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**VOLUME 6 ROAD GEOMETRY**  
**SECTION 2 JUNCTIONS**

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**PART 1**

**TD 22/06**

**LAYOUT OF GRADE SEPARATED  
JUNCTIONS**

**SUMMARY**

This standard sets out the design requirements and methodology for the geometric design and layout of grade separated junctions on trunk roads and motorways. It revises and combines the previous standard (TD 22/92) and advice note (TA 48/92). It takes into account the amendments included in the interim revision (TD 22/05).

**INSTRUCTIONS FOR USE**

1. Remove Contents pages from Volume 6 and insert new Contents pages for Volume 6 dated February 2006.
2. Remove TD 22/05 from Volume 6, Section 2 which is superseded by this Standard and archive as appropriate.
3. Insert TD 22/06 into Volume 6, Section 2.
4. Please archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.



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**THE DEPARTMENT FOR REGIONAL DEVELOPMENT  
NORTHERN IRELAND**

# Layout of Grade Separated Junctions

**Summary:** This standard sets out the design requirements and methodology for the geometric design and layout of grade separated junctions on trunk roads and motorways. It revises and combines the previous standard (TD 22/92) and advice note (TA 48/92). It takes into account the amendments included in the interim revision (TD 22/05).

**REGISTRATION OF AMENDMENTS**

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

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**Contents**

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1. Introduction
2. Design Procedure
3. Traffic Flows
4. Geometric Standards
5. Layout Options
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# 1. INTRODUCTION

## General

1.1 This standard sets out the layout and size requirements for new and improved grade separated junctions and interchanges on rural and urban trunk roads and motorways. It sets out requirements for the provision of weaving sections for traffic between junctions. It gives guidance on access to and egress from service areas.

1.2 This standard does not cover the design requirements and methodology for the geometric layout of either major interchanges (including the expansion and improvement of existing interchanges and junctions) or compact grade separated junctions (principally for use on rural and inter-urban roads). These are set out in **TD 39 (DMRB 6.2.4)** and **TD 40 (DMRB 6.2.5)**.

1.3 Guidance on the structured process of choosing between junction types is given in advice note **TA 30 (DMRB 5.1)**.

1.4 The main changes from the previous standard and advice note are summarised as follows:

- i This standard combines and supersedes the previous standard TD 22/92 and the advice note TA 48/92. It includes the revisions included in the interim revision **TD 22/05 (DMRB 6.2.1)**.
- ii Junctions onto connector roads are prohibited.
- iii New design requirements for diverge and merge slip roads to ensure adequate length for deceleration and acceleration.
- iv Existing two lane merges which are subject to improvement must be altered to a one lane parallel merge or two lane ghost island merge as appropriate.
- v Introduction of the ghost island diverge layout ("tiger tail").
- vi Principle of averaging for weaving lengths at ghost island layouts.
- vii Comprehensive requirements for merge and diverge layouts for Motorway Service Areas.

- viii Revised requirements for determining hourly traffic flows for design.
- ix Use of absolute maximum gradient on motorway connector roads of 6% is permitted.
- x Introduction of three types of loops.
- xi Clarification of the requirements for sight distance for diverge and merge slip roads.
- xii Auxiliary lanes on climbing lane sections to be extended beyond crest to enable visibility of the end of the lane.
- xiii More guidance on facilities for non-motorised users.

## Scope

1.5 This standard sets out the design requirements and methodology for the geometric design of and choice between different grade separated junction layouts on trunk roads and motorways. It draws on the experience gained since the publication of the previous standard (TD 22/92) and advice note (TA 48/92) and revises and combines the two documents. It takes into account the amendments included in the interim revision (TD 22/05). It provides guidance on the principles for safety and traffic operation and on the choice between different grade separated junction layouts. Recommendations are given on the siting of grade separated junctions in urban and rural areas, geometric design and the provision for non-motorised users. Some aspects of signs and road marking are included for completeness, although policy and detailed guidance on these matters are given in the Traffic Signs Regulations and General Directions (TSRGD), the Traffic Signs Manual, DMRB Volumes 8 and 9 and Local Transport Note 1/94.

## Implementation

1.6 This standard must be used forthwith for the design of all schemes for the construction and improvement of all-purpose and motorway trunk roads currently being prepared, provided that in the opinion of the Overseeing Organisation, this would not result in any significant additional expense or

delay. The Design Organisation must confirm its application to particular schemes with the Overseeing Organisation.

## Definitions

1.7 The terminology used in this standard follows, where possible, the definitions contained in BS 6100: Subsection 2.4.1: 1992.

1.8 The following additional terms have been defined for use in this Standard (see also Figure 1/1).

1.9 **Auxiliary Lane:** An additional lane at the side of the mainline carriageway to provide increased merge or diverge opportunity or additional space for weaving traffic. See Figure 2/4.1B and Figure 2/6.3D Option 2.

1.10 **Connector Road:** A collective term for interchange links, link roads, slip roads and loops.

1.11 **Design Organisation:** The organisation commissioned to undertake the various phases of scheme preparation.

1.12 **Downstream:** That part of the carriageway(s) where the traffic is flowing away from the section in question.

1.13 **Fork:** An at-grade junction of two roads, usually within an interchange, which diverge from the approach road at similar angles. Usually both diverging roads have equal status. (For a fork junction, as defined in BS 6100: Subsection 2.4.1, the minor road deviates from the straight major road.) See Figure 4/6.

1.14 **Ghost Island:** An area of the carriageway suitably marked to separate lanes of traffic travelling in the same direction on both merge and diverge layouts. The purpose of the ghost island at a merge is to separate the points of entry of two slip road traffic lanes. At a diverge it is to separate the points of exit to a slip road. See Figures 2/4.4F, 2/6.1B Option 1 and 2/6.3D Option 1.

1.15 **Interchange:** A grade separated junction that provides free flow from one mainline to another.

1.16 **Interchange Link:** A connector road, one or two way, carrying free flowing traffic within an interchange between one level and/or direction and another. See Paragraphs 4.2 and 4.3.

1.17 **Lane Gain:** A layout where a merging connector road becomes a lane or lanes of the downstream main carriageway. See Figures 2/4.3E, 2/4.4F and 2/4.5G.

1.18 **Lane Drop:** A layout where a lane or lanes of the upstream carriageway becomes the diverging connector road. See Figures 2/6.2C, 2/6.3D and 2/6.4E.

1.19 **Large Goods Vehicle (LGV):** A goods vehicle, the permissible maximum weight of which exceeds 7.5 tonnes.

1.20 **Link Road:** In the context of junctions, a one way connector road adjacent to but separate from the mainline carriageway carrying traffic in the same direction, which 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. See Figure 5/6.

1.21 **Loop:** A connector road, one or two way, which is made up of the elements of the loops shown in Figure 4/1 and which passes through an angle in the range of approximately 180 to 270 degrees. 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.

1.22 **Low Radius:** A radius between the minimum loop radius in Table 4/2 and the Two Steps below Desirable Minimum Radius with Superelevation of 7% as required by TD 9 (DMRB 6.1.1) for the slip road or interchange link design speed.

1.23 **Mainline:** The carriageway carrying the main flow of traffic; generally traffic passing straight through the junction or interchange.

1.24 **Near Straight:** A length of road with a radius no less than the Desirable Minimum Radius with Superelevation of 5% as required by TD 9 (DMRB 6.1.1) for the mainline design speed.

1.25 **Nose:** A paved area, approximately triangular in shape, between a connector road and the mainline at a merge or diverge, suitably marked to discourage drivers from crossing it.

1.26 **Overseeing Organisation:** The highway or road authority for the road construction or improvement scheme.

1.27 **Parallel Merge/Diverge:** A layout where an auxiliary lane is provided alongside the mainline carriageway. See Figures 2/4.1B, 2/4.5H, 2/6.1B Option 2 and 2/6.3D Option 2.

1.28 **Reserved Lane:** A lane carrying traffic that is segregated from weaving traffic.

1.29 **Rural Road:** As defined in TA 46 (DMRB 5.1.3), namely all-purpose roads and motorways that are generally not subject to a local speed limit.

1.30 **Slip Road:** A connector road within a junction between a mainline carriageway and the local highway network, or vice versa, which meets the local highway network at-grade. Traffic using a slip road usually has to give way to traffic already on the mainline or on the local highway network. See Paragraph 4.2.

1.31 **Taper Merge/Diverge:** A 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. See Figures 2/4.1A and 2/6.1A.

1.32 **“Tiger Tail”:** A ghost island layout at a diverge utilising TSRGD diagram 1042.1 to separate the points of exit to a slip road. So called because the vertical sign used to inform drivers of the layout incorporates an illustration that resembles a tiger’s tail. See Figures 2/6.1B Option 1 and 2/6.3D Option 1.

1.33 **Upstream:** That part of the carriageway(s) where traffic is flowing towards the section in question.

1.34 **Urban All-Purpose Road (UAP):** 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.

1.35 **Urban Motorway:** A motorway with a speed limit of 60 mph or less within a built up area.

1.36 **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. See Figure 2/9 and Figures 4/9 to 4/14.

## Mandatory Sections

1.37 Mandatory sections of this document are contained in boxes. The Design Organisation must comply with these sections or obtain agreement to a Departure from Standard from the Overseeing Organisation. The remainder of the document contains advice and explanation, which is commended to users for consideration.

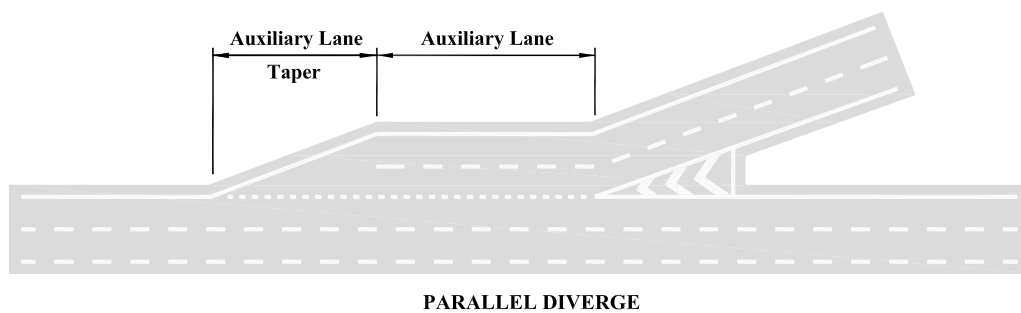
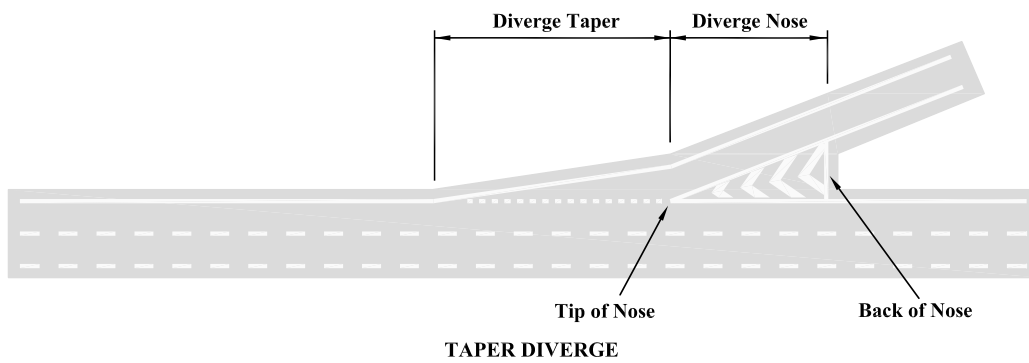
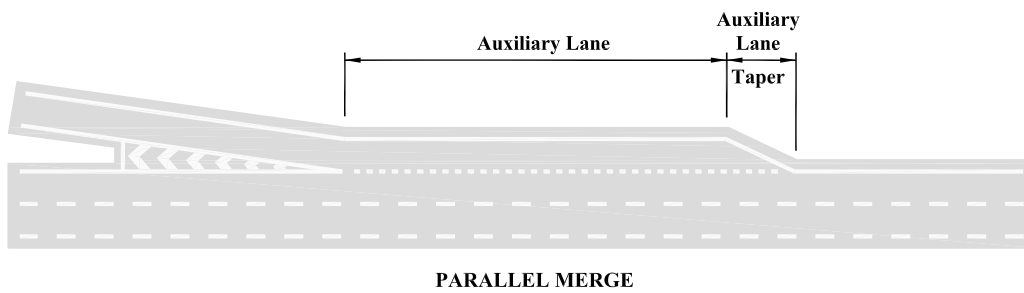
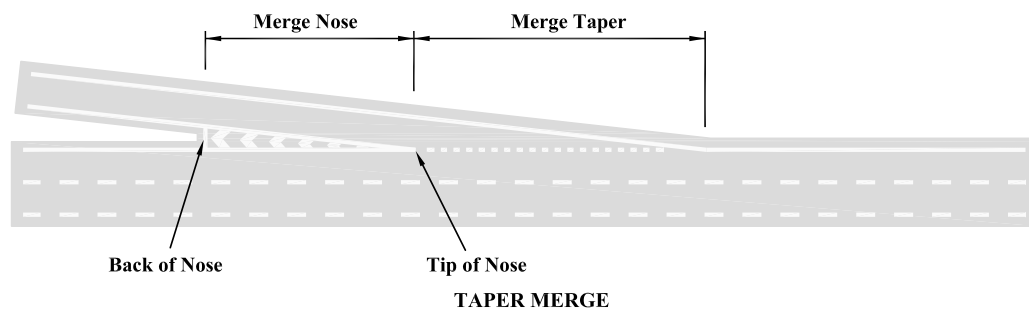
## Departures from Standards

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

## Relaxations

1.39 In difficult circumstances Relaxations may be introduced at the discretion of the Design Organisation, having regard to all relevant local factors, but only where specifically permitted by this standard. Careful consideration must be given to layout options incorporating Relaxations, having weighed the benefits and any potential disbenefits. Particular attention must be given to the safety aspects (including operation, maintenance, construction and demolition) and the environmental and monetary benefits/disbenefits that would result from the use of Relaxations. The consideration process must be recorded. The preferred option must be compared against options that would meet full standards.





Taper Merge/Diverge and Parallel Merge/Diverge  
Design details are given in Chapter 2 of this document.

**Figure 1/1 Definition of Main Terms**

## 2. DESIGN PROCEDURE

### General Principles

2.1 Junction and Interchange design is an iterative process which is a key part of the overall design process for schemes. Figure 2/1 is a flowchart for junction and interchange design. Figure 2/2 outlines the connector road design process.

2.2 The design of junctions is affected by decisions taken on the degree of access to be provided on the scheme. It is important to consider from the outset how much access should be allowed. It may not be possible to cater for the full predicted demand. The fact that other roads are crossed, does not imply that a junction should be provided, or that if one is provided, it should be omni-directional.

2.3 There may be occasions when the design should not provide for certain movements to prevent use of the trunk road by local commuters for the benefit of longer distance traffic and for environmental reasons. The process of choosing between options is covered more fully in **TA 30 (DMRB 5.1)**.

2.4 A junction layout should give drivers and other road users a clear understanding of what is required of them. Poor layouts lead to driver confusion, indecisiveness and rash decisions that could contribute to accidents.

The design should provide:

- advance notification of the layout on the approach to a junction;
- conspicuous junction locations and layouts;
- understanding of permitted changes to the direction of travel;
- understanding of other traffic movements;
- avoidance of potential hazards.

Thus, in assembling the design components, designers should ensure that as drivers approach a junction they are able to easily perceive the junction form and layout so that they can select their path through the junction accordingly. Ease of use should be checked for night-time conditions.

2.5 It is important to ensure that adequate forward visibility is provided in accordance with **TD 9 (DMRB 6.1.1)**. The possible adverse effects on forward visibility of features such as mature vegetation, lighting columns, signs and vehicle restraint systems should be considered at an early stage in design. Drivers will more readily understand the use of standard features than unusual features and if it is necessary to use unusual features these should be well signed or be readily understood.

2.6 Earthworks and landscaping should be an integral part of junction design rather than an afterthought.

2.7 Design Organisations should consider the potential for dazzle and silhouetting of signs when the sun is low in the sky. The designer should also attempt to avoid the need for drivers to approach a manoeuvre or a decision point looking into the rising or setting sun.

### Urban/Rural

2.8 The design of grade separated junctions is based on the design hourly flow which usually varies according to road type and according to whether the road is motorway or all-purpose or rural or urban. Urban standards for most elements of road design are, however, lower than those applicable to rural design, since lower driver expectation accompanied by higher perception offset the increased risks caused by reductions in standards. For example, the presence of kerbs, frequent lack of hardstrips, narrow central reserve, lighting and speed limits would all indicate the urban nature of a road. The lower urban standards are shown within the hierarchy of geometric standards, ranging from rural motorways down to urban all-purpose roads, related to Design Speed (see Table 4/3 and Table 4/4).

### Location

2.9 The location of a grade separated junction can have a significant effect on both its operational performance and environmental impact. Therefore, consideration of the major contributing issues should be undertaken at the initial design stage to produce the optimum design for comparison with other junction types. Some major contributing issues are listed in paragraph 5.4.

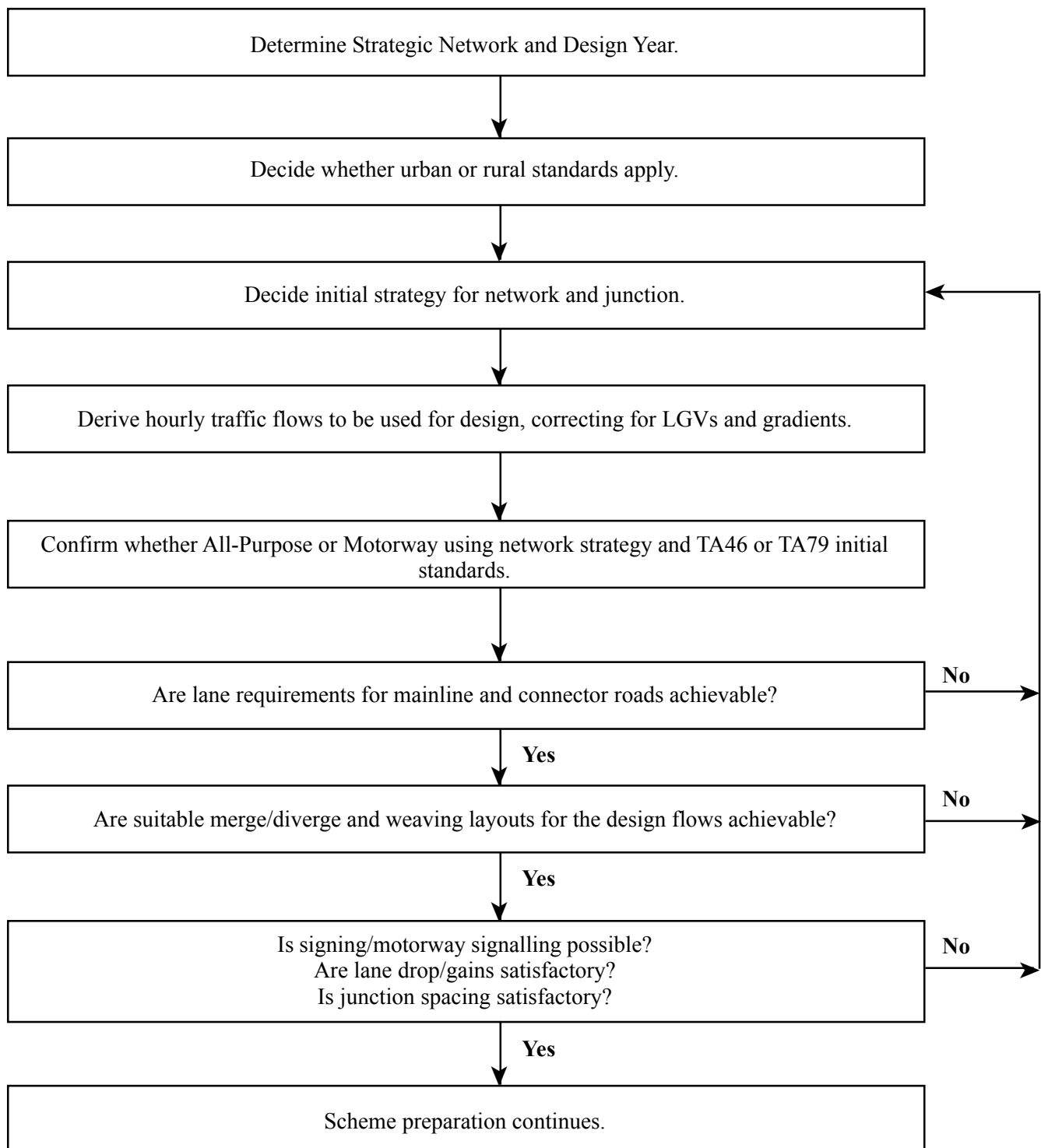


Figure 2/1 Flow Chart Showing the Junction/Interchange Design Process

## Safety

2.10 The main objective of grade separated junction design is to provide a junction which is safe for the forecast traffic flows. Certain layouts are not recommended for safety reasons and should be avoided. These are:

- (i) grade separated junctions on single carriageways (see **TD 9 (DMRB 6.1.1)** and **TD 40 (DMRB 6.2.5)**);
- (ii) grade separation on dual carriageways within 0.5 km of a changeover to single carriageway standard, measured from the end of the merge taper to the beginning of the right hand lane hatching that removes the offside lane or lanes (see **The Traffic Signs Manual, Chapter 4** and **TD 42 (DMRB 6.2.6)**);
- (iii) offside merges and diverges;
- (iv) major/minor junctions, particularly those with right turning movements, on an otherwise grade separated route.

## Recommended Layouts

2.11 Recommended layouts for consideration in order of increasing traffic flow level are:

- i) diamond or half clover-leaf – simple priority junctions with the minor road;
- ii) dumb-bell roundabout – junctions with the minor road are provided by two normal roundabouts which are connected by a central link road either under or over the mainline;
- iii) two bridge roundabout – a single large roundabout with the circulatory carriageway either under or over the mainline;
- iv) 3 level roundabout – a junction usually between two roads of similar flow. The two mainlines are on the upper and lower levels of the junction with the roundabout on the central level;
- v) interchange – a junction between major roads with all movements catered for by free flowing connector roads.

With the exception of the Interchange these junctions have merge and diverge slip roads which may be signalised at their junction with the side road or roundabout.

2.12 The design of an at-grade junction within a grade separated junction is subject to the appropriate Standards and Advice Notes as follows:

**TA 23 (DMRB 6.2)** – (Advice Note – Junctions and Accesses: Determination of the Size of Roundabouts and Major/Minor Junctions);

**TD 16 (DMRB 6.2.3)** – (Standard – Geometric Design of Roundabouts);

**TD 42 (DMRB 6.2.6)** – (Standard – Geometric Design of Major/Minor Priority Junctions);

**TD 50 (DMRB 6.2.3)** – (Standard – Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts);

**TD 51 (DMRB 6.3.5)** – (Standard – Segregated Left Turn Lanes and Subsidiary Deflection Islands at Roundabouts).

A more detailed discussion of the layout options is contained in Chapter 5.

## The Design Process

2.13 Following through the flow-chart, (Figure 2/1) the first stages would be to determine a network strategy, fix a design year, and decide whether urban or rural standards apply (see paragraphs 1.29, 1.34 and 1.35). The next stage would then be to decide on an initial network and junction strategy, including the connections to be made, for example whether the junction should be omni-directional.

2.14 Having made those starting decisions, it is possible to derive hourly flows to be used in the design process following the guidance in Chapter 3. An examination of these flows, applied to the network strategy adopted, will enable a decision to be taken (or confirmed) that the route should be Motorway or All-Purpose. Reference to **TA 46** and **TA 79 (DMRB 5.1.3)**, will give a starting point on the level of carriageway provision for the links on the network assumed.

2.15 The next stage, and the first step that could lead to iteration, is to assess the likely lane provision on the mainline and the connector roads. If the basic scheme cannot be tailored to cope with demands, including those likely to arise when maintenance work needs to be undertaken, then network and junction strategy will need to be reviewed and alternatives investigated; for example – reducing the number of junction accesses or using link roads. Link roads reduce the frequency of

direct access points along the mainline in order to eliminate sub-standard weaving lengths thus promoting free flow to minimise the potential for accidents and to preserve the high capacity of the mainline. They can also be used where it is unsafe or not possible to make direct connections. Link roads can be useful for maintenance and diversions.

2.16 The following stage may also lead to iteration. This is to determine the merge and diverge facilities and to check that weaving sections at or above the desirable minimum length can be provided. If these cannot be achieved, then the junction strategy should be reviewed.

2.17 The next stage is to check that desirable geometric standards can be achieved with the junction spacing, and any lane gains or drops proposed, and that an effective and economic signing system can be provided. Again the strategy may have to be adjusted. Figure 2/2 is a flowchart showing the connector road design process. It refers to the particular paragraphs, figures and tables of this standard applicable to connector road design and to **TD 27 (DMRB 6.1.2)**.

2.18 If the junction and interchange designs pass these stages, the scheme can then be taken to the next stage in its preparation which is likely to be a cost/benefit assessment. Analysis may not be sufficiently fine to evaluate the performance of individual junction elements. The best means of ensuring that a junction is effective is to carry out the operational check outlined above and in Figure 2/1.

## Junction and Interchange Design

### General Principles

2.19 Where lane drops and lane gains occur, the lane configurations ahead should be made clear to drivers by the consistent use of signs and road markings as outlined in **TSRGD** and **TA 58 (DMRB 8.2.1)**. These principles have been incorporated in the recommended layouts.

2.20 Where large traffic flows are joining the mainline in an interchange or junction, turbulence can occur, with short headways and sudden braking. A length of auxiliary lane may be necessary to provide increased local capacity. This is covered more fully in paragraphs 4.23 to 4.26.

2.21 The signing of junctions and interchanges should give clear and timely information to drivers. This is particularly important at lane gains and lane drops and

at other decision type locations or in situations where the driver's view may be obstructed by high traffic volumes or large proportions of LGVs. At these locations consideration should be given to the provision of gantries to mount the signs. Where these are proposed the design of the junction or interchange should take the siting of the gantries into account, (see **TD 18 (DMRB 9.1)**).

2.22 It may also be that the predicted turning flows are not realised in the proportions expected in the design year and the consequences of being wrong should be examined. Sensitivity testing of differing flow proportions should be undertaken.

2.23 Correction factors to take account of gradients and proportion of large goods vehicles, as detailed in Tables 3/2 and 3/3, may need to be made to the flows to be entered in Tables 3/1a and 3/1b, and Figures 2/3, 2/5 and 4/14.

### Merges – General Principles

2.24 It is important on safety grounds and to limit interference to mainline traffic that joining traffic is channelled into the merging area (i.e. from the tip of the nose to the end of the taper(s)) and arrives there in an orderly fashion to perform a safe and comfortable merge with the mainline.

2.25 If joining flows are greater than one lane capacity then an additional lane should normally be added to the mainline as a lane gain. The individual merging area for each joining lane within a merge should be separated from the previous one and there should be space between them for mainline traffic to adjust to the new traffic flow.

2.26 Where design flows are close to capacity on both the connector road and on the mainline it is important to ensure that there is adequate provision for those merging. If the availability of merging opportunities is estimated to be low for long periods of the day, improved merging opportunities could be provided by auxiliary lanes.

2.27 There may be occasions when the merge flow is greater than the mainline flow. The junction should nevertheless be set out so that mainline traffic has priority over traffic entering from the left, except at a lane gain.

