief of pore pressures within embankments. These layers need to exhibit both adequate drainage and load bearing properties. There is a conflict in that a well graded material is needed for load bearing but this is detrimental to the drainage properties.

The selection of coarse materials for use as drainage layers is usually achieved by the specification of a grading envelope. Large variations in permeability within these grading envelopes have been noted. Where there is a need to specify the permeability of such layers (e.g. according to Clause 640 of the MCHW [Ref 4.N]) the test described in Appendix C provides a mean to determine the horizontal permeability of drainage, subbase and capping materials in their compacted states.

## C2 Apparatus

### C2.1 Introduction

The permeameter consists of a steel box capable of accepting a sample of size approximately 1.0 m x 0.3 m x 0.3 m (Figure C.1). The sample is retained by a grid at either end of the box. The aperture size of the grids depends on the grading of the material, so that the particles are supported without impeding the flow. Experience has shown that an aperture size of 1-2 mm is satisfactory for the materials likely to be tested.

**Figure C.1 Schematic diagram of apparatus**

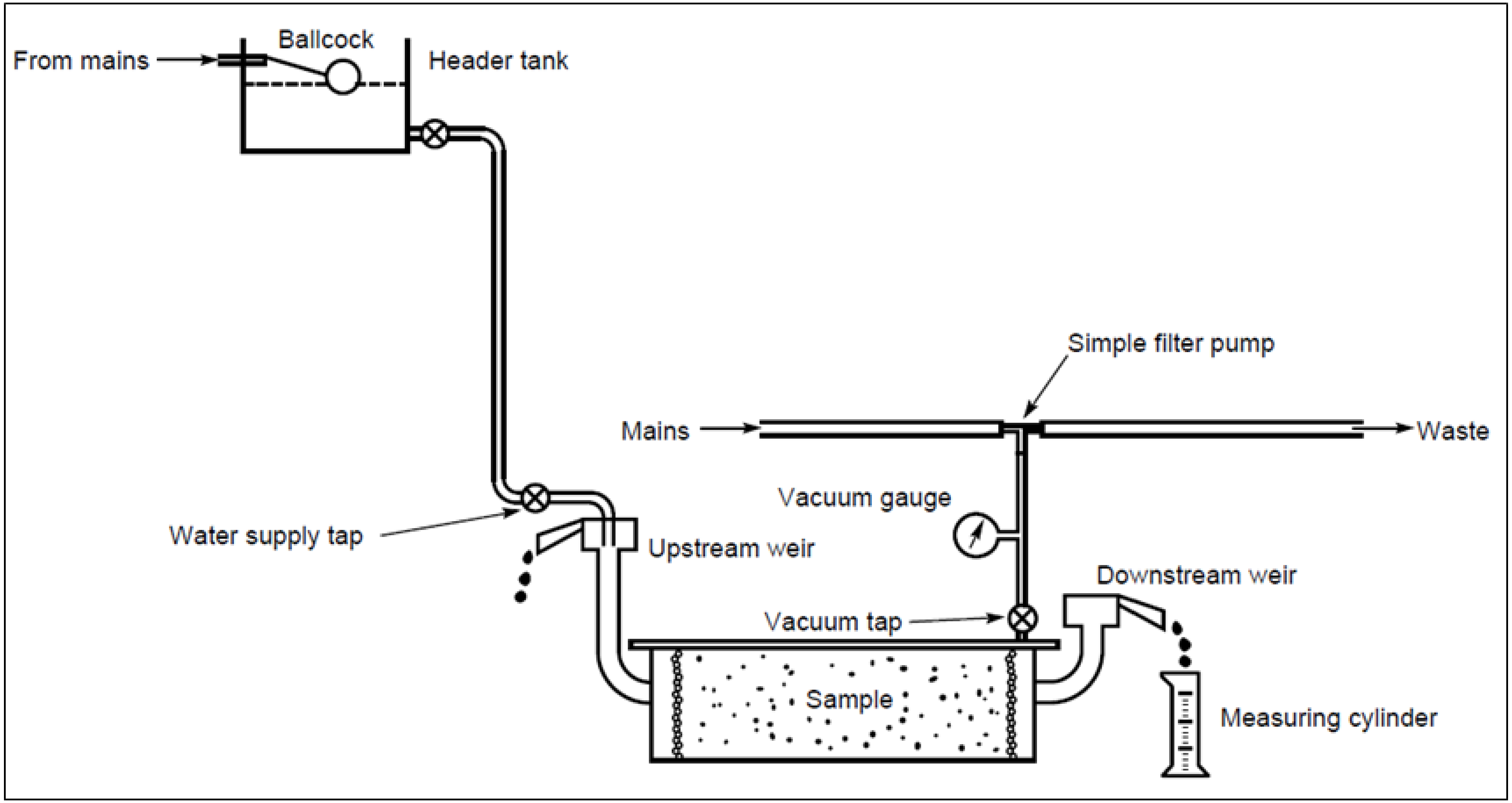


**Figure C.2 Test box typical details**

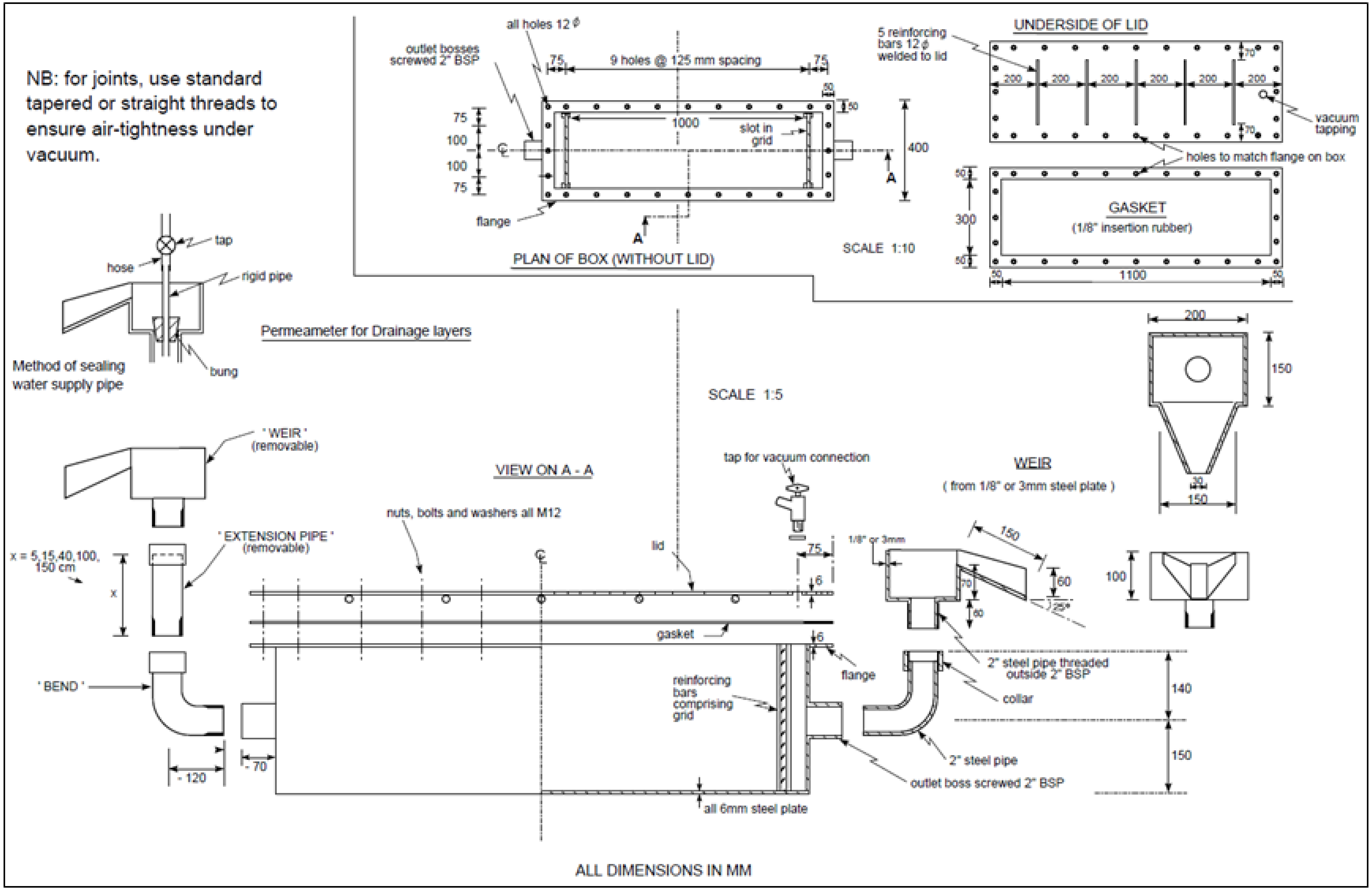
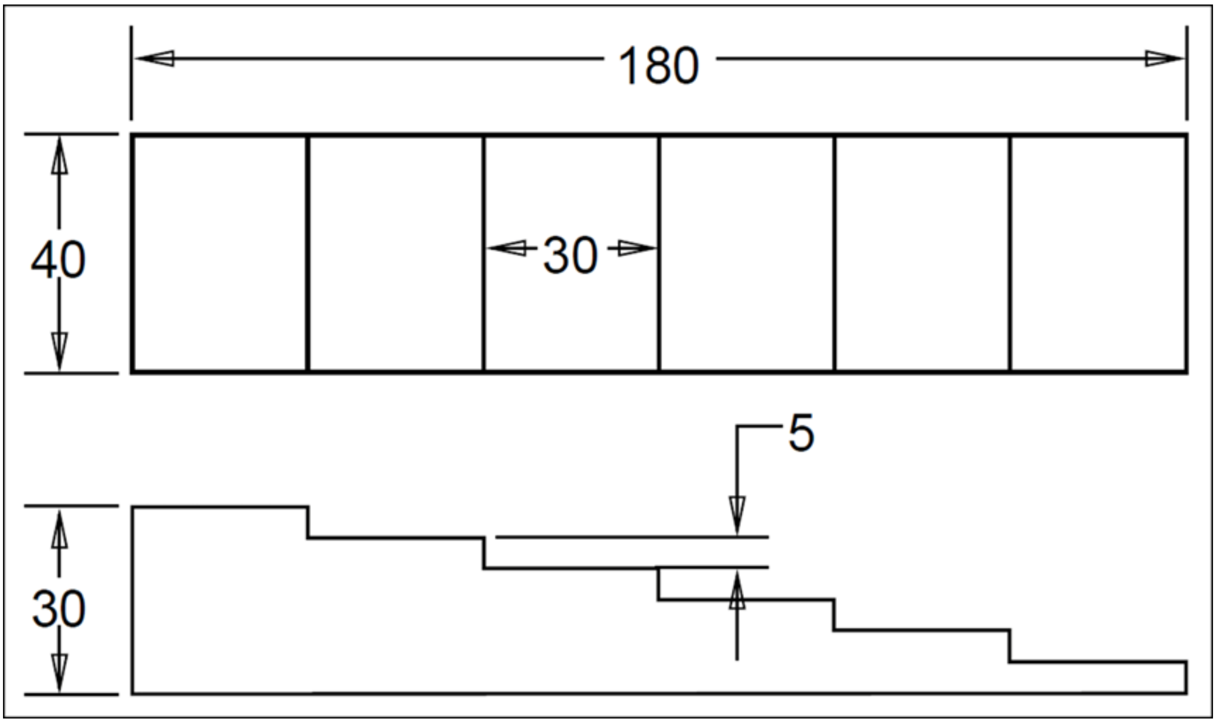


**Figure C.3 Stepped wedge suggested dimensions (mm)**




**C2.2 Apparatus required**

1) A test box as described in C2.1 and as shown in the drawing (Figure C.2) with associated extension pipes and weirs. All dimensions are suggested dimensions, hence no manufacturing tolerances are indicated.
2) A jack and suitable stepped wedges (Figure C.3) to incline the permeameter and thus achieve small differences in head.
3) About 250 kg of the material to be tested, which has been sampled in an approved manner according to BS EN 932-1 [Ref 9.I].
4) An electric vibrating hammer as called for in BS 1377-4 [Ref 4.I], Clause 3.7, but fitted with a square tamping foot of approx. 125 mm side.
5) A layer of sealed cell (impermeable) foam, such as a 12 mm non-intercellular neoprene foam sheet (NINS).
6) A simple, laboratory type filter pump, to fit a 12 mm hose from the mains water supply and an (approx.) 7 mm, see-through suction hose connected to the vacuum tap in the lid of the box via a vacuum gauge. The vacuum gauge to be calibrated and readable to 20 mm of mercury or the equivalent, or better.
7) Two rubber bungs to fit the holes in the base of each weir. One to be intact, the other to have a piece of rigid pipe (at least 7 mm internal diameter) pushed through it such that the bung forms a seal on the outside of the pipe. With the bung plugging the weir, the water supply hose is sealed to the exposed end of the pipe.
8) A supply of settled water consisting of mains water being supplied via a ballcock to a header tank of at least 150 litre capacity. Water is supplied to the pipe/bung assembly by a hose, with valves at both the tank outlet and the bottom of the hose. The lower valve is referred to as the water supply tap. [Note: For tests at low hydraulic gradients, requiring smaller volumes of water, the use of de-aired water, instead of settled water, may be used].
9) Some pipe jointing compound, and pipe wrenches.

10) Manometers and scale. The manometers to be mounted on a board behind the apparatus to measure the water levels in the two weirs by means of flexible PVC tubing submerged in each weir away from the circular hole in the base of the weir. (An inclined manometer board is useful for measuring small differences in head).
11) A spirit level.
12) A metre rule with scale divisions every 0.5 mm.
13) A stopwatch, calibrated to within 1 s in 5 min.
14) A one litre measuring cylinder, graduated every 10 ml, calibrated by weighing the amount of distilled water that it contains at a measured temperature using a calibrated balance and applying the tables in BS EN ISO 4787 [Ref 1.I].
15) A thermometer, readable to 0.1°C, calibrated against a reference standard before using.
16) Facilities for determination of water content to BS EN 1097-5 and relative density according to BS EN 1097-6 [Ref 11.I].

## C3 Method of test for horizontal permeability of drainage layers

### C3.1 General

This method is suitable for testing materials having median ($d_{50}$) particle size up to 30 mm. When compacting in layers, the layer thickness needs to be chosen in relation to the maximum particle size ($d_{100}$). During testing, a differential head of water is maintained across the sample by an upstream and downstream weir. This can be achieved by varying the pipe heights or by lifting the permeameter at one end. The coefficient of permeability is obtained according to Darcy's Law by measuring the steady-state flow through the sample.

It is recommended that at least two test runs (each on a different sample) are carried out, each sample being tested at a range of head differences (minimum of 3).

In order to ensure complete saturation of the sample, a vacuum is applied to the box and maintained whilst slowly filling with water.

### C3.2 Procedure

#### C3.2.1 Preparation

1) The box should be placed on a firm, horizontal surface allowing water to be collected or run to waste at either end.
2) The material should be weighed before it is compacted into the box to find its mass.
3) Compact the material in 3, 4 or 5 layers (depending on maximum particle size) into the central part of the box between the two end grids. Each layer should be compacted to the density expected on site at the optimum water content determined from BS 1377-4 [Ref 4.I] Clause 3.7 or from BS 5835-1 [Ref 5.I].
4) Take a sample of the remaining material for water content (w) determinations according to BS EN 1097-5 [Ref 12.I], loose bulk density according to BS EN 1097-3 [Ref 10.I] and relative density $G_{sa}$ determination according to BS EN 1097-6 [Ref 11.I].
5) Measure the dimensions of the sample, i.e. length (L), width (W) and depth (D) to an accuracy of ± 0.5 mm.
6) Fit appropriate extension pipes and weirs at either end to give a suitable head difference of 30 to 40 mm across the sample. Ensure that all joints are well tightened as they should be capable of holding a vacuum (use pipe jointing compound and PTFE tape where appropriate).
7) Place a piece of sealed cell foam of appropriate size on top of the sample.
8) Fit the gasket and then the lid on to the box (the vacuum tap can be at either end of the box) and tighten all nuts and bolts, forcing the bars on the lid down into the foam sheet and ensuring a good seal across the top of the sample and also between the lid and the flange.

9) Connect the water supply from the storage tank to the bung fitted to the weir furthest from the suction tapping. Fit the plain bung in the other weir. Leave the water supply tap closed.
10) Open the vacuum tap and lift that end of the box slightly. Apply a vacuum using the filter pump. Tighten the bolts on the lid while the box is under vacuum.
11) When a vacuum of at least 7 m water (508 mm Hg) and preferably around 9.5 m water (699 mm Hg) below atmospheric has been achieved, open the water supply tap slightly, allowing water to flow in slowly and saturate the sample.
12) Water should flow in so as to fill the box in about 15 minutes. When water is seen in the clear hose attached to the vacuum tap, let it flow briefly before shutting the vacuum tap.
13) Leave the water supply tap open for a few minutes to allow the water pressure to build up. Briefly open the vacuum tap to bleed off any more air which has collected.
14) Remove the bungs. Fill the box until there is some water in the lower weir. Turn off the water supply tap.

**C3.2.2 Testing**

1) Supply the water to the higher (upstream) weir and adjust the flow throughout the test so that this weir just overflows.
2) Measure the flow rate (q) at the discharge end at 15 minute intervals.
3) Measure the head difference ( $\Delta H$ ) between the upstream and downstream weirs, by means of the manometers.
4) Measure the water temperature (T) at both ends of the permeameter throughout the duration of the test and calculate the average.
5) Continue the test until a steady flow rate is achieved i.e. subsequent measurements within 5% of each other (this may take several hours). Occasionally remove accumulated air by briefly opening the vacuum tap.
6) Observe when the discharge water appears to be clear. If it continues to be very dirty, take some samples, noting the time of sampling.
7) Results should be reported on an appropriate record sheet.
8) Test the material over a range of head differences. The head difference can be altered either by changing the extension pipes or, for small changes, by lifting the permeameter at one end. During test maintain a plot of flow rate (q), against head difference ( $\Delta H$ ). The plot indicates the linear region for which Darcy's law is applicable.
9) After testing, take a representative sample of material from the permeameter for a particle size distribution analysis (wet sieving test).
10) When removing the sample from the box, take note of anything which may adversely have affected the results (e.g. evidence of piping, flow across top of sample, non-saturation of sample).

## C3.3 Notes on testing errors

### C3.3.1 Sampling errors

These can be overcome by rigid adherence to BS EN 932-6 [Ref 8.I].

### C3.3.2 Aerated water

This can be avoided by providing a header tank in which mains water is allowed to settle before being used in the test. The de-airing achieved in this way is not necessarily complete, but usually this is a method appropriate to the volume of water required and the scale of the experiment.

### C3.3.3 Non-saturation

This is potentially the greatest source of error. The saturation procedures described in part C3.2.1 should minimise the problem. If required, the degree of saturation ($S_r$) can be calculated by equation C.1.

**Equation C.1 Degree of saturation**

$$S_r = \frac{(M_w1 - M_w2) + \rho_s}{1000n}$$

where:

| | |
|---|---|
| $M_w1$ | is the total mass of water added (kg) |
| $M_w2$ | is the mass of water required to fill box ends and fittings only (kg) |
| n | is porosity (%) |
| $S_r$ | is the degree of saturation |
| V | is the volume of sample ($m^3$) |
| $\rho_s$ | is the dry density of sample ($kg/m^3$) |

### C3.3.4 Flow around sample (piping)

Care is needed to ensure that flow does not occur over the sample. The sealed cell impermeable foam sheet provides an effective seal across the top of the specimen as the reinforcing bars on the permeameter lid press firmly into the sheet.

### C3.3.5 Wall effects

ASCE Proc Paper 5433 [Ref 14.I] quotes a widely accepted value for the permeameter diameter: median ($d_{50}$) grain size ratio of 10:1. This should be sufficient to ensure that the zones of higher porosity next to the walls of the test box do not allow an unacceptably high flow and thus produce an 'average' flow which is too large. This can allow materials with $d_{50}$ up to 30 mm to be tested.

### C3.3.6 Washing out of fines

A small amount of fine material may be discharged at the beginning of the test. If this is of concern, sampling the dirty water outflow gives an estimate of the percentage loss of fines. Erosion of the sample and subsequent piping may occur if high flow rates are used. This can be avoided by conducting the test using lower head differences and correspondingly low flow rates.

### C3.3.7 Transitional/turbulent flow

The method of test described in Section C3 with small head differences, ensures that non-Darcy flow is unlikely and that a laminar flow is obtained. The calculation procedure given below rejects data not obeying Darcy's law.

### C3.3.8 Temperature effects

The dynamic viscosity of water is temperature dependent. Figure C.4 gives the ratio of dynamic viscosity of water at temperature T°C to that at 20°C, $\mu_T$ / $\mu_{20}$ , i.e. the temperature correction factor, c, used in the calculations.

### C3.3.9 Reproducibility

Experience indicates that the results can differ between samples tested by as much as a factor of 10, but it is believed that this reflects sample and compaction variation rather than inaccuracies in the test method. The results indicate a characteristic range rather than a single absolute value of horizontal permeability.

## C4 Results calculation

### C4.1 Coefficient of permeability

The coefficient of permeability, k, at any temperature T is given by equation C.2.

**Equation C.2 Coefficient of permeability**

$$k = \left(\frac{q}{Ai}\right)\left(\frac{10^{-6}}{60}\right)ms^{-1}$$

where:

| | |
|---|---|
| A | is the cross sectional area ($m^2$) |
| i | is the hydraulic gradient |
| k | is the coefficient of permeability |
| q | is the steady state flow rate (ml/min) |

For each head difference, $\Delta H$ , the hydraulic gradient, i, and the flow rate per unit area, $q_{20}/A$, corrected to the standard laboratory temperature of 20°C are calculated using the equations C.3 and C.4.

**Equation C.3 Hydraulic gradient**

$$i = \left(\frac{\Delta H}{L}\right)$$

where:

| | |
|---|---|
| i | = hydraulic gradient |
| L | = length of the specimen (m) |
| $\Delta H$ | = Head difference across specimen (mm) |

**Equation C.4 Flow rate per unit area**

$$\frac{q_{20}}{A} = \left(\frac{q.c}{W.D}\right)$$

where:

| | |
|---|---|
| A | is the cross sectional area ($m^2$) |
| c | is the temperature correction factor $\mu_T/\mu_{20}$, obtained from a standard chart (Figure C.4, based on Kaye & Laby [Ref 7.I]) |
| D | is depth (m) |
| q | is the steady state flow rate (ml/min) |
| $q_{20}/A$ | is the flow rate per unit area standardised to 20°C |
| W | is width (m) |

$q_{20}/A$ is plotted against i and the best straight line drawn from the origin through those points exhibiting a linear relationship. (refer to Figure C.5, plot for sample results). The gradient of this line gives $k_{20}$, the coefficient of permeability at standard laboratory temperature.

**Figure C.4 Relationship between dynamic viscosity of water and temperature**

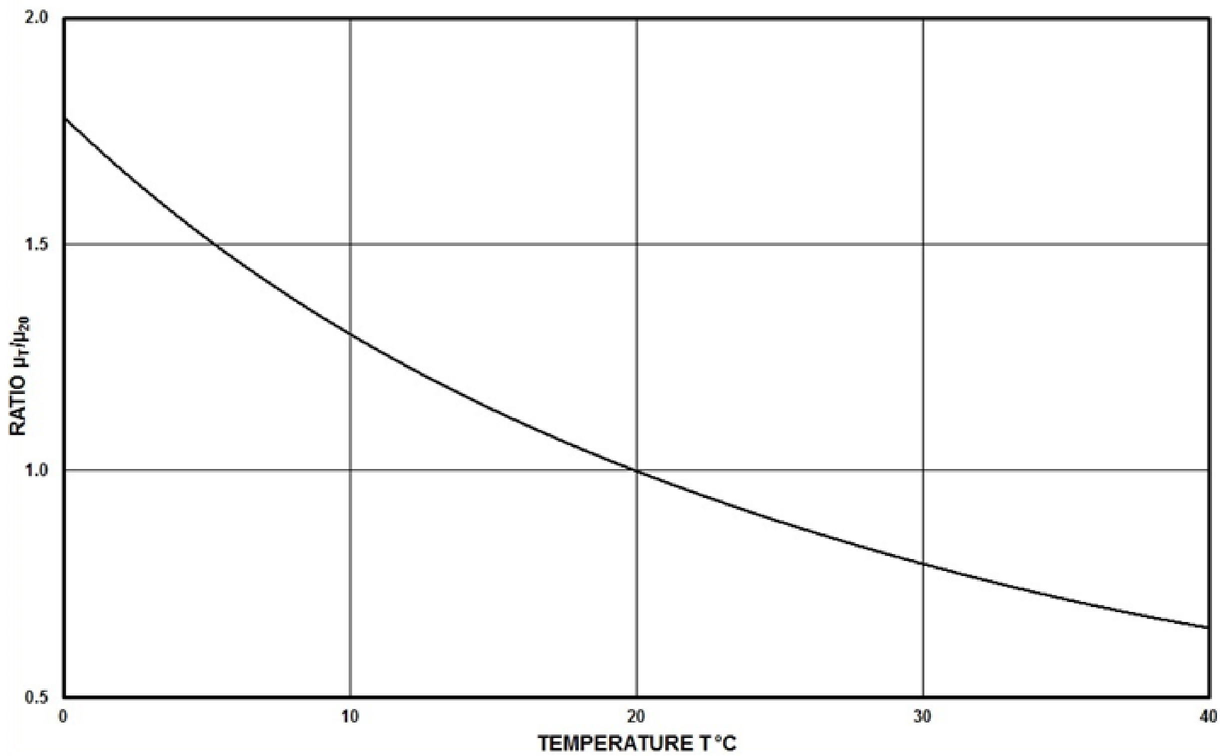
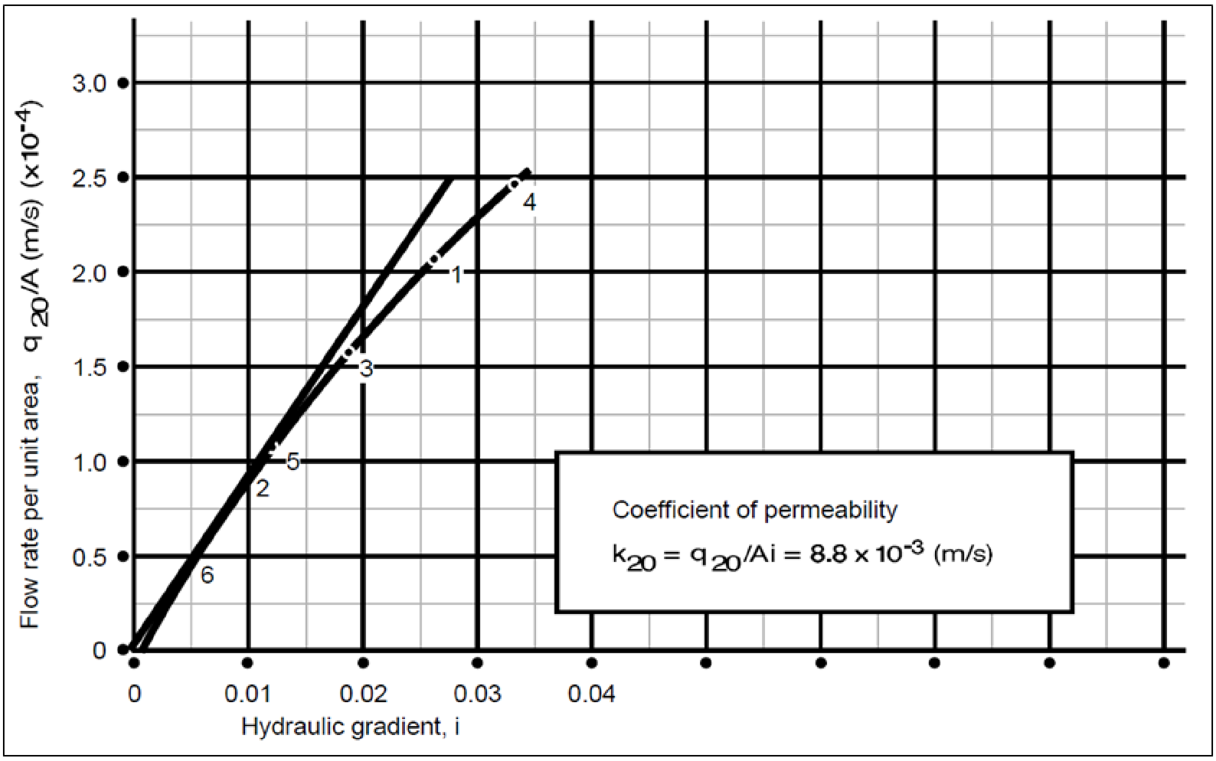



**Figure C.5 Sample results plot of flow rate per unit area (q20) vs. hydraulic gradient (i)**



### C4.2 Total porosity

Total porosity, n, can be calculated with equation C.5 if required.

**Equation C.5 Total porosity**

$$n = 1 - \left(\frac{M}{L.W.D}\right)\left(\frac{1}{1000G_{sa}\left(1+\frac{w}{100}\right)}\right)$$

where:

| | |
|---|---|
| D | is depth (m) |
| $G_{sa}$ | is the apparent relative particle density |
| L | is length (m) |
| M | is the total mass of aggregate in permeameter (kg) |
| n | is porosity (%) |
| W | is width (m) |
| $\omega$ | is water content (%) |

### C4.3 Recording of results and sample calculations

A results test sheet should be created that records all relevant data including the permeability, bulk density, water content, relative density, porosity and saturation results. For the coarse granular materials falling within the scope of the test, the values of $k_{20}$ are normally in the range $10^{-4}$ m/s to $10^{-2}$ m/s.

### C4.4 Sample results and calculation

Sample description:

**Table C.1 Sample results**

| | |
|---|---|
| **Specimen preparation** | 190 kg compacted in 5 layers at 0% water content. |
| **Dry density** | 2290 kg/m³ |
| **Dimensions** | Length, L = 0.934 m; Width, W = 0.300 m; Depth, D = 0.296 m; Area, A = W x D = 0.089 m² |
| **Apparent relative particle density ($G_{sa}$)** | 2.82 (measured); |
| **Water absorption (WA)** | 2.9% |
| **Total porosity, n** | 18.9% |

Test results and determination:

**Table C.2 Sample calculation**

| **Test number** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| **Head difference, $\Delta H$ (mm)** | 24.5 | 8.3 | 17 | 32 | 10.5 | 3.3 |
| **Hydraulic gradient, $\Delta H$ /L** | 0.026 | 0.0089 | 0.018 | 0.034 | 0.0112 | 0.0035 |
| **Steady state flow rate, q (ml/min)** | 899 | 429 | 706 | 1091 | 476 | 158 |
| **Temperature (°C)** | 12.75 | 13.5 | 13.25 | 13.25 | 13.25 | 13.5 |
| **Temperature correction factor, c** | 1.21 | 1.18 | 1.19 | 1.19 | 1.19 | 1.18 |
| **Flow rate per unit area $Q_{20}/A = qc\ x10^{-6}$ / 60A m/s** | 2.03 $x10^{-4}$ | 0.95 $x10^{-4}$ | 1.56 $x10^{-4}$ | 2.43 $x10^{-4}$ | 1.06 $x10^{-4}$ | 0.35 $x10^{-4}$ |

# Notification

This document was notified in draft to the European Commission in accordance with Technical Standards and Regulations Directive 2015/1535/EU.

Pavement
Design

# CD 226
# Design for new pavement construction

(formerly HD 26/06)

Version 0.1.0

**Summary**
This document gives the requirements for the design of pavement construction for new build carriageways, widening of existing carriageways, or reconstruction of existing pavements on the UK motorway and all-purpose trunk road network.

**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated National Highways team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 226 | 0.**1**.0 | November 2021 | Core document, England NAA | Incremental change to requirements |

Equation 2.43a corrected to include a natural logarithm in the second term plus minor amendments for clarification. Updates made to England National Application Annex.

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 226 | 0 | March 2020 | | |

# Foreword

## Publishing information

This document is published by National Highways.

This document supersedes HD 26/06 and HD 27/15, which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This document sets out the pavement design approaches to be used when constructing a new carriageway, widening an existing carriageway, upgrading an existing pavement or reconstructing an existing pavement. Standard designs are presented that cover the permitted materials and design thicknesses required for various design traffic volumes and the requirements for designs using alternative procedures are set out.

This revision of the document introduces a new design option using roller compacted concrete (RCC) and updates the terminology for the permitted asphalt base and binder course materials.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 6.N] apply to this document.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a "British Standard" or other technical specification, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 6.N].

# Abbreviations and symbols

**Abbreviations**

| Abbreviations | Definition |
|---|---|
| AC | Asphalt concrete |
| CBGM | Cement bound granular mixture |
| CRCB | Continuously reinforced concrete base |
| CRCP | Continuously reinforced concrete pavement |
| des | Design mixtures (that have undergone type testing) |
| EA | Emergency area |
| EME2 | Enrobés á module elevé (2nd generation) |
| FABGM | Fly ash bound granular mixture |
| HBM | Hydraulically bound mixture |
| HBGM | Hydraulically bound granular mixture |
| HDM | Heavy duty mixture |
| HRA | Hot rolled asphalt |
| IT-CY | Indirect tension test on cylindrical specimens |
| JRC | Jointed reinforced concrete |
| msa | Million standard axles |
| PA | Porous asphalt |
| RCC | Roller compacted concrete |
| SBGM | Slag bound granular mixture |
| SMA | Stone mastic asphalt |
| TSCS | Thin surface course system |
| URC | Unreinforced jointed concrete |
| VRS | Vehicle restraint systems |

**Symbols**

| Symbol | Definition |
|---|---|
| D | Diameter of reinforcement bar (mm) |
| e | Base of the natural logarithm |
| E | Foundation surface modulus |
| $f_f$ | Mean flexural strength (N/mm$^2$ or MPa) at 28 days |
| H | Total thickness of asphalt (mm) |
| $H_1$ | Thickness (mm) of the concrete slab without a tied lane or 1-m edge strip |
| $H_2$ | Thickness (mm) of the concrete slab with a tied lane or 1-m edge strip |
| Ln | Natural logarithm |
| R | Level of reinforcement (% of the cross section area) |
| $R_c$ | Mean compressive cube strength (N/mm$^2$ or MPa) at 28 days |
| s | Maximum distance, centre to centre, between bars across the width of the slab (mm) |
| t | Concrete design thickness (mm) |
| T | Design traffic (msa) |

# Terms and definitions

**Terms and definitions**

| Term | Definition |
|---|---|
| Cold recycled base material | asphalt base material produced using using specialist plant to pulverise and stabilise existing road materials, at ambient temperature, with the addition of hydraulic cement and/or bitumen binders |
| Full reconstruction | maintenance treatment that involves replacement of all the bound layers and extends into the foundation |
| New carriageway | a new road or carriageway (as opposed to an existing lane or one or more new lanes abutting an existing pavement) |
| On-line widening | where additional carriageway is constructed abutting the existing carriageway |
| Partial reconstruction | replacement of all the bound layers |
| Upgrading of an existing pavement | upgrading of an existing pavement includes conversion of a hard shoulder to a running lane and incorporation of an existing pavement into new construction |

# 1. Scope

## Aspects covered

1.1 The requirements in this document shall be used for the design of the pavement when constructing a new carriageway, widening an existing carriageway, upgrading an existing pavement or reconstructing an existing pavement on the UK motorway and all-purpose trunk road network.

*NOTE 1 This document does not include the estimation of design traffic (see CD 224 [Ref 13.N]).*

*NOTE 2 This document does not cover the design of pavement foundations (see CD 225 [Ref 3.N]).*

*NOTE 3 This document does not cover the design of surfacing materials (see CD 236 [Ref 10.N]).*

1.2 Where the reconstruction of an existing pavement is being undertaken, the design requirements in this document shall be used in conjunction with CD 227 [Ref 4.N].

## Implementation

1.3 This document shall be implemented forthwith on all schemes involving the design of pavement construction for new build carriageways, widening of existing carriageways, or reconstruction of existing pavements on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 6.N].

## Use of GG 101

1.4 The requirements contained in GG 101 [Ref 6.N] shall be followed in respect of activities covered by this document.

# 2. Standard designs

2.1 This section sets out the requirements that shall be followed for the design of a new pavement using one of the Overseeing Organisations' "standard" pavement design types.

2.2 Where a design other than those given in this section is proposed for the design of a pavement for a new carriageway, approval to proceed shall be obtained from the Overseeing Organisation before the design is finalised.

## Foundations

2.3 Where a pavement is being designed for a new carriageway, the foundation shall be designed in accordance with CD 225 [Ref 3.N].

*NOTE Foundation stiffness classes (1 to 4) are defined in CD 225 [Ref 3.N].*

2.4 Where a pavement is being designed for a new carriageway, foundation class 1 shall only be used for design traffic of 20 million standard axles (msa) or less.

*NOTE Calculation of design traffic is set out in CD 224 [Ref 13.N].*

2.5 Where a pavement is being designed for a new carriageway, foundation class 2 shall only be used for design traffic of 80 msa or less.

*NOTE A departure from standard is not necessary where widening or reconstructing an existing pavement where the foundation is equivalent to a foundation class 2, irrespective of design traffic.*

2.6 Where a rigid pavement is being designed for a new carriageway, this shall use a class 3 or class 4 foundation.

2.7 Where a flexible pavement with an asphalt base using EME2 is being designed for a new carriageway, this shall use a class 3 or class 4 foundation, unless a class 2 foundation can be demonstrated to achieve a minimum stiffness of 100 MPa.

## Surface course

2.8 The surface course shall be designed in accordance with CD 236 [Ref 10.N].

## Pavement types and materials

2.9 Pavement type shall either be "flexible" or "rigid" construction.

*NOTE 1 Flexible pavements include a lower (base) layer containing asphalt or HBGM (hydraulically bound granular mixture). These are designated as "flexible with an asphalt base" or "flexible with an HBGM base" respectively.*

*NOTE 2 Rigid pavements can be "continuously reinforced" or "roller compacted" concrete pavements.*

*NOTE 3 Design equations for unreinforced jointed concrete (URC) and jointed reinforced concrete (JRC) rigid pavements are provided in this document for maintaining or widening existing pavements.*

### Flexible pavements with an asphalt base

2.10 For flexible pavements with an asphalt base, the base and binder course materials shall be selected from the materials in Table 2.10.

**Table 2.10 Permitted base and binder course materials for flexible pavements with an asphalt base**

| Material type | Base | Binder course |
|---|---|---|
| AC 40/60 | Dense and heavy-duty base materials designed in accordance with Clause 929 of MCHW Series 0900 [Ref 8.N] with the designations:<br><br>AC 32 dense base 40/60 des<br>AC 32 HDM base 40/60 des | Dense and heavy-duty binder materials designed in accordance with Clause 929 of MCHW Series 0900 [Ref 8.N] with the designations:<br><br>AC 20 dense bin 40/60 des<br>AC 32 dense bin 40/60 des<br>AC 20 HDM bin 40/60 des<br>AC 32 HDM bin 40/60 des |
| EME2 | EME2 base course asphalt concrete designed in accordance with Clause 930 of MCHW Series 0900 [Ref 8.N] and targeting a penetration value of 10/20 or 15/25 | EME2 binder course asphalt concrete designed in accordance with Clause 930 of MCHW Series 0900 [Ref 8.N] and targeting a penetration value of 10/20 or 15/25 |

### Flexible pavements with an HBGM base

2.11 For flexible pavements with an HBGM base, the hydraulically bound base layer shall be selected from the following materials:

1) cement bound granular mixture (CBGM);
2) fly ash bound granular mixture (FABGM); and,
3) slag bound granular mixture (SBGM).

*NOTE Further details of HBGM materials are given in MCHW Series 0800 [Ref 7.N].*

2.12 Transverse induced cracks shall be formed during installation for HBGM with 28-day compressive strength class C8/10 or higher at a maximum spacing of 5 m under a rigid pavement or 3 m under other pavements induced in accordance with Clause 818 of MCHW Series 0800 [Ref 7.N].

*NOTE 1 Guidance on design considerations for induced cracking of HBGMs is provided in BS 9227 [Ref 3.I].*

*NOTE 2 There is a risk that HBGM mixtures designed to reach a compressive strength <10 MPa can exceed this strength on site.*

2.13 For flexible pavements with an HBGM base, the asphalt base and binder course layers shall be selected from the materials in Table 2.13.

**Table 2.13 Permitted asphalt base and binder course materials for flexible pavements with an HBGM base**

| Material type | Base | Binder course |
|---|---|---|
| AC 40/60 | Dense and heavy-duty base materials designed in accordance with Clause 929 of MCHW Series 0900 [Ref 8.N] with the designations:<br><br>AC 32 dense base 40/60 des<br>AC 32 HDM base 40/60 des | Dense and heavy-duty binder materials designed in accordance with Clause 929 of MCHW Series 0900 [Ref 8.N] with the designations:<br><br>AC 20 dense bin 40/60 des<br>AC 32 dense bin 40/60 des<br>AC 20 HDM bin 40/60 des<br>AC 32 HDM bin 40/60 des |
| EME2 | EME2 base course asphalt concrete designed in accordance with Clause 930 of MCHW Series 0900 [Ref 8.N] and targeting a penetration value of 10/20 or 15/25 | EME2 binder course asphalt concrete designed in accordance with Clause 930 of MCHW Series 0900 [Ref 8.N] and targeting a penetration value of 10/20 or 15/25 |
| HRA | - | HRA binder course designed in accordance with Clause 943 of MCHW Series 0900 [Ref 8.N] |
| SMA | - | SMA binder course specified in accordance with Clause 937 of MCHW Series 0900 [Ref 8.N] |

### Rigid pavements

2.14 For rigid pavements designed for a new carriageway, the pavement type shall be selected from the following:

1) continuously reinforced concrete pavement (CRCP);
2) continuously reinforced concrete base (CRCB); and,
3) roller compacted concrete (RCC).

2.15 Design equations for unreinforced jointed concrete (URC) and jointed reinforced concrete (JRC) rigid pavements are provided in this document and these pavement types shall be used only for maintaining or widening existing jointed rigid pavements.

## Design

### Options

2.16 Where designing a pavement for a new carriageway, designs shall be carried out using a minimum of three options covering the range of pavement types from the "standard designs" described in this section.

2.16.1 The design options should include flexible with an asphalt base, flexible with an HBM base and at least one type of rigid pavement.

### Design life

2.17 Where designing a pavement for a new carriageway, the design life shall be 40 years.

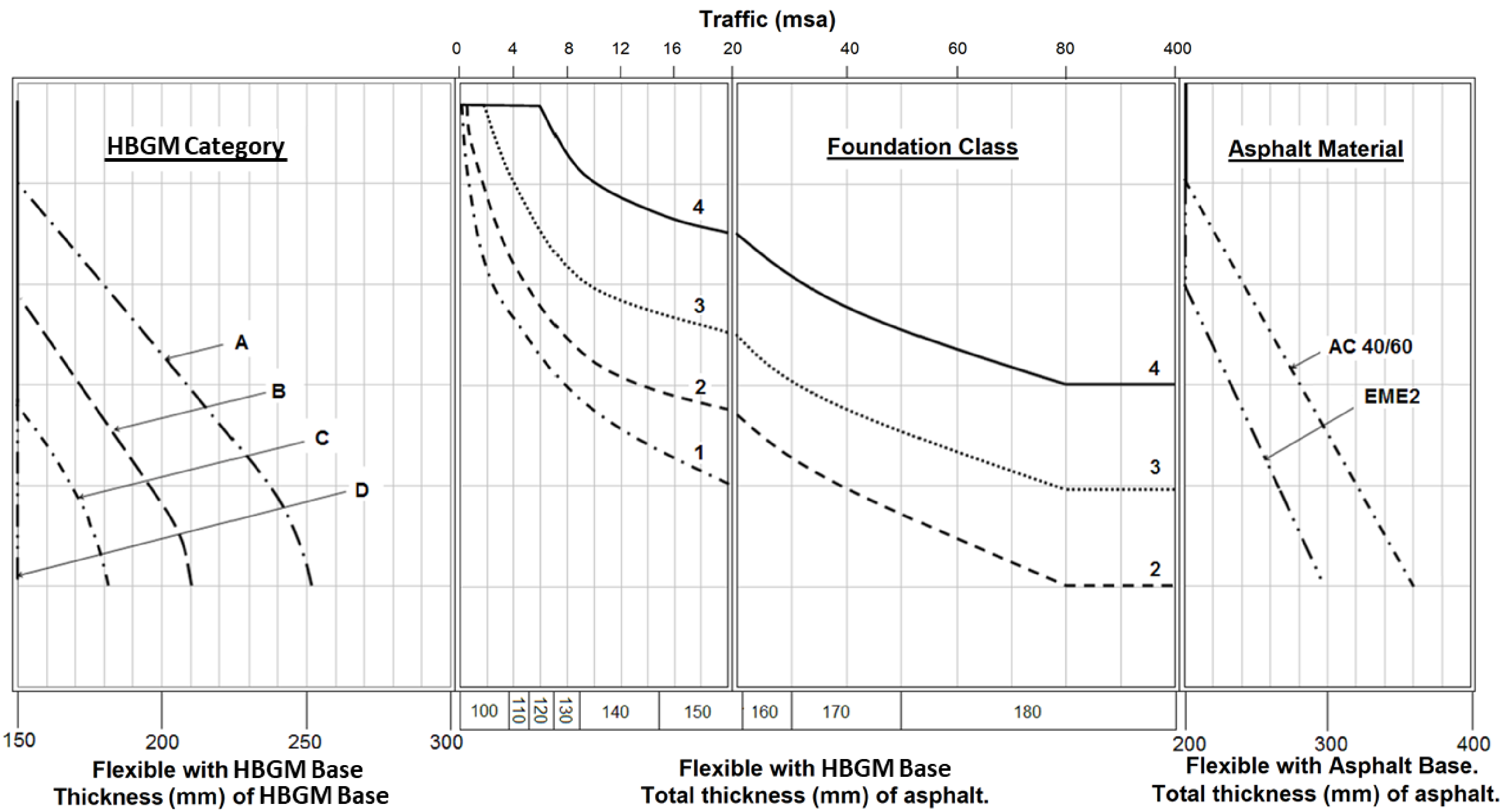
2.18 Where designing a pavement for a new carriageway, all lanes, including the hard shoulder and lay-bys, shall be constructed to carry the design traffic in the heaviest loaded lane (commonly the left hand lane) as calculated in accordance with CD 224 [Ref 13.N].

2.19 The minimum design traffic for new roads shall be 1 msa, as calculated in accordance with CD 224 [Ref 13.N].

## Flexible pavement designs

2.20 The design thickness of the layers for flexible pavements shall be determined using the nomograph in Figure 2.20.

**Figure 2.20 Nomograph for determining the design thickness for flexible pavements**



*NOTE 1 For flexible pavements with an asphalt base, the right hand side of the nomograph is used to determine asphalt thickness (comprising the surface course, binder course and base).*

*NOTE 2 For flexible pavements with an HBGM base, the left hand side of the nomograph is used to determine HBGM thickness and the middle section is used to determine asphalt thickness.*

*NOTE 3 Thicknesses of materials are to be rounded up to the nearest 5 mm.*

*NOTE 4 Total thicknesses of asphalt shown include the thickness of the surface course.*

*NOTE 5 AC 40/60 refers to the permitted dense and heavy-duty base, and binder course materials, for flexible pavements with an asphalt base, including SMA and HRA, described earlier in this document.*

*NOTE 6 For flexible pavements with an asphalt base, the class 2 foundation line can be used with EME2 when widening or reconstructing an existing pavement which has a class 2 foundation.*

*NOTE 7 Worked examples are included in Appendix A.*

2.20.1 For flexible pavements with an asphalt base, the base and binder course should use the same material type, that is both layers contain AC 40/60 or both layers contain EME2.

2.21 Where a design for a flexible pavement with an asphalt base combines an EME2 layer with an AC 40/60 layer, the design thickness shall be based on the AC 40/60 line in Figure 2.20.

2.22 Where traffic exceeds 80 msa, the coarse aggregate in all the asphalt materials shall contain only crushed rock or slag.

2.23 For flexible pavements with an HBGM base, the minimum design thickness of HBM shall be 150 mm.

*NOTE 1 HBGM materials are defined in MCHW Series 0800 [Ref 7.N].*

*NOTE 2 Examples of HBGM materials that can be expected to meet the HBGM material categories in Figure 2.20 are listed in Table 2.23N2.*

**Table 2.23N2 Examples of HBGM materials**

| HBGM Category | A | B | C | D |
|---|---|---|---|---|
| Crushed rock coarse aggregate: (using aggregate with a coefficient of thermal expansion <10×10 $^{-6}$ per $^{o}$C) | - | Clause 822 CBGM 1 C8/10 (or T3) Clause 835 SBGM 1 C8/10 (or T3) Clause 830 FABGM 1 C8/10 (or T3) | Clause 822 CBGM 1 C12/16 (or T4)Clause 835 SBGM 1 C12/16 (or T4)Clause 830 FABGM 1 C 12/16 (or T4) | Clause 822 CBGM 1 C15/20 (T5)Clause 835 SBGM 1 C15/20 (or T5)Clause 830 FABGM 1 C 15/20 (or T5) |
| Gravel coarse aggregate: (using aggregate with a coefficient of thermal expansion ≥10×10 $^{-6}$ per $^{o}$C) | Clause 822 CBGM 1 C8/10 (or T3)Clause 835 SBGM 1 C8/10 (or T3)Clause 830 FABGM 1 C8/10 (or T3) | Clause 822 CBGM 1 C12/16 (or T4) Clause 835 SBGM 1 C12/16 (or T4) Clause 830 FABGM 1 C12/16 (or T4) | Clause 822 CBGM 1 C15/20 (T5)Clause 835 SBGM 1 C15/20 (or T5)Clause 830 FABGM 1 C 15/20 (or T5) | - |

2.24 For flexible pavements with an HBGM base, the total thickness of asphalt (comprising the surface course, binder course and base, where present) shall be determined using either the middle section of Figure 2.20 or Equation 2.24 (rounded up to the nearest 5 mm):

**Equation 2.24 Total thickness of asphalt (mm) for flexible pavements with an HBM base**

$$H = -16.05(\log T)^2 + 101\log T + 45.8$$

where:

| | |
|---|---|
| H | is the total thickness of asphalt (mm) |
| T | is the design traffic (msa) |

*NOTE 1 Maximum design traffic is 400 msa.*

*NOTE 2 The total thickness of asphalt is between 100 mm and 180 mm.*

*NOTE 3 Where the design traffic is $\geq$ 80 msa, the total thickness of asphalt is 180 mm.*

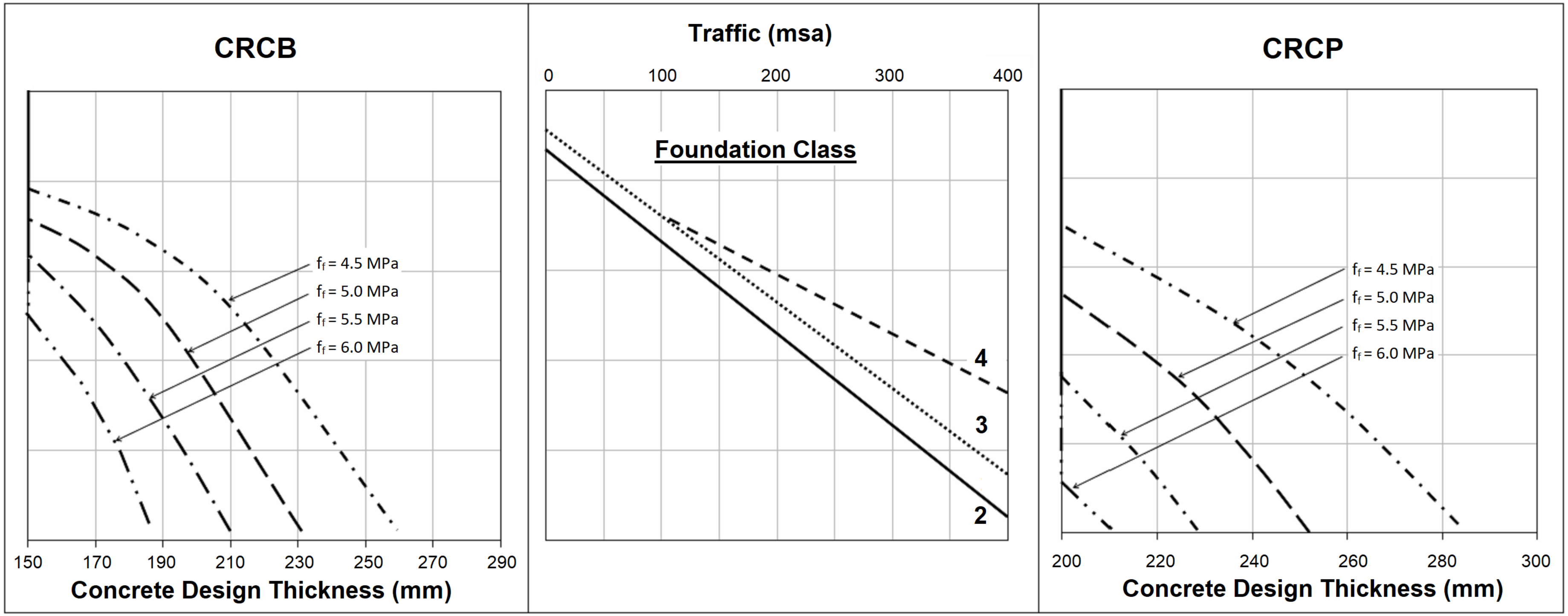
*NOTE 4 The total thickness of asphalt is applicable to all permitted base materials in Table 2.13.*

2.25 For HBGM with 28-day compressive strength class C8/10 or higher individual construction widths of HBGM base shall not exceed 4.75 m unless crack induction is provided.

## Rigid construction with continuous reinforcement (CRCP and CRCB)

2.26 The design thickness of the concrete layers for continuously reinforced rigid pavements shall be determined using the nomograph in Figure 2.26.

**Figure 2.26 Nomograph for determining concrete layer design thickness for continuously reinforced concrete pavements (CRCB and CRCP)**



*NOTE 1 For CRCP, the right hand side of the nomograph is used to determine the thickness of concrete.*

*NOTE 2 For CRCB, the left hand side of the nomograph is used to determine the thickness of concrete.*

*NOTE 3 The class 2 foundation line is provided for reconstruction and widening of an existing pavement which has a the foundation equivalent to a foundation class 2.*

*NOTE 4 Thicknesses shown are for the concrete layer only; that is ithey do not include the asphalt layers, if present.*

*NOTE 5 Where a concrete surface is used in a CRCP design, its thickness is included in the total concrete design thickness.*

*NOTE 6 Thicknesses of materials to be rounded up to the nearest 5 mm.*

*NOTE 7 $f_f$ denotes mean concrete flexural strength (N/mm$^2$ or MPa) at 28 days measured in accordance with BS EN 12390-5 [Ref 11.N].*

*NOTE 8 The design thickness is based on the presence of a (minimum) 1 m-wide edge strip or tied shoulder.*

*NOTE 9 Worked examples using Figure 2.26 are included in Appendix A.*

2.27 Where an integral minimum 1 m wide edge strip or tied lane is not adjacent to the most heavily trafficked lane, the design thickness for the concrete layer shall be increased by 30 mm.

2.28 Where a CRCP is designed with a TSCS, the TSCS shall have a minimum thickness of 30 mm.

*NOTE For CRCP construction with an asphalt surface course, no binder course is required.*

2.29 CRCB shall be designed with a total minimum asphalt thickness of 100 mm with the binder course selected from one of the materials in Table 2.29.

**Table 2.29 Permitted binder course materials for CRCB**

| Material type | Binder course |
|---|---|
| AC 40/60 | Dense and heavy-duty binder materials designed in accordance with Clause 929 of MCHW Series 0900 [Ref 8.N] with the designations:<br><br>AC 20 dense bin 40/60 des<br>AC 32 dense bin 40/60 des<br>AC 20 HDM bin 40/60 des<br>AC 32 HDM bin 40/60 des |
| EME2 | EME2 binder course asphalt concrete designed in accordance with Clause 930 of MCHW Series 0900 [Ref 8.N] and targeting a penetration value of 10/20 or 15/25 |
| HRA | HRA binder course designed in accordance with Clause 943 of MCHW Series 0900 [Ref 8.N] |
| SMA | SMA binder course specified in accordance with Clause 937 of MCHW Series 0900 [Ref 8.N] |

*NOTE The total asphalt thickness includes the thickness of the surface course.*

### Concrete material details

2.30 The CRCP/CRCB concrete layer shall contain both longitudinal and transverse steel reinforcement.

*NOTE 1 The continuous longitudinal reinforcement is designed to hold the transverse cracks tightly closed to ensure high load transfer across the cracks and to maintain the structural integrity of the pavement.*

*NOTE 2 The transverse reinforcement is used for ease and consistency of construction and to prevent longitudinal cracking and local deterioration.*

*NOTE 3 The maximum spacing of longitudinal steel reinforcement can be calculated using Equation 2.30N3:*

**Equation 2.30N3 Maximum spacing of longitudinal steel reinforcement**

$$s = \frac{100\pi D^2}{4tR}$$

where:

| | |
|---|---|
| s | is the maximum distance, centre to centre, between bars across the width of the slab (mm) |
| D | is the diameter of reinforcement bar (mm) |
| R | is the level of reinforcement (% of the cross section area) |
| t | is the concrete design thickness (mm) |

2.30.1 Transverse bars may be incorporated into the support arrangement for the steel.

2.31 Where transverse bars are incorporated into the support arrangement for the steel, the required quantities and position of the steel shall be maintained.

2.32 Longitudinal crack control steel in CRCP shall be 0.6% of the concrete slab cross-section area, comprising 16 mm-diameter, deformed steel bars (T16 reinforcement).

2.33 Transverse steel in CRCP shall be 12 mm-diameter, deformed bars at 600 mm spacing.

2.34 Longitudinal crack control steel in CRCB shall be 0.4% of the concrete slab cross-section area, comprising 12 mm-diameter, deformed steel bars (T12 reinforcement).

