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Transport Infrastructure Ireland

# TII Publications

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## Geometric Design of Junctions (priority junctions, direct accesses, roundabouts, grade separated and compact grade separated junctions)

DN-GEO-03060

May 2023

DN Design

Standards

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## TII Publications



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**Updates to TII Publications resulting in changes to  
Geometric Design of Junctions (priority junctions, direct accesses, roundabouts, grade  
separated and compact grade separated junctions) DN-GEO-03060**

**Date:** June 2017

**Amendment Details:**

This Standard supersedes:

- a) DN-GEO-03043 (TD 41-42) Geometric Design of Priority Junctions and Vehicular Access to National roads.
- b) DN-GEO-03033 (TD 16) Geometric Design of Roundabouts.
- c) DN-GEO-03035 (TD 22) Layout of Grade Separated Junctions.
- d) DN-GEO-03042 (TD 40) Layout of Compact Grade Separated Junctions.
- e) DN-GEO-03045 (TD 51) Segregated Left Turn Lanes and Subsidiary Deflection Islands at Roundabouts.
- f) DN-GEO-03032 (TD 10) Road Link Design for Type 2 and Type 3 Dual Carriageways. The details in relation to junctions on Type 2 and Type 3 Dual Carriageways have been incorporated.

This standard combines the requirements of the above superseded standards into one consolidated standard for the geometric design of junctions.

This version of the Standard supersedes the April 2017 Publication of DN-GEO-03060. The principal changes from the April 2017 version of this Standard are as follows:

**Chapter 1 – Definitions**

- a) The definition of a near straight that is required downstream and upstream of diverge and merge noses as per Section 7.5 & 7.6 has been corrected to specify the Desirable Minimum Radius for the mainline design speed.

**Chapter 2 – Junction Types**

- a) Figure 2.4 updated with photograph showing channelising island in the minor road approach.
- b) Section 2.2.4 d) updated to clarify that priority junctions incorporating traffic signals shall generally not be provided on national roads in rural areas.
- c) Section 2.4 a) has been updated to clarify that diamond junctions are not permitted on national roads in rural areas, however diamond junctions incorporating traffic signals at the connector road junction with the minor road are permitted in urban locations.

**Chapter 4 – Selection of Junction Type**

- a) Section 4.4.1 has been revised to clarify that remedial measures at junctions on existing roads are required to be submitted as part of the Preliminary Design Report in accordance with DN-GEO-03030.

**Chapter 5 – Geometric Design of Priority Junctions and Vehicular Access to National Roads**

- a) Figure 5.4 updated to reference Table 5.10: Direct Taper Length.

**Date:** June 2017

**Amendment Details:**

- b) Table 5.5: 'y' Visibility distances from the minor road has been updated to include parameters for lower design speeds of 60km/h, 50km/h and 42km/h.
- c) The minimum circular corner radii in Section 5.6.5 for left in-left out priority junctions on Type 2 Dual Carriageways and left in-left out junctions forming part of a compact grade separated junction have been revised.
- d) Section 5.6.8 has been updated to clarify that channelising islands at left in-left out junctions shall be set back 0.6m from the lane markings.
- e) Figure 5.20 has been updated to apply to priority left in-left out junctions only with reference made to Chapter 8 for left in-left out priority junctions forming part of a compact grade separated junction.
- f) Section 5.6.11.2 wording and Figure 5.27 updated to confirm ghost island turning lanes should normally be developed symmetrically about the centreline of the major road to and from the turning lane width at the tapers shown in Table 5.9.
- g) Additional wording added to Section 5.6.11.2 and new Figure 5.25 added to clarify the required details where a right turn lane off the major road is provided at both junctions within a right/left staggered junction.
- h) Section 5.7 updated in relation to Merge and diverge auxiliary lanes and tapers on single carriageway roads.
- i) Section 5.10.1 updated to clarify the hard shoulder opposite a ghost island junction shall be tapered to form a 1.5m hard strip over the length of the ghost island taper, figure 5.27 updated accordingly.
- j) Section 5.11.12 updated to provide clarity in relation to the provision of diverge auxiliary lanes on Type 2 Single Carriageway roads.

**Chapter 6 – Geometric Design of Roundabouts**

- a) Section 6.2 has been updated to include a minimum distance between two roundabouts on a national road of 90m
- b) The requirements for the ICD of roundabouts contained in Section 6.6.1 have been updated.
- c) A maximum entry path radius for roundabouts on rural national roads has been added to Section 6.6.13.
- d) Section 6.7.7 has been updated to allow for a relaxation of 50m on the provision of new priority junctions or direct accesses on Regional and Local roads as per Section 5.2.2.

**Chapter 7 – Layout of Grade Separated Junctions**

- a) Urban Motorway details included in Tables 7.1, 7.2 and 7.6.
- b) Weaving calculation details for Urban Motorways included in Section 7.9.
- c) Table 7.7 has been updated to relate the minimum radii for loops to the design speed of the mainline.
- d) Section 7.14 in relation to transitioning between a hard shoulder and hard strip at merges and diverges has been updated, figures 7.4.3 and 7.4.5 have been updated accordingly.

**Date:** June 2017

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**Amendment Details:**

**Chapter 8 – Layout of Compact Grade Separated Junctions**

- a) New figure added for left in-left out junction forming part of a compact grade separated junction has been included.
- b) Corner radii for left in-left out junctions forming part of a compact grade separated junction have been updated and design details for compact grade separated junctions with diverge auxiliary lanes have been added to Section 8.2.11.

**Date:** September 2017

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**Amendment Details:**

The following minor amendments have been incorporated into the June 2017 version of this Standard:

**Chapter 4 – Selection of Junction Type**

- a) Section 4.4.1 has been updated to state that low cost remedial measures at existing priority junctions require a Departure from Standards.

**Chapter 5 – Geometric Design of Priority Junctions and Vehicular Access to National Roads**

- b) Table 5.5: 'y' Visibility distances from the minor road has been updated to include parameters for a design speed of 42km/h.

**Date:** December 2017

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**Amendment Details:**

The following minor amendment has been incorporated into the June 2017 version of this Standard:

**Chapter 5 – Geometric Design of Priority Junctions and Vehicular Access to National Roads**

- a) Note 1 in Figure 5.13 Direct Access Bend In Crossing and Figure 5.14 Direct Access Bend Out Crossing have been updated to clarify the required 'x' distance = 2.0m from the cycle facility as per 5.5.4.
- b) The title of Figure 5.18 has been revised to Visibility envelopes for cycle route junctions with roads for clarity.

**Date:** October 2019

**Amendment Details:**

The following minor amendment has been incorporated into the June 2017 version of this Standard:

**Chapter 6 – Geometric Design of Roundabouts**

- a) Section 6.3 Landscaping within a Roundabout has had text within rearranged. No supplementary text has been added.

**Date:** May 2023

**Amendment Details:**

This version of the Standard supersedes the June 2017 Publication of DN-GEO-03060. The principal changes from the June 2017 version of this Standard are as follows:

**Chapter 1 – Introduction**

- General review and update of definitions undertaken.
- Type 2 and Type 3 Dual Carriageway have been renamed to Type 2 and Type 3 Divided Roads.

**Chapter 2 – Junction Types**

- Section 2.5 Compact Grade Separated Junctions – Layout figures revised to require roundabout at minor road junction.

