Design Manual for Roads and Bridges

Road Layout
Design

CD 122
Geometric design of grade separated junctions

(formerly TD 22/06, TD 39/94, TD 40/94)

Version 1.1.1

Summary
This document provides requirements for the geometric design of grade separated junctions.

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 122	1.1.**1**	January 2022	Core document	Incremental change to notes and editorial updates
Minor editorial changes to correct alignments in Tables 3.21 and 3.32				

Previous versions

Document code	Version number	Date of publication of relevant change	Changes made to	Type of change
CD 122	1.**1**.0	November 2021	Core document, England NAA	Incremental change to requirements
CD 122	1	January 2020		
CD 122	0	August 2019		

Foreword

Publishing information

This document is published by National Highways.

This document supersedes TD 22/06 and TD 39/94. In combination with CD 123 [Ref 2.N] , this document also supersedes TD 40/94.

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 provides requirements and advice on the geometrical design of grade separated junctions. It merges and rationalises the content of TD 22/06 and TD 39/94 and incorporates the connector road elements of compact grade separated junctions, which were previously covered by TD 40/94.

With the incorporation of the requirements and advice of TD 39/94, this document covers the geometrical design of grade separated junctions with up to three lanes joining or leaving the mainline.

Notable changes from the previous documents listed above include:

1) merge layout referencing has been updated to better reflect the progression in capacity provision through the types; for example Layout D in TD 22/06 is now Layout A Option 2 in this document. The associated flow diagram references have therefore been updated to reflect this;
2) 3-lane merge and diverge layouts from TD 39/94 have been reviewed and amended to ensure that only those layouts that reflect the safe design ethos of the more contemporary TD 22/06 are included;
3) merge and diverge datum points that were originally included only in Interim Advice Note 149/17 for existing motorways have been included; and,
4) simplification of the curve widening requirements and advice relating to compact connector roads.

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
AADT	Annual average daily traffic
HGV	Heavy goods vehicle
kph	Kilometres per hour (km/h)
SSD	Stopping sight distance
vph	Vehicles per hour

Terms and definitions

Terms

Term	Definition
Auxiliary lane	an additional lane parallel to the mainline carriageway to provide increased merge or diverge opportunity or additional space for weaving traffic
Compact connector road	a two-way connector road between a major and a minor road designed as part of a compact grade separated junction
Compact grade separated junction	a grade separated junction designed with a two-way unsegregated link road between the major and minor road. The connector road joins the major road via a priority junction designed to CD 123 [Ref 2.N] .
Connector road	a collective term for interchange links, link roads, slip roads and loops designed as part of a full grade separated junction. A connector road starts/ends at the back of a diverge/merge nose.
Datum points	defined points at merges and diverges used for the purposes of locating features such as signs and signals and measuring weaving lengths
Direct access	a connection to an all-purpose trunk road providing access to only one of the following, which does not provide a through route: 1) a single dwelling; 2) a single field; 3) a single use public utilities site (such as an electric substation) where access is needed for maintenance of that specific site only; or, 4) a single use highway maintenance site (such as an attenuation pond) where access is needed for maintenance of that specific site only
Downstream	that part of the carriageway(s) where the traffic is flowing away from the section in question
Fork	an at-grade junction of two roads, usually within an interchange, which diverge from the approach road at similar angles NOTE: Usually both diverging roads have equal status.
Full grade separated junction	a grade separated junction designed with free-flowing merges and/or diverges in accordance with this document
Ghost island	an area of the carriageway marked to separate lanes of traffic travelling in the same direction on merge and diverge layouts NOTE 1: The purpose of the ghost island at a merge is to separate the points of entry of two slip road traffic lanes. NOTE 2: The purpose of the ghost island at a diverge is to separate the points of exit to a slip road.
Grade separated junction	A grade separated junction has at least two carriageway links at different levels, and usually involves the provision of a structure to accommodate carriageways crossing.

Terms (continued)

Term	Definition
Interchange	a grade separated junction that provides free flow from one mainline to another
Interchange link	a connector road carrying free-flowing traffic within an interchange between one level and/or direction and another
Intrajunction	the section of mainline within a junction, between a diverge and merge.
Lane drop	a layout where a lane or lanes of the upstream carriageway becomes a lane or lanes of the diverging connector road
Lane gain	a layout where a lane or lanes of the merging connector road becomes a lane or lanes of the mainline carriageway
Link road	In the context of junctions, a link road is one-way connector road adjacent to but separate from the mainline carriageway carrying traffic in the same direction. It is used to connect the mainline carriageway to the local highway network where successive direct connections cannot be provided to an adequate standard because the junction spacing is too close.
Loop	a connector road, one- or two-way that is made up of the elements of the loops shown in Figure 5.10N (this document) and which passes through an angle in the range of approximately 180 to 270 degrees NOTE: The loop is considered to extend to the end of the near straight length of road contiguous with the back of the diverge or merge nose.
Mainline	the major route within a junction that typically is a higher road classification and/or carries greater traffic volumes
Near straight	a length of connector road with a radius no less than the desirable minimum radius with superelevation of 5% as detailed in CD 109 [Ref 3.N] for the mainline design speed
Nose	a paved area, approximately triangular in shape, situated between merging or diverging lanes and the mainline. The nose includes hatched road markings to discourage drivers from crossing it.
Nose ratio	Nose ratio is the ratio of the back of nose width and the nose length.
Parallel merge/diverge	a merge or diverge layout where an auxiliary lane is provided alongside the mainline carriageway
Priority junction	a junction controlled by a 'Give Way' or 'Stop' arrangement. NOTE 1: Stop arrangements are only used where there are severe visibility restrictions. NOTE 2: Direct accesses can operate in a similar manner but are not classed as priority junctions. NOTE 3: A priority junction can include a merge taper where the formal 'Give Way' road marking is replaced by an edge of carriageway road marking.

Terms (continued)

Term	Definition
Rural road	an all-purpose road or motorway that is generally not subjected to a local speed limit
Slip road	a connector road between a mainline carriageway and another road NOTE: At the end of a slip road, traffic usually encounters a priority junction, a roundabout or traffic signals.
Stopping sight distance	as defined in CD 109 [Ref 3.N]
Taper merge / diverge	a merge or diverge layout where merging or diverging traffic joins or leaves the mainline carriageway through an area forming a funnel to or flare from the mainline carriageway
Through route	a road that is for public use, which provides a connection to the wider road network NOTE: A road that does not form part of a through route requires a road user to access and leave a site through the same junction.
Transition curves	Transition curves have a changing radius to provide a smooth transition between two different radius curves, or a curve and a straight.
Upstream	that part of the carriageway(s) where traffic is flowing towards the section in question
Urban road - motorway	a motorway with a speed limit of 60 mph or less within a built--up area.
Urban road - all-purpose roads	an all-purpose road within a built-up area, either a single carriageway with a speed limit of 40 mph or less, or a dual carriageway with a speed limit of 60 mph or less
Weaving section	the length of the carriageway between a successive merge or lane gain and diverge or lane drop, where vehicles leaving the mainline at the diverge or lane drop have to cross the paths of vehicles that have joined the mainline at the merge or lane gain
Weaving section lanes calculation	The weaving section lanes calculations determine the requirements for overall carriageway width based on the traffic flows and the length of the weaving section.

1. Scope

Aspects covered

1.1 This document shall be used for the geometric design of grade separated junctions, including merges, diverges, forks and connector roads.

NOTE 1 *This document is applicable to both new and improved junctions.*

NOTE 2 *This document does not cover the general provision of walking, cycling and horse riding facilities at grade separated junctions. Requirements and advice relating to this are provided in CD 143 [Ref 2.I] and CD 195 [Ref 1.I] .*

1.2 This document shall be used for the geometric design of the compact connector road element of a compact grade separated junction.

NOTE *Requirements and advice for the geometric design of the priority junction element of a compact grade separated junction are provided in CD 123 [Ref 2.N] .*

1.3 The relaxations prescribed by CD 109 [Ref 3.N] shall not be applied to this document.

NOTE *CD 109 [Ref 3.N] provides the base geometric parameters for a number of elements covered by this document; however, the relaxations prescribed by CD 109 [Ref 3.N] do not apply.*

Implementation

1.4 This document shall be implemented forthwith on all schemes involving geometric design of grade separated junctions 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

1.5 The requirements contained in GG 101 [Ref 4.N] shall be followed in respect of activities covered by this document.

2. Selection of grade separated junction form

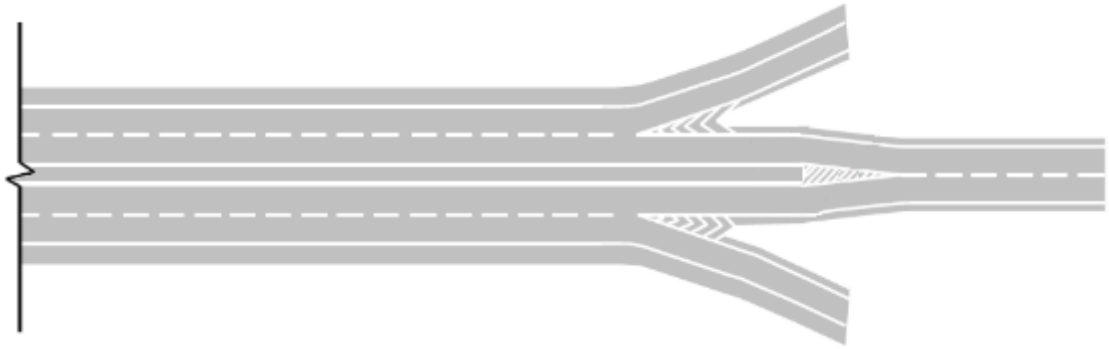
Full grade separated junctions

2.1 Full grade separated junctions shall only be used on dual carriageways and motorways.

NOTE 1 Appendix A provides examples of typical full grade separated junction layouts.

NOTE 2 The transition between a dual carriageway and a single carriageway can be formed using a merge and diverge as illustrated in Figure 2.1N2.

Figure 2.1N2 Dual carriageway to single carriageway transition



2.2 Where transitions between dual carriageway and single carriageways are at lane gain/lane drop grade separated junctions (as illustrated in Figure 2.1N2), there shall be a minimum distance of 400 metres between the end of the physical central reserve and the back of the merge nose.

NOTE A distance of 400 metres allows for an appropriate sequence of lane gain warning traffic signs to be accommodated prior to the merge.

2.3 The transitional section between a dual carriageway and a single carriageway at lane gain/lane drop grade separated junctions shall include hard strips.

2.3.1 A merge forming part of a grade separated junction should not be located within 500 metres upstream of a transition from a dual carriageway to a single carriageway, measured from the end of the merge taper to the start of the lane reduction hatching.

2.3.2 Interchanges may be provided at the intersection of motorways and/or dual carriageways to provide one or more free flow links to accommodate traffic flows that would normally exceed the capacity of priority junctions, roundabouts and signal-controlled junctions.

NOTE Appendix A provides examples of typical interchange layouts.

Compact grade separated junctions

2.4 Compact grade separated junctions shall not be used on motorways.

2.4.1 Compact grade separated junctions should not be used on dual- and single-carriageway roads when mainline flows are above 30,000 AADT.

2.5 On single carriageways, compact grade separated junctions shall only be used where the junction layout includes a section of physical central reserve on the mainline to prevent right turn movements.

NOTE Compact grade separated junctions consist of left-in left-out priority junction(s), between the mainline and connector road, designed in accordance with CD 123 [Ref 2.N] , and connector roads designed in accordance with this document.

3. Full grade separated: merges and diverges

General

3.1 Offside merges and diverges shall not be provided at full grade separated junctions.

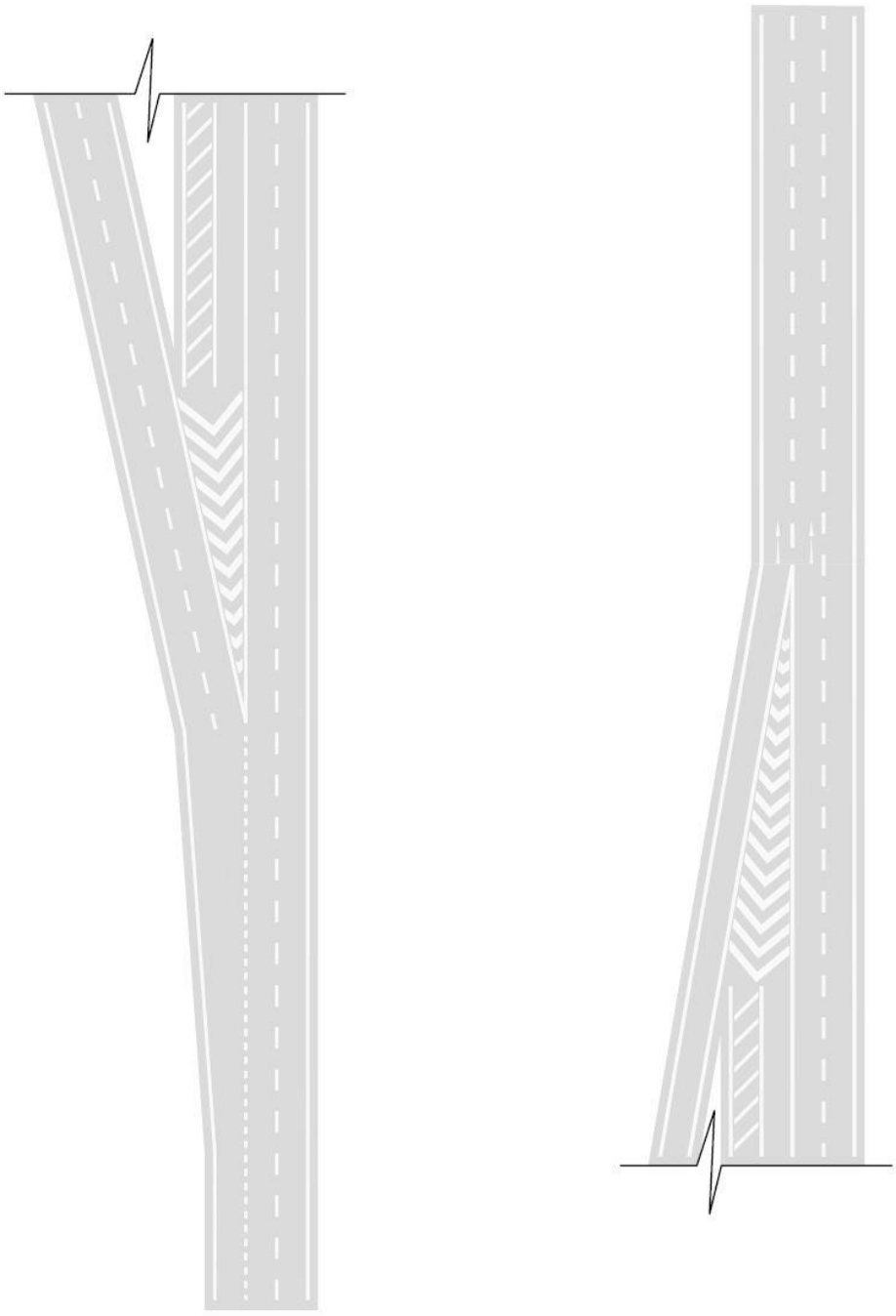
NOTE *Offside diverges do not include forks.*

3.1.1 At a diverge, or as part of an interchange, the principal signed or through route should continue ahead as the secondary route diverges on the left.

3.2 Reduction in the number of lanes (excluding climbing lanes) shall not take place on the intra-junction link.

3.3 At lane drop/lane gain junctions with 3 lanes upstream of the diverge and 3 lanes downstream of the merge, the intrajunction carriageway shall be the width of 3 lanes (plus hard shoulder if a motorway), with the nearside pavement adjacent to the 2 running lanes hatched out to leave a normal width of hard strip (or hard shoulder if a motorway) as shown in Figure 3.3.

Figure 3.3 Lane drop to two lanes and subsequent lane gain showing hatched pavement for maintenance and traffic management



NOTE *Maintaining a 3-lane width intrajunction provides the necessary space for maintenance and traffic management purposes.*

3.4 At lane drop/lane gain junctions with 3 lanes upstream of the diverge and 3 lanes downstream of the merge, the diverge and merge areas shall allow for the future conversion of the junction from a lane drop/lane gain to a taper diverge and merge with 3 lanes intrajunction.

Datum points

3.5 Merge datum points for the purposes of locating signs and signals, and for measuring weaving lengths for certain layouts, shall be as defined in Table 3.5 and illustrated on Figures 3.14a to 3.14k.

Table 3.5 Merge datum points

Merge layout	Entry datum
A Options 1 & 2, B, C, and E Option 2	end of downstream taper
D	tip of nose
E Option 1, F, G Option 1 & 2, and H	downstream tip of ghost island tail

3.6 Diverge datum points for the purposes of locating signs and signals, and measuring weaving lengths for certain layouts, shall be as defined in Table 3.6a and illustrated on Figures 3.30a to 3.30k.

Table 3.6a Diverge datum points

Diverge layout	Exit datum	
	Motorways	All-purpose roads
A Options 1 & 2, B Options 1 & 2, C Option 2 and D Option 2	Start of upstream taper	
D Layout 1, F and G	200 metres upstream of the tip of ghost island head	A distance as given in Table 3.6b upstream of the tip of ghost island head
C Option 1 and E	200 metres upstream of the tip of nose	A distance as given in Table 3.6b upstream of the tip of nose

Table 3.6b All-purpose roads datum distances

Mainline design speed (kph)	Distance (metres)
120	200
100	170
85	145
70	120
60	100
50	85

Ghost island width

3.7 The minimum width of a ghost island shall be 1.2 metres at a distance of 50 metres from the tip of the ghost island head or tail.

NOTE 1 Ghost islands less than 1.2 metres in width cannot be marked with a chevron, and therefore 50 metres keeps the unmarked section to a minimum.

NOTE 2 Ghost island layouts can require significant length and this needs to be reflected in land requirements.

Merges and diverges traffic flows

3.8 The mainline maximum vehicles per hour (vph) per lane shall be taken as:

1) 1,800 for motorways; and,
2) 1,600 for all-purpose roads.

NOTE The flows for maximum vph per lane do not represent the maximum hourly throughputs that are possible, but greater flows often results in decreasing levels of service and safety.

3.9 Where there is an uphill gradient and a presence of HGVs the hourly design flows for the mainline and merges shall be adjusted in accordance with Table 3.9a and 3.9b.

Table 3.9a Adjustment factors for uphill gradients and for the presence of large goods vehicles on the mainline

% HGVs on mainline	Mainline gradient	
	<2%	≥2%
5	none	1.10
10	none	1.15
15	none	1.20
20	1.05	1.25

Table 3.9b Adjustment factors for uphill gradients and for the presence of large goods vehicles on merge connector roads

% HGVs on merge connector	Merge connector gradient		
	<2%	2% to 4%	>4%
5	-	1.15	1.30
10	-	1.20	1.35
15	1.05	1.25	1.40
20	1.10	1.30	1.45

NOTE *Adjustments are not made to diverge flows.*

3.10 The mainline gradient used to calculate the adjusted hourly design flows shall be the average gradient over a distance 0.5 km either side of the merge or diverge nose tip.

3.11 The merge connector road gradient used to calculate the adjusted hourly design flows shall be the average of the 0.5 km section before the nose tip.

Merge

Merge layout

3.12 For up to 2 lane merges onto the main carriageway, the adjusted hourly design flows for the worst case peak flow (see Section 3, sub-section "Merge and diverge traffic flows") shall be inserted into Figure 3.12a for all-purpose roads and Figure 3.12b motorways to determine the minimum merge layout to be provided.