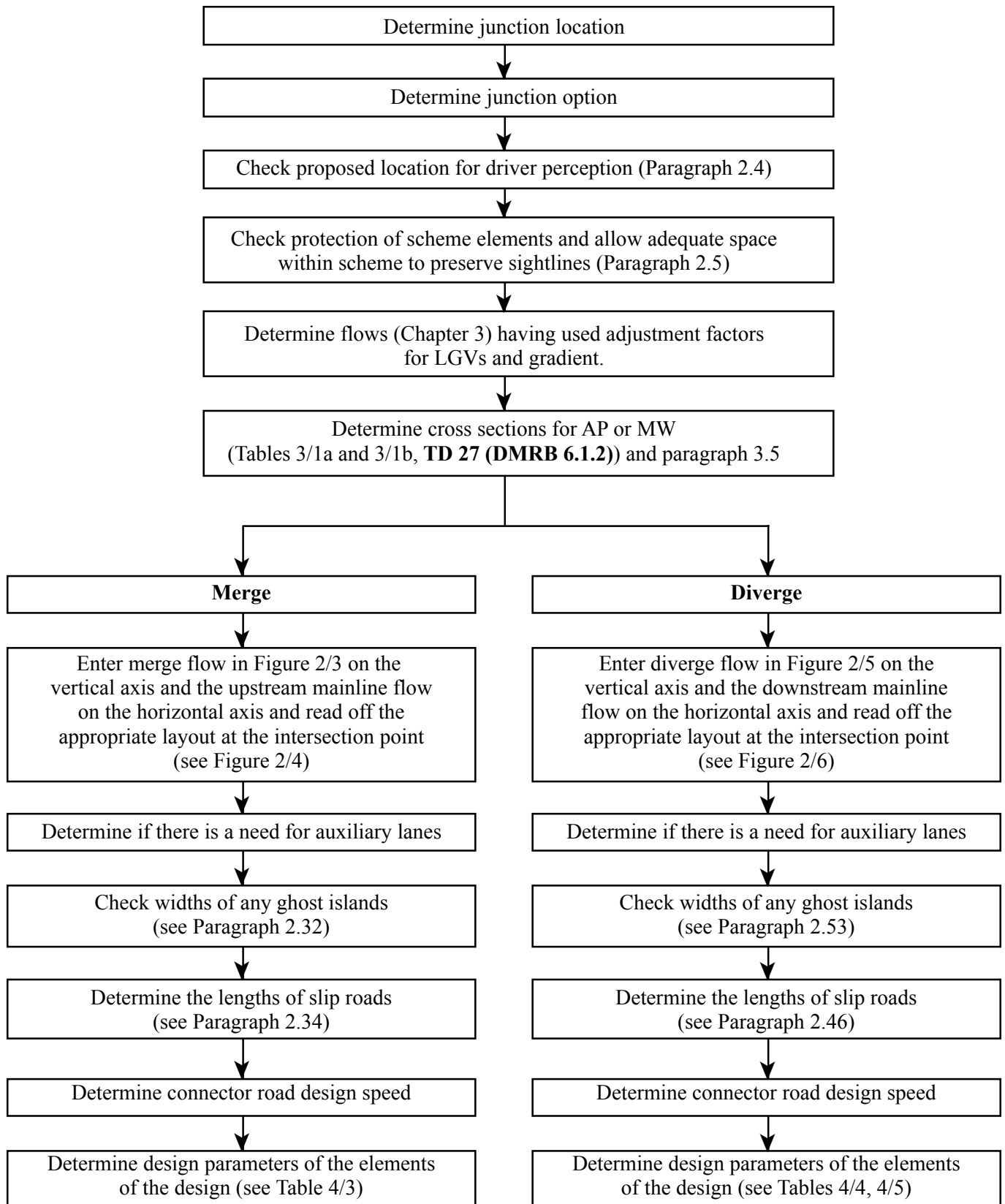


Figure 2/2 Flow Chart Showing the Connector Road Design Process

2.28 There are many sites throughout the network that have a two-lane taper merge layout; such layouts are not now recommended. When junctions that contain these features are to be improved, the layout must be altered to a standard layout as appropriate for the merge and mainline flow levels. When urban two lane taper merge layouts are to be improved, Figure 2/4.2, layout D must be used. Ghost island merge layouts must not be used on urban roads.

### Designing Merges

2.29 Hourly flows, as determined from Chapter 3 for the merge and the mainline upstream must be inserted in Figure 2/3 to select a merge layout as shown in Figures 2/4.1 to 2/4.5. Where design flows lie close to, or on, a boundary between the flow regions, the probability of the particular flow actually occurring should be carefully reviewed. The provision of a layout that differs from that derived from the use of Figure 2/3 is a departure from standard, whether the proposed design is an under or over provision.

2.30 Where, for reasons of route continuity, the mainline capacity provided is in excess of the design flows and a merging design flow of over one lane capacity is expected, then layout C of Figure 2/4.2 may be substituted for layout F of Figure 2/4.4, but normally, with such a large flow expected to merge, a lane would be added to the mainline. For layout C the meaning of 'where design flows on the mainline are light' (see Figure 2/4.2) is that there is sufficient capacity on the mainline to accept the flow from the slip road. Layout H (see Figure 2/4.5) may be considered as a departure from standards where it is not possible to use Layout F (see also paragraph 4.29). For Figure 2/4.4 layout F, Option 1 is the preferred option due to the likely usage of Lane 1 of the connector road by the majority of large and/or slow vehicles and Lane 2 predominantly by light vehicles. Option 2 has been retained for use in circumstances where it is appropriate.

2.31 Ghost island road markings should be designed in accordance with TSRGD diagram 1042.1.

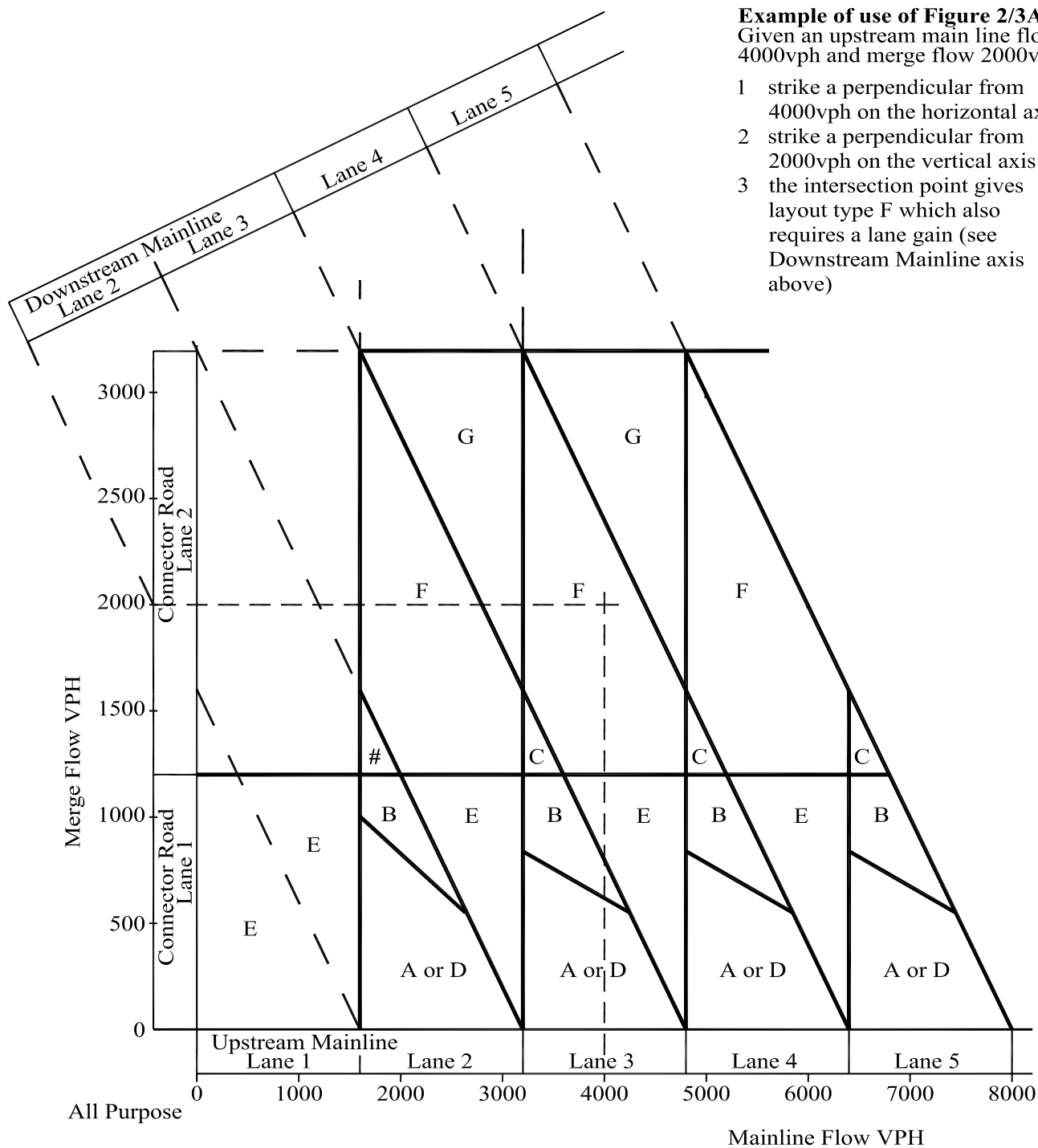
2.32 The minimum width of a ghost island is 2.0m at its widest point and the minimum width of a chevron is 0.5m (TSRGD diagram 1042.1). If the ghost island marking is less than 1.2m wide it will be too narrow to mark with chevrons. The length of ghost island that is unmarked with a chevron could extend over a long distance. In order to prevent this problem, the minimum width of a ghost island must be 1.2m at a distance of 50m from the tip of the ghost island head or tail. It should be noted that ghost island layouts can require significant length to comply with the standard and this may be reflected in the land requirement especially where the layout is being provided within an existing highway boundary.

2.33 The minimum length of a merge slip road will normally be dictated by the requirements given at paragraph 2.29 and the topographical layout of a junction. Where this is not the case, as for instance at the merge slip road leading out of a service area, then the requirements set out in paragraph 2.34 must be followed.

2.34 Gap finding is assisted when the merging traffic has the opportunity to match the speed of the mainline traffic. For all connector roads, a near straight at least equal in length to the nose length given in Table 4/3 column (3) for the appropriate Road Class must be provided upstream of the back of the merge nose. This requirement will enable merging traffic to achieve a matching speed.

2.35 Where the required length of near straight cannot be achieved, it may be appropriate to provide an auxiliary lane instead or in combination. An application must be made for a departure from standard.

2.36 Platoons of traffic can enter a merge slip road if junctions upstream are signal-controlled. This traffic can have a significant effect on the mainline flow especially at peak times when available gaps in the mainline traffic flow are few. Turbulence and congestion are the result. Care should be taken to program such traffic signals with a view to reducing their impact on the mainline flow.



**Example of use of Figure 2/3AP**  
Given an upstream main line flow 4000vph and merge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type F which also requires a lane gain (see Downstream Mainline axis above)

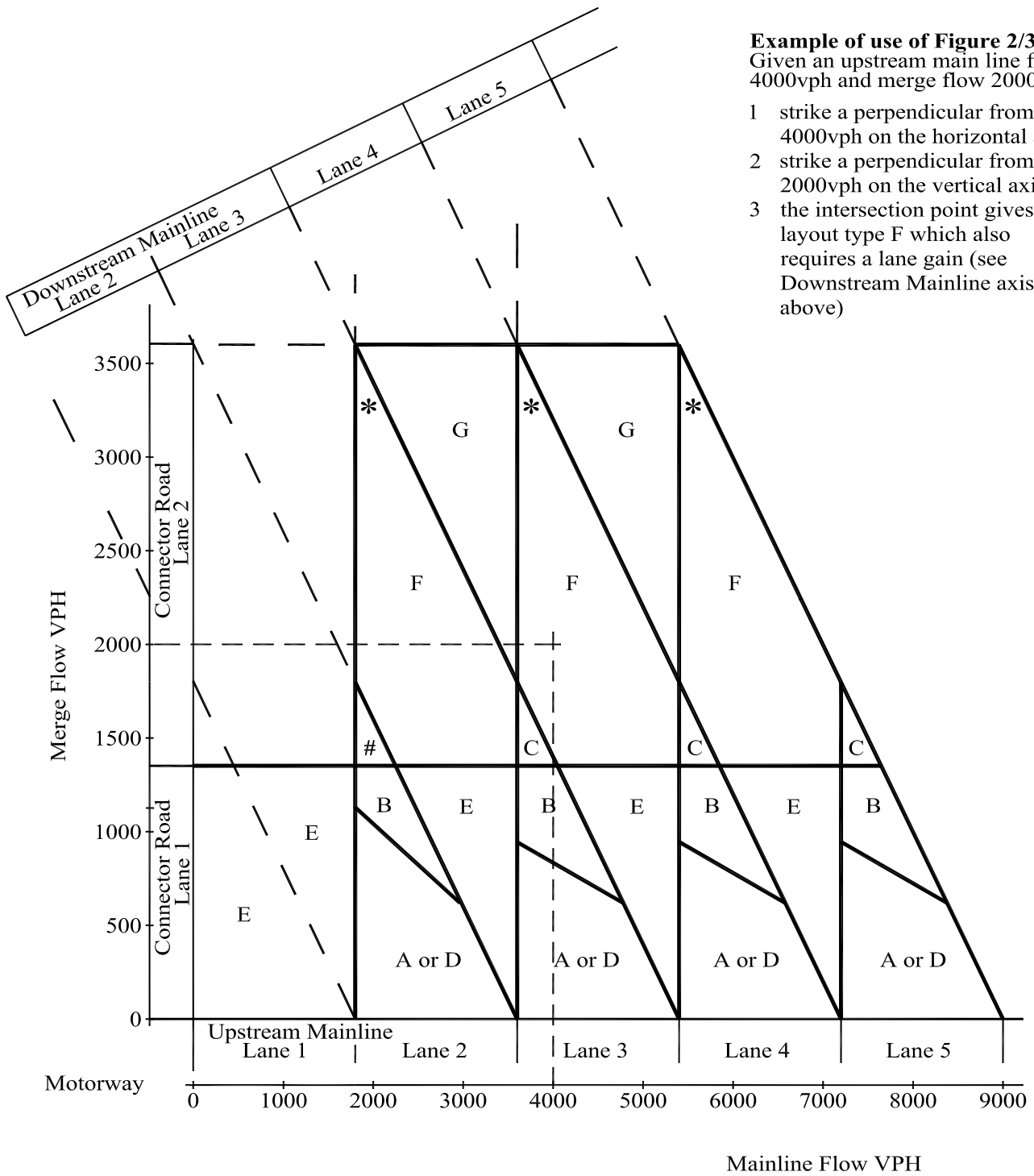
Notes:

# Area of uncertainty – In this area the choice will depend on the downstream provision. If there is a lane gain then use Layout E or F.

See paragraph 2.29 and the example above, for explanation of the usage of this diagram.

**Figure 2/3 AP All-Purpose Road Merging Diagram**





**Example of use of Figure 2/3MW**  
Given an upstream main line flow 4000vph and merge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type F which also requires a lane gain (see Downstream Mainline axis above)

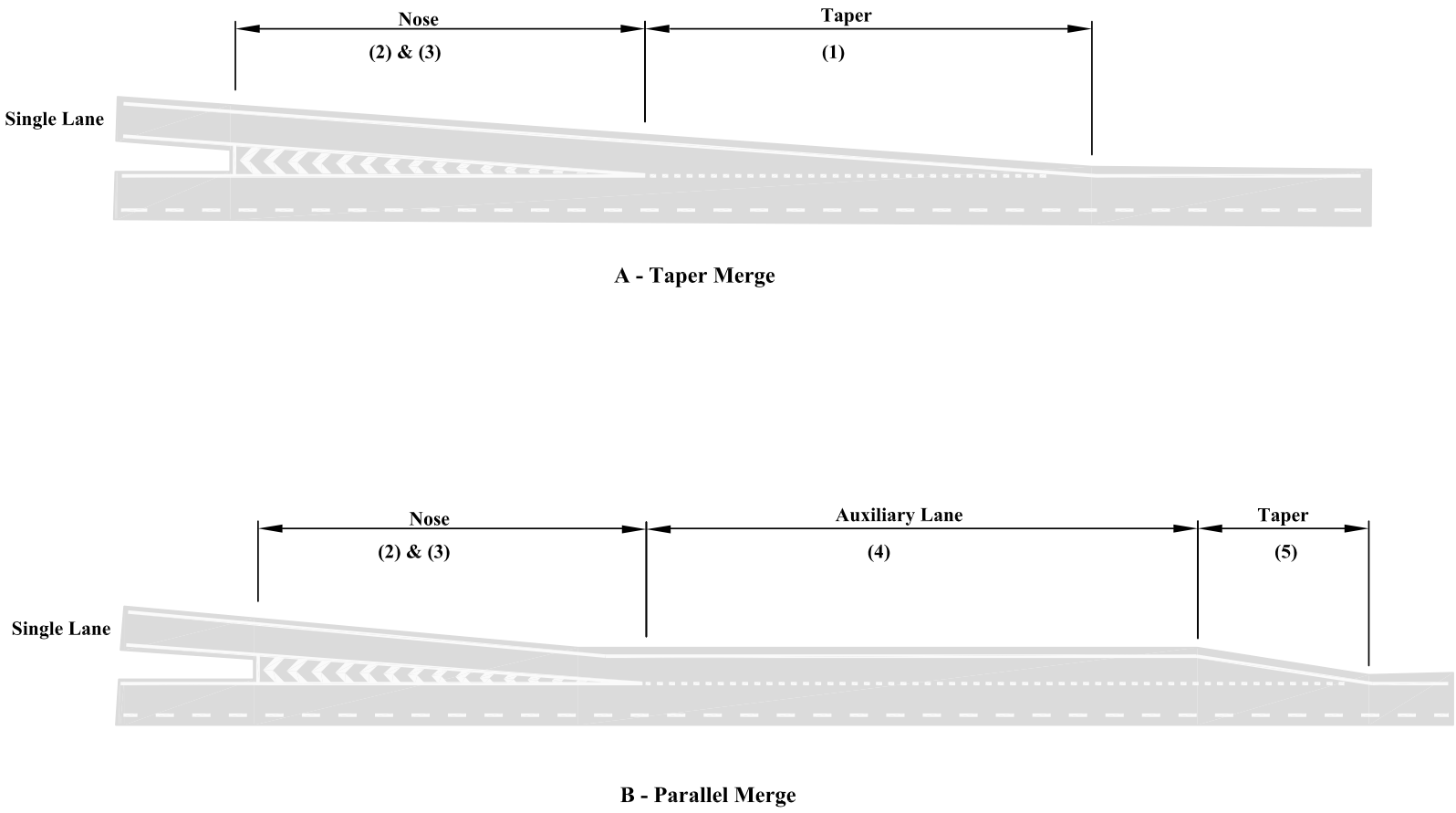
Notes:

- \* If Layout F Option 2 is used consider extended Auxiliary Lane (see paragraph 4.23).
- # Area of uncertainty – In this area the choice will depend on the downstream provision. If there is a lane gain then use Layout E or F.

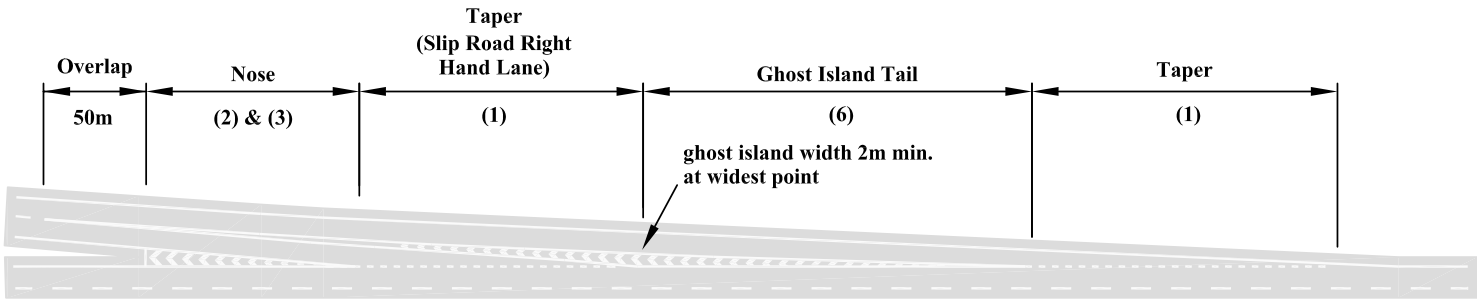
See paragraph 2.29 and example above, for explanation of the usage of this diagram.

**Figure 2/3 MW Motorway Merging Diagram**

Merge with  
No Lane Gain

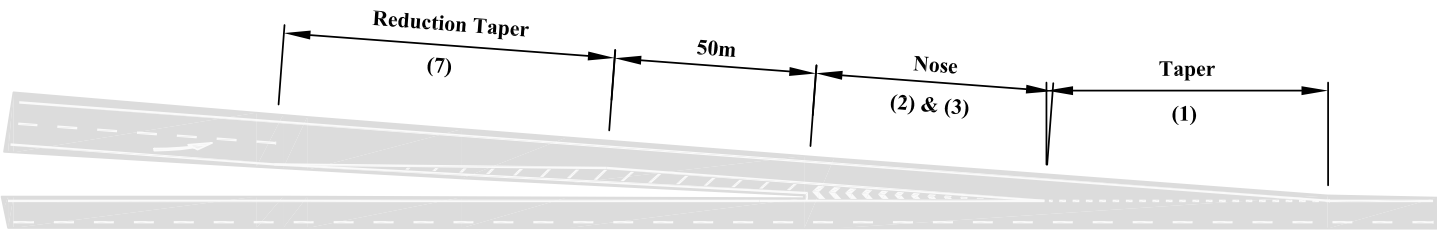


N.B. Figures in brackets refer to columns in Table 4/3  
Figure 2/4.1 Merge Lane Layouts for use with Figure 2/3



**C - Ghost Island Merge**

(Only used where design flows on mainline are light, there are 3 lanes or more on mainline and merging flow is over one lane capacity, see paragraph 2.30).



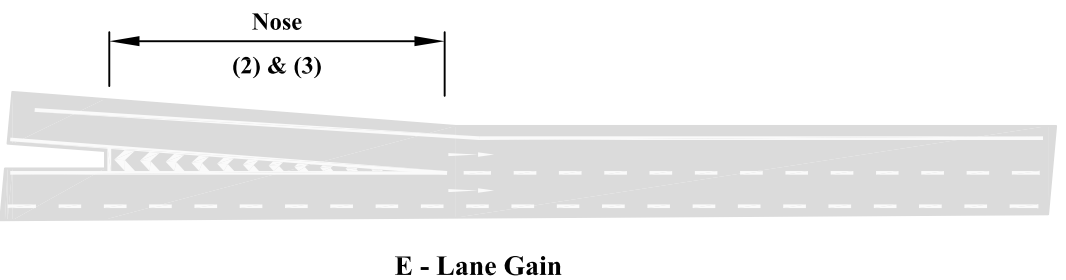
**D - 2 Lane Urban Merge**

Merge with  
No Lane Gain

N.B. Figures in brackets refer to columns in Table 4/3

Figure 2/4.2 Merge Lane Layouts for use with Figure 2/3

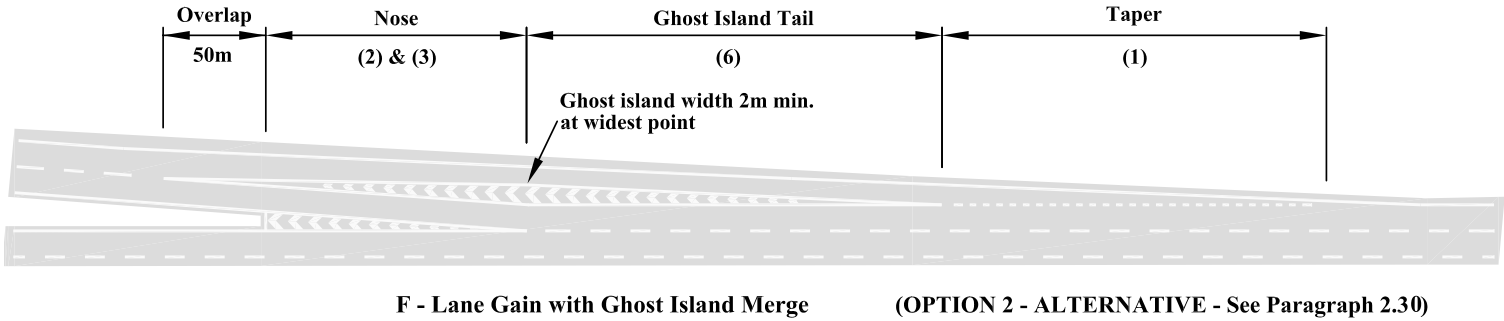
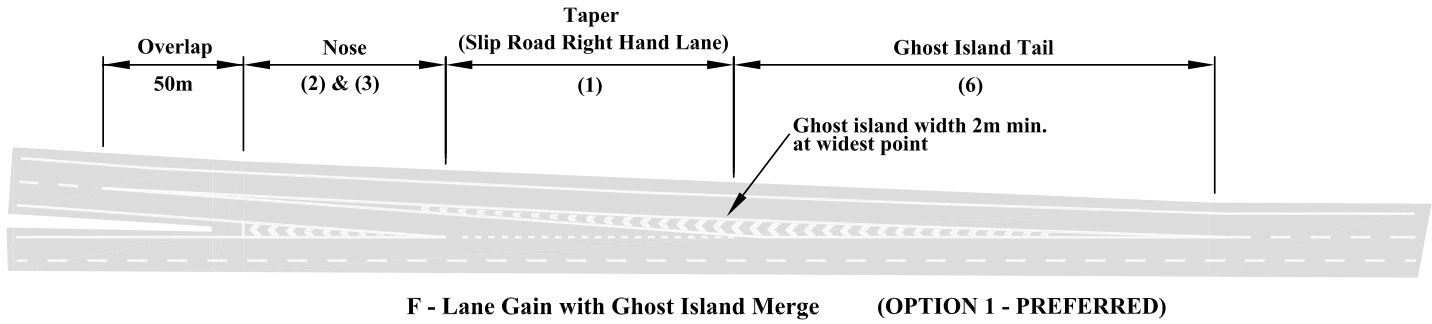
Merge with  
Lane Gain



N.B. Figures in brackets refer to columns in Table 4/3

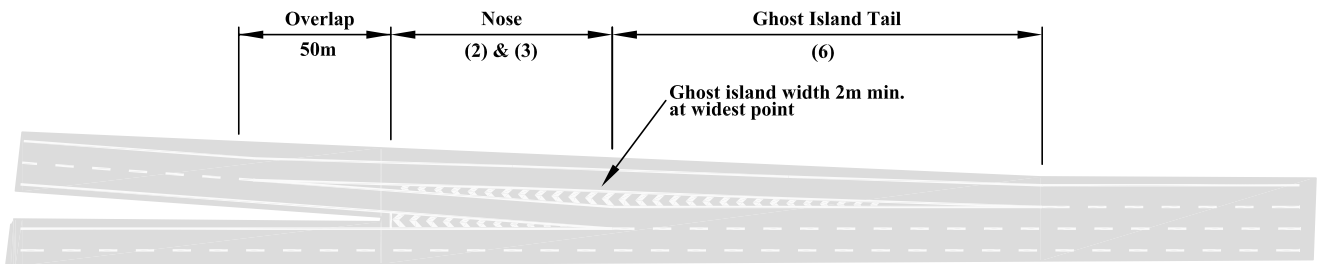
Figure 2/4.3 Merge Lane Layouts for use with Figure 2/3

Merge with  
Lane Gain

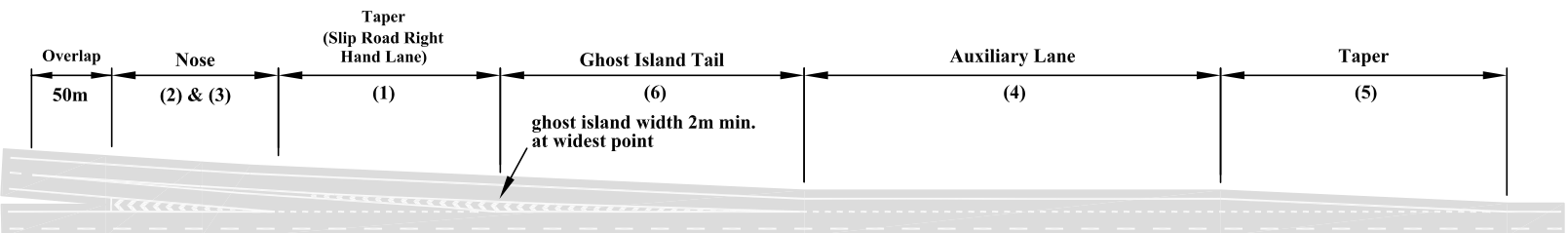


N.B. Figures in brackets refer to columns in Table 4/3

Figure 2/4.4 Merge Lane Layouts for use with Figure 2/3



**G - 2 Lane Gain with Ghost Island**



**H - Alternative Ghost Island Merge with Auxiliary Lane**  
(This Layout is for use where Layout F would be used but is not possible to implement because of site restraints. Its use requires approval as a departure from standard, see paragraph 2.30)

Merge with  
Lane Gain

N.B. Figures in brackets refer to columns in Table 4/3

**Figure 2/4.5 Merge Lane Layouts for use with Figure 2/3**

## Ramp Metering

2.37 Ramp metering is a remedial measure to improve the flow of traffic on a mainline by controlling traffic entering from the slip road. Currently it is only used on motorways. Traffic signals installed on motorway entry slip roads control vehicle flow on to the main carriageway at a 'metered' rate. The traffic signals are linked to sensors which measure speed, flow and lane occupancy rates of traffic using the motorway and identify an appropriate metering rate for the traffic conditions.

2.38 The use of ramp metering is still being tested at selected sites in England and the initial signs are that it increases the flow of traffic on the motorway by reducing congestion that results from merging traffic.