**Chapter 3 – Road Safety**

- Section 3.3 Visibility – includes guidance on Active Travel infrastructure visibility.
- Section 3.5 Lighting – specific guidance removed with reference retained to DN-LHT-03038.
- Section 3.9 Detailing of Severed Roads – new figures included on detailing of severed roads and the use and layout of Turning Heads.

**Chapter 4 – Selection of Junction Type**

- Section 4.2 – updated guidance on the selection of junction type for roundabouts and compact grade separated junctions.
- Section 4.4 – includes new recommendations for the assessment of active travel users movements when improving a existing junction.

**Chapter 5 – Geometric Design of Priority Junctions and Vehicular Access to National Roads**

- Figure 5.3 updated to clarify required clearance between junctions on Major National Roads.
- Section 5.2.4 – includes figure to clarify visibility requirement of adjoining direct access or junctions.
- Section 5.3.1 – updated requirements and recommendations for simple priority junctions on single carriageway roads.



**Date:** May 2023

**Amendment Details:**

- Section 5.4 – expanded guidance on provision for Active Travel Users at priority junctions when no dedicated facility is provided. Layout details have been moved to Chapter 7.
- Section 5.5 – Direct Accesses onto National Primary Roads are now a Departure. Updated requirements on direct access layouts to be used in different scenarios.
- Section 5.6.2 – updated guidance on visibility requirements for dual carriageways and one way roads.
- Table 5.4 – updated to remove absolute minimum ‘x’ distance on minor road when the minor road is a cycle route.
- Chapter 5 – all requirements for Active Travel provision at junctions and crossings moved to new Chapter 7.
- Figure 5.14 – updated Left-in/Left-out junction design to make the junction cycle friendly when no dedicated facility for Active Travel Users is provided.
- Section 5.6.9.3 – includes amended requirements for through lane width.
- Section 5.6.10 – new section with requirements for the introduction of raised median at ghost island junction on single carriageway where overtaking is restricted.
- Section 5.10 – updated and includes all requirements for priority junctions on Dual Carriageways and Divided Roads.
- Section 5.10.3 – additional guidance and layout details for priority junction with right turn off the major road on Type 3 Divided Roads. Clarified that a Departure is required for this type of junction.

**Chapter 6 – Geometric Design of Roundabouts**

- Section 6.1 – new Figure 6.2 included to define geometric elements of roundabouts.
- Section 6.1 – new Figure 6.3 included presenting a roundabout design flow chart.
- Section 6.1 – updated requirements and guidance for number of entry, circulating and exit lanes.
- Section 6.4 – additional guidance to distinguish between single lane and multi-lane roundabouts.
- Section 6.6.1 – removed upper limit of 36m for single lane roundabout ICD. Larger single lane roundabouts are now permitted, aimed at discouraging the design of multi-lane roundabouts in all rural areas where not required on capacity grounds.
- Section 6.6.2 – updated guidance included on number of circulating lanes.
- Section 6.6.3 – updated requirements and guidance included for overrun areas.
- Section 6.6.13 – includes additional requirements for evaluating entry path radius on multi-lane roundabouts (accompanied by new figures).
- Section 6.6.14 – updated guidance on number of exit lanes, exit width and layout.
- Section 6.10 – updated guidance on termination of hard shoulder/hard strip.

**Date:** May 2023

**Amendment Details:**

- Chapter 6 – all requirements for Active Travel provision at junctions and crossings moved to new Chapter 7.
- Additional advice on road markings is included in Appendix E
- Section 6.12 – a Departure from Standard is now required for the provision of Segregated Left Turn Lanes. Design principles are moved to Appendix F.

**Chapter 7 – Active Travel Facility Junctions and Crossings**

- New Chapter included covering all details of Active Travel Facility junctions and crossings.

**Chapter 8 – Layout of Grade Separated Junctions**

- Layout of Grade Separated Junction has been renumbered to Chapter 8 due to introduction on new Chapter 7.
- Section 8.3, updated to include ATUs as a key consideration at planning and design stage as particularly vulnerable to fast moving traffic.
- Section 8.9 – updated requirements on spacing between junctions for different road types.
- Section 8.9.3 – clarified that a Departure from Standard is required where the weaving length available is less than desirable minimum.
- Section 8.9.3 – new guidance on function and requirements for parallel service roads, where proposed to eliminate substandard weaving lengths.

**Chapter 9 – Layout of Compact Grade Separated Junctions**

- Layout of Compact Grade Separated Junction has been renumbered to Chapter 9.
- Section 9.2.11 – includes requirements for Single Lane Dualling when providing compact grade separated junctions on single carriageway roads.

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# 1. Introduction

## 1.1 General

This standard sets out the standards and advice for the geometric design of junctions, including active travel crossings on national roads. The design principles and geometric parameters which shall be considered by Designers when developing safe and efficient junction layouts and vehicular accesses onto new and improved national roads are outlined.

This standard does not cover the design requirements and methodology for the geometric layout of major interchanges (including the expansion and improvement of existing interchanges and junctions). This is set out in DN-GEO-03041: The Design of Major Interchanges.

## 1.2 Scope

This standard sets out the design requirements and methodology which shall be followed when developing junction and access layouts for Motorways and all-purpose national roads, including dual carriageways, divided roads and single carriageways, taking into consideration traffic operation, physical elements, economic and safety factors and the requirements of Active Travel Users (ATUs). This standard also provides guidance on junction and access layouts on regional and local roads which form part of a national road scheme.



This standard also provides requirements and guidance for Active Travel crossing treatments on National Roads remote from a junction and crossing treatments at at-grade junctions such as priority junctions, vehicular accesses, and roundabouts. Specific requirements related to Active Travel are highlighted by the inclusion of the icons above and below this paragraph.



This standard provides recommendations on the siting of junctions with respect to topography and driver expectations and limitations.

This standard shall not be used for the design of road markings and signage at junctions. Road markings and signage for junctions on national roads shall be designed in accordance with the requirements of the Traffic Signs Manual (TSM) issued by the Department of Transport.

## 1.3 Implementation

This Standard shall be used for the design of junction layouts on all new or improved national roads. The design of national, regional and local roads which are constructed or improved as part of a national road scheme shall also be developed in accordance with this standard.

## 1.4 Relaxations and Departures

The standards contained in this document represent the maximum/minimum levels of provision whose incorporation in the junction design would achieve a desirable level of performance in average conditions in terms of traffic safety, operation, economic and environmental effects and sustainability. In most cases, with care, designs can be achieved which do not utilise the lowest levels of design parameters given. At some locations on new roads or major improvements, however, it may not be possible to justify even the lowest levels of design parameters in economic or environmental terms, due to high costs, low traffic levels, and environmental damage, etc. In such cases, sufficient advantages might justify either a Relaxation within the standards or, in more constrained locations, a Departure from the standards.

Relaxations and Departures should be assessed in terms of their effects on the economic worth of the scheme, the environment, and the safety of the road user. Further details on the use of Relaxations and Departures are as follows.

#### 1.4.1 Relaxations within Standard

In difficult circumstances, the Designer may relax a standard set out in this document, where specifically provided for within the text (refer to DN-GEO-03031 for all combinations of allowable relaxations from standard). The Designer shall record the fact that a Relaxation has been used in the design and the corresponding reasons for its use. The record shall be endorsed by the Designer responsible for the scheme. The Designer shall report all Relaxations incorporated into the design within the Design Report in accordance with the Project Management Guidelines.