Figure 3.12a All-purpose road merging diagram

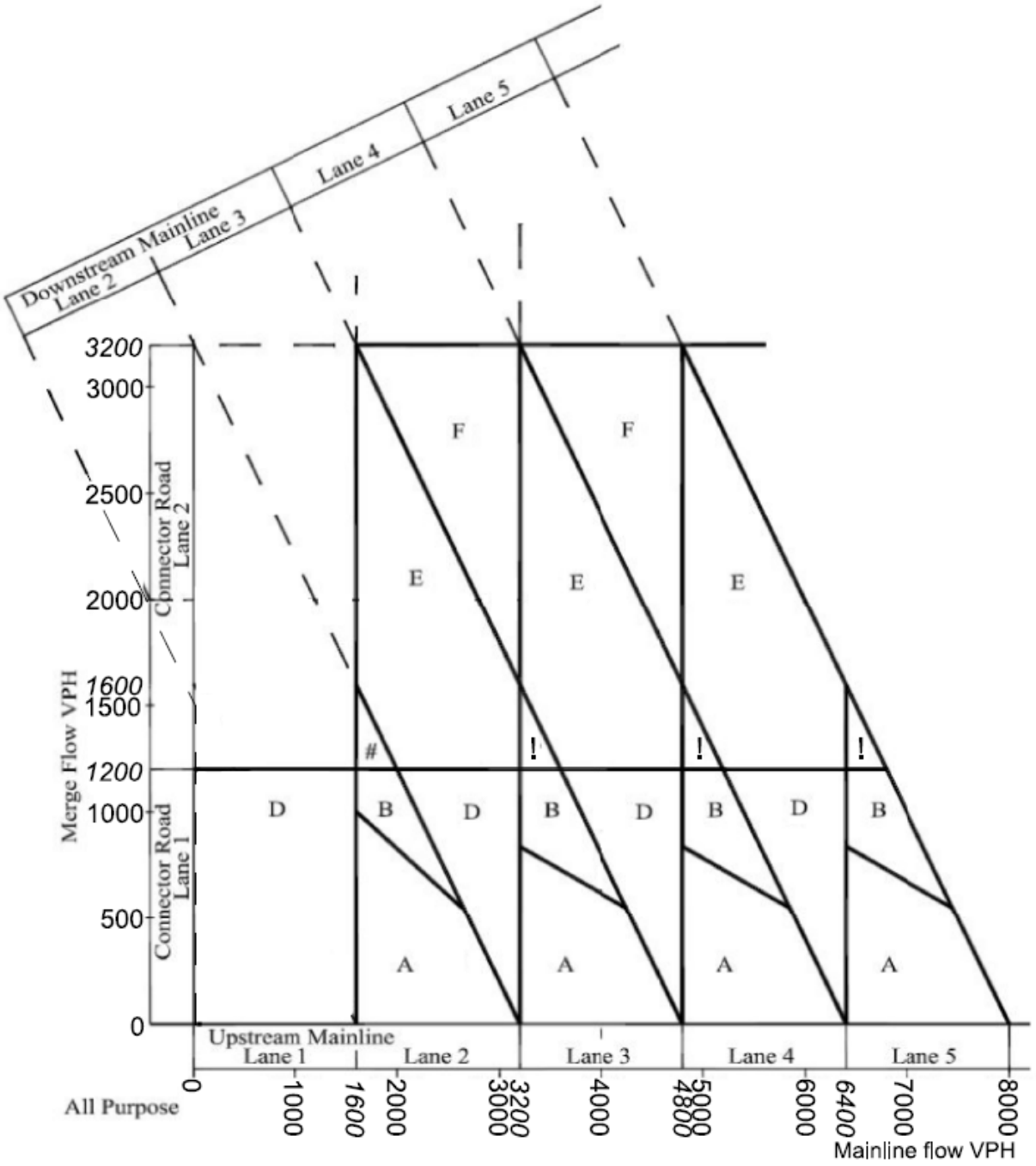
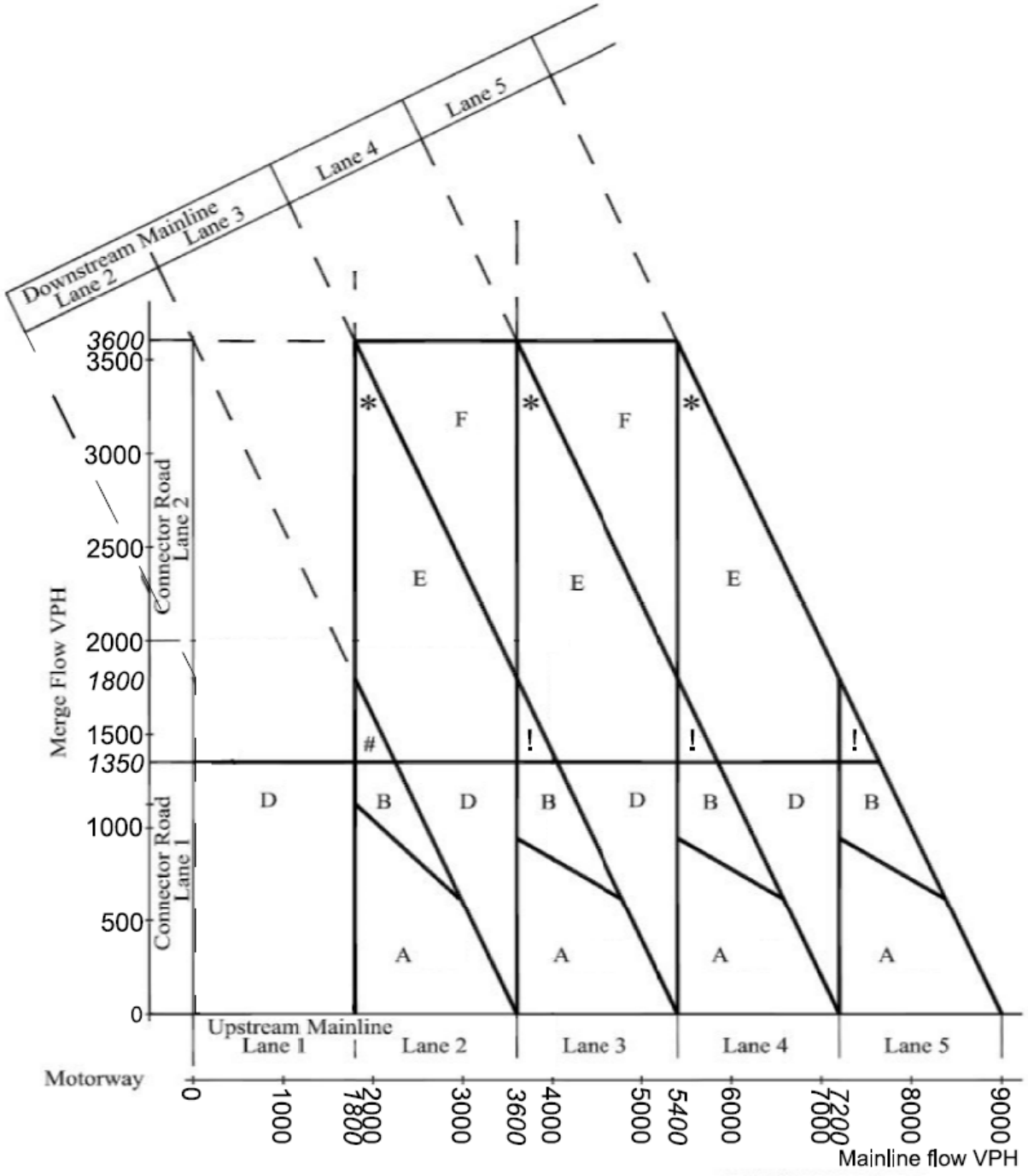


Figure 3.12b Motorway merging diagram



NOTE 1 *As an example of how to use Figures 3.12a and 3.12b, if the merge flow is 2000 vph and the upstream mainline flow is 4000 vph, this would give a Type E layout with 3 lanes upstream and 4 lanes downstream.*

NOTE 2 *On Figures 3.12a and 3.12b, the # symbol indicates areas of uncertainty and the choice depends on the upstream and downstream provision and the ability for the mainline to accept the flows from the merge.*

NOTE 3 *On Figures 3.12a and 3.12b, the ! symbol indicates that the minimum layout to be provided is:*

1) Layout C for rural roads; or,

2) Layout A Option 2 for urban roads.

3.12.1 Where the flows are in the region indicated by the * symbol in Figure 3.12b and Layout E option 2 is to be used, an extended auxiliary lane should be provided instead of a taper merge.

3.12.2 A merge layout that offers a higher level of capacity than the worst case peak flow may be provided, for example Layout C instead of Layout A.

NOTE *A merge layout that offers less capacity than the worst case peak flow cannot be used, such as a Layout C instead of Layout F.*

3.13 For 3-lane merges onto the main carriageway, Layout G or H (see Figures 3.14i to 3.14k) shall be used based on the number of downstream lanes to be provided.

3.14 Merge layouts shall be as shown in Figures 3.14a to 3.14k below.

Figure 3.14a Layout A option 1 - taper merge

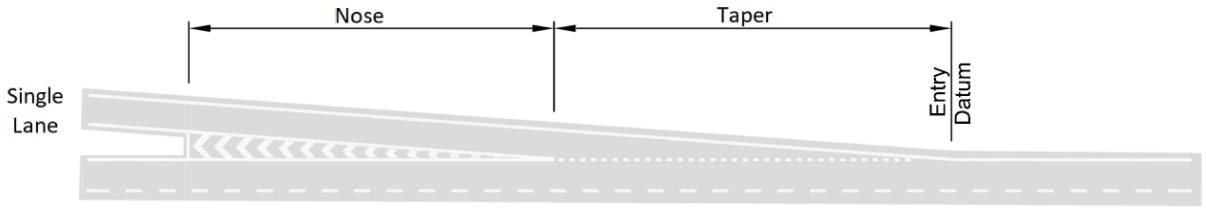


Figure 3.14b Layout A option 2 - 2 lane taper

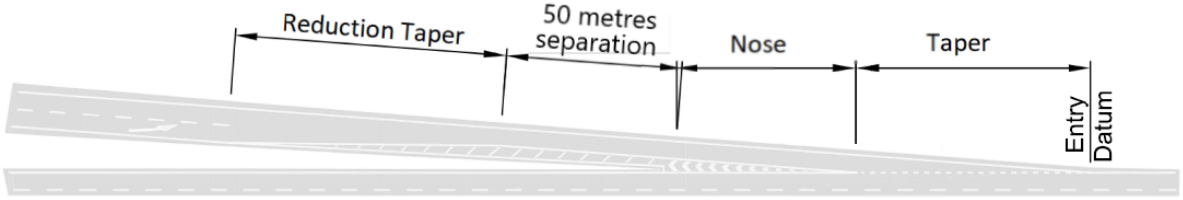


Figure 3.14c Layout B - parallel merge

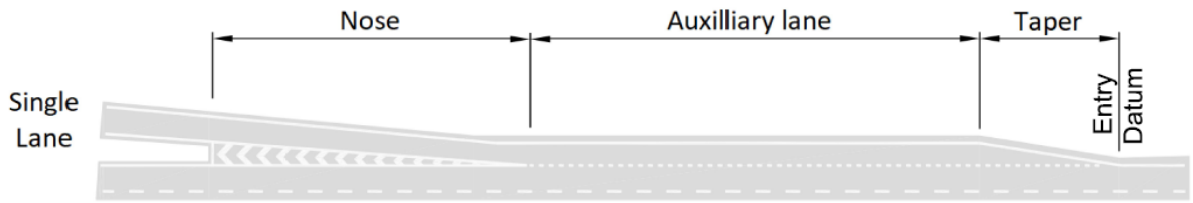


Figure 3.14d Layout C - ghost island merge

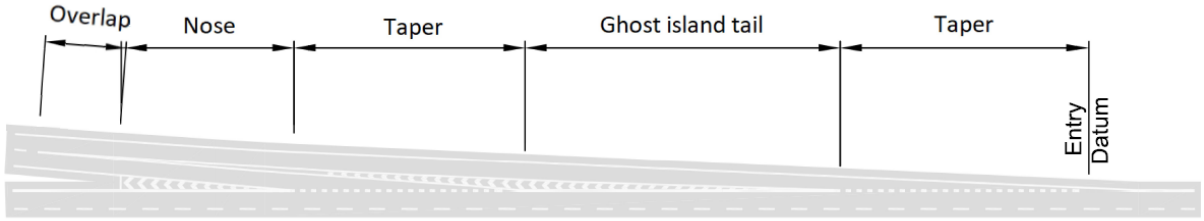


Figure 3.14e Layout D - lane gain

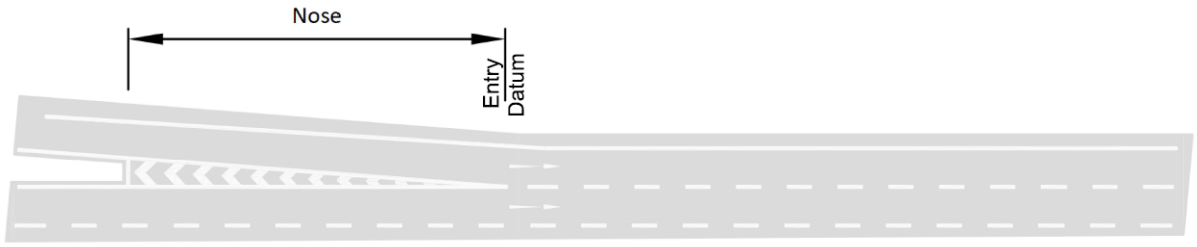


Figure 3.14f Layout E Option 1 - lane gain with ghost island offside merge

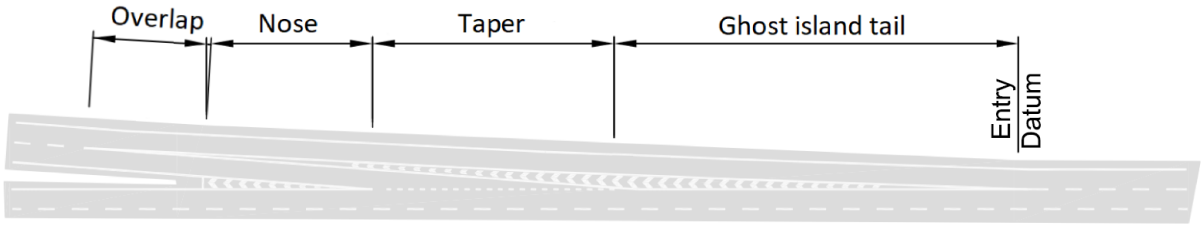


Figure 3.14g Layout E Option 2 - lane gain with ghost island nearside merge

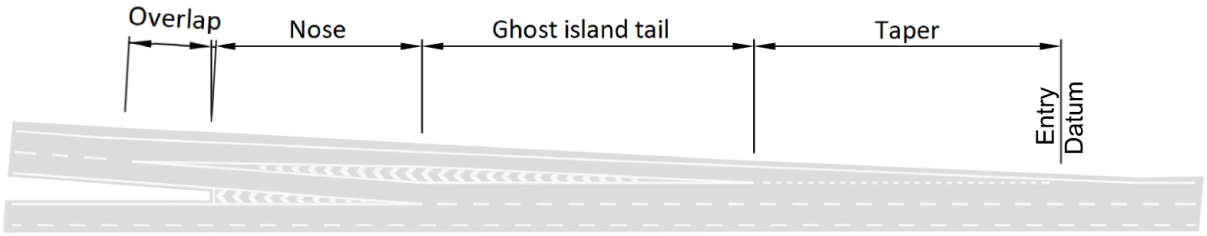


Figure 3.14h Layout F - 2 lane gain with ghost island

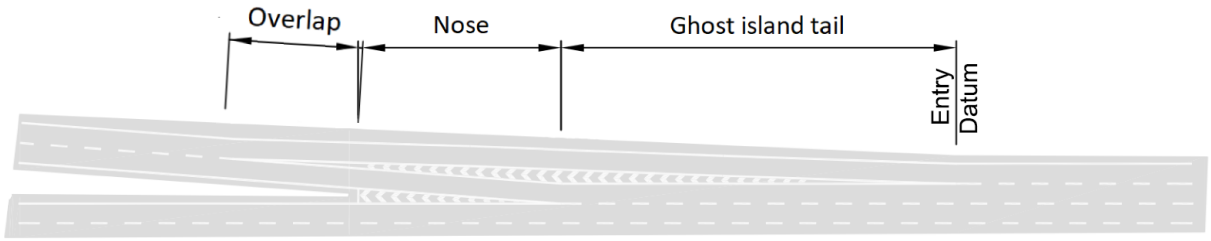


Figure 3.14i Layout G Option 1 - mainline lane gain and double ghost island merge

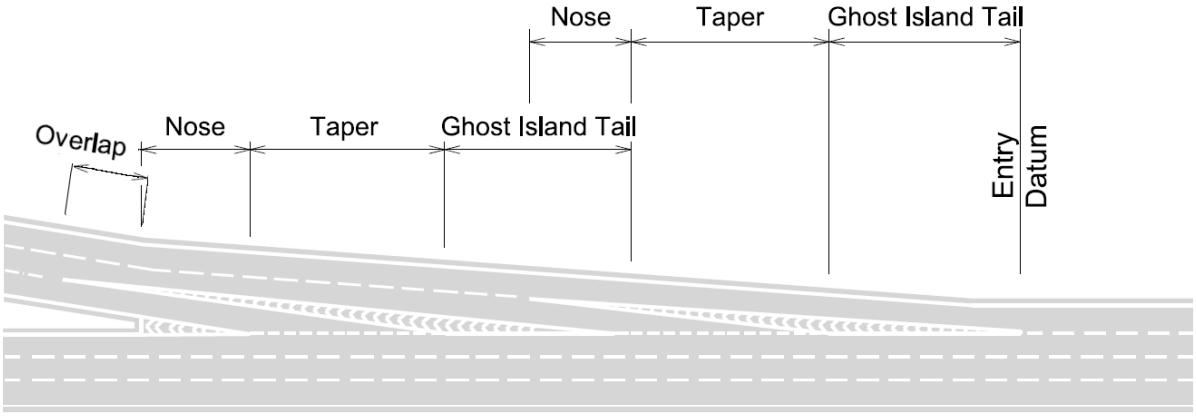


Figure 3.14j Layout G Option 2 - mainline lane gain and single ghost island merge

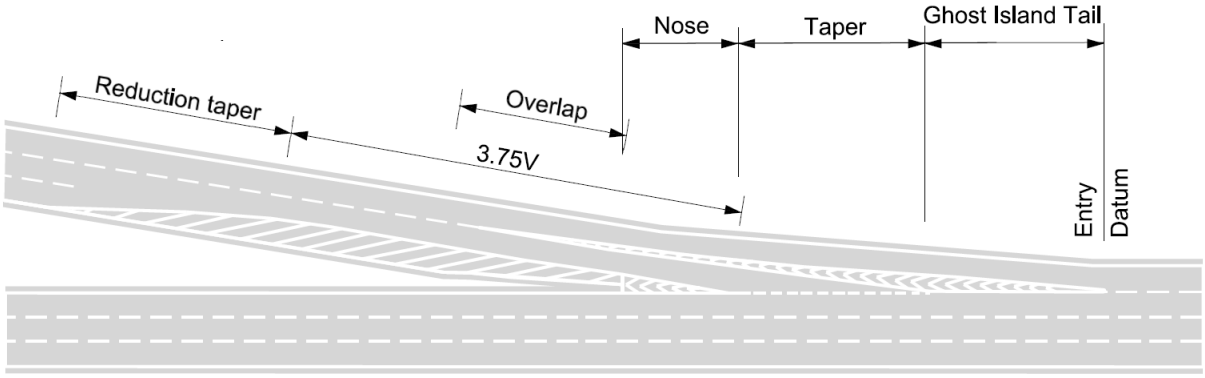
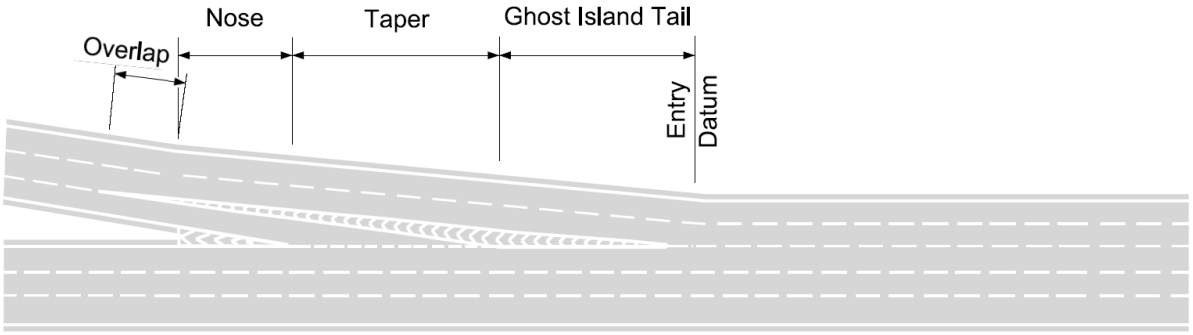


Figure 3.14k Layout H - mainline 2 lane gain and ghost island merge



3.14.1 Layout C should only be used where there are 3 lanes or more on the mainline.

3.14.2 Layout E option 2 should only be used where physical constraints on existing roads prevent Layout E option 1 from being feasible.