2.35 Transverse steel in CRCB shall be 12 mm-diameter, deformed bars at 600 mm spacings.

2.36 Where concrete of flexural strength $\geq$ 5.5 MPa is used, this shall use aggregate that has a coefficient of thermal expansion less than 10 x$10^{-6}$ per °C.

2.37 Crack inducers shall not be used with CRCP or CRCB designs.

**Termination details**

2.38 The termination details of CRCP and CRCB pavements shall be designed to ensure that forces are not transmitted to structures and adjacent forms of pavement construction by thermally induced movements.

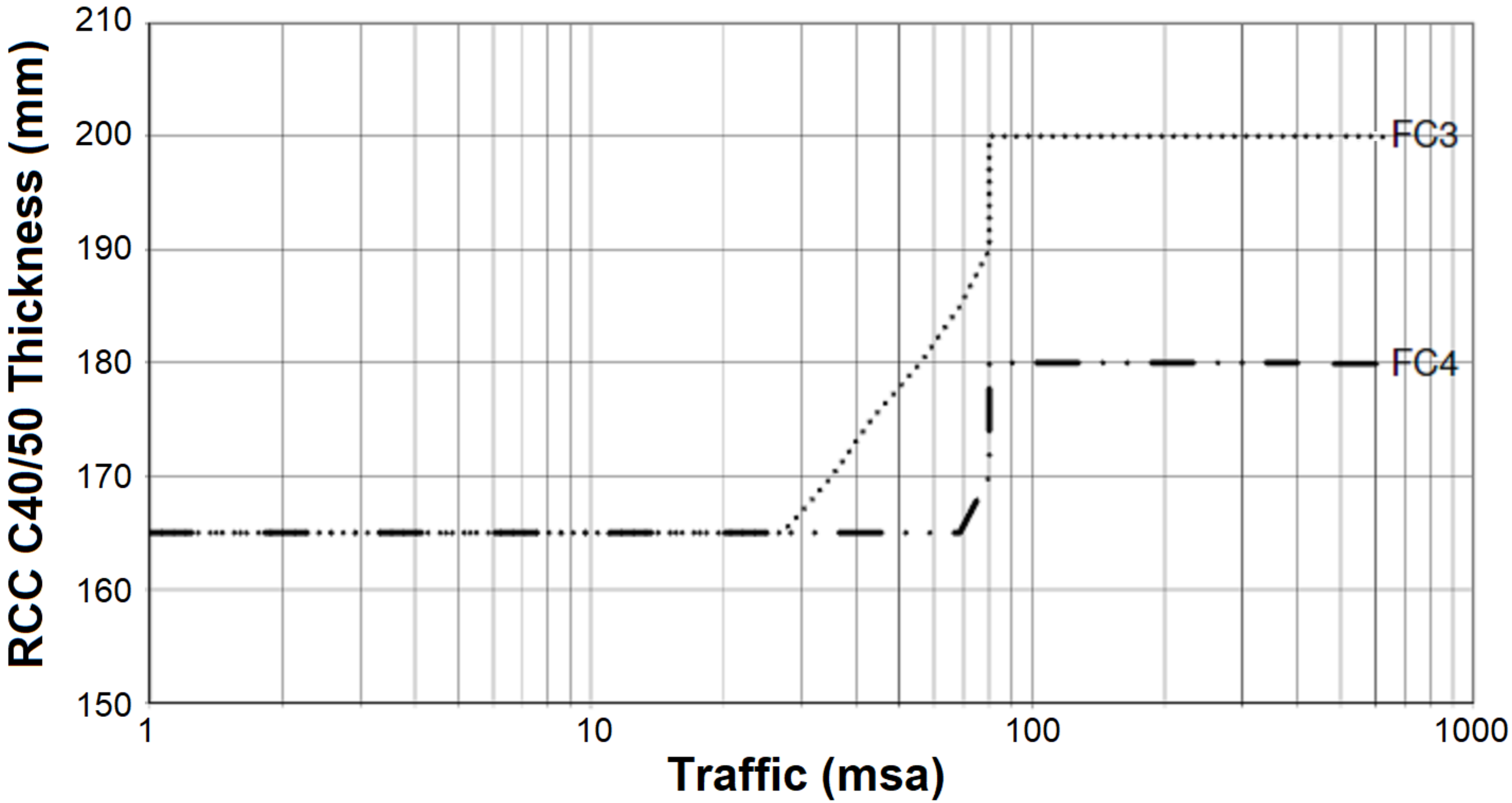
*NOTE* *Standard examples of terminations are provided in MCHW HCD Series C [Ref 4.I].*

2.39 The termination details of CRCP and CRCB shall be subject to approval by the Overseeing Organisation.

## Rigid construction with roller compacted concrete (RCC)

2.40 The design thickness of the concrete layer for RCC pavements shall be determined using Figure 2.40.

**Figure 2.40 Design thickness for the concrete layer in roller compacted concrete (RCC) pavements**



*NOTE 1 Thicknesses of materials to be rounded up to the nearest 5 mm.*

*NOTE 2 FC3 and FC4 are foundation class 3 and foundation class 4, respectively.*

*NOTE 3 C40/50 concrete used in RCC is assumed to have the following characteristics:*

*1) flexural strength of 5.0 MPa;*

*2) modulus E = 50,000 MPa; and,*

*3) Poisson's Ratio = 0.20.*

*NOTE 4 RCC design (fatigue) life can be determined using multi-layer, linear elastic modelling and Equation 2.40N4:*

**Equation 2.40N4 Design life calculation for RCC**

$$T = \frac{e^{\frac{StressRatio - 0.9157}{-0.039}}}{10^6}$$

where:

| | |
|---|---|
| T | is the design traffic (msa) |
| e | is the base of the natural logarithm |
| Stress ratio | is the tensile stress at the bottom of the RCC due to a standard wheel load divided by the flexural strength of the RCC. |

*NOTE 5 Further background to the development of RCC in the UK is given in Abouabid et al [Ref 5.I].*

2.41 RCC pavements shall be designed with a total minimum asphalt thickness of 90 mm with the binder course selected from one of the materials in Table 2.41.

**Table 2.41 Permitted binder course materials for RCC**

| Material type | Binder course |
|---|---|
| EME2 | EME2 binder course asphalt concrete designed in accordance with Clause 930 of MCHW Series 0900 [Ref 8.N] and targeting a penetration value of 10/20 or 15/25 |
| HRA | HRA binder course designed in accordance with Clause 943 of MCHW Series 0900 [Ref 8.N] |

*NOTE The total asphalt thickness includes the thickness of the surface course.*

## Rigid construction with jointed concrete pavements

2.42 Where an existing jointed concrete pavement is being reconstructed or widened using the same type of pavement, the design shall be in accordance with either the URC or JRC designs, defined below.

### Unreinforced jointed concrete pavement design (URC)

2.43 The design thickness of URC pavements shall be determined using Equations 2.43a and 2.43b.

**Equation 2.43a Design thickness of URC pavements (no tied shoulder or edge strip)**

$$\text{Ln}(H_1) = \frac{\text{Ln}(T) - 3.466\text{Ln}(R_c) - 0.484\text{Ln}(E) + 40.483}{5.094}$$

**Equation 2.43b Effect on design thickness of URC pavements of a tied shoulder or edge strip**

$$H_2 = 0.934H_1 - 12.5$$

where:

| | |
|---|---|
| $H_1$ | is the thickness (mm) of the concrete slab without a tied lane or 1-m edge strip |
| $H_2$ | is the thickness (mm) of the concrete slab with a tied lane or 1-m edge strip |
| ln or Ln | is the natural logarithm |
| T | is the design traffic (msa) |
| $R_c$ | is the mean compressive cube strength (N/mm$^2$ or MPa) at 28 days |
| E | is the foundation stiffness (MPa) related to foundation class:<br>E = 200 MPa for foundation class 3<br>E = 400 MPa for foundation class 4 |

*NOTE 1 Minimum slab thickness ($H_1$) is 150 mm.*

*NOTE 2 Maximum design traffic (T) is 400 msa.*

*NOTE 3 Load-induced stresses at slab corners and edges are greater than in the slab centre, necessitating dowel bars to distribute loads between slabs.*

*NOTE 4 Thicknesses to be rounded up to the nearest 5 mm.*

*NOTE 5 Further information on the design of rigid pavements is given in TRL RR 87 [Ref 6.I].*

2.44 For URC pavements, where the slab thickness is $<$ 230 mm, the maximum spacing between transverse contraction joints shall be 4 m.

*NOTE 1 Contraction joints enable the slab to shorten when its temperature falls and allow the slab to expand subsequently by approximately the same amount.*

*NOTE 2 The permitted spacing of transverse joints is a function of slab thickness and aggregate type. Joint spacing reflects the capacity of the slab to distribute strain rather than allow damaging strain concentrations.*

2.45 For URC pavements, where the slab thickness is $\geq$ 230 mm, the maximum spacing between transverse contraction joints shall be 5 m.

### Reinforced jointed concrete pavement design (JRC)

2.46 The design thickness of JRC pavements shall be determined using Equations 2.46a and 2.46b.

**Equation 2.46a Design thickness of JRC pavements (no tied shoulder or edge strip)**

$$\text{Ln}(H_1) = \frac{\text{Ln}(T) - R - 3.171\text{Ln}(R_c) - 0.326\text{Ln}(E) + 45.150}{4.786}$$

**Equation 2.46b Effect on design thickness of JRC pavements of a tied shoulder or edge strip**

$$H_2 = 0.934H_1 - 12.5$$

where:

| | |
|---|---|
| $H_1$ | is the thickness (mm) of the concrete slab without a tied lane or 1-m edge strip |
| $H_2$ | is the thickness (mm) of the concrete slab with a tied lane or 1-m edge strip |
| Ln | is the natural logarithm |
| T | is the design traffic (msa) |
| $R_c$ | is the mean compressive cube strength (N/mm$^2$ or MPa) at 28 days |
| E | is the foundation stiffness (MPa) related to foundation class:<br>E = 200 MPa for foundation class 3<br>E = 400 MPa for foundation class 4 |
| R | is the percentage of longitudinal steel reinforcement:<br>R = 8.812 for 500 mm$^2$/m reinforcement<br>R = 9.071 for 600 mm$^2$/m reinforcement<br>R = 9.289 for 700 mm$^2$/m reinforcement<br>R = 9.479 for 800 mm$^2$/m reinforcement |

*NOTE 1 Minimum slab thickness (H1) is 150 mm.*

*NOTE 2 Load induced stresses at slab corners and edges are greater than in the slab centre, necessitating dowel bars to distribute loads between slabs.*

*NOTE 3 Thicknesses to be rounded up to the nearest 5 mm.*

*NOTE 4 Further information on the design of rigid pavements is given in TRL RR 87 [Ref 6.I].*

*NOTE 5 A worked example is included in Appendix A.*

2.47 For JRC, the minimum level of longitudinal reinforcement shall be 500 mm$^2$/m.

2.48 For JRC pavements, where the aggregate has a coefficient of thermal expansion $\geq$ 10 x 10$^{-6}$ per ºC, the maximum spacing between transverse joints shall be determined using Table 2.48.

**Table 2.48 Maximum transverse joint spacing in JRC**

<table>
<tr><th rowspan="3">Slab thickness (mm)</th><th colspan="2">Level of reinforcement</th></tr>
<tr><th>< 600 mm²/m</th><th>≥ 600 mm²/m</th></tr>
<tr><th colspan="2">Maximum joint spacing (m)</th></tr>
<tr><td>< 290</td><td>25</td><td rowspan="6">25</td></tr>
<tr><td>≥ 290 to <300</td><td>24</td></tr>
<tr><td>≥ 300 to <310</td><td>23</td></tr>
<tr><td>≥ 310 to <320</td><td>22</td></tr>
<tr><td>≥ 320 to <330</td><td>21</td></tr>
<tr><td>≥ 330</td><td>20</td></tr>
</table>

*NOTE In JRC, the spacing of transverse joints is a function of slab thickness, aggregate type, and the quantity of reinforcement. Joint spacing reflects the capacity of the slab to distribute strain rather than allow damaging strain concentrations.*

2.48.1 For JRC pavements, where concrete is used with an aggregate that has a coefficient of thermal expansion <10 x $10^{-6}$ per ºC, the maximum transverse joint spacings in Table 2.48 may be increased by 20%.

## Design of central reserves, maintenance areas and emergency areas (EAs)

2.49 Where there is a need for a hardened central reserve, the minimum standard for construction shall be designed using the heavy vehicle loading category for footways/cycleways in CD 239 [Ref 5.N].

2.50 Other forms of central reserve construction are subject to approval by the Overseeing Organisation and shall require a minimum of 70 mm thickness of bound material.

*NOTE 1 The design thickness of an EA using concrete construction are based on the presence of a (minimum) 1 m wide edge strip or tied shoulder.*

*NOTE 2 This thickness of material is intended to inhibit weed penetration and minimise future maintenance.*

2.51 EAs shall be based on a minimum design life of 5 msa.

2.52 Where an EA is included, the design shall maintain sub-base and capping drainage paths.

# 3. On-line widening and upgrading of existing pavements

## General

3.1 This section sets out the pavement design requirements that shall be followed where on-line widening and/or upgrading of an existing pavement on a motorway or all-purpose trunk road is being undertaken.

*NOTE 1 On-line widening is where additional carriageway is constructed abutting the existing carriageway.*

*NOTE 2 Upgrading of an existing pavement includes conversion of a hard shoulder to a running lane and incorporation of an existing pavement into new construction.*

3.1.1 Where on-line widening and/or upgrading of an existing pavement is being undertaken, design should be undertaken using at least two options.

3.2 The design of the widened and upgraded pavements shall provide a structural life of 40 years.

3.3 Where a design that results in an increase in pavement height is being proposed, an assessment shall be made of the consequential impacts on the following:

1) headrooms at structures, gantries and overhead lines;
2) carriageway surface geometry;
3) kerb and vehicle restraint system heights;
4) drainage and ironwork;
5) heights of copings and parapet walls adjacent to retaining walls and underbridges; and,
6) overloading at under-bridges and adjacent to retaining walls.

*NOTE Requirements for headrooms are set out in CD 127 [Ref 2.N].*

3.4 Where a design that results in an increase in carriageway width or projected traffic flow is being proposed, an assessment shall be made of the consequential impact on the following:

1) headrooms at structures, gantries and overhead lines;
2) carriageway surface geometry (including slip road and weaving length);
3) wide carriageway drainage; and,
4) VRS set back and containment.

3.5 Where on-line widening and/or upgrading of an existing pavement is being undertaken, the condition of the existing pavement, including the foundation, shall be determined in accordance with CD 227 [Ref 4.N].

*NOTE The condition and construction thicknesses of the layers in the existing pavement are key to the design of the widened or upgraded pavement.*

## On-line widening

3.6 The design of the widened part of the pavement shall be in accordance with the 'standard designs' for new pavements as set out in Section 2 of this document.

3.7 Where on-line widening is being undertaken, the ground conditions beneath the existing, adjacent pavement, as determined during the investigation and evaluation process, shall be used to inform the assessment of the long-term condition beneath the adjacent new pavement.

*NOTE The information from the pavement investigation can be used in the assessment of the condition of the subgrade and to establish whether the existing pavement requires strengthening.*

3.8 The foundation for the widened road shall be designed in accordance with CD 225 [Ref 3.N].

3.9 Where on-line widening is being undertaken, the design, materials and thickness of the new pavement shall be selected to ensure continuity of drainage.

*NOTE 1 It is a requirement of CD 225 [Ref 3.N] that drainage paths in the existing foundation are maintained.*

*NOTE 2 Maintaining drainage paths can result in a thicker bound construction than is required to meet the design traffic. This can be significant where an overlay is applied to strengthen or reprofile the existing pavement.*

3.9.1 The total thickness of the bound materials for the widened pavement should match those of the existing pavement.

*NOTE 1 Bound materials in clause 3.9.1 excludes bound materials in the foundation.*

*NOTE 2 Where it is required to provide increased load carrying capacity for the additional lane(s), this can be achieved using stiffer binder and base materials than the existing pavement.*

*NOTE 3 Where the design thickness for the widened pavement is greater than the existing pavement, drainage paths can be maintained by applying an overlay to the existing pavement.*

3.9.2 Where the new and existing construction cannot be adequately matched due, for example, to the use of different forms of construction or materials, the use of drainage layers and adjustments to crossfall may be required to ensure water is not trapped beneath the pavement.

*NOTE Information on crossfall and other surface drainage factors for wide carriageways is contained in CG 501 [Ref 1.I].*

3.9.3 Where the requirements to match bound layer thickness and to achieve design life cannot both be achieved, the Overseeing Organisation should be consulted.

3.10 Where on-line widening of an existing rigid pavement is being undertaken using a tied-in design, the thermal expansion coefficient of the coarse aggregate used in the new material shall not be more than $5.5 \times 10^{-6}$ per °C different to those in the existing pavement.

3.11 Where on-line widening of an existing jointed rigid pavement (URC or JRC) is being undertaken, this shall not be undertaken using a continuously reinforced concrete construction (CRCP or CRCB).

*NOTE 1 It is not possible to tie the two construction types to provide satisfactory edge and corner support while accommodating relative movement due to thermal effects.*

*NOTE 2 When widening an existing jointed rigid pavement, there are advantages in providing continuity across the carriageway by using the same form of construction as a base layer, prior to receiving an asphalt overlay.*

## Upgrading

3.12 The design of upgraded pavements shall be in accordance with CD 227 [Ref 4.N].

# 4. Alternative design procedures

4.1 This section sets out the requirements that shall be followed for the design of a new pavement using alternative design procedures.

*NOTE Alternative pavement designs are designs not covered by Section 2 of this document and normally use analytical methods to model the stresses and strains and assumed material properties to determine design thicknesses.*

4.2 All alternative designs shall require 'departure from standard' approval by the Overseeing Organisation.

4.3 The foundation shall be designed in accordance with CD 225 [Ref 3.N].

4.4 Where designing a pavement for a new carriageway, the design life shall be 40 years.

4.5 Where designing a pavement for a new carriageway, all lanes, including the hard shoulder and lay-bys, shall be constructed to carry the design traffic in the heaviest loaded lane (commonly the left hand lane) as calculated in accordance with CD 224 [Ref 13.N].

4.6 The minimum design traffic for new roads shall be 1 msa, as calculated in accordance with CD 224 [Ref 13.N].

4.7 The surface course shall be designed in accordance with CD 236 [Ref 10.N].

4.8 Where an alternative design is proposed, the pavement design report shall include a justification for the choice and an indication of any additional specification requirements or testing regime necessary for their validation.

*NOTE Requirements for the pavement design report are set out in Section 6 of this document.*

## Analytical pavement design

4.9 The steps that shall be followed when undertaking an analytical pavement design are as follows:

1) determine the pavement life requirement in terms of traffic loading (msa) using CD 224 [Ref 13.N];
2) determine the available and permitted pavement materials and design types;
3) estimate the in situ dimensions and long-term performance properties (stiffness and/or strength) of each individual layer of pavement material;
4) carry out a structural analysis using a simplified multi-layer linear elastic model of the pavement structure;
5) compare critical stresses/strain and/or deflections with allowable values;
6) make adjustments to in situ dimensions and long-term performance properties until the pavement life requirement is achieved; and,
7) calculate the embodied carbon compared to that of a standard design.

*NOTE 1 Critical stresses/strains used in the standard UK design approach include excessive stresses/strains (combination of magnitude and number of load application) causing fatigue cracking (typically at the bottom of the base layer) of the asphalt, HBGM or concrete material.*

*NOTE 2 Principles for alternative flexible pavement designs are set out in TRL 615 [Ref 2.I].*

*NOTE 3 Principles for alternative rigid pavement designs are set out in TRL RR 87 [Ref 6.I] (for jointed concrete pavements) or TRL 630 [Ref 9.N] (for continuously reinforced concrete pavements).*

4.10 The analysis method used to model the pavement response and to calculate critical stresses and strains shall employ elastic multi-layer analysis based on Burmister's equations described in Burmister [Ref 12.N] with all layers modelled linearly including an infinite depth foundation.

*NOTE All new pavements are constructed to behave as a monolithic block, assuming complete bond between layers.*

4.11 For asphalt materials, the elastic stiffness moduli used for pavement design shall be the long-term stiffnesses determined at the reference condition of 20ºC and 5 Hz.

*NOTE* *These conditions are not the same as those used for indirect tension testing (IT-CY) testing which uses the lower frequency of 2.5 Hz. Results for the two sets of conditions are not interchangeable.*

4.12 Unless reliable data is available that indicates a divergence from these figures, the values of long-term elastic stiffness modulus for the following standard UK asphalt materials that shall be used in analytical design (at 20ºC) are shown in Table 4.12.

**Table 4.12 Elastic stiffness moduli for standard UK asphalt materials (at 20 degC and 5 Hz)**

| Material | Stiffness (MPa) |
| --- | --- |
| TSCS | 2000 |
| HRA binder course | 3100 |
| AC 40/60 des (binder course or base) | 4700 |
| EME2 (binder course or base) | 8000 |

**Materials**

4.13 Where the use of non-standard materials is proposed, the design shall clearly address how the material properties assumed in the design are to be achieved in situ.

*NOTE 1* *Non-standard materials are those not included in Section 2 of this document as permitted materials.*

*NOTE 2* *Proprietary materials cannot be specified in a design.*

*NOTE 3* *Factors that can affect pavement performance include:*

1) *durability of the pavement structure (such as resistance of the materials to the deleterious effects of water, air and other environmental factors);*
2) *serviceability (such as skidding resistance and permanent deformation);*
3) *maintainability (such as reflection cracking in composite pavements, and surface initiated fatigue cracking in thicker/long-life pavements); and,*
4) *construction tolerances (allowable construction thickness reductions to be added to the minimum analytical design thickness).*

4.14 For non-standard bound materials, the properties to be characterised shall include:

1) effective stiffness modulus;
2) deformation resistance (asphalt);
3) fatigue resistance (asphalt); and,
4) strength (HBGM).

*NOTE* *Properties can be tested in various ways depending on the nature of the material and the properties required in relation to the needs of the design.*

## Continuously reinforced concrete pavements (CRCP and CRCB)

4.15 Where designing an alternative CRCP or CRCB pavement, the design shall be based on the principles set out in TRL 630 [Ref 9.N].

4.16 Where designing a CRCP or CRCB pavement, the longitudinal reinforcement value of 900 $mm^2$/m width is the maximum value that shall be used for design calculations, despite the pavement containing more reinforcement than this.

*NOTE* *This design limit is explained in TRL 630 [Ref 9.N].*

# 5. Use of cold recycled base materials

## Alternative design using cold recycled base materials

5.1 The surface course for all pavements incorporating cold recycled base materials shall be designed in accordance with CD 236 [Ref 10.N].

### Cold recycled designs using TRL report 611

5.2 Pavement designs containing cold recycled base material shall only be used for a design traffic of 30 msa or less.

5.3 The design method shall be in accordance with the process set out in TRL report TRL 611 [Ref 1.N].

5.4 Where the design incorporates a hydraulic binder, the design shall specify the permitted minimum and maximum strengths of the recycled material.

5.5 Where an HBGM layer is designed to reach a compressive strength of 10 MPa at 7 days, it shall have cracks at a maximum spacing of 5 m induced in accordance with Clause 818 of MCHW Series 0800 [Ref 7.N].

5.6 The minimum thickness of bituminous surface course shall be 20 mm provided that a compensating increase in the thickness of the cold recycled base following is made as described in Equation 7.5 of TRL report TRL 611 [Ref 1.N].

*NOTE 1 The minimum thickness replaces those in Table 7.3 of TRL report TRL 611 [Ref 1.N].*

*NOTE 2 Polymer fibres and rubberising additives can be incorporated into the surface course to delay the onset of reflective cracking if an hydraulic binder has been used.*

### Deep in-situ recycling: the down cut process

5.7 Alternative designs utilising the down cut process shall require departure from standard approval by the Overseeing Organisation.

5.8 A detailed pavement investigation shall be carried out, including recovery of cores at 100-m intervals and bulk samples, before design can be carried out, to provide:

1) depths and types of bound materials present; and,
2) samples of materials for laboratory design.

5.9 A separate design shall be carried out for each area where the existing construction thickness or material types vary.

5.10 The existing surface course shall be planed out and stockpiled.

5.11 Only bound layers shall be recycled.

5.12 Materials shall be recycled to depths of between 100 mm and 300 mm below the existing surface layer.

*NOTE The pulverising drum can operate down to 450 mm but complete compaction of the recycled material to this depth can be difficult to attain.*

5.13 The recycling mixture design shall determine the amount of hydraulic binder, bituminous binder and water to be added during the recycling process to achieve an indirect tensile stiffness modulus between 3.1 GPa (min) and 6.5 GPa (max).

5.14 The design shall be carried out using bulk samples that have been crushed using a pulveriser identical to that to be used on site.

5.15 A water-resisting layer below the surface course, complying with Clause 929 asphalt concrete, Clause 930 EME2 or Clause 943 performance related HRA, laid on a bond coat complying with Clause 920 of MCHW Series 0900 [Ref 8.N], shall be applied on top of the compacted recycled material prior to installation of a surface course.

### Ex-situ recycling

5.16 The design process shall assume that the recycled material has a minimum stiffness equivalent to Class B3 materials complying with Clause 948 of MCHW Series 0900 [Ref 8.N].

5.17 The design shall specify the type of recycled material to be produced from Table 5.17.

**Table 5.17 Types of recycled material**

| Type | Primary binder |
|---|---|
| Quick hydraulic | Cement as the main component and excluding bituminous binders. |
| Slow hydraulic | Hydraulic binders (such as PFA/lime and GBS/lime) excluding bituminous and Portland cement. |
| Quick viscoelastic | Bituminous binder as the main component but also including Portland cement. |
| Slow viscoelastic | Bituminous binder as main component but excluding Portland cement. |

5.18 All recycled materials shall be mixed in a plant with additional binder, aggregates and other additives and comply with the requirements of Clause 948 of MCHW Series 0900 [Ref 8.N].

# 6. Pavement design verification

6.1 Where pavement design verification is required by the Overseeing Organisation, the requirements set out in the appropriate National Application Annex shall be followed.

*NOTE Pavement design verification can involve production of a pavement design report or the need to follow an alternative design checking procedure.*

# 7. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Transport Research Laboratory. Merrill, D et al. TRL 611, 'A guide to the use and specification of cold recycled materials for the maintenance of road pavements ' |
| Ref 2.N | Highways England. CD 127, 'Cross-sections and headrooms' |
| Ref 3.N | Highways England. CD 225, 'Design for new pavement foundations' |
| Ref 4.N | Highways England. CD 227, 'Design for pavement maintenance' |
| Ref 5.N | Highways England. CD 239, 'Footway and cycleway pavement design' |
| Ref 6.N | National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 7.N | Highways England. MCHW Series 0800, 'Manual of Contract Documents For Highway Works. Volume 1 Specification for Highway Works. Series 800 Road Pavements — Unbound, Cement and Other Hydraulically Bound Mixtures' |
| Ref 8.N | Highways England. MCHW Series 0900, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 900 Road Pavements – Bituminous Bound Materials.' |
| Ref 9.N | TRL. Hassan, KE et al. TRL 630, 'New continuously reinforced concrete pavement designs' |
| Ref 10.N | Highways England. CD 236, 'Surface course materials for construction' |
| Ref 11.N | BSI. BS EN 12390-5, 'Testing hardened concrete. Flexural strength of test specimens' |
| Ref 12.N | American Institutue of Physics, Journal of Applied Physics, Vol 23, pp 126-128. Burmister, DM. Burmister, 'The General Theory of Stresses and Displacements in Layered Soil Systems III' |
| Ref 13.N | Highways England. CD 224, 'Traffic assessment' |

# 8. Informative references

The following documents are informative references for this document and provide supporting information.



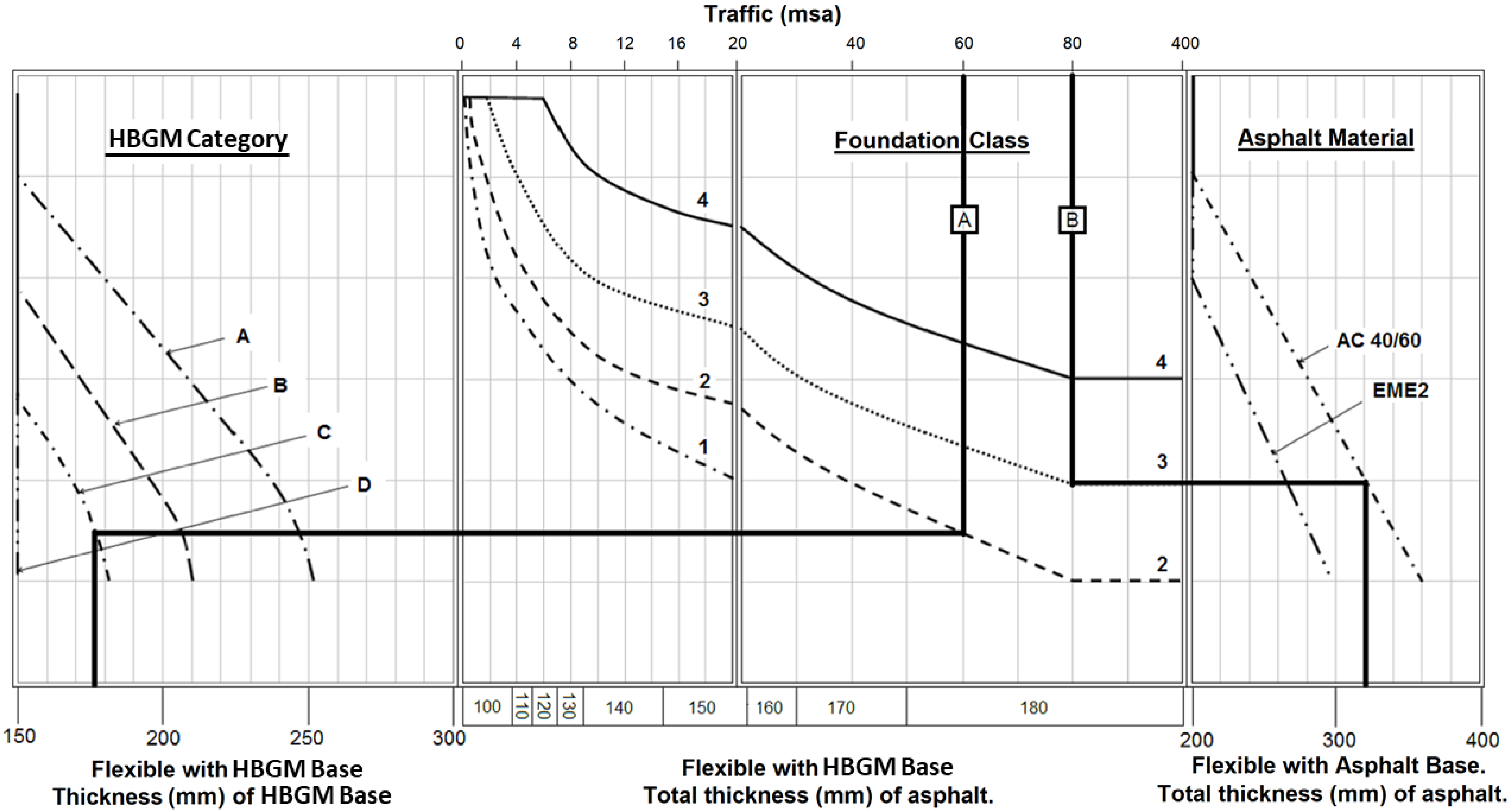
| | |
|---|---|
| Ref 1.I | Highways England. CG 501, 'Design of highway drainage systems' |
| Ref 2.I | TRL. Nunn, M. TRL 615, 'Development of a more versatile approach to flexible and flexible-composite pavement design' |
| Ref 3.I | BSI. BS 9227, 'Hydraulically bound materials for civil engineering purposes. Specification for production and installation in pavements' |
| Ref 4.I | Highways England. MCHW HCD Series C, 'MCHW Volume 3: HCD Section 1 Series C - Concrete Carriageway' |
| Ref 5.I | AECOM Pavement and Materials Team. Abouabid M, Casey D & Jones M. Abouabid et al, 'Roller Compacted Concrete - Background to the Development of Highways England's Design Guidance and Specification' |
| Ref 6.I | Transport Research Laboratory. Mayhew, HC & Harding, HM. TRL RR 87, 'Thickness design of concrete roads' |

# Appendix A. Worked examples

## A1 Standard flexible pavement design using Figure 2.20

Figure A.1 reproduces Figure 2.20, annotated to show two examples for the design of flexible pavements.

**Figure A.1 Nomograph for determining the design thickness for flexible pavements**



### A1.1 Example "A": flexible pavement with an HBGM base

Design factors:

1) design traffic = 60 msa;
2) foundation stiffness class 2.

Using Figure 2.20 (reproduced as Figure A.1) and with HBGM category C base material:

Total asphalt thickness of 180 mm asphalt (surface course, binder course and base), over

180 mm HBGM Category C (rounded up to the nearest 5 mm).

Note: Table 2.23N2 gives HBGM Category C options e.g.a Clause 822 CBGM 1 with laboratory performance category C12/16 (or T4). Laboratory performance categories are detailed in MCHW Series 0800 [Ref 7.N].

### A1.2 Example "B": flexible pavement with an asphalt base

Design factors:

1) design traffic >80 msa (that is, 'long life' pavement);
2) foundation stiffness class 3.

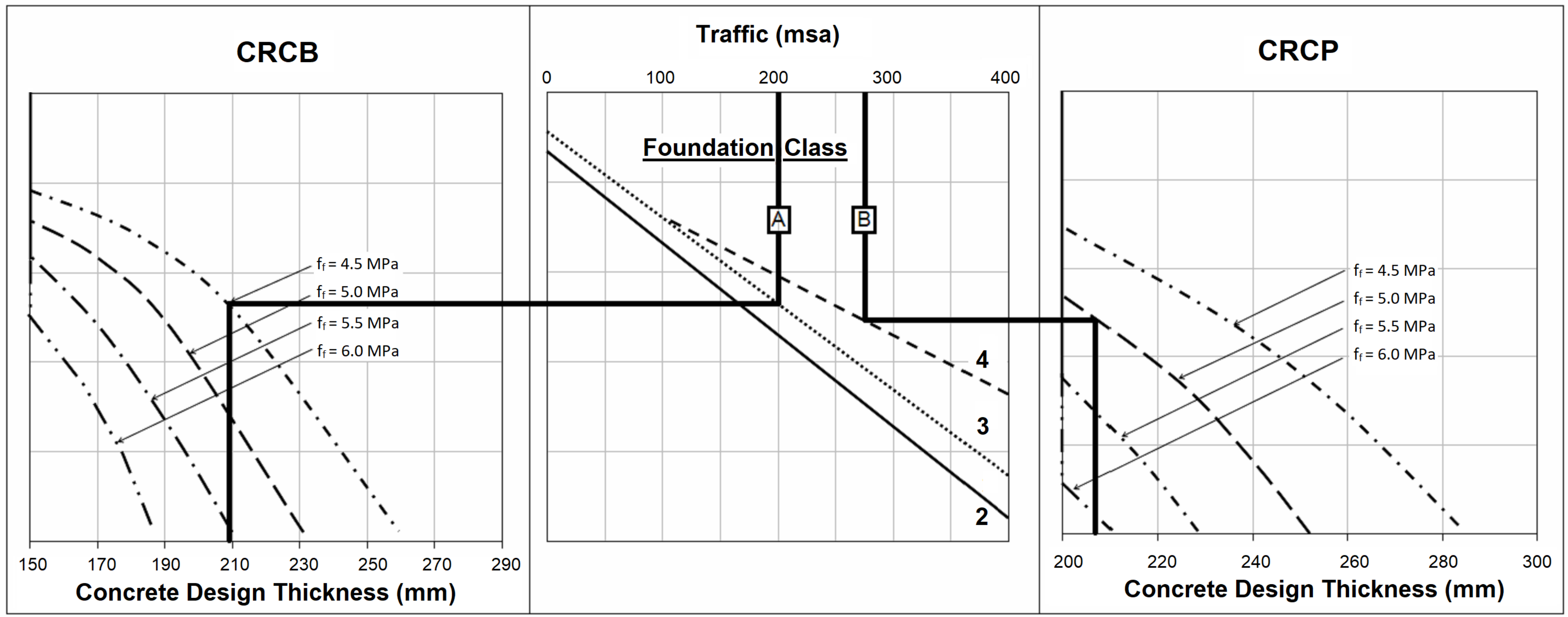
Using Figure 2.20 (reproduced as Figure A.1) and with AC 40/60 selected as the binder and base material:

Total asphalt thickness of 320 mm (surface course, AC 40/60 binder course and AC 40/60 base).

## A2 Standard rigid (CRCP and CRCB) pavement design using Figure 2.26

Figure A.2 reproduces Figure 2.26, annotated to show two examples for the design of rigid pavements.

Figure A.2 Nomograph for determining concrete layer design thickness for continuously reinforced concrete pavements (CRCB and CRCP)



**A2.1 Example "A": CRCB**

Design factors:

1) design traffic of 200 msa;
2) foundation stiffness class 3;
3) design uses concrete with a flexural strength of 4.5 MPa and a 1-m edge strip.

Using Figure 2.26 (reproduced as Figure A.2) and with concrete with a flexural strength of 4.5 MPa:

100 mm asphalt, over

210 mm of concrete (with a tied shoulder or 1-m edge strip).

Note: All CRCB designs require 100 mm asphalt.

Note: CRCB designs require T12 longitudinal reinforcement at 0.4%. The spacing of the T12 longitudinal reinforcement can be calculated using Equation 2.30N3 (reproduced as Equation A.2):

**Equation A.1 Maximum spacing of steel reinforcement**

$$s = \frac{100\pi D^2}{4tR}$$

where:

| | |
|---|---|
| s | is the maximum distance, centre to centre, between bars across the width of the slab (mm) |
| D | is the diameter of reinforcement bar (mm) |
| R | is the level of reinforcement (% of the cross section area) |
| t | is the concrete design thickness (mm). |

Using Equation A.2, the reinforcement spacing is:

$\frac{100 \cdot \pi \cdot 12^2}{4 \cdot 210 \cdot 0.4} = 135$ mm

**A2.2 Example "B": CRCP**

Design factors:

1) design traffic of 275 msa;
2) foundation class 4;
3) design uses concrete with a flexural strength of 5.0 MPa and no edge strip or tied shoulder;
4) asphalt TSCS surfacing.

Using Figure 2.26 (reproduced as Figure A.2) and with concrete with a flexural strength of 5.0 MPa:

30 mm asphalt surfacing, over

210 mm + 30 mm = 240 mm of a 5.0 MPa flexural strength concrete (without a tied shoulder or 1-m edge strip).

NOTE: CRCP designs require T16 longitudinal reinforcement at 0.6%. The spacing of the T16 longitudinal reinforcement using Equation 2.30N3 (reproduced as Equation A.2) is:

**Equation A.2 Example equation for reinforcement spacing**

$$\frac{100 \cdot \pi \cdot 16^2}{4 \cdot 240 \cdot 0.6} = 140mm$$

## A3 RCC design using multi-layer linear elastic analysis and Equation 2.40N4

Using linear elastic modelling, a standard 40-kN wheel load with a contact radius of 0.151 m and the pavement material properties in Table A.1 results in a tensile stress at the bottom of the RCC layer of 1.10 MPa.

**Table A.1 Material properties for RCC design example**

| Layer description | Thickness (mm) | Stiffness (MPa) | Poisson's ratio |
|---|---|---|---|
| TSCS | 40 | 2000 | 0.35 |
| HRA binder course | 50 | 3100 | 0.35 |
| RCC | 180 | 50,000 | 0.2 |
| Foundation (class 3) | $\infty$ | 200 | 0.35 |

Using Equation 2.40N4:

Stress ratio (= induced tensile stress / RCC flexural strength) = 0.220.

Design life (msa) =

**Equation A.3 RCC design life equation example**

$$e^{\frac{0.220-0.9157}{-0.039}}/10^6 = 56msa$$

## A4 Rigid (JRC) pavement design for widening of an existing pavement using Equations 2.46a and 2.46b

Design factors:

1) design traffic of 130 msa;
2) foundation class 3;
3) reinforcement 500 mm$^2$/m;
4) aggregate has a coefficient of thermal expansion less than 10 x 10$^{-6}$ per $^{o}$C;
5) concrete has a mean compressive cube strength of 50 N/mm$^2$.

Using Equation 2.46a:

Design thickness of JRC slab is 285 mm (without a tied shoulder or 1-m edge strip).

The transverse joint spacing (using Table 2.48) is 25 m which may be increased by 20% to 30 m.

Using Equation 2.46b:

Design thickness of JRC slab is 255 mm (with a tied shoulder or 1-m edge strip).

The transverse joint spacing (using Table 2.48) is 25 m which may be increased by 20% to 30 m.

# Notification

This document was notified in draft to the European Commission in accordance with Technical Standards and Regulations Directive 2015/1535/EU.

Pavement
Design

# CD 226
# England National Application Annex to CD 226 Design for new pavement construction

(formerly HD 26/06, HD 27/15)

Version 1.0.0

**Summary**
This National Application Annex gives the National Highways-specific requirements for the design of pavement construction for new build carriageways, widening of existing carriageways, or reconstruction of existing pavements on the UK motorway and all-purpose trunk road network.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated National Highways team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 226 | **1**.0.0 | November 2021 | England NAA | Change to policy, major revision, new document development |
| New sections on whole life cost method, traffic delay costs plus corresponding appendices added. Terms, definitions and abbreviations updated. | | | | |

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 226 | 0 | March 2020 | | |

# Foreword

## Publishing information

This document is published by National Highways.

This document supersedes HD 26/06 and HD 27/15, which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the National Highways-specific requirements for the design of pavement construction for new build carriageways, widening of existing carriageways, upgrading of existing pavements or reconstruction of existing pavements on the UK motorway and all-purpose trunk road network.

Specifically, it covers the requirements for the reporting and certification requirements for pavement designs.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 5.N] apply to this document.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a "British Standard" or other technical specification, that requirement may be met by compliance with the mutual recognition clause in GG 101 [Ref 5.N].

# Abbreviations

| Abbreviation | Definition |
|---|---|
| AADF | Annual average daily flow (1-way traffic) |
| AADT | Annual average daily traffic (2-way traffic) |
| CRDc | Capacity-related delay in closure conditions |
| CRDn | Capacity -elated delay in normal conditions |
| DC | Direct costs |
| DF | Discount factor |
| DTc | Drive time in closure conditions |
| DTn | Drive time in normal conditions |
| EF | Economic factor |
| EV | Equivalent value |
| HBGM | Hydraulically bound granular mixtures |
| HGV | Heavy goods vehicle |
| IC | Indirect costs |
| NPSV | Net present service value |
| PCF | Project control framework |
| RV | Residual value |
| TSCS | Thin surface course system |
| TTM | Temporary traffic management |
| TVD | Total vehicle delay |
| VC | Vehicle cost (per hour) |
| VCS | Visual condition survey |
| WLC | Whole life cost |

# Terms and definitions

| Term | Definition |
|---|---|
| Analysis period | period over which the life-cycle cost appraisal is to be undertaken. Normally 60 years |
| Pavement design option | pavement design selected for inclusion in the analysis |
| Direct costs | this is the direct cost of undertaking planned maintenance activities on site |
| Discounting | discounting is a technique used to compare costs (and benefits) that occur at different times throughout the analysis period. It works by adjusting these future costs (and benefits) to their present-day values. This enables competing pavement design options to be compared on a common basis |
| Discount rate | the rate at which future costs are discounted to the present value year. This is set by Government and can be found in the Green Book produced by HM Treasury at the time of writing. (See Green Book [Ref 10.N]) |
| Discounted residual value | present-day value of the asset at the end of the analysis period |
| Discounted direct costs | present-day cost of all future maintenance activities. It provides a basis for comparing alternative pavement design options by indication of the level of investment that will be required to meet future expenditure |
| Hard strip | a surfaced strip that abuts the carriageway to provide additional paved width, often in the absence of a hard shoulder |
| Indirect costs | these costs are not borne by National Highways. These are costs incurred by road users, the public and industry during the asset's lifetime |
| Life-cycle plan | a plan for managing a pavement comprising a schedule of all construction, routine maintenance, inspection, and maintenance activities together with associated costs on a pavement over the analysis period. After a number of alternatives have been appraised in accordance with this document the life-cycle management plan is the outcome for the preferred option |
| Maintenance activity | individual maintenance activity undertaken to a pavement in a particular year, which may include works, inspection or monitoring |
| Narrow width widening | where additional carriageway of less than a full lane width is constructed to abut the existing carriageway |
| Net present service value | the whole life cost of maintaining the asset throughout the analysis period. It is the sum of the discounted costs minus the discounted residual value |
| Preliminaries | pavements share of preliminaries costs for the construction contract including site establishment and accommodation |
| Residual value | the value associated with the pavement asset condition at the end of the analysis period |

(continued)

| | |
|---|---|
| Scheme or project | a plan or arrangement that includes the construction of a new pavement asset or undertaking of activities to upgrade or replace elements of the existing pavement asset |
| Serviceable life | the remaining life in the pavement design option at the end of the analysis period |
| Unit cost | this is the cost per unit measure (number/length/area/volume) to maintain the pavement asset or part of the asset |
| Whole life cost | summation of all the costs incurred in the construction and maintenance of an asset over the evaluation period |
| Works duration | time in days that a particular inspection, maintenance, or construction activity could take |

# E/1. Pavement design verification

## Pavement design report (CD 226, 6.1)

E/1.1 A pavement design report shall be produced for all designs developed under National Highway's PCF.

*NOTE 1 The report can be used by National Highways to review the proposed designs and assess their appropriateness.*

*NOTE 2 The information in the report can be used to support the application for any departures from standard.*

*NOTE 3 The content of the pavement design report depends on the nature and complexity of the designs.*

E/1.2 The pavement design report shall:

1) be produced at the preliminary design stage (PCF stage 3);
2) be a live document until it is finalised at the construction preparation stage (PCF stage 5); and,
3) at each stage of its production, be submitted along with a pavement design certificate appended.

*NOTE 1 It is not anticipated that draft contract specific appendices will be submitted with a pavement design report until the final design option has been selected (PCF stage 5).*

*NOTE 2 Any changes made at the construction stage (PCF stage 6) are beyond the scope of this procedure and are captured and recorded as part of the PCF process.*

### Pavement design report

E/1.3 For standard designs, for a new pavement or the widening of an existing pavement, the pavement design report shall include the following information:

1) scheme details;
2) the range of standard designs identified as options;
3) technical justification for why particular designs were rejected as options (where appropriate);
4) interpretation of the current condition of the pavement or the adjacent pavement (where appropriate);
5) detailed design traffic calculations;
6) foundation design outputs (for each foundation design) including any assumptions made;
7) details of the design thicknesses and materials proposed for each design option identified;
8) details of the surfacing proposed (including aggregate properties);
9) details and results of the whole life cost analysis;
10) a recommendation for the preferred design option with justification for its selection;
11) any proposed departures from standard; and,
12) outline how DMRB GG 103 [Ref 4.N] 'Introduction and general requirements for sustainable development and design' has been implemented in the design.

E/1.4 For designs for new pavements undertaken using alternative design procedures, the pavement design report shall include the following information:

1) scheme details;
2) the range of designs considered;
3) technical justification for why standard designs described in Section 2 of CD 226 [Ref 2.N] were rejected as options (if appropriate);
4) interpretation of the current condition of the pavement or the adjacent pavement (where appropriate);
5) detailed design traffic calculations;
6) foundation design calculations (for each foundation design proposed) including any assumptions made;

7) for each design option proposed:
   a) comparisons with other published designs, especially from countries with similar trafficking levels, climatic conditions and material properties to the UK (if appropriate);
   b) material properties assumed and supporting information, for examples from in situ or laboratory testing, or published data;
   c) details of the pavement design approach used and any assumptions, including failure mechanisms, made in the design;
   d) experience of long-term performance of similar pavements, both in the UK and overseas;
   e) details of the analysis software/model used;
   f) details of the design thicknesses and materials proposed (including calculations);
   g) sensitivity analysis to identify the parameters that have most influence on life;
   h) details of the surfacing proposed (including aggregate properties);
   i) procedures to be adopted on site to reduce the variability of pavement construction, in particular the most influential parameters identified from the sensitivity analysis;
   j) details of end performance test procedures proposed to ensure that the mean and minimum properties of materials assumed in the design, are achieved on site;
8) details and results of the whole-life cost analysis;
9) a recommendation for the preferred design option with justification for its selection;
10) any proposed departures from standard; and,
11) outline how DMRB GG 103 [Ref 4.N] 'Introduction and general requirements for sustainable development and design' has been implemented in the design.

**Pavement design certificate**

E/1.5 The pavement design certificate shall contain the information and be certified as set out in the template shown in Table E/1.5.

**Table E/1.5 Pavement design certificate template**

| Pavement design certificate | |
|---|---|
| PCF Stage: | |
| Scheme name: | |
| Scheme details: | |
| Certificate version number: | |
| Certificate version date: | |
| A. We certify that the reports*, design data*, drawings* and/or other documents* for the pavement design activities listed below have been prepared by us with reasonable professional skill, care and diligence, and that in our opinion:<br>1) constitute an adequate and economic design for the project;<br>2) the work intended is accurately represented and conforms to National Highways' requirements;<br>3) has been prepared in accordance with the relevant standards from the Design Manual for Roads and Bridges and the Manual of Contract Documents for Highways Works; and,<br>4) where departures from standards are being requested, these are detailed in the accompanying documents and are listed in "C" below. | |
| The design elements covered by this certificate are not detrimental to the design elements previously certified and not amended by this certificate.** | |

**Table E/1.5 Pavement design certificate template** (continued)

<table>
<tr><td colspan="2">Pavement design certificate</td></tr>
<tr><td colspan="2">B. List of reports, design data, drawings or documents submitted with this certificate:</td></tr>
<tr><td colspan="2">C. Details of departures from standards:***</td></tr>
<tr><td colspan="2">Authorisations</td></tr>
<tr><td colspan="2">D. Designer (Designer's Pavement Design Engineer)</td></tr>
<tr><td>Signed:</td><td>Designer (Designer's Pavement Design Engineer)</td></tr>
<tr><td>Name:</td><td></td></tr>
<tr><td>Date:</td><td></td></tr>
<tr><td>On behalf of:</td><td></td></tr>
<tr><td colspan="2">E. National Highways Pavement Engineering Adviser****</td></tr>
<tr><td colspan="2">This Certificate (and the submission accompanying the certificate) is:<br>(a) received*:<br>(b) received with comments as follows*:<br>(c) returned marked with comments as follows*:</td></tr>
<tr><td>Signed:</td><td>National Highways Pavement Engineering Adviser</td></tr>
<tr><td>Name:</td><td></td></tr>
<tr><td>Date:</td><td></td></tr>
</table>

*NOTE 1* ** Delete as appropriate.*

*NOTE 2* *** This statement is only to be included where the certificate is accompanying a revision to design data that has already been certified.*

*NOTE 3* **** List any departures from relevant standards. If none write "none".*

*NOTE 4* ***** Section E to be completed by National Highways pavement engineering adviser including comments on the submission and any amendments or revisions expected before resubmission.*

*NOTE 5* *'received' = submission accompanying the certificate is accepted.*

*NOTE 6* *'received' with comments = submission accompanying the certificate is generally acceptable but requires amendment.*

*NOTE 7* *'returned marked with comments' = submission accompanying the certificate is unacceptable and requires revision before resubmitting.*

E/1.6 The pavement design engineer authorising the certificate (Section D) shall be a certified pavement engineer.

*NOTE* *Details of how to attain certified pavement engineer status are available from National Highways.*

# E/2. Whole life cost (WLC) (additional to CD 226)

## Pre-WLC screening criteria

E/2.1 When constructing a new carriageway, widening an existing carriageway, upgrading an existing pavement or reconstructing an existing pavement on England's motorway and all-purpose trunk road network, designs shall be carried out using a minimum of three options covering the range of pavement types from the "standard designs" described in CD 226 [Ref 2.N].

E/2.2 The design options shall include flexible with an asphalt base, flexible with an hydraulically bound granular mixture (HBGM) base and at least one type of rigid pavement.

E/2.2.1 Technical justification should be provided if a particular pavement type is to be excluded from the analysis.

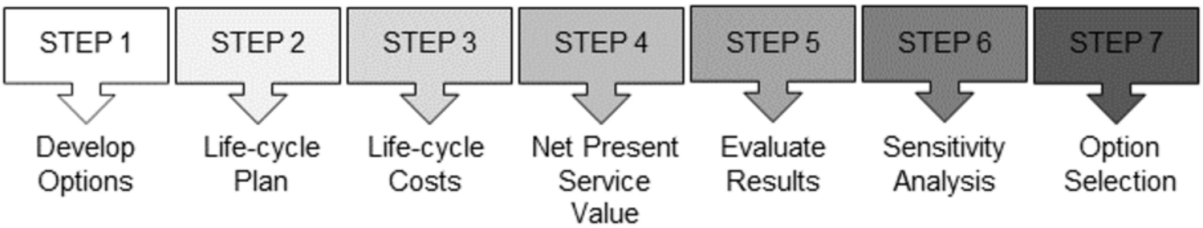
*NOTE 1 Where there is only one clear design option for pavement improvement works (for example, hard strip widening) a WLC analysis is not necessary. Where design options are available for narrow widening a WLC analysis is necessary (for example to compare the use of wet lean concrete with a tied-in design).*

*NOTE 2 Whole life costing is only one factor when selecting a preferred design option. Other factors such as engineering judgement, network operations, affordability, compatibility, buildability, sustainability, environment and risk management also require identification and assessment for the design throughout the analysis period.*

## WLC procedure

E/2.3 The preferred pavement design option shall be determined by an appraisal following the steps outlined in Figure E/2.3.

**Figure E/2.3 WLC Procedure**




**Step 1 - Develop options**

E/2.4 The pavement design options that have passed the prescreening criteria shall be analysed.

E/2.5 Each design shall be clearly described and highlighted as part of the design report.

E/2.6 Valid pavement design options shall explore a range of pavement types and materials meeting the requirements of CD 226 [Ref 2.N] and MCHW Series 0800 [Ref 7.N], MCHW Series 0900 [Ref 8.N] or MCHW Series 1000 [Ref 6.N] where appropriate.

**Step 2 – Life-cycle plan**

E/2.7 For each of the options identified in Step 1, a maintenance life-cycle plan shall be produced.

E/2.8 The analysis period shall be for a period of no less than 60 years in accordance with WebTAG Unit A1-1 [Ref 1.N].

E/2.9 The same analysis period shall be used for all design options.

E/2.10 Maintenance activities that shall be included in the life-cycle plan are those expected to be required during the life of the pavement asset, including:

1) routine maintenance (such as sealing or filling of cracks, local pothole repairs);

2) periodic maintenance (such as renewal of road markings and road studs);
3) renewal (such as replacement of surface, binder or base layers); and,
4) reconstruction (that is to design and construct an entire new pavement).

E/2.11 Costs of procuring technical surveys and investigations in accordance with CD 227 [Ref 3.N] shall also be included in the life-cycle plan.

E/2.11.1 The timing, costs and work duration of each of the activities for each of the pavement design options should be estimated.

E/2.11.2 Justifications should be given for the values chosen to show why they are appropriate for that scheme.

E/2.11.3 When modelling future maintenance interventions, historical maintenance records and experience with similar materials performance should be used to inform potential maintenance activities to be included in the life-cycle plan.

E/2.11.4 Any scheme specific requirements that impact on future maintenance activities should be recorded, that is if special temporary traffic management (TTM) arrangements are needed.

*NOTE Future maintenance interventions vary depending upon the type of pavement, materials used, construction details, time of year and the quality of construction.*

E/2.12 A life-cycle plan showing future maintenance activities, timings and preliminaries shall be produced for each pavement design option using the template in Appendix Table E/B.2.

*NOTE 1 The monetary values used for examples in the appendices are not based on true unit costs.*

*NOTE 2 Although other (non-pavement) works need not be explicitly included in the analysis, it is expected that the works associated with the timing of current work and future maintenance activities are taken into account when developing the life-cycle plan for each design option.*

E/2.13 The life-cycle plan for the recommended pavement design option shall be included in the pavement design report.

*NOTE It is important that accurate usable survey/condition data is obtained prior to developing pavement design options and undertaking the whole life cost analysis. Changes to the pavement design, details or materials required to overcome difficulties encountered on site can have a significant impact on the whole life cost of the pavement.*

**Step 3 – Life-cycle costs**

E/2.14 Direct costs (DC), that is works costs, shall be estimated using current unit cost data relevant to the location/situation of the road.

E/2.15 Indirect costs (IC) such as user delay costs and temporary traffic management costs for all of the activities identified in Step 2 shall be estimated.

*NOTE How to calculate user delay and temporary traffic management costs is set out in subsequent sections.*

E/2.16 The construction and life-cycle costs of the pavement design options shall be compared to determine the most cost-effective solution.

E/2.17 All data and assumptions (for all pavement design options) shall be shown.

**Discounting**

E/2.18 All costs and benefits over the analysis period for each pavement design option shall be calculated using Equation E/2.22 using the discount factors (DF) applied in accordance with the Green Book [Ref 10.N].

E/2.19 The discounting of all future costs and the discount rates that shall be applied are contained in the Green Book [Ref 10.N].

E/2.20 Discounting costs when a single discount rate applies (years 1 to 30 at time of writing) shall be calculated using Equation E/2.20.

**Equation E/2.20 Calculation of discount factor when a single discount rate applies**

$$DF = \frac{1}{\left(1 + \frac{r}{100}\right)^{n}}$$

where:

| | |
|---|---|
| n | is the year discount factor is to be applied |
| r | is the discount rate (in percent) |

E/2.21 Discounting costs when two discount rates apply in the analysis year shall be calculated using Equation E/2.21.