#### 1.4.2 Departures from Standards

In exceptional situations, Transport Infrastructure Ireland (TII) may be prepared to agree to a Departure from Standards where the standard, including permitted Relaxations, is not realistically achievable. Designers faced by such situations and wishing to consider pursuing this course shall discuss any such option at an early stage in design with TII. Proposals to adopt Departures from Standard must be submitted by the Designer to TII and formal approval received BEFORE incorporation into a design layout. Further information can be found in GE-GEN-01005 Departures from Standards and Specification.

### 1.5 Definitions

The terminology used in this Standard are defined as follows:

- a) **Active Travel:** Walking, wheeling, and cycling for all users for all trip purposes where walking, wheeling, and cycling mean<sup>1</sup>:
  - i) **Walking and Wheeling:** Engaging in the typical act of walking plus jogging, using mobility aids (i.e., manual and electric wheelchairs as well as motorised mobility scooters), and using non-motorised scooters.
  - ii) **Cycling:** Cycling using any type of cycle, such as bicycles, electric cycles, adapted cycles and cargo cycles. Cycles must, except for specific situations, be treated as 'vehicles', not as 'pedestrians'.
  - iii) **Active Travel Infrastructure:** All types of pedestrian and cycle facilities which improve conditions for people walking, wheeling, and cycling.
  - iv) **Ancillary Infrastructure:** Constructed features that provide added value to the cycle route and enhance the user's experience.
  - v) **Off-line Facility:** Element of active travel network catering for people walking, wheeling, and cycling that is not part of the road cross-section (notwithstanding, potential sole designation as cycleway).
  - vi) **On-line Facility:** Element of active travel network catering or rural cycleway catering for people walking, wheeling, and cycling that is part of the road cross-section. On-line active travel facilities may be provided as on-road pavement or off-road pavement facilities:

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<sup>1</sup> Walking and wheeling are of equal importance to cycling as they are much more commonly utilised modes; they form part of all trips, even those where the primary mode is the private vehicle or public transport.

- a) **Off-road Facility:** Facility that is physically segregated from the road pavement by, for example, a verge;
  - b) **On-road Facility:** Facility that forms part of the road pavement without physical separation or demarcation from the road / vehicular carriageway.
- b) **Active Travel Users (ATUs):** All users of an Active Travel facility.
  - c) **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.
  - d) **Carriageway:** The area of the paved width which is trafficked by road users under normal operation. Notes:
    - i) This includes designated lanes such as bus lanes and cycle lanes; and
    - ii) The carriageway excludes hard shoulders and hard strips.
  - e) **Central reserve:** The area which separates the carriageways of a dual carriageway, divided road or Motorway. Note that this includes any offside hard strips.
  - f) **Channelising Island:** A raised kerbed island constructed (a) within the bellmouth of a priority junction to guide traffic movements into and out of the minor road (b) at a roundabout junction entry/exit to direct traffic onto or from a roundabout circulatory carriageway or (c) at a segregated left turn lane, located between an entry and exit on the same roundabout arm and shaped so as to direct and also separate opposing traffic movements onto and from a roundabout circulatory carriageway.
  - g) **Compact Connector Road:** In the context of compact grade separated junctions a two way connector road between the major and minor roads.
  - h) **Compact Grade Separated Junction:** A grade separated junction designed in accordance with Chapter 9 of this standard.
  - i) **Connector Road:** A collective term for slip roads, link roads, interchange links and loop roads.
  - j) **Cycle Facilities:** Refers to all types of measures which improve conditions for cyclists and include:
    - i) **Cycleways:** an off-line public road reserved for the exclusive use of people cycling or people walking, wheeling, and cycling (see also definitions of 'Greenway' and 'Shared Use Active Travel Facility'). All mechanically propelled vehicles, other than mechanically propelled wheelchairs and electric bikes, are prohibited from entering except for the purpose of maintenance and access.
    - ii) **Greenway:** A cycleway that caters for people walking, wheeling and cycling in a mainly recreational environment.
    - iii) **Cycle Track:** A part of the road cross-section, separated from the road / vehicular carriageway by a verge, which is reserved for the use of cycles and from which all mechanically propelled vehicles, other than mechanically propelled wheelchairs and electric bikes, are prohibited from entering except for the purpose of maintenance and access. A cycle track can be adjacent to a footway (see also definition of 'Shared Use Active Travel Facility')



- iv) **Shared Use Active Travel Facility:** A Cycle Track or Cycleway that is provided for people walking, wheeling, and cycling.
- v) **Cycle Lane:** part of the road pavement reserved for use by cycles. The cycle lane forms part of the road pavement, and it is thus located within the contiguous road surface. It is not a cycleway nor cycle track and therefore, generally not for the exclusive use of cyclists.
- vi) **Cycle Network:** A defined collection of routes which connect key origins and destinations in a specified area for cyclists.
- k) **Cycle Friendly:** Cycle Friendly refers to situations where dedicated cycle infrastructure has not been provided, but road space is nonetheless designed such that competent cyclists feel comfortable travelling alongside other traffic. A cycle friendly road should not result in cyclists having to behave unpredictably, i.e., changing their position on the carriageway to avoid an obstacle or a sudden change in width of the hard shoulder. It is considered the most basic level of cycle provision to be implemented on all-purpose roads.
- l) **Designer:** The organisation responsible for undertaking and/or certifying the design.
- m) **Direct Access:** An access that connects directly to a national road including field accesses and accesses serving one or more properties as described in Chapter 5 national road.
- n) **Downstream:** That part of the carriageway(s) where the traffic is flowing away from the section under consideration.
- o) **Dual Carriageway:** A divided road with one or more (generally two) lanes in each direction with carriageway widths of up to 7.5m (for two lanes in each direction i.e. 2 x 3.75m lanes).
- p) **Dumb-bell Link Road:** A short link road connecting two roundabouts either side of a dual carriageway or motorway at a grade separated junction (Refer to Chapter 8).
- q) **Express Road:** An Express Road is a legal category of road designed for motor traffic, which is accessible primarily from interchanges or controlled junctions and which:
  - i) Prohibits stopping and parking on the road pavement; and
  - ii) Does not cross at grade with any railway or tramway track.
- r) **Fork:** At an at-grade junction, usually on a link road within a grade separated interchange, where the road splits into two. Usually both diverging roads have equal status and diverge from the single approach at similar angles.
- s) **Ghost Island Junction:** A junction within which an area is marked on the carriageway, shaped and located so as to direct traffic movement.
- t) **Ghost Island on Merges/Diverges:** 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.
- u) **Heavy Goods Vehicle (HGV):** Vehicles designed and constructed for the carriage of goods. Heavy Goods Vehicle refers to vehicle categories N2 (maximum mass between 3.5 tonnes and 12 tonnes) and N3 (maximum mass exceeding 12 tonne).
- v) **Interchange:** A grade separated junction that provides free flow of traffic from one mainline carriageway to another. Refer to DN-GEO-03060.