NOTE *Layout E option 1 has a larger footprint than Layout E option 2; however it requires potentially slower moving vehicles such as HGVs to merge into a lane carrying potentially faster moving traffic.*

3.14.3 Layout G option 2 should only be used where the merging flow is less than 3 lanes capacity but there is a need to maintain continuity with the number of upstream lanes (on the slip road).

3.15 Parallel merges (Layout B) shall be used instead of taper merges (Layout A) if one or more of the

following apply:

1) the mainline horizontal radius is less than desirable minimum in a left hand curve direction;
2) the mainline is on an uphill or downhill gradient of 3% or steeper for longer than 1.5 km prior to the start of the taper;
3) the connector road entering a merge is on an uphill gradient of 3% or steeper for longer than 400 metres before the back of nose.

3.16 Ghost island merge layouts shall not be used on urban roads.

3.16.1 For new slip roads on urban roads where a Layout A merge is required, Layout A option 2 may be provided.

3.17 For new slip roads on rural roads where a Layout A merge is to be provided, Layout A option 1 shall be used.

3.18 Where a single lane Layout A option 1 or Layout B merge is to be provided from an existing 2 -ane slip road, the slip road shall be reduced to a single lane prior to the nose in accordance with Layout A option 2.

3.19 The reduction taper in Layout A option 2 and Layout G option 2 shall be in accordance with Table 7-4 of TSM Chapter 5 [Ref 5.N] .

NOTE *For Layout G option 2, the lane reduction followed by the merge are successive merges and therefore the 3.75v spacing requirements apply (see Section 3, "Successive diverges and merges").*

3.20 An overlap of 50 metres shall be provided on Layouts C, E, F, G option 1 and 2 and H.

3.21 The geometric design parameters for a merge layout shall be in accordance with Table 3.21.

Table 3.21 Merge layouts geometric parameters

Road class	Length of entry taper (metres)	Minimum nose ratio	Nose length (metres)	Minimum auxiliary lane length (metres)	Length of auxiliary lane taper (metres)	Length of ghost island tail (metres)
Rural motorway						
Mainline	205	1:40	115	230	75	180
Within Inter-change	130	1:25	75	160	55	150
Rural all-purpose design speed						
120 kph	150	1:30	85	190	55	150
100A kph or less	130	1:25	75	160	55	150
Urban road speed limit						
60 mph	95	1:15	50	125	40	n/a
50 mph or less	75	1:12	40	100	40	n/a

NOTE 1 *The nose ratio is the relationship between the width of the back of the nose and the nose length. The minimum ratio gives the minimum angle to be provided at the tip of the nose.*

NOTE 2 *The maximum permitted width of the hatched road marking that forms the nose (TSRGD diagram 1042 - Schedule 9 Part 6 Item 22) is 8 metres SI 2016 No.362 (TSRGD) [Ref 4.I] .*

NOTE 3 *The merge layout lengths are measured along the projected nearside edge of the mainline carriageway, with the exception of the overlap, reduction taper and the 50 metres and 3.75V separations (Layouts A Option 2 and G Option 2 respectively), which are measured along the nearside edge of the connector road.*

3.21.1 On rural motorway mainlines, auxiliary lane lengths should be extended to 370 metres or greater where merge and mainline traffic flows are both forecast to reach or exceed 85% of the maximum design capacities given in Figure 3.12b for more than 1,000 hours per year.

3.21.2 On uphill gradients in excess of 2% and where the proportion of HGVs is greater than 10%, the minimum auxiliary lane lengths given in Table 3.21 should be extended to allow merging traffic to match mainline traffic speed.

NOTE *An extended auxiliary lane on a gradient in excess of 2% where there is a higher proportion of HGVs can provide increased opportunity for merging vehicles to match their speed with mainline traffic.*

3.22 For extended auxiliary lanes, or auxiliary lanes on crests, at least one sign indicating that the number of traffic lanes reduces ahead shall be provided.

3.22.1 For extended auxiliary lanes, or auxiliary lanes on crests, more than one sign indicating that the number of traffic lanes reduces ahead should be provided suitable to the length of auxiliary to be provided.

NOTE *Signs indicating that the number of traffic lanes reduces ahead are useful to drivers merging on extended auxiliary lanes as they can mistake them for lane gains, and on crests because the end of the auxiliary lane might not be be obvious.*

Merge visibility

3.23 The connector road stopping sight distance (SSD) shall be provided along the length of the connector road up to the back of nose with the SSD being available at any point along this length.

3.24 The mainline SSD shall be provided from the back of nose.

3.25 Obstructions to visibility between the connector road and mainline shall not occur along the full length of the merge nose.

NOTE *Visibility across the merge nose is necessary to allow merging drivers to see vehicles on the mainline in advance of merging.*

Diverge

Diverge layout

3.26 For up to 2 lane diverges from the main carriageway, the adjusted hourly design flows for the worse case peak flow (see Section 3, sub-section "Merge and diverge traffic flows") shall be inserted into Figure 3.26a and Figure 3.26b to determine the minimum diverge layout to be provided.

Figure 3.26a All-purpose road diverging diagram

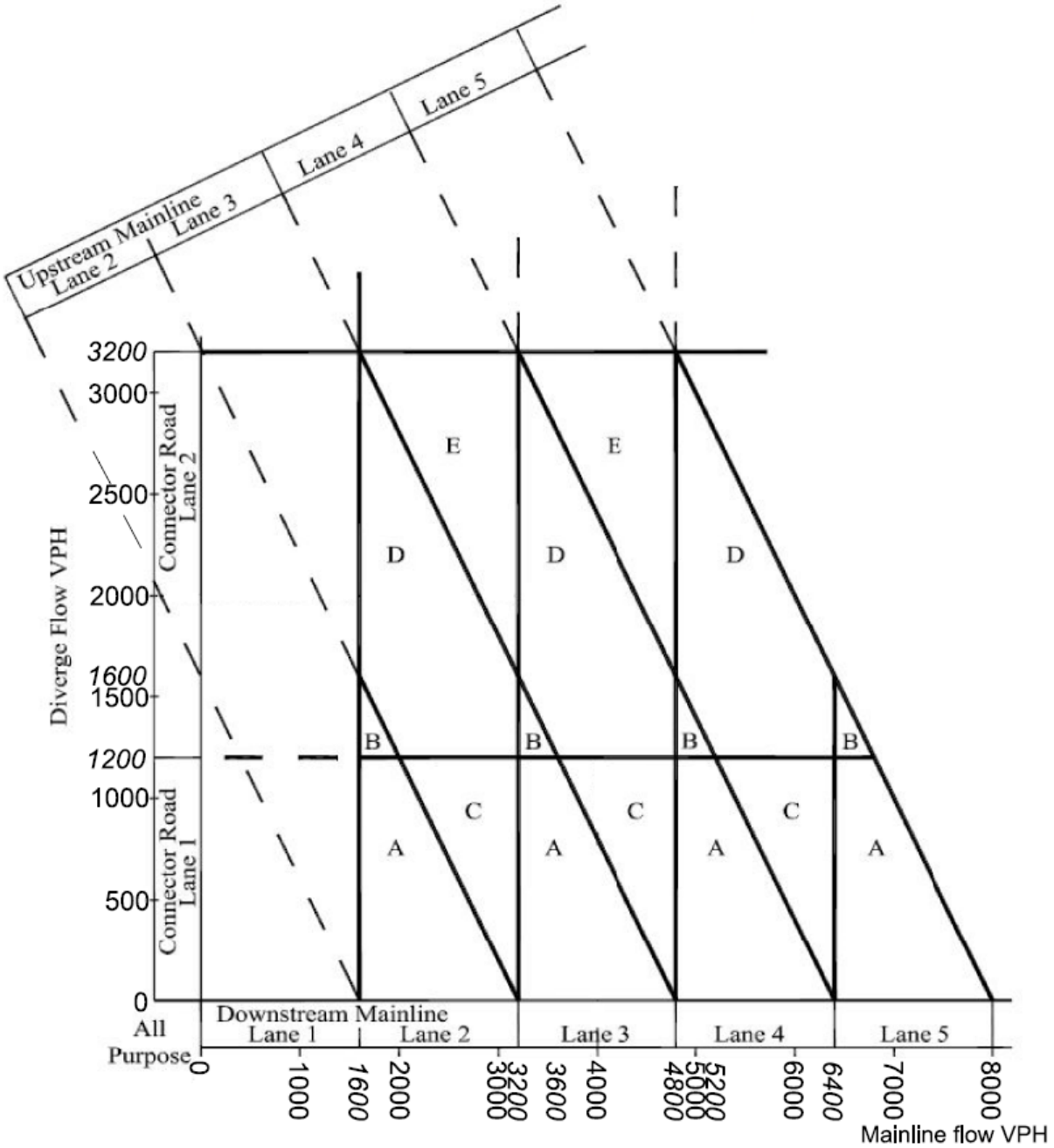
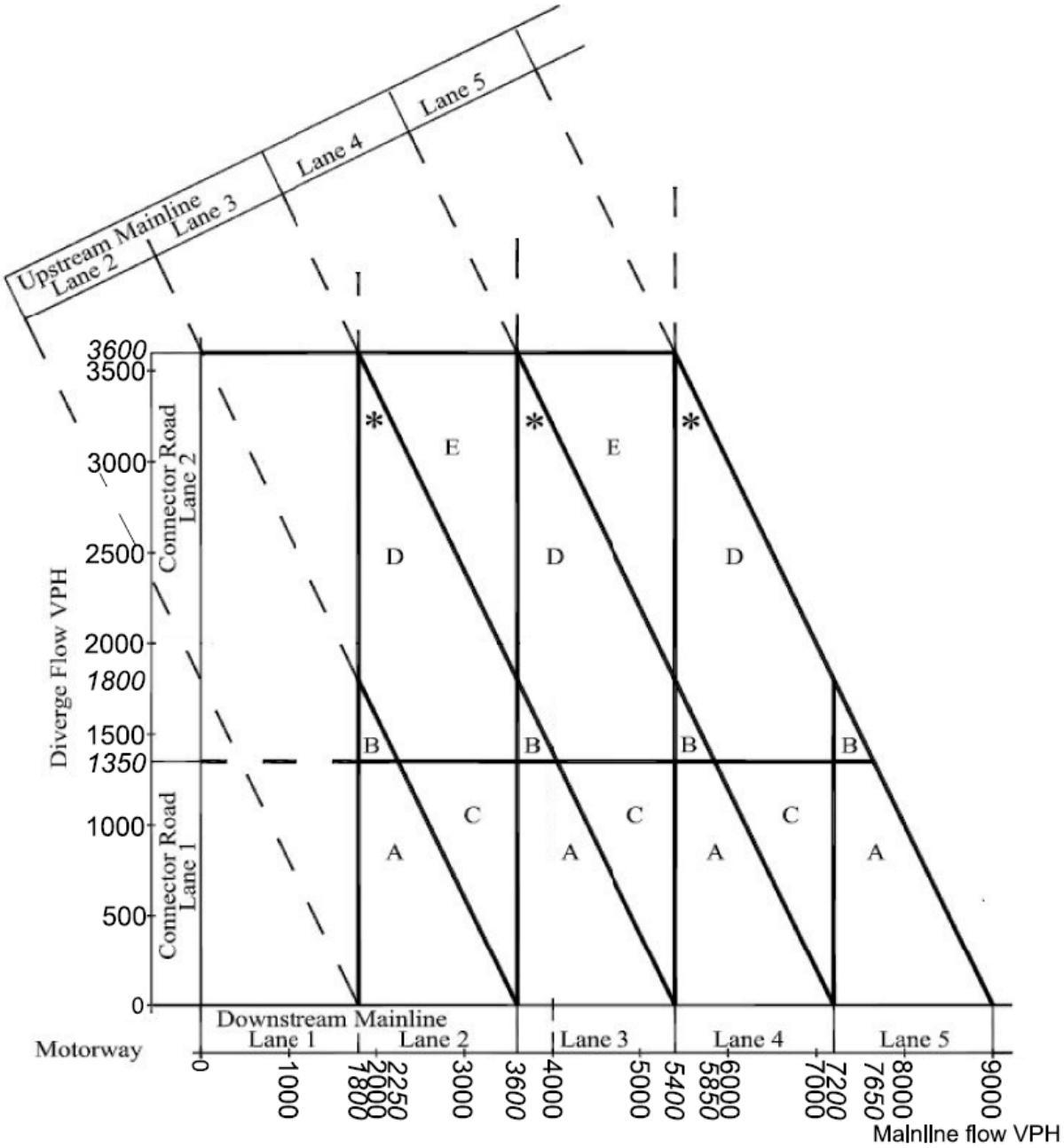


Figure 3.26b Motorway diverging diagram



NOTE *As an example of how to use Figures 3.24a and 3.24b, if the diverge flow is 2000 vph and the downstream mainline flow is 4000 vph, this would give a Type D layout with 3 lanes downstream and 4 lanes upstream.*

3.26.1 Where the flows are in the region indicated by the * symbol in Figures 3.25b and Layout D option 2 is to be used, an extended auxiliary lane should be provided instead of a taper diverge.

3.26.2 A diverge layout that offers a higher level of capacity than the worst case peak flow may be provided, for example Layout C instead of Layout A.

NOTE *A diverge layout that offers less capacity than the worst case peak flow cannot be used, such as a Layout C instead of Layout E.*

3.27 For 3-lane diverges from the main carriageway, Layout F or G shall be used based on the number of

upstream lanes to be provided.

3.28 A parallel diverge (Layout A option 2) shall be used instead of a taper diverge (Layout A option 1) if one or more of the following apply:

1) the mainline horizontal radius is less than the desirable minimum in a right hand curve direction;
2) the mainline is on an uphill or downhill gradient of 3% or steeper for longer than 1.5 km prior to the start of the taper.

3.29 Diverge Layouts B option 2 and D option 2 shall only be used when modifying an existing diverge.

NOTE *For the construction of new junctions and new slip roads at existing junctions, Layouts B option 2 and D option 2 are not used.*