**Equation E/2.21 Calculation of discount factor when two discount rates apply in the anlaysis year**

$$DF = \frac{1}{\left(1 + \frac{r}{100}\right)^{n}} \times \frac{1}{\left(1 + \frac{r}{100}\right)^{n}}$$

*NOTE Example: Year 45 of the analysis period; years 1 to 30 have a discount rate of 3.50% and years 31 – 60 have a discount rate of 3.00%*

**Equation E/2.21N Example equation where two discount rates apply in the analysis year**

$$DF = \frac{1}{\left(1 + \frac{3.50}{100}\right)^{30}} \times \frac{1}{\left(1 + \frac{3.00}{100}\right)^{15}} = 0.2287$$

E/2.22 Discounted direct and indirect costs shall be calculated using Equation E/2.22

**Equation E/2.22 Calculation of discounted costs (direct and indirect)**

$$\text{discounted cost} = \text{cost}(DC \quad \text{or} \quad IC) \times DF$$

where:

| | |
|---|---|
| cost | is the sum of the costs incurred during the analysis year |
| DC | is direct cost |
| IC | is indirect cost |
| DF | is the discount factor |

E/2.22.1 It should be made clear in the analysis if the costs at the start of the analysis period (in the base year) are n = 1 or n = 0. If the base year costs are not discounted, then n = 0 in that year and n = 1 is the first year of trafficking.

**Step 4 – Net present service value (NPSV)**

E/2.23 The NPSV of each pavement design option shall be determined by using Equation E/2.23.

**Equation E/2.23 Calculation of NPSV**

$$\sum NPSV = \sum DC_{\text{discounted}} + \sum IC_{\text{discounted}} - RV_{\text{discounted}}$$

where:

| | |
|---|---|
| $DC_{\text{discounted}}$ | is the discounted direct costs incurred over the analysis period |
| $IC_{\text{discounted}}$ | is the discounted indirect costs over the analysis period |
| $RV_{\text{discounted}}$ | is the discounted residual value at the end of the analysis period |

*NOTE Whereas the direct costs (DC) and indirect costs (IC) included in the whole life costing process are expenditures, residual value is instead regarded as a benefit (or income) when calculating the NPSV.*

E/2.24 To allow comparison between different pavement design options calculated within the analysis period and for the purposes of this document the residual value (RV) in £ shall be determined using Equation E/2.24.

**Equation E/2.24 Calculation for residual value**

$$RV = \frac{D_1}{D} \times \text{cost}$$

where:

| | |
|---|---|
| cost | is the cost of most recent pavement maintenance activity (in £) |
| D | is the design life (in years) |
| $D_1$ | is the remaining service life at the end of the analysis period (in years) |

*NOTE 1 This allows for an equal comparison between a scheme that leaves no serviceable life in the pavement to a scheme that intervenes just before the end of the analysis period leaving the pavement in good serviceable condition.*

*NOTE 2 Pavements designed to provide a service life of 40 years are deemed to be long-life pavements, and each maintenance activity prescribed throughout the life-cycle plan needs to assess what treatment is required in order to restore the design life to its original value.*

*NOTE 3 It is acknowledged that different running lanes will often have differing remaining service lives at the end of the analysis period, due to the variation of traffic type and maintenance activities. It is acceptable to base the residual life for the purpose of this analysis on lane 1 only.*

E/2.25 The residual value of each pavement design option shall be calculated and the discount factor at the end of the analysis period applied using Equation E/2.25.

**Equation E/2.25 Calculation of discounted residual value**

$$RV_{\text{discounted}} = RV \times DF$$

**Step 5 – Evaluate results**

E/2.26 The pavement design option with the lowest WLC based on NPSV shall be regarded as the most economically beneficial pavement option.

**Step 6 – Sensitivity analyses**

E/2.27 The following input parameters can be subject to uncertainty and shall be included in the sensitivity analyses;

1) unit rates; and,
2) required timings and temporary traffic management (TTM) costs of predicted activities.

E/2.28 These input parameters shall be varied across all pavement design options developed as part of the design report in Step 1.

E/2.29 The life expectancy of equivalent pavement surfaces shall be consistent for all pavement design options, showing all data and assumptions.

E/2.30 When undertaking this process only one input parameter should be varied at a time. The outcomes shall reveal:

1) whether the selection of a preferred pavement design option (based on lowest NPSV) is affected; and,
2) the likely variability in the resulting whole life cost of the preferred design option.

E/2.31 Variability represents a risk that needs to be managed. The effect of variability shall be assessed when selecting the preferred pavement design option with conclusions presented in the design report.

E/2.32 All assumptions made, and input parameter variations undertaken shall be documented and included in the pavement design report for the selected pavement design option.

**Step 7 – Option selection**

E/2.33 Step 5 shall be revisited when the outcome of any sensitivity analyses become available.

E/2.34 The data used in each pavement design option shall be presented using the example whole life cost summary sheet in Appendix Table E.B/1 to be included as part of the results of the analyses.

# E/3. Traffic delay costs

E/3.1 An assessment of traffic delay costs shall be undertaken throughout the analysis period for the pavement asset for the following:

1) the initial construction of the pavement; and,

2) the subsequent maintenance and renewal activities.

E/3.2 The TTM required for the initial construction or improvement activity shall be well defined.

*NOTE For subsequent life-cycle activities the temporary traffic management requirements and their duration can be less clear. Due to this lack of precision a sophisticated traffic delay analysis is not warranted in most cases.*

E/3.3 For future TTM arrangements, current practice shall be assumed for each intervention unless there is good reason for knowing methods and costs are likely to change and what they will change to.

E/3.4 The assessment of traffic delay costs shall be undertaken using a methodology that includes each of the following:

1) characteristics of the roads affected, that is the number of lanes, road type;

2) predicted traffic flows;

3) characteristics of the lane closures; and,

4) potential diversion routes.

E/3.4.1 Lane closures should represent the length closed, which can be longer than the length maintained, or shorter if the work is carried out in shorter part-lengths of the intervention, due to site geometry etc.

*NOTE The expected way of working also affects the costs (for examples, day/night/weekend working, lane closures/contraflow etc).*

E/3.5 The carriageways that are to be affected by the life-cycle activities shall be identified from the location and extent of the activity to be undertaken.

E/3.6 The annual average daily flow (AADF) or annual average daily traffic (AADT) traffic figures along with the year of the traffic data shall be given for the length of route that can be affected by the activities.

E/3.7 Traffic flows shall be determined from available sources.

*NOTE The primary source of AADT is http://webtris.highwaysengland.co.uk ( WebTRIS [Ref 1.I])*

E/3.8 AADT shall be converted into AADF assuming a 50:50 directional split, unless traffic counts or studies show a directional bias.

E/3.9 The impact of the life-cycle activities on the affected carriageways shall be assessed to determine:

1) the number of lanes available at pinch points which have the greatest potential to cause delay to traffic;
2) the length over which the restrictions apply;
3) any temporary speed limits;
4) length of diversion routes and probable speed of travel (if diversions applicable);
5) time of day (that is day or night closures); and,
6) day of the week.

*NOTE An example of an acceptable approach to calculating traffic delay costs is given in Appendix E/A. Where life-cycle activities for a pavement form part of a larger project for which a detailed analysis is required then the more detailed analysis can be used to determine the traffic delay costs.*

### Total vehicle delay (TVD) through roadworks

E/3.10 Calculations for TVD shall be calculated using Equation E/3.10a.

**Equation E/3.10a Calculating TVD**

$$TVD = \left(\frac{(DTc + CRDc) - (DTn + CRDn)}{60}\right) \times EV \times EF$$

where:

| | |
|---|---|
| TVD | is the total vehicle delay in hours |
| $DT_c$ | is the expected drive time (in minutes) in lane closure conditions over the length of the restriction at the restricted speed limit (in km/h) using Equation E/3.10b |
| $DT_n$ | is the expected drive time (in minutes) in normal conditions over the length of the proposed restriction at the normal speed limit (in km/h) using Equation E/3.10c |
| $CRD_c$ | is the capacity related delay time in lane closure conditions (in minutes) using Equation E/3.10e |
| $CRD_n$ | is the capacity related delay time in normal conditions (in minutes) using Equation E/3.10f |
| EV | is the expected equivalent hourly volume of traffic for each closure period using Equation E/3.10d |
| EF | is an economic factor to be applied to the cost to take account of the extent of planning and forewarning that has been provided prior to imposition of the lane closure(s)<br>EF = 0.3 for planned works with advanced notice to users<br>EF = 1.0 for unplanned works, e.g. required to rectify defects |

**Equation E/3.10b Calulation of expected drive time in lane closure conditions**

$$DTc = \frac{L \times 60}{SL_R}$$

where:

| | |
|---|---|
| L | is length of closure (including tapers), in metres |
| $SL_R$ | is the restricted speed limit (in km/h) |

**Equation E/3.10c Calculation of the expected drive time in normal conditions**

$$DTn = \frac{L \times 60}{SL_N}$$

where:

| | |
|---|---|
| L | is the length, in kilometres |
| $SL_N$ | is the speed limit for the road/motorway, in km/h |

**Equation E/3.10d Calculation of the expected equivalent hourly volume of traffic for each closure period**

$$EV = \text{AADF} \times T_f$$

where:

| | |
|---|---|
| AADF | is the annual average daily flow |
| $T_f$ | is the traffic factor from Table E/3.10 |

**Table E/3.10 Traffic factors for closure periods**

| Day | Time | Traffic factor |
|---|---|---|
| Mon-Fri | Night-time 22:00-06:00 | 0.011 |
| Sat-Sun | | 0.010 |
| Mon-Fri | Day-time 06:00-22:00 | 0.062 |
| Sat-Sun | | 0.048 |

**Equation E/3.10e Calculation of capacity-related delay time in lane closure conditions**

$$CRD_C = \left[\left(\frac{\text{EV}}{1925 \times n_c}\right) \div 0.94\right]^{7.5}$$

where:

$n_c$ is the number of running lanes available to traffic during the lane closure(s)

EV is the expected equivalent hourly volume of traffic for each period

**Equation E/3.10f Calculation of capacity-related delay time in lane normal conditions**

$$CRD_N = \left[\left(\frac{\text{EV}}{1925 \times n}\right) \div 0.94\right]^{7.5}$$

where:

n is the number of running lanes in normal conditions

EV is the expected equivalent hourly volume of traffic for each period

E/3.10.1 The values of the factors used in the equations should be shown in the design report with the life-cycle analysis results.

## Monetary cost

E/3.11 If the traffic data for the site does not show the proportion of cars to heavy goods vehicles (HGVs), a ratio of 85:15 shall be used.

E/3.12 To give a monetary cost to the delay, the weekly average vehicle operating cost (per hour) for cars and HGVs shall be in accordance with the TAG Data Book [Ref 9.N] Table A 1.3.6.

*NOTE The cost of user delays can be established from the online data provided in the TAG Data Book [Ref 9.N] .*

E/3.13 The vehicle cost (VC) per hour calculated using Equation E/3.13 shall be shown in the pavement design report with the life-cycle analysis results.

**Equation E/3.13 Calculation of vehicle cost per hour**

$$VC = \left(\frac{P_{\text{HGV}}}{100} \times C_{\text{HGV}}\right) + \left(\frac{P_{\text{cars}}}{100} \times C_{\text{cars}}\right)$$

where:

| | |
|---|---|
| $P_{HGV}$ | is the proportion of HGVs |
| $P_{cars}$ | is the proportion of cars |
| $C_{HGV}$ | is the weekly average operating cost (£) |
| $C_{cars}$ | is the weekly average operating cost (£) |

# E/4. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Department for Transport (UK). WebTAG Unit A1-1, 'Cost-Benefit Analysis' |
| Ref 2.N | National Highways. CD 226, 'Design for new pavement construction' |
| Ref 3.N | Highways England. CD 227, 'Design for pavement maintenance' |
| Ref 4.N | Highways England. GG 103, 'Introduction and general requirements for sustainable development and design' |
| Ref 5.N | National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 6.N | Highways England. MCHW Series 1000, 'Manual of Contract Documents for Highway Works. Volume 1 - Specification for Highway Works. Series 1000 Road Pavements – Concrete Materials' |
| Ref 7.N | Highways England. MCHW Series 0800, 'Manual of Contract Documents For Highway Works. Volume 1 Specification for Highway Works. Series 800 Road Pavements — Unbound, Cement and Other Hydraulically Bound Mixtures' |
| Ref 8.N | Highways England. MCHW Series 0900, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 900 Road Pavements – Bituminous Bound Materials.' |
| Ref 9.N | Department for Transport . TASM Division. TAG Data Book, 'TAG Data Book' |
| Ref 10.N | HM Treasury. Green Book, 'The Green Book: Central Government guidance on appraisal and evaluation' |

# E/5. Informative references

The following documents are informative references for this document and provide supporting information.

| | |
|---|---|
| Ref 1.I | Highways England. WebTRIS, 'http://www.webtris.highwaysengland.co.uk/' |

# Appendix E/A. Guidance on traffic delay cost

In the absence of a more detailed method the following has been devised as a quick, though unrefined, method of calculating traffic delay costs due to restrictions imposed on the network. This method has been developed for use in pavement design option WLC analyses described in this document for the life-cycle plan and is not intended for other applications.

Formulae are given on the following pages to allow a quick assessment of cost. Different factors apply if the lane closures are to be imposed on a weekday, weekday night, weekend day or weekend night. The approximate length of the restriction is estimated and the AADF derived for the carriageway where the works are to be located.

## E/A1 Worked example

Scheme with AADF of 80,000 vehicles along a 3-lane motorway with a national speed limit of 113 km/h (70 mph). Reduced to two lanes at a restricted speed limit of 80 km/h (50mph) for 10 weekday shifts during the hours of 06:00 until 22:00. Length of restriction is 3 km (including tapers). Vehicle cost per hour = £12.56. Activity is planned works with advanced notice to road users.

**Equation E/A.1 Calculation of the expected drive time in normal conditions**

$$Dtn = \frac{3 \times 60}{113} = 1.59$$

**Equation E/A.2 Calculation of the expected drive time in closure conditions**

$$Dtc = \frac{3 \times 60}{80} = 2.25$$

**Equation E/A.3 Calculation of the expected equivalent hourly volume of traffic (week day shifts)**

$$EV = 80,000 \times 0.062 = 4960$$

**Equation E/A.4 Calculation of capacity related delay time in lane normal conditions**

$$CRD_N = \left[\left(\frac{4960}{1925 \times 3}\right) \div 0.94\right]^{7.5} = 0.51$$

**Equation E/A.5 Calculation of capacity related delay time in closure conditions**

$$CRD_C = \left[\left(\frac{4960}{1925 \times 2}\right) \div 0.94\right]^{7.5} = 10.63$$

**Equation E/A.6 Economic factor for planned works with advanced notice to users**

$$EF = 0.3$$

**Equation E/A.7 Total vehicle delay**

$$TVD = \frac{(2.25 + 10.63) - (1.59 + 0.51)}{60} \times 4960 \times 0.3 = 267hrs$$

**Equation E/A.8 Cost per vehicle per hour over 267 hours**

$$\pounds 12.56 \times 267 = \pounds 3,354$$

Total delay cost (per shift of 16 hours) for restriction over 10 shifts:

**Equation E/A.9 Cost of delay for duration of closure**

$$16 \times 10 \times 3,800 = \pounds 536,600$$

# Appendix E/B. WLC analysis example

**Table E/B.1 Whole life cost analysis summary sheet**

| Whole Life Cost Analysis Summary | |
|---|---|
| **Scheme Name** | PCF 0123 |
| **Scheme Location** | M123 Junction A to B |
| **Description of Works** | NB + SB HS - New construction<br>NB + SB Lane 1 - New construction<br>NB + SB Lane 2 - Inlay<br>NB + SB Lane 3 - Inlay |
| **Scheme Length** | 8 km NB, 8 km SB |
| **Pavement Design Option 1**<br>**Flexible pavement with an HBGM base**<br>**Design Life: 40 years** | 690 mm New Construction - 80 msa, Class 3 foundation, HBGM B + AC 40/60<br>310 mm Class 3 Foundation<br>200 mm HBGM B (CBGM 1 C8/10)<br>180 mm Flexible surfacing using AC 40/60 |
| **Pavement Design Option 2**<br>**Flexible pavement with an asphalt base**<br>**Design Life: 40 years** | 575 mm New Construction - 80 msa, Class 3 foundation, EME2<br>310 mm Class 3 foundation<br>265 mm EME2 |
| **Pavement Design Option 3**<br>**Rigid pavement**<br>**Design Life: 40 years** | 590 mm New Construction - 80 msa, Class 3 foundation, RCC, EME binder, TSCS<br>310 mm Class 3 foundation<br>190 mm RCC<br>60 mm AC 10 EME2 base/bin<br>30 mm thin surface course system (TSCS) |
| **Associated carriageway works** | 24 (No.) Traffic loop counters<br>Renew road markings + studs every 8 years |
| **Traffic delay costs** | £30,400 per shift/closure<br>Based on:<br>Vehicle cost per hour = £12.56<br>80,000 AADF<br>3 km of TTM<br>3 lanes, 113 km/h in normal conditions<br>2 lanes, 80 km/h in closure conditions<br>Traffic flow profile: 0.062 (week day shifts)<br>16 hour shift (06:00 - 22:00)<br>EF = 0.3 for planned works with advanced notice to users<br>3 phases of TTM required to cover 8 km |

**Table E/B.1 Whole life cost analysis summary sheet** (continued)

| | |
|---|---|
| **Discounted Costs option 1** | £190,805,000 |
| **Discounted Costs option 2** | £222,009,000 |
| **Discounted Costs option 3** | £155,240,000 |
| **Residual Value option 1** | £29,600,000 |
| **Residual Value option 2** | £29,600,000 |
| **Residual Value option 3** | £13,200,000 |
| **NPSV Option 1** | £186,460,000 |
| **NPSV Option 2** | £217,664,000 |
| **NPSV Option 3** | £153,302,000 |
| **Sensitivity tests** | Expected service life of surfacing: 10 and 12 years (HS, L1) 14 and 16 years (L2, L3) |
| **Promoted Option** | Pavement design option 3 |

**Table E/B.2 Life-cycle plan**

| Pavement Design Option 3 | | 590mm New Construction - 80msa, Class 3 foundation, RCC, EME binder, TSCS | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Life-cycle Plan | Extent of work (units) | Works Duration (days) | Direct costs | | Indirect Cost ( £) | Discounted direct cost (£) | Discounted indirect cost (£) |
| | | | | Works Cost (£) | Prelimi-nary | | | |
| 0 | New pavement construction HS, L1 (NB + SB) | 8 km x 4 | 80 | 75,000,000 | 375,000 | 5,264,000 | 75,375,000 | 5,264,000 |
| 0 | Inlay L2, L3 (NB + SB) | 8 km x 4 | 18 | 10,000,000 | 50,000 | 1,184,400 | 10,050,000 | 1,184,000 |
| 0 | Install traffic loops (12No. NB, 12No. SB) | 24 (No.) | 14 | 500,000 | 500 | 921,200 | 501,000 | 921,200 |
| 8 | Renew road markings + Studs HS, L1, L 2, L3 (NB + SB) | 8 km x 8 | 18 | 2,000,000 | 10,000 | 1,184,400 | 1,526,000 | 899,000 |
| 12 | 30-mm inlay HS, L1 (NB + SB), Resurfacing at loops (L2,L3 NB + SB) | 8 km x 2<br>0.015 km x 24 | 20 | 10,500,000 | 52,500 | 1,316,000 | 6,983,000 | 871,000 |
| 12 | Install traffic loops (12 No. NB, 12 No. SB) | 24 (No.) | 14 | 500,000 | 500 | 921,200 | 331,000 | 610,000 |
| 12 | Renew road markings + Studs HS, L1 (NB + SB) and at loop locations L2, L3 (NB + SB) | 8 km x 2<br>0.015 km x 24 | 16 | 2,100,000 | 10,500 | 1,052,800 | 1,397,000 | 697,000 |
| 16 | 30 mm inlay L2, L3 (NB + SB) | 8 km x 4 | 18 | 10,000,000 | 50,000 | 1,184,400 | 5,796,000 | 683,000 |
| 16 | Renew road markings + Studs L2, L3 (NB + SB) | 8 km x 4 | 12 | 2,000,000 | 10,000 | 789,600 | 1,159,000 | 455,000 |
| 24 | 90 mm inlay HS, L1 HS, L1 (NB + SB) Resurfacing at loops L2,L3 (NB + SB) | 8 lane km x 2<br>0.015 km x 24 | 24 | 25,000,000 | 125,000 | 1,159,200 | 11,004,000 | 692,000 |
| 24 | Install traffic loops (12No. NB, 12No. SB) | 24 (No.) | 14 | 500,000 | 500 | 921,200 | 219,000 | 403,000 |
| 24 | Renew road markings + Studs HS, L1 (NB + SB) and at loop locations L2, L3 (NB + SB) | 8 km x 2<br>0.015 km x 24 | 16 | 2,100,000 | 10,500 | 1,052,800 | 924,000 | 461,000 |

**Table E/B.2 Life-cycle plan** (continued)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 32 | 100 mm inlay L2, L3 (NB + SB) | 8 lane km x 4 | 20 | 30,000,000 | 150,000 | 1,316,000 | 10,125,000 | 442,000 |
| 32 | Renew road markings + Studs HS, L1, L 2, L3 (NB + SB) | 8 km x 8 | 18 | 2,000,000 | 10,000 | 1,184,400 | 675,000 | 398,000 |
| 36 | 30 mm inlay HS, L1 (NB + SB), Resurfacing at loops (L2,L3 NB + SB) | 8 km x 2<br>0.015 km x 24 | 20 | 10,600,000 | 53,000 | 1,316,000 | 3,179,000 | 393,000 |
| 36 | Install traffic loops (12 No. NB, 12 No. SB) | 24 (No.) | 14 | 500,000 | 500 | 921,200 | 149,000 | 275,000 |
| 36 | Renew road markings + Studs HS, L1 (NB + SB) and at loop locations L2, L3 (NB + SB) | 8 km x 2<br>0.015 km x 24 | 16 | 2,100,000 | 10,500 | 1,052,800 | 630,000 | 314,000 |
| 40 | Renew road markings + Studs L2, L3 (NB + SB) | 8 km x 4 | 12 | 2,000,000 | 10,000 | 789,600 | 533,000 | 209,000 |
| 48 | 90 mm inlay HS, L1 HS, L1 (NB + SB) Resurfacing at loops L2,L3 (NB + SB) | 8 lane km x 2<br>0.015 km x 24 | 24 | 25,000,000 | 125,000 | 1,579,200 | 5,258,000 | 330,000 |
| 48 | Install traffic loops HS, L1, L2, L3 (NB + SB) | 24 (No.) | 14 | 500,000 | 500 | 921,200 | 105,000 | 193,000 |
| 48 | Renew road markings + Studs HS, L1, L 2, L3 (NB + SB) | 8 km x 8 | 18 | 2,000,000 | 10,000 | 1,184,400 | 421,000 | 248,000 |
| 56 | Renew road markings + Studs HS, L1, L 2, L3 (NB + SB) | 8 km x 8 | 18 | 2,000,000 | 10,000 | 1,184,400 | 332,000 | 196,000 |
| 60 | 30 mm inlay HS, L1 (NB + SB), Resurfacing at loops (L2,L3 NB + SB) | 8 km x 2<br>0.015 km x 24 | 20 | 10,600,000 | 53,000 | 1,316,000 | 1,564,000 | 193,000 |
| 60 | Renew road markings + Studs HS, L1 (NB + SB) and at loops location L2, L3 (NB + SB) | 8 km x 2<br>0.015 km x 24 | 16 | 2,100,000 | 10,500 | 1,052,800 | 310,000 | 155,000 |
| 60 | Install traffic loops (12 No. NB, 12 No. SB) | 24 (No.) | 14 | 500,000 | 500 | 921,200 | 73,000 | 135,000 |
| **Residual Life (yrs)** | | 40 | | | | | | |
| **Design Life (yrs)** | | 40 | | | | | | |
| **Residual Value (£)** | | 13,200,000 | | | | | | |

**Table E/B.2 Life-cycle plan** (continued)

| | | |
|---|---|---|
| **Discounted residual value (£)** | 1,938,000 | |
| $\sum$ **Discounted direct costs (£)** | 138,619,000 | |
| $\sum$ **Discounted indirect costs (£)** | 16,621,000 | |
| **NPSV (£)** | 153,302,000 | |

NOTE: The monetary values used for this example are not based on true unit costs.

Pavement
Design

# CD 226
# Northern Ireland National Application Annex to CD 226 Design for new pavement construction

(formerly HD 26/06)

Revision 0

**Summary**
This National Application Annex gives the Department for Infrastructure Northern Ireland specific requirements for the design of pavement construction for new build carriageways, widening of existing carriageways, upgrading of existing pavements or reconstruction of existing pavements on the Northern Ireland motorway and all-purpose trunk road network.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Mar 2020 | Department for Infrastructure Northern Ireland National Application Annex to CD 226. |

# Foreword

## Publishing information

This document is published by Highways England on behalf of Department for Infrastructure, Northern Ireland.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the Department for Infrastructure Northern Ireland specific requirements for the design of pavement construction for new build carriageways, widening of existing carriageways, upgrading of existing pavements or reconstruction of existing pavements on the NI motorway and all-purpose trunk road network.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 3.N] apply to this document.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a "British Standard" or other technical specification, that requirement may be met by compliance with the mutual recognition clause in GG 101 [Ref 3.N].

# NI/1. Pavement materials

## Pavement materials (Tables 2.10 and 2.13)

NI/1.1 In addition to the materials outlined in Tables 2.10 and 2.13 of CD 226 [Ref 2.N], in Northern Ireland recipe mixes to BS EN 13108-1 [Ref 1.N] shall be used where considered appropriate by the Department for Infrastructure.

NI/1.2 Hot rolled asphalt shall be used as a base and binder course material if considered appropriate by the Department for Infrastructure.

# NI/2. Pavement design verification

NI/2.1 The requirements for pavement design checks and certification shall be set out within the project-specific contract documentation.

# NI/3. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | BSI. BS EN 13108-1, 'Bituminous mixtures – Material specifications. Asphaltic concrete.' |
| Ref 2.N | Highways England. CD 226, 'Design for new pavement construction' |
| Ref 3.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |

Pavement
Design

# CD 226
# Scotland National Application Annex to CD 226 Design for new pavement construction

(formerly HD 26/06)

Revision 0

**Summary**
There are no specific requirements for Transport Scotland supplementary or alternative to those given in CD 226.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Mar 2020 | Transport Scotland National Application Annex to CD 226. |

Llywodraeth Cymru
Welsh Government

Pavement
Design

# CD 226
# Wales National Application Annex to CD 226 Design for new pavement construction

(formerly HD 26/06)

Revision 0

**Summary**
There are no specific requirements for the Welsh Government supplementary or alternative to those given in CD 226.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

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# Contents

## Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Mar 2020 | Welsh Government National Application Annex to CD 226. |

Design Manual for Roads and Bridges

Pavement
Design

# CD 236
# Surface course materials for construction

(formerly CD 236 (rev. 3 inc. HD 36/06 and IAN 156/16), HD 37/99, HD 38/16, IAN 157/11, TA 81/16)

Version 4.1.0


**Summary**
This document provides requirements for pavement surfacing for both flexible and rigid pavements


**National Variation**
This document has associated National Application Annexes providing alternative or supplementary content to that given in the core document, which is relevant to specific Overseeing Organisations. National Application Annexes are adjoined at the end of this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated National Highways team. The online feedback form for all enquiries and feedback can be accessed at: www.standardsforhighways.co.uk/feedback.

**This is a controlled document.**

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 | 4.**1**.0 | December 2022 | Core document, England NAA, Scotland NAA, Wales NAA | Incremental change to requirements |

Revision 4.1.0 (Published Dec. 2022) removes a duplicate requirement relating to the use of visually contrasting surfaces on central reservations. This topic is covered by CD 127.

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 | 4.0.**1** | July 2021 | Core document, Wales NAA | Incremental change to notes and editorial updates |
| CD 236 | 4 | March 2020 | | |

# Foreword

## Publishing information

This document is published by National Highways.

This document supersedes HD 36/06, HD 37/99, HD 38/16, IAN 156/16, IAN 157/11 and TA 81/16 which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

The appropriate choice of surface course material plays a key role in providing roads that are safe, meet the needs of the user and offer good value for money. Permitted surface course materials and guidance on their selection are presented in this document.

In dry conditions all clean, surfaced roads have a high skidding resistance. However in wet conditions the skidding resistance is reduced. Using aggregates with an appropriate resistance to polishing for a particular site and traffic loading should result in a surfacing giving wet skidding resistance above the appropriate investigatory level (IL) assigned in accordance with CS 228 [Ref 7.N].

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 3.N] apply to this document.

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
| --- | --- |
| AADF | Annual average daily flow (1-direction) |
| AAV | Aggregate abrasion value |
| CAUTS | Cold applied ultra-thin surfacing |
| CSC | Characteristic skid coefficient |
| EAC | Exposed aggregate concrete |
| HFS | High friction surfacing |
| HRA | Hot rolled asphalt |
| IL | Investigatory level |
| PSV | Polished stone value |
| TSCS | Thin surface course system |

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| Departure | Variation or waiving of a requirement carried out in accordance with the Overseeing Organisation's procedures. |
| High friction surfacing | Specialised high friction surfacing conforming to Clause 924 of the Specification for Highway Works MCHW Series 0900 [Ref 5.N]. |
| Thin surface course systems | Thin surface course systems conforming to Clause 942 of the Specification for Highway Works MCHW Series 0900 [Ref 5.N]. |

# 1. Scope

## Aspects covered

1.1 This document shall be applied to surface course materials for new and maintenance construction on both flexible and rigid pavements.

*NOTE 1 This document gives requirements for aggregates in surface course materials, which aim to ensure that appropriate skidding resistance is provided on roads.*

*NOTE 2 Additional requirements for aggregates used in pavement construction can be found in the Specification (MCHW1) MCHW Series 0700 [Ref 6.N], MCHW Series 0900 [Ref 5.N] and MCHW Series 1000 [Ref 4.N] together with the Notes for Guidance MCHW Series NG 0700 [Ref 4.I], MCHW Series NG 0900 [Ref 5.I] and MCHW Series NG 1000 [Ref 3.I].*

*NOTE 3 Detailed information on maintenance of asphalt and concrete roads can be found in CM 231 [Ref 6.I] and CD 227 [Ref 1.I].*

*NOTE 4 This document does not cover the requirements for footways and cycleways, which can be found in CD 239 [Ref 2.I].*

1.2 This document shall be read in conjunction with 'Skidding resistance' CS 228 [Ref 7.N].

## Implementation

1.3 This document shall be implemented forthwith on all schemes involving design of road pavement surface on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 3.N].

## Use of GG 101

1.4 The requirements contained in GG 101 [Ref 3.N] shall be followed in respect of activities covered by this document.

# 2. Surface course material options

2.1 The specific requirements for surface course material options shall apply as provided in the National Application Annexes.

# 3. Aggregate selection

### Polished stone value (PSV) and aggregate abrasion value (AAV)

3.1 The aggregates used in pavement quality concrete complying with Clause 1026 of the Specification MCHW Series 1000 [Ref 4.N] shall be exempt from the requirements of Section 3 of this document.

3.2 Coarse aggregates or chippings shall undergo polished stone value (PSV) testing in accordance with BS EN 1097-8 [Ref 8.N] to determine the resistance to polishing under the action of traffic.

3.3 For all roads, PSV shall be selected from the rows of Table 3.3a or Table 3.3b for the relevant material type, and corresponding site category and traffic level.

**Table 3.3a PSV for chippings or coarse aggregate in surfacings excluding thin surface course systems complying with clause 942 and pavement quality concrete complying with clause 1026 of the Specification (MCHW1)**

| Site category | Site description | Default | IL | PSV required for given IL, traffic level and type of site | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Traffic (cv/lane/day) at design life | | | | | | | | | |
| | | | | 1 - 250 | 251 - 500 | 501 - 750 | 751 - 1000 | 1001 - 2000 | 2001 - 3000 | 3001 - 4000 | 4001 - 5000 | 5001 - 6000 | Over 6000 |
| A | Motorway | | 0.30 | 50 | 50 | 50 | 50 | 50 | 55 | 55 | 60 | 65 | 65 |
| | | * | **0.35** | **50** | **50** | **50** | **50** | **50** | **60** | **60** | **60** | **65** | **65** |
| B | Non-event carriageway with one-way traffic | | 0.30 | 50 | 50 | 50 | 50 | 50 | 55 | 55 | 60 | 65 | 65 |
| | | * | **0.35** | **50** | **50** | **50** | **50** | **50** | **60** | **60** | **60** | **65** | **65** |
| | | | 0.40 | 50 | 50 | 50 | 55 | 60 | 65 | 65 | 65 | 65 | 68+ |
| C | Non-event carriageway with two-way traffic | | 0.35 | 50 | 50 | 50 | 55 | 55 | 60 | 60 | 65 | 65 | 65 |
| | | * | **0.40** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** | **68+** |
| | | | 0.45 | 60 | 60 | 65 | 65 | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ |
| Q | Approaches to and across minor and major junctions; approaches to roundabouts and traffic signals | * | **0.45** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** | **68+** | **68+** | **HFS** |
| | | | 0.50 | 65 | 65 | 65 | 68+ | 68+ | 68+ | HFS | HFS | HFS | HFS |
| | | | 0.55 | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| K | Approaches to pedestrian crossings and other high risk situations | * | **0.50** | **65** | **65** | **65** | **68+** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** |
| | | | 0.55 | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| R | Roundabout | * | **0.45** | **50** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** |
| | | | 0.50 | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ |
| G1 | Gradients 5-10% longer than 50 m | * | **0.45** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** | **68+** |
| | | | 0.50 | 60 | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| G2 | Gradient >10% longer than 50 m | | 0.45 | 55 | 60 | 60 | 65 | 65 | 68+ | 68+ | 68+ | 68+ | 68+ |
| | | * | **0.50** | **60** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** |
| | | | 0.55 | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |

**Table 3.3a PSV for chippings or coarse aggregate in surfacings excluding thin surface course systems complying with clause 942 and pavement quality concrete complying with clause 1026 of the Specification (MCHW1)** (continued)

| Site category | Site description | Default | IL | PSV required for given IL, traffic level and type of site | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Traffic (cv/lane/day) at design life | | | | | | | | | |
| | | | | 1 - 250 | 251 - 500 | 501 - 750 | 751 - 1000 | 1001 - 2000 | 2001 - 3000 | 3001 - 4000 | 4001 - 5000 | 5001 - 6000 | Over 6000 |
| S1 | Bends radius <500 m – carriageway with one-way traffic | ***** | **0.45** | **50** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **HFS** | **HFS** |
| | | | 0.50 | 68+ | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| S2 | Bends radius <500 m – carriageway with two-way traffic | | 0.45 | 50 | 55 | 60 | 60 | 65 | 65 | 68+ | 68+ | HFS | HFS |
| | | ***** | **0.50** | **68+** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** |
| | | | 0.55 | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |

**Table 3.3b PSV for coarse aggregate in thin surface course systems complying with clause 942 of the Specification (MCHW1)**

| Site category | Site description | Default | IL | PSV required for given IL, traffic level and type of site | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Traffic (cv/lane/day) at design life | | | | | | | | | |
| | | | | 1-250 | 251- 500 | 501- 750 | 751- 1000 | 1001- 2000 | 2001- 3000 | 3001- 4000 | 4001- 5000 | 5001- 6000 | Over 6000 |
| A | Motorway | | 0.30 | 50 | 50 | **50** | 50 | 50 | 50 | 50 | 53 | 63 | 63 |
| | | * | **0.35** | **50** | **50** | **50** | **50** | **50** | **53** | **53** | **53** | **63** | **63** |
| B | Non-event carriageway with one-way traffic | | 0.30 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 53 | 63 | 63 |
| | | * | **0.35** | **50** | **50** | **50** | **50** | **50** | **53** | **53** | **53** | **63** | **63** |
| | | | 0.40 | 50 | 50 | 50 | 50 | 53 | 58 | 58 | 58 | 63 | 68+ |
| C | Non-event carriageway with two-way traffic | | 0.35 | 50 | 50 | 50 | 50 | 50 | 53 | 53 | 58 | 63 | 63 |
| | | * | **0.40** | **50** | **53** | **53** | **58** | **58** | **63** | **63** | **63** | **68+** | **68+** |
| | | | 0.45 | 53 | 53 | 58 | 58 | 63 | 63 | 63 | 63 | 68+ | 68+ |
| Q | Approaches to and across minor and major junctions, approaches to roundabouts and traffic signals | * | **0.45** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** | **68+** | **68+** | **HFS** |
| | | | 0.50 | 65 | 65 | 65 | 68+ | 68+ | 68+ | HFS | HFS | HFS | HFS |
| | | | 0.55 | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| K | Approaches to pedestrian crossings and other high risk situations | * | **0.50** | **65** | **65** | **65** | **68+** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** |
| | | | 0.55 | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| R | Roundabout | * | **0.45** | **50** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **68+** | **68+** |
| | | | 0.50 | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ | 68+ |
| G1 | Gradients 5-10% longer than 50 m | | 0.45 | 55 | 60 | 60 | 65 | 65 | 68+ | 68+ | 68+ | 68+ | 68+ |
| | | * | **0.50** | **60** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** |
| G2 | Gradient >10% longer than 50 m | | 0.45 | 55 | 60 | 60 | 65 | 65 | 68+ | 68+ | 68+ | 68+ | 68+ |
| | | * | **0.50** | **60** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** |
| | | | 0.55 | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |

**Table 3.3b PSV for coarse aggregate in thin surface course systems complying with clause 942 of the Specification (MCHW1)** (continued)

| Site category | Site description | Default | IL | PSV required for given IL, traffic level and type of site | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Traffic (cv/lane/day) at design life | | | | | | | | | |
| | | | | 1-250 | 251- 500 | 501- 750 | 751- 1000 | 1001- 2000 | 2001- 3000 | 3001- 4000 | 4001- 5000 | 5001- 6000 | Over 6000 |
| S1 | Bends radius <500 m – carriageway with one-way traffic | * | **0.45** | **50** | **55** | **60** | **60** | **65** | **65** | **68+** | **68+** | **HFS** | **HFS** |
| | | | 0.50 | 68+ | 68+ | 68+ | HFS | HFS | HFS | HFS | HFS | HFS | HFS |
| S2 | Bends radius <500 m – carriageway with two-way traffic | | 0.45 | 50 | 55 | 60 | 60 | 65 | 65 | 68+ | 68+ | HFS | HFS |
| | | * | **0.50** | **68+** | **68+** | **68+** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** | **HFS** |
| | | | 0.55 | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS | HFS |

3.3.1 PSV should be selected from those rows marked with a * in the default column of Table 3.3a or Table 3.3b.

*NOTE 1 Table 3.3a applies to all types of surface course materials with the exception of Clause 942 thin surface course systems (TSCS), Clause 942TS (Stone Mastic Asphalt Surface Course (TS2010), Clause 942WG (Welsh Government Procedure W2F and Advice Guidance (PAG) 112/20 – Stone Mastic Asphalt Specification) and Clause 1026 (pavement quality concrete). Table 3.3b is applicable to Clause 942 TSCS only*

*NOTE 2 There is no PSV requirement for the aggregate used in clause 1026 materials (pavement quality concrete) , Clause 942TS (Stone Mastic Asphalt Surface Course (TS2010)) and), Clause 942WG (Welsh Government Procedure W2F and Advice Guidance (PAG) 112/20 – Stone Mastic Asphalt Specification) .*

*NOTE 3 Surfacing material containing a high proportion of calcined bauxite and 68+ psv natural aggregate blend in the mix can offer a similar skid resistance performance and durability to that provided by HFS in some of the site category and investigatory level combinations in table 3.3b.*

3.4 The appropriate PSVs taken from Table 3.3a or Table 3.3b and AAVs from Table 3.10 shall be inserted in Appendix 7/1 of the Specification MCHW Series 0700 [Ref 6.N].

3.5 For all roads the justification for selecting PSV from rows other than those marked with a * in the default column of Table 3.3a or Table 3.3b shall be recorded.

*NOTE 1 The default column * marked rows in Table 3.3a or Table 3.3b indicate the levels of PSV appropriate to the lowest CSC 'ST' marked cell in Table 4.1 (Site categories and investigatory levels) of CS 228 [Ref 7.N] .*

*NOTE 2 Aggregates with a lower PSV than indicated in Table 3.3a or Table 3.3b can be proposed if evidence is available that the aggregate has achieved the required life, skid resistance and skidding accident rate on a road of similar geometry, traffic volume and meteorological conditions.*

3.6 Where '68+' material is listed in Table 3.3a or Table 3.3b, none of the three most recent results from consecutive PSV tests relating to the aggregate to be supplied shall fall below 68.

3.7 Basic oxygen steel slag complying with the chemical composition in Table 3.7 shall be classified as equivalent to PSV60 aggregate up to and including 5,000 cv/lane/day traffic at design life in site categories A, B and C when used in a TCSC complying with Clause 942 of the Specification MCHW Series NG 0900 [Ref 5.I].

**Table 3.7 Permitted chemical composition for basic oxygen steel slag**

| Chemical | Percentage by mass (%) |
|---|---|
| $Fe_2O_3$ | 20-30 |
| CaO | 40-50 |
| $SiO_2$ | 10-51 |
| MgO | 4-10 |

### Site category and investigatory level

3.8 The site category and investigatory level to be used in Table 3.3a or Table 3.3b shall be those which have been allocated to the specific site on which the material is to be laid.

3.9 Site category and investigatory level shall be determined by following the procedures in CS 228 [Ref 7.N].

### Aggregate abrasion value

3.10 The AAV for the coarse aggregate shall be selected from Table 3.10, based on the relevant site categories and traffic levels.

**Table 3.10 Maximum AAV of chippings, or coarse aggregates in unchipped surfaces, for new surface courses excluding Clause 1026 (pavement quality concrete)**

| Traffic (cv/lane/day) at design life | ≤ 250 | 251 - 1000 | 1001 - 1750 | 1751 - 2500 | 2501 - 3250 | >3250 |
|---|---|---|---|---|---|---|
| Max. AAV for chippings for hot rolled asphalt, surface dressing and for aggregate in slurry and microsurfacing systems | 14 | 12 | 12 | 10 | 10 | 10 |
| Max. AAV for aggregate in thin surface course systems, CAUTS, exposed aggregate concrete surfacing and asphalt concrete surface course | 16 | 16 | 14 | 14 | 12 | 12 |
| Note: The maximum AAV requirement for porous asphalt is specified in Clause 938 of the Specification ( MCHW Series 0900 [Ref 5.N]). | | | | | | |

*NOTE* *The aggregate abrasion value (AAV) of the coarse aggregate or chippings is determined in accordance with Annex A BS EN 1097-8 [Ref 8.N] having regard to the durability or resistance of the aggregate to abrasion under the action of traffic.*

3.11 Limestone aggregates shall not be specified as the coarse aggregate or chippings in surface courses as noted in PD 6691 [Ref 2.N].

## Traffic flow

3.12 The traffic flow used to determine the PSV and AAV for a particular surfacing shall be the design traffic as commercial vehicles per lane per day (cv/lane/day) based on the annual average daily flow (AADF) predicted to be using the lane at the end of the anticipated life of the surfacing.

*NOTE* *Information on traffic flow can be found in CD 224 [Ref 7.I].*

3.13 For maintenance schemes where classified traffic counts are not generally available and automatic counters are used for vehicle counts, the number of commercial vehicles per lane shall be regarded as equivalent to the number of vehicles >6.6 m in length.

3.14 For new construction and complete carriageway resurfacing, the level of PSV chosen shall reflect the design traffic flows for each individual lane.

3.15 Where a single lane is being resurfaced for maintenance purposes the appropriate PSV and AAV shall be used for that lane.

*NOTE* *The PSVs and AAVs chosen need not match the values of existing adjacent surfacing.*

3.16 For lanes with a design traffic of zero commercial vehicles the minimum PSV for surface coarse aggregates shall be 50.

3.17 Where the traffic flow on motorways within site category A exceeds 6,000 commercial vehicles per day, the specified PSV for surface coarse aggregates shall not exceed those specified in Table 3.3a or Table 3.3b.

## Gyratory junctions

3.18 A maximum nominal aggregate size of 10 mm shall be specified in a thin surface course system on the circulatory part of a roundabout or other gyratory junctions or other highly stressed sites.

## High friction surfacing (HFS)

3.19 High friction surfacing (HFS) shall not be specified on the circulatory parts of roundabouts, even if traffic signal controlled.

3.20 HFS shall not be specified solely because a coloured road surface is required.

## Coloured surfacing

3.21 Any requirements for the use of coloured surfacing as determined in CD 127 [Ref 1.N] shall use materials provided in the National Application Annexes.

# 4. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| Ref. | Document |
|---|---|
| Ref 1.N | National Highways. CD 127, 'Cross-sections and headrooms' |
| Ref 2.N | BSI. PD 6691, 'Guidance on the use of BS EN 13108, Bituminous mixtures. Material specifications' |
| Ref 3.N | National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 4.N | Highways England. MCHW Series 1000, 'Manual of Contract Documents for Highway Works. Volume 1 - Specification for Highway Works. Series 1000 Road Pavements – Concrete Materials' |
| Ref 5.N | Highways England. MCHW Series 0900, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 900 Road Pavements – Bituminous Bound Materials.' |
| Ref 6.N | Highways England. MCHW Series 0700, 'Manual of Contract Documents for Highways Works, Volume 1 Specification for Highways Works, Series 700 Road Pavements - General' |
| Ref 7.N | Highways England. CS 228, 'Skidding resistance' |
| Ref 8.N | BSI. BS EN 1097-8, 'Tests for mechanical and physical properties of aggregates - Determination of the Polished Stone Value (PSV)' |

# 5. Informative references

The following documents are informative references for this document and provide supporting information.

| Ref. | Document |
|---|---|
| Ref 1.I | National Highways. CD 227, 'Design for pavement maintenance' |
| Ref 2.I | National Highways. CD 239, 'Footway and cycleway pavement design' |
| Ref 3.I | Highways England. MCHW Series NG 1000, 'Manual of Contract Documents for Highway Works. Volume 2 - Notes for Guidance on the Specification for Highway Works. Series NG 1000 Road Pavements – Concrete Materials.' |
| Ref 4.I | Highways England. MCHW Series NG 0700, 'Manual of Contract Documents for Highway Works. Volume 2 - Notes for Guidance on the Specification for Highway Works. Series NG 700 Road Pavements - General' |
| Ref 5.I | Highways England. MCHW Series NG 0900, 'Manual of Contract Documents for Highway Works. Volume 2 - Notes for Guidance on the Specification for Highway Works. Series NG 900 Road Pavements – Bituminous Bound Materials.' |
| Ref 6.I | Highways England. CM 231, 'Pavement surface repairs' |
| Ref 7.I | National Highways. CD 224, 'Traffic assessment' |

Pavement
Design

# CD 236 - ENAA
# England National Application Annex for Surface course materials for construction

(formerly CD 236 (revision 4 including HD 36/16), )

Version 4.0.1

**Summary**
This National Application Annex gives the National Highways specific requirements on pavement surfacing for both flexible and rigid pavements.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated National Highways team. The online feedback form for all enquiries and feedback can be accessed at: www.standardsforhighways.co.uk/feedback.

**This is a controlled document.**

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 - ENAA | 4.0.**1** | December 2022 | England NAA | Incremental change to advice |

(Pub. Dec. 2022: Version 4.0.1) National Highways National Application Annex to CD 236. This document contains National Highways requirements and advice for section 2 of CD 236 related to pavement surfacing for both flexible and rigid pavements. Revision 4.01 Amends the choice of surfacing for existing lay-bys to include the 'same surfacing type as the adjacent carriageway' - see E/1.4.

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 | 4 | March 2020 | | |
| CD 236 | 1 | December 2018 | | |

# Foreword

## Publishing information

This document is published by National Highways.

This document is a National Application Annex to CD 236 [Ref 10.N].

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the National Highways-specific requirements related to pavement surfacing for both flexible and rigid pavements.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 4.N] apply to this document.

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| CAUTS | Cold applied ultra-thin surfacing |
| DEFRA | Department for Environment, Food and Rural Affairs |
| EA | Emergency area |
| EAC | Exposed aggregate concrete |
| ELPV | Enhanced longitudinal profile variance |
| HRA | Hot rolled asphalt |
| MCHW | Manual of contract documents for highways works |
| NSC | Network structural condition |
| TRACS | Traffic speed condition survey |
| TRASS | Traffic speed structural survey |
| TSCS | Thin surface course systems |

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| Departure | Variation or waiving of a requirement carried out in accordance with the Overseeing Organisation's procedures. |
| Emergency area(s) | The full legal term is 'emergency refuge area(s)'; see UKSI 2015/392 [Ref 11.N] |
| Smart motorway(s) | Smart motorways are defined in GD 301 [Ref 9.N] |

# E/1. Surface course material options (CD 236, 2.1)

## Choice of surfacing

E/1.1 Surface course materials shall be selected from the permitted options provided in Table E/1.1 from MCHW Series 0900 [Ref 7.N] & MCHW Series 1000 [Ref 5.N].

**Table E/1.1 Pavement surface course materials for new and maintenance construction**

| | Material |
|---|---|
| New Construction | MCHW1 Clause 924 high friction surfacing<br>MCHW1 Clause 942 thin surface course system<br>MCHW1 Clause 943 hot rolled asphalt<br>MCHW1 Clause 1026 performance concrete surface (see Note 2) |
| Maintenance | MCHW1 Clause 923 cold applied ultra-thin surfacing<br>MCHW1 Clause 924 high friction surfacing<br>MCHW1 Clause 942 thin surface course system<br>MCHW1 Clause 943 hot rolled asphalt<br>MCHW1 Clause 1026 performance concrete surface (see Note 2)<br>MCHW1 Clause 1026 brushed concrete surface (see Note 2) |
| Note 1: The choice of materials has been determined by National Highways based on: the nature of the existing network; population density; traffic intensity; climatic conditions; historic performance; availability of materials; and noise requirements.<br>Note 2: Rigid construction only. | |

*NOTE 1 Some of the particular factors that can influence the selection of a surface course material are provided in Appendix E/A.*

*NOTE 2 Traffic noise in lower speed zones (up to 50 km/h) is mainly attributable to engine, transmission and exhaust noise, especially from lorries.*

*NOTE 3 Where noise levels are high due to the intensity of high-speed traffic, surfacing materials are available that can significantly reduce tyre/road generated noise emission compared to hot rolled asphalt (HRA). These include, for example, hot, paver-laid thin surface course systems, performance concrete and exposed aggregate concrete.*

E/1.1.1 HRA, cold applied ultra-thin surfacing (CAUTS) , performance concrete finished surface and exposed aggregate concrete (EAC) may be options for the surface course unless the site is 'noise sensitive'.

E/1.2 Details of which surface course materials are selected (including the aggregate properties) shall be recorded as required by CD 226 [Ref 1.N] Section 6.

## Lay-bys, emergency areas and hardstanding locations

E/1.3 New lay-bys and hardstanding locations including emergency areas (EAs) shall use a surfacing from one of the following options:

1) concrete (see MCHW Series 1000 [Ref 5.N]);
2) block paving (see MCHW Series 1100 [Ref 6.N]); or,
3) bituminous mixtures with deformation and fuel resisting properties.

*NOTE 1 'Fuel resisting' is defined as a bituminous mixture that conforms to Cimax6 when tested to BS EN 12697-43 [Ref 1.I].*

*NOTE 2 'Deformation resisting' is defined as a bituminous mixture developing a rut depth (RD) of less than 2.5 mm when tested with a small device at 60C using procedure A for 1000 cycles to BS EN 12697-22 [Ref 2.I].*

E/1.4 Existing lay-bys shall be resurfaced with either:

1) the same surfacing type as the adjacent carriageway;
2) bituminous mixtures with deformation and fuel resisting properties;
3) block paving (see MCHW Series 1100 [Ref 6.N]); or,
4) concrete (see MCHW Series 1000 [Ref 5.N]).

E/1.4.1 Existing bus lay-bys should be resurfaced with either:

1) bituminous mixtures with deformation and fuel resisting properties ( MCHW Series 0900 [Ref 7.N]);
2) block paving ( MCHW Series 1100 [Ref 6.N]); or,
3) concrete ( MCHW Series 1000 [Ref 5.N]).

E/1.5 Emergency areas (EAs) shall be surfaced in accordance with MCHW Series 0900 [Ref 7.N].

## Noise sensitive sites

E/1.6 Where any of the following applies, a site shall be classed as 'noise sensitive':

1) the location has been identified as a noise important area in any of England's noise action plans published by DEFRA NAP(E) [Ref 3.N];
2) noise 'sensitive receptors' are located within 600 m from the roadside (and 600 m from the ends of the sections);
3) noise barriers or earth bunds have been installed as a noise mitigation measure; or,
4) there are designated areas of landscape or biodiversity value within 600 m of the roadside (and 600 m from the ends of the sections).

*NOTE 1 Examples of 'sensitive receptors' are given in LA 111 [Ref 8.N].*

*NOTE 2 Areas of landscape or biodiversity value include areas of bird nesting or areas with multiple footpaths used regularly for recreation.*

E/1.7 Where the site is 'noise sensitive', a low noise surfacing (as defined in E/1.10) shall be used where traffic speeds are greater than 50 km/h.

E/1.7.1 All departure applications to use non-low-noise surfacing should be supported with a value for money calculation.

E/1.7.2 Where traffic speeds are 50 km/h or lower, a low noise surfacing may not be required even if the site is 'noise sensitive'.

*NOTE Guidance on calculating the value for money of a 'noise sensitive' departure approval is provided in Appendix E/B.*

E/1.8 HRA shall be used during resurfacing on bridge decks that have not been designed for a TSCS, even if the site is 'noise sensitive' and the approaches are surfaced in TSCS.

*NOTE 1 Ponding of water in the surface layers, particularly TSCS, can occur if the bridge deck has not been fitted with an asphalt drainage system. Ponded water can contribute to reduced durability of the surface under trafficking and freeze/thaw conditions.*

*NOTE 2 Further information on bridge deck surfacing is available in CD 358 [Ref 12.N] .*

## Noise levels

E/1.9 Surfacing with noise levels 0 and 1 contained in Clauses 923, 942 and 1026 of the Specification MCHW Series 0900 [Ref 7.N] & MCHW Series 1000 [Ref 5.N] shall not be specified at sites with existing noise barriers or earth bunds that have been specifically installed as a noise mitigation measure or at locations that have been identified as an important area in any of England's noise action plans published by DEFRA NAP(E) [Ref 3.N].

### Texturing

E/1.10 Selected surface course materials shall meet the required texture depth requirements specified in Clauses 921, 942 or 1026 of the specification MCHW Series 0900 [Ref 7.N] & MCHW Series 1000 [Ref 5.N].

E/1.11 Retexturing of existing surfaces shall be permitted for pavements with a particular skidding concern pending replacement of the surface.

*NOTE Further guidance on retexturing is provided in CD 227 [Ref 2.N].*

### Coloured surfacing

E/1.12 The surface course material or system to be used for coloured surfacing shall be selected from Table E/1.12.2N.

E/1.12.1 Coloured surfacing materials or systems may be used to provide a contrasting colour to the adjacent pavement surfaces, and/or to supplement prescribed signs/markings such as for bus and cycle lanes.

E/1.12.2 Coloured surfacing may be provided by using individually (or a combination of) the following:

1) natural coloured aggregates;
2) artificially pigmented aggregates;
3) pigmented binder; and,
4) addition of pigments to a mixture.

*NOTE The surface course materials or systems presented in Table E/1.12.2N can be produced as a coloured surfacing.*

**Table E/1.12.2N Material options for coloured surfacing**

| Material | Specification clause MCHW Series 0900 [Ref 7.N] |
|---|---|
| Thin surface course systems | Clause 942 |
| Cold applied ultra thin surfacing | Clause 923 |
| Slurry surfacing and microsurfacing | Clause 918 |
| Surface dressing | Clause 922 |
| High friction surfacing | Clause 924 |
| Grouted macadam surfacing | N/A |
| Hot rolled asphalt | Clause 943 |

E/1.12.3 Where the coloured surfacing selected forms a layer <10 mm thick the underlying material should be in a sound condition such that it:

1) is free of visual defects;
2) has TRACS rut depth and ELPV all in condition category 1;
3) has TRACS lane fretting intensities all <2; and,
4) has TRASS NSCs all in category 1 or 2.

*NOTE Information on network level surveys is provided in CS 229 [Ref 3.I].*

E/1.13 Bright orange coloured surface course shall be used on EAs on smart motorway schemes as defined in GD 301 [Ref 9.N].

E/1.14 Bright orange coloured surface course shall not be used for any application other than EAs on smart motorway schemes as defined in GD 301 [Ref 9.N].

# E/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| Ref. | Document |
|---|---|
| Ref 1.N | National Highways. CD 226, 'Design for new pavement construction' |
| Ref 2.N | National Highways. CD 227, 'Design for pavement maintenance' |
| Ref 3.N | DEFRA. NAP(E), 'England's Noise Action Plans' |
| Ref 4.N | National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 5.N | Highways England. MCHW Series 1000, 'Manual of Contract Documents for Highway Works. Volume 1 - Specification for Highway Works. Series 1000 Road Pavements – Concrete Materials' |
| Ref 6.N | Highways England. MCHW Series 1100, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 1100 Kerbs, Footways and Paved Areas.' |
| Ref 7.N | Highways England. MCHW Series 0900, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 900 Road Pavements – Bituminous Bound Materials.' |
| Ref 8.N | Highways England. LA 111, 'Noise and vibration' |
| Ref 9.N | National Highways. GD 301, 'Smart motorways' |
| Ref 10.N | National Highways. CD 236, 'Surface course materials for construction' |
| Ref 11.N | The National Archives. legislation.gov.uk. UKSI 2015/392, 'The Motorways Traffic (England And Wales) (Amendment) (England) Regulations 2015' |
| Ref 12.N | National Highways. CD 358, 'Waterproofing and surfacing of concrete bridge decks' |

# E/3. Informative references

The following documents are informative references for this document and provide supporting information.

| Ref. | Document |
|---|---|
| Ref 1.I | BSI. BS EN 12697-43, 'Bituminous mixtures. Test methods for hot mix asphalt. Resistance to fuel' |
| Ref 2.I | BSI. BS EN 12697-22, 'Bituminous mixtures. Test methods for hot mix asphalt. Wheel tracking' |
| Ref 3.I | Highways England. CS 229, 'Data for pavement assessment' |
| Ref 4.I | Department for Transport. TAG Unit A1-3, 'Transport Appraisal Guidance Unit A1-3 user and provider impacts' |
| Ref 5.I | Department for Transport. TAG Unit A3, 'Transport Appraisal Guidance Unit A3 environmental impact appraisal' |

# Appendix E/A. Surfacing selection guidance

## E/A1 Examples of scheme specific factors

A scheme may include particular issues that can influence the selection of a surface course material or surface course material system. Typical examples of scheme-specific requirements can include:

1) water permeability or impermeability;
2) existing road geometry and traffic management constraints;
3) speed of installation required;
4) weather conditions;
5) coloration;
6) high resistance to scuffing;
7) high deformation resistance;
8) adhesion to particular substrates; and,
9) fuel resisting properties.