- w) **Interchange Link:** A connector road, one or two way, carrying free flowing traffic within an interchange.
- x) **Lane Drop:** A layout where a lane or lanes of the upstream carriageway becomes the diverging connector road.
- y) **Lane Gain:** A layout where a merging connector road becomes a lane or lanes of the downstream carriageway.
- z) **Link Road:** A connector road separate from the mainline carriageway, which is used to connect the mainline carriageway to the local road network.
- aa) **Loop:** A connector road, one or two way, which is made up of the elements of the loops shown in Chapter 8 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.
- bb) **Low Radius:** A radius between the minimum loop radius in Table 9.2 and the Two Steps below Desirable Minimum Radius with Superelevation of 7% as required by DN-GEO-03031 for the slip road, link road or interchange link design speed.
- cc) **Mainline/Major Road:** The carriageway carrying the main flow of traffic (generally traffic passing through a junction or interchange).
- dd) **Maintaining Organisation:** The organisation which will be responsible for the maintenance of the road or thoroughfare after construction.
- ee) **Major Interchanges:** Interchanges provided at the intersection of motorways, dual carriageways and national roads to provide free flow for all movements accommodated. The free flow arrangement removes the conflict points, however they are generally larger and more complex than the type of junction described in this standard and must be designed in accordance with DN-GEO-03041.
- ff) **Minor road:** A minor road is a road which has to give priority to the major road.
- gg) **Motorway Service Area (MSA):** Motorway service areas are places where drivers can leave a motorway to refuel, rest or take refreshments.
- hh) **Near Straight:** A length of road with a radius no less than the Desirable Minimum Radius with Superelevation of 5% as required by DN-GEO-03031 for the mainline design speed.
- ii) **Non-physical Segregated Left Turn Lane:** A left turn lane from adjacent roundabout entry and exit, shaped to direct and separate the traffic movement from the roundabout circulatory carriageway by means of an island delineated using road markings only.
- jj) **Nose:** A paved area, approximately triangular in shape, between a connector road and the mainline at a merge or diverge.
- kk) **Parallel Merge/Diverge:** A layout where an auxiliary lane is provided alongside the mainline carriageway. This term incorporates the auxiliary lane, the nose and the taper.
- ll) **Pedestrian Facilities:** All types of measures which improve conditions for people walking and wheeling, and include:
  - i) **Footpath:** A path, separated from the road / vehicular carriageway by a kerb, for use by pedestrians which does not form part of the road pavement.

- ii) **Footway:** A path for use by pedestrians, separated from the road / vehicular carriageway by a verge, which does not form part of a road pavement.
- iii) **Bridleway:** A road (surfaced or unsurfaced) for use on foot or horseback.
- mm) **Physical Segregated Left Turn Lane:** A left turn lane from a roundabout entry to the first exit, separated from the roundabout entry, circulatory carriageway and exit by means of Channelised islands (See definition of Channelised Islands).
- nn) **Priority Junction:** An at grade junction between a major road and a minor road whereby the traffic on the minor road must yield to the traffic on the major road.
- oo) **Reserved Lane:** A lane carrying traffic that is segregated from weaving traffic.
- pp) **Road Authority:** The authority responsible for the road construction or improvement scheme.
- qq) **Rural Area:** an area outside of a built-up area which is generally controlled by speed limits greater than 60 km/h.
- rr) **Rural National Road:** A road outside of built-up areas including:
  - i) Single Carriageway roads;
  - ii) All-purpose Divided roads;
  - iii) All-purpose Dual Carriageway roads; or
  - iv) Motorways.
- ss) **Single Carriageway:** Two-lane single carriageway road with lane widths of up to 3.65m.
- tt) **Skew or Y-Junction:** An at-grade junction of two roads, at which the minor road approaches the major road at an oblique angle and terminates at the junction.
- uu) **Slip Road:** A connector road within a junction between a mainline carriageway and the local road network, or vice versa, which meets the local road network at-grade. Traffic using a slip road usually has to yield to traffic already on the mainline or on the local road network.
- vv) **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.
- ww) **Transition Zone:** A 50 to 60 km/h posted speed limit zone passing through areas of low density residential and commercial development and/or industrial areas.
- xx) **Type 1 Dual Carriageway:** A divided all-purpose road with a minimum of two lanes and hard shoulder in each direction constructed to the geometric standards of DN-GEO-03031 and CC-SCD-00006.
- yy) **Type 1 Single Carriageway:** An all-purpose road with a 3.65m lane in each direction constructed to the geometric standards of DN-GEO-03031 and CC-SCD-00001.
- zz) **Type 2 Divided Road:** A divided all-purpose road with two lanes and hard strip in each direction constructed to the geometric standards of DN-GEO-03031 and CC-SCD-00005.
- aaa) **Type 2 Single Carriageway:** An all-purpose road with a 3.50m lane in each direction constructed to the geometric standards of DN-GEO-03031 and CC-SCD-00002.

- bbb) **Type 3 Divided Road:** A divided all-purpose road with two lanes in one direction of travel and one lane in the other direction, constructed to the geometric standards of DN-GEO-03031 and Standard Construction Details CC-SCD-00004. The two-lane section alternates with a one-lane section at intervals of 2km approximately.
- ccc) **Type 3 Single Carriageway:** An all-purpose road with a 3.00m lane in each direction constructed to the geometric standards of DN-GEO-03031 and CC-SCD-00003.
- ddd) **Upstream:** That part of the carriageway(s) where traffic is flowing towards the section in question.
- eee) **Urban All-Purpose Road:** An all-purpose road within a built-up area which can be either a single carriageway or a dual carriageway.
- fff) **Urban Motorway:** A motorway with a speed limit of 100kph or less within a built-up area.
- ggg) **Urban Relief Road:** An urban road where the primary purpose of the road is to facilitate the movement of traffic and avoid congestion or other obstacles to movement.
- hhh) **Urban Street:** A road within a built-up area where the primary purpose of the road is to provide direct access to premises.
- iii) **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 must cross the paths of vehicles that have joined the mainline at the merge or lane gain.

## 2. Junction Types

### 2.1 General

This section describes the various junction types permitted for use on new national road schemes. Photographs and/or figures are used to portray the general layouts for each junction type. All road marking and signing details in photos and figures are diagrammatic only and shall not be relied upon for road marking and signing layout design.

A junction is formed whenever two or more roads cross or meet. Junction types are characterised by their basic geometric configuration. There are two main categories of junction which can be further subdivided as follows:

- a) At Grade Junctions
  - i) Priority Junctions
  - ii) Roundabouts
- b) Grade Separated Junctions
  - i) Full Grade Separated Junctions
  - ii) Compact Grade Separated Junctions

Junction types can vary greatly in arrangement, shape, and degree of channelisation. Junctions are often categorised based on the number of roads intersecting and their angle of intersection, the way in which right-turning and left-turning movements are accommodated, the way in which Active Travel Users (ATUs) are catered for, and the presence and shape of channelising islands.

This Standard provides advice and requirements for each junction type. Table 2.1 outlines some key features and limitations for each of the different junction types discussed in this document.

**Table 2.1 Key features and limitations by junction type**

| Junction Type                    | Key Features  | Disadvantages/ Limitations   |
|----------------------------------|---|--|
| Priority Junction                | Through traffic on the major road is not delayed.<br><br>Land take and construction cost reduced relative to more complex junction layouts.   | All turning movements have potential to create conflict.<br><br>Right turn movements onto and off the major road can lead to serious collisions.<br><br>Not suitable for high flows and turning movements.<br><br>Major road through traffic speeds need to be controlled. |
| Roundabout                       | Simplifies conflicts and provides a clear indication of priority.<br><br>Facilitates right turning flows and U-turns.<br><br>Can facilitate a change in road standard/cross-section.  | Major road traffic must yield to traffic from the right which may cause delays.<br><br>Dominant flows on one approach may lead to excessive delays on other approaches.  |
| Grade Separated Junctions        | Turning vehicles are removed from the major road.<br><br>Major road through traffic is not delayed.<br><br>Can facilitate large turning flows.  | Land take and construction costs high relative to less complex junction layouts.<br><br>Not suitable for single carriageway roads, Type 2 and Type 3 Divided Roads.  |
| Compact Grade Separated Junction | Reduced land take relative to full Grade Separated Junctions.<br><br>Design enforces low traffic speeds through the junction.<br><br>Suitable for use where high major road and minor road through traffic.<br><br>Can be used on single carriageway roads and Type 2 and Type 3 Divided Roads. | Not suitable for Motorways or Type 1 Dual Carriageways.  |

## 2.2 Priority Junctions

Priority junctions are the most common form of junction control. The basic concept of priority junctions is that traffic on the minor road gives way to traffic on the major road, such that through traffic on the major road is not delayed. However, high speeds and/or overtaking traffic manoeuvres on the major road should be discouraged at priority junctions. For more heavily used junctions, more complex forms of junction layout are required.