2.39 Guidance on the use of ramp metering on existing slip roads is available from the Overseeing Organisation.

## Diverges – General Principles

2.40 Diverging traffic should be able to leave the mainline easily and without impeding the progress of through traffic.

2.41 There is potential for accidents on diverge connector roads if the capacity of the connection to the local road network is insufficient and causes queuing on the connector road. Drivers leaving the mainline should have sufficient time to react and brake safely before the end of any queue. The designer must therefore ensure that the downstream cross-section (designed in accordance with **TD 27 (DMRB 6.1.2)**) and junctions (**see DMRB 6.2**) do not cause queues that approach the back of the diverge nose. This will allow drivers to use the diverge area and length of nose to decelerate in reasonable comfort, as intended.

2.42 For existing junctions, if even after improvement to the downstream connection to the local road network, there is a likelihood of queuing extending back onto the mainline carriageway, then auxiliary lanes should be considered as an exceptional case so that queues occur off the mainline. Motorway Incident Detection and Automatic Signalling (MIDAS) should also be considered in such circumstances. When auxiliary lanes are specified in this situation a departure from standards approval will be required.

## Designing Diverges

2.43 Hourly flows, as determined from Chapter 3 for the diverge and the mainline downstream must be inserted in Figure 2/5 to select a diverge layout as shown in Figures 2/6.1 to 2/6.4. Where design flows lie close to, or on, a boundary between the flow regions, the probability of the particular flow actually occurring should be carefully reviewed. The provision of a layout that differs from that derived from the use of Figure 2/5 is a departure from standard, whether the proposed design is an under or over provision.

2.44 The provision of a Layout B parallel diverge (Option 2) on a 4-lane mainline would create a 6-lane carriageway, contrary to the requirements of **TD 27 (DMRB 6.1.2)**. Any proposal for such a layout must be referred to the Overseeing Organisation.

2.45 The minimum length of a diverge slip road will normally be dictated by the requirements given at paragraphs 2.41 and 2.43 and the topographical layout of a junction. Where this is not the case, as for instance at the diverge slip road leading into a service area, then the requirements set out in paragraph 2.46 must be followed.

2.46 For all connector roads, a near straight at least equal in length to the nose length given in Table 4/4 column (4) for the appropriate Road Class must be provided downstream of the back of the diverge nose. This requirement will enable drivers to comprehend the layout ahead and adjust their speed accordingly.

2.47 Where the required length of Near Straight cannot be achieved, it may be appropriate to provide an auxiliary lane instead or in combination. An application must be made for a departure from standard.

2.48 For diverges, the layout of the edge line must incorporate the radii shown on Figure 2/6.

## Ghost Island Diverges

2.49 Ghost Island diverge layouts are preferred to the equivalent auxiliary lane layouts and should be selected in preference to the auxiliary lane layouts except where the Ghost Island layout may be unsuitable (see paragraph 2.52).

2.50 Ghost Island diverge layouts are for use when the diverge flow is high and are designed to reduce the likelihood of queues of slow moving traffic in Lane 1 together with 'swooping' movements (late manoeuvres from Lane 2 or 3) to the slip road. By providing two access points to a two-lane exit slip road, the capacity of the diverge is increased, congestion on the mainline is reduced and swooping is discouraged.

2.51 A full sequence of gantry direction signing is essential for a Ghost Island diverge layout. The Overseeing Organisation should be consulted for guidance on the provision and location of sign and signal gantries. In addition, it is essential that drivers are informed of the behaviour expected at a Ghost Island diverge. Two verge-mounted advance direction signs, to the design illustrated in Figure 2/7, must be provided. The first of these signs will be between the 1 mile gantry and the ½ mile gantry; the second sign will be between the ½ mile gantry and the final gantry. The main objective of these signs is to highlight to drivers the existence of the second exit point and encourage its use. It has been found that the installation of these verge-mounted signs improves the utilisation of the second exit with the effect of balancing the vehicle flows on the slip road lanes. Signs authorisation will be required for the non-standard signs designed for a particular site.

2.52 There may be occasions when the Ghost Island diverge layout is not suitable, for instance if signing is difficult to implement or if a high turning movement at the junction downstream of the diverge may lead to slip road queues in one or more lanes tailing back towards the mainline (see paragraphs 2.40, 2.41 and 2.42); in such cases the auxiliary lane layouts may be used instead. Note that for a Lane Drop at Parallel Diverge (Figure 2/6.3 Layout D Option 2), a full sequence of gantry direction signing should be provided in order to encourage utilisation of Lane 2 by diverging traffic. To date, ghost island diverges have been used only on rural motorways. For the application of ghost island diverge layouts to other roads, guidance should be sought from

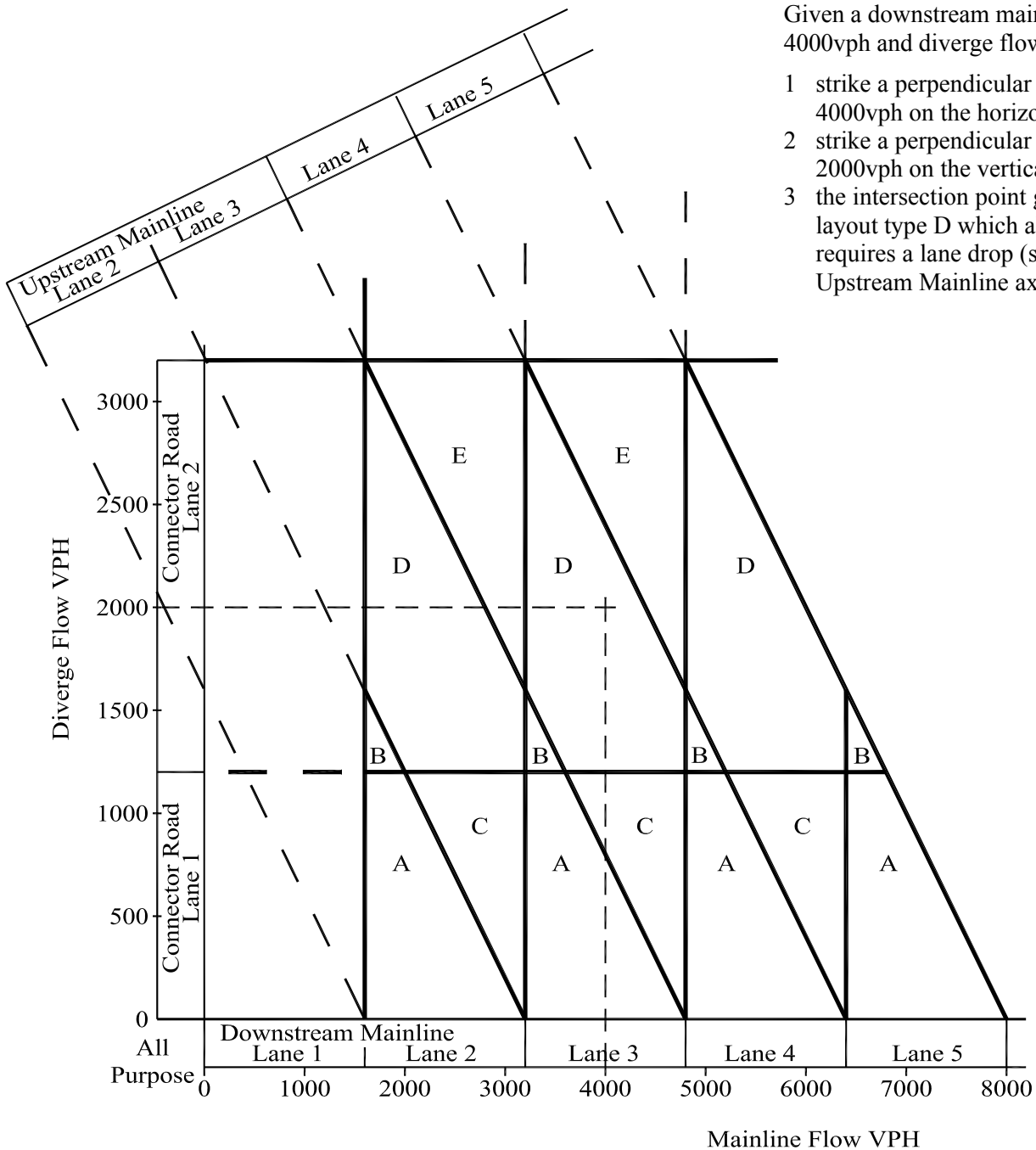
the relevant Overseeing Organisation. The layouts have also been developed for use at existing junctions and there may be constraints at a particular site that prevent the dimensions of the recommended layouts from being achieved. Designers may need to consider amendments to the lengths and widths of the various elements of the layouts. Where there are land constraints, for example, encroaching on the hardshoulder may be considered an acceptable means of achieving the additional capacity and safety offered by a ghost island diverge layout subject to obtaining agreement to a departure from standard. Figures 2/8(i) and 2/8(ii) are examples of the conversion of existing layouts. Note that these layouts also require provision of a full sequence of gantry direction signing plus two verge-mounted signs to the design illustrated in Figure 2/7.

2.53 The minimum width of a ghost island is 2.0m at its widest point and the minimum width of a chevron is 0.5m (TSRGD diagram 1042.1). If the ghost island marking is less than 1.2m wide it will be too narrow to mark with chevrons. The length of ghost island that is unmarked with a chevron could extend over a long distance. In order to prevent this problem, the width of a ghost island must be not less than 1.2m at a distance of 50m from the tip of the ghost island head or tail. It should be noted that ghost island layouts can require significant length to comply with the standard and this may be reflected in the land requirement especially where the layout is being provided within an existing highway boundary.



**Example of use of Figure 2/5AP**  
 Given a downstream main line flow 4000vph and diverge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type D which also requires a lane drop (see Upstream Mainline axis above)



Notes:

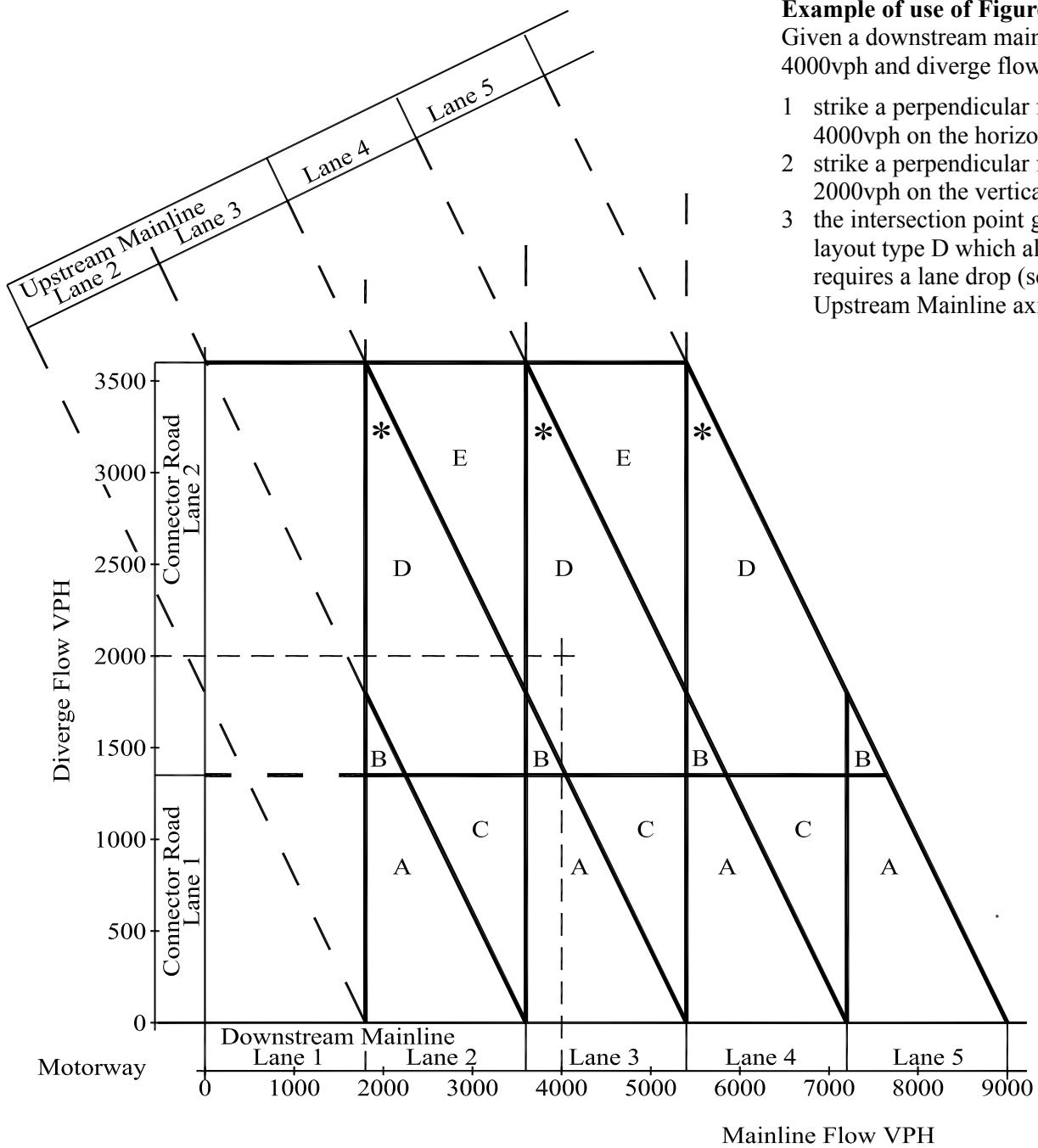
See paragraph 2.43 and the example above, for explanation of the usage of this diagram.

**Figure 2/5 AP All-Purpose Road Diverging Diagram**

**Example of use of Figure 2/5MW**

Given a downstream main line flow 4000vph and diverge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type D which also requires a lane drop (see Upstream Mainline axis above)



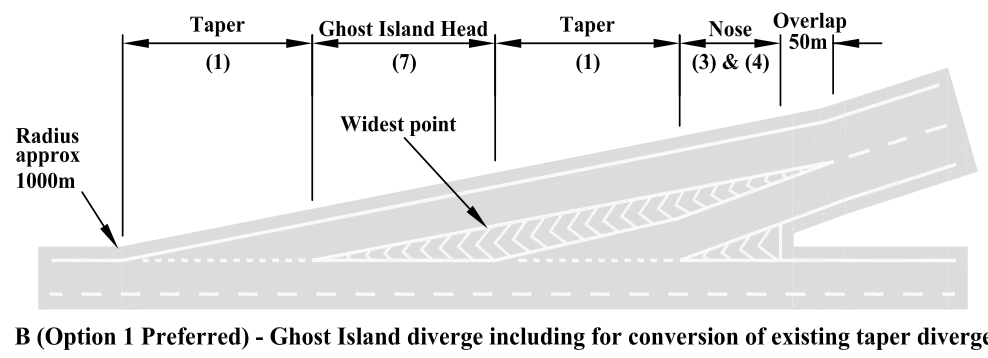
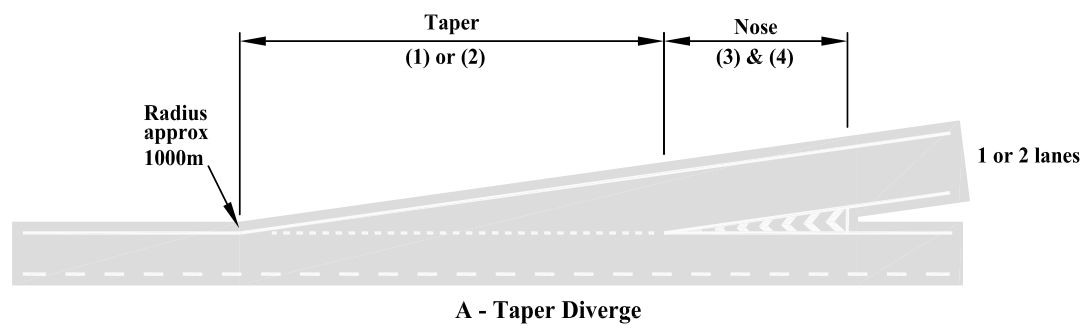
Notes:

\* If Layout D Option 2 is used consider extended Auxiliary Lane (see paragraph 4.24).

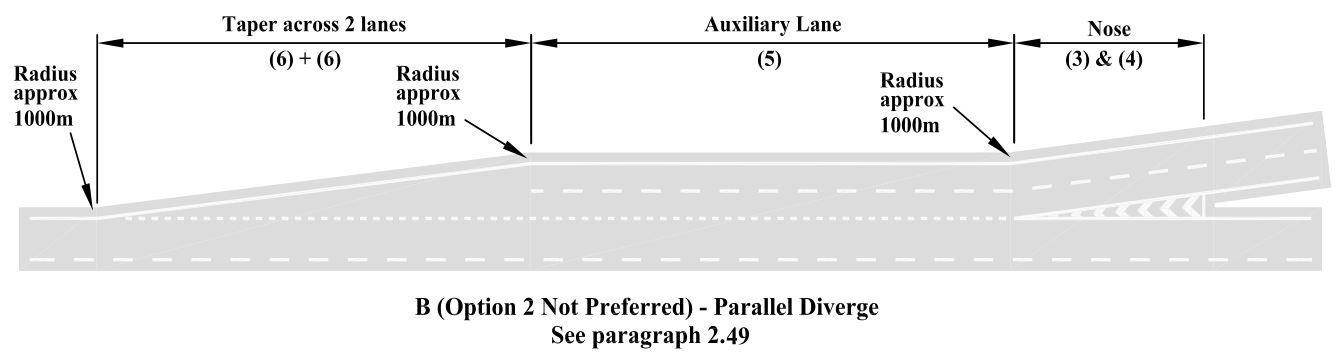
See paragraph 2.43 and the example above, for explanation of the usage of this diagram.

**Figure 2/5 MW Motorway Diverging Diagram**

Diverge with  
No Lane Drop



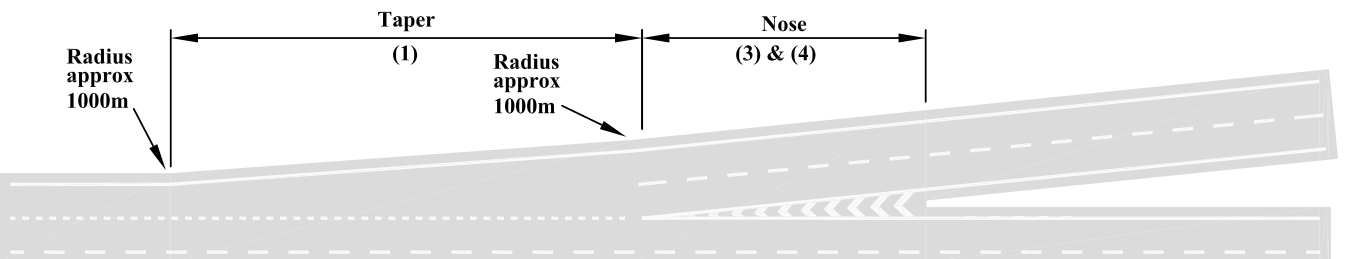
- 1 - Ghost Island and nose markings to Traffic Signs Regulations and General Directions Diagram No. 1042.1 and 1042.
- 2 - Ghost Island width 2m minimum at widest point.
- 3 - The edge line must be laid to the radii indicated.



N.B. Figures in brackets refer to columns in Table 4/4

Figure 2/6.1 Diverge Lane Layouts for use with Figure 2/5

Diverge with  
Lane Drop



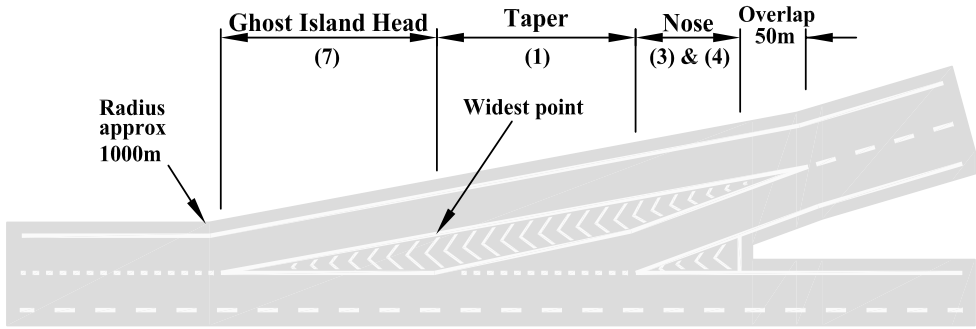
The edge line must be laid to the radii indicated

C - Lane Drop at Taper Diverge

N.B. Figures in brackets refer to columns in Table 4/4

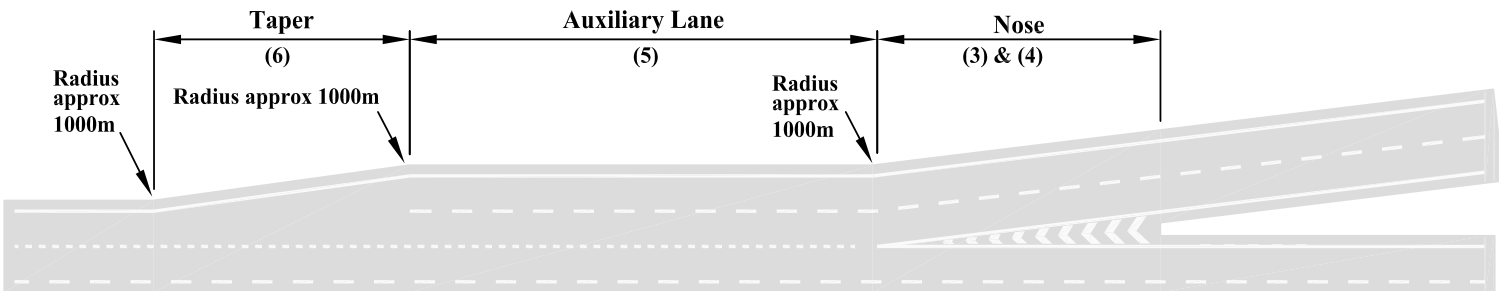
Figure 2/6.2 Diverge Lane Layouts for use with Figure 2/5

Diverge with  
Lane Drop



**D (Option 1 Preferred) - Ghost Island diverge for Lane Drop including for conversion of existing Lane Drop at Taper Diverge**

- 1 - Ghost Island and nose markings to Traffic Signs Regulations and General Directions Diagram No. 1042.1 and 1042.
- 2 - Ghost Island width 2m minimum at widest point.
- 3 - The edge line shall be laid to the radii indicated.

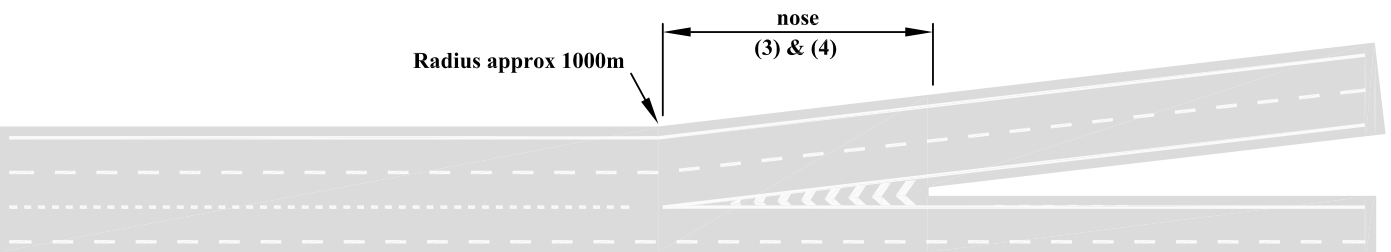


**D (Option 2 Not Preferred) - Lane Drop at Parallel Diverge**  
See paragraph 2.49

N.B. Figures in brackets refer to columns in Table 4/4

**Figure 2/6.3 Diverge Lane Layouts for use with Figure 2/5**

Diverge with  
Lane Drop



The edge line must be laid to the radii indicated

E - 2 Lane Drop

N.B. Figures in brackets refer to columns in Table 4/4

Figure 2/6.4 Diverge Lane Layouts for use with Figure 2/5

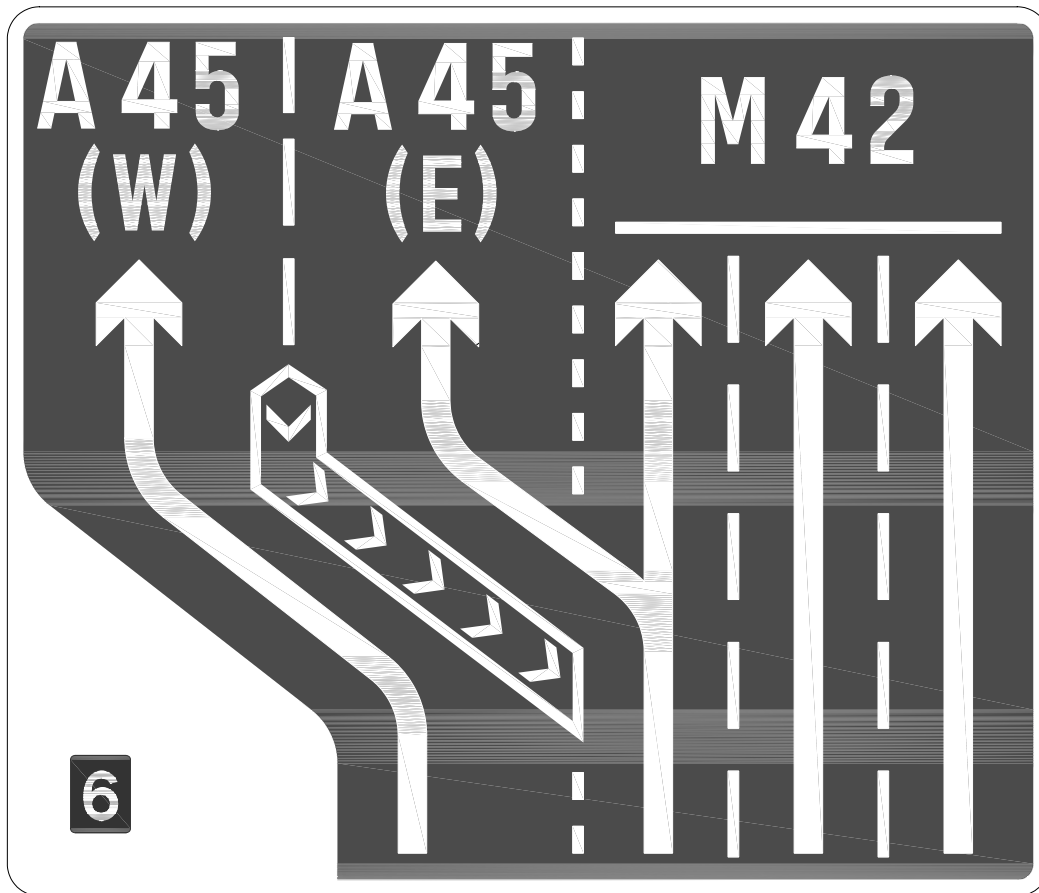


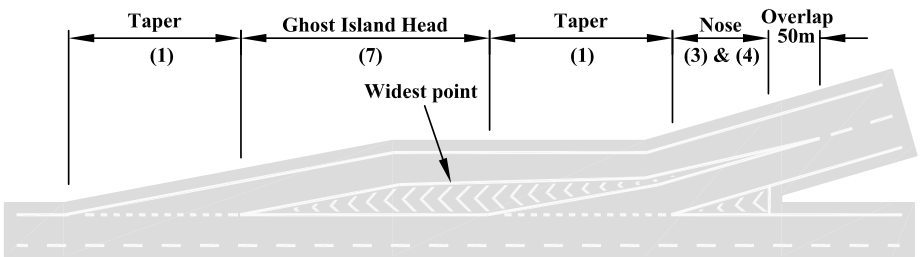
Figure 2/7 Typical Sign for Ghost Island Diverge Layout (“tiger-tail”)

### Motorway Service Areas (MSAs)

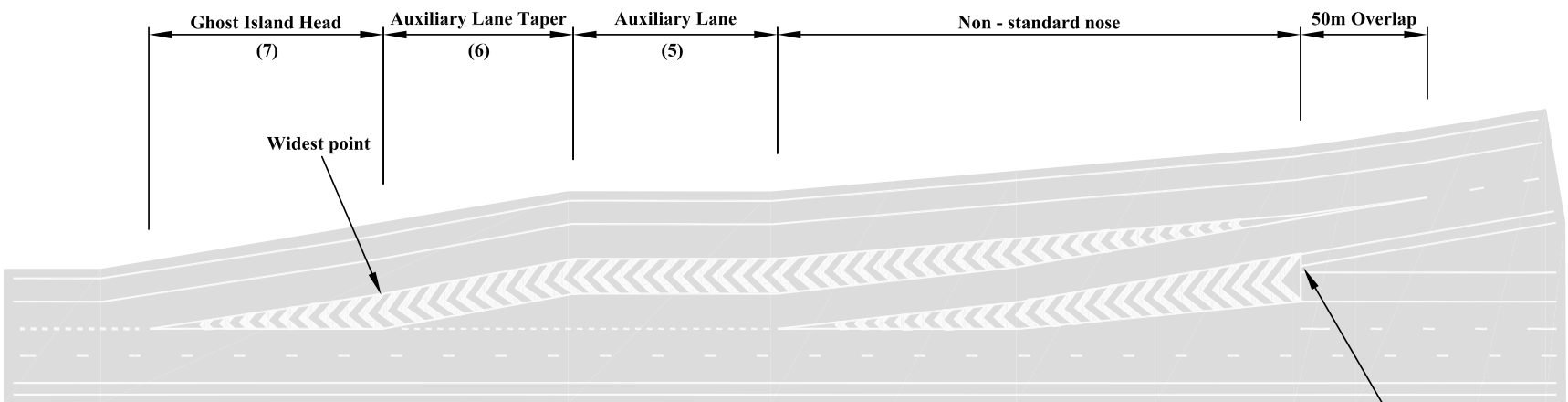
2.54 The merge and diverge layout design and junction spacing parameters in this standard apply to MSAs.