3.30 Diverge layouts shall be as shown in Figures 3.30a to 3.30k.

Figure 3.30a Layout A option 1 - taper diverge

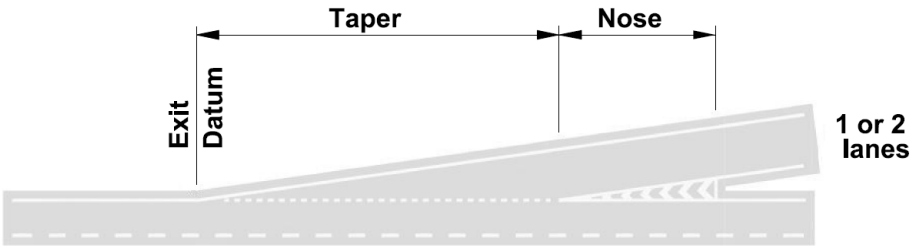


Figure 3.30b Layout A option 2 - Single lane auxiliary diverge

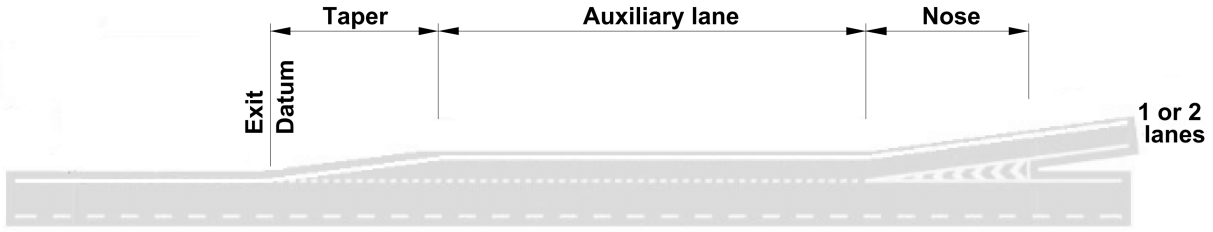


Figure 3.30c Layout B option 1 - ghost island diverge

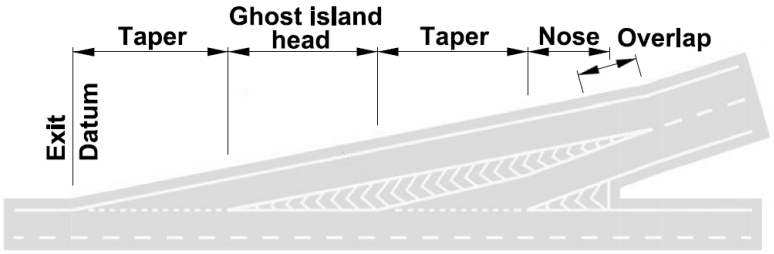


Figure 3.30d Layout B option 2 - Two-lane auxiliary diverge

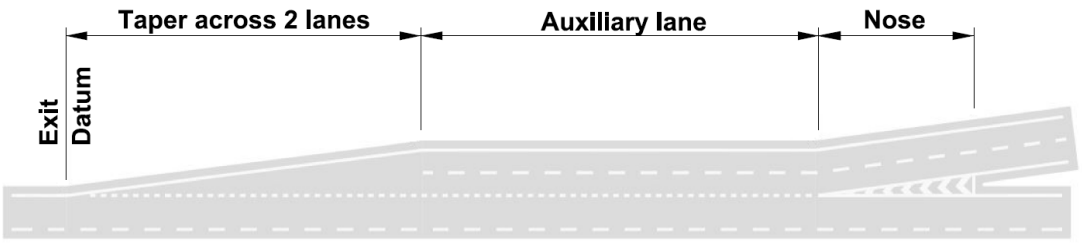


Figure 3.30e Layout C Option 1 - lane drop with 1-lane connector road

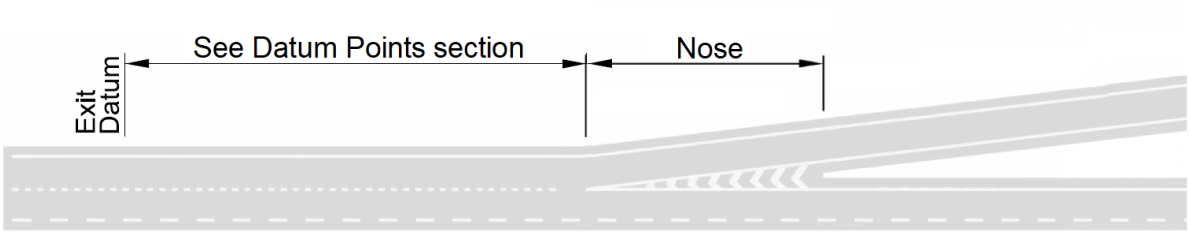


Figure 3.30f Layout C Option 2 - lane drop with 2-lane connector road

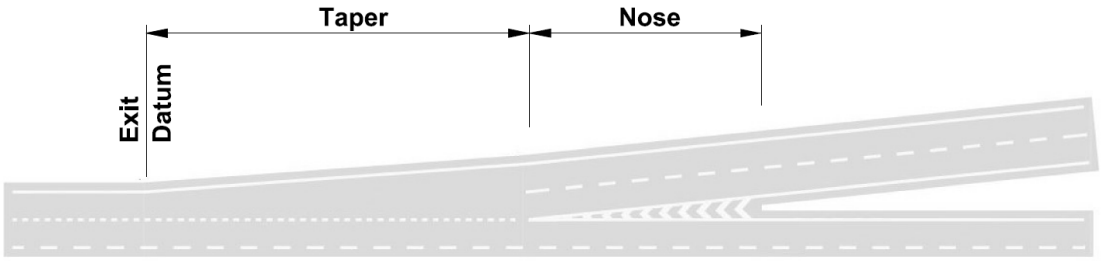


Figure 3.30g Layout D option 1 - ghost island lane drop

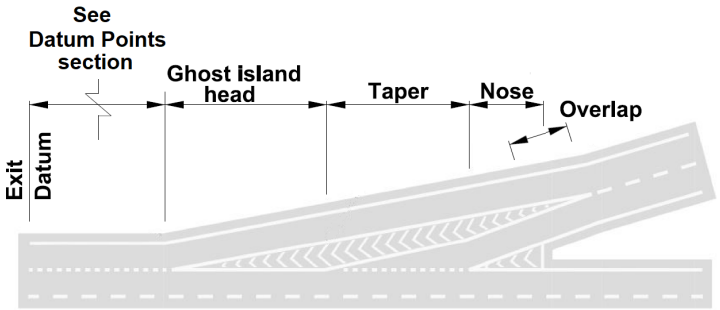


Figure 3.30h Layout D option 2 - auxiliary lane lane drop

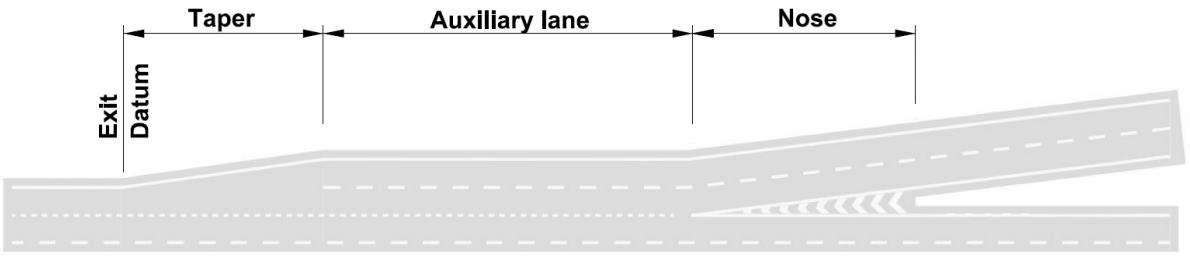


Figure 3.30i Layout E - 2-lane drop

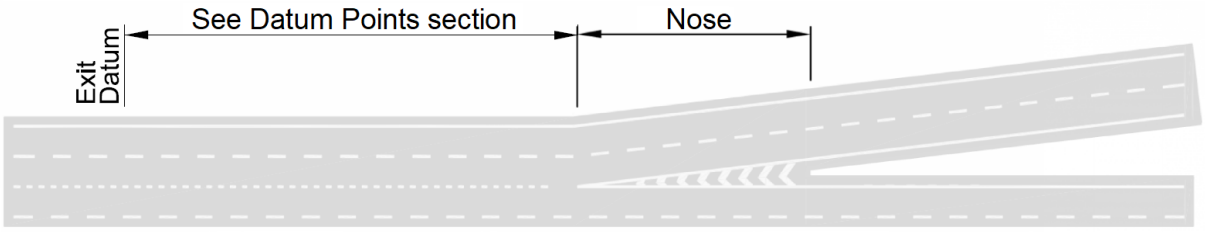


Figure 3.30j Layout F - mainline lane drop and ghost island diverge

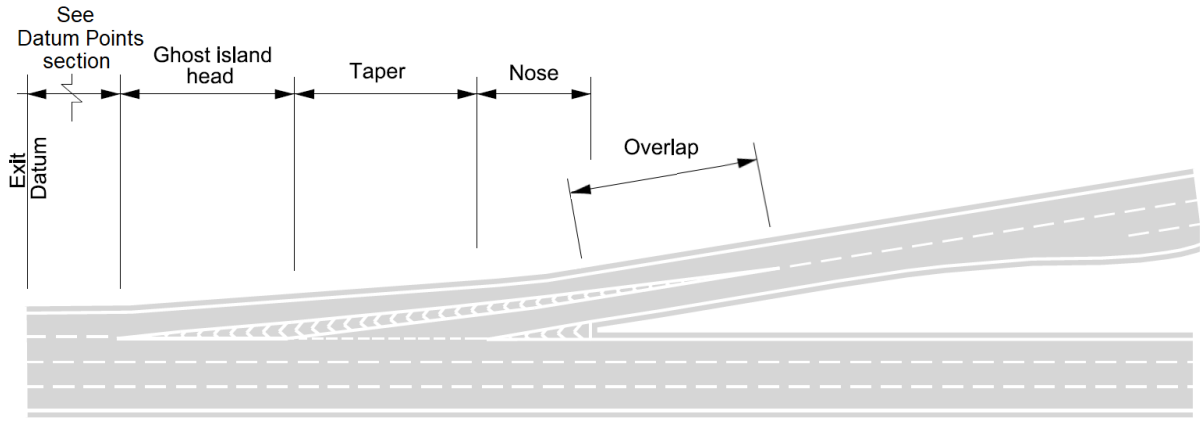
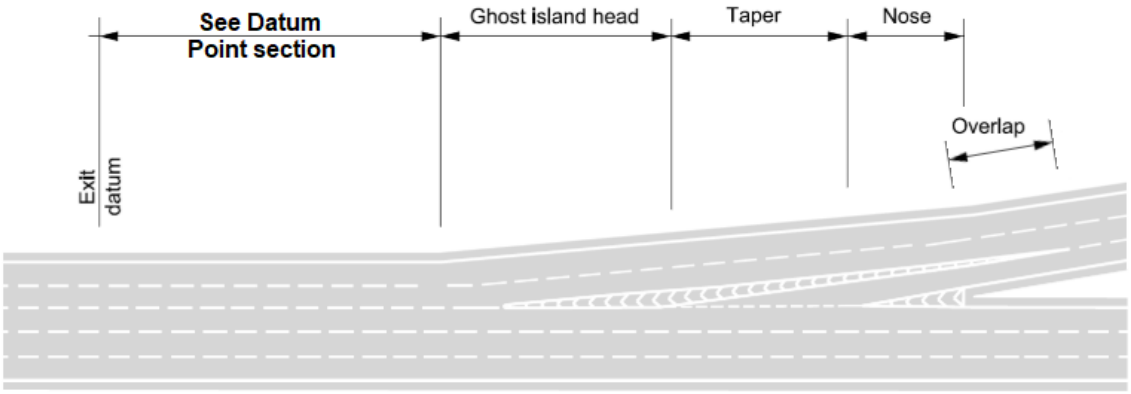


Figure 3.30k Layout G - mainline 2-lane drop and ghost island diverge



NOTE *The use of Layout C Option 1 or Layout C Option 2 depends on the required connector road cross section (refer to Section 5 of this document).*

3.31 The overlap dimension on Layouts B option 1, D option 1, F and G shall be 50 metres.

3.32 The geometric design parameters for a diverge shall be as shown in Table 3.32.

Table 3.32 Diverge layouts geometric parameters

Road class	Length of exit taper (metres)		Minimum nose ratio	Nose length (metres)	Minimum auxiliary lane length (metres)	Length of auxiliary lane taper (metres)	Length of ghost island head (metres)
	1 lane	2 lane					
Rural motorway							
Mainline	170	185	1:15	80	200	75	180
Within Inter-change	130	130	1:15	70	150	55	n/a
Rural all-purpose design speed							
120 kph	150	150	1:15	70	170	55	160
100A kph or less	130	130	1:15	70	150	55	140
Urban road speed limit							
60 mph	95	110	1:15	50	125	40	100
50 mph or less	75	90	1:12	40	100	40	80

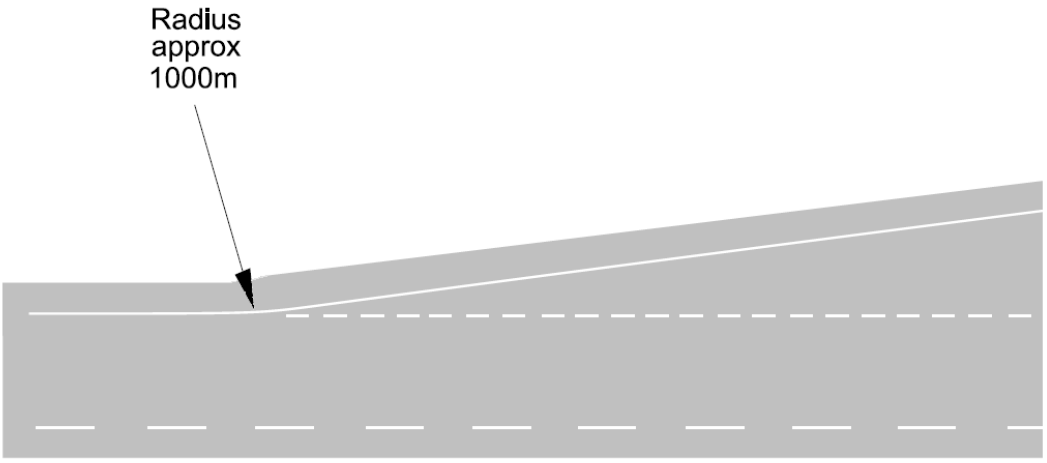
NOTE 1 *The nose ratio is the relationship between the width of the back of the nose and the nose length. The minimum ratio gives the minimum angle to be provided at the tip of the nose.*

NOTE 2 *The maximum permitted width of the hatched road marking that forms the nose (TSRGD diagram 1042 - Schedule 9 Part 6 Item 22) is 8 metres SI 2016 No.362 (TSRGD) [Ref 4.I] .*

NOTE 3 *The diverge layout lengths are measured along the projected nearside edge of the mainline carriageway, with the exception of the overlap, which is measured along the nearside edge of the connector road.*

3.32.1 For diverges, the layout of the edge line should incorporate radii of approximately 1,000 metres at the corners, as illustrated in Figure 3.32.1.

Figure 3.32.1 Example of a 1,000 metres radius edge line corner at a diverge



3.33 Countdown markers indicating the distance in hundreds of yards shall be provided on the approaches to all diverges, except where the diverge includes a lane drop.

Diverge visibility

3.34 On diverges, mainline SSD shall be provided:

1) along the diverge and into the connector road up until the back of the nose, where the length of the connector road is greater than the mainline SSD, as illustrated in Figure 3.34a; or,
2) to a 0.26 metre object height at the 'give way' line or 'stop' line from a distance equal to the mainline SSD, where the length of the connector road is equal to or less than the mainline SSD, as illustrated in Figure 3.34b.

Figure 3.34a Application of mainline SSD where the length of connector road is greater than the mainline SSD

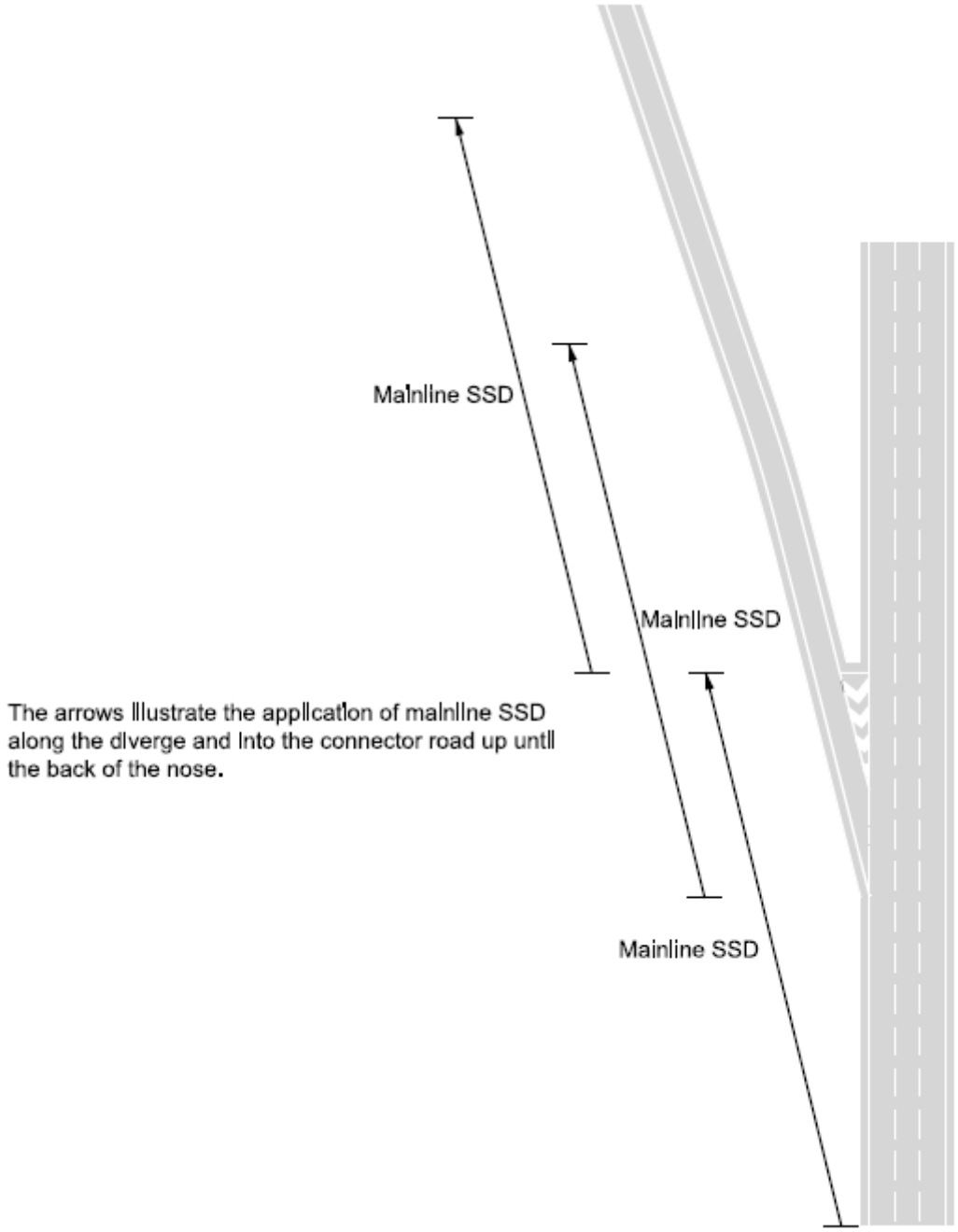
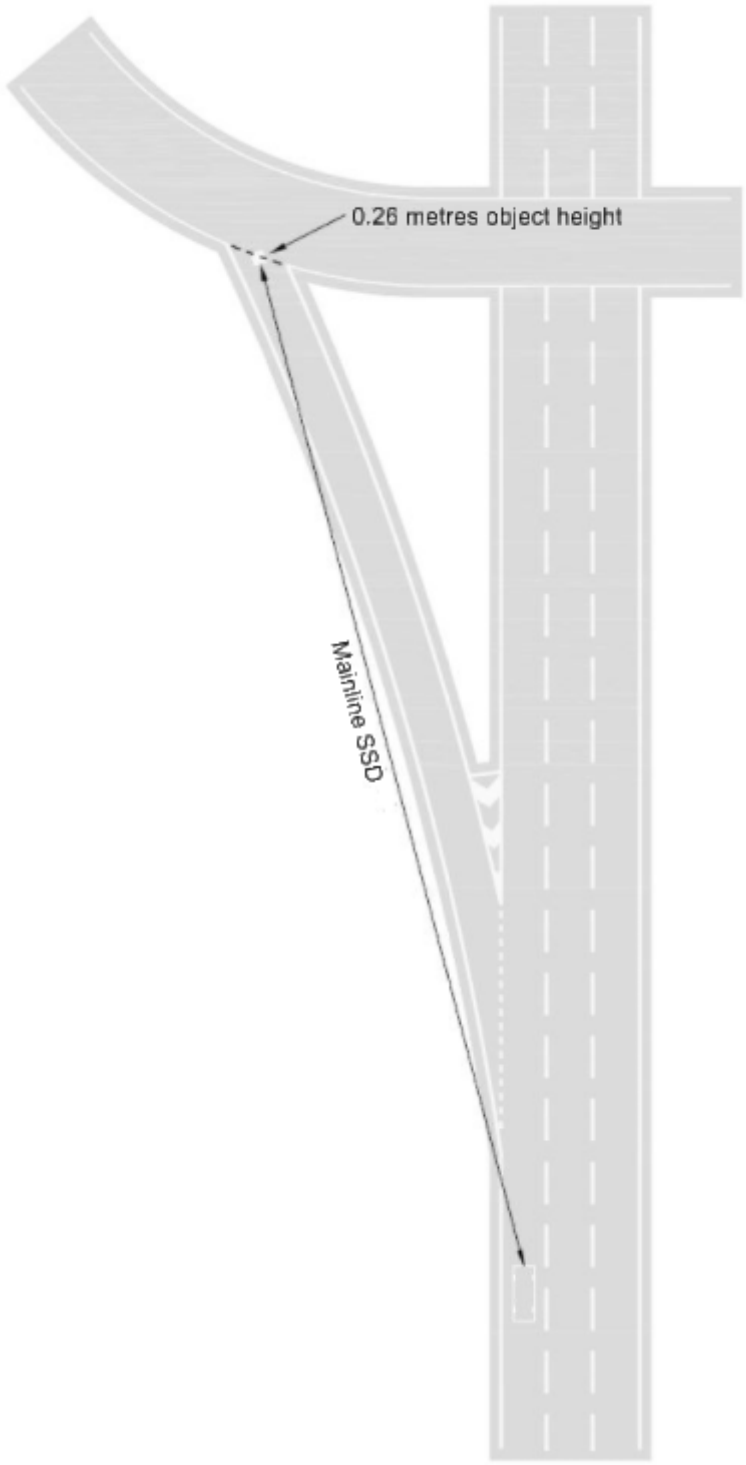


Figure 3.34b Application of mainline SSD where the length of connector road is less or equal to the mainline SSD



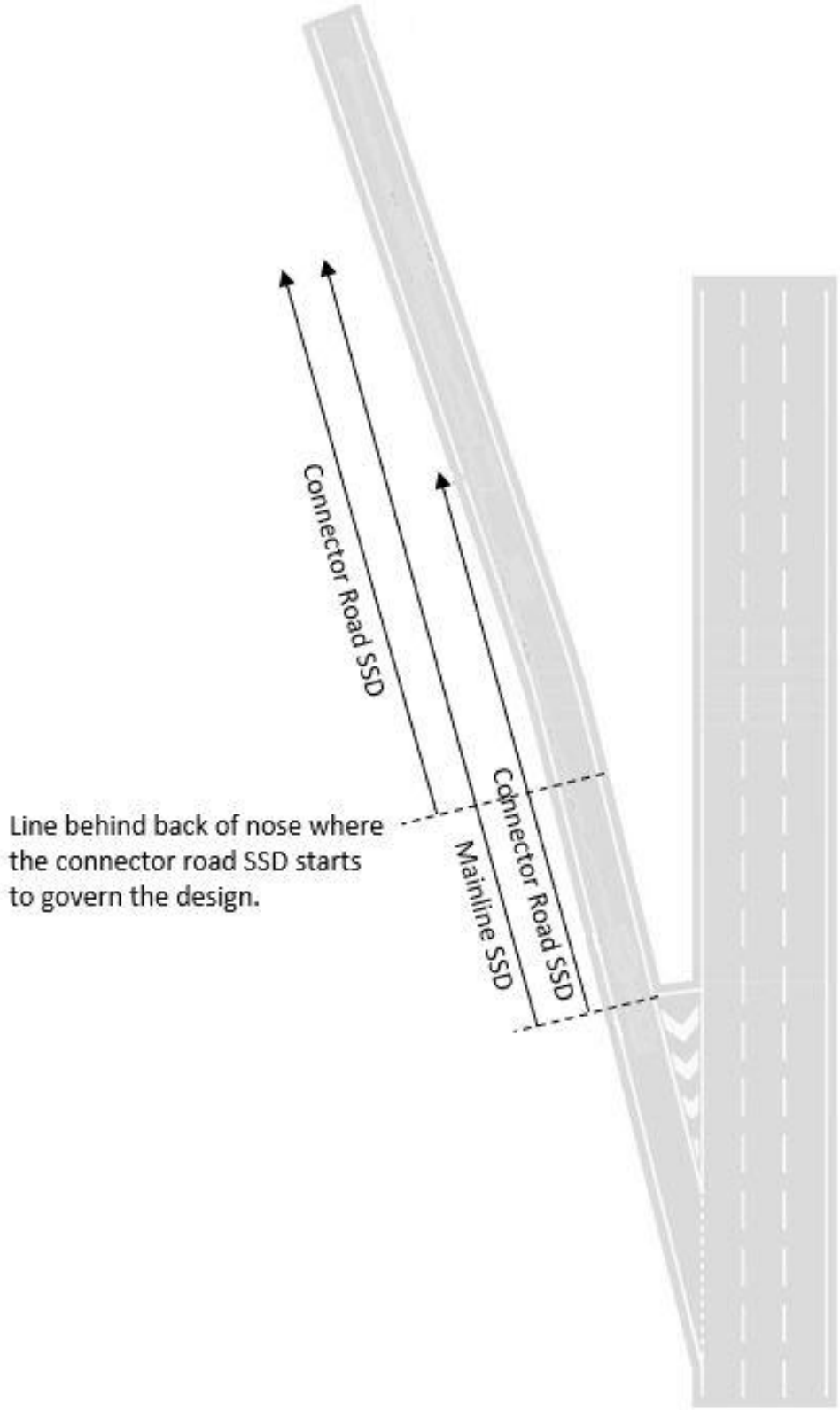
NOTE *The mainline SSD needs to be available at any point along the diverge up to the back of the nose.*

3.35 On diverges, connector road SSD shall be provided from any point downstream of the back of the nose, except where the connector road SSD would extend beyond the give way or stop line, in which case the SSD needs only to extend to the give way or stop line.