Priority junctions can be categorised by the configuration of the minor road(s) in relation to the major road as described below. Priority junction types are described in further detail in Chapter 5.

### 2.2.1 T-Junction

An at-grade junction of two roads, at which the minor road joins the major road approximately at right angles as shown in Figure 2.1.



**Figure 2.1 Simple T-Junction**

### **2.2.2 Staggered Junction**

An at-grade junction of three roads, at which the major road is continuous through the junction, and the minor roads connect with the major road so as to form two opposing T-junctions at a minimum distance apart (Figure 2.2).



Figure 2.2 Simple Right/Left Stagger

### 2.2.3 Crossroads

An at-grade junction of two roads that cross approximately at right angles (Figure 2.3). Crossroads are not permitted on national roads.

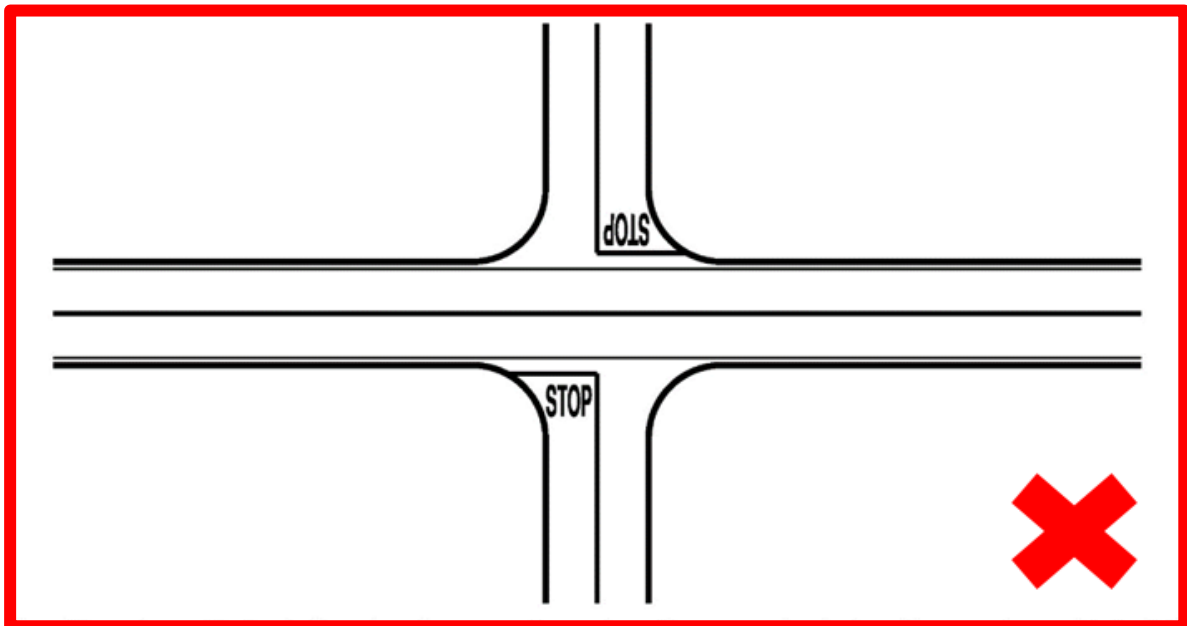


Figure 2.3 Crossroads



## 2.2.4 Traffic Control at Priority Junctions

Priority junctions can be further distinguished by the type of traffic control used at the junction. These traffic controls include:

- a) **Simple Junction** – A 'T' or staggered junction without a ghost island in the major road. Channelising islands can be provided in the minor road approach (Figure 2.1).
- b) **Ghost Island Junction** – An at-grade junction, usually a 'T' or staggered junction, within which an area is marked on the carriageway, shaped and located so as to direct traffic movement by providing a right turning lane. A channelising island shall be provided on the minor road approach (Figure 2.4).



Figure 2.4 Ghost Island Junction

- c) **Left-In/Left-Out Junction** – An at-grade junction where left turn movements only are permitted onto and off the minor road. Sign posting and physical lane segregation are used to prevent any right turning movements. Figure 2.5 shows an indicative layout for a left in/left out junction at a direct access.
- d) **Signalised Priority Junctions** – Priority junctions incorporating traffic signals shall generally not be provided on national roads in rural areas and require a Departure from Standards where they are proposed for incorporation into a national road scheme.



**Figure 2.5 Left-In/Left-Out Junction**

### **2.2.5 Skew Junctions**

Priority junctions where the minor road approaches and intersects the major road at an oblique angle are not permitted on national roads. The design criteria outlined in Chapter 5 requiring suitable curvature to be applied to the minor road approach so as it connects to the major road at 90° in order to eliminate any driver confusion as to which route has priority, must be applied at such junctions.

## **2.3 Roundabouts**

Roundabouts are junctions with a one-way circulatory carriageway around a central island. Vehicles on the circulatory carriageway have priority over those approaching the roundabout.

The principal objective of roundabout design is to minimise delay for vehicles whilst maintaining the safe passage of all road users through the junction by simplifying conflicts and providing a clear indication of priority. This is achieved by a combination of geometric layout features that, ideally, are matched to the flows and speeds in the traffic streams and to any local topographical or other constraints that apply.

Roundabouts are most suitable when traffic flows from all legs are balanced and there is a high density of right turn movements. Dominant flows on one approach may lead to excessive delays on the subsequent approach.

Roundabouts can be Single Lane Roundabouts or Multi-lane Roundabouts. Each roundabout type is described in further detail in Chapter 6.

### **2.3.1 Single Lane Roundabouts**

A Single Lane Roundabout (Figure 2.6) has single lane entries and exits on each arm. The width of the circulatory carriageway shall be designed such that such that two vehicles are not encouraged to move through the roundabout side-by-side.



**Figure 2.6**      **Single Lane Roundabout**

### 2.3.2 Multi-lane Roundabouts

Multi-lane Roundabouts (Figure 2.7) have multi-lane entries and/or exits on at least one arm and allow two cars to travel side by side on the circulatory carriageway.



Figure 2.7 Multi-lane Roundabout

## 2.4 Grade Separated Junctions

A grade separated junction is a separation of the levels at which major and minor roads cross each other in order to reduce traffic conflicts. A grade separated junction involves the use of an at-grade junction at the commencement or termination of slip roads.

There are two main types of grade separated junction; Dumb-bell roundabout and Half-Cloverleaf. These junction types are mandatory on Motorways and are generally required on Type 1 Dual Carriageways where the turning volumes warrant such provision.

Diamond junctions are not permitted on national roads in rural areas, however diamond junctions incorporating traffic signals at the connector road junction with the minor road are permitted in urban locations. Grade Separated Junction types are described in further detail in Chapter 8.