2.55 Generally all vehicle types are permitted to enter an MSA via a connector road directly from the mainline or as an integral part of a grade separated junction.

2.56 Drivers wishing to make a stop at MSAs will have made a choice about their immediate destination and know that they will have to slow down. The provisions set out below should facilitate safe layouts for access to and egress from MSAs.



(i) Ghost Island Diverge



(ii) Ghost Island Diverge with quasi-lane drop

Notes:

- 1 - Ghost Island and nose markings to Traffic Signs Regulations and General Directions Diagram No. 1042.1 and 1042.
- 2 - Ghost Island width 2m minimum at widest point.
- 3 - Where there is inadequate land to provide a full width hard shoulder consideration may be given to reducing the width. See para 2.52

Figure 2/8 Examples of Existing Parallel Diverges Converted to Ghost Island Diverges



2.57 The following requirements must apply to MSAs accessed directly from motorways:

- The design speed of connector roads must be the same as a slip road in Table 4/1.
- For diverge slip roads for MSAs, stopping sight distance and horizontal curvature may be reduced by one design speed step as a Relaxation (see paragraph 1.39 and **TD 9 (DMRB 6.1.1)**).
- Near straights must be provided on the slip roads as described in paragraph 2.34 for merges and paragraph 2.46 for diverges.
- Street Lighting (see also paragraphs 5.33, 5.34 and 5.35):
  - If the mainline is lit then the slip road must be lit
  - If the mainline is not lit then:
    - ~ for a merge, the lighting must be ended as soon as possible after the MSA boundary;
    - ~ for a diverge, the lighting must start before the point where MSA lighting occurs but such as not to cause light spillage onto the mainline.
- The layout must include a comprehensive traffic sign and road marking scheme and consideration should be given to the inclusion of ‘chevron’ warning signs, reflective road studs, edge of carriageway markings, rumble strips and advisory speed limit signs.
- High containment kerbs must not be used on slip roads as high speed impacts may lead to the overturning of vehicles.
- Measures must be taken to reduce any ‘see-through’ effects when looking from a diverge slip to the merge slip or internal road system of the MSA, e.g. suitable landscaping.

2.58 For online service areas, at the end of the MSA diverge slip road, it is recommended that a gateway be erected. The object of the gateway is to draw the attention of the driver to the change to the lower standards of the MSA. It will also highlight the need for greater care and emphasise the probability of encountering slow vehicles and pedestrians using the internal roads of the MSA. The gateway must be sited on the MSA side of the ‘End of Motorway’ signs.

2.59 The gateway should include speed restriction signs, which may be emphasised by the use of calming measures such as dragon’s teeth and coloured road markings. Additional gateway features may also be used provided that they do not create a road safety hazard.

2.60 A similar or simpler gateway may be provided at the start of a merge slip road on leaving the MSA. The gateway must be sited on the MSA side of the point where the motorway regulations start.

#### Other Service Areas

2.61 The merge and diverge layout design of all-purpose road service areas should be based on the geometric parameters within this standard as set out in paragraph 2.57 above or **TD 42 (DMRB 6.2.6)**, as appropriate for each site.

#### Application to Maintenance Compounds

2.62 Where maintenance compounds are accessed off the mainline, the standards set out in paragraph 2.57 for MSAs must be used.

#### Design for Maintenance

2.63 Any area of pavement that can be driven over in an emergency or during maintenance or other road works should be designed to make it safe to do so. Although it is illegal to drive over noses and other chevron areas bounded by continuous edge lines, they may be trafficked during road works if drivers are directed to do so.

2.64 Paragraph 4.32 gives advice relating to lane drops and lane gains and the intervening length of carriageway through a junction.

### Emergency and Maintenance Accesses

2.65 Where an emergency or maintenance access is required, a suitable layout must be chosen from **TD 41 (DMRB 6.2.7)**. The preferred layout is that shown as Layout 1 but the designer must check that this would be adequate for its likely use. The access must be gated and locked to prevent unauthorised use. The entrance gate or gates must be set back to accommodate, behind the hardstrip or hardshoulder, one vehicle of the largest type expected to use the access. For a maintenance access, provision must be made for two vehicles of the largest type expected to use the access to pass in opposite directions in the vicinity of the access. The design of the emergency or maintenance access must comply with the requirements of **TD 41 (DMRB 6.2.7)** with respect to avoiding steep gradients on the access road in the immediate vicinity of its connection to the trunk road.

### Designing Weaving Sections

2.66 The principle of calculating weaving sections is that the length is fixed using paragraphs 4.34 to 4.37 and the width is calculated from the formula in paragraph 2.71. This determines the number of lanes and can indicate the addition of one or two auxiliary lanes. The formula shows that the minor weaving flow has an impact on the traffic demand of up to 3 times its numerical value.

2.67 An actual weaving length less than the desirable minimum must not be entered into the formula.

2.68 Weaving lengths for taper layouts must be measured between the end of the merge and start of the diverge tapers, see Figure 4/9A. For auxiliary lane layouts, the auxiliary lane is ignored and the length between the end of the notional merge and the start of the notional diverge must be measured as illustrated in Figure 4/9B. In the case of lane gains and lane drops, the methods set out in Figures 4/10, 4/11 and 4/12 must be used.

2.69 In the case of ghost island merges and diverges, the examples in Figure 4/13 show the two points which must be used for the two connector road lanes to provide the averaged weaving lengths between junctions. Similar techniques must be applied for diverges.

2.70 In the case of wide (5 lane or more) carriageways, there should be no reduction below the desirable minimum weaving length. A vehicle on a 5-lane carriageway requires at least 1km to cross between Lanes 5 and 1 in safety to leave at a diverge and the driver will need advance warning. The formula in paragraph 2.71 should still be used, but non-weaving traffic may be excluded from the calculation if it travels in a reserved lane.

2.71 For weaving sections on motorways and dual carriageway roads, design flows must be calculated as in Chapter 3. In measuring  $L_{act}$ , it will be necessary to consider whether distance is available to adequately sign the second junction and allow adequate visibility to the sign from all lanes. To calculate the number of traffic lanes required for weaving the following equation must be used (and see Figure 2/9):

$$N = \frac{1}{D} (Q_{nw} + Q_{w1} + Q_{w2} (2 L_{min} / L_{act} + 1))$$

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 mainline flow from paragraph 3.3 in vph per lane

$L_{min}$  = Desirable Minimum weaving length for the road class as in paragraphs 4.34 to 4.37

$L_{act}$  = Actual weaving length available

( $L_{act}$  must always be greater than or equal to  $L_{min}$ )

2.72 In calculating the number of traffic lanes required (paragraph 2.71) a fractional part will inevitably require a decision to round up or down. If it is possible to vary the position of the junctions and thus increase or decrease the weaving length, the fractional part will converge approximately to a whole number of lanes and the decision is simplified. However, if this is not possible the decision becomes more difficult. Where the fractional part is small and is combined with a low weaving flow rounding down is suggested, whereas a high fractional part with a high weaving volume suggests rounding up. For example the addition of a fourth lane would have operational advantages in releasing the two middle lanes for weaving traffic. Other factors which may influence the decision are:

- i the number of lanes required for merging and diverging (paragraphs 2.29 and 2.43);
- ii when the fractional part is about 0.5 the uncertainty of the design flows (Chapter 3) suggests always rounding up from 2 to 3 lanes;
- iii on recreational routes there can be a high proportion of drivers who are not local and therefore behave less efficiently than commuters would at the same flow levels;
- iv the consequences of under provision should be borne in mind, as the acquisition of land at a later date could be costly or impossible;
- v. relevant environmental factors should be taken into account.

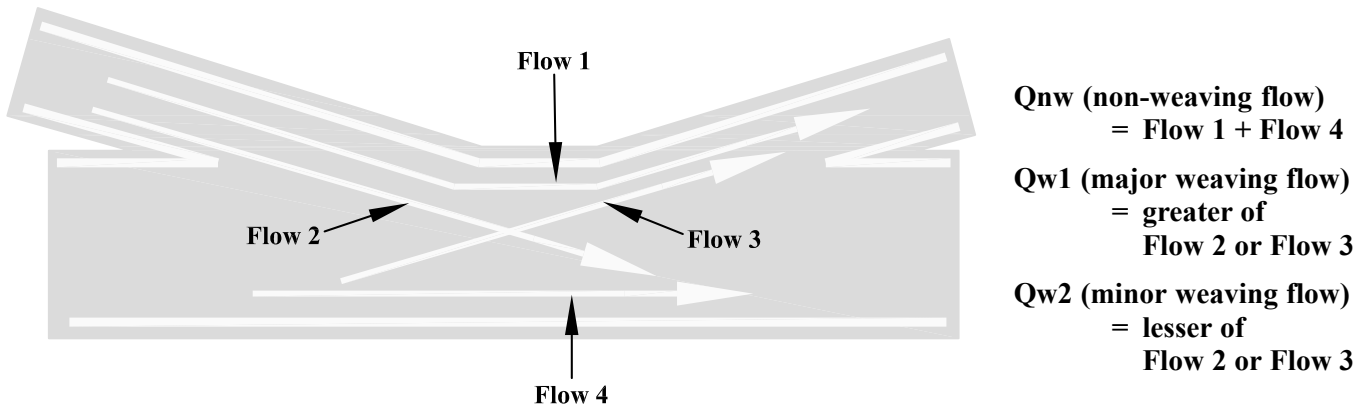


Figure 2/9 Terms used in Weaving

## 3. TRAFFIC FLOWS

### Introduction

3.1 At the time of publishing this standard, the procedure for determining traffic flows for use in design is undergoing change and development.

3.2 Until such time as guidance has been published, designers must contact the Overseeing Organisation for instructions on how to proceed for individual schemes.

3.3 The Highway Code advises that a minimum two-second headway should be maintained between vehicles on roads carrying fast traffic. For the purpose of designing grade separated junctions and interchanges, the maximum flow per lane for motorways must be taken as 1,800 vehicles per hour (vph) and for all-purpose roads as 1,600 vph. These flows do not represent the maximum hourly throughputs but flows greater than these will usually be associated with decreasing levels of service and safety. These values have been used in Figures 2/3 and 2/5 in this standard.

### Design Flow Ranges and Connector Road Cross Sections

3.4 Connector road cross sections are set out in **TD 27 (DMRB 6.1.2)** and the corresponding design traffic flow ranges are given in Tables 3/1a and 3/1b.

3.5 Designers should consider the possible benefits of providing greater widths for connector roads than those derived solely from Tables 3/1a and 3/1b and the standard cross-sections in **TD 27 (DMRB 6.1.2)**. This would be, for example, to provide for future maintenance activities.

Connector Road Flow <sup>+</sup>	Merge (Rural)	Merge (Urban)	Diverge (Rural)	Diverge (Urban)	Interchange Link/Loop (Rural)	Interchange Link/Loop (Urban)
<b>0-800</b>	MG1C Single lane with hardshoulder	MG1D Single lane with hardshoulder	DG1C Single lane with hardshoulder	DG1D Single lane with hardshoulder	IL1C Single lane* with hardshoulder	IL1D Single lane* with hardshoulder
<b>801-1200</b>	MG1C Single lane with hardshoulder	MG1D Single lane with hardshoulder	DG2E Two lanes with hardstrip	DG2F Two lanes with hardstrip	IL1C Single lane* with hardshoulder	IL1D Single lane* with hardshoulder
<b>1201-2400</b>	MG2E Two lanes with hardstrip	MG2F Two lanes with hardstrip	DG2E Two lanes with hardstrip	DG2F Two lanes with hardstrip	IL2C Two lanes with hardstrip	IL2D Two lanes with hardstrip
<b>2401-3200</b>	MG2E Two lanes with hardstrip	MG2F Two lanes with hardstrip	DG2E Two lanes with hardstrip	DG2F Two lanes with hardstrip	IL2C Two lanes with hardstrip	IL2D Two lanes with hardstrip

**Table 3/1a Cross-Sections for Connector Roads To/From Mainline All-Purpose Roads**

Connector Road Flow <sup>+</sup>	Merge (Rural)	Merge (Urban)	Diverge (Rural)	Diverge (Urban)	Interchange Link/Loop (Rural)	Interchange Link/Loop (Urban)
<b>0-900</b>	MG1A Single lane with hardshoulder	MG1B Single lane with hardshoulder	DG1A Single lane with hardshoulder	DG1B Single lane with hardshoulder	IL1A Single lane* with hardshoulder	IL1B Single lane* with hardshoulder
<b>901-1350</b>	MG1A Single lane with hardshoulder	MG1B Single lane with hardshoulder	DG2A Two lanes with hardstrip	DG2B Two lanes with hardstrip	IL1A Single lane* with hardshoulder	IL1B Single lane* with hardshoulder
<b>1351-2700</b>	MG2C Two lanes with hardshoulder	MG2D Two lanes with urban hardshoulder	DG2A Two lanes with hardstrip	DG2B Two lanes with hardstrip	IL2A Two lanes with hardshoulder	IL2B Two lanes with urban hardshoulder
<b>2701-3600</b>	MG2C Two lanes with hardshoulder	MG2D Two lanes with urban hardshoulder	DG2C Two lanes with hardshoulder	DG2D Two lanes with urban hardshoulder	IL2A Two lanes with hardshoulder	IL2B Two lanes with urban hardshoulder

**Table 3/1b Cross-Sections for Connector Roads To/From Mainline Motorways**

**Notes For Tables 3/1a and 3/1b**

\* See paragraph 4.3 for restrictions on use of single lane interchange links

+ Design flow (vehicles per hour) adjusted for gradients and LGVs

Refer to **TD 27 (DMRB 6.1.2)** for actual dimensions of cross-section components

These tables can indicate, for low connector road flows, that a single lane connector road should be provided for a Layout C diverge, which has two connector road lanes. In such cases, two lanes should be provided.

**Flow Adjustments for Uphill Gradients and for LGVs**

3.6 Before using Figures 2/3 and 2/5 for the selection of merge and diverge layouts respectively, the design flows must be adjusted for uphill gradients and the presence of LGVs by using Tables 3/2 and 3/3. Note that adjustments are made to flows on the mainline and on merge connector roads but not to flows on diverge connector roads.

3.7 To establish the mainline gradient at merges or diverges, a 1 kilometre section must be used, 0.5 km either side of the merge or diverge nose tip, and the average gradient determined. The merge connector road gradient must be based on the average of the 0.5 km section before the nose tip.

3.8 Before using Figure 4/14 and the weaving formula in paragraph 2.71, the design flows must be adjusted for uphill gradients and the presence of LGVs by using Table 3/2.

3.9 To establish the mainline gradient at a weaving section, the weaving length,  $L_{act}$ , must be determined and the average gradient calculated over that length.

% LGVs on Merge Connector	Merge Connector Gradient		
	<2%	2% – 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

**Table 3/3 Adjustment Factors for Uphill Gradients and for the presence of Large Goods Vehicles Merge Connector**

%LGVs on mainline	Mainline Gradient	
	<2%	≥2%
5	–	1.10
10	–	1.15
15	–	1.20
20	1.05	1.25

**Table 3/2 Adjustment Factors for Uphill Gradients and for the presence of Large Goods Vehicles Mainline**

## 4. GEOMETRIC STANDARDS

### Cross Sections

4.1 For the purpose of designing junctions and interchanges, cross sections for the mainline and all connector roads are given in **TD 27 (DMRB 6.1.2)**. The design flow ranges corresponding to these cross sections are shown in Table 3/1a and 3/1b.

### Maximum Lengths of Slip Roads and Interchange Links

4.2 A Slip Road longer than 0.75 km must be designed as an Interchange Link.

4.3 Single Lane Interchange Links must only be provided:

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

4.4 Where two lane interchange links are proposed, care will be needed to ensure that any subsequent merge can be designed in accordance with this standard. Layout A and Layout B merges are not permitted for

two lane slip roads. One solution could be the reduction from two lanes to one lane near the end of the interchange link in accordance with **TA 58 (DMRB 8.2.1)**. This may not be possible on loops where the accident risk of a lane reduction on a tight bend should be avoided, normally by providing a length of near straight at the end of the loop. Alternatively, on loops it may be preferable to adopt a one-lane interchange link throughout (subject to the requirements of paragraph 4.3) or remove one lane prior to the loop.

### Design Speed

4.5 Design speeds for the mainline must be determined from **TD 9 (DMRB 6.1.1)**. The design speeds of connector roads must be as given in Table 4/1. The design speed for link roads should normally be one design speed step below that of the mainline, as shown in Table 4/1 and this reduced design speed will need to be made clear to the vehicle driver. To help achieve this, link roads should be subject to an appropriate speed limit, either mandatory or advisory. Where the proposed link road design speed is one design speed step below that of the mainline and this cannot be made obvious to the driver, the higher design speed should be used. Where the link road is a connection to a motorway, motorway merge parameters apply, regardless of the 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	85 or 70	120 or 100A	100A or 85
	Dumb-bell Link Road	70	70	70	70

Table 4/1 Connector Road Design Speed

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

**Horizontal and Vertical Alignment**

4.7 The geometric standards for horizontal and vertical alignment and stopping sight distance for the mainline through a grade separated junction and for the connector roads must be provided in accordance with **TD 9 (DMRB 6.1.1)**. **TD 9** specifies an absolute maximum gradient for motorways of 4%. For motorway connector roads, this may be increased to 6%.

4.8 Low radius connector roads must be widened on curves in accordance with **TD 9 (DMRB 6.1.1)** and **TD 42 (DMRB 6.2.6)**.

**Loops**

4.9 In the case of the horizontal curvature and superelevation for loops (as defined in paragraph 1.21), there is evidence to suggest that the radii of loops (Figure 4/1) can safely be much less than for curves turning through lesser angles, provided that adequate warning is given to drivers and clear sight lines are maintained. For loops the minimum radii may therefore be those given in Table 4/2. Within the loop, successive radii of the same hand must not reduce in radius. The standards for superelevation for loops are set out in **TD 9 (DMRB 6.1.1)**. Superelevation greater than 7% and up to 10% may be provided as shown in **TD 9 (DMRB 6.1.1)** but superelevation greater than 7% should be used with caution where there is a risk of prolonged icy conditions. Where loops leave or join the mainline, crossfall alongside the nose must be the minimum required for drainage design as laid down in **TD 9 (DMRB 6.1.1)**. Widening on loops must be as set out in **TD 42 (DMRB 6.2.6)**.

Motorway	All-Purpose	
	On to Mainline	Off Mainline
75	30	50

**Table 4/2 Minimum Loop Radii – (m)**

4.10 Research into loops carried out from 1985 to 1994 did not reveal any systemic safety problems. Accident levels at sites surveyed were generally low with approximately a third of the sites having no personal injury accidents over the study period. If the general decrease in accident rates over time is considered, then the overall accident rates in the study are consistent with those found in the earlier study that underpinned the design advice in the now superseded TD 22/92 and TA 48/92.

4.11 The research looked at whether non-compliance with existing standards gave rise to safety problems and a variety of non-complying loops were examined. The study examined the following loops which are shown in Figure 4/1:

**Basic merge** A loop that passes through approximately 270° where traffic merges with the mainline flow. This Basic Merge, when combined with the Hook Diverge, forms the layout in Figure 4/2b.

**Basic diverge** A loop that passes through approximately 270° where traffic diverges from the mainline flow. This Basic Diverge, when combined with the Hook Merge, forms the layout in Figure 4/2a.

**D merge** The loop commences at a T-junction or roundabout and merges with the mainline flow. The angle turned is typically approximately 180°.

**D diverge** The loop commences at a diverge from the mainline flow and ends at a T-junction or roundabout. The angle turned is typically approximately 180°.

**Hook merge** This layout is classified as a loop and the notional total angle is between 180° and 270°. This Hook merge, when combined with the Basic diverge, forms the layout in Figure 4/2a.

**Hook diverge** This layout is classified as a loop and the notional total angle is between 180° and 270°. This Hook diverge, when combined with the Basic merge, forms the layout in Figure 4/2b.



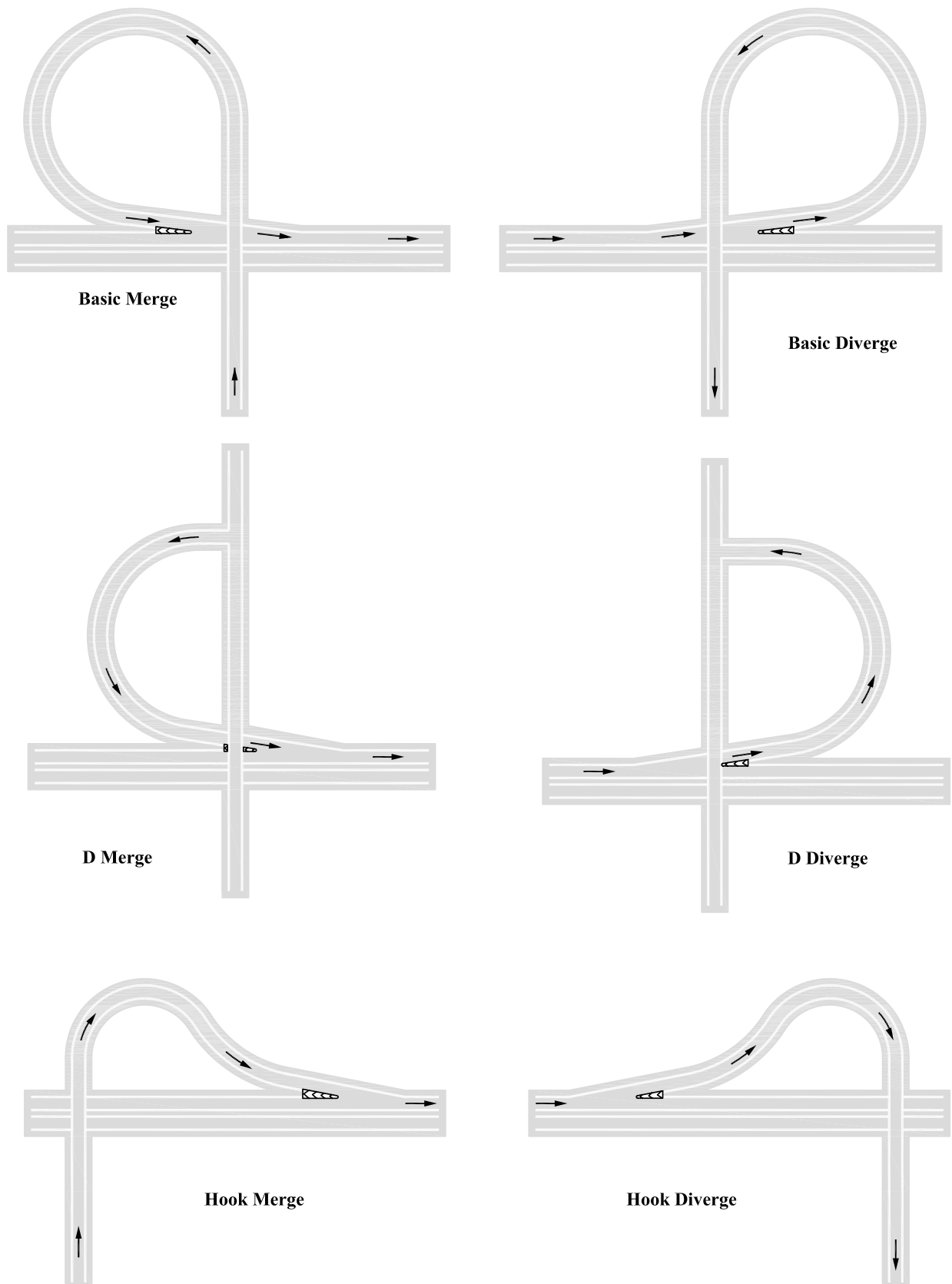


Figure 4/1 Types of Loop

Note: A near straight is required beyond the back of each nose (see paragraphs 2.34 and 2.46)

4.12 Motorway to motorway one-way loops and motorway to all-purpose road two-way loops were identified as the loop types with the highest average accident rate. Rates on loops on all-purpose routes and between all-purpose routes and motorways tended to be lower.

4.13 The findings give support to the argument that average speed of approach to a loop may have an impact on its safety record. It is possible that the higher speeds on motorways on the approach to loops may be a contributory factor to accidents, particularly on diverge loops. Measures to maintain safety are necessary, and measures to consider include:

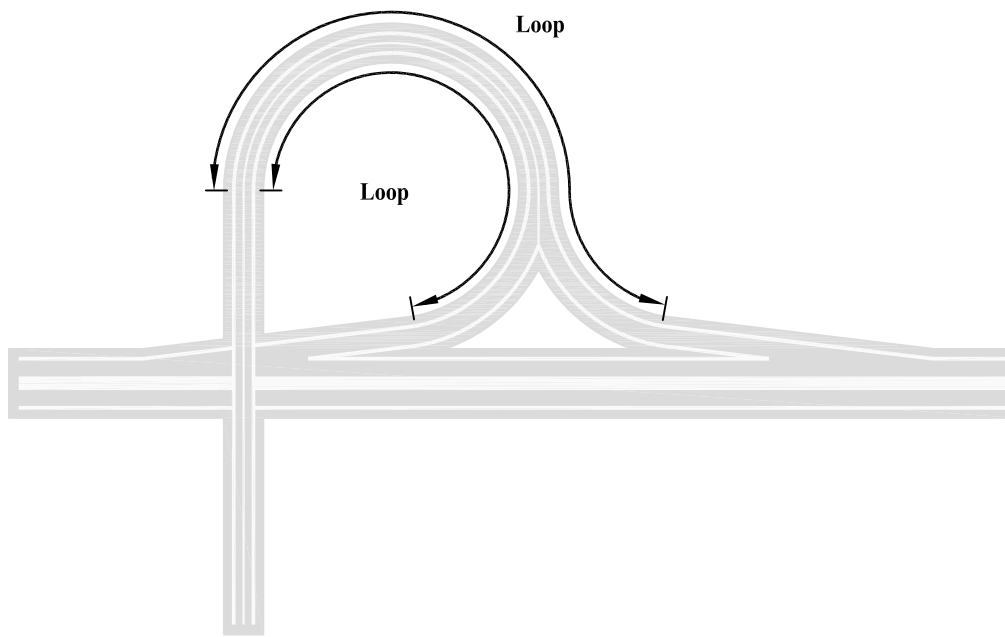
- i. provision and maintenance of clear visibility over the whole of the loop on the approaches, especially beyond an underbridge (see paragraph 4.19);
- ii. advisory speed limits and/or bend signs and “chevron” warning signs;
- iii. widening of lanes on the loops as appropriate for lower radii in accordance with **TD 42 (DMRB 6.2.6)**;
- iv. the provision of vehicle restraint systems on the outside of the curve;
- v. physical separation of opposing traffic streams (see paragraph 5.27 for mandatory requirements);
- vi. lighting;
- vii. high skid resistant surfacing.

4.14 The provisions for loops in this document must apply only to the layouts shown in Figure 4/1, which may be used in combination as shown in Figure 4/2.