# Appendix E/B. Value for money calculation for noise

## E/B1 Calculation

Value for money with respect to noise abatement measures may be calculated as follows:

1) benefit: cost saving of the proposed surface over 60 years, when compared to standard surface (taking into account the number of renewals anticipated over 60 years);
2) cost: additional cost of noise at properties within 600 m of the proposed surfaces over 60 years as defined by TAG Unit A1-3 [Ref 4.I] TAG Unit A3 [Ref 5.I] or any update thereof.

## E/B2 Noise cost

Further information on how to calculate noise cost is provided as follows:

1) all properties within 600 m should experience the same noise change if the surface noise characteristics change;
2) the noise cost of a surface should increase by a maximum of £25,000 per property over 60 years for every increase of 3 dB(A). This figure can be used to quickly calculate the maximum cost of additional noise in sparsely populated areas;
3) if a noise model is available for the scheme it can be used to accurately calculate noise exposure for each individual property, which can thereafter be used to calculate cost. If no noise model is available, existing noise exposure for properties can be estimated using DEFRA noise mapping data.

Pavement
Design

# CD 236 - NINAA
# Northern Ireland National Application Annex for Surface course materials for construction

(formerly CD 236 revision 3 including HD 36/06)

Version 4.1.0

**Summary**
This National Application Annex sets out the Department for Infrastructure, Northern Ireland specific requirements on surface course material options.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

**This is a controlled document.**

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 - NINAA | 4.**1**.0 | December 2022 | Northern Ireland NAA | Incremental change to requirements |

Version 4.1.0 (Dec. 2022) Department for Infrastructure, Northern Ireland National Application Annex to CD 236. Revision 4 has additional requirements for lay-bys and hardstanding locations.

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 | 4 | March 2020 | | |
| CD 236 | 3 | April 2019 | | |
| CD 236 | 0 | October 2018 | | |

# Foreword

## Publishing information

This document is published by National Highways on behalf of the Department for Infrastructure, Northern Ireland.

This document is a National Application Annex to CD 236 [Ref 7.N].

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the Department for Infrastructure, Northern Ireland-specific requirements related to surface course materials options.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

# Abbreviations

| Abbreviation | Definition |
|---|---|
| DAERA | Department of Agriculture, Environment and Rural Affairs (NI) |
| HRA | Hot rolled asphalt |
| NMA | Noise management area |
| SMA | Stone mastic asphalt |

# Terms and definitions

| Term | Definition |
| --- | --- |
| Departure | Variation or waiving of a requirement carried out in accordance with the Overseeing Organisation's procedures. |

# NI/1. Surface course material options (CD 236, 2.1)

## Choice of surfacing

NI/1.1 Surface course materials shall be selected from the permitted options provided in tables NI/1.1a, NI/1.1b, and NI/1.1c ( MCHW Series 0900 [Ref 4.N] & MCHW Series 1000 [Ref 2.N]).

**Table NI/1.1a : Permitted pavement surface course materials for new and maintenance construction (flexible and flexible composite construction)**

| | | | | Use without restriction | Departure required |
|---|---|---|---|---|---|
| New construction or major maintenance? | Yes | High speed? (85%ile above 65 km/h) | Yes | MCHW clause 924 high friction surfacing<br>MCHW clause 942 thin surface course system<br>MCHW clause 910 hot rolled asphalt | MCHW clause 938 porous asphalt 1 |
| | | | No | MCHW clause 924 high friction surfacing<br>MCHW clause 942 thin surface course system<br>MCHW clause 910 hot rolled asphalt | MCHW clause 938 porous asphalt 1 |
| | No (minor) | High speed? (85%ile above 65 km/hr) | Yes | MCHW clauses 919 and 922 surface dressing<br>MCHW clause 924 high friction surfacing<br>MCHW clause 942 thin surface course system<br>MCHW clause 910 hot rolled asphalt<br>MCHW clause 912 Asphalt concrete surface course | MCHW clause 938 porous asphalt 1 |
| | | | No | MCHW clause 924 High friction surfacing<br>MCHW clause 942 thin surface course system<br>MCHW clause 910 hot rolled asphalt<br>MCHW clause 912 Asphalt concrete surface course<br>MCHW clauses 919 and 922 surface dressing<br>MCHW clause 918 slurry surfacing | MCHW clause 938 porous asphalt 1 |
| NOTE 1 Not permitted on flexible composite construction | | | | | |

**Table NI/1.1b Permitted pavement surface course materials for new and maintenance construction (rigid)**

| | | | | Use without restriction | Departure required |
|---|---|---|---|---|---|
| New construction or major maintenance | Yes | High speed? (85%ile above 65km /h) | Yes | MCHW clause 1044 exposed aggregate concrete | MCHW clause 1026 textured concrete |
| | | | No | MCHW clause 1044 exposed aggregate concrete | MCHW clause 1026 textured concrete |
| | No | High speed? (85%ile above 65km /h) | Yes | MCHW clause 1044 exposed aggregate concrete<br>MCHW clause 910 hot rolled asphalt<br>MCHW clauses 919 and 922 surface dressing | MCHW clause 1026 textured concrete<br>MCHW clause 938 porous asphalt<br>MCHW clause 942 thin surface course system |
| | | | No | MCHW clause 1044 exposed aggregate Concrete<br>MCHW clause 910 hot rolled asphalt<br>MCHW clauses 919 and 922 surface dressing<br>MCHW clause 918 slurry surfacing | MCHW clause 1026 textured concrete<br>MCHW clause 938 porous asphalt<br>MCHW clause 942 thin surface course system |

**Table NI/1.1c Permitted pavement surface course materials for new and maintenance construction (rigid composite)**

| | | | | Use without restriction | Departure required |
|---|---|---|---|---|---|
| New construction or major maintenance? | Yes | High speed? (85%ile above 65 km/h) | Yes | MCHW clause 910 Hot rolled asphalt<br>MCHW clause 942 thin surface course system | MCHW clause 938 porous asphalt |
| | | | No | MCHW clause 910 hot rolled asphalt<br>MCHW clause 942 thin surface course system<br>MCHW clauses 919 and 922 surface dressing | MCHW clause 938 porous asphalt |
| | No (minor) | High speed? (85%ile above 65 km/h) | Yes | MCHW clause 910 Hot rolled asphalt<br>MCHW clause 942 thin surface course system | MCHW clause 938 porous asphalt |
| | | | No | MCHW clause 910 hot rolled asphalt<br>MCHW clause 942 thin surface course system<br>MCHW clauses 919 and 922 surface dressing<br>MCHW clause 918 slurry surfacing | MCHW clause 938 porous asphalt |

NI/1.2 Retexturing of existing surfaces shall not be carried out without departure approval.

NI/1.3 Where small lengths of pavement with a particular skidding or other safety concern are the object of proposed retexturing then departure approval shall not be unreasonably withheld.

NI/1.4 Where a materials option in tables NI/1.1a, NI/1.1b or NI/1.1c is shown in the 'departure required' column then a departure from standard shall be obtained from the Overseeing Organisation before use.

## Lay-bys and hardstanding locations

NI/1.5 New lay-bys and hardstanding locations on trunk roads shall use a surfacing from one of the following options:

1) concrete (see Series 1000 of MCHW Series 1000 [Ref 2.N]);
2) block paving (see Series 1100 of MCHW Series 1100 [Ref 3.N]);
3) bituminous mixtures with deformation and fuel resistant properties.

*NOTE 1 'Fuel resistant' is defined as a bituminous mixture that suffers a loss of less than 6% mean value of the combined loss of mass (Cimax) when tested to BS EN 12697-43 [Ref 1.I].*

*NOTE 2 'Deformation resistant' is defined as developing a rut of less than 2.5 mm when tested to BS EN 12697-22 [Ref 2.I].*

*NOTE 3 Grouted macadam can provide a suitable surfacing for lay-bys and hardstanding locations.*

NI/1.6 Existing lay-bys shall be resurfaced with either:

1) the same surfacing type as the adjacent carriageway in agreement with the project sponsor.
2) bituminous mixtures with deformation and fuel resisting properties
3) block paving ( MCHW Series 1100 [Ref 3.N]); or,
4) concrete ( MCHW Series 1000 [Ref 2.N]).

### Noise sensitive sites

NI/1.7 Where any of the following applies, a site shall be classed as 'noise sensitive':

1) the location has been identified as a noise important area in any of Northern Ireland's noise action plans published by DAERA NAP(NI) [Ref 6.N];
2) noise 'sensitive receptors' are located within 600 m from the roadside (and 600 m from the ends of the sections);
3) noise barriers or earth bunds have been installed as a noise mitigation measure; or,
4) there are designated areas of landscape or biodiversity value within 600 m of the roadside (and 600 m from the ends of the sections).

*NOTE 1 Examples of 'sensitive receptors' are given in LA 111 [Ref 5.N].*

*NOTE 2 Areas of landscape or biodiversity value include areas of bird nesting or areas with multiple footpaths used regularly for recreation.*

NI/1.8 Noise sensitive areas shall be assessed and appropriate mitigation provided, taking account of site specific factors, in agreement with the project sponsor.

NI/1.8.1 Where noise levels are high due to the intensity of high-speed traffic, surfacing materials may be used that can significantly reduce tyre/road-generated noise emission compared to hot-rolled asphalt (HRA).

*NOTE 1 Surfacing materials that can significantly reduce tyre/road-generated noise emission can include, for example, hot, paver-laid thin-surface course systems (TSCS) complying with clause 942 of the specification MCHW Series 0900 [Ref 4.N].*

*NOTE 2 Traffic noise at lower speed zones (85%ile traffic speed below 50 km/h) is mainly attributable to engine, transmission and exhaust noise, especially from lorries.*

*NOTE 3 Further information on NMAs can be obtained from the Overseeing Organisation.*

### Coloured surfacing

NI/1.9 The surface course material or system to be used for coloured surfacing shall be selected from Table NI/1.9.2N.

NI/1.9.1 Coloured surfacing materials or systems may be used to provide a contrasting colour to the adjacent pavement surfaces, and/or to supplement prescribed signs/markings such as for bus and cycle lanes.

NI/1.9.2 Coloured surfacing may be provided by using individually (or a combination of) the following:

1) natural coloured aggregates;
2) artificially pigmented aggregates;
3) pigmented binder; or,
4) addition of pigments to a mixture.

*NOTE The surface course materials or systems presented in Table NI/1.9.2N can be produced as a coloured surfacing.*

**Table NI/1.9.2N Material options for coloured surfacing**

| Material | Specification clause MCHW Series 0900 [Ref 4.N] |
| --- | --- |
| Thin surface course systems | Clause 942 |
| Cold applied ultra thin surfacing | Clause 923 |
| Slurry surfacing and microsurfacing | Clause 918 |
| Surface dressing | Clause 922 |
| High friction surfacing | Clause 924 |
| Grouted macadam surfacing | N/A |
| Hot rolled asphalt | Clauses 910 and 943 |

NI/1.9.3 Where the coloured surfacing selected forms a layer <10 mm thick the underlying material should be in a sound condition and free of visual defects.

# NI/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| **Ref.** | **Document** |
|---|---|
| Ref 1.N | National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 2.N | Highways England. MCHW Series 1000, 'Manual of Contract Documents for Highway Works. Volume 1 - Specification for Highway Works. Series 1000 Road Pavements – Concrete Materials' |
| Ref 3.N | Highways England. MCHW Series 1100, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 1100 Kerbs, Footways and Paved Areas.' |
| Ref 4.N | Highways England. MCHW Series 0900, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 900 Road Pavements – Bituminous Bound Materials.' |
| Ref 5.N | Highways England. LA 111, 'Noise and vibration' |
| Ref 6.N | DAERA. NAP(NI), 'Northern Ireland's Noise Action Plans' |
| Ref 7.N | National Highways. CD 236, 'Surface course materials for construction' |

# NI/3. Informative references

The following documents are informative references for this document and provide supporting information.

| Ref. | Document |
|---|---|
| Ref 1.I | BSI. BS EN 12697-43, 'Bituminous mixtures. Test methods for hot mix asphalt. Resistance to fuel' |
| Ref 2.I | BSI. BS EN 12697-22, 'Bituminous mixtures. Test methods for hot mix asphalt. Wheel tracking' |

Design Manual for Roads and Bridges

Pavement
Design

# CD 236 - SNAA
# Scotland National Application Annex for Surface course materials for construction

(formerly CD 236 revision 3 including HD 36/06)

Version 4.1.0


**Summary**
This National Application Annex sets out the Transport Scotland specific requirements on surface course materials options.


**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

**This is a controlled document.**

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 - SNAA | 4.**1**.0 | December 2022 | Scotland NAA | Incremental change to requirements |

[Version 4.1.0; Published Dec. 2022] New requirements on lay-bys and hardstanding for HGVs (Sec. S/) and other PSV values allowed if performance demonstrated (Sec. 2) and updated reference. Transport Scotland National Application Annex to CD 236.

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 | 4 | March 2020 | | |
| CD 236 | 3 | April 2019 | | |

# Foreword

## Publishing information

This document is published by National Highways on behalf of Transport Scotland.

This document is a National Application Annex to DMRB document CD 236 [Ref 5.N].

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the Transport Scotland-specific requirements related to pavement surfacing for both flexible and rigid pavements.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

# S/1. Surface course material options (CD 236, 2.)

## Choice of surfacing

S/1.1 Surface course materials shall be selected from those listed in Table S1.1 as permitted options.

**Table S/1.1 Permitted pavement surface course materials**

| | New construction | Maintenance |
|---|---|---|
| Clause 911TS Hot rolled asphalt[1] | ✓ | ✓ |
| Clause 918 Slurry surfacing and microsurfacing | X | ATP |
| Clause 922 Surface dressing[1] | X | ATP |
| Clause 924 High-friction surfacing | ✓ | ✓ |
| Clause 938 Porous asphalt | ATP | ATP |
| Clause 942 Thin surface course system | ATP | ATP |
| Clause 942TS Stone mastic asphalt surface course (T S2010) | ✓ | ✓ |
| Clause 943 Hot rolled asphalt[1] | ✓ | ✓ |
| Clause 1044 Exposed aggregate concrete[1] | ATP | X |

| **NOTE: Key:** | |
|---|---|
| ✓ | Use permitted without further approval |
| ATP | ATP - 'Approval to Proceed' to be obtained from Overseeing Organisation |
| X | Not permitted for use |
| Note 1: Not generally permitted within noise management areas – see Cl. S/1.10 | |

*NOTE More information on the permitted materials can be seen in the 0900 and 1000 Series of the Manual of Contract Documents for Highway Works, Volume 1 MCHW Series 0900 [Ref 4.N] & MCHW Series 1000 [Ref 2.N].*

S/1.2 Where required by Table S1.1, an Approval to Proceed shall be obtained from the Overseeing Organisation for use of the material.

S/1.3 The decision on which permitted surface course materials are selected or excluded shall be made on a site- specific basis.

S/1.4 A record of the decision on which permitted surface course have been selected shall be made.

S/1.5 A departure shall not be required for retexturing.

S/1.6 High friction surfacing shall be grey in colour unless colour contrast is specifically required for demarcation purposes.

S/1.7 High friction surfacing shall not be used for the sole purpose of achieving colour contrast.

## Lay-bys and hardstanding locations frequented by heavy goods vehicles

S/1.8 Lay-bys and hardstanding locations that are frequented by heavy goods vehicles shall use a deformation-resisting and fuel-resisting surfacing from one of the following options:

1) concrete (see MCHW Series 1000 [Ref 2.N]);
2) block paving (see MCHW Series 1100 [Ref 3.N]); or,

3) bituminous mixtures with deformation and fuel resistant properties.

*NOTE 1* *'Fuel resisting' is defined as a bituminous mixture that suffers a loss of less than 6% mean value of the combined loss of mass ($Ci_{max}$) when tested to BS EN 12697-43 [Ref 3.I].*

*NOTE 2* *'Deformation resisting' is defined as a bituminous mixture developing a rut of less than 2.5 mm when tested to BS EN 12697-22 [Ref 4.I].*

*NOTE 3* *Grouted macadam can provide a suitable surfacing for lay-bys and hardstanding locations.*

*NOTE 4* *All dual-carriageway lay-bys and hardstandings are considered to be subject to frequent use by heavy goods vehicles.*

### Noise management areas

S/1.9 The design of maintenance and construction schemes within Scotland Noise Management Areas (see Noise Map (S) [Ref 5.I]) shall incorporate the requirements of the Transportation Noise Action Plan TNAP 2014 [Ref 7.N] in the selection of surface course materials.

S/1.9.1 Where traffic speeds are lower than 30 mph the full range of surface course materials may be selected.

S/1.10 A submission for justification for selecting materials not generally permitted within noise management areas as shown in Table S1.1 shall not be based solely on value for money.

*NOTE 1* *More information on Scotland Noise Management Areas can be found in the Scottish Government 'Transportation Noise Action Plan' 2014 TNAP 2014 [Ref 7.N].*

*NOTE 2* *Further advice with respect to road noise can be found in TRL report TRL PPR 443 [Ref 2.I].*

# S/2. Aggregate selection (CD 236, 3)

S/2.1 For clause 942 thin surface course systems (TSCS) aggregate with a PSV other than those contained within CD 236 [Ref 5.N] Table 3.2b shall be permitted providing it has been demonstrated that the aggregate is able to provide the required skid resistance based on previous uses of the aggregate.

*NOTE PSV tables in the main document do not apply to TS2010 material other than for consideration prior to approval of initial stage 3 trials.*

S/2.2 When aggregate with a PSV other than those contained with Table 3.2b is adopted, technical and historical data along with the reasoning and justification shall be documented, as well as the methodology adopted to support the case.

*NOTE One methodology usable for supporting a case for the use of lower PSV aggregates with adequate skid resistance is presented in TRL PPR 820 [Ref 1.I].*

S/2.3 Site category definitions used for PSV selection shall be as given in the Transport Scotland Interim Amendment - Skidding Resistance TS IA 51/22 2022 [Ref 6.N].

## S/3. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| **Ref.** | **Document** |
|---|---|
| Ref 1.N | National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 2.N | Highways England. MCHW Series 1000, 'Manual of Contract Documents for Highway Works. Volume 1 - Specification for Highway Works. Series 1000 Road Pavements – Concrete Materials' |
| Ref 3.N | Highways England. MCHW Series 1100, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 1100 Kerbs, Footways and Paved Areas.' |
| Ref 4.N | Highways England. MCHW Series 0900, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 900 Road Pavements – Bituminous Bound Materials.' |
| Ref 5.N | National Highways. CD 236, 'Surface course materials for construction' |
| Ref 6.N | Transport Scotland. TS IA 51/22, 'Transport Scotland Interim Amendment 51/22 – Skidding Resistance ' , 2022 |
| Ref 7.N | Scottish Government. TNAP 2014, 'Transportation Noise Action Plan 2014' |

# S/4. Informative references

The following documents are informative references for this document and provide supporting information.

| Ref. | Document |
| --- | --- |
| Ref 1.I | Transport Research Laboratory. TRL PPR 820, 'A procedure for justifying aggregate use based on skid resistance' |
| Ref 2.I | Transport Research Laboratory. P G Abbot, P A Morgan and B McKell (AECOM). TRL PPR 443, 'A review of current research on road surface noise reduction techniques' |
| Ref 3.I | BSI. BS EN 12697-43, 'Bituminous mixtures. Test methods for hot mix asphalt. Resistance to fuel' |
| Ref 4.I | BSI. BS EN 12697-22, 'Bituminous mixtures. Test methods for hot mix asphalt. Wheel tracking' |
| Ref 5.I | Scottish Government. Noise Map (S), 'Scotland's Noise Maps' |

Design Manual for Roads and Bridges

Pavement
Design

# CD 236 - WNAA
# Wales National Application Annex for Surface course materials for construction

(formerly CD 236 revision 3 including HD 36/06)

Version 4.2.0

**Summary**
This National Application Annex sets out the Welsh Government specific requirements on surface course materials options.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards$_{F}eedback_{a}nd_{E}nquiries@gov.wales$

**This is a controlled document.**

## Latest release notes

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 - WNAA | 4.**2**.0 | December 2022 | Wales NAA | Incremental change to requirements |
| [PUB. DATE Dec. 2022] Approvals changes to Table W/1.1. Other changes for MDD compliance. | | | | |

## Previous versions

| Document code | Version number | Date of publication of relevant change | Changes made to | Type of change |
|---|---|---|---|---|
| CD 236 | 4.**1**.0 | July 2021 | Wales NAA | Incremental change to requirements |
| CD 236 | 4 | March 2020 | | |
| CD 236 | 3 | April 2019 | | |
| CD 236 | 0 | October 2018 | | |

# Foreword

## Publishing information

This document is published by National Highways on behalf of the Welsh Government.

This document is a National Application Annex to CD 236 [Ref 6.N].

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex gives the Welsh Government-specific requirements related to surface course materials options.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| BSI | British Standards Institution |
| DMRB | Design Manual for Roads and Bridges |
| HSCA | High stone content asphalt |
| MCHW | Manual of Contract Documents for Highway Works |
| SMA | Stone mastic asphalt |
| PAG | Procedure advice and guidance |

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| Approval to proceed | Formal agreement to be obtained from the Overseeing Organisation before use, as listed in Table W/1.1. |
| Departure | Variation or waiving of a requirement carried out in accordance with the Overseeing Organisation's procedures. |
| Overseeing Organisation | The highways or roads authority of the Welsh Government and its successors. |

# W/1. Surface course material options (CD 236, 2.1)

## Choice of surfacing

W/1.1 Surface course materials shall be selected from MCHW Series 1000 [Ref 2.I] & MCHW Series 0900 [Ref 3.N] using the permitted options provided in Table W/1.1.

**Table W/1.1 Permitted pavement surface course materials for new and maintenance construction**

| Is the scheme within a noise priority area? | Use can be without approval | 'Approval to proceed' is required |
|---|---|---|
| No | Clause 911W and 943 Hot rolled asphalt;<br>Clause 923 Cold-applied ultra-thin surfacing.<br>WG Stone mastic asphalt[1]. | Clause 918 Slurry and microsurfacing;<br>Clause 922 Surface dressings;<br>Clause 942 Thin surface course system;<br>Clause 1026 Textured concrete [2] ;<br>Clause 1044 Exposed aggregate concrete [2] ; |
| Yes | Clause 911W Hot rolled asphalt[3];<br>WG Stone mastic asphalt[1]. | Clause 911W and Clause 943 Hot rolled asphalt;<br>Clause 918 Slurry and microsurfacing;<br>Clause 923 Cold-applied ultra-thin surfacing;<br>Clause 942 Thin surface course system; |
| Note 1: To comply the latest issue of Welsh Government's PAG 112/20 [Ref 5.N] | | |
| Note 2: Rigid construction only. | | |
| Note 3: 55/14C and 55/10C mixtures only. | | |

W/1.2 Where a material option in Table W/1.1 requires an 'approval to proceed', an approval shall need to be obtained from the Overseeing Organisation.

W/1.3 Materials complying with MCHW clauses 918, 922 & 923 shall only be used for maintenance purposes.

W/1.3.1 All other materials in Table W/1.1 should be proposed for new constructions.

W/1.4 The choice to use a material outside or not in accordance with Table W/1.1, must require a departure from standard.

## Noise priority areas

W/1.5 Materials complying with MCHW clauses 911WG, 922, 923 and 943 shall only be used for sites where:

1) the location has not been identified as a priority area in the Welsh Government's 'Noise and Soundscape action plan 2018-2023' N&SAP [Ref 4.N]published in December 2018 or any update thereof ;
2) no noise action priority areas are located within an envelope of 600 metres from the roadside and 600 metres from the ends of section;
3) the scheme is not considered noise-sensitive and has not received any noise mitigation measures; and,

4) no residential areas, schools, hospitals or similar are within 600 metres of the proposed scheme.

W/1.5.1 Traffic noise at speeds <50 km/h is mainly attributed to engine, transmission and exhaust noise, especially from larger vehicles and therefore, all materials should be assessed for use.

*NOTE In this instance HRA complying with Clause 911WG refers to chipped surfaces.*

### Aggregate selection

W/1.6 Section 3 CD 236 [Ref 6.N] shall not apply to materials complying with Clause 1026 and PAG 112/20.

W/1.7 When an aggregate with a lower PSV than indicated in CD 236 Table 3.3a or 3.3b is proposed, previous usage and supporting evidence shall demonstrate the aggregates durability with a satisfactory skid resistance performance and skidding accident rate, before approval can be obtained from the Overseeing Organisation.

W/1.8 The minimum PSV values indicated in CD 236 Table 3.3a and 3.3b shall only be used if no alternative information is available.

### Texture

W/1.9 Any retexturing of existing surfaces shall require an approval to proceed from the Overseeing Organisation.

W/1.10 Texture depth for MCHW Clauses 911WG, 918, 922 and 943 shall comply with Clause 921.

W/1.11 Any use of asphalt preservation treatments, including sealants and rejuvenators, shall require an approval to proceed from the Overseeing Organisation.

### Coloured surfacing

W/1.12 When applied as a veneer (<10 mm thick) the existing surface course shall be in a sound condition with no:

1) visual sign of, or recorded, defects;
2) rutting in condition category 1; nor,
3) deflectograph in condition categories 1.

*NOTE Network level condition survey information is provided in CS 229 [Ref 1.I].*

### Lay-bys and hardstanding locations

W/1.13 Laybys and hardstanding locations including emergency areas shall use a deformation- and fuel- resisting surfacing from the following options:

1) concrete (see MCHW Series 1000 [Ref 2.I]);
2) block paving ( MCHW Series 1100 [Ref 2.N]); or,
3) bituminous mixtures with deformation- and fuel-resistant properties.

# W/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| **Ref.** | **Document** |
|---|---|
| Ref 1.N | National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 2.N | Highways England. MCHW Series 1100, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 1100 Kerbs, Footways and Paved Areas.' |
| Ref 3.N | Highways England. MCHW Series 0900, 'Manual of Contract Documents for Highway Works. Volume 1 Specification for Highway Works. Series 900 Road Pavements – Bituminous Bound Materials.' |
| Ref 4.N | Welsh Government. N&SAP, 'Noise and soundscape action plan 2018 to 2023' |
| Ref 5.N | Welsh Government. PAG 112/20, 'Stone Mastic Asphalt Specification' |
| Ref 6.N | National Highways. CD 236, 'Surface course materials for construction' |

# W/3. Informative references

The following documents are informative references for this document and provide supporting information.

| Ref. | Document |
|---|---|
| Ref 1.I | Highways England. CS 229, 'Data for pavement assessment' |
| Ref 2.I | Highways England. MCHW Series 1000, 'Manual of Contract Documents for Highway Works. Volume 1 - Specification for Highway Works. Series 1000 Road Pavements – Concrete Materials' |

Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

# CD 377
# Requirements for road restraint systems

(formerly TD 19/06)

Revision 4


**Summary**
This document details the requirements for permanent and temporary safety barriers, vehicle parapets, terminals, transitions, crash cushions, pedestrian parapets, pedestrian guardrails and pedestrian restraint and protection, vehicle arrester beds, anti-glare systems and cattle grids.


**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 4 | Jan 2021 | Revision 4 (January 2021) Northern Ireland National Application Annex requirements created. Revision 3 (December 2020) Update to Scotland National Application Annex only. Revision 2 (July 2020) Wales National Application Annex requirements created. Revision 1 (June 2020) Scotland National Application Annex requirements created. Revision 0 (March 2020) CD 377 replaces TD 19/06. This full document has been re-written to make it compliant with the new Highways England drafting rules. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes TD 19/06, and partially supersedes IAN 68/05 and IAN 75/06 which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This document is an update to TD 19/06 and reflects changes to the Overseeing Organisations' requirements. It also takes account of updated and new EU standards and legislation.

This document gives requirements for road restraint systems and it, together with the associated RRRAP [Ref 43.N] and RRRAP User Guide [Ref 14.N], assists those involved in determining where road restraint systems are warranted, and the minimum required parameters.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 19.N] apply to this document.

This document is written on the basis that road restraint systems will be supplied and constructed in accordance with the MCHW [Ref 22.N] and all other works will be designed and specified in accordance with the Design Manual for Roads and Bridges.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a British Standard, technical specification or quality mark, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 19.N].

# Abbreviations and symbols

### Abbreviations

| Abbreviation | Definition |
|---|---|
| AADT | Average annual daily traffic |
| AIP | Approval in Principle |
| ALARP | As low as reasonably practicable |
| CPR | Construction Products Regulation |
| DfT | Department for Transport |
| ECP | Emergency crossing point |
| EqIA | Equality Impact Assessment |
| ISL | Impact severity level |
| LGV | Large Goods Vehicle |
| LoN | Length of Need |
| m | Metres |
| MCP | Maintenance crossing point |
| mm | Millimetre |
| mph | Miles per hour |
| OLE | Overhead line equipment |
| PNR | Point of no recovery |
| Psb | Point from which set-back is measured |
| RRRAP | Road Restraint Risk Assessment Process |
| RRS | Road restraint system |
| SO | Special Order |
| STGO | Special Types General Order |
| TTM | Temporary traffic management |
| VI | Vehicle intrusion |
| VMS | Variable message sign |
| VRS | Vehicle restraint system |
| WMCP | Winter maintenance crossing point |
| W | Working width |

### Symbols

| Symbol | Definition |
|---|---|
| kN | Kilo Newtons |
| Wn | Normalised working width |
| γfl | Partial factor for load |
| $Y_m$ | Partial factor on material strength |

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| **Risk associated terms, also refer to GG 104 [Ref 31.N]** | |
| 'Acceptable', 'broadly acceptable' and 'as low as reasonably practicable level of risk. | The Road Restraint Risk Assessment Process ( RRRAP [Ref 43.N]) that forms part of this document uses the term 'acceptable' to indicate where a 'broadly acceptable' level of risk is achieved in respect of vehicle restraint system provision.<br><br>NOTE: Depending on the situation, this can be where safety barrier is not warranted, or can be achieved over a range of safety barrier lengths. |
| Hazard | A source of potential harm, loss or failure. |
| Other Parties (referred to as "Others" in the RRRAP [Ref 43.N]) | A group or collection of people in a public place, such as a school, hospital or railway, that can be injured in numbers by an errant vehicle or by a hazard that is hit by an errant vehicle; or a high value asset or facility that can be adversely affected by an impact from an errant vehicle or by a hazard this is hit by an errant vehicle. |
| Safety risk | The expected consequence of a specified hazard being realised with the combination of the likelihood and expected severity of the outcome.<br><br>NOTE: Safety risk is a measure of harm or loss associated with an activity |
| Secondary event | An incident that can arise as a result of an initial event.<br><br>NOTE: For instance, if a lighting column is struck and falls onto a carriageway or a railway, the struck lighting column has the potential to cause a secondary event, such as being hit by a vehicle or train and hence creates a risk of a secondary incident occurring. |
| **Other terms** | |
| Adjoining paved surface | The paved area on the traffic side of a parapet immediately adjacent to the plinth or base of the parapet. |
| Bi-directional crash cushion | A crash cushion which has successfully been tested with tests 1 to 5 inclusive, in accordance with BS EN 1317-1 [Ref 33.N] and BS EN 1317-3 2010 [Ref 26.N] |

**Terms** (continued)

| Term | Definition |
|---|---|
| Cattle grid | A device set into a road that consists of a number of transverse members supported over a pit. It forms a barrier to livestock but allows access for vehicles. |
| Crash cushion | An energy absorption device installed in front of one or more hazards to reduce the severity of an impact. |
| Deformable safety barrier | A safety barrier that when tested in accordance with BS EN 1317-1 [Ref 33.N] and BS EN 1317-2 [Ref 32.N], deflects from its pre-impact position. |
| Directional crash cushion | A crash cushion which has successfully been tested with tests 1 to 3 inclusive, and either test 4 or test 5 in accordance with BS EN 1317-3 2010 [Ref 26.N] |
| Energy absorbing terminal | A terminal attached to a VRS which, in test Approach 1 (i.e. head-on centre - refer to BS DD ENV 1317-4 [Ref 27.N]), does not allow the most forward point of the car to cross the vehicle exit line R, or which crosses line R at a speed less than or equal to 11 km/h. |
| Front face of parapet | The face or part of the parapet nearest to vehicular traffic. |
| Impact severity level (ISL) | A measure of the severity of an impact with a vehicle restraint system using a combination of vehicle acceleration and the theoretical head impact velocity.<br><br>NOTE 1: Refer to BS EN 1317-2 [Ref 32.N]).<br><br>NOTE 2: Impact severity level A affords a greater level of safety for the occupant of an errant vehicle than level B. |
| Large goods vehicles (LGV) | A vehicle with a gross combination mass of over 3500kg.<br><br>NOTE: Previously referred to as heavy goods vehicle (HGV) |
| Legacy system | Permanent safety barriers, parapets and crash cushions currently on the road network that were manufactured and installed before CE Marking under the Construction Products Regulations ( 2011/305/EU [Ref 15.N]) became a statutory requirement. |

**Terms** (continued)

| Term | Definition |
|---|---|
| Length of need | The total minimum length of full containment vehicle restraint systems (VRS) stipulated as being required in advance of, alongside, and after a hazard(s) to achieve a 'broadly acceptable' level of risk.<br><br>NOTE 1: The length over which various VRS reach full containment can vary and need to be checked with the manufacturer.<br><br>NOTE 2: When assessing whether the length of need and containment level are sufficient for a temporary situation, the speed limit used in the RRRAP [Ref 43.N] is usually the temporary mandatory limit that is to be in force. |
| Main structure | Any part of a bridge, viaduct, retaining wall or similar structure upon which a pedestrian or vehicle parapet is mounted, including the plinth. |
| Non re-directive crash cushion | A crash cushion which has successfully been tested with tests 1 to 3 inclusive, in accordance with BS EN 1317-1 [Ref 33.N] and BS EN 1317-3 2010 [Ref 26.N] |
| Normalised values (of working width and vehicle intrusion) | Values that have been adjusted to take account of any differences between the specified total mass of a vehicle, its velocity and angle of approach, and the values measured during testing.<br><br>NOTE: Refer to BS EN 1317-2 [Ref 32.N]. |
| Parapet | A restraint system that is installed on the edge of a bridge, retaining wall or similar elevated structure where there is a vertical drop. |
| Pedestrian parapet | A restraint system that is installed on the edge of a bridge, retaining wall or similar elevated structure where there is a vertical drop where vehicular traffic is excluded, but where pedestrians, equestrians, cyclists or livestock can be present. |
| Pedestrian restraint system | A restraint system installed to reduce the risk of a fall from a height at locations where pedestrian movement could occur due to highway use or maintenance activities. |
| Pedestrian guardrail | A restraint system along the edge of a footway or footpath intended to restrain pedestrians and other users from stepping onto or crossing a road, or entering other areas likely to be hazardous. |

**Terms** (continued)

| Term | Definition |
|---|---|
| Planned maintenance | Planned work required to parts of the motorway and all-purpose trunk roads that have become unserviceable because of general wear or tear, or due to a major upgrade or changes to parts of the network.<br><br>NOTE: This excludes work associated with incident damage. |
| Plinth | A continuous upstand on the edge of a structure upon which a vehicle parapet or pedestrian parapet is mounted. |
| Point of no recovery | The point at which the driver of an errant vehicle has no chance of recovering an errant vehicle back on the carriageway and, unless hit or diverted by an intervening hazard, is going to end up on (in) the adjacent road, railway, water hazard, etc.<br><br>NOTE: This point can be the top of an embankment slope, the top of the cutting to a railway, the bank of a water hazard if the road is at grade, etc. |
| Psb | Point from which set-back of the safety barrier or parapet face is measured.<br><br>NOTE: Refer to CD 127 [Ref 4.N] for minimum requirements for permanent safety barriers. |
| Railway authority | Authority responsible for the railway infrastructure (e.g. Network Rail) |
| Re-directive crash cushion | A crash cushion which has successfully been tested with tests 1 to 4 inclusive for a directional crash cushion, and tests 1 to 5 inclusive for a bidirectional crash cushion, in accordance with BS EN 1317-3 2010 [Ref 26.N] |
| Rigid safety barrier | A safety barrier that when tested in accordance with BS EN 1317-1 [Ref 33.N] and BS EN 1317-2 [Ref 32.N], does not deflect from its pre-impact position. |
| Road restraint system (RRS) | General name for vehicle restraint system or pedestrian restraint system used on the road. |
| Routine maintenance | Works which include all routine and cyclic work, and ad-hoc repairs. |

**Terms** (continued)

| Term | Definition |
|---|---|
| Running lane | That part of the trafficked carriageway nearest to the verge or central reserve that is under consideration.<br><br>NOTE: Under normal running conditions, the hard shoulder of a motorway would not be trafficked and would therefore not be classed as the running lane. It can however become a temporary running lane under temporary traffic management. |
| Safety barrier | A type of vehicle restraint system installed alongside or on the central reserve of a road which is typically comprised of metal and/or concrete and/or plastic components. |
| Set-back | The distance between the Psb and the traffic face of a RRS.<br><br>NOTE: Refer to CD 127 [Ref 4.N] for minimum requirements for permanent safety barriers. |
| Sidelong ground | Ground that falls away from the carriageway, where the road is not on a formed embankment.<br><br>NOTE: Sidelong ground typically occurs where the road is cut into the side of a hill such that the road is effectively in cutting on one side and the ground drops away from the carriageway on the other. |
| Smooth face | A face which has a surface finish with a maximum size of any undulation or depression in the surface not exceeding 30mm, when measured with respect to a plane through the peaks, the plane being broadly parallel to the road alignment.<br><br>A structure having a 25mm wide chamfered construction joint in its surface is also regarded as smooth. |
| Temporary safety barriers | Safety barriers that are to be in place for less than 4 years. |
| Vehicle intrusion (VI) | The vehicle intrusion of an LGV is the maximum dynamic lateral position from the undeformed traffic side of the barrier in consideration of a notional load having the width and length of the vehicle platform, and a total height of 4 m. The vehicle intrusion of a bus is the maximum dynamic lateral position of the bus from the undeformed traffic side of the barrier.<br><br>NOTE: Further detail is given in BS EN 1317-2 [Ref 32.N]. |

**Terms** (continued)

| Term | Definition |
|---|---|
| Vehicle intrusion class | The designation VI1, VI2, VI3, etc for classes of vehicle intrusion levels, as defined in BS EN 1317-2 [Ref 32.N]. |
| Vehicle parapet | A vehicle restraint system that is installed on the edge of a bridge, retaining wall or similar elevated structure where there is a vertical drop. |
| Vehicle restraint system (VRS) | A tested system installed on a road to provide a level of containment for an errant vehicle.<br><br>NOTE: A typical system consists of a terminal-safety barrier-terminal, or a terminal-safety barrier-parapet-safety barrier-terminal, and includes transitions where appropriate. |
| Working width (W) | The maximum lateral distance between any part of a safety barrier on the undeformed traffic side, and the maximum dynamic position of any part of the barrier during impact testing to BS EN 1317-2 [Ref 32.N].<br><br>NOTE 1: If the vehicle body deforms around the vehicle restraint system so that the latter cannot be used for the purpose of measuring the working width, the maximum lateral position of any part of the vehicle is the working width.<br><br>NOTE 2: Further detail is given in BS EN 1317-2 [Ref 32.N] |
| Working width class | The designation W1, W2, W3, etc for classes of working width levels, as defined in BS EN 1317-2 [Ref 32.N]. |

# 1. Scope

## Aspects covered

1.1 This document details the requirements that shall be used for:

1) permanent and temporary safety barriers;
2) vehicle parapets;
3) terminals;
4) transitions;
5) crash cushions;
6) pedestrian parapets;
7) pedestrian guardrails;
8) vehicle arrester beds;
9) anti-glare systems; and
10) cattle grids.

## Implementation and application

1.2 This document shall be implemented forthwith on the Overseeing Organisations' motorway and all-purpose trunk roads with speed limits of 50 mph or more, and two-way traffic flows of 5,000 average annual daily traffic (AADT) or more, according to the implementation requirements of GG 101 [Ref 19.N].

1.3 More specifically, this document shall be applied:

1) on all new roads;
2) on schemes where the highway cross-section is being altered permanently;
3) whenever the road restraint system (RRS) is life (serviceable life) expired and needs replacing;
4) whenever a hazard is introduced and/or moved, and/or modified;
5) whenever there is a change in risk at or near the edge of the carriageway;
6) whenever a RRS needs to be dismantled (other than where localised sections need to be removed to gain access), e.g. during planned maintenance schemes.

1.3.1 Unless otherwise agreed with the Overseeing Organisation, this document should also be applied:

1) when other works (excluding routine maintenance) are being carried out near a hazard that is currently without provision, or near an existing RRS that does not meet the requirements of this document (e.g. with regard to its containment level, normalised working width class, normalised vehicle intrusion class);
2) when other works (excluding routine maintenance) are being carried out near an existing vehicle restraint system (VRS) which is life (service life) expired;
3) when other works (excluding routine maintenance) are being carried out near an existing RRS that has less than 5 years serviceable life remaining and no other major maintenance works are planned during the remaining life of the existing RRS.

1.3.2 An existing VRS may be reused if it is CE marked and the declaration of performance meets the specified performance class requirements, and can be reinstalled to meet the normalised working width class and normalised vehicle intrusion class requirements.

*NOTE For post and rail safety barriers, it is normal for posts to be renewed rather than reused.*

1.4 Where a RRS can be made compliant with current requirements without significant undue additional expense and or delay, the opportunity shall be taken.

1.5 This document shall apply to all structures accommodating vehicles and/or vulnerable users, where the Overseeing Organisation is responsible for that structure.

1.6 Where a length of less than 500 m between terminals in a section of post and rail safety barrier needs to be dismantled or replaced as part of planned maintenance and the remaining length is less than 500 m, the entire length shall be installed in accordance with the requirements of this document.

1.7 On the all-purpose trunk road network where the design speed or imposed speed limit is less than 50 mph, a risk assessment which is acceptable to the Overseeing Organisation, shall determine whether RRS is necessary.

*NOTE Guidance on the specification of vehicle restraint systems for low speed and/or low flow roads can be found within Appendix A of this document.*

1.8 RRS provision and requirements shall be assessed at an early stage in the scheme's development and design processes to:

1) ensure all factors such as land take, road and cross-section geometry, location of hazards, the safety of construction and maintenance workers, road users, those that work on the road, and other parties, are taken account of in determining the overall optimum solution; and
2) minimise the need for departures from requirements; and
3) avoid abortive work.

### Use of GG 101

1.9 The requirements contained in GG 101 [Ref 19.N] shall be followed in respect of activities covered by this document.

# 2. General requirements

## Risk assessment and hazard mitigation

2.1 A site inspection shall be carried out to identify all local hazards which are to be mitigated by the design.

*NOTE A physical site inspection ensures that all local hazards have been identified, and to avoid abortive work if hazards are not identified at an early stage.*

2.2 The RRRAP [Ref 43.N] shall be used to formally record the type and location of all of the hazards which are to be mitigated by the design.

*NOTE 1 The RRRAP is a software tool which is available to assist in making an assessment in many situations, based on risk, as to whether a VRS is warranted to prevent the occupants of a vehicle from hitting near side or offside hazards.*

*NOTE 2 The RRRAP can be used on motorways and all purpose trunk roads having a speed limit of 50 mph or greater, and an AADT of 5,000 or greater.*

*NOTE 3 Guidance is given in Appendix A on how users of the RRRAP can deal with roads that have a low flow (i.e. < 5,000 AADT) and/or low speed limit (i.e. < 50 mph).*

*NOTE 4 The RRRAP is potentially inappropriate for a direct assessment of central reserves, roundabouts and junction areas or lay-bys, due to the complexity and variability of hazards and their locations, traffic speed limits, road layouts and alignments, and variability of traffic incident data in these situations.*

*NOTE 5 In order to estimate the level of risk, the RRRAP uses a combination of road data such as the road type, speed limit and AADT, default data and factors for each hazard type, and user input details relating to the nature and location of each hazard. The output shows the category of risk (unacceptable, tolerable, or acceptable) without a safety barrier and with the optimum length of safety barrier provision and its containment level. Indicative risk and benefit cost ratios can also be obtained.*

*NOTE 6 The RRRAP does not cover pedestrian restraint systems, vehicle arrester beds, anti-glare systems or cattle grids.*

2.3 The effect of mitigation options on the associated risk level and the benefits / cost ratio shall be reviewed within the RRRAP [Ref 43.N], and the risk reduced to an acceptable level or ALARP.

2.3.1 Mitigation options may involve:

1) eliminating the risk (by removing the hazard);
2) reducing the risk of impacting the hazard (by relocating the hazard to a position posing less overall risk and/or by redesigning the hazard to make it less aggressive e.g. by installing passively safe supports);
3) informing road users, road workers and third parties of the risk posed by the hazard (by providing additional signage and lining, for example);
4) controlling the risk (by the installation of a VRS).

*NOTE It is preferable to eliminate the risk over reducing it. In turn, reducing the risk is preferred over informing road users, road workers and third parties of the risk and controlling the risk.*

2.3.2 Other measures which also reduce the level of risk should be identified including:

1) additional risk management requirements contained in the DfT report 'Managing the accidental obstruction of the railway by road vehicles' MAOR [Ref 21.N];
2) a lower speed limit;
3) revision of the road layout and/or cross-section;
4) the installation of high friction road surfacing.

2.4 For each defined hazard, the need for a VRS, its parameters and minimum performance requirements shall be identified by using the RRRAP.

2.5 Where, having reviewed all the options, a solution is found within the RRRAP that produces an "acceptable" level of risk, then this option shall be used as the basis for the final design.

2.6 A record of the design for hazard mitigation shall include the hazards identified and the assumptions made to mitigate each of these hazards to demonstrate that the design meets the requirements of this document.

## Information to be provided and/or specified

2.7 The following shall be provided for each adopted hazard mitigation layout:

1) the risk assessment;
2) the output from the RRRAP;
3) a completed contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N];
4) all relevant supporting information for each design as part of the Health and Safety documentation required under the Construction (Design and Management) Regulations SI 2015/51 [Ref 41.N].

*NOTE The minimum risk assessment information required is:*

*1) basic common details;*
*2) collation of data;*
*3) user comments;*
*4) detailed results;*
*5) VRS summary output;*
*6) temporary hazards (where applicable); and*
*7) barrier and options costs worksheets.*

2.8 Factors relevant to the installation, maintenance and demolition of the RRS that can influence the choice of RRS shall be identified in the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N] to ensure that suitable systems are used.

# 3. Requirements for permanent safety barriers

3.1 All VRS installations that include permanent safety barriers shall be compatible with each other throughout the entire installation length (including any other safety barriers, parapets, terminals, transitions and crash cushions) and meet the requirements of this Section 3.

3.2 For each permanent safety barrier installation, based on the site specific conditions, the following and all other relevant requirements of MCHW Series 400 [Ref 23.N] and the associated MCHW Series NG400 [Ref 24.N] shall be specified in the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]:

1) containment level;
2) impact severity level (ISL);
3) set-back;
4) normalised working width class (W);
5) normalised vehicle intrusion class (VI);
6) location and maximum height that allows the required visibility (refer to CD 127 [Ref 4.N] and CD 109 [Ref 16.N]);
7) length of need;
8) any special requirements (e.g. environmental considerations, motorcyclist protection, lengths of removable safety barrier, ground conditions, proximity to embankment slopes, requirements to accommodate pedestrians on verges, clearance to hazards that are vulnerable to residual loading and loading requirements for structures, measures to reduce the risk of injury to pedestrians, equestrians and other vulnerable users (e.g. no sharp edges));
9) specific connection requirements to existing safety barriers, vehicle parapets or other structures.

*NOTE 1 The objective of installing safety barriers alongside or within a motorway and/or all-purpose trunk road is to reduce the consequences of vehicles leaving the carriageway and entering areas where hazards exist.*

*NOTE 2 Safety barriers are intended to contain and redirect vehicles along the line of the barrier in the direction of travel, so they do not rotate or overturn, for the benefit of road users.*

3.3 The design shall be the optimum solution for the hazard having achieved compliance with the mandatory requirements, the conditions of a relaxation (where applicable), a broadly acceptable level of risk, or having obtained a departure from requirements.

3.3.1 Guidance may be sought from safety barrier manufacturers on the most appropriate arrangement to prevent vehicles from hitting the ends of parapets, hazards in the verges and the adjacent road at entry slip and link roads, where the safety barrier arrangement is determined by the local geometry.

## Minimum containment levels

3.4 On roads with a speed limit of 50 mph or more, the minimum containment level for permanent safety barriers shall be:

1) normal containment level: N2;
2) higher containment level: H1;
3) very high containment level: H4a.

3.5 On roads with a speed limit of less than 50 mph, the minimum containment level for permanent safety barriers shall be:

1) normal containment level: N1;
2) higher containment level: H1;
3) very high containment level: H4a.

3.6 Where a site-specific risk assessment indicates that a containment level higher than the minimum level is required, the higher containment level shall be specified.

3.7 Where the need for a higher containment level or very high containment level safety barrier has been identified, the nature of the risk, any mitigation with the steps taken to reduce the risk and the resulting containment level required shall be recorded.

## Impact severity level

3.8 The impact severity level (ISL) shall be either level A or B.

## Normalised working width classes and normalised vehicle intrusion classes

3.9 For normal containment level safety barriers, the maximum identified value of normalised working width class that the local hazard(s) allow, shall be used.

3.10 For higher and very high containment level safety barriers, the maximum identified values of normalised working width class and normalised vehicle intrusion class that the local hazard(s) allow, shall be used.

3.11 For all higher and very high containment level safety barriers included in the contract specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N], the required clearance to any hazard that is vulnerable to residual loading shall be given in the site specific information.

## Length of need

3.12 During testing to BS EN 1317-2 [Ref 32.N], the test length of the safety barrier shall be sufficient to demonstrate the full performance characteristics of the barrier at the length of need.

3.13 The length of full containment safety barrier, i.e. the length of need in advance of and beyond a hazard(s), required to reduce the risk to occupants of an errant vehicle and to other parties that can be affected to an acceptable level as identified by the RRRAP [Ref 43.N], shall be specified (refer to contract specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]).

3.13.1 In the case of structures, part of the length of need may be provided by a vehicle parapet of sufficient containment, connected to lengths of safety barrier via transitions.

3.13.2 Where traffic can travel in both directions along the same carriageway, either under normal conditions or under temporary traffic management such as contraflow, it should be determined whether the minimum length of need is sufficient under both conditions.

3.13.3 The greater of the two lengths of need should be used.

3.13.4 Where the length of need for a temporary situation exceeds the length of need for normal conditions, the extra length of need may be provided only for the period of time that the temporary situation is in operation, or provided as a permanent solution.

3.14 The total length of safety barrier shall be the length of need plus the additional lengths declared by the manufacturer in advance of, and after the length of need, to ensure that the safety barrier attains full containment at the points required (see Figure 3.19).

*NOTE 1 Example 1: a gantry in the verge of a dual carriageway has a length of 5.5m. If the length of need of an N2 safety barrier is 43 m (30m + hazard length of 5.5m + 7.5m), but full containment is only achieved 20m from the safety barrier end of the terminal, then the minimum required length of safety barrier between terminals will be 83 m (i.e. 20 m + 30 m + hazard length of 5.5 m +7.5 m + 20 m).*

*NOTE 2 Example 2: a gantry in the verge of a single carriageway has a length of 5.5 m. If the length of need of an N2 safety barrier is 65.5 m (30m + hazard length of 5.5m + 30m), but full containment is only achieved 20m from the safety barrier end of the terminal, then the minimum required length of safety barrier between terminals will be 105.5 m (i.e. 20 m + 30 m + hazard length of 5.5 m + 30 m + 20 m).*

## Set-back

3.15 All parts of a permanent VRS, including the terminals, shall meet the minimum set-back requirements of CD 127 [Ref 4.N].

3.15.1 Greater set-back should be provided where space allows.

3.16 Rates of change of set-back shall not be greater than that declared by the manufacturer.

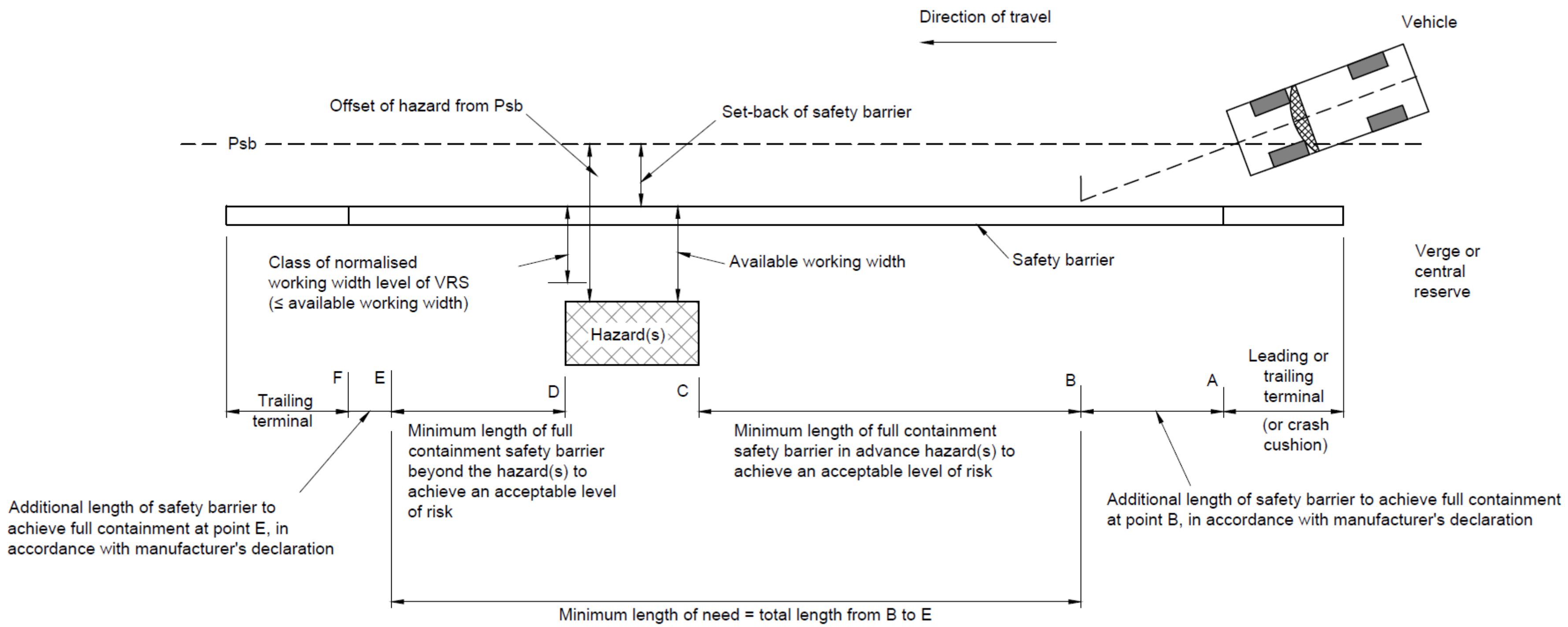
3.17 The proposed design layout of the safety barrier shall be such that it:

1) has a flowing alignment along the length of the safety barrier;
2) changes in safety barrier profile do not occur abruptly;
3) any changes in angle of the safety barrier presented to oncoming traffic (i.e. the approach angle) are not going to be significantly different in effect on an errant vehicle or on the safety barrier, to the angle(s) of approach at which the safety barrier has been tested or those declared by the manufacturer;
4) changes in alignment do not give rise to a 'pocketing' effect.

3.18 On the approach to structures, where the existing site geometry is restricted, if the taper or part of the taper is included in the length of need, the structure shall be fully collision resistant.

3.19 At locations other than the approach to structures, any taper catering for changes in set-back shall not be placed beyond point A on the approach and in advance of point D on the departure to a hazard, as shown in Figure 3.19.

**Figure 3.19 Set-back, working width, and length of need of safety barrier at an individual hazard**



## General requirements

3.20 All hazards within or immediately adjacent to the highway boundary that can cause a danger to the occupants of a vehicle or give rise to a secondary event were the vehicle to reach the hazard, or affect other parties shall be identified and assessed.

3.20.1 Where appropriate, hazards within or immediately adjacent to the highway boundary that can cause a danger to the occupants of a vehicle or give rise to a secondary event were the vehicle to reach the hazard, or affect other parties should also be listed in the risk assessment.