### 2.4.1 Dumb-Bell Roundabout

The dumb-bell roundabout junction comprises two roundabouts situated either side of the major road. The minor road crosses over or under the major road at one location using a bridge – see Figure 2.8.

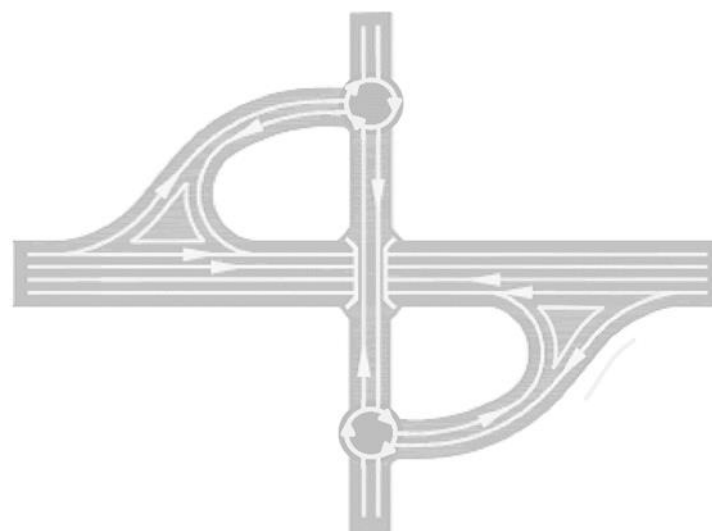
A Departure from Standards shall be required for a half dumb-bell junction where access onto and off the major road is provided in one direction only.



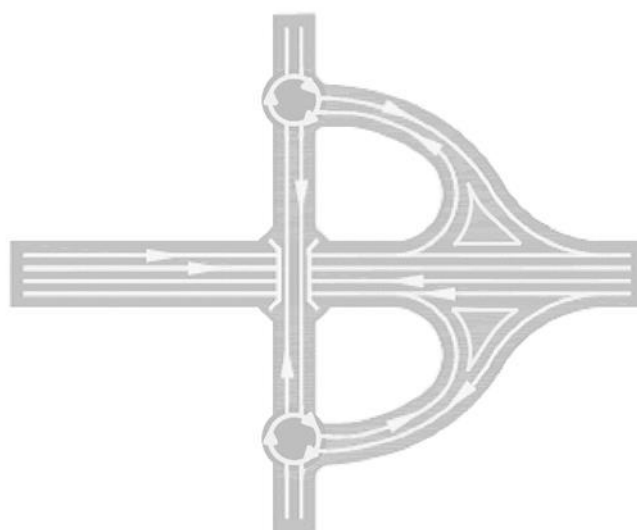
**Figure 2.8** “Dumb-bell” Grade Separated Junction

#### **2.4.2 Half-Cloverleaf**

A half-cloverleaf is used where site conditions are such that a dumb-bell roundabout junction cannot be provided and the use of all four quadrants is not possible for the provision of a full interchange in accordance with DN-GEO-03041 (see Figure 2.9). The at-grade junction element should normally utilise two roundabouts. The half-cloverleaf requires the use of only 2 quadrants, which if possible, should be chosen so as to minimise any right turn movements where priority junctions are provided. Consideration should be given to future improvement when considering this layout.



**Half-Cloverleaf  
Quadrants 1 and 3**



**Half-Cloverleaf  
Quadrants 2 and 3**

**Figure 2.9 Half Cloverleaf Grade Separated Junctions**

## 2.5 Compact Grade Separated Junctions

Compact Grade Separated Junctions provide an alternative to at-grade or full grade separation and are designed to a standard intended to enforce low traffic speeds and minimise land take. As shown in Figure 2.10, they are designed with an unsegregated connector road between the major and the minor road, with the connector road joining the major road via a left-in/left-out priority junction.

Compact grade separated junctions are suitable for use on Type 2 Divided Roads where mainline flows are high but turning traffic may be relatively low.

They are also suitable for use on Type 3 Divided Roads and on Single Carriageway roads where there is a high level of through traffic to reduce the conflict points for turning traffic.

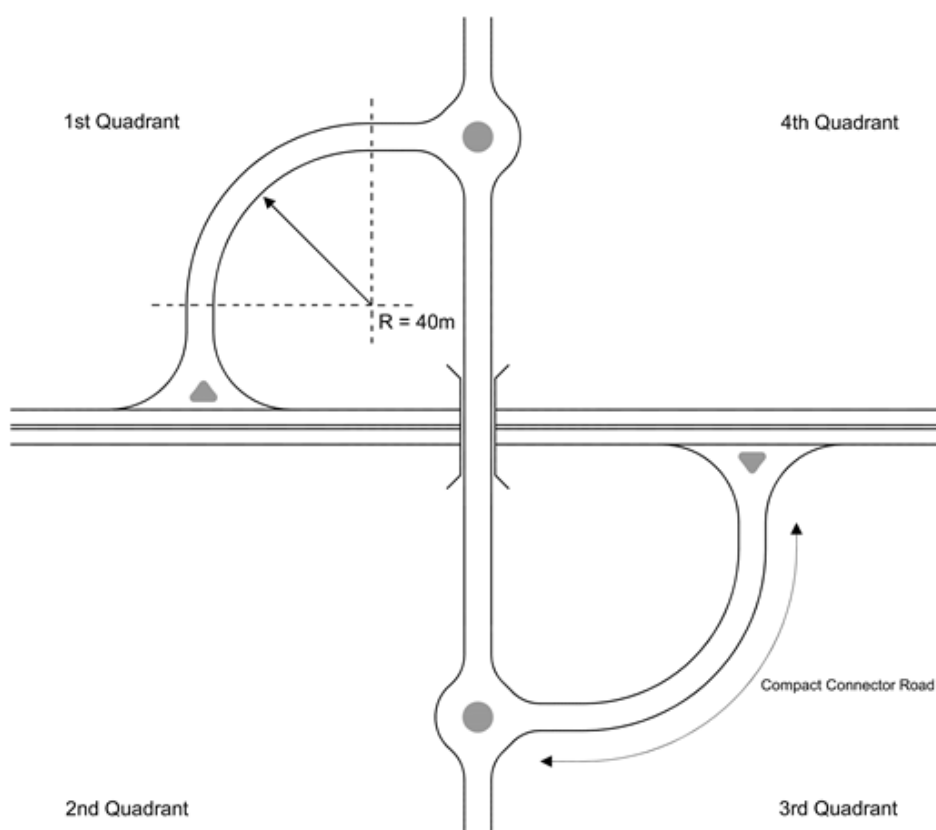
The objectives of compact grade separated junctions are to:

- a) reduce the environmental impact by providing a compact junction layout with less landtake;
- b) extend the use of grade separation on the national road network;

The benefits that a compact grade separated junction is intended to provide when compared to an at-grade junction are:

- a) improvement of safety by reducing the number and severity of collisions;
- b) separation of high through traffic from minor road off the major road.
- c) a safer means of crossing high speed routes for all road users, including ATUs;
- d) regulation and continuity of vehicle speed for minor route traffic through the junction at a level appropriate to the layout standards;
- e) removal of right turn manoeuvres from high speed roads;

The layout of the compact grade separated junction will in many cases be dictated by the constraints imposed by the existing junction to be modified, or site topography in the case of new routes.



**Figure 2.10 Compact Grade Separated Junction**

Compact Grade Separated Junction types are discussed in further detail in Chapter 9.