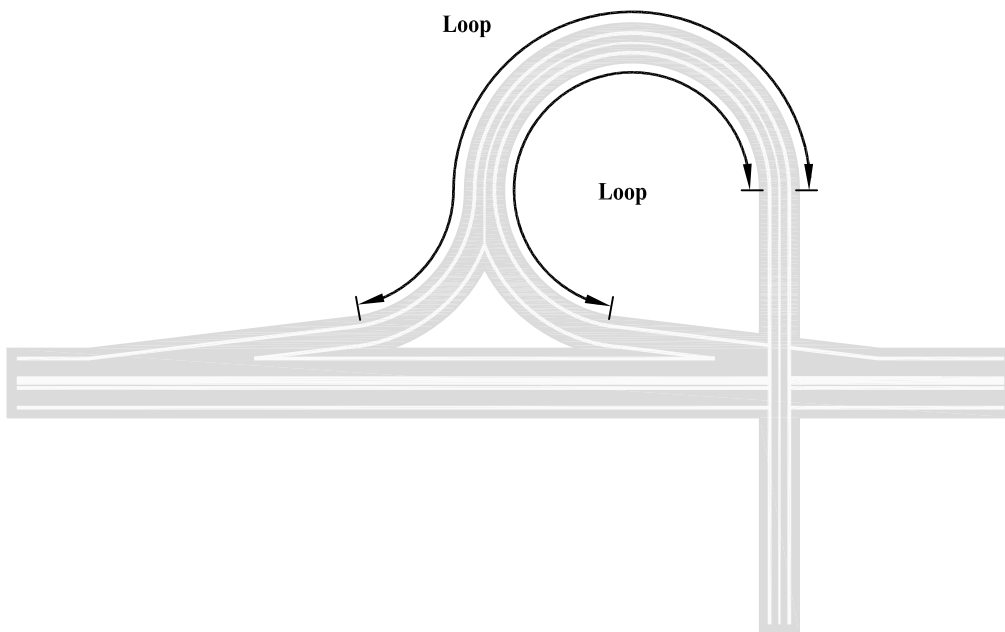
4.15 The provisions of paragraphs 2.33 and 2.34 for merges must be applied and will assist drivers to adjust their speed and join the mainline traffic. Similarly, the provisions of paragraphs 2.45 and 2.46 for diverges must be applied and will assist drivers to adjust their speed and to comprehend the layout of the loop in front of them.

### Sight Distances

4.16 Desirable Minimum Stopping Sight Distances must be provided on all connector roads in accordance with the design speed selected and **TD 9 (DMRB 6.1.1)**.



a) Basic diverge plus hook merge



b) Basic merge plus hook diverge

Figure 4/2 Examples of Combinations of Different Types of Loop

Note: A near straight is required beyond the back of each nose (see paragraphs 2.34 and 2.46)

4.17 For **merges**, the Stopping Sight Distance on the connector road must be that related to the design speed selected for that road (see paragraph 4.5 and Table 4/1). This will apply along the length of the connector road until the driver's eye is square with the back of the merge nose. From that point forward, the Stopping Sight Distance must be that for the mainline design speed. There must be no obstruction to sight lines between the connector road and the mainline and vice versa for the length of the merge nose. There is a minimum approach angle at which drivers can merge on direct sight, otherwise blind spots to the rear of the vehicle will be troublesome. Below this minimum approach angle drivers will be moving nearly parallel to the mainline carriageway and will have to merge using mirrors. It follows that there is a minimum width of merge nose and this can be derived from geometric parameters (paragraph 4.22). The width of the back of the nose must be sufficient to accommodate the mainline hardshoulder/hardstrip and the connector road off side hardstrip.

4.18 For **diverges**, the Stopping Sight Distance related to the mainline design speed must be maintained into the diverge until the drivers eye is square with the back of the diverge nose. The Stopping Sight Distance can then be progressively reduced to that for the design speed selected for the connector road in the manner illustrated in Figure 4/3A i.e. an object at a distance from the back of the nose equal to mainline SSD must remain visible as the vehicle moves forward along the connector road. If the length of the connector road between the back of the nose and the give way line of the at-grade junction at the end of the connector road is less than the mainline Stopping Sight Distance, then a 0.26m object at the give way line must be visible from a distance equal to the mainline Stopping Sight Distance. See Figure 4/3B. Similarly, for a diverge leading into an MSA, a 0.26m object at the downstream end of the slip road, the minimum length of which has been determined from paragraphs 2.46 and 2.57, must be visible from a distance equal to the mainline Stopping Sight Distance. Beyond that point drivers will expect a reduction of standards to that of the MSA.

4.19 For **loops**, in addition to the general stopping sight distance requirements, there must also be no obstruction to sightlines across the full extent of loops of low radius. This includes where the loops connect to the main carriageway as shown in Figure 4/2. This is to ensure that drivers are able to perceive the whole of the loop layout on their approach from upstream and adjust their speed and conduct accordingly. The only available relaxation to these requirements is when the necessary vehicle restraint systems obstruct the view to the 0.26m object height, in which case a clear sightline must be available above the vehicle restraint system to the 1.05m object height.

4.20 For the connections to the local road system, guidance on sight distance standards at major/minor junctions is given in **TD 42 (DMRB 6.2.6)** and for roundabouts in **TD 16 (DMRB 6.2.3)**. Advice on signal-controlled junctions is contained in **TD 50 (DMRB 6.2.3)**.

#### Hardstrip and Hardshoulder

4.21 Where the hardshoulder has to taper into a slip road or interchange link hardstrip or vice versa, this must be done in accordance with **TD 27 (DMRB 6.1.2)**. The slip road or interchange link hardstrip must terminate prior to an at-grade junction in accordance with the requirements of **TD 16 (DMRB 6.2.3)** for terminating edge strips on the approach to a roundabout.

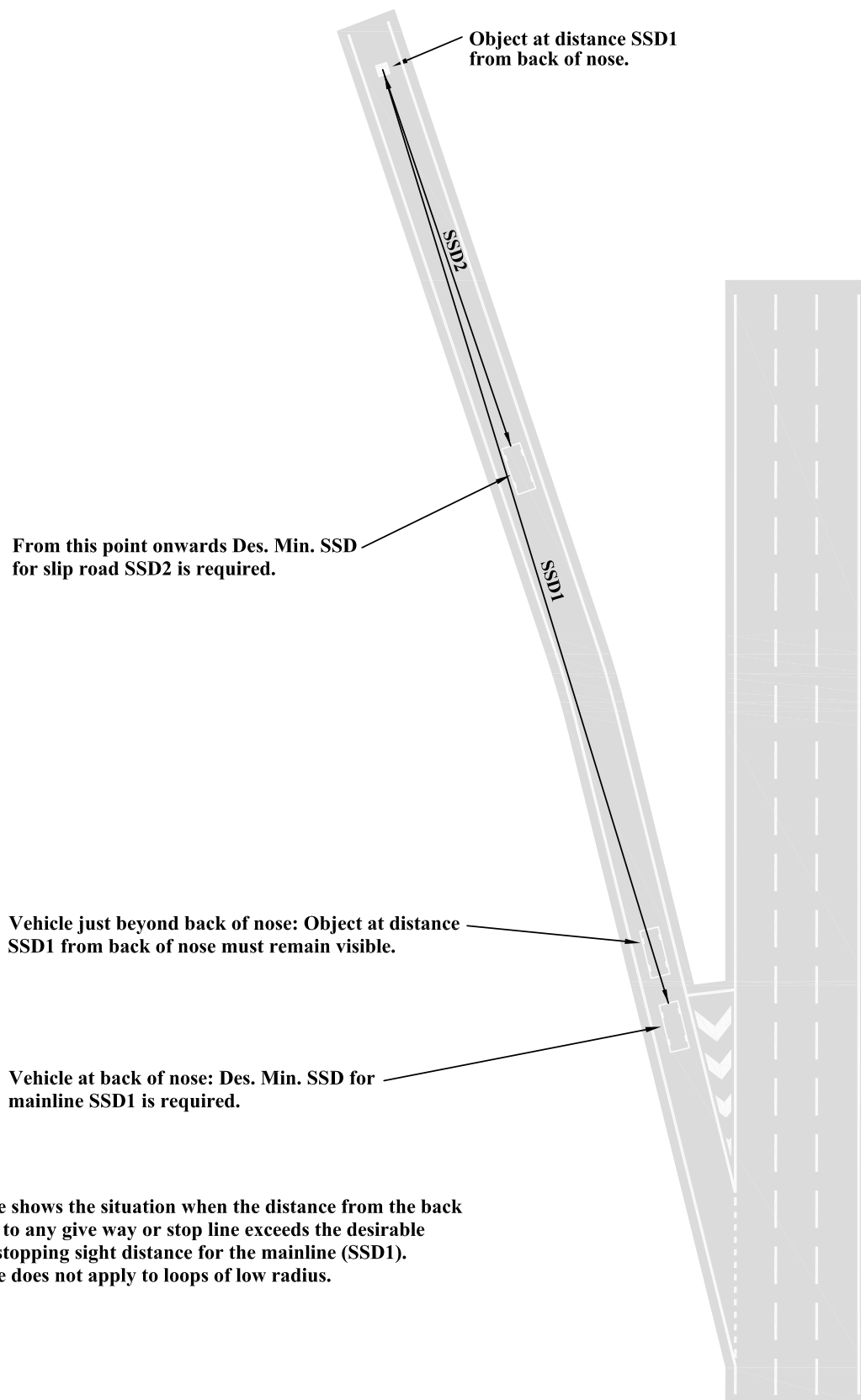


Figure 4/3A Illustration of Stopping Sight Distance on Slip Road

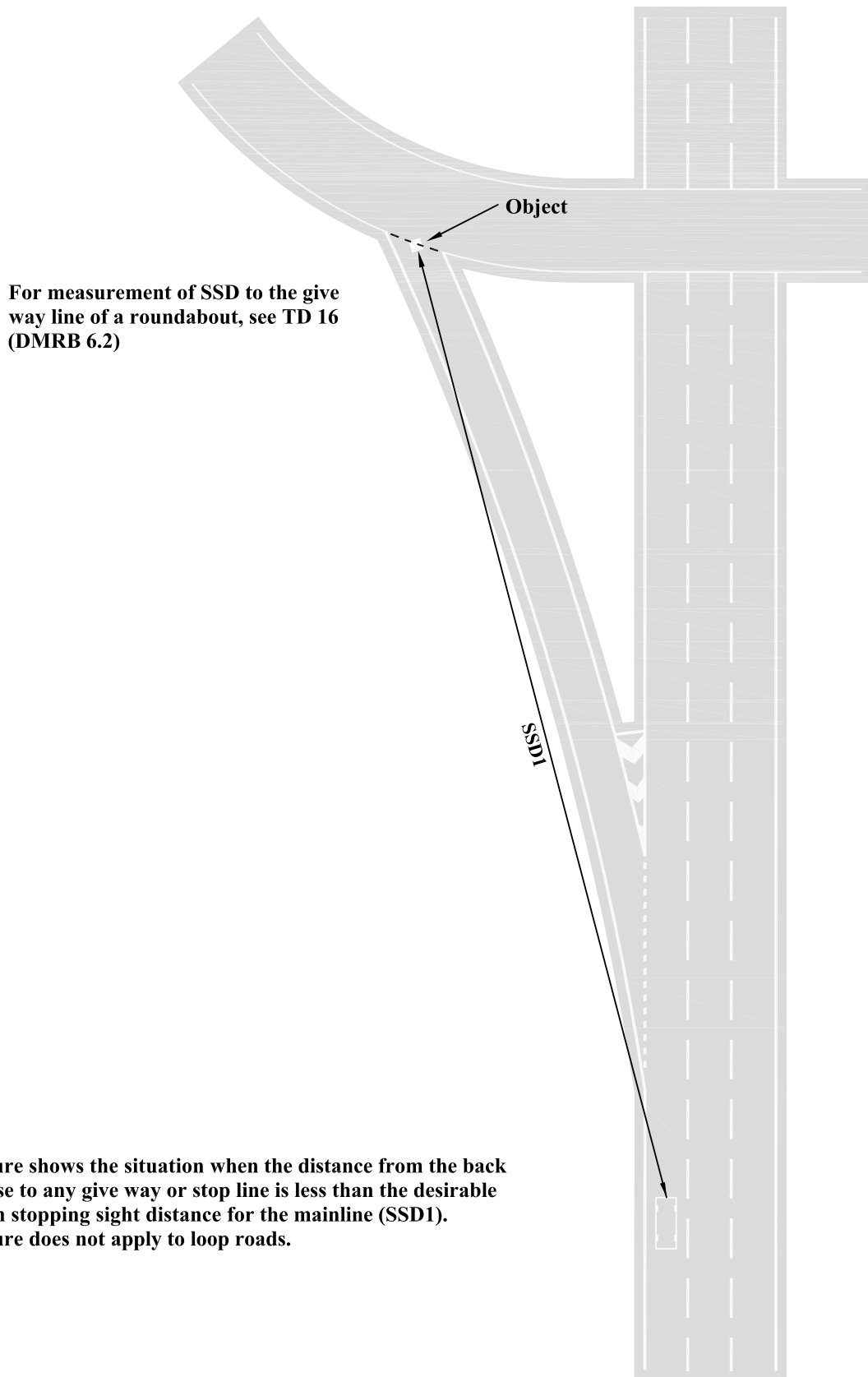


Figure 4/3B Illustration of Stopping Sight Distance on Slip Road

Merges and Diverges

4.22 The geometric parameters applicable to merges and diverges must be those in Tables 4/3 and 4/4 respectively. Figures 2/4 and 2/6 illustrate their use in typical layouts. Lengths are measured along the left edge of the carriageway. For merges, the layout of the edge line shown on Figure 2/4 does not require the use of larger radii. For diverges, the layout of the edge line should incorporate the radii shown on Figure 2/6. Ghost island merges are not permitted for urban roads (see Table 4/3).

Road Class	Length of Entry Taper m (1)	Nose Ratio (See Note 1) (2)	Nose Length m (3)	Minimum Auxiliary Lane Length m (4)	Length of Auxiliary Lane Taper m (5)	Length of Ghost Island Tail m (6)	Reduction Taper Length m (7)
Rural Motorway							
Mainline	205	1:40	115	230	75	180	n/a
Within Interchange	130	1:25	75	160	55	150	n/a
Rural All-Purpose Design Speed							
120kph	150	1:30	85	190	55	150	n/a
100A kph or less	130	1:25	75	160	55	150	n/a
Urban Road Speed Limit							
60 mph	95	1:15	50	125	40	n/a see Note 2	see Note 2
50 mph or less	75	1:12	40	100	40	n/a see Note 2	see Note 2

**Note 1** Nose Ratio is the ratio of nose back width to nose length for minimum angle at nose. The maximum angle will be limited by the ability of vehicles to negotiate the change in direction.

**Note 2** Ghost islands for merges on urban roads are not permitted (see paragraph 4.22) and the layout in Figure 2/4.2D should be used for all new or improvement work. For slip road reduction taper, (7) on Figure 2/4.2D, tapers are as given in Table 10-3 of Traffic Signs Manual Chapter 5. When the angle is less or the ratio is greater than the preferred minimum taper in Table 10-3, it is a departure from standards.

**Table 4/3 Geometric Design Parameters for Merging Lanes (See also Figure 2/4)**

Road Class	Length of Exit Taper m		Nose Ratio (See Note 1)	Nose Length	Minimum Auxiliary Lane Length	Length of Auxiliary Lane Taper	Length of Ghost Island Head
	1 lane (1)	2 lane (2)	(3)	m (4)	m (5)	m (6)	m (7)
Rural Motorway Mainline	170	185	1:15	80	200	75	180
Within Interchange	130	130	1:15	70	150	55	n/a
Rural All-Purpose Design Speed							
120kph	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** Nose Ratio is the ratio of nose back width to nose length for minimum angle at nose. The maximum angle will be limited by the ability of vehicles to negotiate the change in direction.

**Table 4/4 Geometric Design Parameters for Diverging Lanes (See also Figure 2/6)**

4.23 Where, in a merge on a rural motorway, it is anticipated that the connector road and mainline will frequently be carrying traffic flows approaching their design capacities, it is desirable to extend the minimum auxiliary lane length of 230 m (Table 4/3) to 370 m. As a guide, this should be considered when connector road and mainline flows reach 85% of capacity, as defined in paragraph 3.3, for more than 1,000 hours per year. Figure 4/4 shows an example for the layout of a ghost island merge with lane gain. Within larger interchanges, the length may be increased to 500 m. The auxiliary lane should be extended to the next diverge if this is close and the termination of the auxiliary lane is considered as a safety hazard.

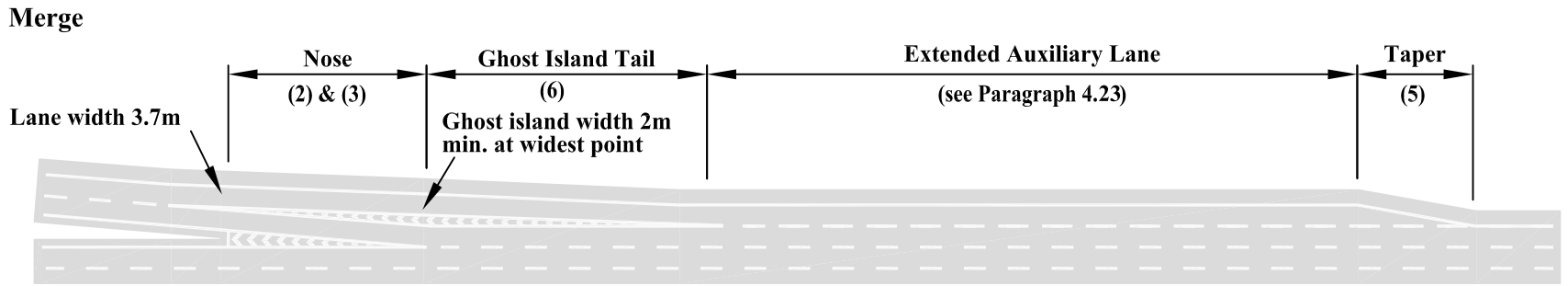
4.24 Where, in a diverge on a rural motorway it is anticipated that the connector road and the mainline will frequently be carrying traffic flows approaching their design capacities, layouts which encourage orderly use of the diverge by the use of ghost islands should be used in preference to layouts which do not have this feature. Use of layouts 2/6.1B Option 2 and 2/6.3D Option 2 is restricted to locations where layout 2/6.1B

Option 1, 2/6.3D Option 1, 2/8(i) and 2/8(ii) cannot be fitted. For layout 2/6.1B Option 2 it is desirable to project a single auxiliary lane upstream for 400m prior to the diverge (an example is shown in Figure 4/4), connected by a taper of length as shown in Table 4/4 column 6 to the two lane section as shown in layout 2/6.1B Option 2. The single auxiliary lane should also commence with such a taper. The same guidance as in paragraph 4.23 may be taken to indicate when an extended auxiliary lane should be considered.

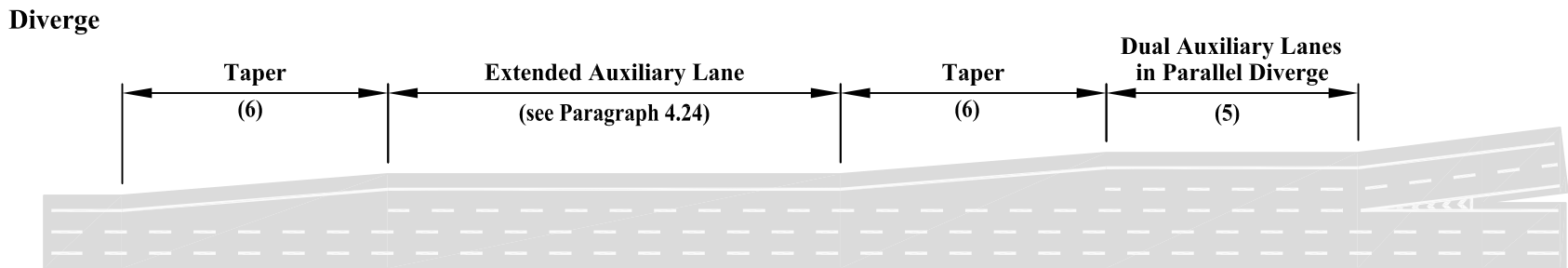
4.25 In order to allow merging drivers using an auxiliary lane to match their speed with those on the mainline where there is an uphill section of road, the auxiliary lane must be extended beyond the crest sufficiently to enable the end of the auxiliary lane to be clearly visible to drivers when:

- the uphill section of road would be sufficiently steep to require a climbing lane; or





Figures in brackets refer to columns in Table 4/3



Figures in brackets refer to columns in Table 4/4

Figure 4/4 Extended Auxiliary Lanes for Rural Motorways

- the proportion of LGVs is greater than 10% and the uphill mainline gradient is in excess of 2% and within 0.5 km of the crest.

For advice on the signing of auxiliary lanes, see paragraph 4.26.

4.26 For extended auxiliary lanes in merges, of length greater than that given in column (4) of Table 4/3, a sign to TSRGD diagram 872.1 (reversed in a mirror image) with a diagram 876 distance plate '200yds', should be placed 200yds from the start of the taper. For very long auxiliary lanes in merges consideration should be given to additional diagram 872.1 signs with the appropriate distance plates.

4.27 Emergency telephones and other equipment that requires vehicles to stop for assistance or highway maintenance must be sited a minimum of 100m from the termination of merges where vehicles may overrun onto the hard shoulder or hard strip.

4.28 The consequences of an incident can be severe if hazards are present within the verge area immediately downstream of the diverge nose. It is therefore desirable to provide a clear zone at the back of diverge noses such that the physical nose is free from all hazards, including safety barriers, to minimise the risk to errant vehicles. Creating a clear zone will normally require the vertical alignment for the connector road to follow that of the main carriageway for a short distance to allow the cross-section to be reasonably level, although it is normal practice to demarcate the paved area from the verge using kerbs. If creation of a clear zone is not achievable due to site constraints, the risk needs to be reduced to as low as is reasonably practical, for example:

- by the use of passively safe sign posts and lighting columns, although following the advice in **TA 89 (DMRB 8.2.2)** this would require approval from the Overseeing Organisation;
- if a safety barrier is required to protect errant vehicles from any hazards, including height differences between adjacent carriageways, the use of P4 terminals or crash cushions is recommended as end treatments to barriers. Sufficient space should be allowed for any safety barriers and end treatments.

At the time of publishing this standard, the standards for safety barriers are under review and designers should consult the most recent publication for the recommended dimensions of clear zones, seeking advice from the Overseeing Organisation in the meantime.

4.29 Parallel merges and diverges (Figure 2/4.1 (Layout B) and Figure 2/6.1 (Layout B Option 2)) must be used in preference to taper merges and diverges (Figure 2/4.1 (Layout A) and Figure 2/6.1 (Layout A)) if one or more of the following apply:

- i) the mainline has a horizontal radius less than the Desirable Minimum (Table 3 of **TD 9 (DMRB 6.1.1)**) for merges in the left hand curve direction and for diverges in the right hand curve direction;
- ii) the mainline is on an upgrade of 3% or steeper for longer than 1.5 km prior to the start of the taper;
- iii) the mainline is on a downgrade of 3% or steeper for longer than 1.5 km prior to the start of the taper;
- iv) the connector road entering a merge is on an upgrade of 3% or steeper for longer than 500 m before the merge.

Where a diverge connector road has a single lane, a single auxiliary lane is appropriate.

### Successive Merges or Diverges Within Interchanges

4.30 Where there are closely spaced successive merges or diverges on mainlines and connector roads within a junction or interchange (Figure 4/5), the minimum spacing between the tips of noses must be  $3.75V$  m, where  $V$  is the design speed in kph, subject to the minimum requirements for effective signing and motorway signalling. If the merges or diverges are on a connector road, the design speed must be that for the connector road. This paragraph applies to successive merges (merge followed by a merge) or successive diverges (diverge followed by a diverge). It also applies to a diverge followed by a merge but not to a merge followed by a diverge (the latter is a weaving section).

4.31 At a fork within an interchange link, the taper must be developed as shown in Table 4/5 and Figure 4/6. Problems may be encountered if a broken down vehicle were to be situated alongside the nose where a single lane fork passes to the right. The only additional width of carriageway available is the hardstrip. Under such circumstances the offside verge should be hardened (and marked using road markings to TSRGD diagram 1040.3) opposite the nose and for a length before and after, in order that vehicles can make their way past the disabled vehicle (see Figure 4/7). The maximum width of the hardened verge should be that of the appropriate hardshoulder. Any vehicle restraint system will require setting back behind such a length of hardened verge.