3.20.2 Examples of common hazards which should be included in the risk assessment are listed below:

1) above ground structural supports, bases or foundations positioned less than 3 m above the adjacent paved carriageway where local conditions at the site make it possible for the hazard to be reached;
2) drainage culvert head walls and ditches where the depth of the ditch relative to the adjacent ground level is 1 m or greater;
3) restricted headroom at a structure or part of a structure (refer to CD 127 [Ref 4.N]);
4) surface of a rigid structure or construction (such as retaining and abutment walls) that do not have a smooth face adjacent to the traffic that extends at least 1.5 m above the adjacent carriageway level;
5) exposed rock faced cutting slopes, rock filled gabions, crib walling or similar structures;
6) soil cutting slopes and earth bunds greater than 1 m high and with a side slope gradient of 1:1 or steeper;
7) embankments and vertical drops;
8) parapets (although these can form part of the VRS, their traffic facing ends can be a hazard and their presence needs to be identified);
9) strengthened or geotextile reinforced slopes;
10) environmental barriers or screens;
11) highway boundary fences and walls;
12) dwarf retaining walls surrounding hazards such as drainage access manholes and communication cabinets;
13) permanent or expected water hazard with a depth of water of 0.6 m or more, such as a river, reservoir, stilling pond or lake or other hazard which, if entered, can potentially cause harm to the vehicle occupants;
14) road lighting columns, not certified as meeting the requirements of BS EN 12767 [Ref 25.N];
15) high mast road lighting columns;
16) sign and signal gantry supports including variable message signs (VMS);
17) sign/signal posts not certified as meeting the requirements of BS EN 12767 [Ref 25.N] and/or which exceed the equivalent section properties of a tubular steel post having an external diameter of 89 mm and a nominal wall thickness of 3.2 mm;
18) large signs (typically those higher than 2m) located in a position where the fascia is 1.5m or less above the adjacent carriageway and can potentially be struck by a vehicle;
19) above ground communications control cabinets, pillars and equipment (other than emergency telephones), CCTV masts and telephone masts (refer to CD 354 [Ref 7.N], and TD 131 [Ref 34.N]);
20) stores for emergency/diversion signs and similar permanent structures;
21) wooden telegraph poles;
22) A tree or trees having, or expected to have, trunk girths of 250 mm or more (measured at a height of 0.3 m above ground level) at maturity;
23) hazards where other parties can be affected:
    a) subway entrance for vulnerable users or agricultural underbridge passing under the highway;
    b) a railway, canal or separate road or carriageway;

c) public meeting places where a number of people are present for a significant time such as bus shelters, places of worship, schools, hospitals, recreational, retail facilities or factories;
d) chemical works, petroleum storage tanks or depots, domestic gas canisters or tanks, facilities manufacturing or storing hazardous materials in bulk;
e) other infrastructure, where the impact on the community / society as a whole is disproportional to the damage caused. This can include significant utility (electrical, gas) or communications infrastructure.

*NOTE* *Vegetation such as small trees, shrubs and hedges in front of a safety barrier can cause a vehicle to impact the safety barrier at a point higher than that at which it was tested, causing the vehicle to mount the vegetation and/or launch the vehicle over the barrier.*

3.21 Where assessment identifies which hazards or groups of hazards require a safety barrier, the length of need, set-back, normalised working width class, normalised vehicle intrusion class (where applicable) and other parameters for each hazard shall be determined.

3.22 Neither road furniture nor equipment shall be positioned on the carriageway side of the safety barrier, adjacent to a terminal or, with reference to Figure 3.19, within the length AC in advance of a hazard(s) or the length DF beyond a hazard(s).

3.23 A VRS shall not be placed within the normalised working width class or normalised vehicle intrusion class of an adjacent VRS other than where a double sided safety barrier is designed to bifurcate into two separate single sided safety barriers.

3.24 Safety barrier layouts shall be planned to minimise the number of approach ends of safety barriers, gaps of 50 m or less between adjacent safety barrier installations closed, and the safety barrier made continuous, unless gaps are required for access or maintenance or the safety barriers are at different offsets.

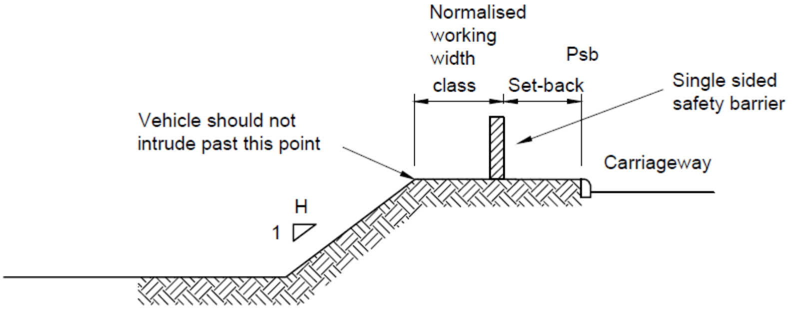
3.25 Gaps of up to 100 m shall be closed, unless there are significant cost, technical and/or access requirements for the gap to remain open.

3.26 Where a gap between safety barrier installations cannot be physically closed due to the safety barriers being at different offsets, or where maintenance or access for vulnerable users is required, the installations shall be arranged to minimise the probability of a vehicle impacting the first safety barrier and being directed into the leading terminal of the second safety barrier, or into the hazard that the second safety barrier is protecting.

3.27 The verge and central reserve below and immediately in front of and behind the safety barrier shall be without abrupt changes in level.

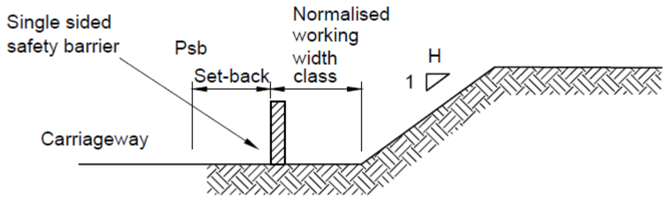
3.28 Where a safety barrier is required by this document, the top of a slope that exceeds 200mm in height shall not be within the normalised working width class of the safety barrier, as shown in Figure 3.28.

**Figure 3.28 Safety barrier location relative to the top of a slope that exceeds 200 mm in height.**




3.29 Where a safety barrier is required by this document, the toe of a slope that exceeds 200mm in height shall not be within the normalised working width class of the safety barrier, as shown in Figure 3.29.

**Figure 3.29 Safety barrier location relative to the toe of a slope that exceeds 200 mm in height.**




3.30 On embankments and sidelong ground where the proximity of the safety barrier to the top of the slope and/or the ground conditions are likely to affect the integrity of the barrier, this shall be included as part of the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

**Drainage and kerbs**

3.31 Positioning of RRS components relative to infrastructure such as drainage and kerbs shall be such that it does not compromise the durability or effectiveness of the RRS or the infrastructure.

**Motorcyclists**

3.32 Where a specific risk to motorcyclists is identified, appropriate mitigation measures to reduce the risk shall be specified in the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

3.33 The risks to motorcyclists, including details of the measures adopted, shall be recorded as part of the design.

**Other factors**

3.34 The design of the permanent safety barrier system shall:

1) accommodate its safe and efficient installation, repair, and removal, and allow access to and maintenance of above and below ground services, equipment and other highway assets, including temporary signs;
2) allow for the safe and efficient maintenance of the safety barrier system;
3) allow for the safe and efficient maintenance of the adjacent verge/central reserve.

3.35 Where the safety barrier system is on a supporting structure, the maximum dead and impact loading limits that can be applied by the safety barrier system to the structure shall be identified within the design and specified in the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

3.36 The form of safety barrier and its height above the adjacent carriageway(s)/verge level(s) shall be such so as to permit future pavement overlay or reconstruction.

3.37 Where appropriate, the range of heights over which the safety barrier needs to be effective and the level(s) relative to which they are to be set, shall be in accordance with the manufacturers' specification.

3.38 In areas where environmental conditions can affect the choice and positioning of the safety barrier, any restrictions on the type or material for the barrier shall be specified in the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

*NOTE* *Environmental considerations can include snow (where a safety barrier with a solid traffic face can give rise to levels of drifting and difficulties in snow or sand clearance), or marine environments (where metal products can be subject to high levels of corrosion and concrete adversely affected).*

3.39 Where there is a risk of falling materials/rocks reaching the verge, mitigation shall be put in place to ensure the safety barrier is not required to contain or restrain this material.

3.40 Any mitigation to reduce the risk of falling materials/rocks shall not effect the performance characteristics of the safety barrier.

3.41 As part of the assessment of appropriate VRS provision, the costs of protecting an asset identified as a hazard against the costs of replacing the asset and/or the costs and implications of the asset being out of service or unavailable for a period of time shall be assessed and recorded.

## Passively safe road furniture and equipment, and vehicle restraint systems

3.42 Passively safe road furniture shall be used in accordance with the National Annex to BS EN 12767 [Ref 25.N], such as sign/signal supports and lighting columns, as an alternative to protecting the hazard through safety barriers:

1) unless there is another hazard at the location which cannot be removed, relocated or made passively safe and that requires the provision of VRS;
2) at roundabouts or junctions where there is insufficient room for full VRS provision;
3) where VRS can be vulnerable to full frontal impact or cannot be provided with the correct orientation for all the anticipated directions of traffic movement.

3.43 Passively safe road furniture or equipment placed within the normalised working width class of a safety barrier shall have an energy absorption category of NE (as defined by BS EN 12767 [Ref 25.N]).

3.43.1 Passively safe road furniture or equipment may be located within the normalised working width class of a single sided safety barrier in the verge, as long as it is demonstrated that:

1) space is limited and the passively safe furniture cannot be located outside the normalised working width class of the existing safety barrier; and
2) a safety barrier with a sufficiently small normalised working width class cannot be used; and
3) it is necessary to install the safety barrier for hazard(s) other than the passively safe furniture (i.e. the barrier cannot be removed); and
4) the sign/signal posts demonstrates the same collapse mechanism(s) as that witnessed in the BS EN 12767 [Ref 25.N] testing if impacted in the proposed installation location; and
5) the arrangement does not present a risk of a secondary incident.

3.43.2 Passively safe sign/signal posts (excluding those with slip bases) may be located within the normalised working width class of a single sided safety barrier in the central reserve, as long as it is demonstrated that:

1) space is limited and the sign/signal posts cannot be placed outside the working width of the safety barrier; and
2) a safety barrier with a sufficiently small working width class cannot be used; and
3) it is necessary to install the safety barrier for hazard(s) other than the passively safe furniture (i.e. the barrier cannot be removed); and
4) the sign/signal posts demonstrates the same collapse mechanism(s) as that witnessed in the BS EN 12767 [Ref 25.N] testing if impacted in the proposed installation location; and
5) the arrangement does not present a risk of a secondary incident.

3.43.3 Reducing the size of sign/signal support posts by providing more posts should not be used to overcome the requirement to provide a safety barrier.

*NOTE* *As post spacing decreases, there is an increasing tendency for more than one post to be hit by a vehicle and for the sign and posts to act together as a relatively stiff and rigid hazard, thus significantly increasing its aggressiveness and potential to cause damage and injury. Further information can be found within BS EN 12767 [Ref 25.N].*

### Safety barrier provision at structural supports

3.44 Where a safety barrier is required at a collision resistant structure or abutment to give an acceptable level of risk to the occupants of an errant vehicle, the structure or abutment's structural integrity shall be maintained following an impact (see CS 453 [Ref 40.N]).

*NOTE 1 Where a normal containment level safety barrier is required, this safety barrier is generally not intended to provide protection for the structure, only to reduce the risk of injury to road users.*

*NOTE 2 Abutments are not normally considered to be at risk as a result of vehicle collision as they are assumed to have sufficient mass to withstand the collision loads for global purposes; (see CS 453 [Ref 40.N] (for existing bridges) or BS EN 1991-1-7 [Ref 11.N] (for new structures).*

3.45 Structural supports, such as bridge abutments and piers shall be assessed in accordance with CS 453 [Ref 40.N] (existing structures) or designed in accordance with BS EN 1991-1-7 [Ref 11.N] (new structures) to determine the minimum containment level and normalised working width class required by a safety barrier.

3.46 Where a safety barrier is required and a CS 453 [Ref 40.N] assessment or BS EN 1991-1-7 [Ref 11.N] design determines that the structure is assessed/designed for main load conditions, a minimum N2 containment level safety barrier with full normalised working width class shall be specified in the contract specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

3.47 Where a safety barrier is required and a CS 453 [Ref 40.N] assessment or BS EN 1991-1-7 [Ref 11.N] design determines that the structure is not assessed/designed for main load or residual load conditions, higher or very high containment level safety barrier shall be specified in the contract specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

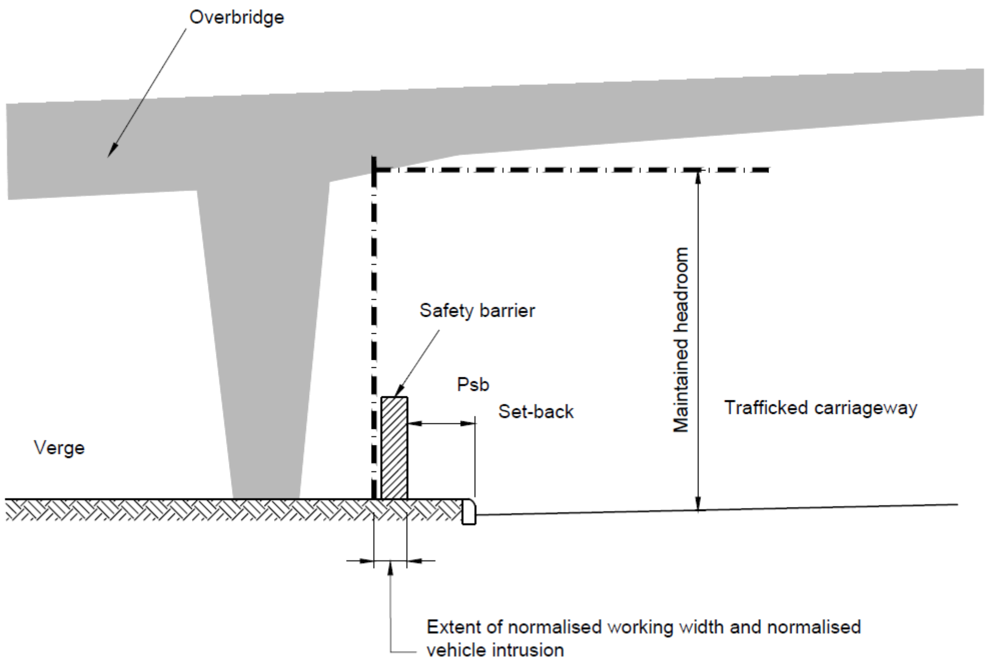
3.48 Where a safety barrier is required and a CS 453 [Ref 40.N] assessment or BS EN 1991-1-7 [Ref 11.N] design determines that the structure is not assessed/designed for main load or residual load conditions, the normalised working width class and normalised vehicle intrusion class shall be specified to minimise the risk of the structure being struck by a vehicle.

3.49 Where the assessment of impact of an overhanging or intruding part of a vehicle with the structure is accepted by the Overseeing Organisation, a higher or very high containment level safety barrier with a minimum height of 1.5 m shall be specified in the contract specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

3.50 Where the assessment of impact of an overhanging or intruding part of a vehicle with the structure is accepted by the Overseeing Organisation, the structure shall be assessed/designed for residual loading.

3.51 Where the minimum headroom to an overbridge in the verge is less than the required maintained headroom, a safety barrier shall be placed no closer to the point where the maintained headroom is lost, than as shown in Figure 3.51.

**Figure 3.51 Provision of safety barrier at restricted headroom**

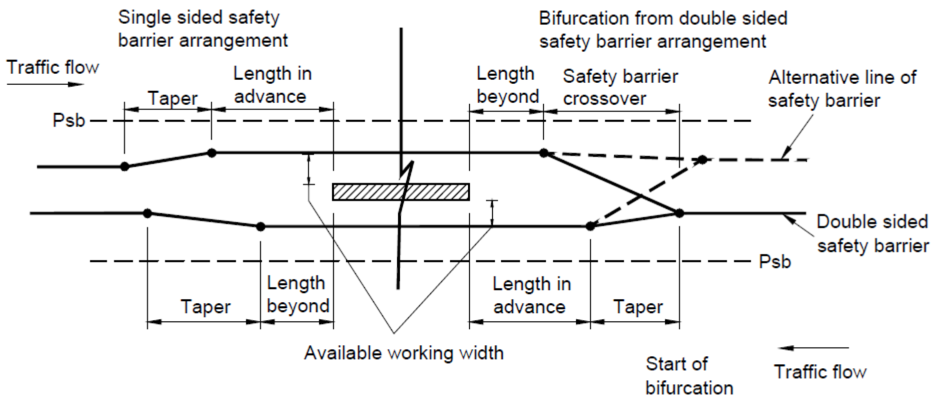


3.52 Where the minimum headroom to an overbridge in the verge is less than the required maintained headroom, and where the set-back to the safety barrier is greater than or equal to 1.5 m, the maintained headroom shall be measured from the adjacent verge level rather than from the edge of carriageway level.

3.53 Where any part of an abutment or structure that is less than the maintained headroom above the adjacent edge of carriageway level is within the normalised working width class and/or normalised vehicle intrusion class, it shall be assessed for main and residual loading.

3.54 Safety barrier alignment around a structural support shall follow the layout described within Figure 3.54 unless there is a restricted width of carriageway.

**Figure 3.54 Provision of safety barrier at a structural support**




*NOTE* *Figure 3.54 shows the central reserve situation only. For verge situations, the layout is similar, but with only one single sided safety barrier.*

3.54.1 Where it is not possible to incorporate the layout described within Figure 3.54 due to a restricted width of carriageway, a safety barrier may be installed in line with the face of a structural support, providing the following conditions apply:

1) the abutment or structure has been assessed/designed for impact load in accordance with CS 453 [Ref 40.N] (existing structures) or BS EN 1991-1-7 [Ref 11.N] (new designs); and
2) the structural support has a smooth face, with a minimum height of 1.5m; and
3) in the case of bridge piers, the pier is a leaf pier; and
4) the structural support's geometric design is such that it does not lean towards on-coming traffic; and
5) approved transitions are used between the safety barrier and the structural support.

3.54.2 Where it is not possible to incorporate the layout described within Figure 3.54 due to a restricted width of carriageway, a safety barrier may be installed in line with a collar constructed around the base of a structural support, providing the following conditions apply:

1) the concrete collar has been assessed/designed for impact load in accordance with CS 453 [Ref 40.N] (existing collars) or BS EN 1991-1-7 [Ref 11.N] (new designs); and
2) the concrete collar has a smooth face, with a minimum height of 1.5m.

## Safety barrier provision at vehicle parapets

3.55 Where a vehicle parapet is required, a safety barrier shall be provided to prevent direct impact with each end of the parapet, and an approved transition provided between the safety barrier and the vehicle parapet.

*NOTE* *The performance classes of the parapet and safety barrier can differ in containment level, normalised working width class and ISL.*

3.56 On two-way roads both ends of the parapet shall be treated as approach ends.

3.57 The safety barrier shall continue the line of the traffic face of the vehicle parapet.

3.58 The safety barrier containment level at each end of the parapet shall be N2, unless a containment level higher than N2 has been determined by assessment.

3.59 At each end of the vehicle parapet, the safety barrier shall have full containment for at least the minimum length at the appropriate containment level.

3.60 The minimum length required for full containment can include the length of any transition between the parapet and safety barrier, but shall not include any taper, change in horizontal alignment, nor terminal.

3.61 The assessment shall be used to determine whether the minimum length of need of safety barrier in advance and beyond the parapet is sufficient to protect a vehicle from the end of the parapet, and from the hazard that the parapet is protecting.

3.62 Where the length of need determined by the assessment is greater than the minimum length, then the length of need determined by the assessment shall be provided.

3.63 The parapet shall be capable of resisting forces applied via or through the safety barrier or transition.

### Safety barrier provision at gantries

3.64 For central reserves, safety barrier shall be provided on both sides of the gantry.

3.65 The safety barrier containment levels at gantries shall be dependant on the outcome of the risk assessment from CD 365 [Ref 28.N] and the UK National Annex NA to BS EN 1991-1-7 [Ref 47.N], as agreed with the Overseeing Organisation.

### Vulnerable users

3.66 Where a safety barrier is required and there is a defined movement of maintenance workers and/or vulnerable users, any proposed safety barrier installation shall allow for such movement by complying with CD 143 [Ref 9.N].

3.67 Where accommodating a right of way through a continuous safety barrier where a need for a pedestrian guardrail has not been identified, the details shown in Figures 3.67a and 3.67b shall be followed.

**Figure 3.67a Accommodating a right of way through a continuous verge safety barrier**

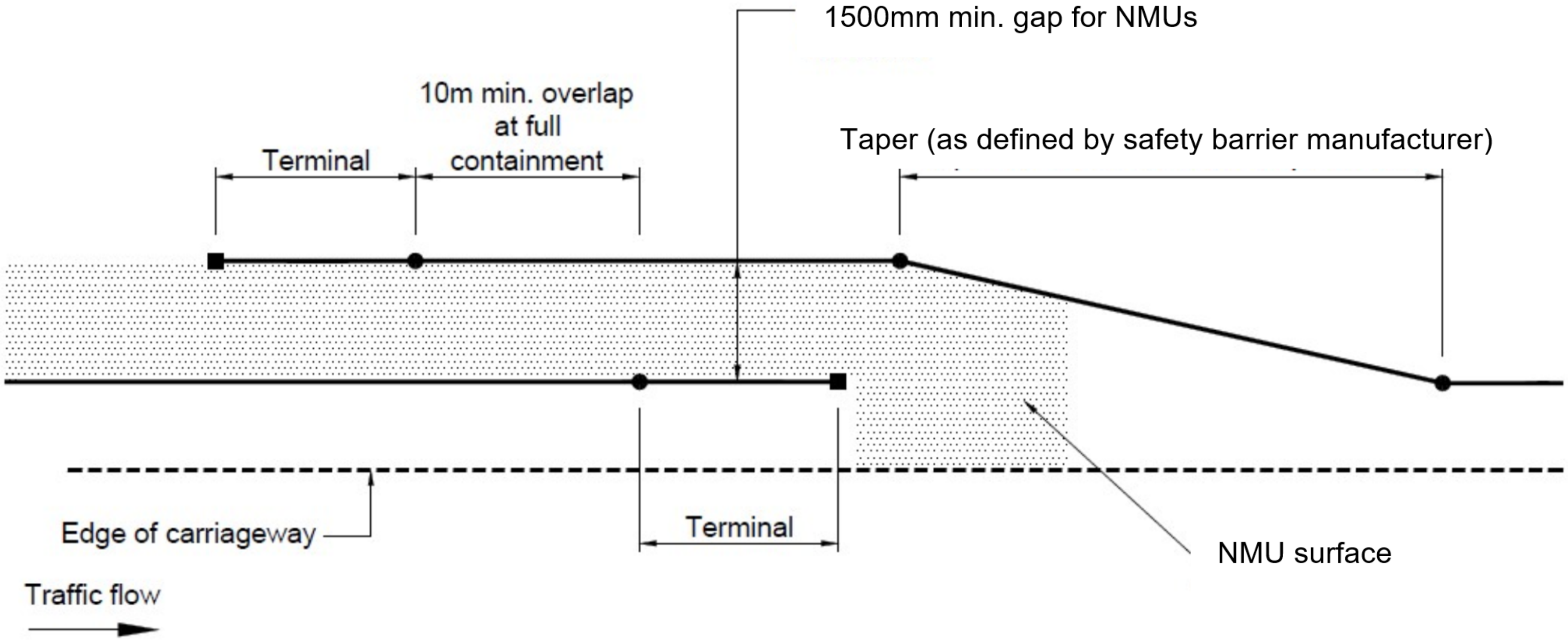
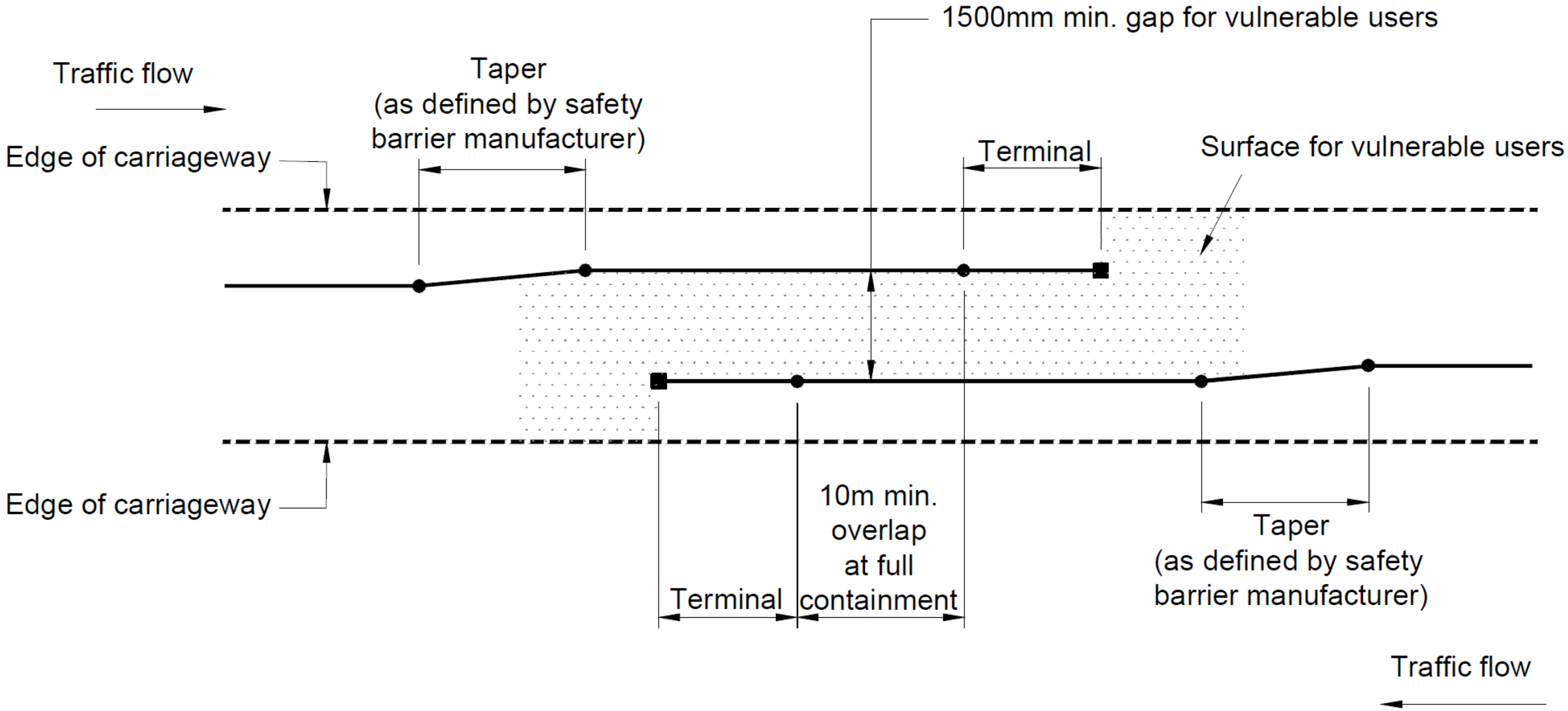


**Figure 3.67b Accommodating a right of way through a continuous central reserve safety barrier**



NOTE *The detail shown in Figure 3.67b is for high speed limit roads where pedestrian use is expected to be low, and either there is no requirement for pedestrian guardrail, or its use cannot be justified.*

3.68 Where accommodating a right of way through a continuous safety barrier where a need for a pedestrian guardrail has been identified, the details shown in Figures 3.68a and 3.68b shall be followed.

**Figure 3.68a Accommodating a right of way through a continuous verge safety barrier, incorporating pedestrian guardrail**

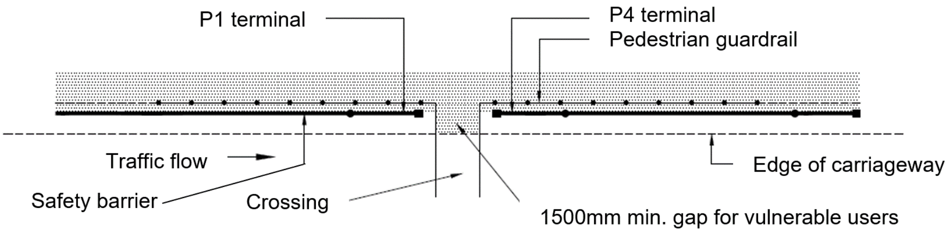
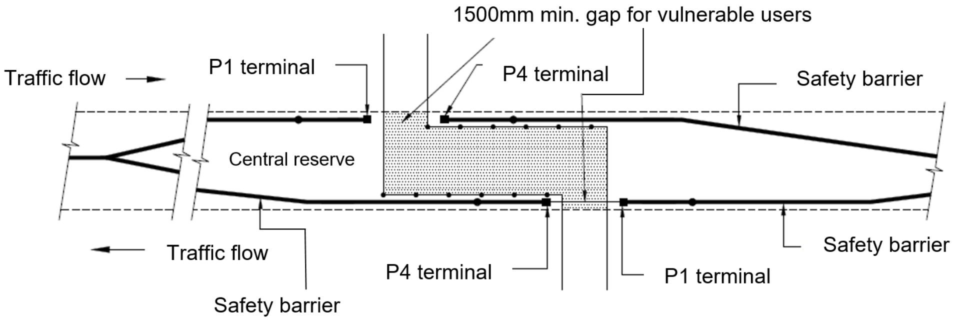



**Figure 3.68b Accommodating a right of way through a continuous central reserve safety barrier, incorporating pedestrian guardrail**




3.69 Safety barrier adjacent to vulnerable users shall not have any sharp edges.

3.70 Any add-on protective measures shall be checked with the VRS manufacturer to ensure they do not adversely effect the performance of the VRS.

3.71 Vulnerable user routes shall be located as far from the rear of the safety barrier as possible.

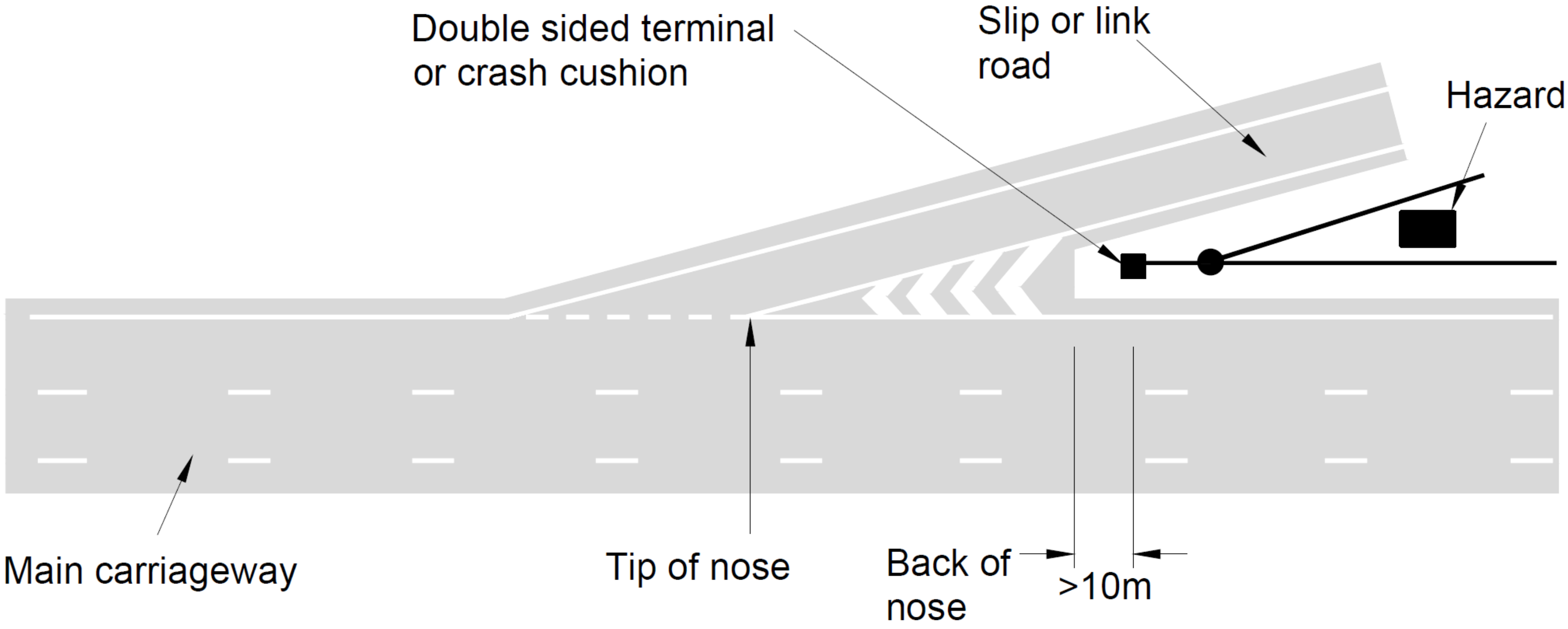
## Safety barrier provision at nosing areas and junctions

3.72 Nosing areas, where one carriageway diverges from another, shall be kept flat and free of hazards (including VRS) whilst being designed to discourage over-running.

3.73 Street furniture and other hazards shall be kept to a minimum and placed as far downstream from the back of the nose as possible commensurate with their function and the physical, and horizontal and vertical constraints of the location.

3.74 VRS shall be placed further than 10 m from the back of the nosing (refer to Figure 3.74).

**Figure 3.74 Hazards and safety barrier adjacent to nosing areas - typical exit slip/link road layout**



3.75 Where safety barrier protection is required to protect hazards, (including the level difference between the adjacent carriageways), the safety barrier shall be positioned relative to the hazard such that the minimum requirements of the safety barrier and its associated terminals (or crash cushions), transitions and tapers are met.

*NOTE 1 Traffic on an adjacent slip or link road that is following a broadly parallel alignment and similar level to the mainline carriageway is not seen as a hazard to traffic on the mainline carriageway, and vice versa.*

*NOTE 2 Safety barrier can be warranted due to the intervening ground profile and the presence of hazards such as street furniture.*

3.76 At junctions without VRS, the level of risk of injury to road users shall be minimised.

3.76.1 The risk of injury may be mitigated through the use of passively safe signs, larger signs placed further from the carriageway, vehicle actuated signs, road markings, high friction surfacing, improved sight lines.

3.76.2 At junctions, where other solutions are unavailable to lower the level of risk of injury to road users, then VRS may be proposed.

### Safety barrier provision in central reserves - general

3.77 Where the distance across the central reserve between the points from which set-back for each carriageway is measured (i.e. Psb to Psb) is 10m or less, a central reserve safety barrier shall be provided.

3.78 Where the distance Psb to Psb across the central reserve is more than 10m, a risk assessment shall be used to determine the need for, location and extent of safety barrier(s) and their containment level based on:

1) the hazards that are present and their location; and
2) the intervening topography; and
3) the likelihood of a vehicle crossing to the other carriageway.

3.79 Where a safety barrier in the central reserve is required, it shall be provided on both sides of a hazard except:

1) where the topography of the central reserve makes it impossible for the hazard to be reached from one carriageway, or
2) where the Overseeing Organisation agrees that road lighting columns, signals or signs, passively safe or fully collision resistant gantry legs or signs can be mounted on the central reserve safety barrier, and the width of the safety barrier is increased to accommodate the column or post and its fixings.

3.80 Where the topography of the central reserve makes it impossible for the hazard to be reached from one carriageway, the safety barrier shall be placed only on the side of the hazard that can be reached.

3.81 Where there are no hazards in the central reserve and there is a difference in the opposing edge of carriageway levels of 200 mm or more, the safety barrier shall be installed adjacent to the higher carriageway.

3.82 Where there is a risk of vehicle impact with a non-traffic face of a safety barrier, vehicles mounting or getting under it or overturning on the slope due to the height difference between the carriageways and the ground profile across the central reserve, a separate safety barrier shall be placed adjacent to the lower carriageway.

3.83 The Overseeing Organisation's specific requirements for the containment level and performance of the central reserve safety barrier shall apply.

*NOTE The specific requirements for the minimum containment level and performance of central reserve safety barrier are provided in the National Application Annexes.*

## Requirements for gaps in the central reserve

3.84 Other than where it has been determined that no safety barrier is required, there shall be no gaps in the central reserve safety barrier on motorways or on roads constructed to motorway requirements.

3.85 Existing gaps in central reserve safety barriers on motorways or all-purpose trunk roads shall be closed unless they are required for the efficient operation and management of the road.

3.86 On other dual carriageway roads, gaps in an otherwise continuous central reserve safety barrier shall be restricted to the absolute minimum necessary for the efficient operation and management of the road.

### General requirements for an emergency crossing point/maintenance crossing point (ECP/MCP)

3.87 An emergency crossing point/maintenance crossing point (ECP/MCP) shall only be installed with the approval of the Overseeing Organisation.

*NOTE For the majority of the time, the ECP/MCP is in the closed configuration and hence, is required to function as a permanent safety barrier.*

3.88 Where an ECP/MCP exists on a road which is to be improved or which is subjected to major maintenance, assessment shall be undertaken to confirm the need for the ECP to be retained with the Overseeing Organisation and relevant Emergency Services.

3.89 An ECP shall have a maximum length of 25 m and be designed using a location specific swept path analysis.

*NOTE An ECP will typically have a minimum length of 16 m, but this can be as short as 4 m, for specific applications.*

3.90 The safety barrier system for an ECP/MCP shall be specified in the contract specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N], in terms of containment level and normalised working width class.

3.91 The ECP/MCP containment level shall be equal to or greater than that of the adjacent safety barrier.

3.92 Transitions in accordance with the requirements of this document shall be used between the safety barrier and the ECP/MCP system.

3.93 The normalised working width class of the ECP/MCP shall not encroach into the opposing carriageway.

3.94 Any location specific requirements for the ECP/MCP shall be specified in contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N], such as maximum acceptable time taken for opening and closing, and storage requirements whilst the ECP/MCP is open (where applicable).

*NOTE An opening time of 30 minutes or less is generally acceptable for an ECP.*

### Use of gates at an ECP/MCP

3.95 Where a gate is provided at an ECP/MCP, the gate shall meet the requirements of BS DD ENV 1317-4 [Ref 27.N].

3.95.1 The length of the openable leaves of the gate (and hence, the overall length of the crossing) should be identified so that it is ensured that, when in the open position, the requisite number of lanes are protected by the safety barrier.

3.95.2 The means by which the openable leaves of the gate are opened/closed and the effect that this operation can have on the practicability of opening and closing the gate, should be identified.

3.95.3 Any tools required for the operation of a gate at an ECP should be supplied within the ECP and/or be easily accessible.

### Use of demountable permanent barrier at an MCP

3.96 For an MCP, it shall be possible to dismantle and reinstate the permanent safety barrier quickly.

3.96.1 Socketed posts may be specified to allow the permanent safety barrier to be dismantled and reinstated quickly.

*NOTE The time for the dismantling and reinstatement of barriers varies depending on the safety barrier and, if used, can mean a lot of repair work to reinstate the safety barrier.*

3.97 With the exception of emergency usage, whenever a section of safety barrier is removed, the ends of the safety barrier shall be made safe.

*NOTE The ends of a safety barrier can be made safe through the use of terminals, crash cushions, transitions and/or a gate.*

**Additional requirements for "open" ECPs**

3.98 Retained "open" ECPs shall be closed with a row of suitable traffic cylinders of at least 600 mm in height.

3.98.1 Retained "open" ECPs should be gated.

3.99 Traffic cylinders used in retained "open" ECPs shall be spaced at a maximum of 1.0m centres between the end terminals of the safety barriers.

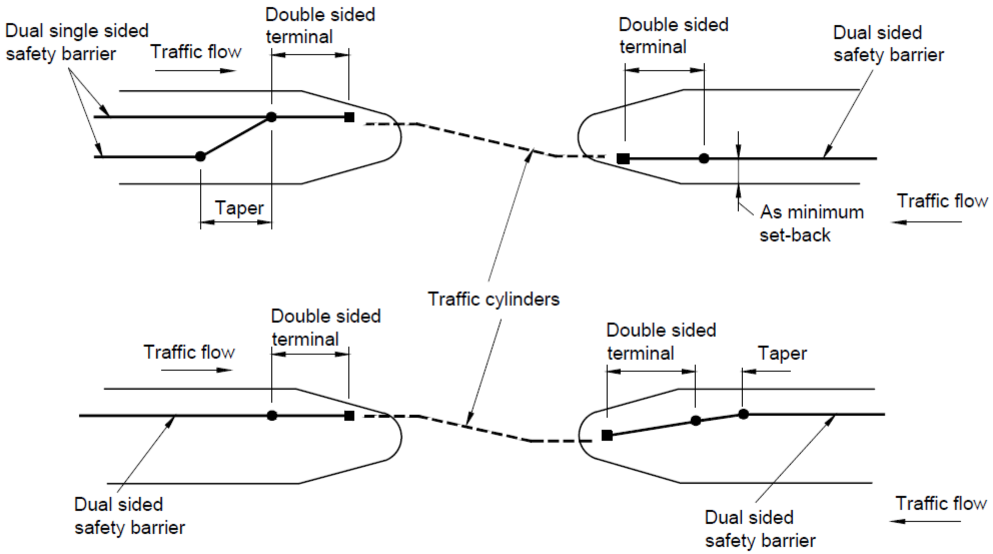
3.100 Verge and central reserve marker posts and/or reflectors shall be erected on each approach to the ECP.

3.101 The alignment of the two opposing sections of safety barrier and their end terminals at an "open" ECP (or other open central reserve crossing point) shall be such that a vehicle impacting the safety barrier prior to the gap is directed away from and not towards the leading terminal of the downstream safety barrier.

3.102 At "open" ECPs, the terminal specification shall be in accordance with Section 5 of this document.

*NOTE Typical alignments are shown in Figure 3.102N.*

**Figure 3.102N Typical arrangements for safety barrier at approaches to an Emergency Crossing Point in the central reserve**



### Additional requirements for maintenance crossing points and maintenance access

3.103 Where MCPs (see CD 192 [Ref 42.N]) are provided to facilitate contraflow traffic flows during schemes and tunnel maintenance, the layout shall be such that the open and closed layouts and the gate deployment do not present additional hazards to the road user or road worker.

*NOTE Guidance on factors relating to ECPs and MCPs is given in Appendix B of this document.*

3.104 Allowance shall be made in the length of gate specified for any impact resistant terminal end to the safety barrier.

3.105 Where the regular routine maintenance regime requires short period contraflow operation, the safety barrier used to close the gap shall have a minimum containment level equal to that of the adjacent safety barrier.

3.106 Where the regular routine maintenance regime does not require short period contraflow operation, on completion of the works, any MCP gap(s) shall be closed by re-instating the original safety barrier(s).

3.107 Any 'above ground' elements of the temporary end termination(s) of the safety barrier shall be removed.

3.108 Transitions shall be used between the permanent sections of safety barrier and 'removable' sections and temporary end termination(s).

### Winter maintenance crossing points (WMCP)

3.109 Where directed by the Overseeing Organisation, a central reserve WMCP shall be provided.

3.110 The WMCP shall preclude unauthorised access or use.

3.111 The central reserve at a WMCP shall safely accommodate transversely between the carriageway and the gate, all winter maintenance vehicles and associated equipment likely to be deployed.

3.112 When open, gates shall not encroach into the set-back of either carriageway.

3.113 Signs and traffic cylinders complying with Diagram 7103 of SI 2016 No.382 [Ref 45.N] and of the TSR(NI) 1997 [Ref 44.N] at 1.0m (maximum) centres shall be placed within the WMCP and either side of any gate that is installed to limit misuse of the WMCP.

### Other gaps in the central reserve, and provision at start and end points of dual carriageways

3.114 Where directed by the Overseeing Organisation to provide a gap complying with CD 123 [Ref 13.N], the arrangement of the safety barrier ends shall comply with the requirements of this document.

3.115 Assessment shall investigate and weigh options and mitigation (other than the provision of safety barrier) against the use of safety barrier, and mitigation in combination with safety barrier, identifying where fully compliant and partially compliant safety barrier installations can be achieved.

# 4. Requirements for vehicle parapets

4.1 All VRS installations that include vehicle parapets shall be compatible with each other throughout the entire installation length (including any safety barriers, other parapets, terminals, transitions and crash cushions) and meet the requirements of this Section 4.

4.2 For each vehicle parapet installation, based on the site specific conditions, the following and all other relevant requirements of MCHW Series 400 [Ref 23.N] and the associated MCHW Series NG400 [Ref 24.N] shall be specified in the contract specific specification, using contract specific Appendix 4/1, as detailed in MCHW Series NG400 [Ref 24.N]:

1) containment level;
2) impact severity level (ISL);
3) set-back;
4) normalised working width class (W);
5) normalised vehicle intrusion class (VI);
6) maximum height that allows the required visibility (refer to CD 127 [Ref 4.N] and CD 109 [Ref 16.N]);
7) length of need;
8) any special requirements (e.g. environmental considerations, minimum height above the paved surface for the purpose intended, clearance to hazards that are vulnerable to residual loading and loading requirements for structures, parapet plinth width).

*NOTE 1 Vehicle parapets are intended to contain errant vehicles and protect road users from a vertical or near vertical drop that is not protected by a safety barrier or other suitable restraint. In addition, they can be required to protect the area below.*

*NOTE 2 A vehicle parapet typically extends along the full length of a bridge deck (including the wing-walls) and/or along the full length of any other structure.*

4.3 The design shall be the optimum solution for the hazard having achieved compliance with the mandatory requirements, the conditions of a relaxation (where applicable), a broadly acceptable level of risk or having obtained a departure from requirements.

### Minimum containment levels where the road is not carried over or adjacent to a railway

4.4 On roads with a speed limit of 50 mph or more, the minimum containment levels for vehicle parapets shall be:

1) normal containment level: N2;
2) higher containment level: H2;
3) very high containment level: H4a.

4.5 On roads with a speed limit of less than 50 mph, the minimum containment level for vehicle parapets shall be:.

1) normal containment level: N1;
2) higher containment level: H2;
3) very high containment level: H4a.

4.6 Where a site-specific risk assessment indicates that a containment level higher than the minimum level is required, the higher containment level shall be specified.

4.7 Where the need for a higher containment level or very high containment level vehicle parapet has been identified, the nature of the risk, any mitigation with the steps taken to reduce the risk and the resulting containment level required shall be recorded.

## Minimum containment level requirements where the road is carried over or adjacent to a railway

### New bridges and structures (except accommodation bridges)

4.8 On a new bridge or structure (except accommodation bridges) over or adjacent to a railway, an H4a containment level vehicle parapet shall be provided, regardless of the road class.

### Existing bridges and structures (except accommodation bridges)

4.9 On an existing structure over or adjacent to a railway (except accommodation bridges), an H4a containment parapet shall be provided.

4.9.1 Where an H4a parapet cannot be provided without undue cost, the highest containment provision possible should be provided, which incorporates the output from the RRRAP and the cost of providing a suitable support structure.

4.9.2 Where an H4a parapet cannot be provided without undue cost, the vehicle parapet containment level should not be lower than the normal containment level.

4.9.3 Where an H4a parapet cannot be provided without undue cost, agreement should be sought through early engagement with the Railway Authority and the Overseeing Organisation.

### New and existing accommodation bridges

4.10 The minimum vehicle parapet containment level shall be the normal containment level.

4.11 Where a site-specific risk assessment indicates that a containment level higher than the minimum level is required, the higher containment level shall be specified following confirmation from the Overseeing Organisation and the Railway Authority.

4.12 Where the need for a higher containment level or very high containment level vehicle parapet has been identified, the nature of the risk, any mitigation with the steps taken to reduce the risk and the resulting containment level required shall be recorded.

## Impact severity level

4.13 The ISL shall be either level A or B.

## Normalised working width class and normalised vehicle intrusion class

4.14 For normal containment level vehicle parapets, the maximum identified value of normalised working width class that the local hazard(s) allow, shall be used.

4.15 For higher and very high containment level vehicle parapets, the maximum identified values of normalised working width class and normalised vehicle intrusion class that the local hazard(s) allow, shall be used.

4.15.1 The edge of the bridge deck should be included as a hazard in the risk assessment.

4.16 An assessment shall be undertaken to determine whether modification of the structure is viable and an AIP obtained.

## Length of need

4.17 During testing to BS EN 1317-2 [Ref 32.N], the test length of the vehicle parapet shall be sufficient to demonstrate the full performance characteristics of the vehicle parapet at the length of need.

4.18 Where higher containment level (H2) or very high containment level (H4a) vehicle parapet is required at a hazard adjacent to the vehicle parapet where other parties can be affected (such as at an adjacent road or railway), the length of the higher or very high containment parapet shall extend to the lesser of:

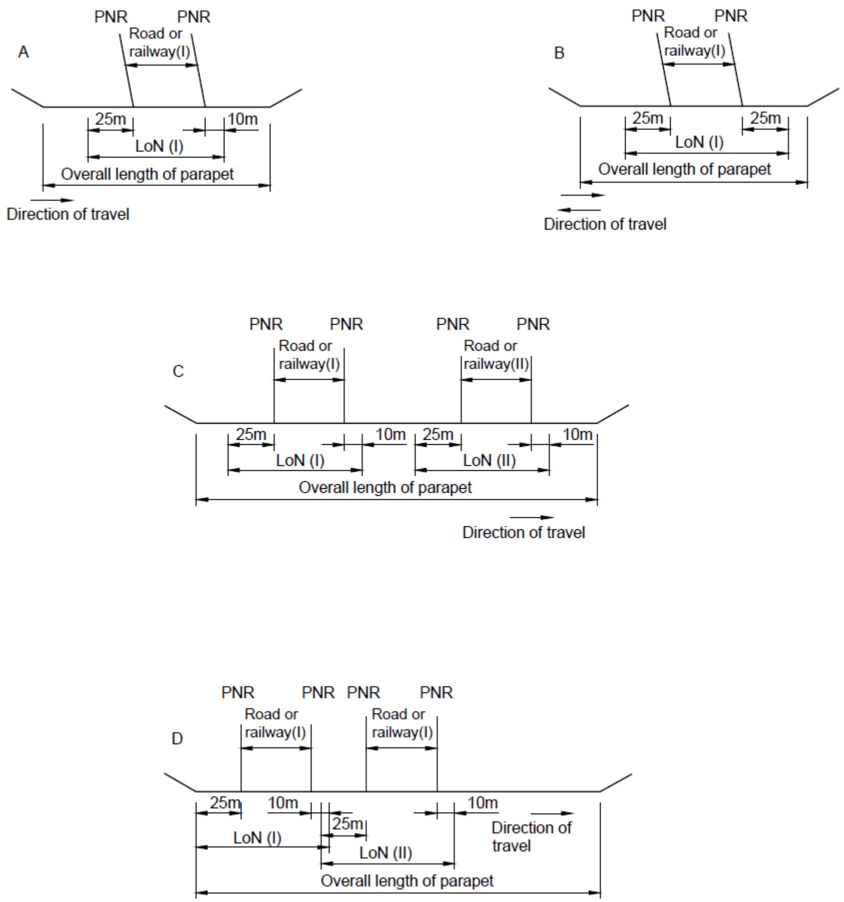
1) the length of the bridge deck and along the full length of the wing-walls where they broadly follow the road alignment, or along the full length of the structure where it runs alongside and or over the adjacent hazard;
2) on two-way carriageways, between a position 25m in advance of the nearer point of no recovery to the adjacent hazard in each direction i.e. 25m plus length of adjacent hazard between these points of no recovery plus 25m; but not further at either end than required by (1) above;
3) on one-way carriageways, from a position 25m in advance of the nearer point of no recovery to the adjacent hazard to a position 10m beyond the further point of no recovery to the adjacent hazard, i.e. 25m plus length of adjacent hazard between these points of no recovery plus 10m; but not further at either end than required by (1) above.

4.18.1 On a long structure spanning more than one adjacent hazard, where the higher containment or very high containment level parapet extents from clause 4.18(2) or clause 4.18(3) do not overlap or extend to the limits in clause 4.18(1) above, normal containment level parapet with suitable transitions may be used over the intermediate length(s).

4.19 Where the length of need for each hazard overlaps and the required containment levels differ, the risk assessment shall confirm that the higher of the containment levels starts/finishes so as to achieve the correct length of need for the hazard requiring the higher containment.

*NOTE* *Refer to Figure 4.19N for examples of length of need and localised parapet containment level, where A and B are short structures and C and D are long structures (such as viaducts).*

**Figure 4.19N Examples of localised parapet containment requirements on short and long structures**



## Minimum height of parapets

4.20 The height of vehicle parapets (including combined vehicle/pedestrian parapets) shall not be less than 1000mm.

4.21 For cycleways immediately adjacent to the vehicle parapet and for accommodation bridges, the minimum height of the parapet shall be 1500mm.

4.22 For very high containment level applications that are not over or adjacent to a railway, the minimum height of the parapet shall be 1500mm.

4.23 For bridleways or equestrian usage immediately adjacent to the vehicle parapet , the minimum height of the parapet shall be 1800mm.

4.24 For all bridges and structures over railways, the minimum height of the parapet shall be 1800mm.

4.25 The height of vehicle parapets (including combined vehicle/pedestrian parapets) shall be measured above the adjoining paved surface.

4.26 At particular sites where a feasibility study as outlined in CD 353 [Ref 6.N] has been undertaken, any height and form of parapet requirements so determined shall be agreed with the Overseeing Organisation and any other responsible authority.

*NOTE 1 Particular sites where a feasibility study as outlined in CD 353 [Ref 6.N] could be undertaken include those where there is a high risk of suicide, vandalism, unauthorised access and/or antisocial behaviour.*

*NOTE 2 Other responsible authorities can include the Railway Authority/Environment Agency/Canals and River Trust.*

4.27 Where it is necessary to increase the height of an existing legacy parapet, any extension shall be compatible with, and not be detrimental to, the performance of the parapet system to which it is attached.

4.27.1 The additional height may be provided by the use of a suitable additional non-participating structural extension to the parapet (designed neither to become detached under impact nor participate in containment and redirection of the vehicle).

4.27.2 The addition of a non-participating structural extension to a legacy parapet should be confirmed as acceptable by the manufacturer/promoter of the parapet system, where the manufacturer/promoter of the system still exists.

4.27.3 The addition of a non-participating structural extension to a legacy parapet should be confirmed as acceptable by the Overseeing Organisation, where the manufacturer/promoter of the system no longer exists.

4.27.4 Where repair parts are available and the increased height variant of the parapet exists, the change in height should be achieved by the exchange of standard parts compliant with the original manufacturer's specification.

4.28 Where it is necessary to increase the height of an existing CE marked parapet product, any extension shall not invalidate the Declaration of Performance for the parapet system to which it is attached.

4.29 Where the height of an existing parapet is to be increased, the effect of any additional loading on the supporting structure as a result of this modification, shall be assessed and remedial measures undertaken, where necessary.

## General requirements

4.30 Vehicle parapets shall be provided on bridges and structures where a safety risk assessment determines that there is a risk of a vehicle falling over a vertical or near vertical drop that is not protected by a safety barrier or other suitable restraint.

4.31 The risk assessment shall determine whether the minimum requirements are sufficient in the particular circumstances being examined and record the proposed containment level and length of need.

### Verges on bridges and structures

4.32 Where deck limitations permit, a raised verge with a kerb shall be provided to discourage the stationing of vehicles with their wheels close to the vehicle parapet.

4.33 The design of the verge on bridges and structures shall minimise the build up of effluents and debris against the base of the vehicle parapet.

4.33.1 Build up may be reduced by ensuring that any paved surfaces and verges fall away from the base of the vehicle parapet.

*NOTE The dimensions of kerbs and raised verges at parapets are given in CD 524 [Ref 10.N] and CD 127 [Ref 4.N] respectively.*

4.33.2 Where a wide verge, for example one used for vehicle access, is carried over a bridge or structure and where agreed by the maintenance authority and the emergency services, the safety barrier may be continued across it on its conventional alignment as long as normalised working width class and set-back requirements are met.

4.34 The crossfall of any designed verge with pedestrian access shall be in the region of 5% (1:20), but no more than 10% (1:10) or less than 2.5% (1:40).

4.34.1 Where there is no pedestrian access permissible, the crossfall of any designated verge may be increased to 20% (1:5).

4.35 The parapet system used shall be suitable for use on the particular bridge, taking into account the height, width and gradient of the verge.

4.36 Any generated gradient shall meet the parapet manufacturer's specifications.

4.37 Where the road does not have a continuous kerb, the kerb and verge shall slope down gradually to the level of the paved surface on the approaches.

4.38 The verge width requirements to accommodate pedestrians and other users shall be met by complying with CD 143 [Ref 9.N] and CD 143 [Ref 9.N].

4.39 A separate pedestrian parapet of the appropriate height and infill for the expected usage shall be provided on the bridge or structure's edge where a need is identified by assessment.

4.40 Protection to prevent injury to the users of the wide verge from the vehicle parapet shall be provided, where necessary.

4.41 Any non-compliance in the above requirements shall be identified in contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

### Plinth upstands

4.42 Where metal parapets are proposed, a plinth upstand of 50mm high with a tolerance of -0/+50mm shall be specified.

*NOTE Not having a plinth affects the overall parapet height and rail positions relative to vehicle impact.*

4.43 Any non-compliance with the requirement for a plinth upstand of 50mm high with a tolerance of -0/+50mm shall be identified in the parapet specification in contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

4.43.1 An upstand to aid drainage and/or reduce the amount of small stones and other debris kicked over the edge of the bridge may be specified in contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

## Parapets on historic monuments and bridges

4.44 Where a structure is subject to a cultural heritage management plan (refer to LA 116 [Ref 5.N]), it shall managed in accordance with the conservation strategies of conservation of highway structures (refer to CG 304 [Ref 3.N]).

4.44.1 New and replacement parapets on historical monuments and bridges may be designed from first principles to meet the requirements of the cultural heritage asset management plan and the particular performance class requirements.

### Infilling of parapets

4.45 Metal vehicle parapets of open construction shall be fitted with anti-climb infill complying with Chapter 8 of BS 6779-1 [Ref 18.N].

4.46 The parapet shall not provide toe-holds nor have projections that would assist climbing of the parapet.

4.47 The bottom 600mm height of infill panel shall be solid where there is a bridleway or equestrian usage adjacent to the vehicle parapet.

4.48 Full height infilling shall be used on motorway underbridges and structures where they cross or are adjacent to a railway.

4.49 Where full height infilling is proposed, the effect of wind loading on the structure to which the parapet is attached, shall be assessed.