## **2.6 Major Interchanges**

Major interchanges will generally be required at the intersection of motorways and dual carriageway national primary roads to provide free flow for all turning movements accommodated. The free flow arrangement removes the conflict points however, they are generally larger and more complex than the types of junctions described in this standard and must be designed in accordance with DN-GEO-03041.



## **3. Road Safety**

### **3.1 General**

TII is responsible for securing a safe and efficient national road network. The performance and safety of roads are strongly influenced by the layout and frequency of junctions and accesses.

Junction layouts should give road users (including ATUs) a clear understanding of what is required of them. Poor layouts lead to road user confusion, indecisiveness and rash decisions that could contribute to collisions.

The design should provide:

- a) advance notification of the layout on the approach to a junction;
- b) conspicuous junction locations and intuitive layouts;
- c) advance notification and clear layout of ATU crossings
- d) an understanding of permitted changes to the direction of travel;
- e) an understanding of other traffic movements;
- f) avoidance of potential hazards.

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

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

### **3.2 Road User's Limitations**

An appreciation of road users' performance is essential to proper road design and operation. The suitability of a design rests as much on how safely and efficiently road users are able to use the road as on any other criterion.

Motorist's perception and reaction time set the standards for sight distance and length of transitions. The driver's ability to understand and interpret the movements and crossing times of the other vehicles, drivers and ATU's using the junction and their associated reactions is equally important when making decisions. The designer needs to keep in mind the user's limitations and therefore design junctions so that they meet user expectation.

Sequences of junctions should not involve many different layout types. Safe road schemes are usually straightforward, containing no surprises for the road users. A length of route or bypass containing roundabouts, ghost islands, simple priority junctions, grade separation and different provision of ATU facilities would inevitably create confusion and uncertainty for drivers and may result in collisions.

The sun can detrimentally affect a road user's vision. Designers should attempt to avoid the need for drivers to approach a manoeuvre or a decision point looking into the rising or setting sun. The designer should consider the potential for dazzle and silhouetting of signs when the sun is low in the sky.

The ability of ATUs to use infrastructure and crossing points will vary depending on user age, experience, mobility, and general fitness. Active Travel infrastructure should therefore be designed with user comfort and attractiveness at the forefront. In this regard for example, gradients should remain shallow wherever possible, crossing points should clearly indicate priority and adequate signage should be provided to notify of any potential hazards.

### 3.3 Visibility

For safety, road users shall be able to see any potential hazard in time to slow down or stop comfortably before reaching it. It is necessary therefore to consider the road user's line of vision in both the vertical and horizontal planes and the stopping sight distance for the vehicle or ATU at the relevant design speed. Visibility requirements for the different junction types are included in the relevant chapters of this standard.



When designing Active Travel infrastructure, including crossing points, both Stopping Sight Distance and Dynamic Sight Distance in the vertical and horizontal planes must be provided. Refer to Section 2.5.1 – Dynamic Sight Distance for Cyclists in DN-GEO-03031.



### 3.4 Road Marking and Signing

Signs and road markings are provided at junctions to warn, regulate and guide traffic. 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 and it may affect the junction geometric design. Traffic signs and road markings can significantly affect the safety and the capacity of a junction. All road markings and signage for national roads shall be designed in accordance with the requirements of the Traffic Signs Manual (TSM) issued by the Department of Transport, which includes guidance on the appropriate use and requirements of road markings at various types of junctions.

Positioning of signs within the junction and on the mainline approach to junctions must be carefully considered so that they do not interfere with road user's visibility. It is essential that there is no over-provision of signing leading to 'sign clutter'.

Road markings are used to channelise traffic and, where required, to indicate a dedicated lane. Lane direction signs complementing the advance direction signs at entries can be beneficial where heavy flows occur in a particular direction.



Where cycle facilities are provided, road markings and signs must be adequately provided at the entry and at suitable distances along the cycle route. Yield signs and road markings shall be provided to indicate vehicle priority at junctions.



### 3.5 Lighting

Road lighting at junctions shall be provided in accordance with DN-LHT-03038 and IS EN 13201.

### 3.6 Landscaping

The design of landscaping and street furniture within the road boundaries shall be carried out in consultation with appropriate specialists. The Designer shall consider the maintenance implications and where the responsibility for maintenance is passed to a third party, maintenance standards must be agreed. If third parties wish to enhance the standard of planting or landscaping at a junction, this shall be with the agreement of TII, and shall not compromise visibility sightlines or safety.

Apart from the amenity benefits, the landscape treatment of junctions can have practical advantages from a traffic engineering point of view. These can be:

- a) To make the layout of a junction more obvious to approaching traffic;
- b) To provide reference points or features for road users waiting to enter the junction, aiding them in judging the speed of drivers approaching or in the junction. This can be useful where a junction is located in an open landscape, where there is a lack of natural reference points; and
- c) To provide a positive background to the road signs around the junction.

It is essential that visibility within the required envelopes remains unobstructed by vegetation and street furniture. The areas required for visibility envelopes should be either hard surface or planted with grass or species having a low mature height and low maintenance characteristics.

Too much visibility can be as problematic as too little, and this can also be addressed by careful landscape treatment.

### **3.7 Enhancing Road Layouts at Existing Priority Junctions to Improve Safety**

Various methods which have been shown to enhance safety at junctions include:

- a) Where there is a history of collisions involving right turning vehicles, the installation of a ghost island on single carriageway roads to shelter right turning traffic and discourage overtaking.
- b) The replacement of a rural crossroads by a staggered junction. This has been shown to reduce collisions by 60%.
- c) The installation of channelising islands on the minor road approaches at existing rural crossroads. This has been shown to reduce collisions (mainly minor road overrun) by about 50%.

### **3.8 Safety Barriers**

Safety Barriers shall be provided at junctions in accordance with DN-REQ-03034 where required. Designers must consider the position of such barriers and their potential for obstructing visibility when assessing the visibility requirements at a junction as outlined in this standard.

### **3.9 Detailing of Severed Roads**

Where an existing road is severed by a new road scheme, resulting in the creation of a cul-de-sac, the approach to the cul-de-sac should be detailed to direct through traffic on to the through road. The access to the cul-de-sac therefore, shall be detailed to require a deliberate turning manoeuvre to prevent drivers assuming the previous road layout still applies.

As per Figure 3.1, a typical well designed cut-off should include the following:

- a) The character of the road on the approach to the cut-off point shall be changed by narrowing to between 3 and 4m for the last 100m (depending on the volume of traffic on the cut-off road).
- b) All lining shall be removed within 100m of the cut-off point.

- c) All old signage relevant to the existing road shall be removed.
- d) New signage shall be put in place to inform a driver that the road they are entering is now a cul-de-sac. The signage should be placed such that it is conspicuous to a driver approaching the junction that leads to the cul-de-sac.
- e) The possibility of see-through between old road and new road must be assessed both by day and by night. If a see-through issue exists then a screening fence of suitable height needs to be erected, possibly supplemented by planting of mature scrubs, to remove the problem.
- f) At some locations, the creation of a Turning Head at the end of the road may be the best treatment; in other cases, just narrowing the road, removing line marking and treating the area in front of the cut-off point may suffice.

A Turning Head allows for vehicles to complete a U-Turn safely and efficiently without causing disruption or creating a hazard for other road users including ATUs.

Refer to Figure 3.2 for details on suggested Turning Head layouts. It should be noted that these layouts are sufficient to accommodate the turning movements of an 8m refuse vehicle, however, swept path analysis must be carried out to ensure the provided layout can accommodate the minimum design vehicle appropriate for the site, without encroaching on any vertical obstructions such as kerbs.