NOTE *Instantaneously at the back of nose where the connector road and mainline SSD are both provided, the*

mainline SSD is the more onerous. However, beyond the back of nose, when continuation of the mainline SSD is not required, the connector road SSD becomes the more onerous, as illustrated on Figure 3.35N. As an example, where the mainline SSD is 295 m and the connector road SSD is 160 m, at a point 135 m behind the back of nose the connector road SSD starts to govern the design instead of the mainline SSD.

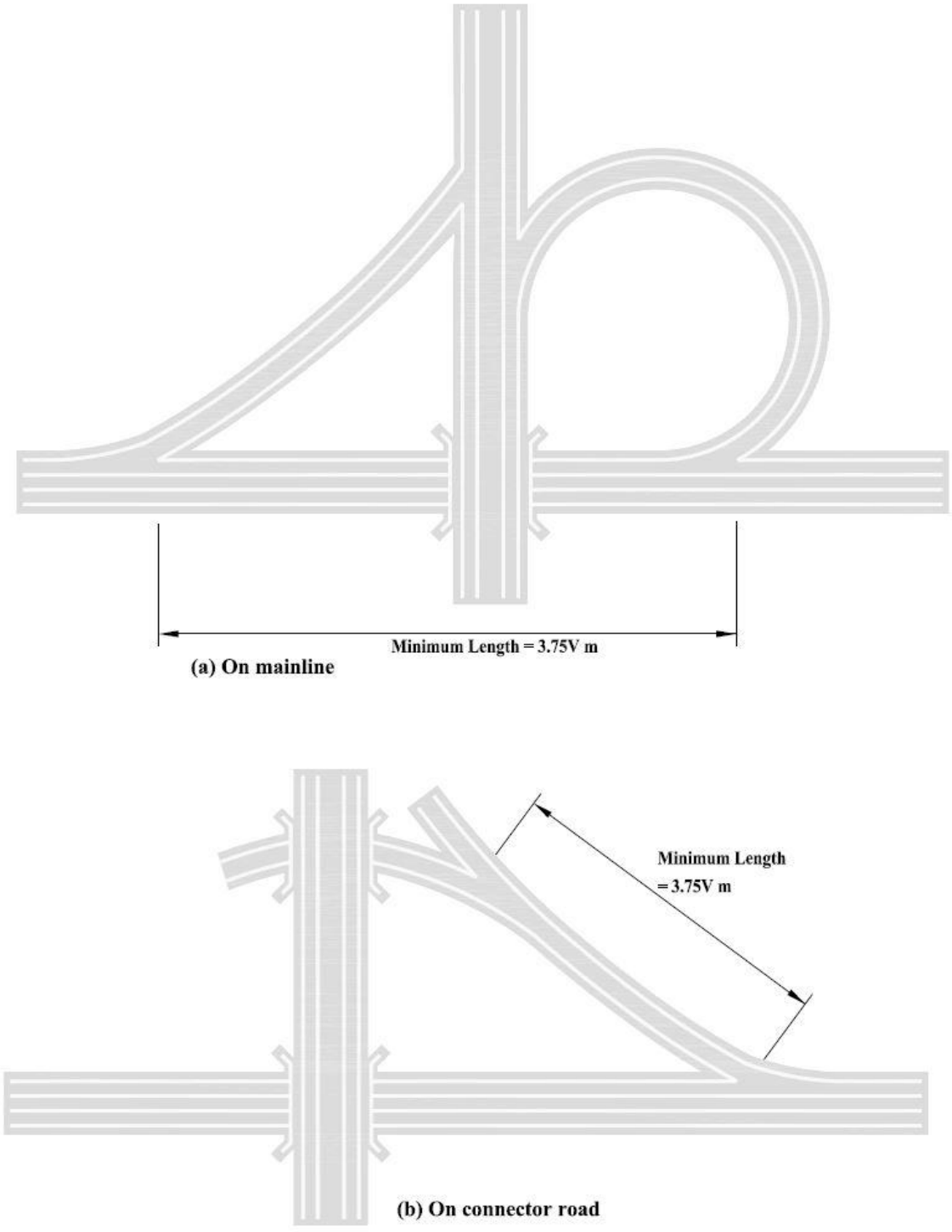
Figure 3.35N Example of transition between mainline and connector road SSD governing design



Successive diverges and merges

3.36 The minimum spacing between the tips of the noses of successive merges, successive diverges or a diverge followed by a merge shall be 3.75V metres, where V is the design speed of the mainline or connector road (see Figure 3.36).

Figure 3.36 Example of successive merges/diverges



NOTE Spacing between a merge and a diverge is determined by weaving lengths.

3.36.1 Spacing greater than the minimum between successive merges and diverges may be provided to accommodate signing and motorway signalling.

3.36.2 Diverges for left and right turning traffic at interchanges should be combined so that all turning traffic leaves the mainline at one diverge, instead of multiple successive diverges from the mainline.

NOTE *Combining both diverging flows results in less complex layout that is easier to sign and reduces the number of route choice made on the mainline.*

Forks

3.37 Forks shall only be used on interchange links with a design speed of 70 kph or 85 kph.

3.38 At a fork, the taper shall be developed as shown in Table 3.38 and Figures 3.38a and 3.38b.

Table 3.38 Geometric design parameters for a fork within an interchange link

Interchange link design speed	Length of taper (metres)		Nose ratio	Nose length (metres)
	1 lane	2 lanes		
70/85 kph	75	90	1:12	40

Figure 3.38a Development of taper at a single lane fork

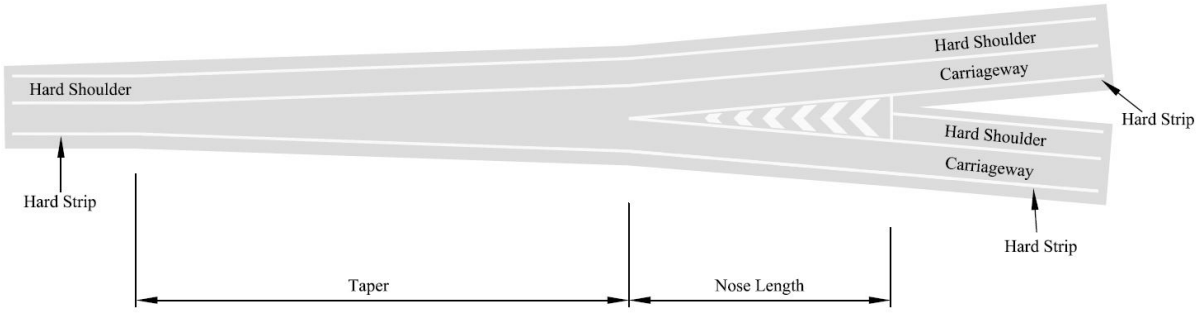
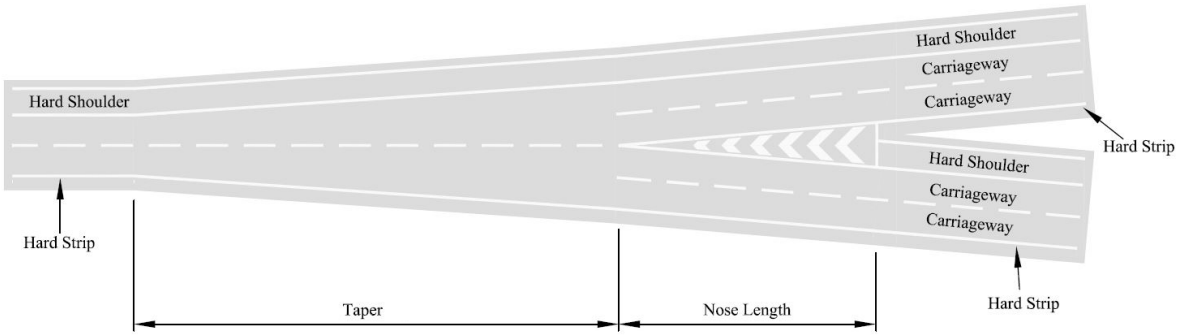
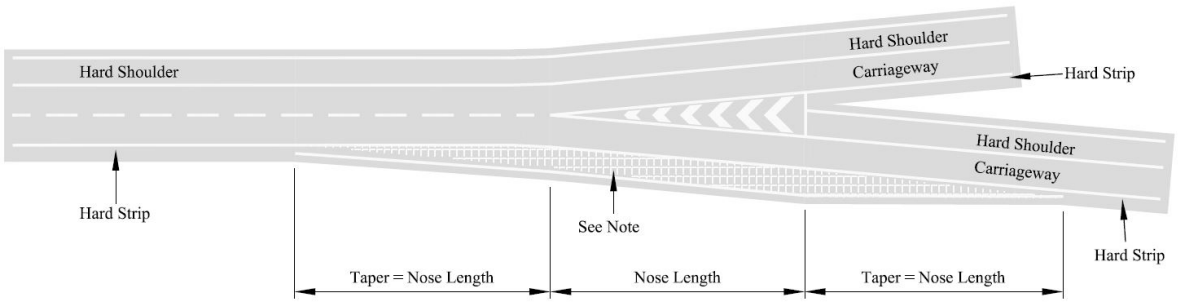


Figure 3.38b Development of taper at a two-lane fork



3.39 On forks where a single lane passes to the right, the offside verge shall be hardened and hatched out using road markings opposite the nose and for a length before and after as illustrated on Figure 3.39.

Figure 3.39 Hardened verge at single lane fork



NOTE *The hardened verge can accommodate a broken down vehicle and allow other road users to pass.*

3.39.1 The hardened verge should be capable of withstanding the weight of traffic.

3.40 The maximum width of the offside hardened verge shall be that of the nearside hard shoulder.

4. Full grade separated: weaving and spacing

General

4.1 For all-purpose roads, the minimum length between a full grade separated junction and an at-grade junction, service area and lay-by shall be:

1) 1 km for rural roads; and,
2) the minimum weaving section length as derived for urban roads.

NOTE At-grade junctions include priority junctions, signal controlled junctions, roundabouts and direct accesses.

4.2 A weaving section shall be assessed using the weaving section lanes calculation where successive full grade separated junctions are spaced less than:

1) 3 km for rural motorways; and,
2) 2 km for rural all-purpose roads.

NOTE 1 An assessment of weaving is only required between closely spaced (less than 3 km for rural motorways and 2 km for rural all-purpose roads) successive junctions where a merge is followed by a diverge.

NOTE 2 On motorways up to 5 lanes wide, merges and diverges tend not to interact where they are spaced over 3 km apart.

NOTE 3 On all-purpose roads up to 3 lanes wide, merges and diverges tend not to interact where they are spaced over 2 km apart.

NOTE 4 Weaving section lanes calculation is provided in Equation 4.7.

4.3 Motorway service areas accesses shall be treated as a junction for the purpose of weaving assessments.

Weaving section length

Measurement of weaving sections

4.4 Weaving sections shall be measured to/from the points detailed in Tables 4.4a and 4.4b.

Table 4.4a Weaving section measurement points - merges

Merge type	Measurement point
Layouts A1, A2 and D	Entry datum point
Layout B	As defined in Figure 4.4a
Layout C	As defined in Figure 4.4b
Layouts E1, E2, G2 and H	As defined in Figure 4.4c
Layout F	As defined in Figure 4.4d
Layout G1	As defined in Figure 4.4e

Table 4.4b Weaving section measurement points - diverges

Diverg e type		Measurement point
Layout A1		Exit datum point
Layouts A2 and B2		As defined in Figure 4.4f
Layout B1		As defined in Figure 4.4g
Layouts C1, C2, D2 and E	≥100kph design speeds	100 metres upstream of the tip of the nose or ghost island head, as defined in Figure 4.4h
	≤85kph design speeds	50 metres upstream of the tip of the nose or ghost island head, as defined in Figure 4.4h
Layouts D1, F and G		As defined in Figure 4.4i