### Provision for divided structures

4.50 Where the longitudinal gap between the two decks on a divided structure is less than 100 mm, vehicle parapets shall not be installed in the central reserve, unless warranted by risk assessment.

4.51 Where a gap between 100 mm and 2 m is unavoidable, a horizontal grid or slab designed in accordance with BS 6779-2 [Ref 17.N] shall be provided, unless it is impractical to do so.

4.52 Where the provision of a horizontal grid or slab designed in accordance with BS 6779-2 [Ref 17.N] is impractical, or the gap is more than 2 m, vehicle parapets shall be provided.

4.53 Where vehicle parapets are provided on structures other than those over railways and the longitudinal gap is between 100 mm and 2 m, the gap shall be protected by a horizontal grid, slab, mesh or plate designed to carry the following nominal loads:

1) uniformly distributed load – 0.75 kN/m2;
2) patch load – 1kN over area of 200 mm x 200 mm positioned to give the most adverse effect.

4.54 Where the divided structure is over a railway and the longitudinal gap is between 100 mm and 2 m, the gap shall be infilled by a solid slab or plate designed to carry special types general order (STGO) and special order (SO) vehicles loading, irrespective of the type of VRS.

### Additional requirements for vehicle parapets over or adjacent to railways

4.55 Assessment shall confirm local overhead line equipment (OLE) clearances and / or trespass risk through early liaison with the Railway Authority, British Transport Police or any other Police Authority.

4.56 Parapets on new structures over or adjacent to railways shall comply with the Railway Authority requirements for height, electrical clearance and protection; refer to NR/L3/CIV/020 Issue 1 [Ref 8.N] incorporating NR/BS/LI/331 Issue 2 [Ref 30.N] and/or any successor documents.

4.57 Where existing vehicle or pedestrian parapets on bridges and structures over or adjacent to a railway are to be replaced, reconstructed or strengthened, the location specific desirable parapet height and electrical clearance and protection requirements shall be met.

4.58 Vehicle parapets over the railway shall be provided with steeple copings that comply NR/BS/LI/331 Issue 2 [Ref 30.N] and/or any successor documents.

4.59 A safety barrier shall be provided on both the vehicle parapet approach and departure ends to prevent a vehicle reaching the railway.

4.60 The minimum lengths of safety barrier required by this document shall be increased where the assessment determines that a significant risk still exists from a vehicle leaving the highway at a greater distance from the bridge and reaching the railway.

### Infilling of parapets over railways

4.61 Infilling for vehicle parapets on bridges or structures over or adjacent to railways shall meet with the requirements of BS EN 12676-1 [Ref 1.N], and this section.

*NOTE Where reference is made in BS EN 12676-1 [Ref 1.N] to "where electrification is likely" this denotes electrification included within the Railway Authority's Investment Programme current at the time when the vehicle parapet provision is being considered.*

4.62 Metal vehicle parapets of open construction shall have smooth solid infill.

*NOTE Toe-holds on the traffic face of the parapet are prohibited.*

4.62.1 Metal vehicle parapets should be provided with additional solid sheeting on the outer (non-traffic) face of the parapet/parapet posts.

4.62.2 The sheeting should extend vertically to the full height of the parapet with the lower part shaped to cover the outer ledge and horizontally for at least the greater of one panel length or 2m.

4.62.3 Sheeting should be fitted at the ends of the vehicle parapet or on both sides of the railway tracks.

4.63 The parapet, the infill sheeting and all conductive (metal) components shall be at least 3m from the outer limit of any railway tracks or any live overhead electrification equipment.

4.64 In the event of failure of or damage to any part of the parapet, no part of the parapet or infill sheeting shall come into contact with any live overhead electrification equipment.

4.65 The outer ledge of a parapet shall not be accessible from any area adjacent to the bridge.

4.65.1 Sheeting should be extended for situations where the outer ledge is accessible from any area adjacent to the bridge.

4.66 All methods of denying access to the outer ledge of the vehicle parapet shall be subject to the agreement of the Railway Authority and the Railway Inspectorate.

## Design requirements for parapets and supporting structures

4.67 Main structural members of bridges shall not be designed to act as vehicle parapets.

*NOTE The design requirements given in this document for vehicle parapets are based on a cantilever action from the bridge deck.*

4.68 The resistance of the member supporting the parapet shall be assessed in accordance with CS 454 [Ref 2.N].

4.69 Any need to modify a bridge or structure to accommodate a CE marked parapet shall be discussed with the structures representatives of the Overseeing Organisation at the earliest opportunity to agree a way forward.

*NOTE 1 For existing bridges and structures, the aim is to provide a CE marked parapet that is compatible with the existing site specific restrictions.*

*NOTE 2 It can be uneconomical or undesirable, perhaps for aesthetic reasons, to strengthen an existing structure to take a parapet of the required containment level and normalised working width class, and or to strengthen the verge of the bridge deck to take the full vehicle loading requirements.*

*NOTE 3 If so, strengthening to allow provision of a vehicle safety barrier meeting the containment level and normalised working width class requirements of this document between the existing parapet and edge of carriageway could warrant investigation.*

4.69.1 In cases where it is decided to strengthening to allow provision of a vehicle safety barrier (meeting the containment and working width requirements of this document) between the existing parapet and edge of carriageway, the existing parapet may be deemed a pedestrian restraint system in accordance with this document.

4.70 For structures with non-carriageway elements that are unsuitable for unrestricted live loading, the assessment shall determine the suitability of intermediate VRS with reference to CS 470 [Ref 20.N].

## Anchorages and structural loading

4.71 The anchorages, plinth and main structure shall be designed to resist, without damage, all loads which the vehicle parapet is theoretically capable of transmitting, up to and including failure, in any mode that can be induced by vehicular impact.

4.72 Removal and replacement of damaged sections of the vehicle parapet shall be readily achievable, without damage to the supporting structure.

4.73 The design shall allow for replacement of holding down bolts or sleeved threaded bar that can be withdrawn from the plinth.

4.74 For new concrete highway bridges and structures, BS EN 1992-2 [Ref 12.N] and, for existing concrete highway bridges and structures on motorways and other trunk roads, CS 455 [Ref 39.N], respectively, shall be used to determine the design resistance of the reinforced concrete support member for concrete cone failure.

4.75 Loads applied to the supporting structure by the parapet potentially have to be estimated, and any limitations arising shall be clearly identified.

4.76 The loading and anchorage requirements that the structure is capable of meeting shall be specified in contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N] such that a compliant parapet product and its associated anchorages can be selected.

4.77 Where a parapet system complying with the minimum containment level and normalised working width class requirements but imparting loads on the structure exceeding those specified is proposed, the adequacy of the proposed anchors shall be checked and calculations undertaken to confirm that the structure is capable of resisting, without damage, all loads which the vehicle parapet system is theoretically capable of transmitting, in any mode that can be induced by vehicular impact.

## Reinforced concrete parapets

4.78 Vehicle parapets in concrete construction shall be CE marked in accordance with BS EN 1317-5 [Ref 29.N].

4.78.1 Vehicle parapets in concrete construction may, subject to a departure from requirements, be designed in accordance with BS 6779-2 [Ref 17.N].

4.78.2 Where vehicle parapets in concrete construction are designed in accordance with BS 6779-2 [Ref 17.N], the following amendments to BS 6779-2 [Ref 17.N] should apply:

1) reinforced concrete vehicle parapet panel walls are to have a minimum thickness of 180mm for normal containment level (N2), and 325mm at the critical design section for very high containment level (H4a).
2) reinforced concrete vehicle parapet panel walls are to have a minimum length of 2.0m and a maximum length of 3.5m.
3) $Y_m$ for the reinforcement in the in-situ vehicle parapet wall is to be 1.0, and not 0.8 as given in Table 4 of BS 6779-2 [Ref 17.N].

4.78.3 Where N2 containment vehicle parapets in concrete construction are designed in accordance with BS 6779-2 [Ref 17.N], the following amendments should also apply:

1) the parapets are to be designed for an equivalent static nominal load for a nominal bending moment of 100kN over 1.0m, and not 50kN over 1.0m as given in Table 2 of BS 6779-2 [Ref 17.N];
2) the parapets are to be designed with shear transfer provision between adjacent panels;
3) an equivalent static nominal load of 50kN is to be transferred between adjacent panels within the top 0.5m of the sections.

NOTE *When designing to BS 6779-2 [Ref 17.N], the normal level of containment of BS 6779-2 [Ref 17.N] is considered to be equivalent to the normal containment (N2) in BS EN 1317-2 [Ref 32.N], and the high containment level of BS 6779-2 [Ref 17.N] is considered to be equivalent to the very high containment level (H4a) in BS EN 1317-2 [Ref 32.N].*

### Stone or precast concrete copings

4.79 Stone or precast concrete copings shall only be used with vehicle parapets of concrete construction where the permitted speed limit is 30 mph or less.

### Masonry or brickwork facings

4.80 Masonry or brickwork facings shall only be provided after consultation with the responsible authorities and with the prior agreement by the Overseeing Organisation.

### Masonry parapets

4.81 New and replacement masonry vehicle parapets shall not be installed except where agreed by the Overseeing Organisation.

4.82 New and replacement masonry vehicle parapets shall not be used on road bridges and structures over or adjacent to railways except where agreed by the Overseeing Organisation and the Railway Authority.

4.83 The treatment of existing masonry parapet structures shall be agreed with the Overseeing Organisation.

NOTE *Existing parapets can have a number of faults and need to be examined and assessed.*

# 5. Requirements for terminals

5.1 All VRS installations that include terminals shall be compatible with each other throughout the entire installation length (including any safety barriers, parapets, other terminals, transitions and crash cushions) and meet the requirements of this Section 5.

5.2 For each terminal installation, based on the site specific conditions, the following and all other relevant requirements of MCHW Series 400 [Ref 23.N] and the associated MCHW Series NG400 [Ref 24.N] shall be specified in the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]:

1) performance class;
2) impact severity level (ISL);
3) set-back;
4) permanent lateral displacement zone;
5) vehicle exit box class;
6) maximum height that allows the required visibility (refer to CD 127 [Ref 4.N] and CD 109 [Ref 16.N]);
7) any special requirements [e.g. environmental considerations, ground conditions, measures to reduce the risk of injury to pedestrians, equestrians and other vulnerable users (e.g. no sharp edges)];
8) specific connection requirements to existing safety barriers, vehicle parapets or other structures.

5.3 Terminal performance class shall be specified in accordance with BS DD ENV 1317-4 [Ref 27.N] for both the approach and departure ends of safety barriers.

*NOTE 1 Terminals are applied to the end of safety barriers such that the barrier ends do not represent a hazard. They are designed to provide a smooth transition from no containment to the containment of the barrier without introducing additional hazards for head on vehicle impacts.*

*NOTE 2 The performance or mode of operation of some types of terminal can make them unsuitable for use in certain situations, e.g. where there is a hazard close to the end of the full height safety barrier, in the central reserve, where space is limited, restricted clear zone, narrow verge, distance to side road or other access, or on the elevated approaches to bridges and other structures.*

*NOTE 3 A full height anchor based on legacy systems details is not considered to be a terminal in the context of this section.*

## Performance class

5.4 On roads with a speed limit of 50 mph or more, terminals that face oncoming traffic, e.g. on both ends of a safety barrier on a two-way single carriageway road, shall have a performance class of P4 and be energy absorbing.

5.5 On roads with a speed limit of 50 mph or more, terminals that do not face oncoming traffic, e.g. on departure ends on dual carriageways or on a one-way road, shall have a minimum performance class of P1.

5.6 On other roads, terminals shall have a minimum performance class of P1.

## Impact severity level

5.7 The ISL shall be either level A or B.

## Permanent lateral displacement zone class

5.8 The maximum permissible permanent lateral displacement zone class (D.x.y) for the terminal shall be selected to ensure that clearance of the terminal to any hazard or area used by motorists and/or non-motorised users is maintained and not compromised.

5.9 Where the safety barrier is to be flared to maintain set-back to the end terminal, this shall be included in the measurement of the permanent lateral displacement zone characteristic D.x.y.

## Vehicle exit box class

5.10 For each installation, the maximum vehicle exit box class that the local hazard(s) allow, shall be used.

5.11 The vehicle exit box class for the terminal (Z1, Z2, Z3 or Z4) shall be selected to ensure that any redirected impacting vehicle can not encroach into any hazard or area used by road users, road workers and/or other parties.

5.11.1 Errant vehicles can end up on the departure side of terminals with exit box classes Z3 and Z4 and therefore systems with exit box classes Z3 and Z4 should be used with caution because of the unlimited dimension for the exit box on the departure side.

## General requirements

5.12 Factors that limit the choice of terminal for a particular situation shall be clearly identified in Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N].

# 6. Requirements for transitions

## Introduction

6.1 All VRS installations that include transitions shall be compatible with each other throughout the entire installation length (including any safety barriers, parapets, terminals, other transitions and crash cushions) and meet the requirements of this Section 6.

6.2 For each transition installation, based on the site specific conditions, the following and all other relevant requirements of MCHW Series 400 [Ref 23.N] and the associated MCHW Series NG400 [Ref 24.N] shall be specified in the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]:

1) containment level;
2) impact severity level (ISL);
3) set-back;
4) class of normalised working width class (W);
5) class of normalised vehicle intrusion class (VI);
6) maximum height that allows the required visibility (refer to CD 127 [Ref 4.N] and CD 109 [Ref 16.N]);
7) length of need;
8) any special requirements (e.g. environmental considerations, motorcyclist protection, ground conditions, proximity to embankment slopes, requirements to accommodate pedestrians on verges, clearance to hazards that are vulnerable to residual loading and loading requirements for structures, measures to to reduce the risk of injury to pedestrians, equestrians and other vulnerable users (e.g. no sharp edges))
9) specific connection requirements to existing safety barriers, vehicle parapets or other structures.

6.3 A transition complying with BS DD ENV 1317-4 [Ref 27.N] shall be specified between two VRS of different cross section and/or lateral stiffness and/or containment level and/or material, whose working widths differ by more than one class.

6.4 The transition shall provide a smooth change in alignment and not allow the safety barrier or parapet as applicable to become exposed to end on impact.

*NOTE 1 The purpose of transitions is to provide a gradual change in performance from the first barrier to the second, and to prevent the hazards of abrupt variations.*

*NOTE 2 A transition is designed to connect two specified VRS.*

*NOTE 3 The length of a transition is the distance between the ends of the two VRS which are connected by the transition.*

## Minimum containment levels

6.5 On roads with a speed limit of 50 mph or more, the minimum containment level for transitions shall be:

1) normal containment level: N2;
2) higher containment level: H1;
3) very high containment level: H4a.

6.6 On roads with a speed limit of less than 50 mph, the minimum containment level for transitions shall be:

1) normal containment level: N1;
2) higher containment level: H1;
3) very high containment level: H4a.

#### Transitions and vehicle parapets

6.7 Where a transition is used to connect an H4a containment vehicle parapet to an N1 containment vehicle parapet, the end section of the N1 containment vehicle parapet shall be strengthened to N2 containment.

6.8 Where a connection is required between a vehicle parapet and a transition, the parapet shall be capable of providing an anchorage to the transition and attached safety barrier such that the full strength of the transition and the safety barrier can be realised.

6.8.1 Adding a connection between the vehicle parapet and a transition may require the end post(s) of the parapet to be modified.

### Impact severity level

6.9 The ISL shall be either level A or B.

### Normalised working width classes and normalised vehicle intrusion classes

6.10 For each transition installation, the maximum identified value of normalised working width class that the local hazard(s) allow, shall be used.

6.11 For higher and very high containment level transition installations, the maximum identified values of normalised working width class and normalised vehicle intrusion class that the local hazard(s) allow, shall be used.

6.12 For all higher and very high containment systems included in the contract-specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]), the required clearance to any hazard that is vulnerable to residual loading shall be given in the site specific information.

### Transitions between safety barriers not on a motorway or all-purpose trunk road, and parapets over a motorway or all-purpose trunk road

6.13 Where a safety barrier not on a motorway or all-purpose trunk road connects to a bridge parapet (via transitions) on a bridge which cross over a motorway or all-purpose trunk road, the safety barrier and transitions shall meet the requirements of this document.

6.14 Where a safety barrier not on a motorway or all-purpose trunk road connects to a bridge parapet (via transitions) on a bridge which cross over a motorway or all-purpose trunk road, the design and specification for the safety barriers and transitions shall be agreed between all parties.

# 7. Requirements for crash cushions

## Introduction

7.1 All VRS installations that include crash cushions shall be compatible with each other throughout the entire installation length (including any other safety barriers, parapets, terminals, and transitions) and meet the requirements of this Section 7.

7.2 For each crash cushion installation, based on the site specific conditions, the following and all other relevant requirements of MCHW Series 400 [Ref 23.N] and the associated MCHW Series NG400 [Ref 24.N] shall be specified in the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]:

1) performance level;
2) re-directive or non re-directive type of crash cushion;
3) directional or bidirectional type of crash cushion;
4) impact severity level (ISL);
5) set-back;
6) vehicle redirection zone class
7) permanent lateral displacement zone class
8) maximum height that allows the required visibility (refer to CD 127 [Ref 4.N] and CD 109 [Ref 16.N]);
9) any special requirements (e.g. environmental considerations, ground conditions, proximity to embankment slopes, measures to to reduce the risk of injury to pedestrians, equestrians and other vulnerable users (e.g. no sharp edges));

7.3 Crash cushions shall be provided in front of fixed and/or rigid objects which cannot be removed, relocated or made passively safe, to reduce the risk of injury to vehicle occupants in the event of an impact.

*NOTE* *Fixed and/or rigid objects include roadside features such as bridge piers and toll booths.*

## Performance levels

7.4 For roads with a speed limit greater than 50 mph, the performance level of the crash cushion shall be 110, as defined by BS EN 1317-3 2010 [Ref 26.N].

7.5 For roads with a speed limit of 50 mph or less, the minimum performance level of the crash cushion shall be 100, as defined by BS EN 1317-3 2010 [Ref 26.N].

## Re-directive and non re-directive types of crash cushion

7.6 Where an assessment has identified that the redirection of an errant vehicle by a crash cushion results in additional risk to the road user, road workers, or other parties, a non re-directive crash cushion shall be specified in the contract-specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]).

7.7 Where an assessment has not identified that the redirection of an errant vehicle by a crash cushion results in additional risk to the road user, road workers, or other parties, a re-directive crash cushion shall be specified in the contract-specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]).

## Bi-directional and directional types of crash cushion

7.8 Crash cushions located such that they could be struck in either direction shall be bi-directional.

7.9 Crash cushions located such that can be struck in one direction only (e.g. on a one-way road) shall be directional.

7.9.1 A check should be made to ensure that the direction in which the crash cushion has been tested is the same as the direction in which it could be struck, when installed.

7.10 The type of crash cushion (bidirectional or directional) shall be specified in the contract-specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]).

### Impact severity level

7.11 The ISL shall be either level A or B.

### Vehicle redirection zone class

7.12 The vehicle redirection zone class for the crash cushion (Z1, Z2, Z3 or Z4) shall be selected to ensure that any redirected impacting vehicle does not encroach into any hazard or area used by motorists and/or non-motorised users.

### Permanent lateral displacement zone class

7.13 The permanent lateral displacement zone class for the crash cushion (D1 to D8) shall be selected to ensure that no part of the deformed crash cushion encroaches into any hazard or area used by motorists and/or non-motorised users.

### Crash cushions used in temporary situations

7.14 Crash cushions used in temporary situations shall be subject to site specific risk assessment in accordance with the TSM Chapter 8 [Ref 46.N].

*NOTE Crash cushions are one of a suite of options possible for the termination of temporary safety barriers.*

7.15 Crash cushions used in temporary situations shall be successfully tested to BS EN 1317-1 [Ref 33.N] and BS EN 1317-3 2010 [Ref 26.N], and CE marked to BS EN 1317-5 [Ref 29.N] in combination with the system and arrangement they are proposed to be used with, or as a stand-alone system.

# 8. Requirements for pedestrian restraint systems

8.1 Pedestrian restraint systems shall:

1) reduce the risk to vulnerable users;
2) withstand envisaged impact loading;
3) avoid creating a visibility hazard; and
4) not become disconnected or break on impact in such a way as to cause a hazard for other road users, road workers, or other parties.

8.2 Pedestrian restraint systems shall not act as a vehicle restraint system.

## General requirements for pedestrian parapets

8.3 For each pedestrian parapet installation, based on the site specific conditions, the following and all other relevant requirements of MCHW Series 400 [Ref 23.N] and the associated MCHW Series NG400 [Ref 24.N] shall be specified in the contract-specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]:

1) designation (the loading class)
2) infill material (if infill required) and protection;
3) infill class (Class C or D) and height;
4) type of holding down bolts (if required), foundations method of fixing, and whether a passively safe support system is required;
5) detailed layout;
6) length of need;
7) set-back;
8) minimum height above the adjacent paved surface;
9) plinth width, and whether a continuous plinth or continuous upstand is required;
10) any additional corrosion protection system required, and any special requirements for maintenance to the corrosion protection system;
11) any special requirements (e.g. environmental considerations).

8.4 All footbridges, cycleways and bridleway bridges shall be provided with a pedestrian parapet.

8.5 Pedestrian parapets shall comply with the requirements of BS 7818 [Ref 36.N] and CG 300 [Ref 38.N].

8.6 The minimum height of a new pedestrian parapet shall be in accordance with Table 8.6.

**Table 8.6 Minimum heights of pedestrian parapets above the adjacent paved surface**

<table>
<tr><th>Use</th><th>Not over railway</th><th>Over railway</th></tr>
<tr><td>Pedestrian</td><td>1150mm</td><td rowspan="3">1800mm</td></tr>
<tr><td>Cyclist</td><td>1500mm</td></tr>
<tr><td>Equestrian</td><td>1800mm</td></tr>
</table>

8.7 On cycleway bridges and accommodation overbridges frequently used by equestrians, the height of the parapet above the adjoining paved surface shall be increased to 1800mm.

8.8 For bridges not over railways that are used by equestrians and/or cyclists, and the parapet height is 1800mm, a solid infill panel of at least 600mm height shall be provided at the bottom of the parapet in order to obstruct the view of the road below.

8.9 Pedestrian parapets over railways, irrespective of parapet height shall have solid infilling to their full height.

8.10 Steel pedestrian parapets shall be of framed construction consisting of posts and longitudinal members with suitable infilling.

8.11 Pedestrian parapets shall be mounted on a continuous plinth or continuous upstand of 50mm height with a tolerance of -0/+50 mm above the adjoining paved surface.

8.12 The pedestrian parapet specification in contract specific Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]) shall identify where the parapet does not have a continuous plinth or continuous upstand of 50mm height with a tolerance of -0/+50 mm above the adjoining paved surface.

*NOTE Not having a plinth affects the overall height.*

8.13 The rails and posts shall meet the Class 3 nominal live loads in BS 7818 [Ref 36.N].

8.14 The bar, sheet or mesh infill shall meet the Class C nominal loads in BS 7818 [Ref 36.N].

8.15 Where the Class 3 nominal live loads for posts and rails and/or the Class C nominal loads for infill are assessed to be inadequate, Class 4 nominal live loads for posts and rails and/or Class D nominal loads for infill shall be used.

8.16 Pedestrian parapets of concrete construction shall be designed in accordance with BS 5400-4 [Ref 37.N].

8.17 Pedestrian parapets of solid construction shall be designed to resist the more severe of a nominal live load of 1400 N/m applied transversely at the level of the top of the pedestrian parapet or wind loading in accordance with CS 454 [Ref 2.N].

8.17.1 The partial load factor $\gamma_{fl}$ should be taken as 1.5 for live load and 1.4 for wind load at the ultimate limit state, or 1.0 for both at the serviceability limit state.

8.17.2 The strength of infilling panels may be proved for a prototype design by test loading with the loads situated in the most adverse positions.

8.17.3 The minimum overload factor should be taken as equal to the product of the partial safety factors used for ultimate limit state design.

8.17.4 When the appropriate design document given in the Technical Approvals Schedule is not to limit state format, a 50% overload should be assumed.

8.18 Stone or precast copings used with pedestrian parapets shall be secured to the concrete backing by fixings capable or resisting at the ultimate limit state a horizontal force of 33 kN per metre of coping.

**Additional requirements for pedestrian parapets over or adjacent to railways**

8.19 No toeholds shall be provided on the pedestrian traffic face of the parapet or the infill panel.

8.20 Infill panels on the front face of a parapet over a railway shall be of a design and material approved by the Railway Authority.

## General requirements for pedestrian guardrails

8.21 For each pedestrian guardrail installation, based on the site specific conditions, the following and all other relevant requirements of MCHW Series 400 [Ref 23.N] and the associated MCHW Series NG400 [Ref 24.N] shall be specified in the contract-specific specification Appendix 4/1 as detailed in MCHW Series NG400 [Ref 24.N]:

1) designation (the loading class)
2) infill material (if infill required) and protection;
3) infill class (Class C or D) and height;
4) type of holding down bolts (if required), foundations method of fixing, and whether a passively safe support system is required;
5) detailed layout;

6) length of need;
7) set-back;
8) minimum height above the adjacent paved surface;
9) any additional corrosion protection system required, and any special requirements for maintenance to the corrosion protection system;
10) any special requirements (e.g. environmental considerations).

8.22 Pedestrian guardrails shall be of steel construction.

8.23 Pedestrian guardrails shall comply with BS 7818 [Ref 36.N].

8.24 Where a guardrail is required for pedestrian safety in close proximity to a road, the guardrail and its end posts shall be designed to be passively safe in accordance with BS EN 12767 [Ref 25.N] unless it is installed outside the working width of safety barrier that is required for other reasons.

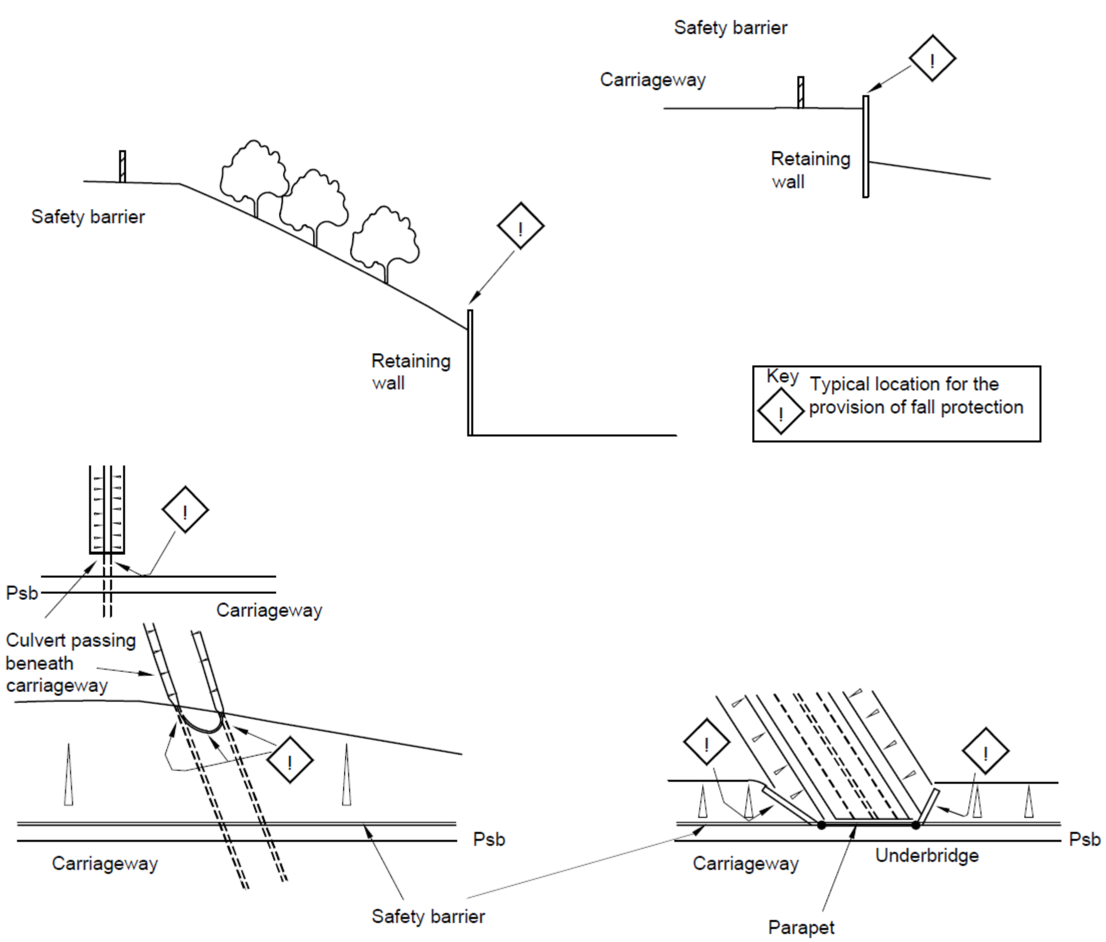
8.24.1 Pedestrian guardrails should not be provided as a deterrent to kerbside vehicle parking.

## Requirements for pedestrian restraint and protection to prevent a fall from a height

8.25 Pedestrian restraint and protection, where determined through design and assessment, shall be specified where any pedestrian movement can occur within the highway boundary from use or maintenance and there is a risk to health and safety from a fall from a height.

*NOTE Typical locations requiring pedestrian restraint and protection are shown in the Figure 8.25N.*

**Figure 8.25N Typical locations requiring fall protection**



8.26 Where a structure, such as a retaining wall, head wall or wing wall, presents a vertical or near vertical face 1.5 m or more in height and it is possible for a person to gain access to the upper edge of the structure, a pedestrian restraint system such as a protective barrier or guardrail shall be installed close to, or on top of, the structure.

8.27 A pedestrian protective barrier or guardrail shall be installed at walls less than 1.5 m high if a particular hazard, such as a watercourse or road, is in close proximity to the wall.

8.28 The form of pedestrian restraint and protection provided, its components, articulation, location and arrangement shall be designed to minimise the risk of injury to the occupants of vehicles, e.g. by penetration of a vehicle cab.

8.29 Handrails within 2 m of Psb that can be reached by an errant vehicle shall be designed to be passively safe unless they are protected by a safety barrier that is required for other purposes.

8.30 Where appropriate, the VRS (if deployed) shall be extended to include the approaches to the structure or potentially hazardous differences in ground levels.

# 9. Requirements for temporary safety barriers at roadworks

9.1 All VRS installations that include temporary safety barriers shall be compatible throughout the entire installation length (including any other safety barriers, parapets, terminals, transitions and crash cushions) and meet the requirements of this Section 9.

9.1.1 A temporary safety barrier may be either a permanent type safety barrier erected temporarily, or a purpose made temporary safety barrier.

*NOTE Temporary safety barriers are classed as safety barriers that are to be in place for less than 4 years.*

9.2 All safety barriers used in temporary situations shall be successfully tested to BS EN 1317-1 [Ref 33.N] and BS EN 1317-2 [Ref 32.N].

9.3 All safety barriers used in temporary situations shall be assessed by one of the independent reviewers appointed by the Overseeing Organisation.

## Minimum containment levels

9.4 On roads where road works are being undertaken and a speed limit of 50 mph or more is in operation, the minimum containment levels for temporary safety barriers shall be:

1) normal containment level: N2;
2) higher containment level: H1;
3) very high containment level: H4a.

9.5 On roads where road works are being undertaken and a speed limit of less than 50 mph is in operation, the minimum containment levels for temporary safety barriers shall be:

1) normal containment level: N1;
2) higher containment level: H1;
3) very high containment level: H4a.

9.6 Low angle containment safety barrier systems referenced in Table 2 of BS EN 1317-2 [Ref 32.N] shall not be used.

9.7 At temporary or permanent bridge supports and other vulnerable structures, very high containment level (H4a) temporary safety barriers shall be used unless the assessment determines that normal containment level (N1 or N2) is sufficient, or no barrier is required.

9.8 At temporary or permanent bridge supports and other vulnerable structures, the principles shown within Figure 9.8a and Figure 9.8b shall be followed, and the structures assessed in accordance with CS 453 [Ref 40.N].

**Figure 9.8a Temporary safety barrier provision adjacent to temporary or permanent bridge supports - temporary propping - no collision loading requirement**

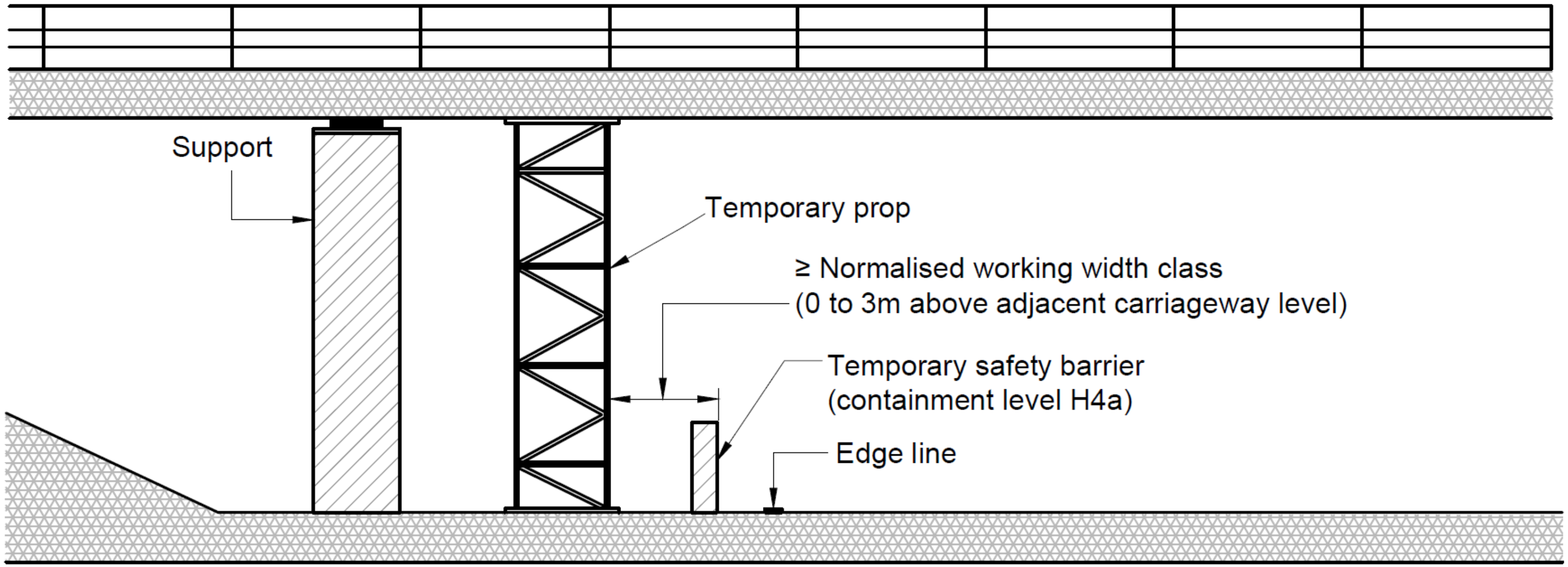
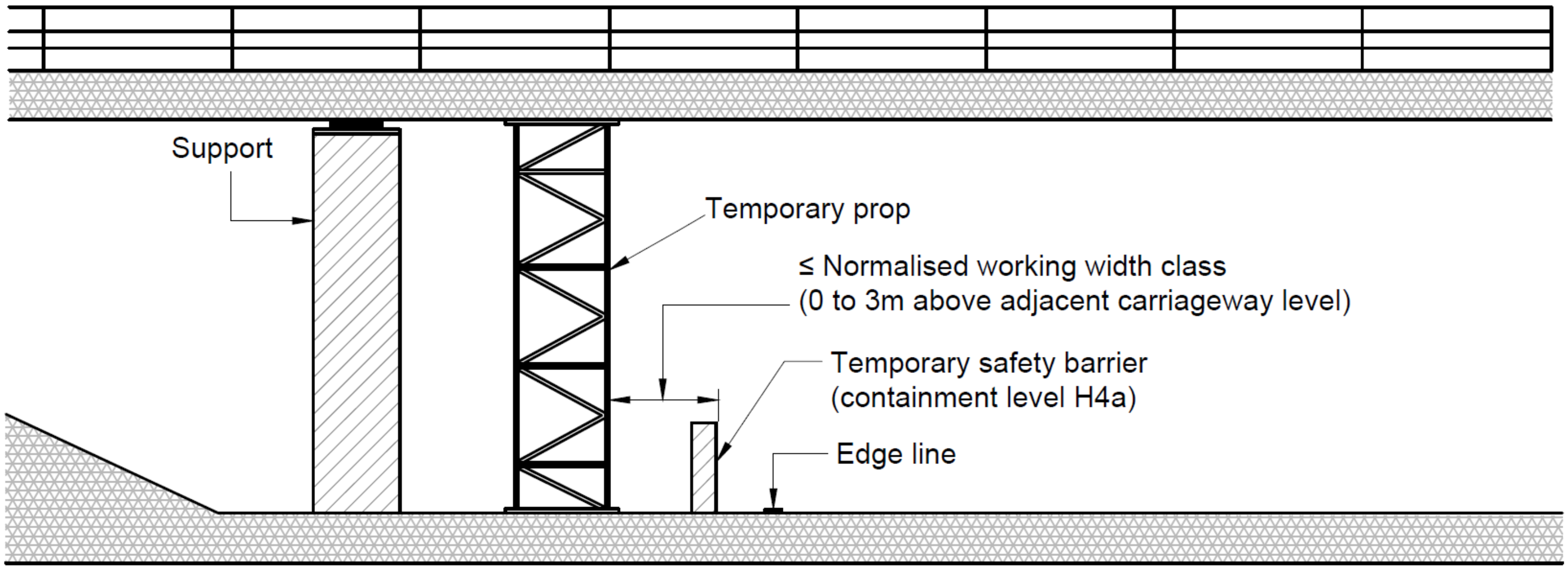


**Figure 9.8b Temporary safety barrier provision adjacent to temporary or permanent bridge supports - temporary propping - to carry residual loading**



### Impact severity level

9.9 The ISL shall be either level A or B.

### Normalised working width classes and classes of normalised vehicle intrusion classes

9.10 For normal containment level temporary safety barriers, the maximum identified value of normalised working width class that the local hazard(s) allow, shall be used.

9.11 For higher and very high containment level temporary safety barriers, the maximum identified values of normalised working width class and normalised vehicle intrusion class that the local hazard(s) allow, shall be used.

9.12 For all higher and very high containment temporary safety barrier systems, the required clearance to any hazard that is vulnerable to residual loading shall be provided for within the design of the temporary works.

*NOTE Where the distance between a line projected vertically from the traffic face of a temporary very high containment level (H4a) safety barrier and the face of a temporary structural support is greater than the normalised working width class of the safety barrier for at least 3m above the adjacent carriageway level, and the distance exceeds the normalised vehicle intrusion class, the temporary support does not need to be designed to resist collision loading.*

### Length of need

9.13 During testing to BS EN 1317-2 [Ref 32.N], the test length of the safety barrier shall be sufficient to demonstrate the full performance characteristics of the safety barrier at the length of need.

9.14 Where the traffic can temporarily travel in both directions along the same carriageway or along the hardshoulder under temporary traffic management, the assessment shall determine the length of need in the temporary situation.

9.15 Where the length of need for the temporary situation is longer than the length of need for normal conditions, the extra length of need shall be provided for the period that the temporary situation is operative.

9.16 As assessment shall be carried out to ensure the length of full containment safety barrier in advance and beyond the hazard(s) or work zone(s) results in an ALARP level of risk with regard to a vehicle reaching the hazard(s) and/or work zone(s).

*NOTE A vehicle entering from the access point can potentially be channelled further into the works than normal due to both the verge/central reserve and the temporary safety barrier preventing a vehicle exiting that restricted area.*

### Set-back

9.17 The minimum set-back for temporary safety barriers shall be in accordance with Table 9.17.

**Table 9.17 Temporary safety barrier minimum set-back requirements (in mm)**

| Speed limit in place at the location of the temporary safety barrier | Desirable set-back | Relaxed set-back |
|---|---|---|
| 70mph | 1000 | 600 |
| 60mph | 1000 | 500 |
| 50mph | 600 | 375 |

9.17.1 At 70mph and 60mph, where it is agreed by the manufacturer of the temporary VRS, set-back should be measured to exclude base plates.

9.17.2 Where a desirable set back is to be used with a temporary 50mph speed limit, and where it is agreed by the manufacturer of the temporary VRS, set-back should be measured to exclude base plates.

9.17.3 Where a relaxed set back is to be used with a temporary 50mph speed limit, set-back should be measured to include base plates.

9.18 Where relaxed values of set-back are proposed, a risk assessment compliant with TSM Chapter 8 [Ref 46.N] shall be undertaken and documented.

*NOTE A TSM Chapter 8 [Ref 46.N] risk assessment can include where extra lanes or extra lane width can be generated, or where other space can be released for operative working and where such space is important.*

9.18.1 Where space is available, an increase in lane widths should be specified as the risk to drivers has the potential to be minimised where lane widths are greater than the minimum in TSM Chapter 8 [Ref 46.N].

9.19 Temporary safety barrier performance in restricted situations is unpredictable and siting of the barrier shall allow for deflection into the lateral clearance safety zone or into the adjacent running lane(s) depending upon demonstrated system performance.

## Method of termination for temporary safety barriers

9.20 The safety barrier and terminal provision shall be assessed in the temporary situation taking account of any temporary traffic flow direction and location, and mandatory speed limit.

9.21 Individual temporary safety barrier ends and the temporary safety barrier shall be installed to the manufacturer's instructions.

9.22 A risk assessment shall be conducted as part of the TSM Chapter 8 [Ref 46.N] temporary traffic management (TTM) design and the benefits and dis-benefits of the options available for the site specific circumstances evaluated.

9.22.1 The risk assessment may include the use of crash cushions for the termination of a temporary safety barrier.

9.23 A record shall be made of the termination layout adopted and reasons for that layout.

## General requirements

9.24 Permanent and temporary local hazards having the potential to cause danger to the occupants of a vehicle, the workforce or to other parties shall be identified within a site specific risk assessment, as required by TSM Chapter 8 [Ref 46.N].

9.24.1 Examples of common design factors that should be evaluated when using temporary safety barriers at road works are listed below:

1) length of time for which a temporary safety barrier is likely to be deployed;
2) speed limits both existing and proposed;
3) traffic flows including the percentage of large goods vehicles (LGVs);
4) containment level required and vehicle intrusion class for 'L' containment safety barriers;
5) length of safety barrier;
6) road alignments, cross-section-pinch points, set-back, headroom clearance, available working widths, etc;
7) sight lines;
8) drainage of carriageway;
9) ground support for temporary safety barrier;
10) clearances for operation and construction;
11) requirements for temporary signing, lighting and road markings;

12) obstructions that can affect the performance of the safety barrier, e.g. lighting columns, signposts, etc;
13) other VRS in the vicinity of the works;
14) access arrangements for works vehicles, emergency and recovery vehicles;
15) end of safety barrier details to ensure errant vehicles cannot pass behind into the work zone; the reduced risk of the leading end of a temporary safety barrier being impacted by a vehicle if flared away from the running lane, but the reduced space available for site vehicles;
16) the risk of an errant vehicle stopping abruptly in the running lane if a crash cushion is installed;
17) the risk of a ramped leading end being installed causing a vehicle to end up in either the running lane or the works area in the event of an impact;
18) traffic movements approaching the safety barrier;
19) where applicable, the effect of a safety barrier on movement of road workers, pedestrians, cyclists, etc;
20) maintenance requirements;
21) traffic management and working space and widths required for installation and removal of safety barriers;
22) where a temporary very high containment level (H4a) safety barrier is to be used, whether it is to be be surface mounted or inset into the carriageway;
23) compliance with contract specific details.

*NOTE 1 This list is not exhaustive and other factors potentially need to be assessed.*

*NOTE 2 The sight stopping distances and visibility requirements of CD 127 [Ref 4.N] and CD 109 [Ref 16.N] are to be taken into account when positioning the temporary safety barrier.*

9.25 The factors evaluated and decisions made shall be recorded and temporary safety barriers with appropriate terminations provided where the conclusion from the site specific risk assessment indicates they are necessary to adequately control the risks.

### Temporary speed limits

9.26 A temporary speed limit of less than 50 mph shall not be imposed on roads to protect short sections of work that can be carried out without closure or restriction of any of the running lanes, solely to allow use of temporary safety barriers with a containment level of N1.

9.27 Where, after undertaking a risk assessment, it is determined that it is necessary to provide protection over a short length (e.g. for the replacement of a vehicle parapet) then a temporary safety barrier with a containment level of N2, H1, or H4a shall be incorporated into the temporary works.

### Use of temporary safety barriers in contraflow operations

9.28 Where temporary safety barrier is used within contraflow, the following parameters shall also apply:

1) a buffer zone between opposing traffic flows of a width relevant to the mandatory speed limit in force, but not less than two times the normalised working width of the temporary safety barrier minus the width of the temporary safety barrier, or the width of the temporary safety barrier plus twice the set-back value, whichever is the greater;
2) the ends of the safety barrier continue beyond the end of the contraflow into a coned off area, to reduce the risk of traffic impacting the ends;
3) no gaps created in the temporary safety barrier between the two opposing flows of traffic in the contraflow;
4) an acceptable means of access provided for the emergency services and recovery vehicles to attend to accidents or breakdowns within the contraflow, if identified as a necessary measure.

*NOTE An acceptable means of access provided for the emergency services and recovery vehicles to attend can include temporary removable sections in the barrier.*

# 10. Legacy systems

10.1 Where a new hazard is introduced in advance of, alongside or beyond an existing legacy system, an assessment shall be made to compare the merits of merging and retaining the legacy system, or replacing it.

10.2 Where a new hazard is introduced in advance of, alongside or beyond an existing legacy system, any proposal to maintain an existing legacy system shall be justified to the Overseeing Organisation.

# 11. Vehicle arrester beds

11.1 On an existing road where there is a known problem involving runaway vehicles on a downhill gradient, both in terms of personal injuries and damage to vehicles or property, the provision of an arrester bed shall be evaluated in conjunction with the relevant landowners, Police, local authorities and the Overseeing Organisation.

*NOTE 1 The function of an arrester bed is to decelerate a runaway vehicle on long, steep descending gradients without causing significant damage to the vehicle, its occupants, other road users, adjacent buildings or property.*

*NOTE 2 Whilst arrester beds are suitable for most types of vehicle, they are particularly effective in bringing to rest large commercial vehicles which suffer brake or gear change mechanism failures.*

*NOTE 3 There are two basic layouts for arrester beds; 'remote' which are incorporated into a separate escape lane leading off the main carriageway and 'adjacent' which are constructed adjacent to the nearside of the carriageway in a widened section of the highway.*

11.2 On new or improved roads where a long, downhill gradient is unavoidable and a potential problem associated with runaway vehicles is identified, the possibility of including an escape lane arrester bed shall be investigated.

*NOTE At severely restricted sites, it is potentially not feasible to construct a full width 'remote' or 'adjacent' arrester bed. In such cases a reduced width 'adjacent' arrester bed, which just accommodates the nearside wheels of a runaway vehicle, can be the only feasible option.*

11.2.1 A 'single track' type of arrester bed only has about 50% of the stopping effect of a full width bed, so requires an increased bed length and should only be proposed when there are no suitable alternatives.

11.3 The provision of any type of arrester bed shall be supported by a risk assessment and details of discussions with the Overseeing Organisation, relevant local authorities and emergency services.

11.4 The bed material shall be free draining and the base of the bed drained to avoid water ponding and potential freezing in winter conditions.

11.5 The sides of the bed shall be restrained by kerbing which restricts sideways movement and scatter of the aggregate.

11.6 On 'remote' arrester beds the horizontal alignment of the bed shall diverge from that of the main carriageway to minimise the potential for the nearside wheels of the vehicle being in the gravel bed and the offside wheels being on an increasingly adverse cross slope, which can induce vehicle overturning.

11.7 On the 'adjacent' type of arrester bed any kerbing used for the edge restraint between the gravel bed and the main carriageway pavement shall be level with the carriageway so that a vehicle driver, who has the potential to overshoot the signed entry to the bed, can still steer into the arrester bed.

# 12. Anti-glare systems

12.1 All new anti-glare systems shall be specified to BS EN 12676-1 [Ref 1.N] and the specific requirements of MCHW Series 400 [Ref 23.N] and the associated MCHW Series NG400 [Ref 24.N].

*NOTE The purpose of an anti-glare system is to cut off light from oncoming vehicle headlights on adjacent roads.*

12.2 Anti-glare screens shall be designed so that light directed towards the driver at oblique angles (12° to 20°) is reduced whilst relatively open vision (around 70°) is maintained in the sideways direction.

*NOTE The height to effectively screen headlight glare from all types of vehicles on level ground is 2.0m.*

12.3 The risks associated with attaching an anti-glare system to a new or existing VRS shall be assessed prior to installation.

12.3.1 The risk assessment should include the change in the performance of the VRS due to the attachment of the anti-glare system, and the risks associated with the detachment of the anti-glare system in the event of an impact with the VRS.

12.4 The police authority responsible for road surveillance and patrol shall be consulted prior to the installation of any anti-glare system that can restrict the police's view of the opposing carriageway.

# 13. Cattle grids

## Design of cattle grids

13.1 Cattle grids shall be designed in accordance with BS 4008 [Ref 35.N].

*NOTE The Office of Rail Regulation document 'Level Crossings: A guide for managers, designers and operators' ORR Level crossings [Ref 1.I] provides additional requirements and advice for the provision of cattle grids at railway level crossings.*

13.1.1 Cattle grids should only be provided where alternative measures, such as gates, have been investigated and found unsuitable.

13.2 An alternative means of by-passing a cattle grid shall be provided for users that are unable to safely cross the grid but are entitled by law to travel along the particular highway in question (such as pedestrians and equestrians).

*NOTE BS 4008 [Ref 35.N] provides design criteria for by-pass facilities.*

## Siting of cattle grids

13.3 Cattle grids and any associated by-pass shall be located within highway land unless a legal agreement with the relevant land owner has been entered in to.

13.3.1 New cattle grids should be located within the highway boundary.

*NOTE The legal responsibility for animals straying or lying on or at the side of the highway lies with their keepers; however, the Overseeing Organisation has a vested interest in ensuring animals cannot access the motorway and trunk road network due to the safety implications this can have. Placing cattle grids within the highway boundary therefore provides the Overseeing Organisation with a greater level of control over this risk.*

13.4 Cattle grids shall not be located within 18 metres of a junction, measured from the projected kerb line, or edge of carriageway if kerbs are not present, of the adjoining road to the start of the grid.

13.4.1 Cattle grids should only be located where there is a minimum of 18 metres of straight road on either side of the grid.

*NOTE Cattle grids can be a skid/slip hazard, which is a particular problem for pedal and motor cycles. Providing a straight section on the approaches removes the need for road users to turn while traversing the grid, which reduces the risk of skidding/slipping.*

13.4.2 Cattle grids should only be sited where there is desirable minimum stopping sight distance available on each approach to the grid in accordance with CD 109 [Ref 16.N] for the relevant design speed.

13.4.3 In situations where a cattle grid is to be placed closer to a major road junction than the desirable minimum stopping sight distance, unobstructed visibility should be available between the edge of the major road and the grid, measured from centre point to centre point in the approach lane.

*NOTE It is necessary for vehicles to cross cattle grids at relatively low speeds. It is therefore important that adequate visibility is available on the approach to cattle grids to ensure that road users can react and slow down safely prior to reaching them.*

# 14. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | BSI. BS EN 12676-1, 'Anti-glare systems for roads. Performance and characteristics' |
| Ref 2.N | Highways England. CS 454, 'Assessment of highway bridges and structures' |
| Ref 3.N | Highways England. CG 304, 'Conservation of highway structures' |
| Ref 4.N | Highways England. CD 127, 'Cross-sections and headrooms' |
| Ref 5.N | Highways England. LA 116, 'Cultural heritage asset management plans' |
| Ref 6.N | Highways England. CD 353, 'Design criteria for footbridges' |
| Ref 7.N | Highways England. CD 354, 'Design of minor structures' |
| Ref 8.N | Network Rail. NR/L3/CIV/020 Issue 1, 'Design of Railway Bridges' |
| Ref 9.N | Highways England. CD 143, 'Designing for walking, cycling and horse riding (vulnerable users)' |
| Ref 10.N | Highways England. CD 524, 'Edge of pavement details' |
| Ref 11.N | BSI. BS EN 1991-1-7, 'Eurocode 1 - Actions on structures - Part 1-7 General actions - Accidental actions' |
| Ref 12.N | BSI. BS EN 1992-2, 'Eurocode 2. Design of concrete structures. Part 2: Concrete bridges. Design and detailing rules' |
| Ref 13.N | Highways England. CD 123, 'Geometric design of at-grade priority and signal-controlled junctions' |
| Ref 14.N | Highways England. RRRAP User Guide, 'Guidance on the use of the Road Restraint Risk Assessment Process (RRRAP) associated with CD 377' |
| Ref 15.N | 2011/305/EU, 'Harmonised conditions for the marketing of construction products' |
| Ref 16.N | Highways England. CD 109, 'Highway link design' |
| Ref 17.N | BSI. BS 6779-2 , 'Highway parapets for bridges and other structures - Part 2: Specification for vehicle containment parapets of concrete construction' |
| Ref 18.N | BSI. BS 6779-1, 'Highway parapets for bridges and other structures. Part 1: Specification for vehicle containment parapets of metal construction.' |
| Ref 19.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 20.N | Highways England. CS 470, 'Management of sub-standard highway structures' |
| Ref 21.N | Department for Transport. MAOR, 'Managing the accidental obstruction of the railway by road vehicles' |
| Ref 22.N | Highways England. MCHW, 'Manual of Contract Documents for Highway Works' |
| Ref 23.N | Highways England. MCHW Series 400, 'Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works, Series 400 Road Restraint Systems' |
| Ref 24.N | Highways England. MCHW Series NG400, 'Manual of Contract Documents for Highway Works, Volume 2 Notes for Guidance on the Specification for Highway Works, Series 400 Road Restraint Systems' |

| | |
|---|---|
| Ref 25.N | BSI. BS EN 12767, 'Passive safety of support structures for road equipment. Requirements, classification and test methods.' |
| Ref 26.N | BS EN 1317-3, 'Performance classes, impact test acceptance criteria and test methods for crash cushions' , 2010 |
| Ref 27.N | BSI. BS DD ENV 1317-4, 'Performance classes, impact test acceptance criteria and test methods for terminals and transitions of safety barriers' |
| Ref 28.N | Highways England. CD 365, 'Portal and cantilever signs/signals gantries' |
| Ref 29.N | BSI. BS EN 1317-5, 'Product requirements and evaluation of conformity for vehicle restraint systems' |
| Ref 30.N | Network Rail. NR/BS/LI/331 Issue 2, 'Requirements for parapet heights on over bridge and footbridge structures spanning overhead line electrification equipment' |
| Ref 31.N | Highways England. GG 104, 'Requirements for safety risk assessment' |
| Ref 32.N | BSI. BS EN 1317-2, 'Road restraint systems. Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets ' |
| Ref 33.N | BSI. BS EN 1317-1, 'Road restraint systems. Terminology and general criteria for test methods.' |
| Ref 34.N | Highways England. TD 131, 'Roadside technology and communications' |
| Ref 35.N | BSI. BS 4008, 'Specification for Cattle Grids' |
| Ref 36.N | BSI. BS 7818, 'Specification for pedestrian restraint systems in metal ' |
| Ref 37.N | BSI. BS 5400-4, 'Steel, concrete and composite bridges. Code of practice for design of concrete bridges' |
| Ref 38.N | Highways England. CG 300, 'Technical approval of highway structures' |
| Ref 39.N | Highways England. CS 455, 'The assessment of concrete highway bridges and structures' |
| Ref 40.N | Highways England. CS 453, 'The assessment of highway bridge supports' |
| Ref 41.N | The National Archives. legislation.gov.uk. SI 2015/51, 'The Construction (Design and Management) Regulations 2015' |
| Ref 42.N | Highways England. CD 192, 'The design of crossovers and changeovers' |
| Ref 43.N | Highways England. RRRAP, 'The Road Restraint Risk Assessment Process ' |
| Ref 44.N | The Stationery Office. Department for Infrastructure (DfI). TSR(NI) 1997, 'The Traffic Signs Regulations (Northern Ireland) 1997' |
| Ref 45.N | The National Archives. legislation.gov.uk. SI 2016 No.382, 'The Traffic Signs Regulations and General Directions 2016' |
| Ref 46.N | The Stationery Office. TSM Chapter 8, 'Traffic Signs Manual Chapter 8 - Road works and temporary situations' |
| Ref 47.N | BSI. NA to BS EN 1991-1-7, 'UK National Annex to Eurocode 1 - Actions on structures - Part 1-7 General actions - Accidental actions' |

# 15. Informative references

The following documents are informative references for this document and provide supporting information.

| | |
|---|---|
| Ref 1.I | Office of Rail Regulation. ORR Level crossings, 'Level Crossings: A guide for managers, designers and operators' |

# Appendix A. Guidance on the specification of vehicle restraint systems for low speed and/or low flow roads

The guidance given below is intended to assist in dealing with situations where the use of a fully compliant vehicle parapet or vehicle safety barrier system may be impracticable or may itself present a similar or greater hazard to the public. These situations, where the application of these requirements is not appropriate, are particularly prevalent on local roads.