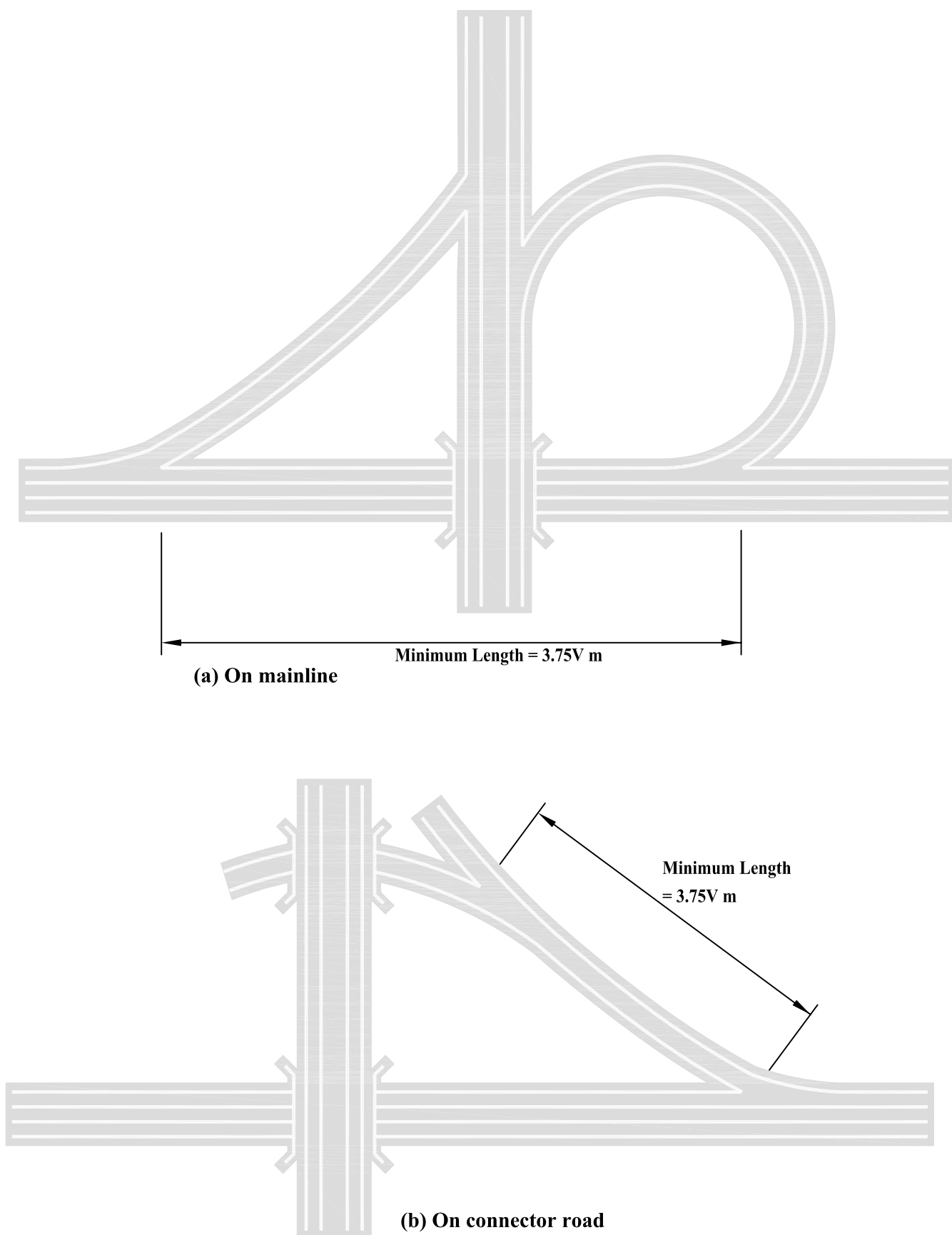


Figure 4/5 Example of Successive Merges/Diverges

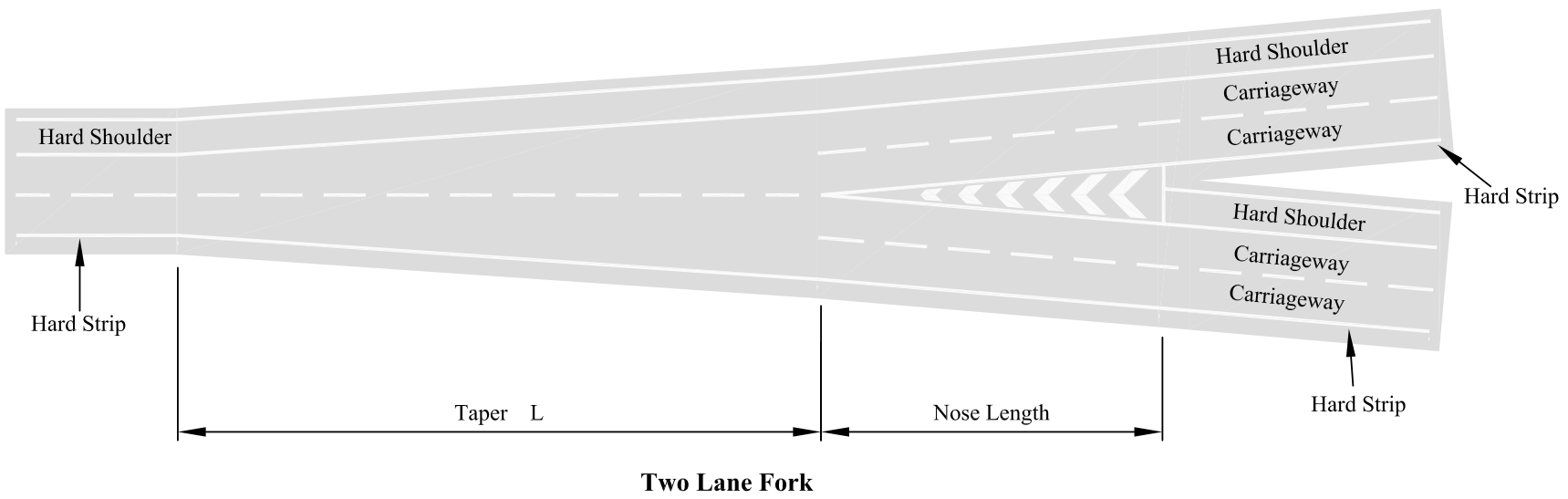
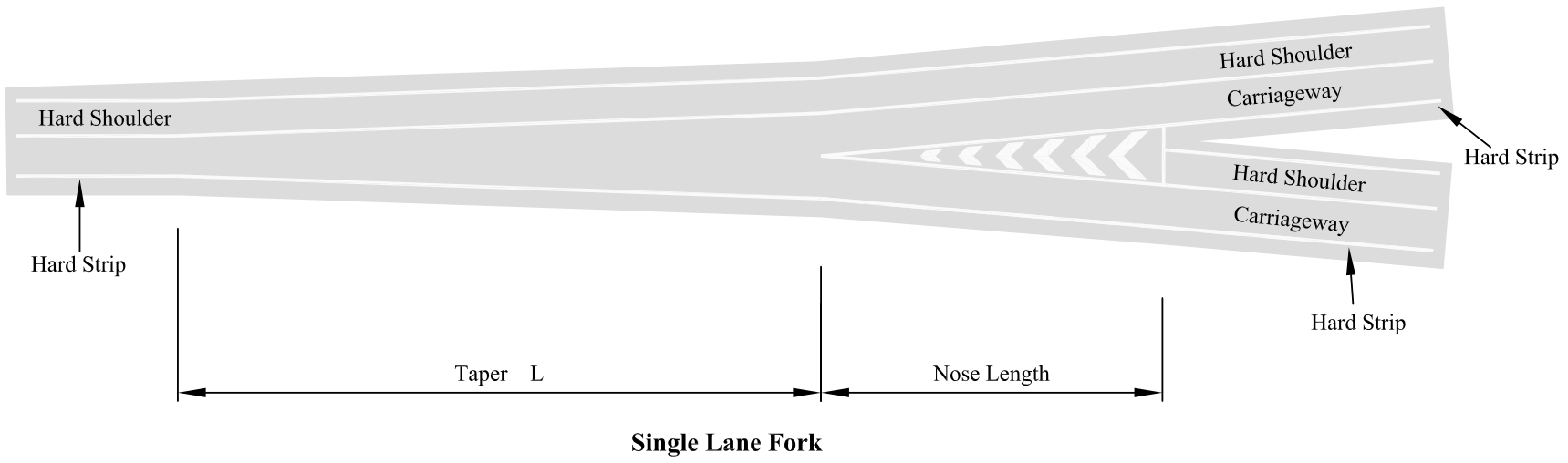
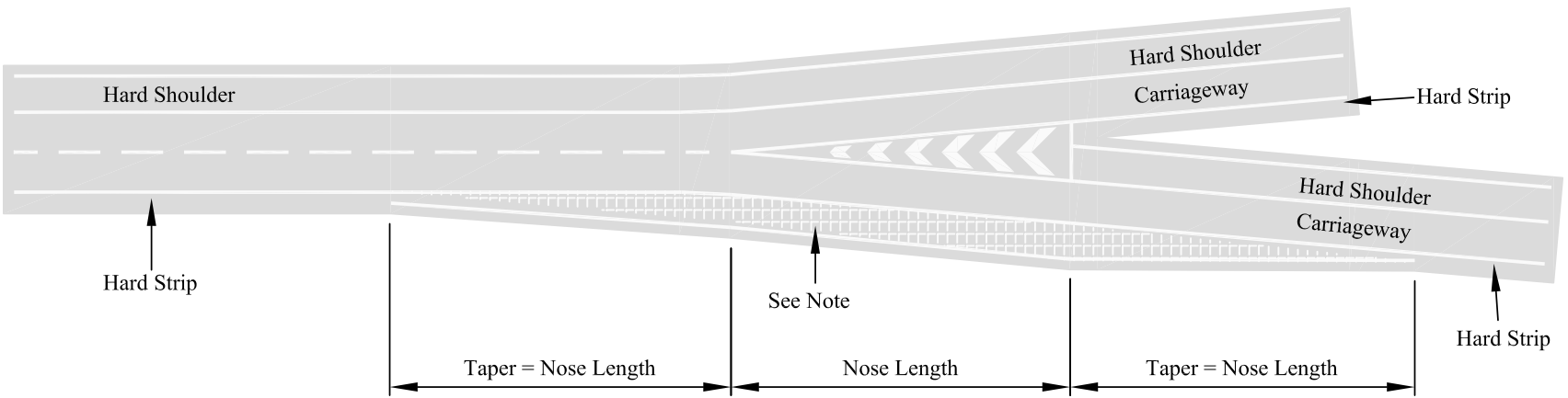


Figure 4/6 Development of Taper at Fork



**Note : Hardened verge capable of withstanding the weight of traffic**

Figure 4/7 Hardened Verge at Single Lane Fork

Interchange Link Design Speed	Length of Taper L (metres)		Nose Ratio	Nose Length (metres)
	1 lane	2 lane		
70/85kph	75	90	1:12	40

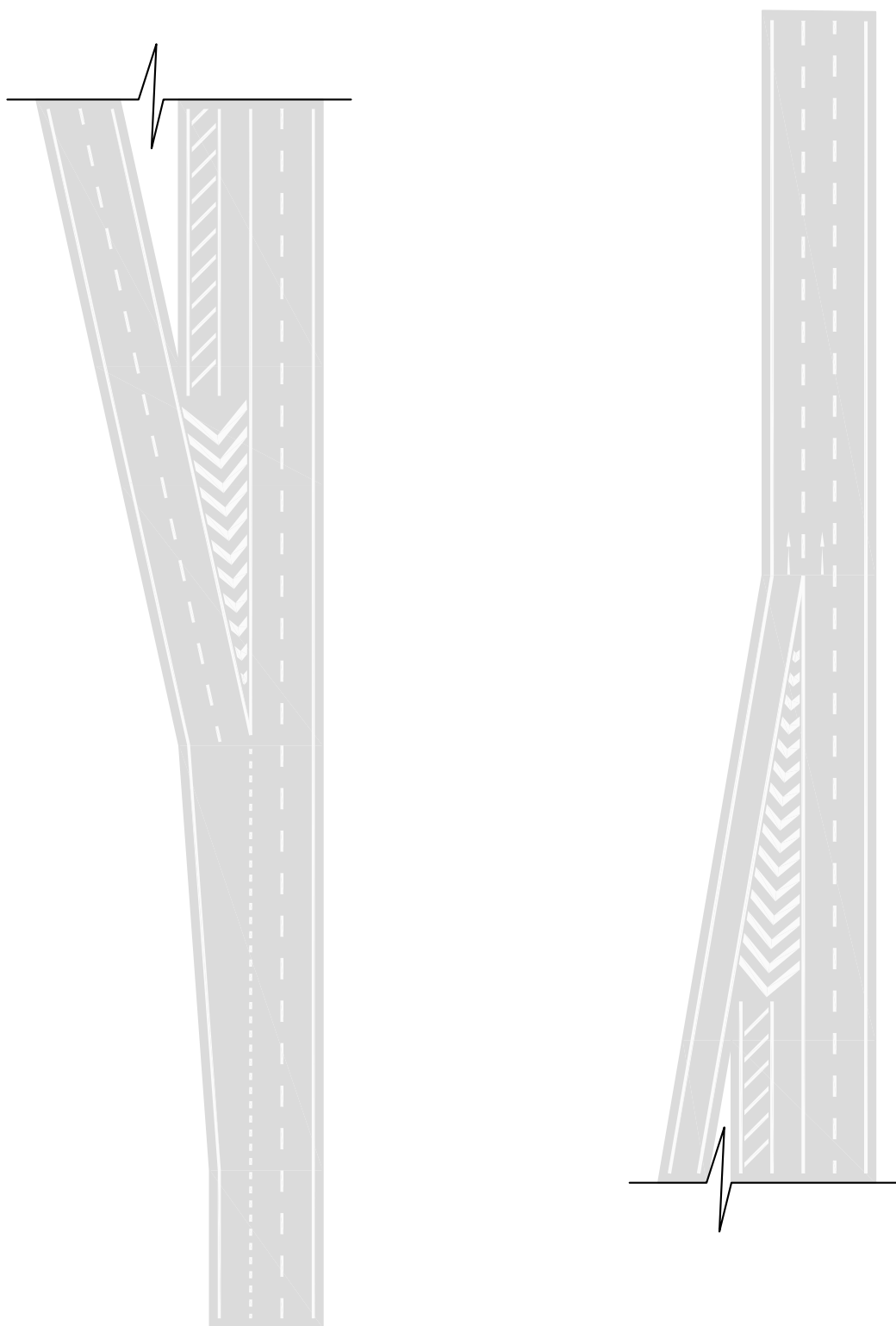
**Note** Nose Ratio is the ratio of nose back width to nose length for minimum angle at nose. The maximum angle will be limited by the ability of vehicles to negotiate the change in direction.

**Table 4/5 Geometric Design Parameters for a Fork Within an Interchange Link**

**Lane Drop/Lane Gain and Through Carriageway**

4.32 Where a 3-lane carriageway is reduced to 2 lanes by means of a lane drop at a junction as shown in Figure 4/8, provision must be made on the link between the lane drop and subsequent lane gain for maintenance activities, incident management and temporary traffic management systems. Therefore the pavement must be constructed to a width of 3 lanes (plus hardshoulder if a motorway) and the pavement adjacent to the 2 running lanes must be hatched out to leave a normal width of hardstrip (or hardshoulder if a motorway) adjacent to the running lane as shown in Figure 4/8. The diverge and merge areas must be designed to provide sufficient pavement to allow conversion of the junction from a lane drop/lane gain to a 3-lane link with taper diverge and merge.

4.33 Advice on the signing of lane gains and lane drops is given in **TA 58 (DMRB 8.2.1)**.



**Figure 4/8 Lane Drop to Two Lanes and Subsequent Lane Gain Showing Hatched Pavement for Maintenance and Traffic Management**

- See Paragraph 4.32



**Weaving Lengths**

4.34 Weaving lengths must be measured as shown in Figures 4/9 – 4/13.

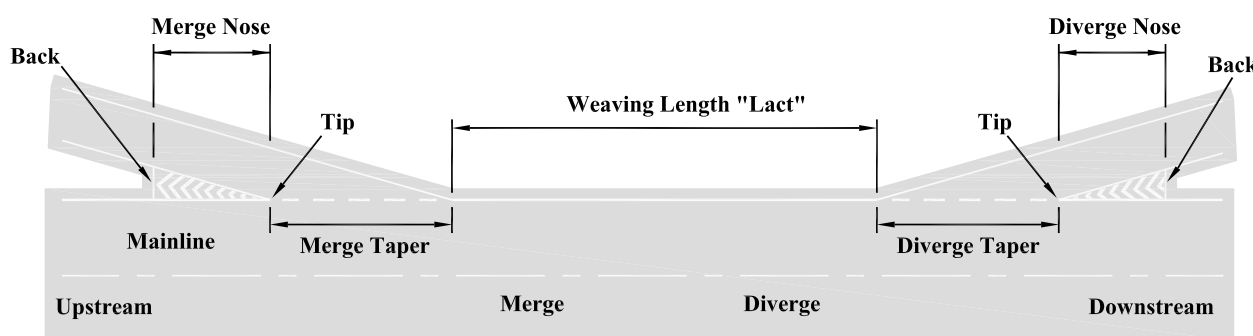
4.35 For **Rural Motorways**, the desirable minimum weaving length must be 2 kilometres. Above about 3 kilometres apart, merges and diverges tend not to interact and can be considered as separate entities, since weaving ceases to occur. The maximum possible weaving length can thus be taken as 3 kilometres. This would appear to be the case up to and including weaving sections 5 lanes wide. The weaving formula is not to be used for weaving lengths above 3 kilometres. The requirements for weaving for MSAs on rural motorways are as for rural motorway junctions.

4.36 For **Rural All-Purpose Roads** the desirable minimum weaving length must be 1 kilometre. On carriageways up to 3 lanes wide, the maximum distance over which successive merges and diverges are likely to interact and cause weaving is

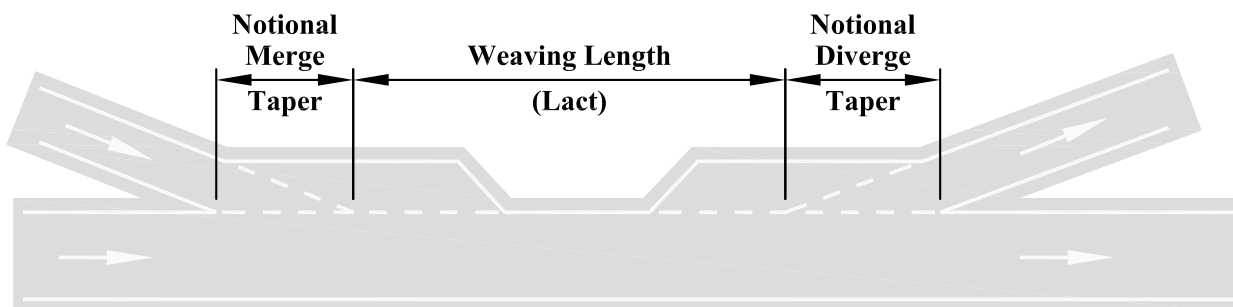
around 2 kilometres and this should be taken as the maximum weaving length. The weaving formula is not to be used for weaving lengths above 2km.

4.37 For **Urban Roads** as defined in Chapter 1, the design flows must be inserted in Figure 4/14 to obtain a minimum weaving length ( $L_{min}$ ). This must then be compared to the Design Speed related Absolute Minimum weaving length in Figure 4/14 and the greater of the two lengths taken as the minimum length of weaving section, provided that signing requirements can be met.

4.38 For **All-Purpose Roads**, the minimum length between a grade separated junction designed to this standard and an at-grade junction (including roundabouts), service area, lay-by or direct access must be the desirable minimum weaving length as defined in paragraph 4.36 for rural roads or the minimum length of weaving section as derived from paragraph 4.37 for urban roads.



**A - Merge, Weaving Length and Diverge**



**B - Parallel Merge/Diverge as for Taper Merge/Diverge by Notional Layout**

N.B. See Figure 4/13 for measurement of weaving length for ghost island layouts.

**Figure 4/9 Definition of Terms used in Weaving and Measurement of Weaving Length for Taper and Auxiliary Lane Layouts**

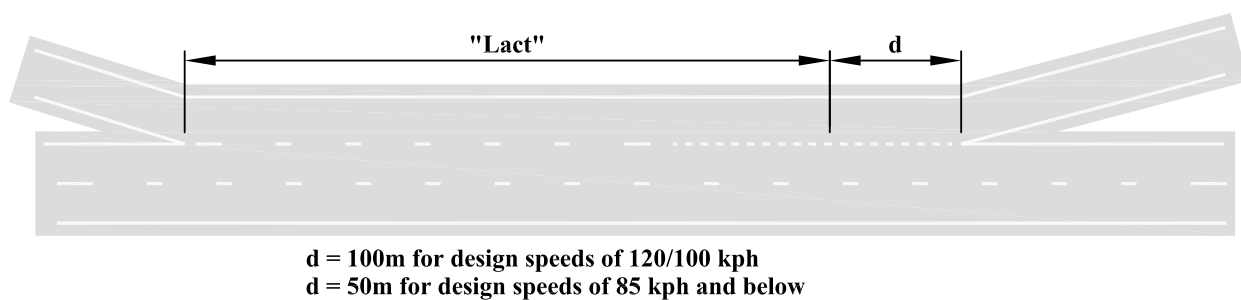


Figure 4/10: Lane Gain/Lane Drop

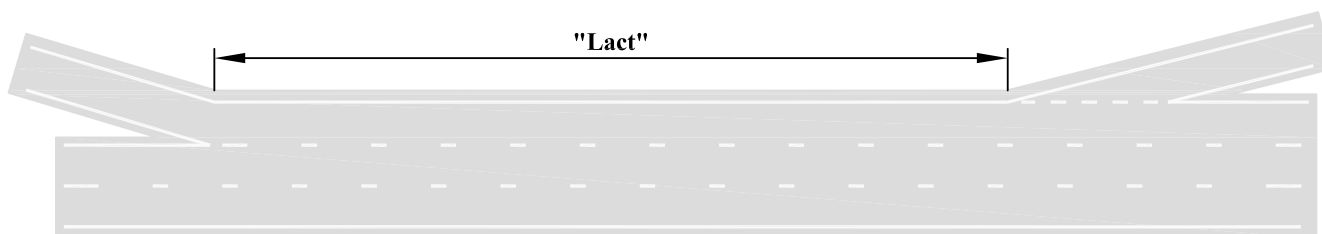


Figure 4/11: Lane Gain only

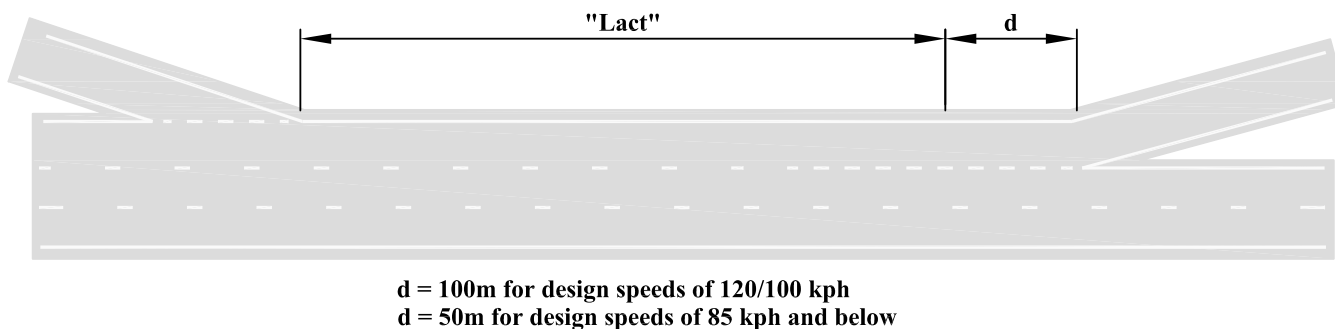
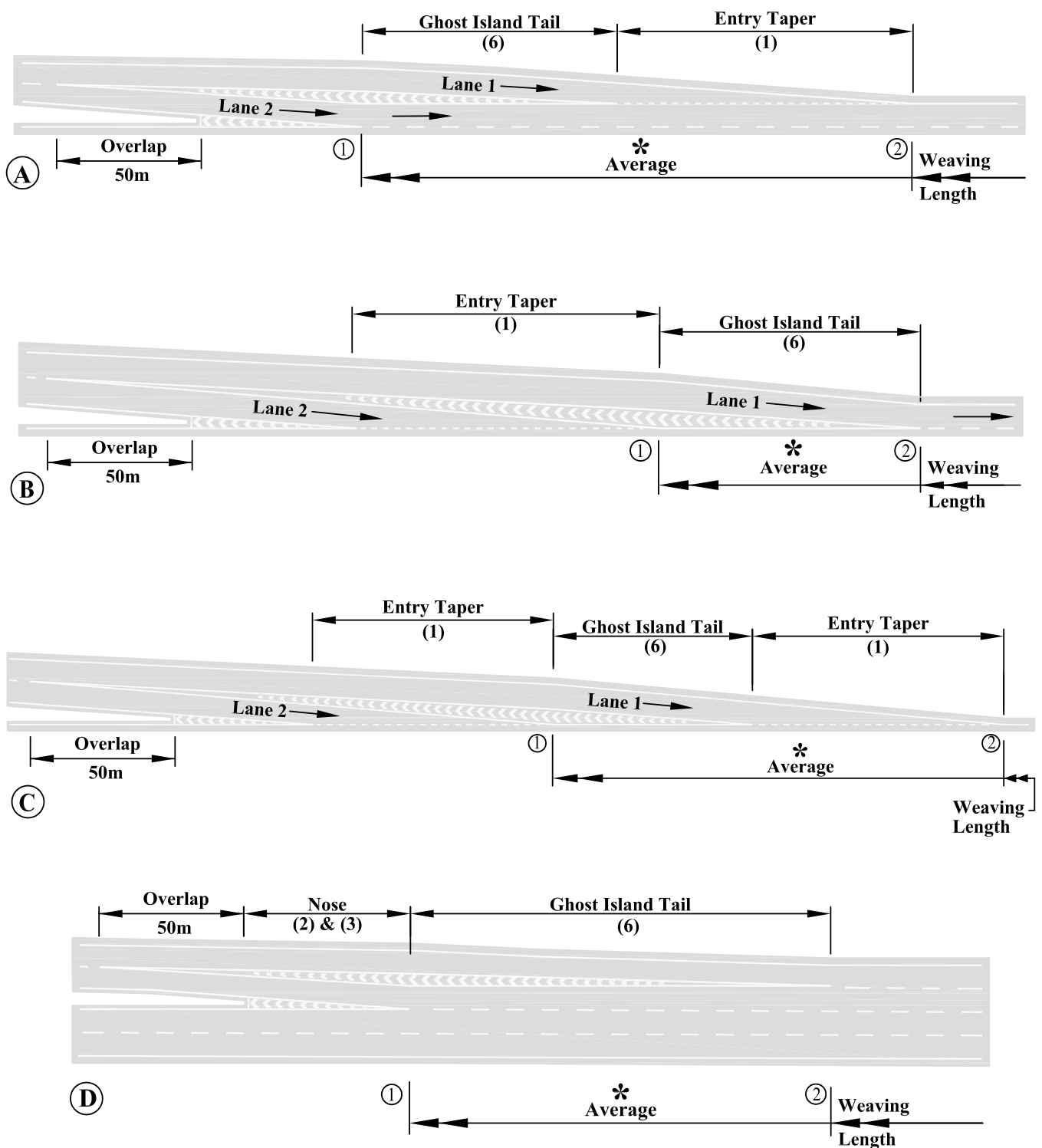


Figure 4/12: Lane Drop only

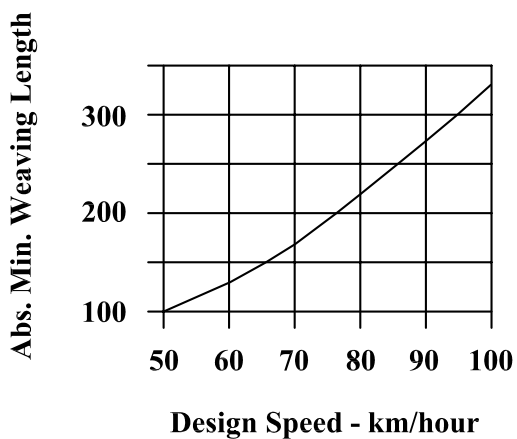
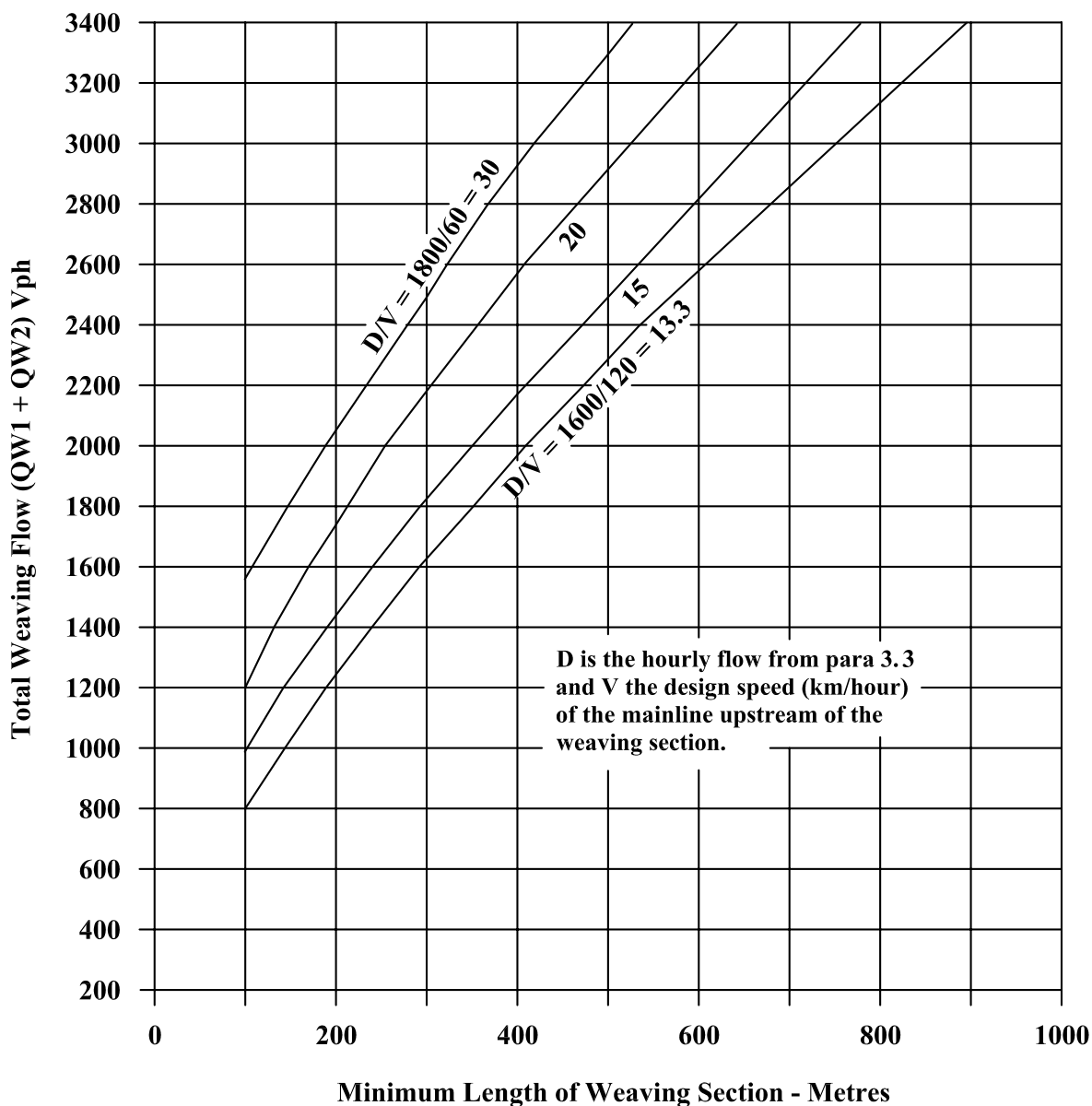
N.B. See Figure 4/13 for measurement of weaving length for ghost island layouts.

Figure 4/10 – 4/12 Definition of Terms used in Weaving and Measurement of Weaving Length for Lane Gain and Lane Drop Layouts



1. \* Total Weaving Length  $L_{act}$  is the distance to point 2 plus half the distance between 1 and 2.
2. Figures in brackets refer to Table 4/3.
3. For diverges, the mirror image shall apply.

Figure 4/13 Measurement of Weaving Length for Ghost Island Layouts



To determine the minimum length of weaving section ( $L_{min}$ ) for insertion within the formula of Paragraph 2.71.

1. For known total weaving flow and chosen D/V value, read off the minimum length of weaving section from the graph above.
2. Check the absolute minimum weaving length allowable for chosen design speed from the graph on the left.
3. Select the greater of the two lengths.

Figure 4/14 Weaving Length Diagram for Urban Roads

## 5. LAYOUT OPTIONS

### INTRODUCTION

5.1 There are two forms of grade separation, namely, grade separated junctions and interchanges.

5.2 The most efficient form of grade separation is that which presents the driver with the minimum number of clear unambiguous decision points as they drive through the junction and in merging and diverging. Additionally, on a motorway or an all-purpose road that is generally grade separated, consistency of design for successive junctions is an important consideration involving the adoption of the same Design Speed. This need for consistency also applies to the signing and road markings to be adopted particularly at the boundary of responsibility between different highway authorities.