Figure 4.4a Auxiliary lane merge weaving section

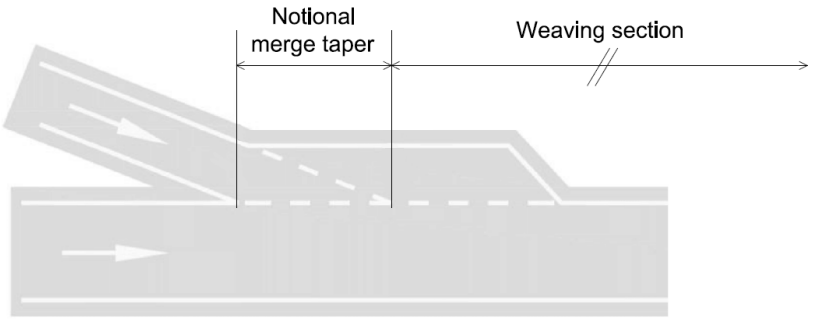


Figure 4.4b Ghost island merge weaving section

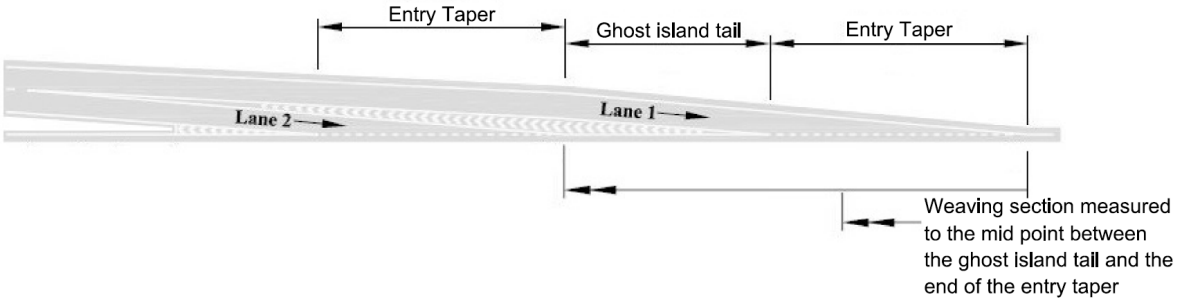


Figure 4.4c Ghost island and lane gain merge weaving section

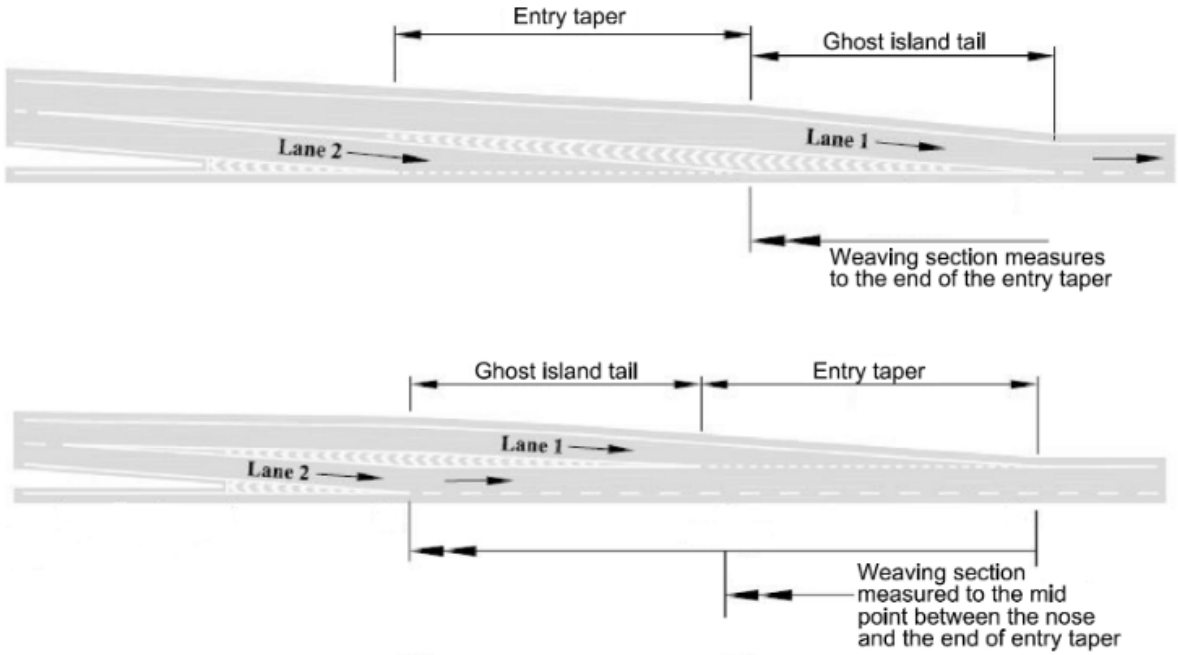


Figure 4.4d Ghost island and two lane gain merge weaving section

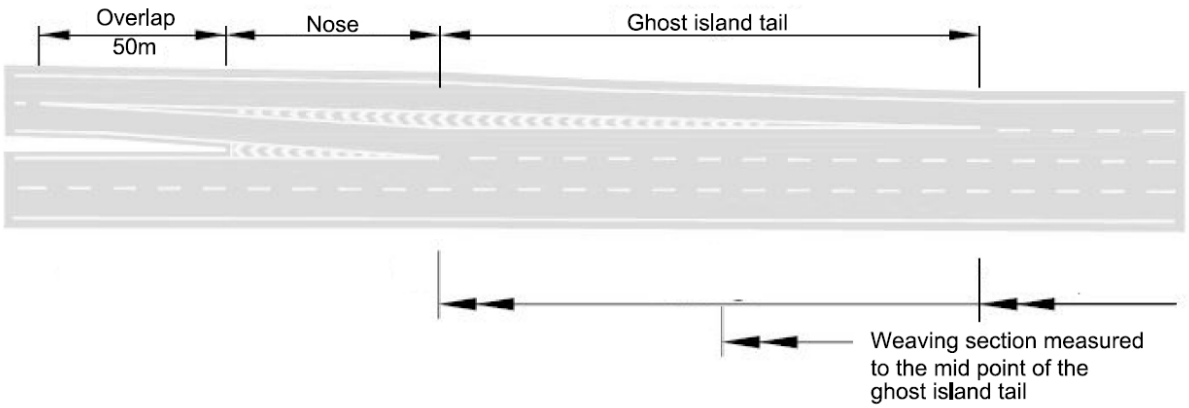


Figure 4.4e Double ghost island and lane gain merge weaving section

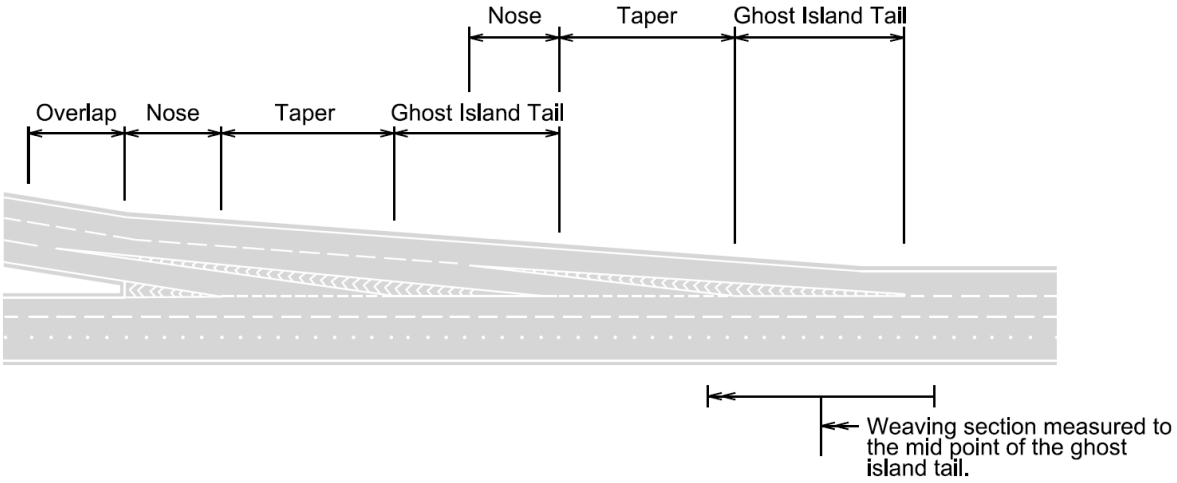


Figure 4.4f Auxiliary lane diverge weaving section

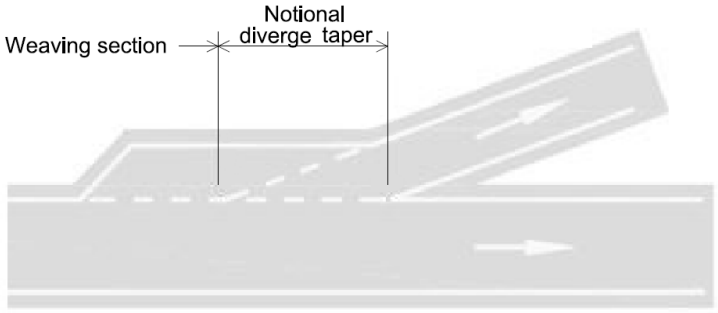


Figure 4.4g Ghost Island and direct taper diverge weaving section

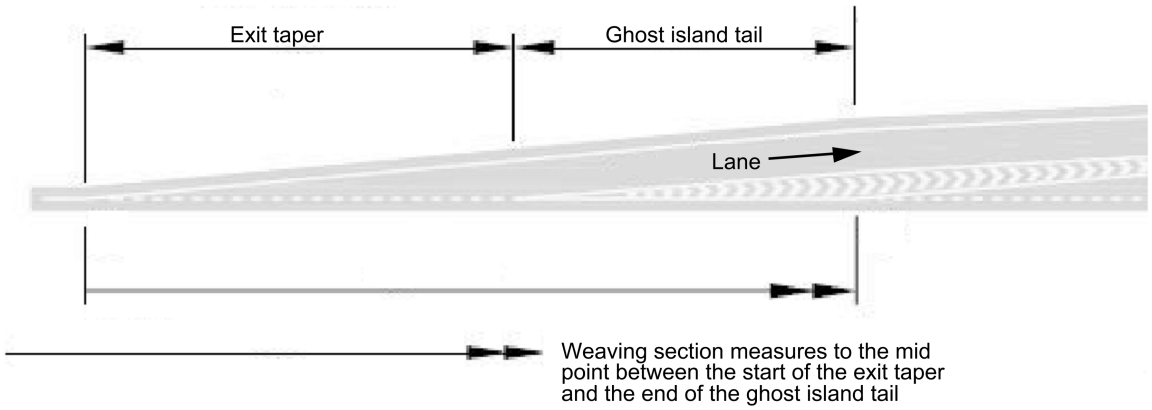


Figure 4.4h Lane drop diverge weaving section

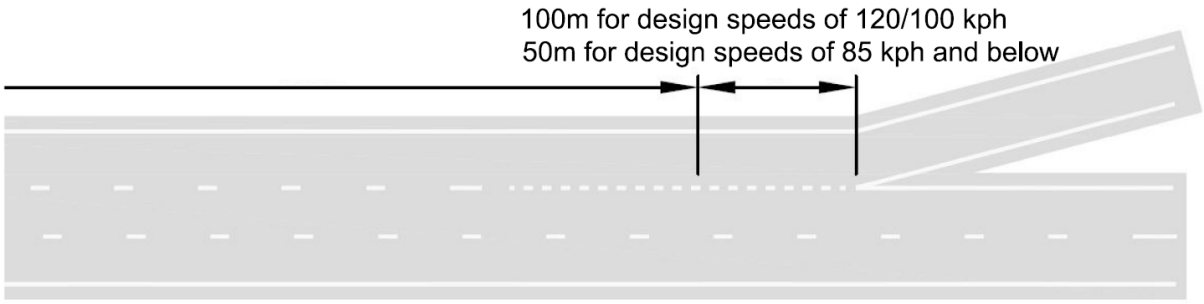
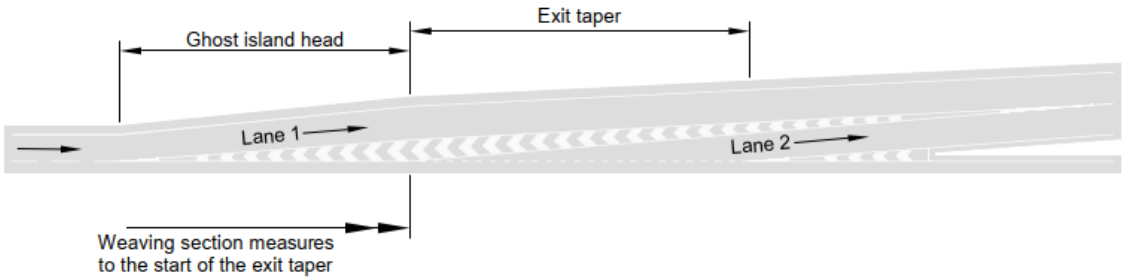


Figure 4.4i Lane drop diverge with ghost island weaving section



NOTE 1 *The notional merge taper shown in Figure 4.4a equates to the length of entry taper given in Table 3.21 for the appropriate road class.*

NOTE 2 *The notional diverge taper shown in Figure 4.4f equates to the length of exit taper given in Table 3.32 for the appropriate road class.*

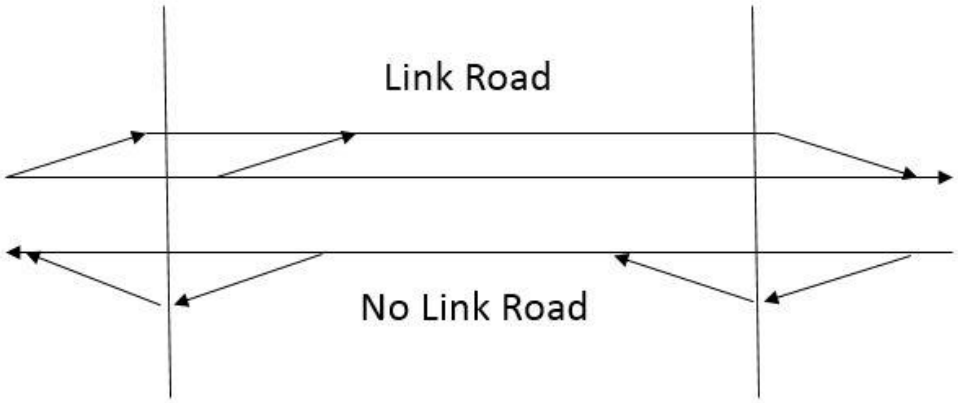
Minimum length of weaving sections

4.5 For rural roads, the minimum weaving section length shall be:

1) 2 km for motorways; and,
2) 1 km for all-purpose roads.

NOTE *Where the minimum weaving section length cannot be provided between two closely spaced grade separated junctions, the need for a weaving section can be eliminated by the inclusion of link roads between the junctions, as illustrated in Figure 4.5N.*

Figure 4.5N Indicative link road layout



4.6 For urban roads, the minimum weaving section length shall be the greater of:

1) the minimum weaving section length from Figure 4.6a based on the design speed; and,
2) the minimum weaving section length from Figure 4.6b based on the design flows.

Figure 4.6a Minimum weaving length for urban roads based on design speed

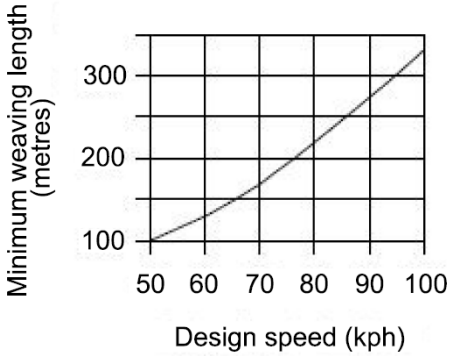
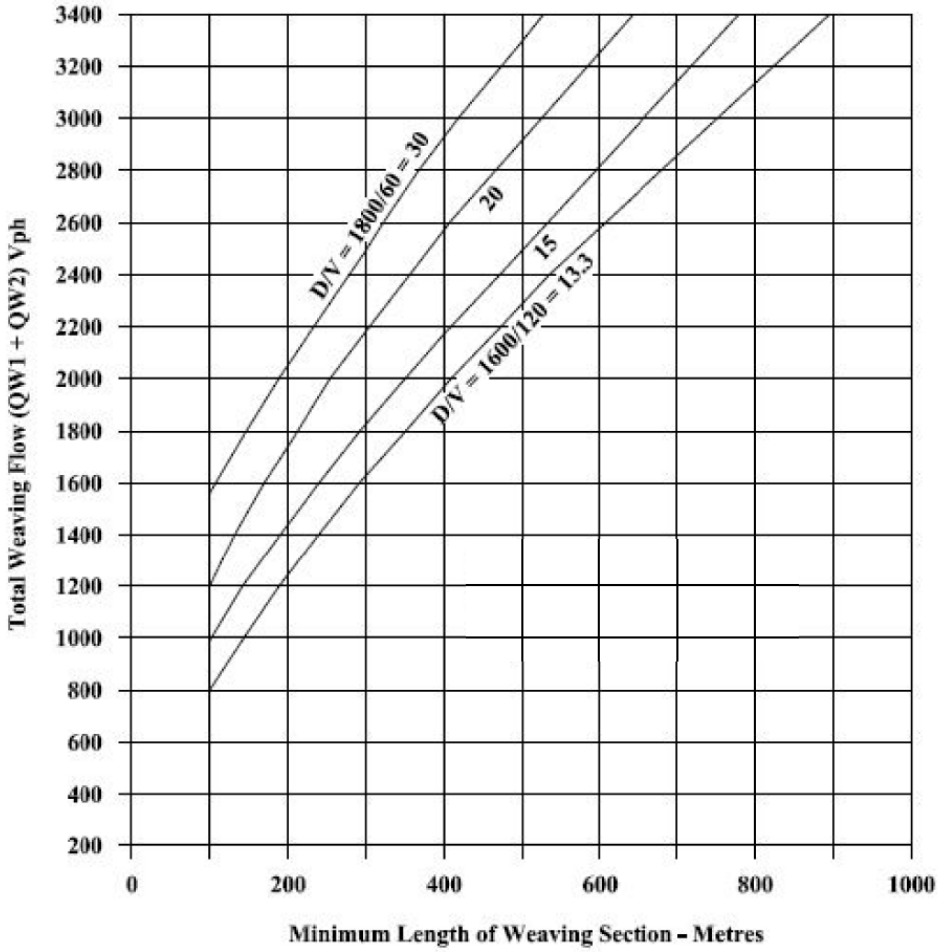


Figure 4.6b Minimum weaving section length for urban roads based on design flows



NOTE 1 *In Figure 4.6b, D is the maximum mainline flow (based on 1,800 vph per lane for motorways or 1,600 vph per lane for all-purpose roads) and V is the design speed of the mainline upstream of the weaving section.*

NOTE 2 *For urban roads, the design flows are adjusted for uphill gradients and the presence of HGVs by using Table 3.9a.*

NOTE 3 *Refer to Fig 4.7N5 for calculating QW1 + QW2.*

NOTE 4 *When determining the appropriate spacing between successive merges and diverges, it is necessary to consider whether the spacing is sufficient to accommodate the necessary advance directional signage.*

Weaving section lanes calculation

4.7 The number of lanes to be provided within a weaving section shall be calculated using Equation 4.7.

Equation 4.7 Number of traffic lanes required for weaving

$$N = \frac{1}{D}\left(Q_{nw} + Q_{w1} + Q_{w2}\left(2\frac{L_{\min}}{L} + 1\right)\right)$$

where:

N	Number of traffic lanes
Q_{nw}	Total non-weaving flow in vph
Q_{w1}	Major weaving flow in vph
Q_{w2}	Minor weaving flow in vph
D	Maximum capacity of a single mainline lane: 1) 1,800 vph for motorways 2) 1,600 vph for all-purpose roads
L_{min}	Minimum weaving length for the road class
L	Actual (measured) weaving length available

NOTE 1 The principle of the weaving section lanes calculation is that the weaving length is fixed based on road type and the carriageway width is calculated from the lane formula. The purpose of this is to establish the need for the addition of one or two auxiliary lanes.

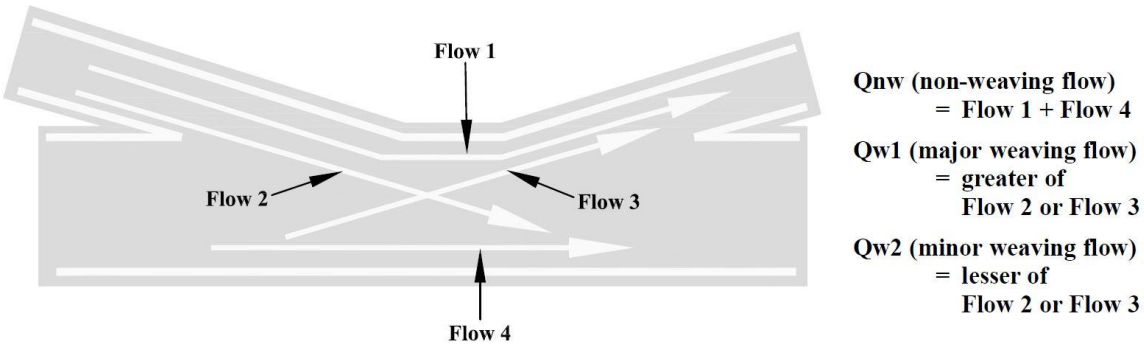
NOTE 2 For the purpose of the calculation the 'available weaving length' is never less than the 'minimum weaving length'.

NOTE 3 The purpose of calculating lanes for weaving sections is to determine whether any additional lanes are needed over and above those provided for in Figures 3.12a, 3.12b. 3.26a and 3.26b.

NOTE 4 For weaving sections on motorways and dual carriageway roads, design flows are calculated as indicated in Section 3.

NOTE 5 The flows Q_{nw}, Q_{w1} and Q_{w2} are formed as indicated in Figure 4.7N5.

Figure 4.7N5 Flow terms used in weaving



4.7.1 Where the calculation of the number of traffic lanes required results in a fractional number of lanes, the number of lanes should be rounded up where the fractional part is 0.5 or greater.

4.7.2 Where the calculation of the number of traffic lanes required results in a fractional number of lanes, the number or lanes should be rounded up or down where the fractional part is less than 0.5 based on:

1) the number of lanes required on the merge or diverge connector roads;

2) whether the route is likely to be used by a high proportion of drivers who can be unfamiliar with the layout and therefore weave less efficiently, such as routes associated with tourist destinations;
3) the potential for future growth and the need for greater provision at a later date; and/or,
4) environmental constraints.

5. Connector roads

Full grade separated connector road geometry

5.1 Two-way slip roads shall be in the form of a dual carriageway with opposing traffic separated by a physical central reserve with vehicle restraint system.

5.2 Direct accesses and priority junctions shall not be provided on connector roads.

5.3 Single-lane interchange links shall only be provided:

1) where their length does not exceed 1 km and they are on an average uphill gradient of up to 3%, are level or on a downhill gradient; and,
2) where their length does not exceed 0.5 km and they are on an average uphill gradient of 3% or steeper.

Design speed, horizontal and vertical geometry and superelevation

5.4 The minimum design speeds for connector roads shall be in accordance with Table 5.4.

Table 5.4 Connector road design speed

		Mainline design speed			
		Urban 100 kph	Urban 85 kph	Rural 120 kph	Rural 100A kph
Connector road design speed (kph)	Interchange link	70	70	85	85
	Slip road	60	60	70	70
	Link road	100 or 85, see 5.4.1	85 or 70, see 5.4.1	120 or 100A, see 5.4.1	100A or 85, see 5.4.1
	Dumb-bell link road	70	70	70	70

NOTE *CD 109 [Ref 3.N] provides the base geometric parameters for the design speeds.*

5.4.1 On link roads the lower design speed in Table 5.4 should only be used where an appropriate mandatory or advisory speed limit is signed.

5.5 A slip road longer than 0.75 km shall be designed as an interchange link.

5.6 Any transition curves at locations where the design speed changes shall be designed to the higher design speed value.

5.7 On connector roads linking to motorways the longitudinal gradient shall not exceed 6%.

5.7.1 Diverge and merge slip roads should be on uphill and downhill gradients respectively.

NOTE *Uphill diverges help diverging traffic reduce their speeds on the approach to the end of the slip road and downhill merges help merging traffic accelerate to the mainline speed.*

5.8 Connector roads shall include a near straight at the back of nose, at least equal in length to the nose.

NOTE 1 *Nose lengths are given in Table 3.21 and Table 3.31 for merges and diverges, respectively.*

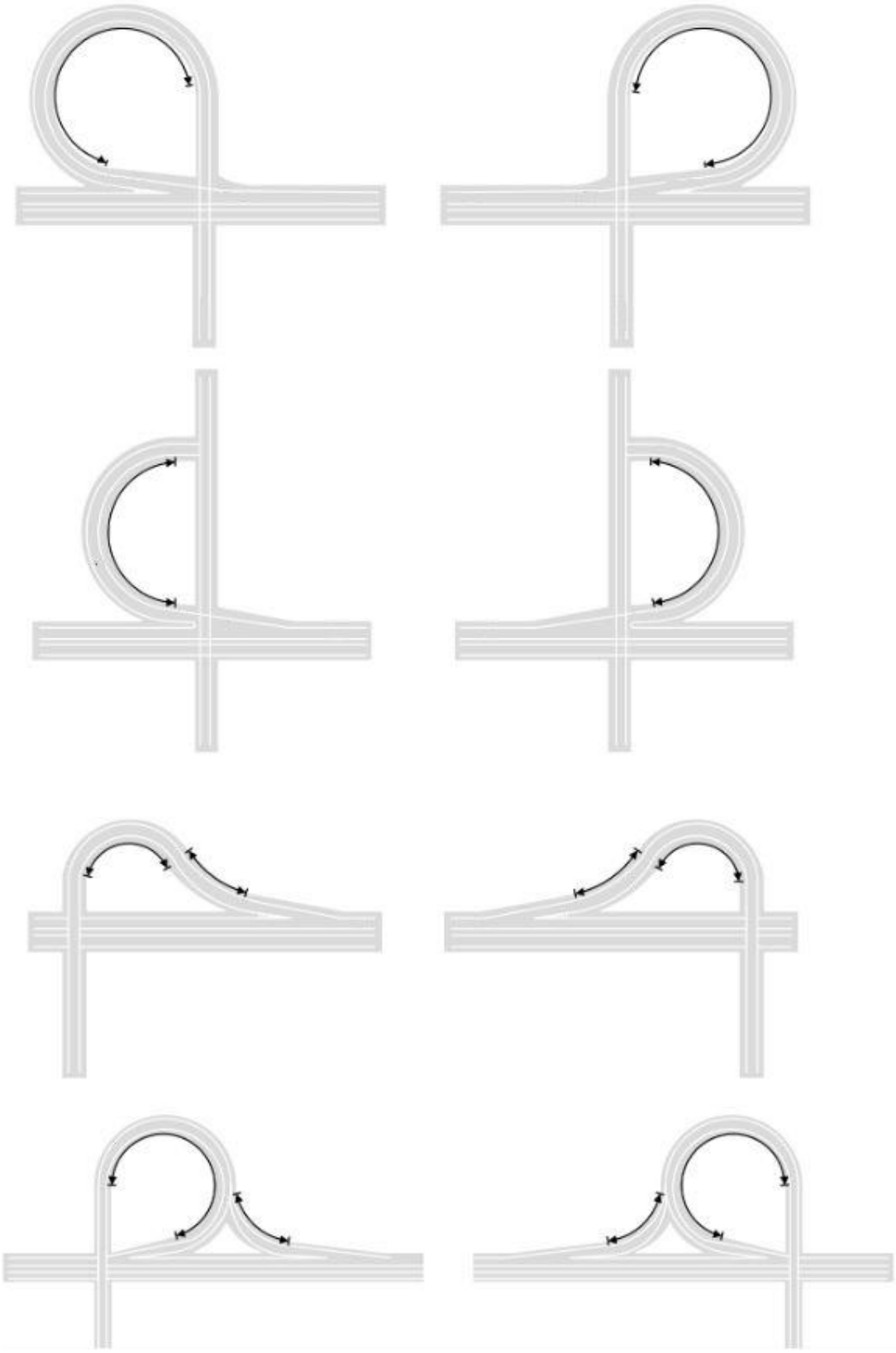
NOTE 2 *Near straights allow drivers to better match their speed to the mainline when merging, and assist drivers to comprehend the layout ahead and adjust their speed accordingly.*

5.9 Connector road loops shall only be provided where they connect to the start/end of the near straight, as illustrated in Figure 5.10N.

5.10 The minimum radii that shall be provided for connector road loops are:

1) 75 metres for loops on to or off a motorway;
2) 30 metres for loops on to an all-purpose carriageway; and,
3) 50 metres for loops off an all-purpose carriageway.