**Table A.1 Considerations for the specification of parapets for low speed and/or low flow roads**

| Function | Potential non-function | Possible reasons for non-function | Assessment criteria | Commentary |
|---|---|---|---|---|
| Vehicle parapet | Does not redirect safely | 1) Redirects effectively, but into oncoming traffic due to narrow carriageway (less than 6.0m).<br>2) Redirects effectively, but into pedestrians on adjacent footway.<br>3) Insufficient length of parapet. | 1) For roads with a speed limit of 50 mph or more and traffic flow less than 5000 AADT, use RRRAP; or<br>2) For roads with a speed limit of less than 50 mph or traffic flow of less than 5,000 AADT, use local in-house risk assessment process to review risk to:<br>a) vehicle occupants and others below or near to the bridge if vehicle is not contained;<br>b) vehicle occupants and others on the bridge (other traffic and pedestrians) if vehicle is redirected effectively.<br>The assessment of risk includes an assessment of actual traffic speed, traffic flows, incident records and the hazards present beneath the bridge. | 1) If the risk from lack of containment is acceptable and the risk from effective redirection is unacceptable, then a parapet may not be necessary other than to delineate for pedestrian safety.<br>2) If the risk from lack of containment is unacceptable and the risk from effective redirection is unacceptable, then a parapet that provides vehicle containment only may optimise the balance of risk.<br>3) If the risk from lack of containment is unacceptable and the risk from effective redirection is acceptable, then a compliant vehicle parapet system should be used if it is practicable to do so. If not, then any alternative (bespoke) system provided should contain the vehicle and reduce risk to the vehicle occupants to ALARP. |

**Table A.2 Considerations for the specification of VRS for low speed and/or low flow roads**

| Function | Potential non-function | Possible reasons for non-function | Assessment criteria | Commentary |
|---|---|---|---|---|
| VRS on bridge approach fully compliant to:<br><br>1) prevent impact on the end of the parapet,<br>2) prevent a vehicle from travelling behind the parapet to the hazard below<br>3) contain and safely redirect an errant vehicle | 1) An errant vehicle impacts on the end of the parapet.<br>2) An errant vehicle gets behind the parapet.<br>3) The vehicle is not redirected safely. | 1) Insufficient space to accommodate a compliant VRS due to:<br>a) adjacent entrances/junctions restricting length;<br>b) verges used as passing bays due to a narrow carriageway (less than 6.0 m);<br>c) insufficient verge/footway width to provide required set-back/working width/vehicle intrusion. | 1) For roads with a speed limit of 50 mph or more, use RRRAP; or<br>2) For roads with a speed limit of less than 50 mph or traffic flow of less than 5,000 AADT, use local in-house risk assessment process to review risk to:<br>a) vehicle occupants and others below or near to the bridge if vehicle is not contained;<br>b) vehicle occupants and others on the bridge (other traffic and pedestrians) if vehicle is redirected effectively. | 1) If the risk from access behind the parapet is acceptable and the risk from effective redirection is unacceptable, then a VRS may not be necessary.<br>2) If the risk from access behind the parapet is unacceptable and the risk from effective redirection is unacceptable then an alternative local vehicle restraint system at the bridge that provides vehicle containment only may optimise the balance of risk. Possible solutions could include splayed wing walls or a short (angled) length of barrier. Such bespoke protection should contain the vehicle and reduce risk to the occupants to ALARP. |

**Table A.2 Considerations for the specification of VRS for low speed and/or low flow roads** (continued)

| Function | Potential non-function | Possible reasons for non-function | Assessment criteria | Commentary |
|---|---|---|---|---|
| VRS on bridge approach fully compliant to:<br><br>1) prevent impact on the end of the parapet,<br>2) prevent a vehicle from travelling behind the parapet to the hazard below<br>3) contain and safely redirect an errant vehicle | 1) An errant vehicle impacts on the end of the parapet.<br>2) An errant vehicle gets behind the parapet.<br>3) The vehicle is not redirected safely. | 2) Redirects effectively, but into oncoming traffic due to narrow carriageway (less than 6.0 m)<br>3) Redirects effectively, but into pedestrians on adjacent footway. | 3) If a non compliant vehicle restraint system or none at all is to be used on the approach to the bridge then review the risk arising from impact on end of parapet.<br><br>The assessment of risk at the bridge approaches include an assessment of of actual traffic speed, traffic flows and accident records, the hazard faced beneath the bridge and the existence of equivalent hazards elsewhere on the route such as parallel ditches/houses/footways | 3) If the risk from access behind the parapet is unacceptable and the risk from effective redirection is acceptable, then a compliant vehicle restraint system should be used if it is practicable to do so. If not then protection at the bridge may again be the solution. Such bespoke protection should contain the vehicle and reduce risk to the occupants to ALARP.<br><br>4) As a result of assessment criteria 3, a crash cushion may be required here to reduce the consequences of an accidental impact on the vehicle occupants to ALARP. |

# Appendix B. Guidance on factors for ECPs and MCPs

## B1 Emergency and maintenance crossing points

There are various options available to create an ECP/MCP. They may take the form of a gate or a permanent safety barrier. Each option varies in cost and ease of operation. Systems that are not suitable to be removed should be avoided near ECPs and MCPs.

For ECPs, the main requirement is the speed with which the ECP can be opened and operational; this depends on the option chosen. It also depends on whether specialist equipment or personnel are required to operate or open the ECP. In most cases, a time of less than 30 minutes to open the gate or dismantle a permanent safety barrier would be desirable.

For MCPs, speed may not be an issue as the opening can be planned. Where regular maintenance is required, for example, near tunnels or on long structures, then it may be beneficial to provide permanent MCPs at each end that can be opened and closed quickly. For other situations, there are two options. Provide an MCP from the outset, or create an MCP only when required (i.e. take down or break out the permanent system; this can often be the most cost effective solution).

### B1.1 Gates at MCP/ECP

A gate is the easiest to open, generally requires no, or minimal, specialist equipment and can be opened in less than 30 minutes. However, personnel do need to be trained to ensure that they know how to operate the gate and close it properly so that it is correctly fixed to the permanent or temporary safety barrier when not in operation. Gates are generally quite expensive. They also have large working widths that can make them unsuitable for narrow central reserves. If they are used, where there is a mismatch in the working widths between the gate and the permanent system, a transition is required to connect the two systems. Any transitions increase the length of the MCP.

### B1.2 Permanent safety barrier at ECP/MCP

A permanent safety barrier may be used to form an ECP/MCP.

If this option is chosen for an ECP, specialist personnel and equipment may be required to dismantle or remove the safety barrier and this can take some time and may exceed the normal 30 minute recommendation required for operational reasons. For an MCP it is a viable option.

Where a concrete H1 or H2 safety barrier is used, an MCP can be created by breaking out the concrete and removing the debris. This operation might take some time depending on length and require specialist equipment. An in-situ concrete section can then be inserted when the MCP is no longer required.

# Notification

This document was notified in draft to the European Commission in accordance with Technical Standards and Regulations Directive 2015/1535/EU.

Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

# CD 377
# England National Application Annex to CD 377 Requirements for road restraint systems

(formerly TD 19/06)

Revision 0

**Summary**
This National Application Annex contains the Highways England specific requirements related to road restraint systems.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Mar 2020 | Highways England National Application Annex to CD 377. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes TD 19/06, and partially supersedes IAN 68/05 and IAN 75/06 which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex contains the Highways England specific requirements related to road restraint systems.

This document is an update to TD 19/06 and reflects changes to the Overseeing Organisations' requirements. It also takes account of updated and new EU standards and legislation.

This document gives requirements for road restraint systems and it, together with the associated RRRAP [Ref 9.N] and RRRAP User Guide [Ref 2.N], assists those involved in determining where road restraint systems are warranted, and the minimum required parameters.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 4.N] apply to this document.

This document is written on the basis that road restraint systems will be supplied and constructed in accordance with the MCHW [Ref 5.N] and all other works will be designed and specified in accordance with the Design Manual for Roads and Bridges.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a British Standard, technical specification or quality mark, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 4.N].

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| AADT | Average annual daily traffic |
| EA | Emergency area |
| ESS | Entry slip signal |
| LGV | Large Goods Vehicle |
| m | Metres |
| Psb | Point from which set-back is measured |
| RRS | Road restraint system |
| VRS | Vehicle restraint system |

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| Cattle grid | A device set into a road that consists of a number of transverse members supported over a pit. It forms a barrier to livestock but allows access for vehicles. |
| Normalised values (of working width and vehicle intrusion) | Values that have been adjusted to take account of any differences between the specified total mass of the vehicle, its velocity and angle of approach and the values measured during testing.<br><br>NOTE: Refer to BS EN 1317-2 [Ref 7.N]. |
| Parapet | A safety barrier that is installed on the edge of a bridge, retaining wall or similar structure where there is a vertical drop. |
| Pedestrian restraint system | A restraint system installed to reduce the risk of a fall from a height at locations where pedestrian movement could occur due to highway use or maintenance activities. |
| Psb | Point from which set-back of the safety barrier or parapet face is measured.<br><br>NOTE: Refer to CD 127 [Ref 1.N] for minimum requirements for permanent safety barriers. |
| Rigid safety barrier | A safety barrier that when tested in accordance with BS EN 1317-1 [Ref 8.N] and BS EN 1317-2 [Ref 7.N], does not deflect from its pre-impact position. |
| Road restraint system (RRS) | General name for vehicle restraint system or pedestrian restraint system used on the road. |
| Set-back | The distance between the Psb and the traffic face of a RRS.<br><br>NOTE: Refer to CD 127 [Ref 1.N] for minimum requirements for permanent safety barriers. |
| Vehicle restraint system (VRS) | A tested system installed on a road to provide a level of containment for an errant vehicle.<br><br>NOTE: A typical system consists of a terminal-safety barrier-terminal, or a terminal-safety barrier-parapet-safety barrier-terminal, and includes transitions where appropriate. |

**Terms** (continued)

| Term | Definition |
|---|---|
| Vehicle intrusion | The vehicle intrusion of an LGV is the maximum dynamic lateral position from the undeformed traffic side of the barrier in consideration of a notional load having the width and length of the vehicle platform, and a total height of 4 metres. The vehicle intrusion of a bus is the maximum dynamic lateral position of the bus from the undeformed traffic side of the barrier.<br><br>NOTE: Further detail is given in BS EN 1317-2 [Ref 7.N]. |
| Working width | The maximum lateral distance between any part of a safety barrier on the undeformed traffic side, and the maximum dynamic position of any part of the barrier during impact testing to BS EN 1317-2 [Ref 7.N].<br><br>NOTE 1: If the vehicle body deforms around the road vehicle restraint system so that the latter cannot be used for the purpose of measuring the working width, the maximum lateral position of any part of the vehicle is the working width.<br><br>NOTE 2: Further detail is given in BS EN 1317-2 [Ref 7.N] |

# E/1. Requirements for permanent safety barriers

## General requirements (additional to CD 377)

E/1.1 For post mounted entry slip signal (ESS) sites, a lack of protection by a vehicle restraint system (VRS), or provision of the required approach length of safety barrier, shall be permitted as acceptable.

E/1.2 Each ESS site shall be assessed, and the decision as to whether to provide VRS, the length of VRS, and the decision making process, recorded in the design strategy record.

E/1.3 Clause 3.26 of CD 377 shall not apply.

E/1.4 Gaps of up to 100 m shall be closed, unless the road is within a smart motorway scheme where the closure of a gap is subject to a risk assessment.

E/1.4.1 A gap may not be closed if there are significant cost, technical and/or access requirements for the gap to remain open.

## Safety barrier provision in central reserves - general (CD 377, 3.85)

E/1.5 On motorways with a two-way annual average daily traffic (AADT) greater or equal to 25,000 vehicles/day where a safety barrier is required in accordance with this document and the distance Psb to Psb is 10 metres or less, the safety barrier shall have a minimum containment level of H1.

E/1.5.1 Where the length of safety barrier to be installed in the central reserve is 500 m or less, an N2 containment level non rigid safety barrier may be installed instead.

*NOTE The installation of a minimum H1 containment rigid safety barrier is to minimise cross-over incidents and reduce the need for safety barriers to be repaired or maintained and hence, minimise the costs and congestion arising from temporary traffic management and reduce the risk to maintenance workers.*

E/1.6 On motorways with a two-way AADT greater or equal to 25,000 vehicles/day where a VRS greater than 500m in length is required in accordance with this document, and the distance Psb to Psb is 10 m or less, the safety barrier shall be rigid, have a serviceable life of not less than 50 years, and be designed such that after testing in accordance with BS EN 1317-1 [Ref 8.N] and BS EN 1317-2 [Ref 7.N], it does not require realignment, replacement or repair.

E/1.7 On new and upgraded all-purpose trunk roads, the requirements of GD 300 [Ref 6.N] shall apply.

E/1.8 On all other roads where a safety barrier is required in accordance with this document and the distance Psb to Psb is 10 m or less, the safety barrier shall have a minimum containment level of N2.

## Requirements for gaps in safety barrier (additional to CD 377)

### Emergency areas (EA) on smart motorway schemes

E/1.9 Full height anchorages shall only be used at EA locations where VRS is required and where there is insufficient room for two full length terminals.

E/1.10 Full height anchorages shall only be used at EA locations where they do not face oncoming traffic, unless behind another VRS (and outside of its working width and vehicle intrusion).

# E/2. Cattle grids

### Siting of cattle grids (CD 377, 13.3)

E/2.1 Cattle grids and any associated by-pass shall be located within highway land unless a legal agreement with the relevant land owner has been entered in to.

*NOTE For cattle grids to be located on non-highway land, a legal agreement is entered into under Section 87 of the Highways Act 1980 [Ref 3.N].*

# E/3. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. CD 127, 'Cross-sections and headrooms' |
| Ref 2.N | Highways England. RRRAP User Guide, 'Guidance on the use of the Road Restraint Risk Assessment Process (RRRAP) associated with CD 377' |
| Ref 3.N | The National Archives. legislation.gov.uk. Highways Act 1980, 'Highways Act 1980' |
| Ref 4.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 5.N | Highways England. MCHW, 'Manual of Contract Documents for Highway Works' |
| Ref 6.N | Highways England. GD 300, 'Requirements for new and upgraded all-purpose trunk roads (expressways)' |
| Ref 7.N | BSI. BS EN 1317-2, 'Road restraint systems. Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets ' |
| Ref 8.N | BSI. BS EN 1317-1, 'Road restraint systems. Terminology and general criteria for test methods.' |
| Ref 9.N | Highways England. RRRAP, 'The Road Restraint Risk Assessment Process ' |

Highway Structures & Bridges
Design

# CD 377
# Northern Ireland National Application Annex to CD 377 Requirements for road restraint systems

(formerly TD 19/06)

Revision 1

**Summary**
This National Application Annex contains the Department for Infrastructure Northern Ireland specific requirements for road restraint systems.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 1 | Jan 2021 | Revision 1 (Jan. 2021) Changes to the the NI OO's requirements, and takes account of updated and new EU standards and legislation. Revision 0 (March 2020) Department for Infrastructure Northern Ireland National Application Annex to CD 377. |

# Foreword

## Publishing information

This document is published by Highways England on behalf of Department for Infrastructure, Northern Ireland.

This document supersedes TD 19/06, and partially supersedes IAN 68/05 and IAN 75/06 which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex contains the Department for Infrastructure Northern Ireland specific requirements related to road restraint systems.

This document is an update to TD 19/06 and reflects changes to the Overseeing Organisations' requirements. It also takes account of updated and new EU standards and legislation.

This document gives requirements for road restraint systems and it, together with the associated RRRAP [Ref 8.N] and RRRAP User Guide [Ref 3.N], assists those involved in determining where road restraint systems are warranted, and the minimum required parameters.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 4.N] apply to this document.

This document is written on the basis that road restraint systems will be supplied and constructed in accordance with the MCHW Series 400 [Ref 5.N] and all other works will be designed and specified in accordance with the Design Manual for Roads and Bridges.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a British Standard, technical specification or quality mark, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 4.N].

# Abbreviations

| Abbreviation | Definition |
|---|---|
| AADT | Average annual daily traffic |
| LGV | Large Goods Vehicle |
| mph | Miles per hour |
| Psb | Point from which set-back is measured |
| RRS | Road restraint system |
| VRS | Vehicle restraint system |

# Terms and definitions

| Term | Definition |
|---|---|
| Cattle grid | A device set into a road that consists of a number of transverse members supported over a pit. It forms a barrier to livestock but allows access for vehicles. |
| Parapet | A restraint system that is installed on the edge of a bridge, retaining wall or similar elevated structure where there is a vertical drop. |
| Pedestrian restraint system | A restraint system installed to reduce the risk of a fall from a height at locations where pedestrian movement could occur due to highway use or maintenance activities. |
| Psb | Point from which set-back of the safety barrier or parapet face is measured.<br><br>NOTE: Refer to CD 127 [Ref 2.N] for minimum requirements for permanent safety barriers. |
| Railway Authority | Authority responsible for the railway infrastructure. |
| Rigid safety barrier | A safety barrier that when tested in accordance with BS EN 1317-1 [Ref 7.N] and BS EN 1317-2 [Ref 6.N], does not deflect from its pre-impact position. |
| Road restraint system (RRS) | General name for vehicle restraint system or pedestrian restraint system used on the road. |
| Set-back | The distance between the Psb and the traffic face of a RRS.<br><br>NOTE: Refer to CD 127 [Ref 2.N] for minimum requirements for permanent safety barriers. |
| Vehicle restraint system (VRS) | A tested system installed on a road to provide a level of containment for an errant vehicle.<br><br>NOTE: A typical system consists of a terminal-safety barrier-terminal, or a terminal-safety barrier-parapet-safety barrier-terminal, and includes transitions where appropriate. |

# NI/1. Scope

## Implementation and application

NI/1.1 Clause 1.2 of CD 377 shall not apply.

NI/1.2 This document shall apply to motorways, trunk, and non-trunk roads with permanent speed limits of 50 mph or more and two-way traffic flows of 5,000 annual average daily traffic (AADT) or more.

NI/1.3 For the application of clause 1.3.1 across the NI road network, contact shall be made with the Overseeing Organisation.

NI/1.4 For trunk, and non-trunk, roads with permanent speed limits of less than 50 mph, or two-way traffic flows of less than 5,000 annual average daily traffic (AADT), contact shall be made with the Overseeing Organisation for design standards and guidance on the introduction or replacement of RRS.

# NI/2. Requirements for permanent safety barriers

## Safety barrier provision in central reserves - general (CD 377, 3.77- 3.83)

NI/2.1 On motorways and all-purpose dual carriageways with a two-way AADT greater or equal to 25,000 vehicles/day where a safety barrier is required in accordance with this document and the distance Psb to Psb is 10 m or less, the safety barrier shall have a minimum containment level of H1.

NI/2.2 The safety barrier shall be rigid, have a serviceable life of not less than 50 years and be designed such that after testing in accordance with BS EN 1317-1 [Ref 7.N] and BS EN 1317-2 [Ref 6.N], it does not require realignment, replacement or repair.

*NOTE The installation of a minimum H1 containment rigid safety barrier is to minimise cross-over incidents and to reduce the need for safety barriers to be repaired or maintained, and hence minimise the costs and congestion arising from temporary traffic management and reduce the risk to maintenance workers.*

NI/2.2.1 Where the length of rigid safety barrier to be installed in the central reserve is 500 m or less, an N2 containment level non-rigid safety barrier may be installed.

NI/2.2.2 A reduction in containment level provision to N2, or use of a non-rigid safety barrier, may be considered for upgrades to an existing dual carriageway. This may be applied for as a Departure from Standards where it can be demonstrated, with the approval of the Overseeing Organisation, that other aspects of the road design are further compromised by the proposed use of a higher containment rigid system.

## Other factors (additional to CD 377, 3.38)

NI/2.3 In accordance with CD 377, in areas where environmental conditions can affect the choice and positioning of the safety barrier, any restrictions on the type or material for the barrier shall be specified in the contract specification, using contract specific Appendix 4/1 as detailed in MCHW Series 400 [Ref 5.N].

NI/2.3.1 The prevalence of wildlife should also be assessed as part of the environmental considerations, so that a suitable barrier is selected which may reduce the risk to animals that could be trapped by an inappropriate system and so unable to leave the carriageway.

# NI/3. Requirements for vehicle parapets

## Minimum containment level requirements where the road is carried over or adjacent to a railway

NI/3.1 Clauses 4.8 to 4.12 inclusive of CD 377 shall not apply.

**New and existing bridges, structures and accommodation bridges (additional to CD 377)**

NI/3.2 A site-specific risk assessment shall be carried out to determine whether the containment level will be normal, high or very high.

NI/3.3 Approval of the risk assessment methodology shall be obtained from the Overseeing Organisation.

NI/3.4 The containment level shall only be specified following consultation with the Railway Authority and approval from the Overseeing Organisation.

NI/3.5 Where the need for a normal, high or very high containment level vehicle parapet has been identified, the nature of the risk, any mitigation measures taken to reduce the risk, and the resulting containment level required shall be recorded.

NI/3.6 The minimum vehicle parapet containment level shall be normal containment level (N2).

# NI/4. Cattle grids

## Siting of cattle grids (CD 377, 13.3)

NI/4.1 Cattle grids and any associated by-pass shall be located within highway land unless a legal agreement with the relevant land owner has been entered into.

*NOTE For cattle grids to be located on non-highway land, a legal agreement is entered into under Article 63 of the R(NI)O 1993 Art 63 [Ref 1.N].*

# NI/5. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | R(NI)O 1993 Art 63, 'Article 63 of the Roads (Northern Ireland) Order 1993' |
| Ref 2.N | Highways England. CD 127, 'Cross-sections and headrooms' |
| Ref 3.N | Highways England. RRRAP User Guide, 'Guidance on the use of the Road Restraint Risk Assessment Process (RRRAP) associated with CD 377' |
| Ref 4.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 5.N | Highways England. MCHW Series 400, 'Manual of Contract Documents for Highway Works, Volume 1 Specification for Highway Works, Series 400 Road Restraint Systems' |
| Ref 6.N | BSI. BS EN 1317-2, 'Road restraint systems. Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets ' |
| Ref 7.N | BSI. BS EN 1317-1, 'Road restraint systems. Terminology and general criteria for test methods.' |
| Ref 8.N | Highways England. RRRAP, 'The Road Restraint Risk Assessment Process' |

Highway Structures & Bridges
Design

# CD 377
# Scotland National Application Annex to CD 377 Requirements for road restraint systems

(formerly TD 19/06)

Revision 2

**Summary**
This National Application Annex gives the Transport Scotland specific requirements for road restraint systems.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 2 | Dec 2020 | Revision 2 (December 2020) To correct error in revision 1 S/2, and reorder clauses. Revision 1 (June 2020) First requirements created for Transport Scotland. Please see sections S/1 to S/6. Revision 0 (March 2020) Transport Scotland National Application Annex to CD 377. |

# Foreword

## Publishing information

This document is published by Highways England on behalf of Transport Scotland.

This document supersedes TD 19/06.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex contains the Transport Scotland specific requirements related to road restraint systems.

This document is an update to TD 19/06 and reflects changes to the Overseeing Organisations' requirements. It also takes account of updated and new EU standards and legislation.

This document gives requirements for road restraint systems and it, together with the associated RRRAP [Ref 7.N] and RRRAP User Guide [Ref 1.N], assists those involved in determining where road restraint systems are warranted, and the minimum required parameters.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

This document is written on the basis that road restraint systems will be supplied and constructed in accordance with the MCHW [Ref 3.N] and all other works will be designed and specified in accordance with the Design Manual for Roads and Bridges.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a British Standard, technical specification or quality mark, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 2.N].

# Abbreviations

**Abbrreviations**

| Abbreviation | Meaning |
|---|---|
| AADT | Average annual daily traffic |
| RRRAP | Road restraint risk assessment process |
| RRS | Road restraint system |
| VRS | Vehicle restraint system |

# S/1. Scope

## Implementation and application

S/1.1 CD 377, clause 1.3 (6) shall not apply.

S/1.1.1 Unless otherwise agreed with the Overseeing Organisation, this document should be applied whenever a RRS needs to be dismantled on a temporary basis, e.g. during planned maintenance schemes.

# S/2. Requirements for permanent safety barriers

## Minimum containment levels (additional to CD 377, 3.4 and 3.5)

S/2.1 In accordance with CD 377, minimum containment levels for permanent safety barriers shall be as defined in 3.4 and 3.5.

S/2.1.1 Where higher or very high containment level systems are required, an 'L' level containment system compliant with BS EN 1317-2 [Ref 5.N] may be used in place of an 'H' level system.

*NOTE Products with an 'L' level are preferred where these are available and meet the contract performance requirements.*

## Other factors (additional to CD 377, 3.38)

S/2.2 In accordance with CD 377, in areas where environmental conditions can affect the choice and positioning of the safety barrier, any restrictions on the type or material for the barrier shall be specified in the contract specific specification, using contract specific Appendix 4/1 as detailed in MCHW Volume 2 Series 400 ( MCHW Series NG 400 [Ref 4.N]).

*NOTE Environmental considerations can also include a local prevalence of wildlife, so a suitable choice of barrier can ensure that animals are able to leave the carriageway and are not trapped by an inappropriate system.*

## Safety barrier provision in central reserves - general (additional to CD 377, 3.83)

S/2.3 On motorways and all-purpose dual carriageways with a two-way AADT greater or equal to 25,000 vehicles/day, where a VRS is required under the other criteria set out in this document, and the distance Psb to Psb is 10 meres or less, a barrier of higher containment level shall be provided.

# S/3. Requirements for vehicle parapets

## Minimum containment levels where the road is not carried over or adjacent to a railway (additional to CD 377, 4.4 and 4.5)

S/3.1 In accordance with CD 377, minimum containment levels for vehicle parapets where the road is not carried over or adjacent to a railway shall be as defined in 4.4 and 4.5.

S/3.1.1 Where higher or very high containment level systems are required, an 'L' level containment system compliant with BS EN 1317-2 [Ref 5.N] may be used in place of an 'H' level system.

*NOTE Products with an 'L' level are preferred where these are available and meet the contract performance requirements.*

## Minimum containment level requirements where the road is carried over or adjacent to a railway (additional to CD 377, 4.8 and 4.9)

S/3.2 In accordance with CD 377, minimum containment levels for vehicle parapets where the road is carried over or adjacent to a railway (except on accommodation bridges) shall be as defined in 4.8 and 4.9.

S/3.2.1 Wherever reference is made in 4.8, 4.9 and associated sub-clauses to 4.9 to 'H4a' containment, this may be extended to include 'H4a or L4a' containment.

*NOTE Products with an 'L' level are preferred where these are available and meet the contract performance requirements.*

# S/4. Requirements for transitions

## Minimum containment levels (additional to CD 377, 6.5 to 6.8)

S/4.1 In accordance with CD 377, minimum containment levels for transitions shall be as defined in 6.5 to 6.8.

S/4.1.1 Where higher or very high containment level systems are required, an 'L' level containment system compliant with BS EN 1317-2 [Ref 5.N] may be used in place of an 'H' level system.

*NOTE* *Products with an 'L' level are preferred where these are available and meet the contract performance requirements.*

# S/5. Requirements for temporary safety barriers at roadworks

## Minimum containment levels (additional to CD 377, 9.4 and 9.5)

S/5.1 In accordance with CD 377, minimum containment levels for temporary safety barriers at roadworks shall be as defined in 9.4 and 9.5.

S/5.1.1 Where higher or very high containment level systems are required, an 'L' level containment system compliant with BS EN 1317-2 [Ref 5.N] may be used in place of an 'H' level system.

*NOTE Products with an 'L' level are preferred where these are available and meet the contract performance requirements.*

# S/6. Cattle grids

### Siting of cattle grids (additional to CD 377, 13.3)

S/6.1 In accordance with CD 377, cattle grids and any associated by-pass shall be located within highway land unless a legal agreement with the relevant land owner has been entered in to.

*NOTE For cattle grids to be located outside of the public road boundary, a legal agreement is entered into under Section 46 of The Roads (Scotland) Act [Ref 6.N].*

# S/7. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. RRRAP User Guide, 'Guidance on the use of the Road Restraint Risk Assessment Process (RRRAP) associated with CD 377' |
| Ref 2.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 3.N | Highways England. MCHW, 'Manual of Contract Documents for Highway Works' |
| Ref 4.N | Highways England. MCHW Series NG 400, 'Manual of Contract Documents for Highway Works, Volume 2 Notes for Guidance on the Specification for Highway Works, Series 400 Road Restraint Systems' |
| Ref 5.N | BSI. BS EN 1317-2, 'Road restraint systems. Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets ' |
| Ref 6.N | The National Archives. legislation.gov.uk. The Roads (Scotland) Act, 'Section 46 of The Roads (Scotland) Act' |
| Ref 7.N | Highways England. RRRAP, 'The Road Restraint Risk Assessment Process' |

Llywodraeth Cymru
Welsh Government

Highway Structures & Bridges
Design

# CD 377 WNAA
# Wales National Application Annex to CD 377 Requirements for road restraint systems

(formerly TD 19/06)

Revision 1

**Summary**
This National Application Annex contains the Welsh Government specific requirements related to road restraint systems.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 1 | Jul 2020 | Welsh Government National Application Annex to CD 377. |

# Foreword

## Publishing information

This document is published by Highways England on behalf Welsh Government.

This document supersedes TD 19/06, and partially supersedes IAN 68/05 and IAN 75/06 which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

This National Application Annex contains the Welsh Government specific requirements related to road restraint systems.

This document is an update to TD 19/06 and reflects changes to the Overseeing Organisations' requirements. It also takes account of updated and new EU standards and legislation.

This document gives requirements for road restraint systems and it, together with the associated RRRAP [Ref 9.N] and RRRAP User Guide [Ref 2.N], assists those involved in determining where road restraint systems are warranted, and the minimum required parameters.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 3.N] apply to this document.

This document is written on the basis that road restraint systems will be supplied and constructed in accordance with the MCHW [Ref 4.N] and all other works will be designed and specified in accordance with the Design Manual for Roads and Bridges.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a British Standard, technical specification or quality mark, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 3.N].

# Abbreviations

| Abbreviation | Definition |
|---|---|
| ALARP | As low as reasonably practicable |
| Psb | Point from which set-back is measured |
| RRS | Road restraint system |
| VRS | Vehicle restraint system |
| WMCP | Winter maintenance crossing point |

# Terms and definitions

| Term | Definition |
|---|---|
| Cattle grid | A device set into a road that consists of a number of transverse members supported over a pit. It forms a barrier to livestock but allows access for vehicles. |
| Parapet | A safety barrier that is installed on the edge of a bridge, retaining wall or similar structure where there is a vertical drop. |
| Pedestrian restraint system | A restraint system installed to reduce the risk of a fall from a height at locations where pedestrian movement could occur due to highway use or maintenance activities. |
| Psb | Point from which set-back of the safety barrier or parapet face is measured.<br><br>NOTE: Refer to CD 127 [Ref 1.N] for minimum requirements for permanent safety barriers. |
| Rigid safety barrier | A safety barrier that when tested in accordance with BS EN 1317-1 [Ref 8.N] and BS EN 1317-2 [Ref 7.N], does not deflect from its pre-impact position. |
| Road restraint system (RRS) | General name for vehicle restraint system or pedestrian restraint system used on the road. |
| Routine | 1. For maintenance: limited to cyclic maintenance work activity as detailed within the Wales Trunk Road Maintenance Manual RRRSG (W) [Ref 6.N];<br>2. Safety critical: Category 1 defect reinstatement as described in the Wales Trunk Road Maintenance Manual RRRSG (W) [Ref 6.N] |
| Set-back | The distance between the Psb and the traffic face of a RRS.<br><br>NOTE: Refer to CD 127 [Ref 1.N] for minimum requirements for permanent safety barriers. |
| Vehicle restraint system (VRS) | A tested system installed on a road to provide a level of containment for an errant vehicle.<br><br>NOTE: A typical system consists of a terminal-safety barrier-terminal, or a terminal-safety barrier-parapet-safety barrier-terminal, and includes transitions where appropriate. |

# W/1. Scope

## Implementation and application (CD 377, 1)

W/1.1 CD 377, clause 1.2 shall not apply.

W/1.2 This document shall apply to all motorways and trunk roads across the Wales road network.

*NOTE Guidance on the implementation of CD 377 and this document can be found in RRRSG (W) [Ref 6.N].*

### Application of document (CD 377, 1.3.1)

W/1.3 In accordance with Clause 1.3 of CD 377, this document shall be applied:

1) on all new roads;
2) on schemes where the highway cross-section is being altered permanently;
3) whenever the road restraint system (RRS) is life- (serviceable life) expired and needs replacing;
4) whenever a hazard is introduced and/or moved, and/or modified;
5) whenever there is a change in risk at or near the edge of the carriageway;
6) whenever a RRS needs to be dismantled (other than where localised sections need to be removed to gain access), e.g. during planned maintenance schemes.

W/1.3.1 Unless otherwise agreed with the Overseeing Organisation, this document should also be applied:

1) when other works (excluding routine maintenance and safety critical interventions) are being carried out near a hazard that is currently without provision, or near an existing RRS that does not meet the requirements of this document (for example, with regard to its containment level, normalised working width class, normalised vehicle intrusion class);
2) when other works (excluding routine maintenance and safety critical interventions) are being carried out near an existing vehicle restraint system (VRS) which is life (service life) expired;
3) when other works (excluding routine maintenance and safety critical interventions) are being carried out near an existing RRS that has less than 5 years serviceable life remaining and no other major maintenance works are planned during the remaining life of the existing RRS.

### Like for like renewal (additional to CD 377, 1.4)

W/1.4 Where an existing RRS needs minor repairs or suffers accidental damage, a like-for-like renewal of a RRS shall be agreed with the Overseeing Organisation.

W/1.4.1 Where making a RRS compliant with current requirements results in significant undue additional expense or delay, a like-for-like reinstatement should be supported by a evidence-based business case, comparing options.

W/1.5 Any evidence-based business case for like-for-like reinstatement shall be recorded and agreed with the Overseeing Organisation.

### Application of risk assessments to determine RRS requirements

W/1.6 CD 377, clause 1.7 shall not apply.

W/1.7 For all motorways and trunk roads across the Wales road network, a risk assessment that is acceptable to the Overseeing Organisation, shall determine whether RRS is necessary.

# W/2. General requirements

## Risk assessment and hazard mitigation (CD 377, 2.2)

W/2.1 CD 377, 2.2 shall not apply.

W/2.2 On all motorways and trunk roads across the Wales road network, the RRRAP [Ref 9.N] for Wales shall be used to formally record the type and location of all of the hazards which are to be mitigated by the design.

*NOTE 1 The RRRAP [Ref 9.N] can be used on motorways and all purpose trunk roads having a speed limit of 50 mph or greater, and an AADT of 5,000 or greater.*

*NOTE 2 Access to the RRRAP [Ref 9.N] for Wales can be obtained from the Overseeing Organisation.*

### Alternative risk assessment methods

W/2.3 Where the use of the RRRAP [Ref 9.N] for Wales is disproportionate to the scale of the works or route, the use of alternative methods of undertaking a risk assessment as to whether an RRS is warranted shall be agreed with the Overseeing Organisation.

*NOTE Examples of alternative methods of undertaking an assessment based on risk as to whether an RRS is warranted include the following:*

1) *RRRAP [Ref 9.N] applied with local considerations, for example on a junction modification scheme, the RRRAP [Ref 9.N] can be applied locally to the junction rather than the entire route;*
2) *CD 377 [Ref 2.I] Appendix A;*
3) *local policies or methods that are acceptable to the Overseeing Organisation.*

# W/3. Requirements for permanent safety barriers

### Passively safe road furniture and equipment, and vehicle restraint systems (additional to CD 377, 3.43)

W/3.1 In accordance with clause 3.43 in CD 377, passively safe road furniture or equipment placed within the normalised working width class of a safety barrier shall have an energy absorption category of NE as defined by BS EN 12767 [Ref 5.N].

W/3.2 The working width of a barrier shall not be obstructed as this will affect the performance of the safety barrier and risk invalidating its 'certified' performance.

W/3.2.1 Where space exists, trees and other vegetation should be placed as far from the kerb face or back of hard strip or hard shoulder as possible.

W/3.2.2 Passively safe road furniture may be located within the working width in exceptional circumstances providing requirements set out within clause 3.42 of CD 377 are met.

W/3.2.3 Passively safe sign/signal posts (excluding those with slip bases) may be located within the normalised working width class of a double-sided safety barrier in the central reserve, as long as it is demonstrated that:

1) there is no alternative location suitable for the sign/signal posts; and
2) the risk of not having the sign/signal is greater than the risk of using this arrangement; and
3) the sign/signal posts demonstrates the same collapse mechanism(s) as that witnessed in the BS EN 12767 [Ref 5.N] testing if impacted in the proposed installation location; and
4) the risk associated with a secondary incident is acceptable to the Overseeing Organisation or ALARP.

*NOTE 1 Obstructions or indifference in levels are likely to influence the operation of barrier under impact and can also have a detrimental effect on the vehicle hitting it. This will increase the risk of injury to its occupants and again, risk invalidating its 'certified' performance.*

*NOTE 2 Vegetation within the working width of the safety barrier will affect its performance. It will also hinder maintenance and create problems for the drivers of broken down vehicles who are likely to seek temporary refuge behind the safety barrier.*

## Requirements for gaps in the central reserve

#### Winter maintenance crossing points

W/3.3 Clauses 3.109 to clause 3.113 inclusive of CD 377 shall not apply.

W/3.3.1 Provision of winter maintenance crossing points (WMCP) may be agreed with the Overseeing Organisation on a case by case basis.

W/3.3.2 Consultations for the provision of WMCP should include the emergency services and operational needs.

# W/4. Cattle grids

## Siting of cattle grids (CD 377, 13.3)

W/4.1 Cattle grids and any associated by-pass shall be located within highway land unless a legal agreement with the relevant land owner has been entered in to.

*NOTE For cattle grids to be located on non-highway land, a legal agreement is entered into under Section 87 of the Highways Act 1980 [Ref 1.I].*

# W/5. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | Highways England. CD 127, 'Cross-sections and headrooms' |
| Ref 2.N | Highways England. RRRAP User Guide, 'Guidance on the use of the Road Restraint Risk Assessment Process (RRRAP) associated with CD 377' |
| Ref 3.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 4.N | Highways England. MCHW, 'Manual of Contract Documents for Highway Works' |
| Ref 5.N | BSI. BS EN 12767, 'Passive safety of support structures for road equipment. Requirements, classification and test methods.' |
| Ref 6.N | Welsh Government. RRRSG (W), 'Requirements for Road Restraint Systems Implementation Guide - Wales' |
| Ref 7.N | BSI. BS EN 1317-2, 'Road restraint systems. Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets ' |
| Ref 8.N | BSI. BS EN 1317-1, 'Road restraint systems. Terminology and general criteria for test methods.' |
| Ref 9.N | Highways England. RRRAP, 'The Road Restraint Risk Assessment Process ' |

# W/6. Informative references

The following documents are informative references for this document and provide supporting information.

| | |
|---|---|
| Ref 1.I | The National Archives. legislation.gov.uk. Highways Act 1980, 'Highways Act 1980' |
| Ref 2.I | Highways England. CD 377, 'Requirements for road restraint systems' |

Design Manual for Roads and Bridges

General Principles and Scheme Governance
General information

# GG 119
# Road safety audit

(formerly HD 19/15)

Revision 2

**Summary**
This document provides the requirements for road safety audit for highway schemes on the trunk road and motorway network.

**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

**This is a controlled document.**

# Contents

# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 2 | Jan 2020 | Revision 2 (January 2020) is for an update to superseded references. Revision 1 (January 2019) was for the removal of the health and safety plus equality, diversity and inclusion clauses that are now covered in GG 101. Revision 0 (October 2018) GG 119 replaces HD 19/15. This full document has been re-written to make it compliant with the new Highways England drafting rules. Technical content changes have also been incorporated throughout where relevant. |

# Foreword

## Publishing information

This document is published by Highways England.

This document supersedes HD 19/15, which is withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

# Introduction

## Background

The objective of the road safety audit process is to provide an effective, independent review of the road safety implications of engineering interventions for all road users.

The Overseeing Organisations attach great importance to the improvement of road safety on the motorway and trunk road network. The application of DMRB requirements, that are based on road safety considerations, help achieve this objective.

However, even with the careful application of design standards by competent professionals, the design process will not remove all hazards for road users.

The road safety audit process, as set out in this document, helps manage the interaction of different design requirements for highway schemes.

The objective of road safety audit is to identify aspects of engineering interventions that could give rise to road safety problems and to suggest modifications that could improve road safety. It is important to note that road safety audit is not intended to be a technical check of compliance with design requirements.

Although road safety has always been considered during design, road safety audit has existed for a number of years to provide an independent check that the design characteristics do not contribute to collisions and/or incidents on highway schemes.

Road safety audit is undertaken by staff with experience of collision data analysis, road safety engineering experience and a reasonable understanding of highway design principles such as design requirements and best practice. 2008/96/EC [Ref 1.N] has mandated the road safety audit process and associated qualification requirements across the European Community. It is undertaken at key stages in the design, construction and early operation of a highway scheme.

Although Overseeing Organisations and design teams do not necessarily contain staff with collision data analysis and road safety engineering experience, these organisations play an equally important role alongside road safety audit teams in achieving the objectives of the process. The road safety audit process does not change the Overseeing Organisation's duty to manage safety for all populations and undertake an appropriate level of risk assessment.

This document is sub-divided into sections aimed at the different parties in the road safety audit process. It is expected that all parties will work in partnership (where appropriate) to identify, manage and mitigate the hazards in the most appropriate way.

## Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

It is assumed that the Overseeing Organisation involved in the road safety audit process will provide the appropriate staff resources and technical support to undertake the process. This may include seeking advice from other appropriate individuals.

It is assumed that staff with the appropriate competency and authority within the Overseeing Organisation will be involved in the decision-making process when responding to RSA and deciding upon subsequent actions.

It is assumed that RSA teams have an awareness of the principles of road design.

It is assumed that RSA teams have an awareness of the principles of road safety risk assessments, and that identified RSA actions will be subject to formal design organisation risk assessments prior to implementation.

It is assumed that the design organisation may not be present to assist in stage 4 road safety audits.

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a "British Standard" or other technical specification, that requirement may be met by compliance with the mutual recognition clause in GG 101 [Ref 2.N].

# Abbreviations

**Abbreviations**

| Abbreviation | Definition |
|---|---|
| TERN | Trans-European Road Network |
| RSA | Road Safety Audit |

# Terms and definitions

**Terms**

| Term | Definition |
|---|---|
| Collision data analysis | The collection and examination of historical road traffic collision data over a period of time in order to identify common trends and factors which can justify corrective action. |
| Design organisation | The organisation(s) commissioned to undertake various phases of scheme preparation.<br>NOTE 1: At some stages of road safety audit, this can be the contractor. |
| Exemption file note | A note held on file, produced by the Overseeing Organisation, which includes the reasons why road safety audit is not applicable to a highway scheme.<br>NOTE 1: An exemption file note is not a substitute for the production of a departure from standard where road safety audit is applicable but the process is not applied.<br>NOTE 2: An exemption file note template can be found in Appendix A. |
| Highway scheme | All works that involve construction of new highway or permanent change to the existing highway layout or features. This is also considered to include the EC Directive 2008/96/EC 2008/96/EC [Ref 1.N] term "Infrastructure Project".<br>NOTE 1: Road safety audit is not applicable to all highway schemes and applicability is determined by the Overseeing Organisation.<br>NOTE 2: The applicability requirements for road safety audit can be found in section 2.<br>NOTE 3: The term highway scheme includes road schemes in Scotland. |
| Interim road safety audit | The application of the road safety audit process to the whole or part of a highway scheme at any time during its design and construction. Interim road safety audit is neither mandatory nor a substitute for the stage 1, 2, 3 and 4 road safety audits. |
| Like for like maintenance highway schemes | A highway scheme proposed as maintenance works, that solely involves the replacement or refurbishment of a highway feature with a corresponding feature, which as a minimum, will appear the same, be located in the same position, perform the same and be constructed of comparable materials as the feature it replaces. |
| Maintaining agent | The organisation responsible for the ongoing maintenance of the motorway and all-purpose trunk road network at the highway scheme location. |

**Terms** (continued)

| Term | Definition |
|---|---|
| Overseeing Organisation specialist | A person from the Overseeing Organisation that has the appropriate training, skills and experience in the road safety discipline.<br>NOTE 1: For Highways England, this will be an appropriate person from the Safer Roads-Design team.<br>NOTE 2: For Transport Scotland this will be the Head of Standards.<br>NOTE 3: For Welsh Government this would be a specialist within the Network Management Division of the Transport Department.<br>NOTE 4: For the Department for Infrastructure Northern Ireland this will be a specialist within the Engineering Directorate. |
| Road safety audit | The review of highway schemes at the completion of preliminary design, completion of detailed design, the completion of construction and as a post opening monitoring exercise.<br>NOTE 1: At stages 1, 2 and 3 the aim is to identify relevant road safety matters and communicate these in the form of road safety audit problems and recommendations.<br>NOTE 2: At stage 4 the aim is to communicate road safety audit problems and recommendations based on collision data analysis. |
| Road safety audit action | An agreed action recorded in the road safety audit decision log in response to each road safety audit problem raised. |
| Road safety audit brief | The instructions to the road safety audit team defining the scope and details of the highway scheme to be subject to road safety audit, including sufficient information for the stage of road safety audit to be undertaken. |
| Road safety audit decision log | A table within the road safety audit response report to record the road safety audit problems and recommendations, the design organisation and Overseeing Organisation responses and agreed road safety audit actions to road safety audit problems. |
| Road safety audit problem | An identified road safety matter together with a resultant potential road traffic collision type, identified highway scheme location and summary.<br>NOTE 1: This can include road user injuries where there is no identifiable road traffic collision type.<br>NOTE 2: This includes existing road safety matters where the proposed highway scheme impacts the existing road safety matter or vice versa. |
| Road safety audit recommendation | A proportionate and viable suggestion for improvement to eliminate or mitigate an identified road safety audit problem.<br>NOTE 1: In some circumstances, the recommendation can include further work to be undertaken by the design organisation to establish an appropriate mitigation measure or improvement. |

**Terms** (continued)

| Term | Definition |
|---|---|
| Road safety audit report | The report produced by the road safety audit team describing any road safety problems identified by the road safety audit team and the associated road safety recommendations. |
| Road safety audit response report | A report produced by the design organisation following road safety audit stages 1, 2 and 3. The report includes both a design organisation and Overseeing Organisation response to each problem and recommendation raised in the road safety audit report.<br>NOTE 1: The road safety audit decision log is part of the road safety audit response report.<br>NOTE 2: The road safety audit response report is produced collaboratively by the design organisation and Overseeing Organisation.<br>NOTE 3: A road safety audit response report is not produced for stage 4 road safety audits. |
| Road safety audit site visit | A visit to the location of a proposed or completed highway scheme by the road safety audit team and other invitees. |
| Road safety audit team | A team that works together on all aspects of the road safety audit, independent of the highway scheme conception, design, construction and operation.<br>NOTE 1: The road safety audit team comprises a road safety audit team leader and at least one road safety audit team member.<br>NOTE 2: The road safety audit team observer is not part of the road safety audit team.<br>NOTE 3: The individuals within the road safety audit team can be drawn from different organisations including the Overseeing Organisation and the design organisation. |
| Road safety audit team leader | A person with the appropriate training, skills and experience who is approved for a particular highway scheme and road safety audit stage by the Overseeing Organisation.<br>NOTE 1: The road safety audit team leader is responsible for leading the road safety audit team through the process and managing the production of the road safety audit report. |
| Road safety audit team member | A member of the road safety audit team with the appropriate training, skills and experience necessary for a particular highway scheme and road safety audit stage, working with the road safety audit team leader. |
| Road safety audit team observer | A person with the appropriate training, skills and experience accompanying the road safety audit team to gain experience of the road safety audit process and/or highway scheme type.<br>NOTE 1: The road safety audit team observer is encouraged to contribute to the road safety audit team discussions. |

**Terms** (continued)

| Term | Definition |
|---|---|
| Road safety engineering | The design and implementation of highway schemes intended to reduce the number and severity of collisions involving road users, drawing on the results of collision data analysis. |
| Road safety matters | An element of the existing road environment or proposed road environment that could potentially contribute to a road traffic collision or features that could present a risk of injuries to road users. |
| Road traffic collision | As defined as personal-injury road traffic accident in Reported Road Casualties in Great Britain STATS19 [Ref 3.I]. |
| Specialist advisor | A person approved by the Overseeing Organisation to provide specialist independent advice to the road safety audit team where the scheme includes features outside the experience of the road safety audit team.<br>NOTE 1: Features can include complex traffic signal controlled junctions or smart motorway technology. |
| Strategic decision | A decision agreed by the Overseeing Organisation on an element that already reflects an appropriate balance of a number of factors including road safety.<br>NOTE 1: This can include items such as route choice, junction type and standard of provision. |
| Third party organisation | Organisations that are not working on behalf of the Overseeing Organisation and are promoting a highway scheme on the Overseeing Organisation's highway network.<br>NOTE 1: A third party organisation can be a government department, government owned company, developer, local authority, statutory undertaker, private individual, private organisation or consultant working for any of these parties. |

# 1. Scope

## Aspects covered

1.1 This document shall be used to implement road safety audit on highway schemes on motorways and all-purpose trunk roads.

*NOTE 1 Highway schemes include:*

1) *work carried out under agreement with the Overseeing Organisation resulting from developments that affect the trunk road and motorway network; or*
2) *a highway scheme being promoted by third party organisations.*

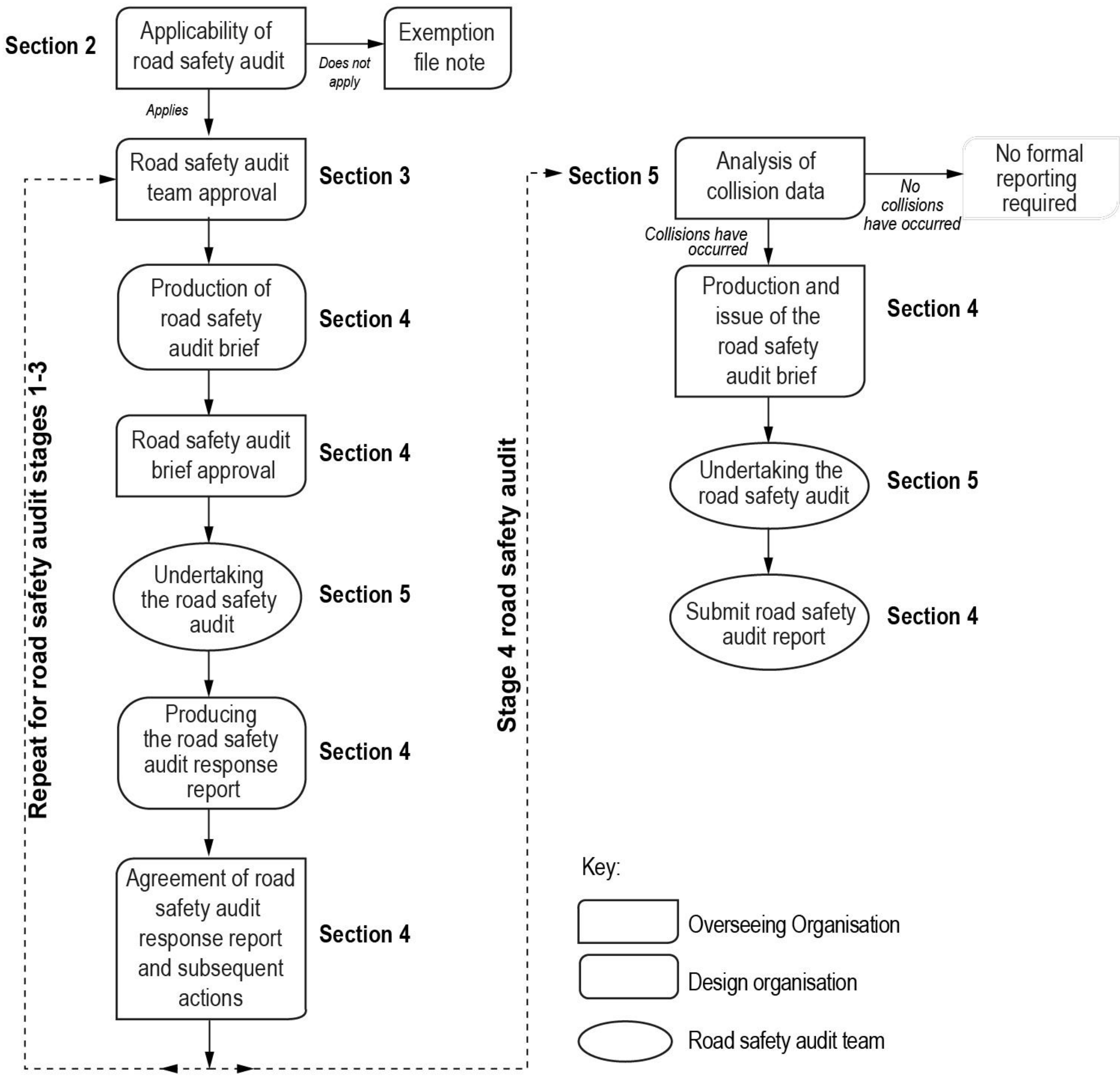
*NOTE 2 The operational safety of temporary traffic management for the construction of highway schemes is covered by chapter 8 of the Traffic Signs Manual TSM Chapter 8 [Ref 3.N].*

1.2 The Overseeing Organisation shall determine the applicability of road safety audit to highway schemes using section 2 of this document.

1.3 Where road safety audit is applied to a highway scheme, it shall be undertaken at each of the following stages:

1) Stage 1 - Completion of preliminary design.
2) Stage 2 - Completion of detailed design.
3) Stage 3 - Completion of construction.
4) Stage 4 - Post opening monitoring.

**Figure 1.3 Road safety audit process overview**




NOTE *Figure 1.3 provides an overview of the road safety audit process and the relevant sections of this document.*

## Implementation

1.4 This document shall be implemented forthwith on all highway schemes on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 2.N].

NOTE 1 *Like for like maintenance highway schemes are excluded from road safety audit.*

NOTE 2 *An exemption file note is not required for like for like maintenance highway schemes.*

## Use of GG 101

1.5 The requirements contained in GG 101 [Ref 2.N] shall be followed in respect of activities covered by this document.

# 2. Applicability of road safety audit

## Trunk road and motorway network

2.1 Where there are physical changes to the highway impacting on road user behaviour or resulting in a change to the outcome of a collision on the trunk road and motorway network, road safety audit (RSA) shall apply, regardless of the procurement method.

*NOTE Temporary traffic management and temporary changes to the highway not associated with the construction of a highway scheme, and that last longer than 6 months in duration, are considered to be physical changes to the highway.*

2.2 RSA shall not apply where a physical change to the highway will not impact on road user behaviour, or change the outcome of a collision on the trunk road and motorway network.

2.3 The Overseeing Organisation shall produce an exemption file note to be kept on the scheme file (or equivalent) where there is no need to apply RSA on the trunk road and motorway network.

*NOTE An exemption file note template is provided in appendix A.*

## Trans-European Road Network (TERN)

2.4 In accordance with the European Directive on Road Infrastructure Safety Management 2008/96/EC [Ref 1.N], RSA must be applied to highway schemes on the TERN.

# 3. Road safety audit team requirements

## RSA team structure

3.1 At all RSA stages the RSA team shall be comprised of the RSA team leader and at least one RSA team member.

3.1.1 RSA team observers may observe the RSA team to gain experience in carrying out RSA.

3.2 The number of RSA team observers shall be limited to a maximum of two.

3.3 The RSA team shall be independent from the highway scheme conception, design, construction and operation.

## Specialist advisors

3.4 Where required by the RSA team, specialist advisors shall be approved by the Overseeing Organisation.

3.5 A specialist advisor shall be independent of the RSA team and highway scheme conception, design, construction and operation.

## Audit team approval

3.6 The Overseeing Organisation shall approve the proposed RSA team before the RSA is undertaken.

3.6.1 The Overseeing Organisation may ask the design organisation to propose a RSA team on their behalf for approval by the Overseeing Organisation.

3.7 RSA team approval shall be recorded within the highway scheme file and communicated to the RSA team.

3.7.1 Approvals of the RSA team are scheme and RSA stage-specific and the use of personnel or organisations on previous RSAs should not guarantee their suitability to undertake a RSA on other schemes.

3.8 Proposed members of the RSA team shall demonstrate their competency by means of a road safety specific curriculum vitae (CV) detailing training, continuing professional development (CPD) and experience.

3.8.1 Experience should be relevant to the type of scheme being subject to RSA and identified in the proposed RSA team members' CV.

*NOTE 1 The CPD record in the CV used to demonstrate competence for a proposed member of the RSA team can include other areas such as highway design, traffic management and highway maintenance.*

*NOTE 2 Relevant CPD does not have to take the form of formal training courses.*

*NOTE 3 Outcome-based structured reading, the preparation and presenting of relevant material and work based learning can all form part of a CPD record.*

3.8.2 Table 3.8.2 should be used for reference when reviewing the training, CPD and experience of the RSA team:

**Table 3.8.2 RSA team competency**

| | RSA team observer | RSA team member | RSA team leader |
|---|---|---|---|
| **Training** | 10 days of formal collision data analysis or road safety engineering/road design training | 10 days of formal collision data analysis or road safety engineering/road design training | 10 days of formal collision data analysis or road safety engineering/road design training |
| **CPD** | N/A | A minimum of 2 days CPD in the field of RSA, collision data analysis or road safety engineering in the last 12 months | A minimum of 2 days CPD in the field of RSA, collision data analysis or road safety engineering in the last 12 months |
| **Experience** | 1 year of collision data analysis or road safety engineering/road design experience | 2 years of collision data analysis or road safety engineering/road design experience | 4 years of collision data analysis or road safety engineering/road design experience |
| | N/A | 5 RSAs completed within the last 24 months as team leader, member or observer | 5 RSAs completed within the last 12 months as team leader or member |

*NOTE 1* *Whilst it is not intended that the RSA team have extensive detailed design knowledge, it is important to include RSA team members with experience or training in road design.*

*NOTE 2* *Experienced road safety professionals who are proposed for the RSA team can have developed their careers from a range of backgrounds.*

*NOTE 3* *RSA team observers are not part of the RSA team.*

3.8.3 Proposed members of the RSA team with the recommended experience of collision data analysis and road safety engineering should not be accepted where this is not evident within the previous 24 months.

3.9 At least one individual within the RSA team undertaking RSA on the motorway and/or trunk road network must hold a certificate of competency in RSA in accordance with the requirements of the European Directive on Road Infrastructure Safety Management 2008/96/EC [Ref 1.N], acquired according to appendix G of this document.