5.3 The siting of a grade separated junction on a hill top should be avoided if possible as approach gradients can cause operational problems in the diverge area, even when the percentage of LGVs is small. Hill top locations could be environmentally damaging to the skyline and might present difficulty to drivers in comprehending road signs which are silhouetted against the sky. There is also the risk of drivers being blinded when the sun is low in the sky.

5.4 Among the aspects of design which should be taken into account and included in a decision framework are:

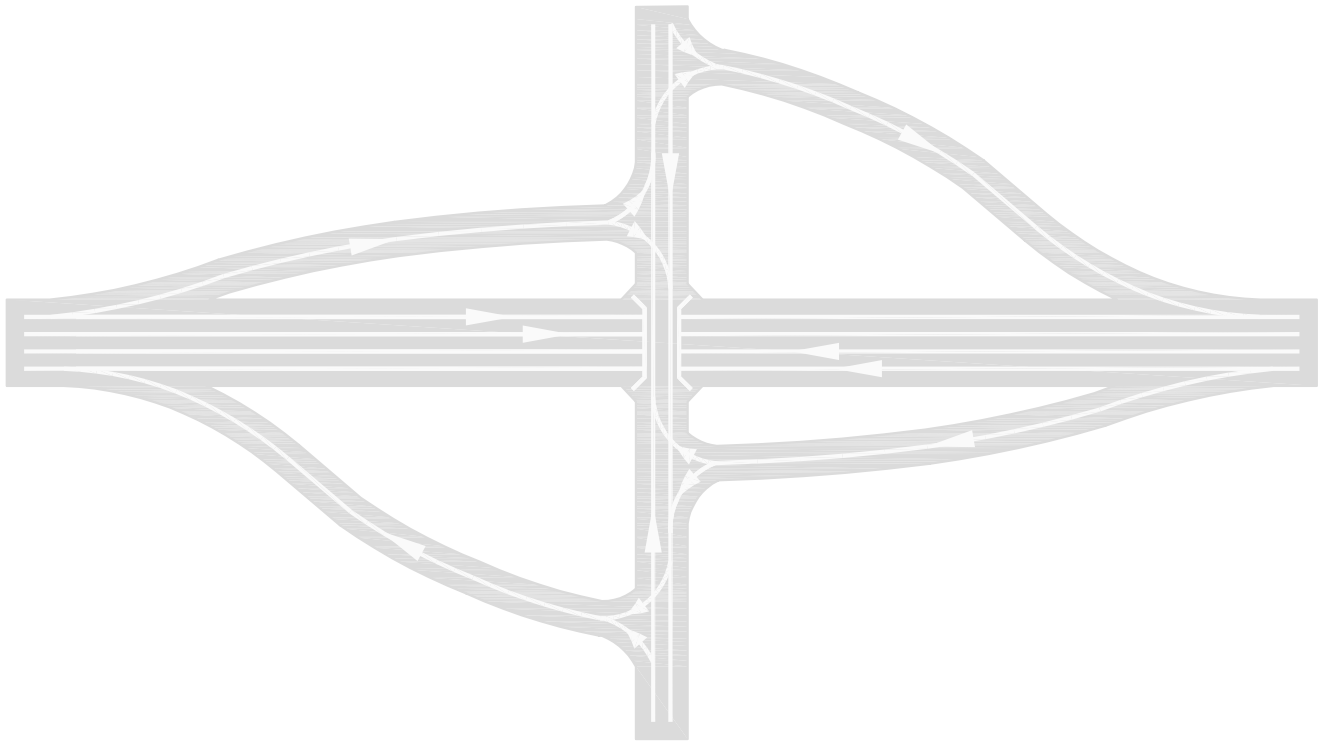
- efficiency;
- safety;
- consistency;
- location;
- maintenance;
- environmental effects;

- land take;
- capital cost;
- economic assessment;
- provision for non-motorised users (this should be assessed using **TA 91 (DMRB 5.2.4)** and **HD 42 (DMRB 5.2.5)**).

5.5 The provision of vehicle restraint systems within a junction should be in accordance with the current Requirements for Road Restraint Systems.

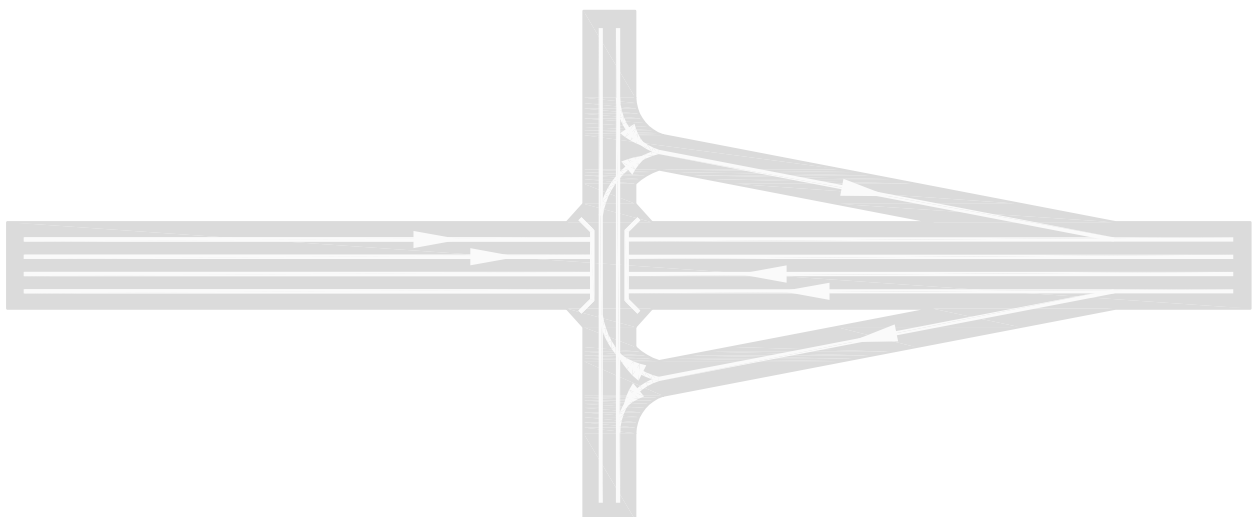
### GRADE SEPARATED JUNCTIONS

5.6 A grade separated junction involves the use of an at-grade junction at the commencement or termination of slip roads. The at-grade junction element, whether a major/minor junction or roundabout and slip roads, can produce 3 main types of grade separated junction: Diamond, Half-Cloverleaf and Roundabout; these are discussed below.



**a) Diamond**

(See Paragraph 5.7)

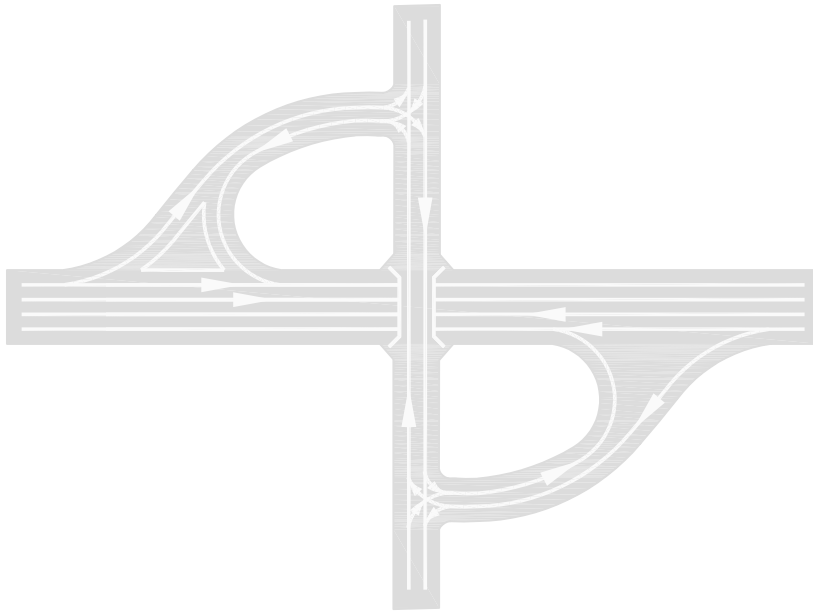


**b) Half-Diamond**

(See Paragraph 5.8)

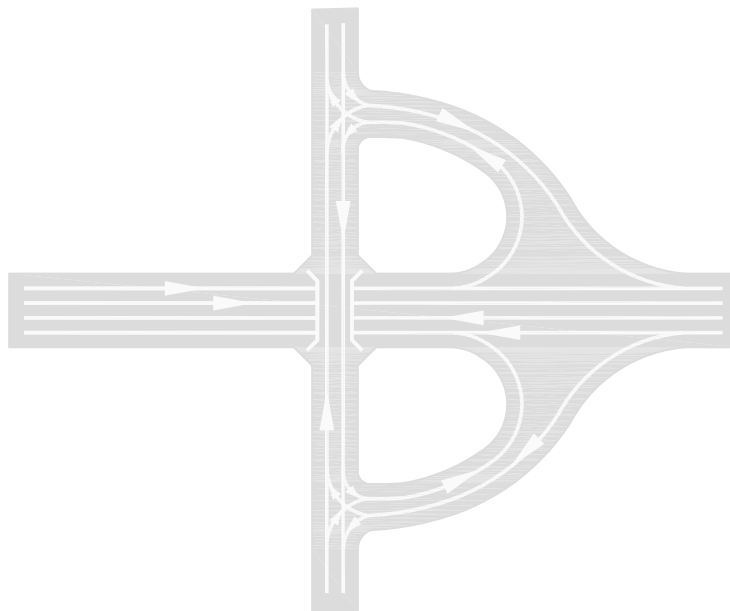
**Figure 5/1.1 Typical Layouts of Grade Separated Junctions**

Note: See also Figure 5/2



**c) Half-Cloverleaf  
Quadrants 1 and 3**

(See Paragraph 5.9)

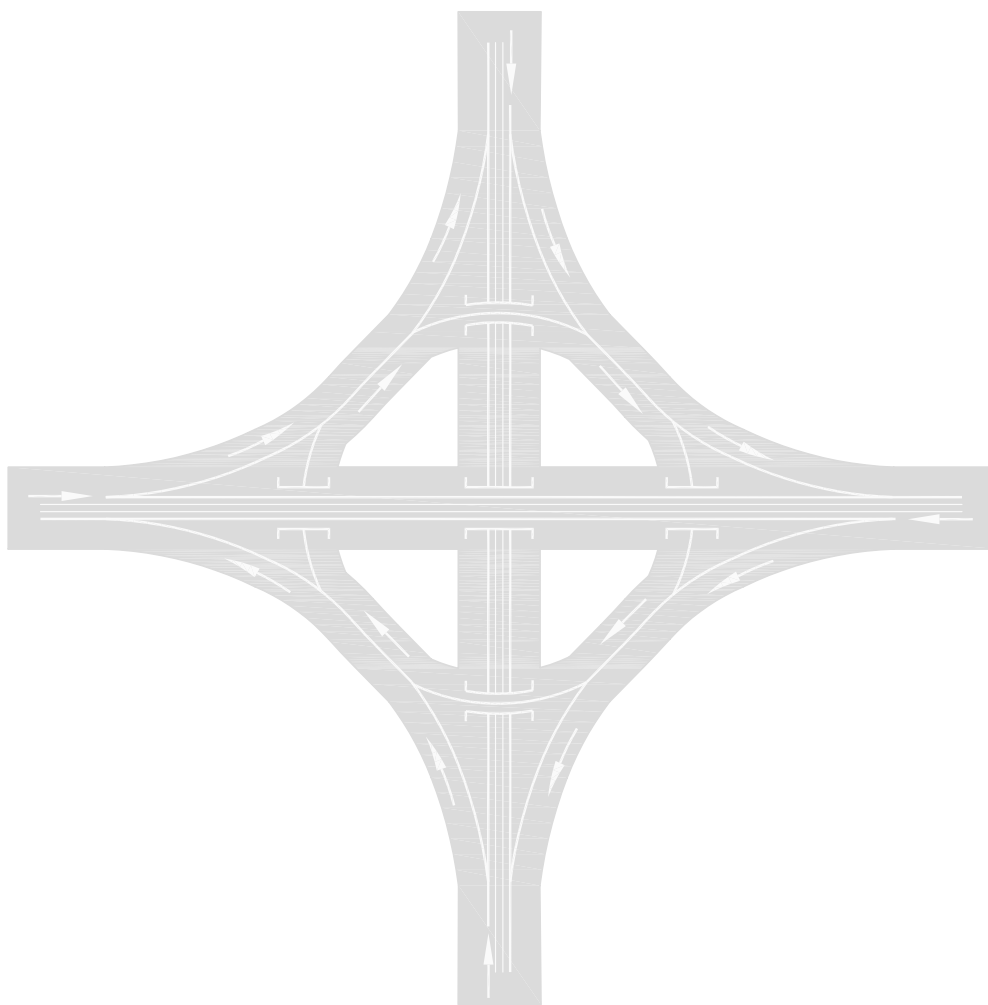


**d) Half-Cloverleaf  
Quadrants 2 and 3**

(See Paragraph 5.9)

**Figure 5/1.2 Typical Layouts of Grade Separated Junctions**

Note: See also Figure 5/2



e) 3 Level Roundabout

(See Paragraph 5.13)

### Figure 5/1.3 Typical Layouts of Grade Separated Junctions

Note: See also Figure 5/2

#### Diamond

5.7 A diamond is the simplest form of grade separated junction and the normal layout will provide turning movements to and from the slip roads by two staggered junctions (see Figure 5/1.1a). The use of non-signalised crossroads is not recommended – see **TD 42 (DMRB 6.2.6)**. The diamond has the advantage that land take is minimised and slip road design is simple. Costs are minimised as only one bridge is required, but consideration should be given to inclusion of a ghost island on the road which crosses the bridge, either at the outset or in the future, as bridge widening at a later stage will be expensive. The disadvantage is that all four quadrants are used to provide turning

movements which for difficult sites, especially in urban areas, may create severe environmental problems.

5.8 A junction such as the half diamond (Figure 5/1.1b), can be designed for restricted traffic movements. However, if there is a possibility that future conversion to provide all movements will be required, then the original design should be capable of conversion without alteration to the built layout.

#### Half-Cloverleaf

5.9 A half-cloverleaf is used at similar flow levels to a diamond, particularly where site conditions are difficult and the use of all four quadrants is not possible



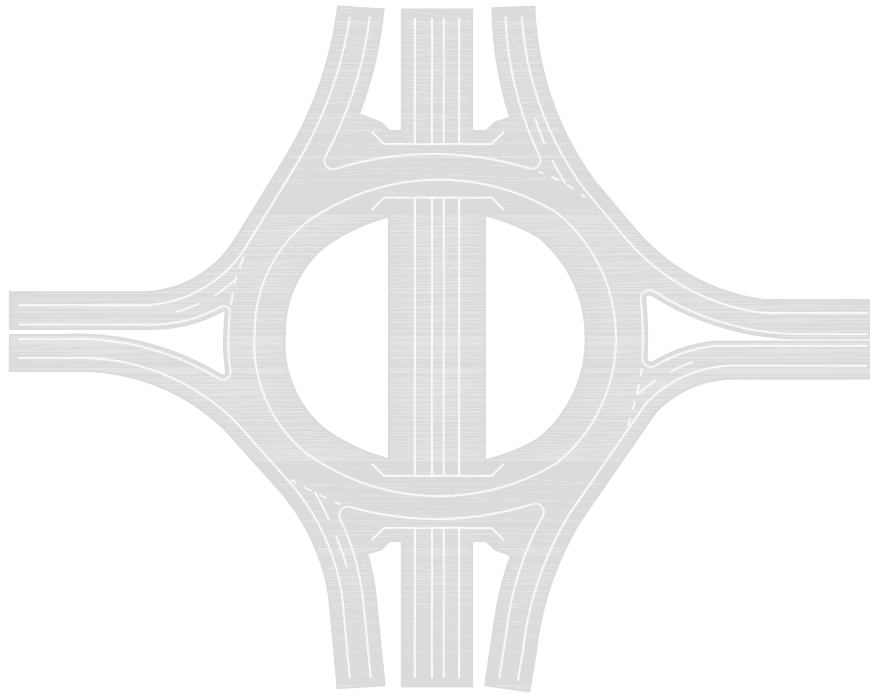
(see Figures 5/1.2c, 5/1.2d). The at-grade junction element normally utilises two ghost island junctions. Whereas the diamond utilises all four quadrants, which can be a problem in urban or environmentally difficult situations, the half-cloverleaf overcomes this problem by requiring the use of only 2 quadrants, which if possible should be chosen so as to minimise the right turn movements. This layout has similar advantages to the diamond but similar consideration of future improvement should be given.

## Roundabout

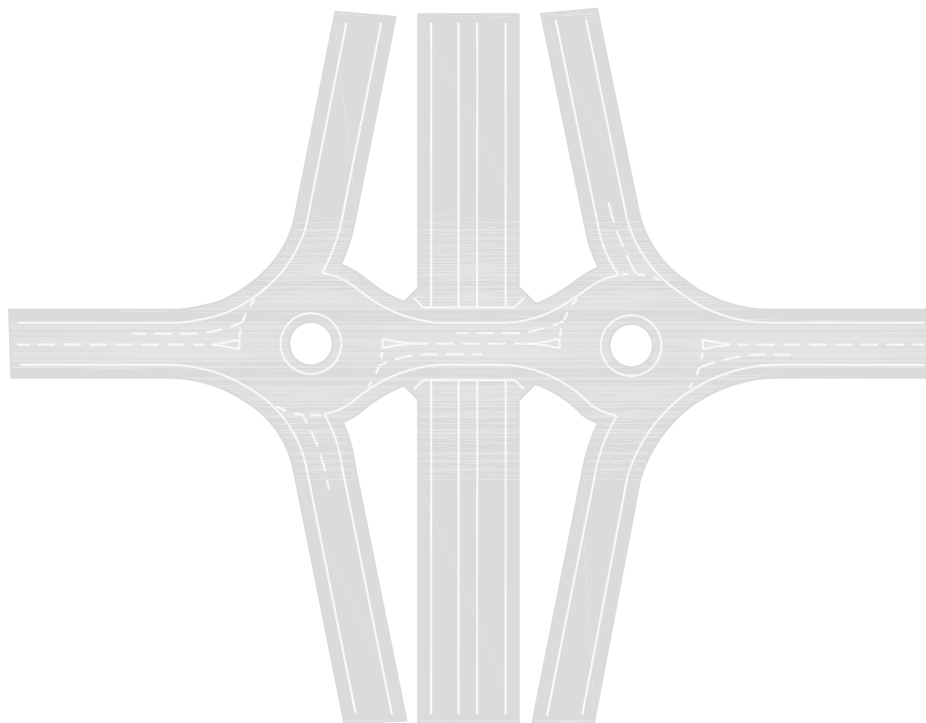
5.10 The two most common forms of grade separated junction are the two bridge roundabout and dumb-bell roundabout types – see Figure 5/2 and **TD 16 (DMRB 6.2.3)**. The dumb-bell roundabout which is an intermediate layout between the diamond and the two bridge roundabout has the advantages of reduced cost (only one bridge) and less land take than the two bridge roundabout. It can be adapted to fit either a diamond or half cloverleaf. It also has increased junction capacity and reduced land take compared with the diamond. In urban locations where large flows have to be accommodated, signalised gyratories can be considered.

5.11 For the dumb-bell layout, it is possible that the distance between the two roundabouts may be less than the desirable minimum SSD for the design speed of the connecting link road. In that case, a low (0.26m) object at the give way line of the next roundabout must be visible from a vehicle as it leaves the circulatory carriageway of the previous roundabout. Attention must be given to the needs of future maintenance of the connecting link road to avoid the need for closure of the road. One lane dual carriageways should, therefore, be avoided and single carriageways would often be preferable.

5.12 The most common type of grade separation is the two bridge roundabout. Observation has shown that if they are constructed too large, high circulating speeds on the roundabout can be induced leading to difficulties for joining traffic. Therefore every effort should be made to achieve a design with a small footprint (**TD 16 (DMRB 6.2.3)**).



**Two Bridge Roundabout**



**One Bridge and Two Roundabouts - "Dumb-bell"**

**Figure 5/2 Typical layouts of Grade Separated Junctions**

5.13 Where two major roads cross, a 3 level arrangement with a roundabout sandwiched between the two major flows, should be considered as an alternative to an interchange, see Figure 5/1.3e. Its advantages are that both the overall land take and the carriageway area are greatly reduced. The disadvantages are that structure costs are high and if the turning movements become greater than predicted, operational problems such as queuing on the roundabout entries can result. If queuing does become a problem, segregated left turn lanes and restricted circulatory carriageway width should be considered before traffic signals are installed. The inclusion of a specific link, as a remedial measure to remove a heavy right turn movement, is rarely a practical solution on either cost or environmental grounds.

### Variants

5.14 Variants on the three basic types of grade separated junctions (diamond, half cloverleaf and roundabout) can be provided if:

- a. the junction is 3 way i.e. a T junction;
- b. not all movements need catering for e.g. a half diamond;
- c. traffic signals, either full-time or part time, are included to remove congestion on an existing grade separated junction. It is recommended that they should only normally be considered as an alternative to a priority junction;
- d. large flows are to be handled and a signalised gyratory is used.

### Compact Grade Separated Junctions

5.15 An alternative for low flow situations in rural and environmentally sensitive areas, is a Compact Grade Separated Junction (**TD 40 (DMRB 6.2.5)**). This provides a junction to a standard intended to enforce low traffic speeds and minimise land take.

### At Grade Junction Design

5.16 Poor design of priority junctions at the end of uphill diverge slip roads can create safety problems. An example is shown in Figure 5/3a where drivers, approaching the left turn splitter island with a merging taper, have misperceived the facing vehicle restraint systems (required by the height of the embankment) as being on a dual carriageway central reserve and have

moved into the path of oncoming traffic. This effect has been most noticeable at junctions where drivers have left long lengths of fully grade separated road. In such situations a dumb-bell roundabout is recommended. Alternatively, a ghost island major/minor junction layout can be considered in accordance with **TD 42 (DMRB 6.2.6)**. If neither option is achievable, the priority junction should be made square to the side road as shown in Figure 5/3b, with no merging lanes or splitter islands and with corner radii in accordance with **TD 42 (DMRB 6.2.6)** to emphasise to the driver the impression of a two way single carriageway, rather than a dual carriageway. This needs to be reinforced by clear signing.

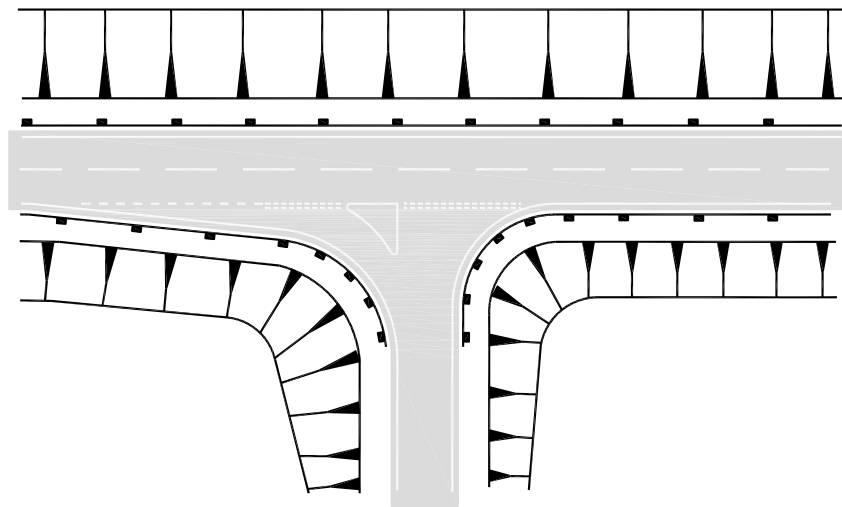
### INTERCHANGES

5.17 An interchange does not involve the use of an at-grade junction and so provides uninterrupted movements for vehicles moving from one mainline to another, by the use of connector roads with a succession of diverging and merging manoeuvres. Good design minimises conflict points and ensures that the path between them is easily understood by drivers, by effective signing and road marking. This design objective should be assessed within the overall framework of the points in paragraph 5.4.

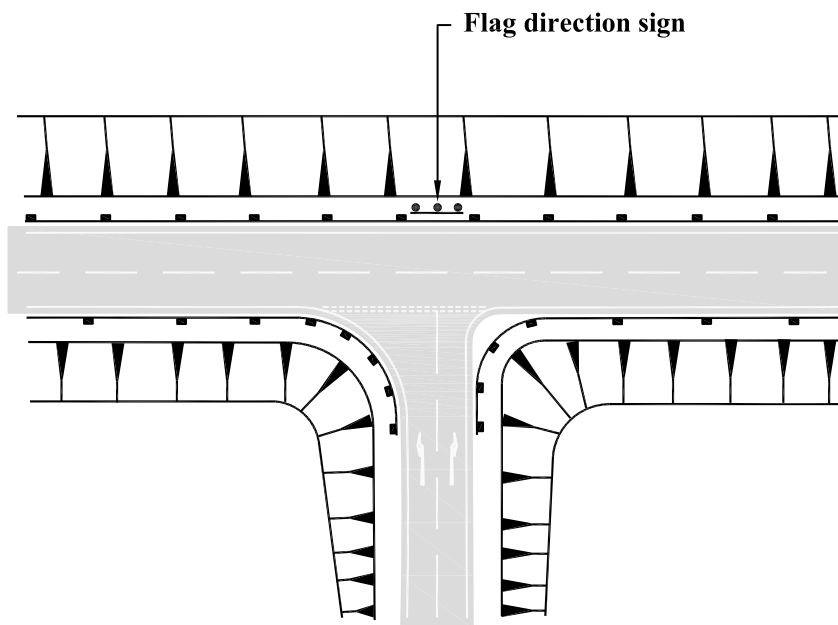
5.18 Figure 5/4 shows three different 4 way interchanges.

- The 4 level interchange layout has the advantages of reduced land take, absence of loops and low structural content, but is visually highly intrusive, has the greater number of conflict points and has therefore been used infrequently. See Figure 5/4.1a.
- The 3 level interchange introduces two loops and reduces conflict points but increases both structural content and cost, whilst still being visually intrusive. A disadvantage is that it requires separate diverge points for left and right movements from one of the mainlines, which can be difficult to sign. See Figure 5/4.1b.