Figure 5.10 Loop layouts (extent of loops indicated by arrows)



5.11 On connector road loops, successively reducing radii of the same direction shall not be used.

5.12 On connector road loops, superelevation shall not exceed 10%.

5.12.1 On connector road loops, superelevation should not exceed 7% where there is a risk of prolonged icy conditions.

NOTE *Further requirements and guidance on superelevation are provided in CD 109 [Ref 3.N] .*

Stopping sight distance/visibility

5.13 Minimum SSD shall be provided in accordance with the connector road design speed.

NOTE *The minimum connector road SSD is determined by the SSD requirements on the merge or diverge as outlined in Section 3.*

5.14 For loops there shall be no obstruction to sight lines across the full extent of loops, including where they connect to the main carriageway, except where a vehicle restraint system obstructs the view to the 0.26 metre object height

NOTE *A clear view across the extent of the loop ensures that drivers are able to perceive the whole of the loop layout on their approach to it and adjust their speed accordingly.*

5.15 For loops, where a vehicle restraint system obstructs the view to the 0.26 metre object height, a low object height of 1.05 m shall be used.

5.16 At a dumb-bell junction, where the distance between the two roundabouts is less than the desirable minimum SSD for the design speed of the connecting link road, a low (0.26-metre) object at the give way line of the next roundabout shall be visible from a vehicle as it leaves the circulatory carriageway of the previous roundabout.

Cross-sections

5.17 The minimum connector road cross section based on the design traffic flow ranges shall be in accordance with Tables 5.17a and 5.17b.

Table 5.17a Cross-sections for connector roads to/from mainline all-purpose roads

	Adjusted connector road flow (vph)			
	0-800	801-1200	1201-2400	2401-3200
Merge (rural)	MG1C		MG2E	
Merge (urban)	MG1D		MG2F	
Diverge (rural)	DG1C	DG2E		
Diverge (urban)	DG1D	DG2F		
Interchange link/loop (rural)	IL1C or IL2C (see clause 5.3)		IL2C	
Interchange link/loop (urban)	IL1D or IL2D (see clause 5.3)		IL2D	

Table 5.17b Cross-sections for connector roads to/from mainline motorways

	Adjusted connector road flow (vph)			
	0-900	901-1350	1351-2700	2701-3600
Merge (rural)	MG1A		MG2C	
Merge (urban)	MG1B		MG2D	
Diverge (rural)	DG1A	DG2A		DG2C
Diverge (urban)	DG1B	DG2B		DG2D
Interchange link/loop (rural)	IL1A or IL2A (see clause 5.3)		IL2A	
Interchange link/loop (urban)	IL1B or IL2B (see clause 5.3)		IL2B	

NOTE 1 Cross sectional layouts are given in CD 127 [Ref 1.N] for each connector road type.

NOTE 2 Design flow (vehicles per hour) are adjusted for gradients and HGVs (see Section 3).

5.18 Lane widening on curves shall be applied to connector road curves with radii of 400 metres or less.

NOTE 1 Lane widening on curves requirements for radii greater than 100 metres up to 400 metres are given in CD 109 [Ref 3.N] .

NOTE 2 Lane widening on requirements for radii of 100 metres or less are given in CD 123 [Ref 2.N] .

Compact connector road geometry

Design speed, horizontal and vertical geometry and superelevation

5.19 The design of compact connector roads shall meet or exceed the minimum geometrical parameter values given in Table 5.19.

Table 5.19 Compact connector road geometrical parameters

Parameter	Minimum value
Horizontal curvature	32 metres
Crest curve (k)	2.3
Sag curve (k) with road lighting	2.3
Sag curve (k) without road lighting	3.2

NOTE The geometrical parameters for compact connector road broadly align with a design speed of 30 kph.

5.19.1 The minimum horizontal curvature of a compact connector road should be 40 metres.

5.19.2 The minimum crest curve (k) of a compact connector road should be 3.3.

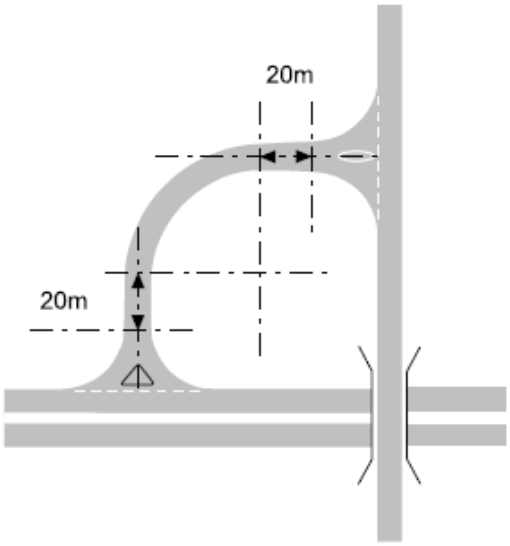
5.20 The maximum vertical gradient of a compact connector road shall be 10%.

5.20.1 The maximum vertical gradient of a compact connector road should be 8%.

5.20.2 Where cyclists are being catered for, the maximum vertical gradient of a compact connector road should be 5%.

5.21 A minimum 20 metres straight section shall be provided at the start and end of compact connector roads prior to formation of the priority junctions, as illustrated in Figure 5.21.

Figure 5.21 Compact connector road start and end straight sections



5.22 Straight sections longer than the 100m within the compact connector road shall not be used, except where they form the connector road linking two minor roads across the mainline (as illustrated on Figure 5.24.1Nb).

NOTE *The inclusion of long straight sections can lead to increased speed of vehicles through the compact connector road.*

5.22.1 Transition curves may be omitted on compact connector roads due to their low speed nature.

5.22.2 The design of a compact grade separated junction should avoid rapid changes in crossfall (through the combined effect of the gradient and superelevation), as this can result in sudden shifts in high loads.

NOTE *The geometric layout of the compact connector road requires successive application and removal of the superelevation between the connector road and the junction mouths.*

5.23 The maximum superelevation on a compact connector road shall be 5%.

Stopping sight distance/visibility

5.24 The minimum SSD that shall be provided on a compact connector road is:

1) 50 metres on a compact connector road linking the mainline and minor road; or,
2) 26 metres on a compact connector road linking two minor roads.

5.24.1 The minimum SSD that should be provided on a compact connector road is:

1) 70 metres on a compact connector road linking the mainline and minor road; or,
2) 33 metres on a compact connector road linking two minor roads.

NOTE *The extents of a compact connector road linking the mainline and minor road is illustrated in Figure 5.24.1Na, and the extents of a compact connector road linking two minor roads is illustrated in Figure 5.24.1Nb.*

Figure 5.24.1Na Compact connector road linking the mainline and minor road (extent of compact connector roads illustrated by arrows)

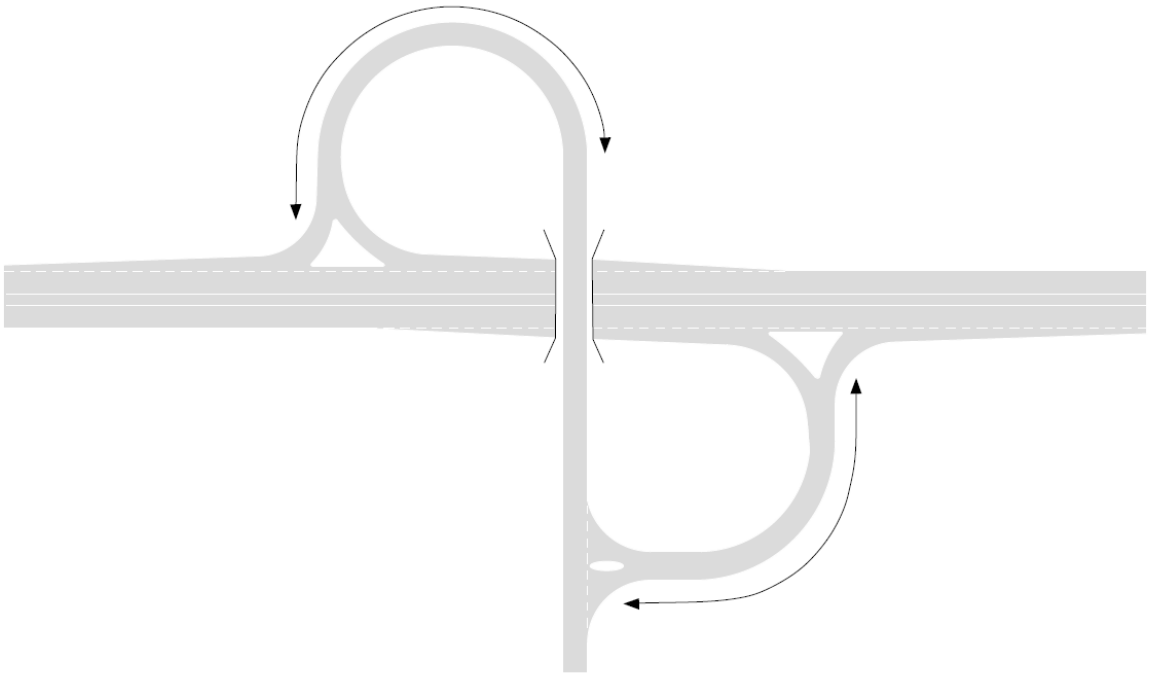
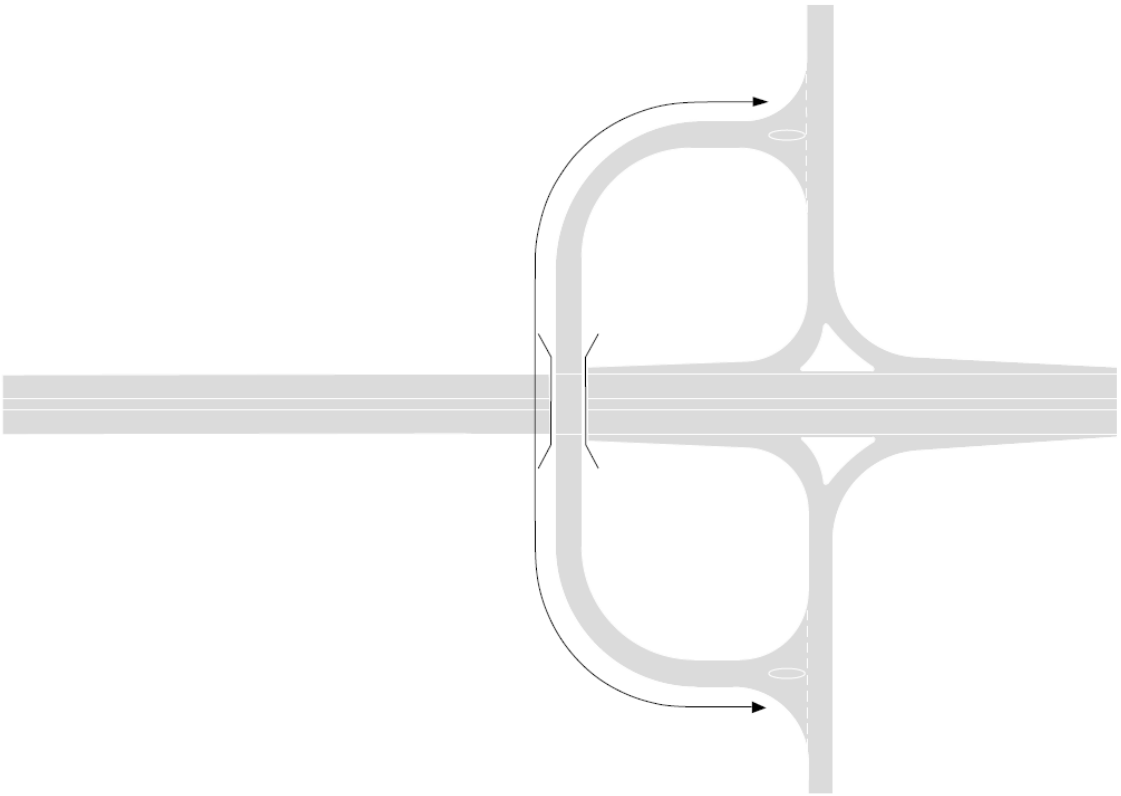


Figure 5.24.1Nb Compact connector road linking two minor roads (extent of compact connector road illustrated by arrows)



Cross-section and widening

5.25 Compact connector roads lane widths, excluding any carriageway widening, shall be in accordance with Table 5.25 based on the minor carriageway width.

Table 5.25 Compact connector lane widths

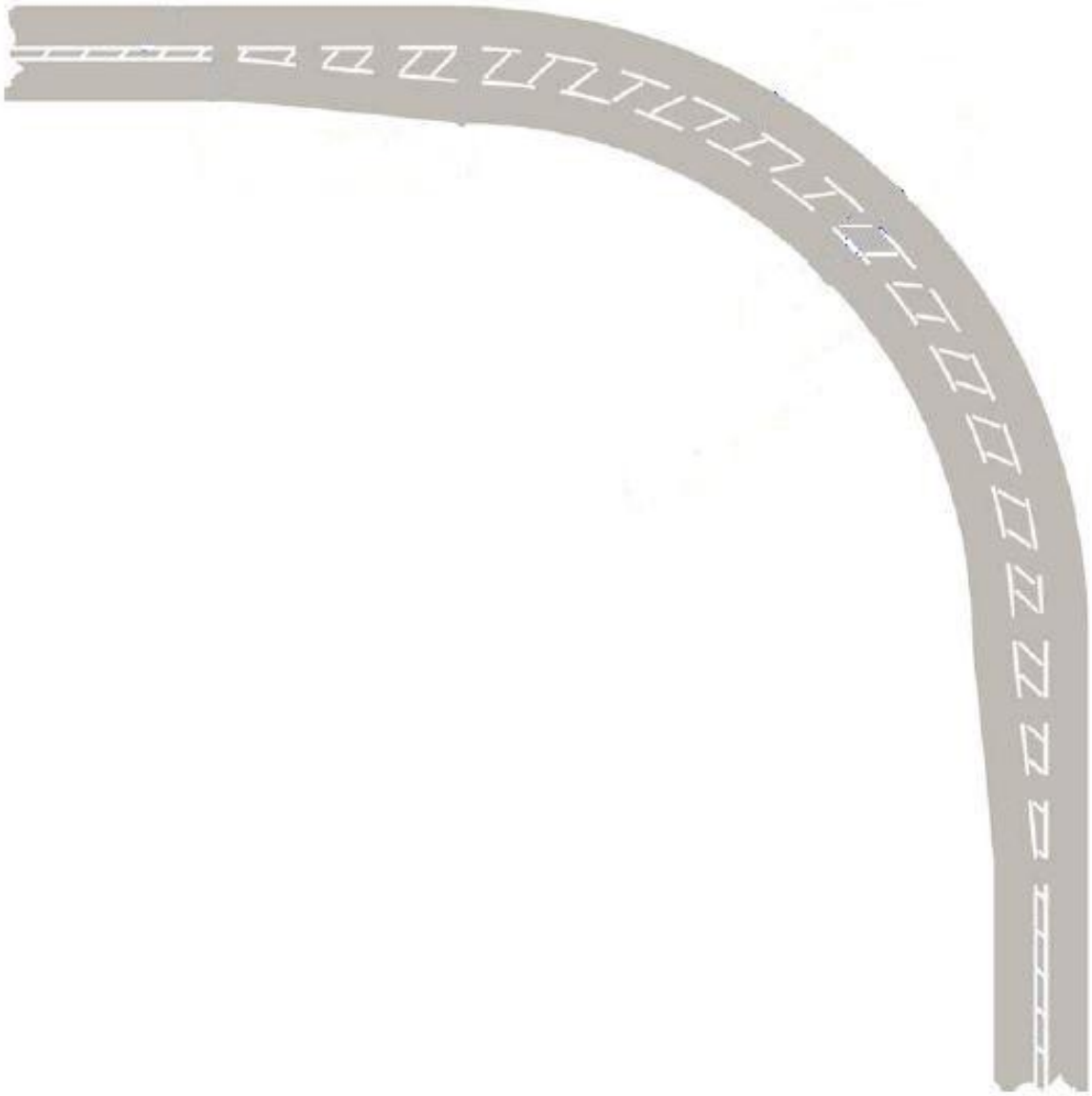
Minor road lane widths (metres)	Compact connector road lane widths (metres)
3.0 or less	3.0
Between 3.0 and 3.65	3.3
3.65 or greater	3.65

NOTE *Carriageway widths for the compact connector road provide a change in standards from the major carriageway width to the minor carriageway width.*

5.26 Where 2-way compact connector roads have a horizontal radius they shall include a minimum 0.6 metre central hatching. (This is in addition to the lane widths given in Table 5.25).

5.27 Widening of compact connector roads shall be applied within central hatching as illustrated in Figure 5.27.

Figure 5.27 Central hatching curve widening



5.27.1 Compact connector roads should be widened in accordance with CD 123 [Ref 2.N] lane widening on curves , with the widening applied within the central hatching (as illustrated in Figure 5.27).

5.28 Hard strips shall not be provided within a compact connector road.

6. 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	National Highways. CD 123, 'Geometric design of at-grade priority and signal-controlled junctions'
Ref 3.N	Highways England. CD 109, 'Highway link design'
Ref 4.N	National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 5.N	TSO. Department for Transport. TSM Chapter 5, 'Traffic Signs Manual Chapter 5 - Road Markings'

7. Informative references

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

Ref 1.I	Highways England. CD 195, 'Designing for cycle traffic'
Ref 2.I	Highways England. CD 143, 'Designing for walking, cycling and horse riding (vulnerable users)'
Ref 3.I	Highways England. CD 116, 'Geometric design of roundabouts'
Ref 4.I	The National Archives. legislation.gov.uk. SI 2016 No.362 (TSRGD), 'The Traffic Signs Regulations and General Directions 2016'

Appendix A. Examples of full grade separated junction layouts

A1 Diamond

A diamond layout includes slip roads leading to/from two staggered priority junctions. The advantages of this layout are minimised land from certain quadrants of the junction, conventional slip roads (rather than loops, which are necessary with half-cloverleaf layouts) and the requirement for only one bridge.

The disadvantage is that there are a number of conflict points on the minor road resulting from the staggered junctions. It is also necessary to evaluate the risk of road users turning into an off-slip from the minor road when considering a diamond layout.

Due to the staggered priority junctions, diamond layouts are unsuitable to cater for high mainline merging and diverging flows and can also be unsuitable where there are high ahead flows on the minor road.

Figure A.1 and Figure A.2 illustrate a diamond layout and a half-diamond layout and the traffic flow movements they cater for.

Figure A.1 Typical layouts of grade separated junctions - diamond

Figure A.2 Typical layouts of grade separated junctions - half diamond

A2 Half-cloverleaf

A half-cloverleaf layout includes 2-way slip roads leading to/from two priority junctions on the minor road. They can be useful at locations where it is not practical to provide slip roads in all four quadrants of the junction.

An advantage of a half-cloverleaf layout is that they include less conflict points compared to a diamond layout; however, a higher concentration of the turning movements occurring at the same point. A disadvantage of half-cloverleaf layouts is that they necessitate greater slip road curvature and loops compared to diamond layouts.

A half-cloverleaf layout caters for similar flow levels to a diamond layout and they are therefore unsuitable for high mainline merging and diverging flows. They can also be unsuitable where there are high ahead flows on the minor road.

Figure A.3 and Figure A.4 illustrate half-cloverleaf layouts with the slip roads provided in alternative quadrants and the traffic flow movements they cater for.

Figure A.3 Typical layout of grade separated junction - half-cloverleaf quadrants 1 and 3

Figure A.4 Typical layout of grade separated junction - half-cloverleaf quadrants 2 and 3

A3 Dumbbell roundabout

A dumbbell roundabout layout includes slip roads leading to/from two roundabouts. In relation to traffic flow capacity, a dumbbell roundabout layout can be considered an intermediate between the diamond/half-cloverleaf and the two bridge roundabout layouts.

The dumb-bell roundabout has the advantage of requiring less land than both the diamond and the two bridge roundabout layouts. It also requires only one bridge.

It is important to ensure that the link road between the two roundabouts can provide queuing storage capacity otherwise queuing could extend back onto the roundabouts.

Requirements and advice on the geometric design of the roundabout elements of this layout are provided in CD 116 [Ref 3.I] .

Figure A.5 illustrates a dumbbell roundabout layout.

Figure A.5 Roundabout - dumbbell configuration (one bridge & two roundabouts)

A4 Two-bridge roundabout

The most common grade separated junction layout is the the two-bridge roundabout. They provide greater traffic flow capacity than the dumbbell roundabout layout and are less complex from a road user perspective. They do however require two bridges and have a greater footprint.

Requirements and advice on the geometric design of the roundabout elements of this layout are provided in CD 116 [Ref 3.I] .

Figure A.6 illustrates a two bridge roundabout layout.