# 4. RSA process requirements

4.1 The Overseeing Organisation shall initiate the RSA process at all stages, allowing time for all parties to complete the full RSA process.

## Producing the RSA brief

4.2 The design organisation shall prepare the RSA brief for submission to the Overseeing Organisation for stage 1, 2 and 3 RSAs.

4.3 The Overseeing Organisation shall have responsibility for approving and issuing the RSA brief to the RSA team.

4.4 For stage 4 RSAs, and where there is no design organisation available, the Overseeing Organisation shall prepare and approve the RSA brief for submission to the RSA team.

*NOTE A RSA brief template is provided in appendix C.*

4.5 Where the RSA team has identified that the RSA brief is insufficient for their purpose, a request for further information shall be made to the Overseeing Organisation.

4.5.1 Any information requested but not supplied to the RSA team should be identified in the introduction to the RSA report.

## Producing the RSA report

4.6 The RSA team leader shall be responsible for leading the RSA team through the process and managing the production of the RSA report.

4.7 The RSA team shall produce and issue a RSA report directly to the Overseeing Organisation for all stages.

4.8 Any misinterpretations of the highway scheme proposals shall be identified by the Overseeing Organisation and discussed with the RSA team.

4.9 Anything agreed to be outside of, or not covered by the RSA process or RSA brief shall be identified by the Overseeing Organisation and discussed with the RSA team.

4.10 Where changes are agreed to a RSA report between the RSA team and Overseeing Organisation, a revised version of the RSA report shall be produced by the RSA team and issued to the Overseeing Organisation.

*NOTE A RSA report template for RSA stages 1, 2 and 3 is provided in appendix D.*

## Producing the RSA response report

4.11 A RSA response report shall be produced for stage 1, 2 and 3 RSAs.

*NOTE A RSA response report is not be required for stage 4 RSAs.*

4.12 The design organisation shall manage the production of the RSA response report in collaboration with the Overseeing Organisation.

4.13 The RSA response report shall include a summary of the scheme, the stage of RSA, the RSA report document reference and date of the RSA report it relates to.

4.14 The RSA response report shall contain details of the representatives from the design organisation who prepared the RSA response report.

4.15 The RSA response report shall contain a RSA decision log to include a reiteration of each road safety problem and recommendation made in the RSA report.

4.16 The design organisation shall, for each RSA problem and recommendation, do one of the following:

1) accept the RSA problem and recommendation made by the RSA team;

2) accept the RSA problem raised, but suggest an alternative solution, giving appropriate reasoning; or
3) disagree with the RSA problem and recommendation raised, giving appropriate reasoning for rejecting both.

4.17 The RSA response report shall contain a response from the Overseeing Organisation and a RSA action for each problem agreed between the design organisation and Overseeing Organisation.

4.18 The RSA response report shall be signed by the Overseeing Organisation and design organisation to indicate their agreement on the RSA actions.

4.18.1 The RSA response report should be produced and finalised within one month of the issue of the RSA report.

*NOTE Appendix F shows a RSA response report and RSA decision log template.*

4.19 For each RSA action, either the design organisation or Overseeing Organisation shall be responsible for its implementation.

### Subsequent actions

4.20 The Overseeing Organisation shall keep a record of all RSA reports and RSA response reports on the highway scheme file.

4.20.1 The Overseeing Organisation should provide electronic copies of the RSA reports and RSA response reports to the Overseeing Organisation specialist.

4.20.2 The Overseeing Organisation should provide an electronic copy of the RSA response report to the RSA team for information.

### Repeating a RSA stage

4.21 Where the Overseeing Organisation deems a repeat RSA to be necessary, the repeated RSA shall only be concerned with the elements of the scheme that have been changed.

*NOTE The design organisation or Overseeing Organisation can request a RSA stage to be repeated where multiple changes or significant changes to the highway scheme are likely to have an impact on road user behaviour or the outcome of a collision.*

4.22 Stage 1 and stage 2 RSAs shall be repeated if the previous RSA for the relevant stage is more than 5 years old.

### Communication

4.23 The design organisation and Overseeing Organisation shall agree an appropriate method of communication with the RSA team to maintain the RSA team independence.

4.23.1 All communication should be recorded, including minutes of meetings if these are held.

# 5. Undertaking the road safety audit

## Scope of road safety audit

5.1 RSA shall only be concerned with road safety matters.

*NOTE 1 RSA is not a technical check that the design conforms to standards and/or best practice guidance.*

*NOTE 2 RSA is not a check that the scheme has been constructed in accordance with the design.*

*NOTE 3 RSA does not consider structural safety.*

*NOTE 4 RSA does not cover health and safety issues concerning road workers during the construction, maintenance and operation of the road.*

5.2 Road safety matters resulting from the operation of facilities for highway maintenance that affect road users shall be included in the scope of RSA.

5.3 The needs of all road users shall be assessed when undertaking the RSA.

## Road safety audit brief

5.4 The RSA brief shall define the scope of the RSA to be undertaken.

5.5 Where the design of the highway scheme includes strategic decisions, this shall be clearly identified within the RSA brief.

5.5.1 The Overseeing Organisation should give sufficient notice to the RSA team of when the scheme will be ready for RSA and the date by which the RSA report will be required.

5.6 A RSA brief shall be stage-specific.

5.6.1 The RSA brief should contain the relevant information for each stage as identified within appendix C.

## Road safety audit report

5.7 At all stages, the RSA team shall prepare a written RSA report.

5.8 The RSA report shall contain a separate statement for each identified RSA problem describing the location and nature of the problem and the type of collisions or road user injuries likely to occur as a result of the problem.

5.9 Each RSA problem shall be followed by an associated RSA recommendation.

5.10 The RSA team shall provide proportionate and viable RSA recommendations to eliminate or mitigate the identified RSA problems.

5.11 RSA recommendations including the words "consider" and "must" shall not be used.

*NOTE The use of the word 'must' in RSA recommendations has the potential to be misinterpreted as an instruction from the RSA team.*

5.12 Recommendations to 'monitor' shall only be made where a need to supplement the stage 4 RSA is specifically identified in terms of frequency and incidence of particular vehicle manoeuvres or collision contributory factors and the monitoring task can be specifically allocated.

5.13 RSA reports shall include:

1) identification of the RSA stage including a unique document reference number and any details of revisions;
2) a brief description of the highway scheme including details of its location and its objectives;
3) details of who supplied the RSA brief, who approved the RSA brief and who approved the RSA team;
4) identification of the RSA team membership as well as the names of others contributing such as the police, maintaining agent and specialist advisors;

5) details of who was present at the site visit, the date and time period(s) when it was undertaken and what the site conditions were on the day of the visit (weather, traffic congestion, etc.);
6) a location plan based on the scheme plan(s), marked up and referenced to problems and if available, photographs of the problems identified;
7) a statement, signed by both the RSA team leader and the RSA team member(s) in the format given in appendix D;
8) a list of information provided to the RSA team.

5.14 The RSA team shall not include any issues in the RSA report that have no implications on road user safety or any other items not covered by the RSA brief.

*NOTE Examples of inappropriate issues include maintenance defects observed during site visits and health and safety issues.*

5.15 The RSA team leader shall report any comments on issues that are not covered by the RSA brief directly to the Overseeing Organisation.

5.15.1 Maintenance defects noted during site visits should be immediately reported directly to the maintaining agent and the Overseeing Organisation.

## Stages of road safety audit

5.16 Highway schemes shall be subject to RSA at stages 1, 2, 3 and 4.

*NOTE 1 General aspects to be addressed at RSA stages 1, 2 and 3 are provided in the lists in appendix B of this document.*

*NOTE 2 The lists provided in appendix B are not intended to be exhaustive and provide a prompt for optional supplementary checks.*

*NOTE 3 A RSA report template is shown in appendix D for stages 1, 2 and 3 and a stage 4 RSA report template is contained in appendix E.*

5.16.1 Interim RSA may be applied at stages 1, 2 and 3.

## Stage 1 road safety audit - Completion of preliminary design

5.17 Stage 1 RSA shall be undertaken at the completion of preliminary design, (for example at the order publication report stage) before publication of draft orders.

*NOTE The end of the preliminary design stage is often the last occasion at which land requirements can have the potential to be changed.*

5.17.1 Stage 1 RSA should include road safety matters which have a bearing upon land take, licence or easement before the draft orders are published or planning consent is applied for.

5.17.2 Where preliminary design is not undertaken, a stage 1 RSA may be combined with a stage 2 RSA at the detailed design stage.

5.18 The RSA team shall review the preliminary design information provided with the RSA brief.

*NOTE Aspects that typically form the focus of the stage 1 RSA are included as appendix B.*

5.19 Site visits shall be carried out in accordance with the requirements under section 5 road safety audit site visits.

## Stage 2 road safety audit - Completion of detailed design

5.20 Stage 2 RSA shall be undertaken at the completion of the detailed design stage.

*NOTE At stage 2, the RSA team focuses on the more detailed aspects of the highway scheme.*

5.21 The RSA team shall review the detailed design information provided with the RSA brief.

*NOTE Aspects that typically form the focus of the stage 2 RSA are included as appendix B.*

5.22 The stage 2 RSA shall include a review of the RSA actions in the stage 1 RSA response report.

5.23 RSA problems and recommendations relating to incomplete RSA actions in the stage 1 RSA shall be reiterated at the stage 2 RSA.

5.24 Site visits shall be carried out in accordance with the requirements under section 5 road safety audit site visits.

## Stage 3 road safety audit - Completion of construction

5.25 The stage 3 RSA shall be undertaken when the highway scheme construction is complete.

5.25.1 The stage 3 RSA should be undertaken before the scheme has opened to avoid the need for the RSA team to traverse the site when fully open to traffic.

5.25.2 Where the stage 3 RSA cannot be undertaken before opening, alternative arrangements should be agreed with the Overseeing Organisation.

*NOTE Alternative arrangements include the RSA being carried out a short time after opening or in phases where a scheme is subject to phased completion and opening.*

5.25.3 The RSA team leader should discuss any alterations recommended at the stage 3 RSA with the Overseeing Organisation to give the opportunity for modifications to be undertaken before opening.

*NOTE Early implementation of alterations recommended at the stage 3 RSA has the potential to provide a safer working environment for the workforce and minimise delays to road users.*

5.26 Stage 3 RSAs shall be carried out within 1 month of opening unless otherwise agreed with the Overseeing Organisation.

5.27 RSA problems and recommendations raised in the stage 1 and stage 2 RSA shall be reviewed at the stage 3 RSA and reiterated if the associated RSA actions are not complete.

5.28 The RSA team shall review the information provided with the RSA brief.

*NOTE Aspects that typically form the focus of the stage 3 RSA are included as appendix B.*

5.29 Site visits shall be carried out in accordance with the requirements under section 5 Road safety audit site visits.

5.29.1 Where there is an accessibility issue that restricts the RSA team from accessing areas of the site, reference to this should be included in the introduction of the RSA report.

*NOTE An example of an accessibility issue is an area of live motorway that cannot be accessed on foot.*

5.30 The RSA team shall examine the highway scheme from the viewpoints of all road users.

5.30.1 The RSA team may decide to drive, walk, cycle and/or ride a horse through the scheme to assist their evaluation.

5.31 The RSA team shall visit the site together in daylight and during the hours of darkness.

*NOTE The purpose of a site visit during darkness is to identify hazards specific to night time operation.*

## Stage 4 road safety audit - Post-opening monitoring

5.32 The Overseeing Organisation shall arrange for stage 4 RSA to be undertaken.

*NOTE The stage 4 RSA is an evidence-led review of road traffic collisions that have occurred in the vicinity of the highway scheme.*

5.33 Stage 4 RSA shall be carried out using 12 months of validated post highway scheme-opening road traffic collision data.

*NOTE 1* *Stage 4 RSAs are carried out so that any post highway scheme-opening road safety matters can be identified and remedial action taken.*

*NOTE 2* *The lag in availability of validated road traffic collision data means the RSA can occur later than 12 months from the opening of the highway scheme.*

*NOTE 3* *The availability of validated road traffic collision data varies depending on the individual Overseeing Organisation.*

5.34 A stage 4 RSA report shall be produced where road traffic collisions have been recorded in the vicinity of the highway scheme over the 12 month period of validated road traffic collision data.

*NOTE* *A stage 4 RSA report is not needed where no road traffic collisions have been recorded in the vicinity of the highway scheme over the 12 month period of post-opening validated road traffic collision data.*

5.35 If the Overseeing Organisation decides not to proceed further with the stage 4 RSA reporting, this decision shall be recorded, and kept on the highway scheme file (or equivalent).

5.36 Where a stage 4 RSA report is required, a RSA brief shall be prepared and issued to the RSA team by the Overseeing Organisation.

5.36.1 The production of the RSA brief may be delegated to the design organisation where they are retained post highway scheme completion.

5.36.2 Where there have been highway layout changes following the period the scheme first became operational, the stage 4 RSA brief should make reference to these changes.

5.36.3 Where operational data exists, this should be provided with the RSA brief to enable the RSA team to understand the implications of any road safety matters that have not resulted in reported collisions.

5.37 The stage 4 RSA report shall include any RSA problems indicated by the road traffic collision data analysis and operational data, and where necessary, include RSA recommendations for remedial action.

*NOTE* *A stage 4 RSA report template is provided in appendix E.*

5.38 During the stage 4 RSA, road traffic collision data shall be analysed in detail by the RSA team to identify:

1) higher than expected numbers of road traffic collisions that have occurred since the scheme became operational (when compared to control data);
2) locations at which road traffic collisions have occurred; and
3) road traffic collisions that appear to arise from similar causes or show common factors or trends.

5.38.1 The analysis of road traffic collision data should include identification of changes in the collision trends in terms of number, rate (taking account of any traffic flow changes), types and other collision variables, and comparisons with control data.

5.39 The RSA team shall visit the sites of highway schemes if characteristics within the road traffic collision data show:

1) higher than expected numbers of road traffic collisions have occurred since the scheme became operational (when compared to control data); or
2) the road traffic collision rate or severity has increased since the scheme became operational; or
3) common trends (e.g. a high frequency of road traffic collisions during the hours of darkness or on a wet road surface); or
4) road safety matters related to vulnerable road users.

5.39.1 Where a site visit is needed, the RSA team should decide if the road traffic collision data analysis justifies an inspection during a particular time period and record their decision making within the RSA report.

*NOTE* *A particular time period could be during the hours of darkness or a peak period.*

### Road safety audit site visits

5.40 Site visits shall be carried out by all members of the RSA team together.

5.41 Site visits shall be limited to a maximum of 6 people.

*NOTE Site visit numbers include the RSA team and any additional specialist advisors, police and maintaining agent representatives.*

5.42 Table 5.42 shall be used for determining site visit requirements for each RSA stage:

**Table 5.42 RSA site visit requirements**

| RSA stage | Visits | Attendees | Invitees |
|---|---|---|---|
| **Stage 1** | Daytime | RSA team | As determined by RSA team |
| **Stage 2** | Daytime | | |
| **Stage 3** | Daytime and darkness | | Police representative<br>Maintaining agent representative |
| **Stage 4** | As required by clause 5.39 (section 5, stage 4 road safety audit - post-opening monitoring) | RSA team | As determined by RSA team |

*NOTE Police and maintaining agent representation can be included at all stages of RSA if deemed beneficial and approved by the Overseeing Organisation.*

5.43 The RSA team shall determine the need to vary the time of the site visit to observe specific traffic conditions at all stages of RSA.

*NOTE Specific traffic conditions can include peak periods, the beginning or end of the school day or during frequent events.*

### Interim RSA

5.44 The Overseeing Organisation shall decide whether to undertake an interim RSA.

*NOTE 1 Interim RSA can provide the benefit of early identification of potential road safety problems leading to savings in both programme and design costs.*

*NOTE 2 Interim RSA is particularly beneficial to larger projects with accelerated programmes, such as highway schemes involving early contractor involvement.*

*NOTE 3 Interim RSA supplements the RSA at stages 1, 2 and 3.*

*NOTE 4 Interim RSA does not replace a particular stage of RSA.*

5.45 The RSA process for an interim RSA shall be completed in accordance with the requirements of the relevant RSA stage.

5.45.1 Interim RSA may be undertaken during the construction process with the agreement of the Overseeing Organisation.

5.45.2 Elements of the constructed scheme may be subjected to interim RSA, when works are partially complete or when individual elements or sections of the scheme are complete and opened to road users in stages.

### Third party organisation-led RSA

5.46 Where third party organisation-led schemes have the potential to result in highway schemes on the trunk road and motorway network, the process set out in this document shall be followed for all stages of RSA including appointment and approval of the RSA team.

*NOTE The highway scheme can be designed by an organisation working for the third-party organisation rather than an organisation working for the Overseeing Organisation.*

5.46.1 A stage 1 RSA report should be undertaken before planning consent is applied for as this demonstrates that the potential for road user safety issues has been addressed.

*NOTE The third party organisation-led scheme is submitted for planning approval to the local planning authority and, where there are highway implications, the highway or Overseeing Organisation is consulted.*

# 6. Certificate of competency curriculum

## Training and assessment

6.1 The curriculum core modules provided in appendix G shall be used to provide appropriate RSA certificate of competency training and assessment.

*NOTE 1 There are two routes through which a certificate of competency can be obtained – a portfolio of evidence route or a training route.*

*NOTE 2 Details of the two routes are also provided in appendix G.*

## Authorisation of certificate of competency

6.2 Organisations wishing to offer a certificate of competency shall have their assessment and certification processes reviewed and accepted in writing by the Highways England Safer Roads-Design team.

*NOTE Highways England's Safer Roads-Design team fulfils this role on behalf of the other Overseeing Organisations.*

6.3 Organisations offering a certificate of competency training course shall be independent of the candidate's employer.

6.4 Prior to the issue of a certificate of competency, organisations offering a training course shall assess the candidate's suitability as RSA team member and RSA team leader against the training, skills and experience guidance in section 3.

## Certificate of competency validity

6.5 The certificate of competency shall not have a finite validity period.

*NOTE It is not intended that holding a certificate of competency will require a mandatory membership of an organisation.*

## Certificates of competency awarded before implementation of EC Directive

6.6 Certificates of competency awarded before the implementation of the 2008/96/EC [Ref 1.N] shall be recognised.

6.6.1 Certificates of competency in RSA awarded in other European Union countries outside the UK may be acceptable.

# 7. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | 2008/96/EC, 'Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on road infrastructure safety management ' |
| Ref 2.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |
| Ref 3.N | The Stationery Office. TSM Chapter 8, 'Traffic Signs Manual Chapter 8 - Road works and temporary situations' |

# 8. Informative references

The following documents are informative references for this document and provide supporting information.

| | |
|---|---|
| Ref 1.I | The Stationery Office. Legislation.gov.uk. CM&CHA 2007, 'Corporate Manslaughter and Corporate Homicide Act (2007)' |
| Ref 2.I | The National Archives. legislation.gov.uk. Highways Act 1980, 'Highways Act 1980' |
| Ref 3.I | gov.uk. STATS19, 'Reported road casualties in Great Britain' |
| Ref 4.I | National Policing Improvement Agency. Association of Chief Police Officers. RDIM, 'Road Death Investigation Manual' |
| Ref 5.I | The National Archives. legislation.gov.uk. Road Traffic Act 1988, 'Road Traffic Act 1988' |
| Ref 6.I | The Stationery Office. Roads(S) 1984, 'Roads (Scotland) Act 1984' |
| Ref 7.I | Highways England. GG 142, 'Walking, cycling and horse-riding assessment and review' |

# Appendix A. Exemption file note template

## A1 Highway scheme details

Details of the highway scheme proposed for exemption from the road safety audit process are provided below.

**Table A.1 Highway scheme name, location and description**

| |
|---|
| |

## A2 Exemption statement

In accordance with GG 119 road safety audit I have examined the details of the above highway scheme.

For the reason/s set out below, the highway scheme is considered exempt from road safety audit as there is no impact on road user behaviour for all potential road users in this location and there will be no adverse changes to the outcome of a collision.

**Table A.2 Reasons for exemption**

| |
|---|
| |

## A3 Overseeing Organisation approval

The Overseeing Organisation approval for the exemption from the road safety audit process is provided below.

**Table A.3 Overseeing Organisation approval**

| | |
|---|---|
| Name: | |
| Role: | |
| Organisation: | |
| Signature: | |
| Date: | |

# Appendix B. Road safety audit checklists

Road safety audit checklists are outlined on the next page.

**Table B.1 LOCAL ALIGNMENT**

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Visibility** | | |
| Are horizontal and vertical alignments consistent with required visibility?<br>Will sight lines be obstructed by permanent or temporary features e.g. bridge abutments and parked vehicles? | Are sight lines obstructed by:<br>1. safety fences;<br>2. boundary fences;<br>3. street furniture;<br>4. parking facilities;<br>5. signs;<br>6.landscaping;<br>7.structures;<br>8.environmental barriers;<br>9.crests;<br>10.features such as buildings, plant or materials outside the highway boundary?<br>Is the forward visibility of at-grade crossings sufficient to ensure they are conspicuous? | Are the sight lines clear of obstruction? |
| **New/existing road interface** | | |
| Will the proposed scheme be consistent with the standard of provision on adjacent lengths of road and if not, is this made obvious to the road user?<br>Does interface occur near any potential hazard, i.e. crest, bend after steep gradient? | Where a new road scheme joins an existing road, or where an on-line improvement is to be constructed, will the transition give rise to potential hazards?<br>Where the road environment changes (e.g. urban to rural, restricted to unrestricted) is the transition made obvious by appropriate signing and carriageway markings? | Is there a need for additional signs and/or road markings? |
| **Vertical alignment** | | |
| Are climbing lanes to be provided?<br>Will the vertical alignment cause any "hidden dips"? | | |

**Table B.2 GENERAL**

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Departures from standards** | | |
| What are the road safety implications of any approved departures from standards or relaxations? (Are these strategic decisions within the scope of the RSA?) | Consider road safety aspects of any departures granted since the stage 1 RSA. | Are there any adverse road safety implications of any departures from standard granted since the stage 2 RSA? |
| **Cross sections and cross-sectional variation** | | |
| How safely do the cross-sections accommodate drainage, ducting, signing, fencing, lighting and pedestrian, cyclist and equestrian routes?<br><br>Could the scheme result in the provision of adverse camber?<br><br>What are the road safety implications if the standard of the proposed scheme differs from adjacent lengths of highway? | | |
| **Landscaping** | | |
| Could areas of landscaping conflict with sight lines (including during windy conditions)? | Could planting (new or when mature) encroach onto the carriageway or obscure signs or sight lines (including during windy conditions)?<br>Could earth bunds obscure signs or visibility?<br>Could trees (new or when mature) be a hazard to an errant vehicle?<br>Could planting affect lighting or shed leaves on to the carriageway? | Could planting obscure signs or sight lines (including during periods of windy weather)?<br>Do earth bunds obscure signs or visibility?<br>Could trees (new or when mature) be a potential hazard to an errant vehicle?<br>Could planting affect lighting or shed leaves onto the carriageway? |
| **Climatic conditions** | | |
| | Is there a need for specific provision to mitigate effects of fog, wind, sun glare, snow, and ice? | Are any extraordinary measures required? |

**Table B.2 GENERAL** (continued)

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Drainage** | | |
| Will the new road drain adequately, or could areas of excess surface water result?<br>Could excess surface water turn to ice during freezing conditions?<br>Could excessive water drain across the highway from adjacent land? | Do drainage facilities (e.g. gully spacing, gully locations, flat spots, crossfall, ditches) appear to be adequate?<br>Are features such as utility covers or gullies located within footpaths, cycle routes or equestrian routes?<br>Are features such as utility covers or gullies located in the likely wheel tracks for motorcyclists or cyclists?<br>Do they give concern for motorcyclist/cyclist stability?<br>Is surface water likely to drain across a carriageway and increase the risk of aquaplaning under storm conditions? | Does drainage of roads, cycle routes and footpaths appear adequate?<br>Are drainage features such as utility covers or gullies located within footpaths, cycle routes or equestrian routes?<br>Are features such as utility covers or gullies located in the likely wheel tracks for motorcyclists or cyclists?<br>Do they give concern for motorcyclist/cyclist stability? |
| **Lay-bys** | | |
| Has adequate provision been made for vehicles to stop off the carriageway including picnic areas?<br>How will parked vehicles affect sight lines?<br>Could lay-bys be confused with junctions?<br>Is the lay-by located in a safe location (e.g. away from vertical crests or tight horizontal alignments with limited visibility)? | Have lay-bys been positioned safely? Could parked vehicles obscure sight lines?<br>Are lay-bys adequately signed?<br>Are picnic areas properly segregated from vehicular traffic? | |

**Table B.2 GENERAL** (continued)

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Public utilities/services apparatus** | | |
| Could utility apparatus be struck by an errant vehicle?<br>Could utility apparatus obscure sight lines? | Can maintenance vehicles stop clear of traffic lanes? If so, could they obscure signs or sight lines?<br>Are boxes, pillars, posts and cabinets located in safe positions away from locations that may have a high potential of errant vehicle strikes?<br>Do they interfere with visibility?<br>Has sufficient clearance to overhead cables been provided?<br>Have any special accesses/parking areas been provided and are they safe?<br>Are there any utility inspection chambers in live traffic lanes and/or wheel tracks including those of motorcyclists or cyclists?<br>Do they give concern for motorcyclist/ cyclist stability? | Can maintenance vehicles stop clear of traffic lanes?<br>If so, could they obscure signs or sight lines?<br>Are boxes, pillars, posts and cabinets located in safe positions away from locations that may have a high potential for errant vehicle strikes?<br>Do they interfere with visibility?<br>Are any special accesses/parking areas provided safe?<br>Are there any utility inspection chambers in live traffic lanes and/or wheel tracks?<br>Has any loose material around utility covers or gullies located in the verge been compacted down and made level with the surrounding ground? |
| **Access** | | |
| Can all accesses be used safely?<br>Can multiple accesses be linked into one service road?<br>Are there any conflicts between turning and parked vehicles? | Is the visibility to/from accesses adequate?<br>Are the accesses of adequate length to ensure all vehicles clear the main carriageway?<br>Do all accesses appear safe for their intended use? | Is the visibility to/from accesses adequate?<br>Are the accesses of adequate length to ensure all vehicles clear the main carriageway? |
| **Skid resistance** | | |
| | Are there locations where high skid resistance surfacing (such as on approaches to junctions and crossings) would be beneficial?<br>Do surface changes occur at locations where they could adversely affect motorcycle stability?<br>Is the colour of any high friction surfacing appropriate? | Do any joints in the surfacing appear to have excessive bleeding or low skid resistance?<br>Do surface changes occur at locations where they could adversely affect motorcycle stability? |
| **Emergency vehicles** | | |
| Has provision been made for safe access and egress by emergency vehicles? | | |

**Table B.2 GENERAL** (continued)

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Future widening** | | |
| Where a single carriageway scheme is to form part of a future dual carriageway, is it clear to road users that the road is for two-way traffic? | | |
| **Agriculture** | | |
| | Have the needs of agricultural vehicles and plant been taken into consideration (e.g. room to stop between carriageway and gate, facilities for turning on dual carriageways)?<br>Are such facilities safe to use and are they adequately signed? | |
| **Fences and road restraint systems** | | |
| | Is there a need for road restraint systems to protect road users from signs, gantries, parapets, abutments, steep embankments or water hazards?<br>Do the road restraint systems provided give adequate protection?<br>Are the road restraint systems long enough?<br>Are specific restraint facilities required for motorcyclists?<br>In the case of wooden post and rail boundary fences, are the rails placed on the non-traffic side of the posts?<br>If there are roads on both sides of the fence is an interlocking-design necessary to prevent impalement on impact? | Is the restraint system adequate?<br>In the case of wooden post and rail boundary fences, are the rails placed on the non-traffic side of the posts?<br>Have specific restraint facilities been provided for motorcyclists? |

**Table B.2 GENERAL** (continued)

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| | **Adjacent development** | |
| Does adjacent development cause interference/ confusion? (e.g. lighting or traffic signals on adjacent roads may affect a road user's perception of the road ahead)<br>Is screening required to avoid headlamp glare between opposing carriageways, or any distraction to road users? | Has screening been provided to avoid headlamp glare between opposing carriageways, or any distraction to road users?<br>Are there any safety issues relating to the provision of environmental barriers or screens? | Have environmental barriers been provided and do they create a potential hazard? |
| | **Basic design principles** | |
| Are the overall design principles appropriate for the predicted level of use for all road users? | | |
| | **Bridge parapets** | |
| | Are parapet heights appropriate for the adjacent road user groups? | Is the projection of any attachment to the parapet likely to be struck by road users? |
| | **Network management** | |
| | | Have appropriate signs and/or markings been installed in respect of Traffic Regulation Orders? |
| | **Specific road users** | |
| Is specific provision required for vulnerable groups? (i.e. the young, older users, mobility and visually impaired, motorcyclists.) | Are gradients appropriate for mobility scooters?<br>Are timings at controlled crossings sufficient for all users?<br>Do surface changes or excessive use of carriageway markings occur at locations where they could adversely affect motorcycle stability?<br>Are specific restraint facilities required for motorcyclists?<br>Are features such as traffic calming, utility covers or gullies located in the likely wheel tracks for motorcyclists or cyclists?<br>Do they give concern for motorcyclist/cyclist stability? | Are the following adequate for specific and vulnerable groups?<br>1. visibility;<br>2. signs;<br>3. surfacing;<br>4. other guardrails;<br>5. drop kerbing/flush surfaces;<br>6. tactile paving;<br>7. gradients;<br>8. lighting levels;<br>9. restraint systems;<br>10. positioning of utility covers/gullies. |

Table B.3 JUNCTIONS

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Layout** | | |
| Is provision for right turning vehicles required?<br>Are acceleration/deceleration lanes required?<br>Are splitter islands required on minor arms to assist pedestrians or formalise road users' movements to/from the junction?<br>Are there any unusual features that affect road safety?<br>Are widths and swept paths adequate for all road users?<br>Will large vehicles overrun pedestrian or cycle facilities?<br>Are there any conflicts between turning and parked vehicles?<br>Are any junctions sited on a crest?<br>Is the junction type appropriate for the traffic flows and likely vehicle speeds? | Are the junctions and accesses adequate for all vehicular movements?<br>Are there any unusual features, which may have an adverse effect on road safety?<br>Have guardrails/safety fences been provided where appropriate?<br>Do any roadside features (e.g. guard rails, safety fences, traffic bollards signs and traffic signals) intrude into drivers' line of sight?<br>Are splitter islands and bollards required on minor arms to assist pedestrians or formalise road users' movements to/from the junction?<br>Are parking or stopping zones for buses, taxis and public utilities vehicles situated within the junction area?<br>Are they located outside visibility splays?<br>Are any utility covers or gullies located in the likely wheel tracks of motorcyclists or cyclists? | Have guard rails/safety fences been provided where appropriate?<br>Do any roadside features (e.g. guard rails, safety fences, traffic bollards signs and traffic signals) intrude into drivers' line of sight?<br>Have bollards been provided to assist pedestrians or formalise road user movements? |
| **Visibility** | | |
| Are sight lines adequate on and through junction approaches and from the minor arm?<br>Are visibility splays adequate and clear of obstructions such as street furniture and landscaping?<br>Will the use of deceleration or acceleration lanes obscure junction visibility? | Are the sight lines adequate at and through the junctions and from minor roads?<br>Are visibility splays clear of obstruction? | Are all visibility splays clear of obstructions? |
| **T, X, Y - junctions** | | |
| | Have ghost island right turn lanes and refuges been provided where required?<br>Do junctions have adequate stacking space for turning movements?<br>Can staggered crossroads accommodate all vehicle types and movements? | Are priorities clearly defined?<br>Is signing adequate? |

**Table B.3 JUNCTIONS** (continued)

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **All roundabouts** | | |
| | Are the deflection angles of approach roads adequate for the likely approach speed?<br>Are splitter islands necessary?<br>Is visibility on approach adequate to ensure drivers can perceive the correct path through the junction?<br>Where chevron signs are required, have they been correctly sited?<br>Are dedicated approach lanes required? If provided, will the road markings and signs be clear to all users?<br>Are any utility covers or gullies located in the likely wheel tracks of motorcyclists or cyclists? | Can the junction be seen from appropriate distances and is the signing adequate?<br>Where chevron signs are required, have they been correctly sited? |
| **Mini roundabouts** | | |
| | Are the approach speeds for each arm likely to be appropriate for a mini roundabout?<br>Is the centre island visible from all approaches? | |

**Table B.3 JUNCTIONS** (continued)

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Traffic signals** | | |
| | Will speed discrimination equipment be required?<br>Is the advance signing adequate?<br>Are signals clearly visible in relation to the likely approach speeds? Is "see through" likely to be a problem?<br>Would lantern filters assist?<br>Is the visibility of signals likely to be affected by sunrise/sunset?<br>Would high intensity signals and/or backing boards improve visibility?<br>Would high-level signal units be of value? Is the stopline in the correct location?<br>Are any pedestrian crossings excessively long?<br>Are the proposed tactile paving layouts correct?<br>Are the markings for right turning vehicles adequate?<br>Is there a need for box junction markings?<br>Is the phasing appropriate?<br>Will pedestrian/ cyclist phases be needed?<br>Does the number of exit lanes equal the number of approach lanes?<br>If not is the taper length adequate?Is the required junction intervisibility provided? | Can the traffic signals be seen from appropriate distances?<br>Can drivers see traffic signal heads for opposing traffic?<br>For the operation of signals: Are the signal phases working correctly, are unnecessary delays being created?<br>Do pedestrian and cycle phases give adequate crossing time?<br>Can pedestrians or cyclists mistakenly view the "green man" signal for other pedestrian or cycle phases? |

**Table B.4 WALKING, CYCLING AND HORSE RIDING**

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Adjacent land** | | |
| Will the scheme have an adverse effect on safe use of adjacent land? | Are accesses to and from adjacent land/properties safe to use?<br>Has adjacent land been suitably fenced? | Has suitable fencing been provided? |
| **Pedestrians** | | |
| Have pedestrian routes been provided where required?<br>Do shared facilities take account of the needs of all user groups?<br>Can verge strips dividing footways/cycleways and carriageways be provided?<br>Where footpaths have been diverted, will the new alignment permit the same users free access?<br>Are footbridges/subways sited to attract maximum use?<br>Is specific provision required for special and vulnerable groups? (i.e. the young, older users, mobility and visually impaired?)<br>Are tactile paving, flush kerbs and guard railing proposed? Is it specified correctly and in the best location?<br>Have all walking needs been considered, especially at junctions?<br>Are these routes clear of obstructions such as signposts, lamp columns etc.? | Have the needs of pedestrians been considered especially at junctions and roundabouts?<br>Are any proposed drop kerbs flush with the adjacent highway?<br>Is tactile paving proposed?<br>Is it specified correctly and in the best location? | Are the following adequate?:<br>1. visibility;<br>2. signs;<br>3. surfacing;<br>4. other guardrails;<br>5. drop kerbing or flush surfaces;<br>6. tactile paving |

**Table B.4 WALKING, CYCLING AND HORSE RIDING** (continued)

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Cyclists** | | |
| Have cycle routes been provided where required?<br>Do shared facilities take account of the needs of all user groups?<br>Can verge strips dividing footways/cycleways and carriageways be provided?<br>Is specific provision required for special and vulnerable groups? (i.e. the young, older users, mobility impaired?)<br>Have all cycling needs been considered, especially at junctions?<br>Are these routes clear of obstructions such as signposts, lamp columns etc.? | Have the needs of cyclists been considered especially at junctions and roundabouts?<br>Are cycle lanes or segregated cycle tracks required?<br>Does the signing make clear the intended use of such facilities?<br>Are cycle crossings adequately signed?<br>Has lighting been provided on cycle routes?<br>Are any proposed drop kerbs flush with the adjacent highway?<br>Are any parapet heights sufficient?<br>Is tactile paving proposed?<br>Is it specified correctly and in the best location? | Do the following provide sufficient levels of road safety for cyclists on, or crossing the road?<br>1. visibility;<br>2. signs;<br>3. guardrails;<br>4. drop kerbing or flush surfaces;<br>5. surfacing;<br>6. tactile paving. |
| **Equestrians** | | |
| Have equestrian needs been considered?<br>Does the scheme involve the diversion of bridleways? | Should bridleways or shared facilities be provided?<br>Does the signing make clear the intended use of such paths and is sufficient local signing provided to attract users?<br>Have suitable parapets/rails been provided where necessary? | Do the following provide sufficient levels of road safety for equestrians?<br>1) visibility;<br>2) signs;<br>3) guardrails. |

**Table B.5 TRAFFIC SIGNS, CARRIAGEWAY MARKINGS AND LIGHTING**

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| | **Signs** | |
| Is there likely to be sufficient highway land to provide the traffic signs required?<br>Are sign gantries needed?<br>Have traffic signs been located away from locations where there is a high strike risk? | Do destinations shown align with signing policy?<br>Are signs easy to understand?<br>Are the signs located behind safety fencing and out of the way of pedestrians and cyclists?<br>Is there a need for overhead signs?<br>Where overhead signs are necessary is there sufficient headroom to enable designated walking, cycling and horse riding usage?<br>Has sign clutter been considered?<br>Is junction signing adequate, consistent with adjacent signing and easily understood?<br>Have the appropriate warning signs been provided?<br>Are signs appropriately located and of the appropriate size for approach speeds?<br>Are sign posts and sign structures passively safe or protected by safety barriers where appropriate?<br>Are traffic signs illuminated where required and the correct reflectivity provided?<br>Are traffic signs located in positions that minimise potential strike risk?<br>Is the mounting height of sign faces appropriate?<br>Are traffic signs orientated correctly to ensure correct visibility and reflectivity? | Are the visibility, locations and legibility of all signs (during daylight and darkness) adequate?<br>Are signposts protected from vehicle impact or passively safe?<br>Will signposts impede the safe and convenient passage of pedestrians and cyclists?<br>Have additional warning signs been provided where necessary? |
| | **Variable message signs (VMS)** | |
| | Are the legends relevant and easily understood?<br>Are signs passively safe or located behind safety fencing? | Can VMS be read and easily understood at distances appropriate for vehicle speeds?<br>Are they adequately protected from vehicle impact or passively safe? |

**Table B.5 TRAFFIC SIGNS, CARRIAGEWAY MARKINGS AND LIGHTING** (continued)

| Stage 1 | Stage 2 | Stage 3 |
|---|---|---|
| **Lighting** | | |
| Is the scheme to be street lit?<br>Has lighting been considered at new junctions and where adjoining existing roads?<br>Are lighting columns located in the best positions? (e.g. behind safety fences) | Has lighting been considered at new junctions and where adjoining existing roads?<br>Is there a need for lighting, including lighting of signs and bollards?<br>Are lighting columns passively safe?<br>Are lighting columns located in the best positions e.g. behind safety fences and not obstructing walking, cycling and horse riding routes? | Does the street lighting provide adequate illumination of roadside features, road markings and non-vehicular users to drivers?<br>Is the level of illumination adequate for the road safety of walkers, cyclists and horse riders?<br>Is lighting obscured by vegetation or other street furniture? |
| **Poles/columns** | | |
| Will poles/columns be appropriately located and protected? | Are poles and columns passively safe?<br>Are poles and columns protected by safety fencing where appropriate? | |
| **Carriageway markings** | | |
| Are any road markings proposed at this stage appropriate? | Do the carriageway markings clearly define routes/priorities?<br>Are the dimensions of the road markings appropriate for the speed limit/design speed of the road?<br>Have old road markings and road studs been adequately removed?<br>Are road markings appropriate to the location?<br>1. centre and edge lines;<br>2. hatching;<br>3. road studs;<br>4. text/destinations;<br>5. approved and/or conform to the Regulations. | Are all road markings/studs clear and appropriate for their location?<br>Have all superseded road markings and studs been removed adequately?<br>Do the carriageway markings clearly define routes and priorities?<br>Have all superseded road markings and studs been removed adequately? |

# Appendix C. Road safety audit brief template

**Table C.1 Project Summary**

| | |
|---|---|
| **Date:** | Insert date |
| **Document reference:** | Insert unique document reference |
| **Prepared by:** | Insert design organisation |
| **On behalf of:** | Insert Overseeing Organisation |
| **AUTHORISATION SHEET** | |
| **Project:** | Insert highway scheme name |
| **Report title:** | Include RSA stage |
| **PREPARED BY:** | |
| **Name:** | Insert author of brief |
| **Signed:** | |
| **Organisation:** | Insert design organisation |
| **Date:** | Insert date |
| **I APPROVE THE RSA BRIEF AND INSTRUCT THE RSA TO TAKE PLACE ON BEHALF OF THE OVERSEEING ORGANISATION:** | |
| **Name:** | |
| **Signed:** | |
| **Organisation:** | Insert Overseeing Organisation |
| **Date:** | |

**Table C.2 General Details**

<table>
<tr><td colspan="6">General details</td></tr>
<tr><td colspan="3">Highway scheme name and road number:</td><td colspan="3">Insert scheme title and road number/name</td></tr>
<tr><td>Type of scheme:</td><td colspan="5">e.g. new road scheme, smart motorway, junction improvement, traffic signs and road markings improvement, traffic calming scheme, etc.</td></tr>
<tr><td colspan="2" rowspan="2">RSA stage tick as appropriate.</td><td>1</td><td>2</td><td>3</td><td rowspan="2">4</td></tr>
<tr><td colspan="3">Interim</td></tr>
<tr><td colspan="3">Overseeing Organisation details</td><td colspan="3">Design organisation details</td></tr>
<tr><td colspan="3">Insert details</td><td colspan="3">Insert details</td></tr>
<tr><td colspan="3">Police contact details</td><td colspan="3">Maintaining agent contact details</td></tr>
<tr><td colspan="3">(Required for stage 3 RSAs)</td><td colspan="3">Insert details</td></tr>
<tr><td colspan="6">RSA team membership</td></tr>
<tr><td colspan="6">Insert details of the approved RSA team and any specialist advisors and observers where appropriate.</td></tr>
<tr><td colspan="6">Terms of reference</td></tr>
<tr><td colspan="6">Make reference to relevant DMRB documents and other guidance where appropriate.</td></tr>
</table>

**Table C.3 Scheme Details**

| |
|---|
| **Scheme description/objective** |
| **General** |
| Define the extents of the RSA, include a brief scheme description, the scheme objectives, a start date for construction if known and a completion date.<br>In addition, for stage 4 RSAs, confirm when all related traffic management has been removed. |
| **Design standards applied to the scheme design** |
| For example, DMRB. |
| **Design speeds** |
| Provide details of applied and/or existing design speeds. |
| **Speed limits** |
| State whether mandatory or advisory, available speed data. |
| **Existing traffic flows/queues** |
| To include current automatic traffic counter (ATC) data, up-to-date turning count and queue information etc. |
| **Forecast traffic flows** |
| Where available and relevant, provide future traffic flow data including vehicle proportions. |
| **Pedestrian, cyclist and equestrian desire lines** |
| Include details of pedestrian, cyclist and equestrian movements in the vicinity of the scheme and, when applicable the relevant walking, cycling and horse riding assessment and review reports GG 142 [Ref 7.I] |
| **Environmental constraints** |
| Include all environmental constraints within the scheme extents, for example sites of special scientific interest (SSSI), conservation areas, listed properties etc. |

**Table C.4 Locality**

| |
|---|
| **Description of locality** |
| Include all environmental constraints within the scheme extents, for example sites of special scientific interest (SSSI), conservation areas, listed properties etc. |
| **General description** |
| Include road network, road type, relevant land uses etc. |
| **Relevant factors which may affect road safety** |
| Factors known to the design organisation and considered as part of the design. This should also include anything that would not be immediately obvious to the RSA team – such as school crossing patrols and large events, for example. |

**Table C.5 Analysis**

| |
|---|
| **Collision data analysis** |
| At stages 1, 2, and 3 provide a summary of road traffic collision data covering both the extent of the scheme and the adjoining sections of highway.<br>As a minimum the most recent 36 months of data.<br>At stage 4, provide 12 months of post-opening validated road traffic collision data.<br>Raw data should be provided as an appendix. |
| **Departures from standards** |
| Include status details, i.e. approved/pending/rejected, and any design strategy records produced for improvements to existing trunk roads and motorways. |
| **Previous road safety audit stage reports, road safety audit response reports and evidence of agreed actions** |
| Attach previous reports to the RSA brief, or provide an explanation where these are not available. |
| **Strategic decisions** |
| Includes items outside the scope of this RSA which will not change irrespective of the RSA, for example route choice, junction type, approved departures from standard. |
| **List of included documents and drawings** |
| **Documents** |
| **Reference and revision................. Title.................... Date...........** |
| For example: previous RSA reports; design responses; departures; road traffic collision data; walking, cycling and horse riding assessment and reviews. This could include any relevant operational data such as damage-only collision data or incident logs.<br>This list could be included as an attachment to the RSA brief or a hyperlink to a shared electronic location where the RSA brief information has been collated. |
| **Drawings** |
| **Drawing no. and revision................... Title.......................** |
| This list could be included as an attachment to the RSA brief or a hyperlink to a shared electronic location where the RSA brief information has been collated. |

**Table C.6 Checklist**

| **Tick all that are included and provide reasons for those that are not included** | | | |
|---|---|---|---|
| Site location plan | | Scale layout plans | |
| Departures and relaxations from standards | | Construction/ typical details | |
| Previous RSA reports | | Previous RSA response reports and evidence of agreed actions | |
| Collision data and collision data analysis | | Road traffic collision plot | |
| Traffic signal staging | | Traffic counts | |
| Speed surveys | | Pedestrian, cyclist and horse riding desire lines and volumes | |
| Walking, cycling and horse riding assessment and reviews | | Items outside the scope of the RSA/ strategic decisions | |
| Other factors that may impact on road safety | | Design speeds/ speed limits | |
| Design standards used | | Adjacent land uses | |

# Appendix D. Stages 1, 2 and 3 Road safety audit report template

## D1 Project details

Provide:

**Table D.1 Project details**

| | |
|---|---|
| **Report title:** | Include stage of RSA |
| **Date:** | Insert date |
| **Document reference and revision:** | Insert unique document reference |
| **Prepared by:** | Insert RSA team organisation |
| **On behalf of** | Insert Overseeing Organisation |

## D2 Introduction

Provide:

1) a description of the proposed highway scheme including details of its location and its objectives. Make reference to any strategic decisions and confirm that any recommendations to make significant changes in relation to these elements are unlikely to be acceptable.
2) details of who supplied the RSA brief, who approved the RSA brief and who approved the RSA team.
3) identification of the RSA team membership as well as the names of other contributors such as the police, maintaining agent and specialist advisors.
4) details of who attended the site visit, the date, time periods when the audit was undertaken and the weather/traffic conditions on the day of the visit. Include the state of completion of the works at the stage 3 RSA.
5) the terms of reference of the RSA confirmation and that the RSA team has examined and reported only on the road safety implications of the scheme as presented and has not examined or verified the compliance of the designs to any other criteria.

## D3 Items raised at previous road safety audits

Report any of the RSA actions in the RSA response report for the previous stage that have been agreed for action but not completed. Where the RSA action is not completed, or an RSA response report is not provided, outstanding problems and recommendations will be repeated here.

Where the circumstances have changed it may be necessary to revise the earlier problem and recommendation and this will be included only in section 4.

## D4 Items raised at this road safety audit

Complete the information below. This does not have to be in the form of a table.

**Table D.2 Items raised at this road safety audit**

| **PROBLEM** | |
|---|---|
| **Location:** | Insert the location of the problem and reference to a scheme drawing. |
| **Summary:** | Provide a short summary of the problem. |
| Describe the nature of the problem supported by background reasoning and include the type of collisions and/or road user injuries likely to occur. | |
| **RECOMMENDATION** | |
| Provide a proportionate and viable recommendation, based on the RSA stage, to eliminate or mitigate the identified RSA problem. | |

## D5 Audit team statement

Include the following statement to be signed by the RSA team leader and RSA team member(s):

**Table D.3 Audit team statement**

| **We certify that this road safety audit has been carried out in accordance with GG 119.** | |
|---|---|
| **ROAD SAFETY AUDIT TEAM LEADER** | |
| Name: | |
| Signed: | |
| Position: | |
| Organisation: | |
| Date: | |
| **ROAD SAFETY AUDIT TEAM MEMBER(S)** | |
| Name: | |
| Signed: | |
| Position: | |
| Organisation: | |
| Date: | |

## D6 Problem location plan

Insert as an appendix to the RSA report.

# Appendix E. Stage 4 Road safety audit report template

## E1 Project details

Provide:

**Table E.1 Project details**

| | |
|---|---|
| **Report title** | Stage 4 RSA report |
| **Date** | Insert date |
| **Document reference and revision:** | Insert unique document reference |
| **Prepared by:** | On behalf of: Insert RSA team organisation |
| **On behalf of:** | On behalf of: Insert Overseeing Organisation |

## E2 Introduction

Provide a brief description of the highway scheme including details of its location and its objectives.

Include details of who supplied the RSA brief, who approved the RSA brief and who approved the RSA team.

Identification of the RSA team membership as well as the names of other contributors.

Details of who attended the site visit, the date, time periods when the audit was undertaken and the weather/traffic conditions on the day of the visit.

## E3 Scheme details

Provide details of the highway scheme, its location and when it was completed.

Clarify the dates of previous RSAs.

## E4 Collision data analysis

Analyse the road traffic collisions recorded since the scheme became operational using 12 months of validated post-scheme opening data.

Compare the road traffic collision data with relevant control data.

Identify any post-opening road traffic collision problems.

## E5 Items raised at stage 3 road safety audit

Report any of the RSA actions in the RSA response report for the previous stage that have not been completed. Where the RSA action is not completed, or an RSA response report is not provided, outstanding problems and recommendations will be repeated here.

Where collisions have occurred related to previous problems, regardless of the RSA response report, a revised problem and recommendation will be included in section 6.

## E6 Items raised at this stage 4 road safety audit

In this section identify any road safety audit problems indicated by the collision data analysis and provide road safety audit recommendations for remedial action where appropriate. This does not have to be in the form of a table.

**Table E.2 Items raised at this stage 4 road safety audit**

| **PROBLEM** | |
|---|---|
| **Location:** | Insert the location of the problem and reference to a scheme drawing |
| **Summary:** | Provide a short summary of the problem |
| Describe the nature of the problem supported by background reasoning and include the type of collisions or road user injuries that have occurred | |
| **RECOMMENDATION** | |
| Provide a proportionate and viable recommendation to eliminate or mitigate the identified RSA problem. This could include recommendations to provide further monitoring where insufficient information can be gathered from the available data. | |

## E7 Audit team statement

Include the following statement to be signed by the RSA team leader and RSA team member(s):

**Table E.3 Audit team statement**

| **We certify that this road safety audit has been carried out in accordance with GG 119.** | |
|---|---|
| **ROAD SAFETY AUDIT TEAM LEADER** | |
| Name: | |
| Signed: | |
| Position: | |
| Organisation: | |
| Date: | |
| **ROAD SAFETY AUDIT TEAM MEMBER(S)** | |
| Name: | |
| Signed: | |
| Position: | |
| Organisation: | |
| Date: | |

## E8 Problem location plan

Insert as an appendix to the report.

# Appendix F. Road safety audit response report template for stages 1, 2 and 3 only

## F1 Project details

Provide:

**Table F.1 Project details**

| | |
|---|---|
| **Report title:** | Include stage of RSA |
| **Date:** | Insert date |
| **Document reference and revision:** | Insert unique document reference |
| **Prepared by:** | Insert design organisation |
| **On behalf of:** | Insert Overseeing Organisation |

**Table F.2 Authorisation sheet**

| | |
|---|---|
| **Project:** | |
| **Report title:** | |
| **Prepared by:** | |
| Name: | |
| Position: | |
| Signed: | |
| Organisation: | |
| Date: | |
| **Approved by:** | |
| Name: | |
| Position: | |
| Signed: | |
| Organisation: | |
| Date: | |

## F2 Introduction

Include a summary of the scheme, the stage of the RSA and the date or reference of the RSA report it relates to.

Provide details of the representatives from the design organisation who prepared the RSA response report.

## F3 Key personnel

Provide:

**Table F.3 Key personnel**

| | |
|---|---|
| **Overseeing Organisation:** | Insert details of the personnel from the Overseeing Organisation |
| **RSA team:** | Insert details of the personnel from the RSA team |
| **Design organisation:** | Insert details of the design organisation |

## F4 Road safety audit decision log

Insert RSA decision log. This can be a spreadsheet appended to the RSA response report.

**Table F.4 Road safety audit decision log**

| RSA problem | RSA recommendation | Design organisation response | Overseeing Organisation response | Agreed RSA action |
|---|---|---|---|---|
| Insert the original problem from the RSA report. | Insert the original recommendation from the RSA report. | Insert the design organisation's response. | Insert the Overseeing Organisation's response. | Insert the design organisation's and the Overseeing Organisation's agreed action to the problem. |

## F5 Design organisation and Overseeing Organisation statements

Include the following statements to be signed by the design organisation and the Overseeing Organisation.

**Table F.5 Design organisation statement**

| **On behalf of the design organisation I certify that:**<br><br>**1) the RSA actions identified in response to the road safety audit problems in this road safety audit have been discussed and agreed with the Overseeing Organisation.** | |
|---|---|
| Name: | |
| Signed | |
| Position: | |
| Organisation: | |
| Date: | |

**Table F.6 Overseeing Organisation statement**

| **On behalf of the Overseeing Organisation I certify that:**<br><br>**1) the RSA actions identified in response to the road safety audit problems in this road safety audit have been discussed and agreed with the design organisation; and**<br>**2) the agreed RSA actions will be progressed.** | |
|---|---|
| Name: | |
| Signed: | |
| Position: | |
| Organisation: | |
| Date: | |

# Appendix G. Routes to obtaining a certificate of competency and outline training curriculum

## G1 Training routes

Table 1 summarises the two routes by which a certificate of competency in road safety audit is obtained; the portfolio of evidence route and the training route. It is envisaged that a training course covering the core modules in the training curriculum in table 2 will be of the order of two days duration.

**Table G.1 Routes to obtaining a Certificate of Competency**

| Portfolio of evidence route | Training course route |
|---|---|
| Evidence to be included in the portfolio:<br><br>Details of how the candidate meets the RSA team training, skills and experience guidance contained in section 3 of this document.<br><br>Example RSA reports with details of the candidate's contribution to the road safety audit process and production of the road safety audit reports.<br><br>A witness statement from an appropriate person vouching for the content of the candidate's portfolio submission and that the candidate has an acceptable level of understanding of the core modules identified in this appendix. The witness to hold a recognised qualification in the field of road safety, civil engineering or transportation planning or hold a senior professional position within a relevant company or organisation.<br><br>The portfolio of evidence is signed by the candidate and submitted to an independent professional organisation or company who have had their certification process accepted by Highways England on behalf of all the Overseeing Organisations. This professional organisation or company is responsible for reviewing candidate's submissions and, where appropriate, issuing the Certificate of Competency in road safety audit. | Prior to completion of the training course and issue of a certificate of competency, the candidate submits the following to the training provider:<br><br>Details of how the candidate meets the RSA team training, skills and experience guidance contained in section 3 of this document.<br><br>Example RSA reports with details of the candidate's contribution to the road safety audit process and production of the road safety audit reports.<br><br>A witness statement, from an appropriate person which vouches for the content of the above submissions. This witness to hold a recognised qualification in the field of road safety, civil engineering or transportation planning or hold a senior professional position within a relevant company or organisation.<br><br>The course provider assesses the candidates regarding their understanding of the content of the training course and verifies the evidence submitted.<br><br>Where a candidate has demonstrated to the training provider that they meet the training, skills and experience guidance and understood the content of the training course, the training provider is responsible for issuing the certificate of competency in RSA. |

## G2 Core modules

Table 2 summarises the core modules to be included in the training curriculum.

**Table G.2 Core modules of training curriculum**

| Core module | | Example module content |
|---|---|---|
| 1 | Road safety legal issues, legislation and policy | Review of the reasons why RSA is undertaken, in terms of the 1980 Highways Act Highways Act 1980 [Ref 2.I];<br>1988 Road Traffic Act Road Traffic Act 1988 [Ref 5.I]; and<br>Roads (Scotland) Act 1984 Roads(S) 1984 [Ref 6.I] where appropriate.<br><br>Introduction to the 2007 Road Death Investigation Manual RDIM [Ref 4.I]<br>The Corporate Manslaughter and Corporate Homicide Act 2007 CM&CHA 2007 [Ref 1.I]<br><br>The 2008/96/EC [Ref 1.N]<br><br>The Manslaughter by Gross Negligence Common Law<br><br>Road safety policies, targets and strategies |
| 2 | Collision investigation focused on the strategic road network or comparable roads | Understanding and applying collision investigation techniques.<br><br>Update on any developments in collision trends. |
| 3 | Road safety audit | Improvement and clarification of known potential issues, focused on the strategic road network or comparable roads, to cover:<br><br>Roles and responsibilities<br><br>RSA administration and practice RSA reporting |

**Table G.2 Core modules of training curriculum** (continued)

| Core module | | Example module content |
|---|---|---|
| 4 | Road safety engineering/ road design | This module includes development in road safety engineering and its influence on road design, with focus on the trunk road and motorway network.<br><br>The 2008/96/EC [Ref 1.N] specifically requires training or experience in road design. Road safety auditors should have an understanding of the Design Manual for Roads and Bridges (DMRB) design standards, and how good design principles reduce collision risk. The module could include the following:<br><br>Road/junction geometry and design:<br>1) Design speed;<br>2) Horizontal and vertical alignment, including cross sections, drainage, stopping sight distances and adverse camber;<br>3) Appropriateness of junction type;<br>4) Visibility;<br>5) Road surfaces, including the use of high friction surfacing.<br><br>Roadside features:<br>1) Passive infrastructure;<br>2) Road restraint systems and guard railing;<br>3) Landscaping;<br>4) Highway lighting.<br><br>Facilities for vulnerable road users:<br>1) Pedestrian/cycling/equestrian facilities;<br>2) Mobility and visually impaired;<br>3) Motorcyclists. |