A variant of Figure 5/4.1b is shown at Figure 5/5 and is an example of how environmental impact and structural content can be substantially reduced without a great increase in land take, by taking advantage of the skew of the intersecting mainlines.



a) Poor layout leading to driver misperception



b) Improved simple junction obvious to driver

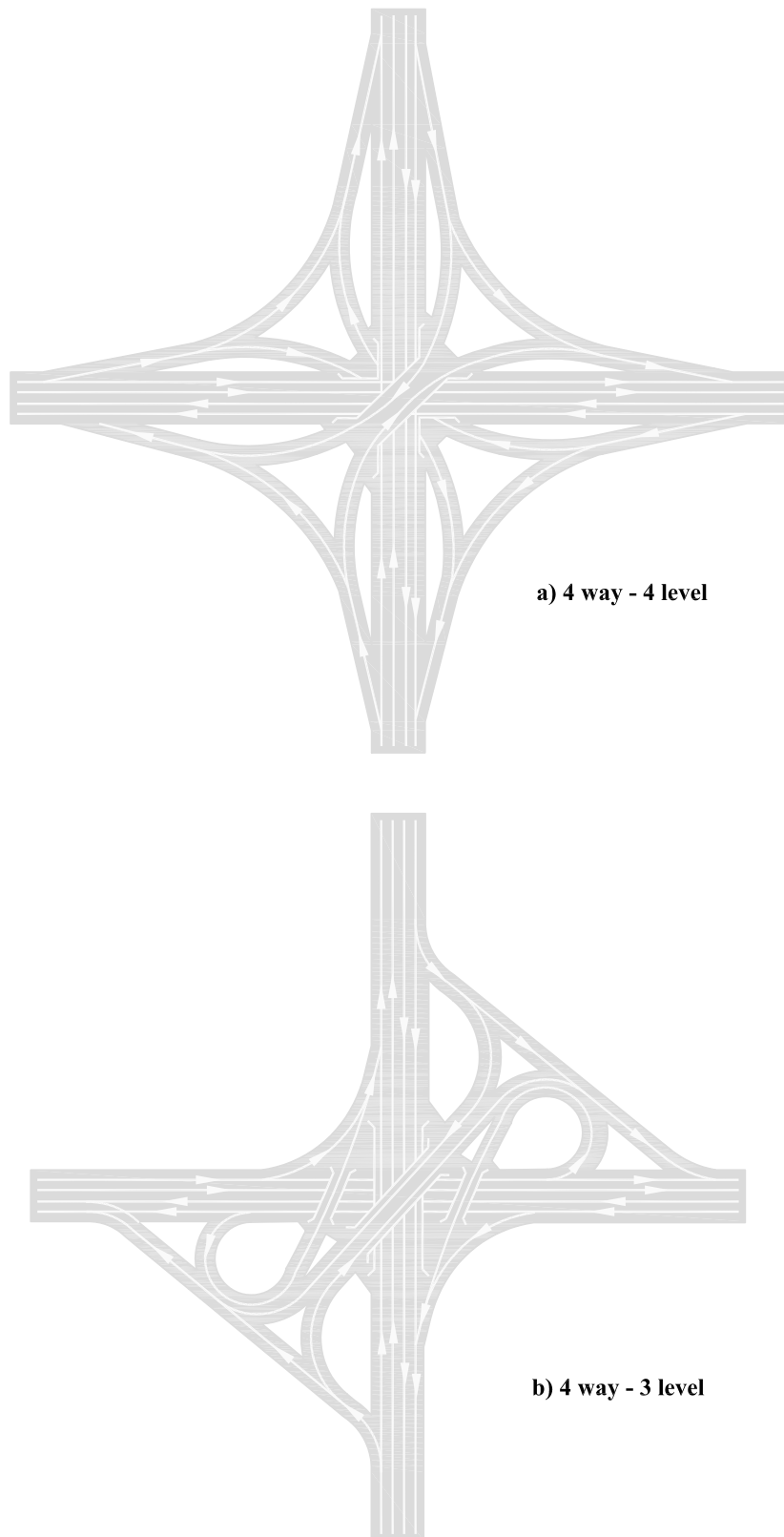
See Paragraph 5.16

Figure 5/3 Example of Poor Design Reducing Safety at Diamond Junction

- A 2 level or 'cyclic' interchange is shown in Figure 5/4.2c. This utilises reverse curves and a low number of conflict points, the land take is extensive and there is a high structural content. However, since this form of interchange fits easily into the topography it is a suitable solution for schemes where land is not at a premium. A disadvantage is that it requires separate diverge points for left and right movements from both mainlines, which can be difficult to sign.

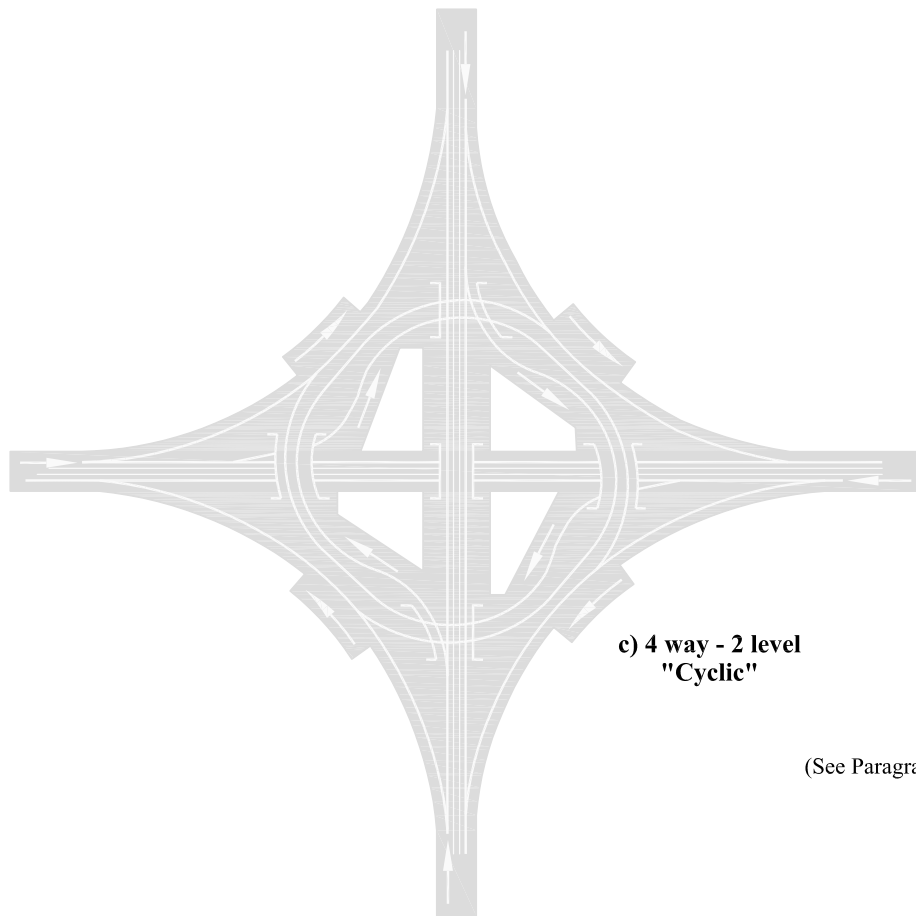
Figure 5/4.2c shows two successive diverges off and one merge on to the mainline. A variant of this uses one diverge and two merges but the distance between the merges should be as great as possible to avoid potential conflicts. One principal connection on the mainline for the diverge, and one for the merge, is actually to be preferred with the final route selection occurring on the slip road. This reduces turbulence on the mainline. It would need a suitable multiple lane layout for the actual connection. Site constraints sometimes make it impossible to have the one connection.

5.19 The three way 'trumpet' interchange (Figure 5/4.2d) should be designed to enable future conversion to a four way without alteration if this is considered a possibility. It has a 2 way slip road which requires careful design for safety. Figure 5/4.2e shows a three way interchange with restricted movement. This enables high vehicle speeds to be maintained with low land take, but it requires a costly skew structure and prohibits any future conversion.



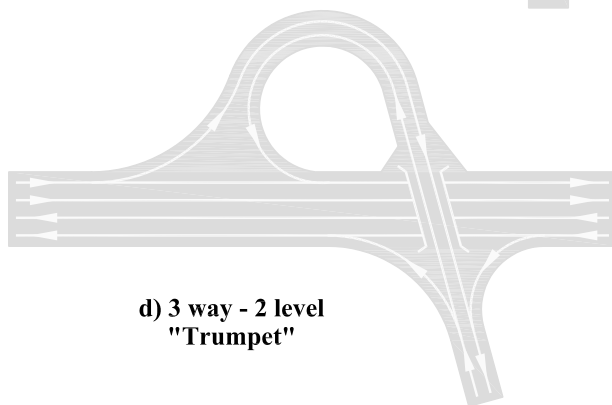
(See Paragraph 5.18)

**Figure 5/4.1 Typical Layouts of Interchanges**

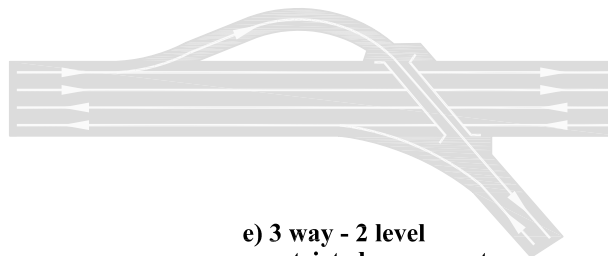


c) 4 way - 2 level  
"Cyclic"

(See Paragraph 5.18)



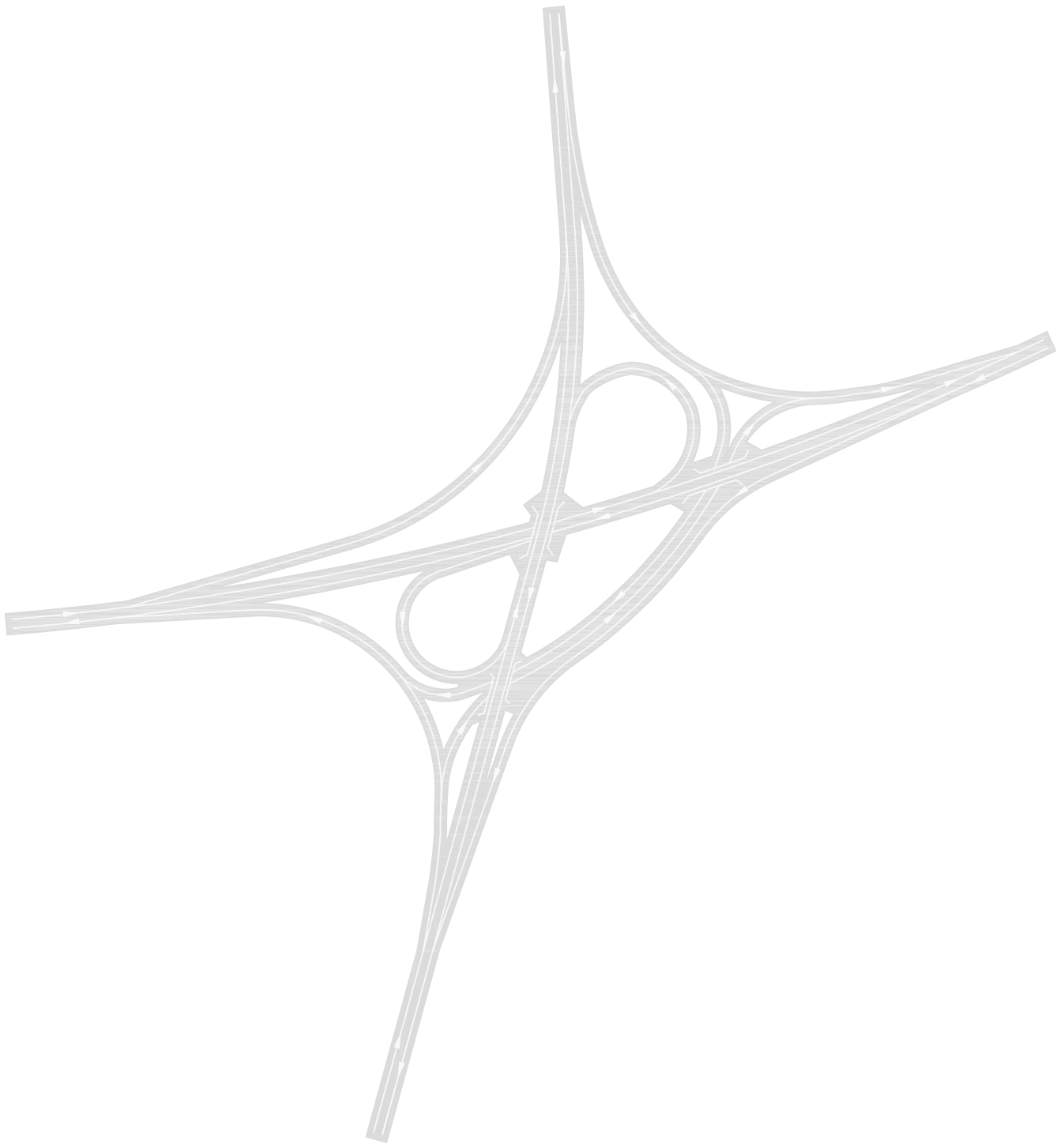
d) 3 way - 2 level  
"Trumpet"



e) 3 way - 2 level  
restricted movement

(See Paragraph 5.19)

Figure 5/4.2 Typical Layouts of Interchanges



(See Paragraph 5.18)

**Figure 5/5 Variant of Figure 5/4.1b Restricted in Height to Reduce Environmental Impact**



5.20 Merges with a flow imbalance, where the merging traffic flow is greater than the mainline traffic flow can occur within an interchange. Priority should still be given to traffic on the mainline. If the merging flow is over a lane capacity, there will need to be a lane gain. LGVs must be given an opportunity to join the mainline safely. Operational problems have occurred where the left hand link has been on a long downhill section and the right hand link uphill, with consequential disparity in vehicle speeds at the merge, and this particular layout is not recommended.

5.21 Loops and certain links may require advisory speed limits (which should be discussed and agreed with the Overseeing Organisation) to warn the driver of the safe negotiating speed for reasons of alignment and visibility. This speed limit should be used in conjunction (where appropriate) with a bend warning sign and 'chevron' warning signs to reinforce the hazard warning. Only one level of speed limit should be used within an interchange as steps down in speed limits may confuse the driver.

5.22 Single lane interchange links can have advantages in cost over 2 lane interchange links for interchanges which contain structures of substantial length. However, where the predicted flows are near the top of the range (Tables 3/1a and 3/1b) the uncertainty of the prediction should be recognised, as it may be prohibitively expensive to convert later to a two-lane interchange link. A disadvantage is that single lane interchange links may require closure during certain maintenance activities. Consequently, a whole life cost assessment (including costs during maintenance) should be carried out to confirm the cost effectiveness of proposed single lane links.

## GENERAL

### Link Roads

5.23 When two grade separated junctions with high flows are closely spaced, potential weaving problems caused by the short length of carriageway available can be removed by the inclusion of link roads. No link should be provided between carriageways other than at the start and finish of the segregated lengths of carriageway. An example of such a junction is shown at Figure 5/6 where weaving is separated from the mainline flow.

### Maintenance

5.24 Designers should allow within their designs for facilities to maintain areas within interchanges which are not readily accessible. Locations for access should be chosen having regard to visibility to and from the proposed access location and the need to maintain traffic flow through the works. Any lay-by should not be sited in an exposed position on the inside of connector roads on left hand curves with radii below Desirable Minimum, as vehicles have been observed to move into the hardshoulder on such sections. They should be located on straights or right hand curve sections with at least desirable minimum radius.

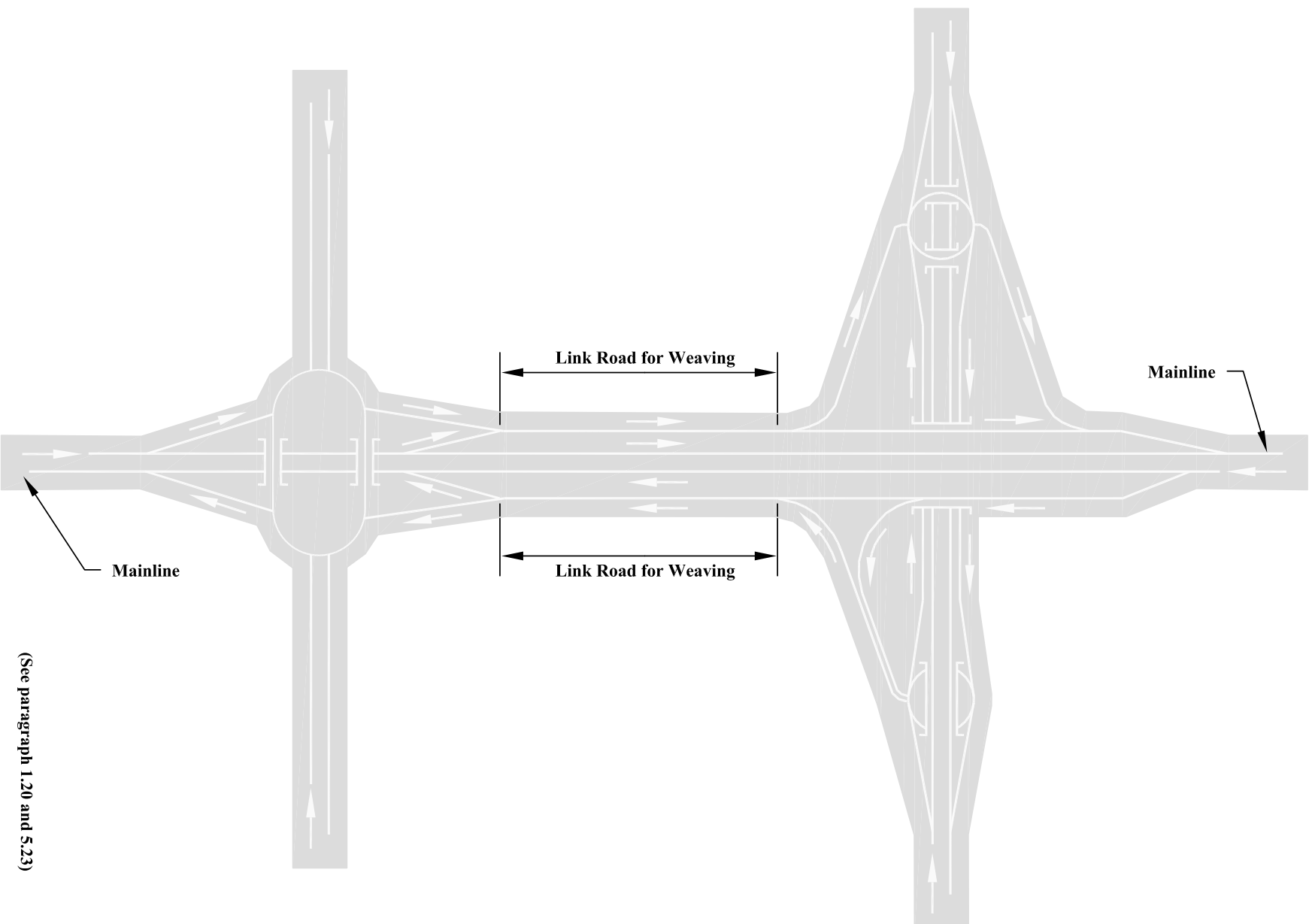
5.25 It may be necessary to provide access to isolated land by means of an underpass linked to adjacent land. This is an expensive solution to this problem and the ownership of isolated land should be acquired to prevent the need for regular access by an owner other than the highway authority.

5.26 Any lay-bys for maintenance vehicles should be provided clear of the hardshoulder or hardstrip. The lay-by should be adequate for the maximum number of vehicles expected to use it at one time. The surfacing of the lay-by should not be attractive to other road users and should be signed for its purpose. Its surfacing need only be adequate for its expected use.

### Connector Roads

5.27 Two way slip roads must be dual carriageway with opposing traffic separated by a physical central reserve with vehicle restraint system. Two way single carriageway slip roads are not permitted. Two way slip roads only occur at half-cloverleaf and trumpet junctions. Studies into the safety of tight loops for 2 way slip roads, as compared to one way, indicated that a physical barrier will improve safety and reduce cross-over accidents.

5.28 For motorway interchanges emergency telephones should not be sited in an exposed position on the inside of connector roads on left hand curves with radii below Desirable Minimum, as vehicles have been observed to move into the hardshoulder on such sections. They should be located on straights or right hand curve sections with at least desirable minimum radius. Advice on the provision of emergency telephones on motorways is given in **TA 73 (DMRB 9.4.2)**. Note that there are separate Annexes for England, Scotland, Wales and Northern Ireland.



(See paragraph 1.20 and 5.23)

Figure 5/6 Example of Link Road Interchange

5.29 The accident risk for slip roads is similar whether the mainline is carried over or under. However, the preferred treatment is to design diverge slip roads uphill and merge slip roads downhill, with the side road over the mainline. This assists vehicles on the slip roads in matching their speeds to those of mainline vehicles on merging and reducing their speeds at the approach to the side road junction on diverging.

5.30 Private means of access and junctions on connector roads are not permitted.

### Merging and Diverging Lanes

5.31 Mainline lane drops within a junction on a 3-lane mainline (3 lanes prior to the diverge, 2 lanes between diverge and merge and then back to 3 lanes) are not generally recommended on operational and safety grounds. They severely impair future maintenance, especially at interchanges where no reasonable diversion route is available. However, if such a layout becomes necessary the requirements of paragraph 4.32 should be followed.

5.32 A lane drop at a junction diverge must be used when changing carriageway standards from 4 lanes to 3 or 3 lanes to 2. Similarly, a lane gain at a junction merge must be used when changing carriageway standards from 2 lanes to 3 or 3 lanes to 4. The layout of the diverge or merge should be selected corresponding to the leaving or joining flow but under light flow conditions could be Figure 2/6.2C and Figure 2/4.3E. Removal of a lane (excluding climbing lanes) must not take place on the link between junctions.

### Signing and Lighting

5.33 Signing and lighting should be considered at the earliest stage of design to ensure the satisfactory operation of a grade separated junction for all users, including cyclists and pedestrians and to ensure that allowances are included for signing and lighting equipment such as columns, feeder pillars, buried cables, cable ducts and draw pits.

5.34 The lighting of the main carriageway will depend on an appraisal carried out in accordance with TA 49 (DMRB 8.3). The design of the lighting will then be carried out in accordance with TD 34 (DMRB 8.3).

5.35 It is normal practice to light grade separated junctions (i.e. the roundabout, the T-junction etc). The lighting of the grade separated junction would normally extend 60m along each entry or exit slip road without lighting the mainline carriageway. However, sometimes a decision may be taken to extend the slip road lighting to include the full length of the slip roads. When the full length of the slip road is lit, the mainline carriageway must be lit all through the junction. Drivers approaching on the mainline carriageway may otherwise think that they are coming to a lit area and drive up the slip road thinking that it is the mainline carriageway.

5.36 The provision and layout of traffic signs and road markings is an integral part of the junction design process and must be considered at an early stage. Advance direction and warning signs must be provided. Positioning of signs within the junction must be carefully considered so that they do not interfere with drivers' visibility. It is essential that there is no over-provision of signing.

5.37 For grade separated junctions two or three advance direction signs must be provided. These are to be located at the start of the diverging lane, ½ mile (⅓ mile in difficult circumstances) from the junction and additionally for motorways and some all-purpose roads 1 mile (⅔ mile in difficult circumstances) from the junction. On motorways either a confirmatory gantry sign or a route number confirmatory sign (TSRGD diagram 2910), located at the back of the nose, must be provided.

5.38 Countdown markers (TSRGD diagram 823, 824 and 825) must be provided on the approaches to all diverges. They must not be provided for lane drops.

5.39 Further requirements and advice for signing are given in the TSRGD, The Traffic Signs Manual, DMRB Volumes 8 and 9 and Local Transport Note 1/94.

## 6. FACILITIES FOR NON-MOTORISED USERS

### Introduction

6.1 This chapter gives guidance on the provision for non-motorised users (NMUs) crossing grade separated junctions. It considers the needs of pedestrians (including the disabled), cyclists and equestrians.

6.2 NMUs have a legal right to use the public highway, unless specifically prohibited, as in the case of Special Roads (including Motorways). All-purpose trunk roads typically carry high flows of fast moving traffic, are designed primarily for such use and are generally unattractive to NMUs. A better standard of provision for NMUs may encourage modal shift from motorised vehicles and may play a part in creating a more integrated and sustainable transport system along trunk road routes that often provide the most direct route between key destinations. Scheme designs should take account of opportunities to provide safe and attractive provision.

6.3 The need for facilities for NMUs, will be identified by the NMU Audits see **HD 42 (DMRB 5.2.5)**.

6.4 The design of facilities for NMUs is addressed in the relevant sections of the DMRB and particularly in the advice notes:

- The Geometric Design of Pedestrian, Cyclist and Equestrian Routes – **TA 90 (DMRB 6.3.5)**; and
- Provision for Non-Motorised Users – **TA 91 (DMRB 5.2.4)**.

### Provision for Cyclists

6.5 Grade separation at junctions is provided to allow vehicles to join or leave the main line with minimum disruption to through traffic. The speed of diverging and merging traffic is similar to that of the mainline flow and at on-slips in particular, drivers are concentrating on the merge. It is essential therefore that NMU crossings of slip roads are only located where traffic is moving relatively slowly, i.e. away from the main line.

6.6 Where slip road traffic joins or leaves the local network in free flow conditions, uncontrolled NMU crossings must be avoided. NMUs must be provided for separately and it may be necessary to provide grade separation for these users.

6.7 For all-purpose trunk roads, where grade separated junctions are provided, the provision for cyclists will depend on whether cyclists are using a broadly parallel off carriageway route (OCR) or are travelling on the trunk road carriageway.

6.8 Where an OCR is provided, it should allow cyclists to cross only at the downstream end of diverge slip roads or at the upstream end of merge slip roads. These will be at similar locations as the crossing points for other NMUs and will avoid proliferation of crossing points. At the crossing locations there should be adequate visibility for both drivers and NMUs. Advice on the design of such crossings is given in **TA 90 (DMRB 6.3.5)**.

6.9 At grade separated junctions, cyclists using the main line and crossing the mouths of slip roads are at risk of coming into conflict with merging or diverging traffic. Traffic Advisory Leaflet TAL 1/88 *Provision for Cyclists at Grade Separated Junctions* contains advice on how to take a cycle route through these junctions but cyclists should also be offered the alternative of leaving the main line and being diverted around the junction. In this case, a cycle by-pass route running broadly parallel to both slip roads should be linked by the local road network or some other dedicated provision. A cycle route running alongside an on-slip road but segregated from it, should not rejoin the carriageway until it reaches a point beyond the end of the merge taper where it is safe to do so.

### Other Advice on Facilities for NMUs

6.10 Advice on the provision of facilities for NMUs can be found in the following documents:

- Local Transport Note 1/86 Cyclists at Road Crossings and Junctions.
- Department of Transport Traffic Advisory Unit Leaflet 1/88 Provision for Cyclists at Grade Separated Junctions.

## 7. REFERENCES

HD 42	DMRB 5.2.5	Non-Motorised Users Audit
TA 23	DMRB 6.2	Junctions and Accesses: Determination of Size of Roundabouts and Major/Minor Junctions
TA 30	DMRB 5.1.4	Choice Between Options for Trunk Road Schemes
TA 46	DMRB 5.1.3	Traffic Flow Ranges for use in the Assessment of New Rural Roads
TA 48/92	DMRB 6.2.2	Layout of Grade Separated Junctions (SUPERSEDED)
TA 49	DMRB 8.3	Appraisal of New and Replacement Lighting on Trunk Roads and Trunk Road Motorways
TA 58	DMRB 8.2.1	Traffic Signs and Road Markings for Lane Gains and Lane Drops on All-Purpose Dual Carriageways and Motorway Trunk Roads
TA 73	DMRB 9.4.2	Motorway Emergency Telephones
TA 79	DMRB 5.1.3	Traffic Capacity of Urban Roads
TA 89	DMRB 8.2.2	Use of Passively Safe Signposts, Lighting Columns and Traffic Signal Posts to BS EN 12767
TA 90	DMRB 6.3.5	Geometric Design of Pedestrian, Cyclist and Equestrian Routes
TA 91	DMRB 5.2.4	Provision for Non-Motorised Users
TD 9	DMRB 6.1.1	Highway Link Design
TD 16	DMRB 6.2.3	Geometric Design of Roundabouts
TD 18	DMRB 9.1	Criteria for the Use of Gantries for Traffic Signs and Matrix Traffic Signals on Trunk Roads and Trunk Road Motorways
TD 22/92	DMRB 6.2.1	Layout of Grade Separated Junctions (SUPERSEDED)
TD 22/05	DMRB 6.2.1	Layout of Grade Separated Junctions (Interim Revision February 2005) (SUPERSEDED)
TD 27	DMRB 6.1.2	Cross-Sections and Headrooms
TD 34	DMRB 8.3	Design of Road Lighting for the Strategic Road Network (IN PREPARATION)
TD 39	DMRB 6.2.4	The Design of Major Interchanges
TD 40	DMRB 6.2.5	The Layout of Compact Grade Separated Junctions
TD 41	DMRB 6.2.7	Vehicular Access to All-Purpose Trunk Roads
TD 42	DMRB 6.2.6	Geometric Design of Major/Minor Priority Junctions
TD 50	DMRB 6.2.3	Geometric Layout of Signal Controlled Junctions and Signalised Roundabouts

TD 51      DMRB 6.3.5      Segregated Left Turn Lanes and Subsidiary Deflection Islands at Roundabouts

Traffic Signs Manual; Chapters 1 to 8

The Traffic Signs Regulations and General Directions (TSRGD)

Local Transport Note 1/94: The Design and Use of Directional Informatory Signs

Local Transport Note 1/86: Cyclists at Road Crossings and Junctions

DfT Traffic Advisory Unit Leaflet: 1/88 Provision for Cyclists at Grade Separated Junctions

BS 6100      Subsection 2.4.1: 1992      Glossary of building and civil engineering terms. Civil engineering.  
Highway, railway and airport engineering. Highway engineering

The Highway Code

## 8. ENQUIRIES

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

Chief Highway Engineer  
The Highways Agency  
123 Buckingham Palace Road  
London  
SW1W 9HA

G CLARKE  
Chief Highway Engineer

Chief Road Engineer  
Scottish Executive  
Victoria Quay  
Edinburgh  
EH6 6QQ

J HOWISON  
Chief Road Engineer

Chief Highway Engineer  
Transport Wales  
Welsh Assembly Government  
Cathays Parks  
Cardiff  
CF10 3NQ

M J A PARKER  
Chief Highway Engineer  
Transport Wales

Director of Engineering  
The Department for Regional Development  
Roads Service  
Clarence Court  
10-18 Adelaide Street  
Belfast BT2 8GB

G W ALLISTER  
Director of Engineering