Figure A.6 Roundabout - 2-bridge configuration

A5 Interchanges

A5.1 4-way, 3-level interchange

Where two major roads cross, a 3-level arrangement with a roundabout can be provided as an alternative to a full interchange where volumes of turning traffic allow. Its advantages are that both the overall land take and the carriageway area are reduced when compared to a full interchange with entirely free flow link roads.

The disadvantages are that this layout requires a relatively high number of structures and if the turning movements exceed capacity, operational problems such as queuing on the roundabout entries can occur. If queuing does become a problem, segregated left-turn lanes and restricted circulatory carriageway width could be provided, or signalisation if the aforementioned would not suffice.

Figure A.7 illustrates a 4-way, 3-level interchange layout

Figure A.7 3-level roundabout

A5.2 4-way, 2-level 'cyclic' interchange

A 2-level 'cyclic' interchange utilises reverse curves. The land take is extensive however and it requires a relatively high number of structures. One particular disadvantage is that it requires separate diverge points for left and right movements from both mainlines, which can be complex to sign. The illustration in Figure A.8 shows two successive diverges off and one merge on to the mainline. A variant of this uses one diverge and two merges but the distance between the merges needs to be as great as possible to avoid potential conflicts. One principal connection on the mainline for the diverge, and one for the merge, is the preferred option with the final route selection occurring on the slip road as this reduces weaving on the mainline.

Figure A.8 4-way, 2-level cyclic interchange

A5.3 4-way, 4-level interchange

A 4 level interchange layout has the advantages of reduced land take, absence of loops and a low number of structures; however, it can be visually intrusive due to its overall height.

Figure A.9 illustrates a 4-way, 4-level interchange layout.

Figure A.9 4-way, 4-level interchange layout

A5.4 4-way, 2-level interchange

A 4-way, 2-level interchange layout, as illustrated in Figure A.10, is an alternative to the 4-level option shown in Figure A.8. It is less visually intrusive, but has a larger land take and larger carriageway area. Another disadvantage is that it includes loops.

Figure A.10 4-way restricted height interchange

A5.5 3-way interchanges

A5.5.1 3-way, 2-level 'trumpet'

A 3-way, 2-level 'trumpet' interchange has 2-way slip roads. It is not suitable for motorway-to-motorway links or generally high-speed approaches to the loop from the minor road. As the minor road could be of a lesser standard to the major road, careful consideration is needed in relation to signing and preventing unauthorised users (in the case of the major road being a motorway) from entering the major road.

A 3-way, 2-level 'trumpet' is illustrated in Figure A.11.

Figure A.11 3-way, 2 -evel 'Trumpet' interchange

A5.5.2 3 way, 2 level restricted movement 'trumpet'

Figure A.12 shows a 3-way, 2-level 'trumpet' interchange with restricted movement. It has one-way slip roads and enables higher vehicle speeds to be maintained with low land take. With the correct horizontal curvature and merge/diverge arrangement this can be suitable for motorway to motorway links.

Figure A.12 3-way, 2-level restricted movement 'Trumpet' interchange

A5.5.3 3-way, 2-level unrestricted 'T'

The 3-way, 2-level unrestricted 'T' layout, as illustrated in Figure A.13 caters for all movements in free-flow conditions.

Figure A.13 3-way free-flow 'T' layout

A5.5.4 3 leg 'Y' interchange with link roads

Figure A.1 4 illustrates a potential solution for an interchange where the roads join at a acute angle and there is a need to incorporate link roads.

Figure A.14 3-leg 'Y' interchange of 2 motorways with mainline motorway and link roads

Road Layout
Design

CD 122
England National Application Annex to CD 122 Geometric design of grade separated junctions

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

Version 0.1.0

Summary
This National Application Annex sets out the National Highways-specific requirements for the geometric design of grade separated junctions.

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 122	0.**1**.0	November 2021	Core document, England NAA	Incremental change to requirements
3-lane diverges section deleted as a result of diverge Layout G moving to the main body of CD 122, plus minor wording improvements/corrections.				

Previous versions

Document code	Version number	Date of publication of relevant change	Changes made to	Type of change
CD 122	0	August 2019		

Foreword

Publishing information

This document is published by National Highways.

This document supersedes those parts of IAN 149/17, IAN 161/15 and IAN 198/17 relating to the geometric design of grade separated junctions.

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 National Highways-specific requirements and additional relaxations relating to the geometric design of grade separated junctions 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 in England.

This National Application Annex is to be used in conjunction with CD 122 [Ref 1.N] and GD 301 [Ref 3.N].

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
SM	Smart motorway

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.

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 122 [Ref 1.N].

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.

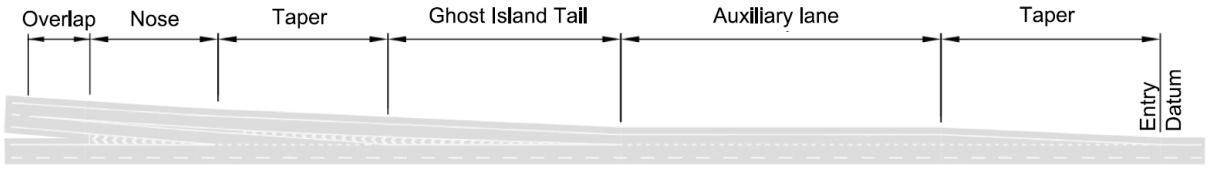
Geometric parameters

Merge layouts (CD 122 3.12 and 3.21)

E/1.3 CD 122 3.12 shall be used to derive the appropriate merge layout; however, for existing motorways, the derived merge layout can be amended by only one of the following options:

1) the road class in CD 122 Table 3.21 can be relaxed to 'rural all-purpose 120kph'; or,
2) the CD 122 layout can be substituted as described below:
   a) Layout D can be used instead of Layout E1 and E2;
   b) Layout B, A1 or A2 can be used instead of Layout C; and,
   c) Layout A1 or A2 can be used instead of Layout B; or,
3) where no lane gains are to be introduced the CD 122 layout can be substituted as described below:
   a) Layout B can be used instead of Layout D; and,
   b) Layout C or Layout E3 (see Figure E/1.3) can be used instead of Layout E1 and E2.

Figure E/1.3 Layout E Option 3 - ghost island merge with auxiliary lane



NOTE *The combination of a reduction in road class and a substitute layout is not permitted.*

E/1.3.1 Where the road class is reduced, the design parameters may be a combination of 'rural all-purpose 120kph' and 'rural motorway' standard to maximise the capacity of the merge layout.

Merge datum points (CD 122 3.5)

E/1.4 The merge datum point for Layout E option 3 shall be the end of the downstream taper, as illustrated in Figure E/1.3.

Diverge layouts (CD 122 3.26 and 3.31)

E/1.5 CD 122 3.26 shall be used to derive the appropriate diverge layout; however, for existing motorways, the derived diverge layout can be amended by relaxing the road class in CD 122 Table 3.31 to 'rural all-purpose 120kph'.

E/1.5.1 Where the road class is reduced, the design parameters may be a combination of 'rural all-purpose 120kph' and 'rural motorway' standard to maximise the capacity of the diverge layout.

Stopping sight distance (CD 122 3.23, 3.24, 3.25, 3.33, 3.34, 5.13 and 5.14)

E/1.6 The minimum stopping sight distance to be provided on existing motorway connector roads shall be equal to or greater than the existing provision.

E/1.6.1 The stopping sight distance to be provided on existing motorway connector roads should be as close as practicable to the requirements of CD 122.

E/1.6.2 Where the stopping sight distance on an existing motorway connector road is less than the minimum required for that class of road, the existing provision should only be retained if a review of the operational performance does not highlight a problem with it.

Near straights (CD 122 5.8)

E/1.7 The near straight length to be provided at an existing motorway slip road shall be equal to or greater than the existing provision.

NOTE *The existing near straight provision could be no near straight at all.*

E/1.7.1 Adjoining near straight and nose lengths to be provided at an existing motorway slip road may be different.

E/1.7.2 The near straight length to be provided at an existing motorway slip road should be as close as practicable to the requirements of CD 122.

E/1.7.3 Where the length of near straight at an existing motorway slip road is less than the minimum required for that class of road, the existing provision should only be retained if a review of the operational performance does not highlight a problem with it.

Weaving lengths (CD 122 4.2, 4.3 and 4.5)

E/1.8 The minimum weaving length to be provided on an existing motorway shall be equal to or greater than the existing provision.

E/1.8.1 The weaving length to be provided on an existing motorway should be as close as practicable to the requirements of CD 122.

E/1.8.2 Where the weaving length on an existing motorway is less than the length derived from CD 122 Figure 4.6b, options for reducing or eliminating weaving should be assessed and implemented where practicable.

NOTE *The need for a weaving section can be eliminated through the use of link roads.*

E/2. Modifying existing 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 122.

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.

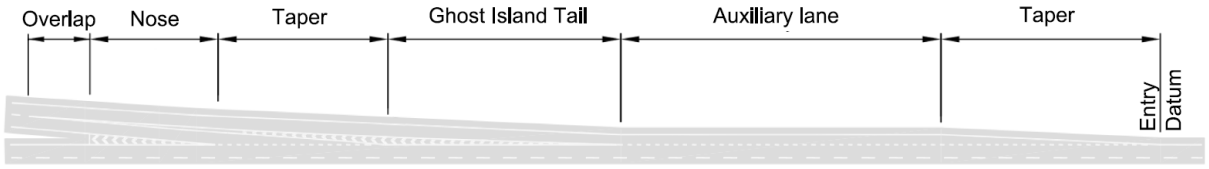
Geometric parameters

Merge layouts (CD 122 3.12 and 3.21)

E/2.3 CD 122 3.12 shall be used to derive the appropriate merge layout; however, for existing dual carriageways, the derived merge layout can be amended by only one of the following options:

1) the road class in CD 122 Table 3.21 can be relaxed to 'urban road speed limit 60 mph'; or,
2) the CD 122 layout can be substituted as described below:
   a) Layout D can be used instead of Layout E1 and E2;
   b) Layout B, A1 or A2 can be used instead of Layout C;
   c) Layout A1 or A2 can be used instead of Layout B; or
3) where no lane gains are to be introduced, the CD 122 layout can be substituted as described below:
   a) Layout B can be used instead of Layout D;
   b) Layout C or Layout E3 can be used instead of Layout E1 and E2.

Figure E/2.3 Layout E option 3 - ghost island merge with auxiliary lane



NOTE *The combination of a reduction in road class and a substitute layout is not permitted.*

E/2.4 When reducing the merge parameters from 'rural all-purpose' to those of 'urban road speed limit 60 mph', only the auxiliary lane length, entry taper and nose length dimensions shall be reduced.

E/2.5 When reducing the merge parameters from 'rural all-purpose' to those of 'urban road speed limit 60 mph', the auxiliary lane length shall be reduced first before reducing the lengths of entry taper and nose length.

E/2.5.1 Where the road class is reduced, the design parameters may be a combination of 'urban road speed limit 60 mph' and 'rural all-purpose' standard to maximise the capacity of the merge layout.

Merge datum points (CD 122 3.5)

E/2.6 The merge datum point for Layout E option 3 shall be the end of the downstream taper, as illustrated in Figure E/2.3.

Diverge layouts (CD 122 3.26 and 3.31)

E/2.7 CD 122 3.26 shall be used to derive the appropriate diverge layout; however, for existing dual carriageways, the derived diverge layout can be amended by relaxing the road class in CD 122 Table 3.31 to 'Urban Road Speed Limit 60mph'.

E/2.8 When reducing the diverge parameters from 'rural all-purpose' to those of 'urban road speed limit 60 mph', the length of ghost island head shall be reduced first before reducing the lengths of the other parameters in the following order:

1) length of exit taper 1-lane and 2-lane;
2) length of auxiliary lane taper;
3) minimum auxiliary lane length; and,
4) nose length.

E/2.8.1 Where the road class is relaxed the design parameters may be a combination of 'urban road speed limit 60mph' and 'rural all-purpose' standard to maximise the capacity of the diverge layout.

Stopping sight distances (CD 122 3.23, 3.24, 3.25, 3.33, 3.34, 5.13 and 5.14)

E/2.9 The minimum stopping sight distance to be provided on existing dual carriageway connector roads shall be equal to or greater than the existing provision.

E/2.9.1 The stopping sight distance to be provided on existing dual carriageway connector roads should be as close as practicable to the requirements of CD 122.

E/2.9.2 Where the stopping sight distance on an existing dual carriageway connector road is less than the minimum required for that class of road, the existing provision should only be retained if a review of the operational performance does not highlight a problem with it.

Near straights (CD 122 5.8)

E/2.10 The near straight to be provided at an existing dual carriageway slip road shall be equal to or greater than the existing provision.

NOTE *The existing near straight provision could be no near straight at all.*

E/2.10.1 Adjoining near straight and nose lengths to be provided at an existing dual carriageway slip road may be different.

E/2.10.2 The near straight length to be provided at an existing dual carriageway slip road should be as close as practicable to the requirements of CD 122.

E/2.10.3 Where the length of near straight at an existing dual carriageway slip road is less than the minimum required for that class of road, the existing provision should only be retained if a review of the operational performance does not highlight a problem with it.

Weaving lengths (CD 122 4.2, 4.3 and 4.5)

E/2.11 The minimum weaving length provided on an existing dual carriageway shall be equal to or greater than the existing provision.

E/2.11.1 The weaving length to be provided on an existing dual carriageway should be as close as practicable to the requirements of CD 122.

E/2.11.2 Where the weaving length on an existing dual carriageway is less than the length derived from CD 122 Figure 4.6b, options for reducing or eliminating weaving should be assessed, and implemented where practicable.

NOTE *The need for a weaving section can be eliminated through the use of link roads.*

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 (SM).

E/3.2 Where a new junction is proposed as part of the upgrade of an existing motorway to a SM, the parameters in section E/3 shall not be used to design the new elements of that junction, e.g. the slip roads, with the exception of the E/3 merge overrun section.

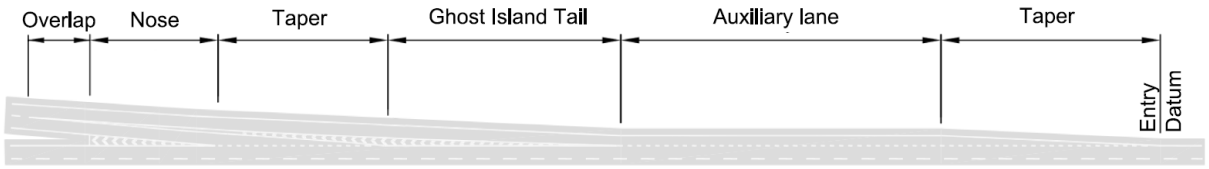
Geometric parameters

Merge layout (CD 122 3.12 and 3.21)

E/3.3 CD 122 3.12 shall be used to derive the appropriate merge layout; however, for SM schemes, the derived merge layout can be amended by only one of the following options:

1) the road class in CD 122 Table 3.21 can be relaxed to 'rural all-purpose 120kph'; or
2) the CD 122 layout can be substituted as described below:
   a) Layout D or E3 can be used instead of Layout E1 and E2; or,
   b) Layout B, A1 or A2 can be used instead of Layout C; or,
   c) Layout A1 or A2 can be used instead of Layout B;
3) where no lane gains are to be introduced, the CD 122 layout can be substituted as described below:
   a) Layout B can be used instead of Layout D.
   b) Layout C or Layout E3 (see Figure E/3.3) can be used instead of Layout E1 and E2.

Figure E/3.3 Layout E option 3 - ghost island merge with auxiliary lane



NOTE *The combination of a reduction in road class and a substitute layout is not permitted.*

E/3.3.1 Where the road class is reduced, the design parameters may be a combination of 'rural all-purpose 120kph' and 'rural motorway' standard to maximise the capacity of the merge layout.

E/3.4 The merge nose width must accommodate the hatched road marking to SI 2016 No.362 (TSRGD) [Ref 4.N] diagram 1042 (Schedule 9 Part 6 Item 22); however, a ratio that differs from that defined in CD 122 Table 3.21 is permissible.

Merge datum points (CD 122 3.5)

E/3.5 The merge datum point for Layout E option 3 shall be the end of the downstream taper, as illustrated in Figure E/3.3.

Merge overrun

E/3.6 Where non-lane gain merges are to be provided, the need for merge overrun shall be assessed.

E/3.6.1 The merge overrun assessment should include monitoring of the existing non-lane gain merge (where applicable) and consultation with the relevant regional operations team to determine if there are any known merging issues with the existing layout.

E/3.6.2 Where the merge overrun assessment indicates the need for overrun provision, this should be provided.

Diverge layout (CD 122 3.26 and 3.31)

E/3.7 CD 122 3.26 shall be used to derive the appropriate diverge layout; however, for SM schemes, the derived diverge layout can be amended by either of the following methods:

1) the road class in CD 122 Table 3.31 can be relaxed to the 'Rural All-Purpose 120kph'; or,
2) the CD 122 layout can be substituted for any other layout, with the exception of:
   a) Layout A, B or C cannot be used instead of Layout E; and,
   b) Layout A cannot be used instead of Layout D.

NOTE *The combination of a reduction in road class and a substitute layout is not permitted.*

E/3.7.1 Where the road class is reduced, the design parameters may be a combination of 'rural all-purpose 120kph' and 'rural motorway' standard to maximise the capacity of the merge layout.

E/3.8 The diverge nose width must accommodate the hatched road marking to SI 2016 No.362 (TSRGD) [Ref 4.N] diagram 1042 (Schedule 9 Part 6 Item 22); however, a ratio that differs from that defined in CD 122 Table 3.31 is permissible.

Stopping sight distance (CD 122 3.23, 3.24, 3.25, 3.33, 3.34, 5.13 and 5.14)

E/3.9 The minimum stopping sight distance to be provided on a SM scheme connector road shall be equal to or greater than the existing provision.

E/3.9.1 The stopping sight distance to be provided on a SM scheme connector road should be as close as practicable to the requirements of CD 122.

E/3.9.2 Where the stopping sight distance on a SM scheme connector road is less than required for that class of road, the existing provision should only be retained if a review of the operational performance does not highlight a problem with it.

Near straights (CD 122 5.8)

E/3.10 The near straight length to be provided at a SM scheme slip road shall be equal to or greater than the existing provision.

NOTE *The existing near straight provision could be no near straight at all.*

E/3.10.1 Adjoining near straight and nose lengths to be provided at an existing motorway slip road may be different.

E/3.10.2 The near straight length to be provided at a SM scheme motorway slip road should be as close as practicable to the requirements of CD 122.

E/3.10.3 Where the length of near straight at an existing motorway slip road is less than the minimum required for that class of road, the existing provision should only be retained if a review of the operational performance does not highlight a problem with it.

Weaving lengths (CD 122 4.2, 4.3 and 4.5)

E/3.11 The minimum weaving length provided on a SM scheme shall be equal to or greater than the existing provision.

E/3.11.1 The weaving length to be provided on an SM scheme should be as close as practicable to the requirements of CD 122.

E/3.11.2 Where the weaving length on a SM scheme is less than the length derived from CD 122 Figure 4.6b, options for reducing or eliminating weaving should be assessed and implemented where practicable.

NOTE *The need for a weaving section can be eliminated through the use of link roads.*

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	National Highways. CD 122, 'Geometric design of grade separated junctions'
Ref 2.N	National Highways. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 3.N	Highways England. GD 301, 'Smart motorways'
Ref 4.N	The National Archives. legislation.gov.uk. SI 2016 No.362 (TSRGD), 'The Traffic Signs Regulations and General Directions 2016'

Department for Infrastructure
An Roinn Bonneagair

Road Layout
Design

CD 122
Northern Ireland National Application Annex to CD 122 Geometric design of grade separated junctions

Revision 0

Summary
There are no specific requirements for Department for Infrastructure Northern Ireland supplementary or alternative to those given in CD 122.

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

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Contents

Release notes

Version	Date	Details of amendments
0	Aug 2019	Department for Infrastructure Northern Ireland National Application Annex to CD 122.

Road Layout
Design

CD 122
Scotland National Application Annex to CD 122 Geometric design of grade separated junctions

Revision 0

Summary
There are no specific requirements for Transport Scotland supplementary or alternative to those given in CD 122.

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	Aug 2019	Transport Scotland National Application Annex to CD 122.

Llywodraeth Cymru
Welsh Government

Road Layout
Design

CD 122
Wales National Application Annex to CD 122 Geometric design of grade separated junctions

Revision 0

Summary
There are no specific requirements for Welsh Government supplementary or alternative to those given in CD 122.

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: CustomerHelp@wales.gsi.gov.uk

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