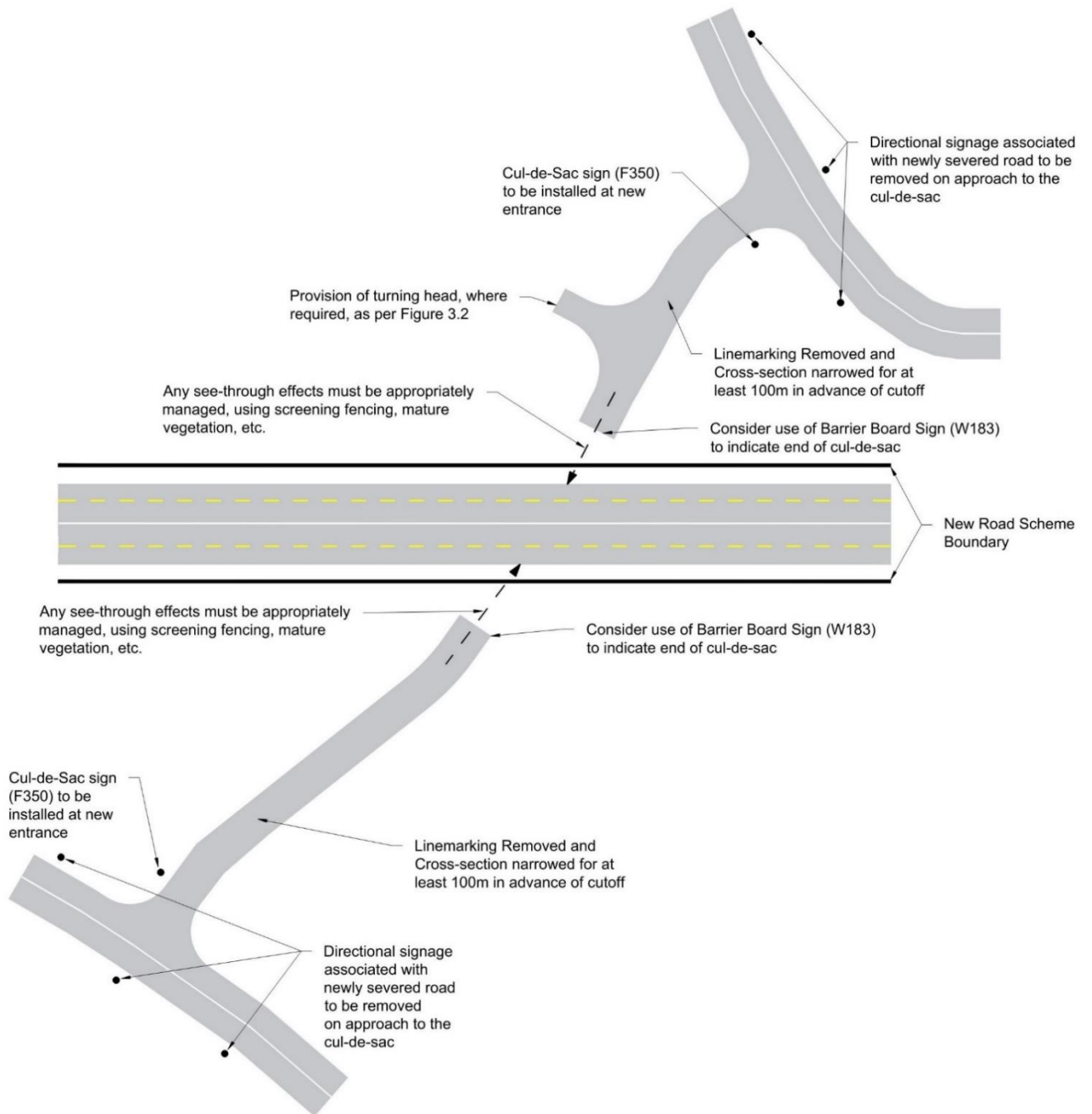
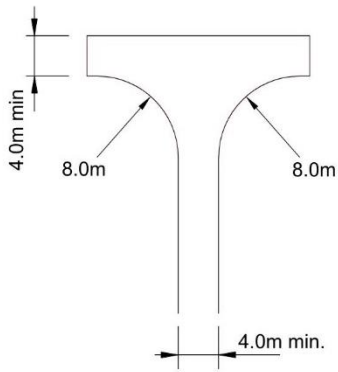
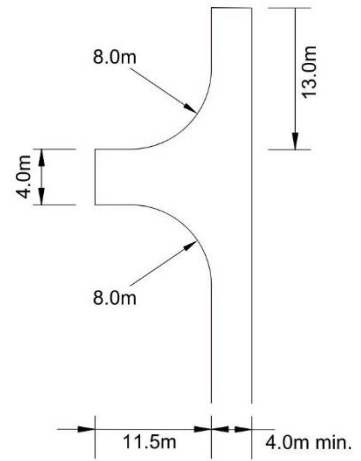


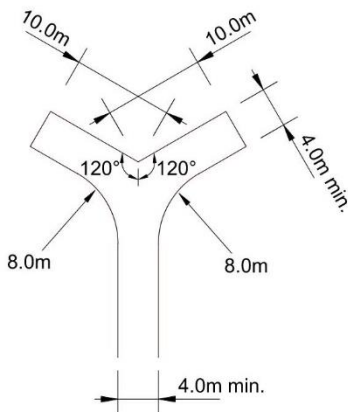
Figure 3.1 Detailing of severed road arrangements



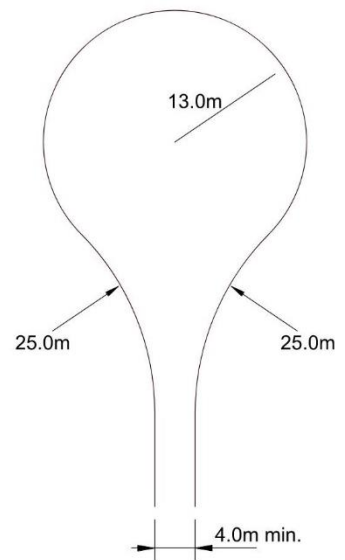
Type (i)



Type (ii)



Type (iii)



Type (iv)

Figure 3.2 Turning Head Layouts

## 4. Selection of Junction Type

### 4.1 General

As an overarching principle, TII supports a junction strategy which seeks to prevent a proliferation of side road junctions along national roads with speed limits of greater than 60 km/h. The application of this strategy will maintain the capacity, efficiency and safety of the national road network.

Recommendations are given in this Standard on the geometric design of the important elements of any junction or access onto the national road network, and how the individual elements can be brought together to produce an overall scheme.

Among the aspects of design critical to junction selection which should be taken into consideration and included in the decision framework are:

- a) traffic flows (operational efficiency);
- b) provision for ATUs;
- c) safety;
- d) collision history;
- e) sight distances;
- f) consistency;
- g) location;
- h) maintenance;
- i) environmental effects;
- j) land take;
- k) capital cost;
- l) economic assessment.

The operation of junctions on the national road network must be readily understood by all road users and therefore sequences of junctions should ensure a consistency of junction type and not involve many different layout types. It is therefore essential that designers prepare a junction strategy when introducing or modifying a junction(s) on a road scheme and evaluate their effect upon the safety and operational performance of the network as a whole.

The siting of a junction will require careful consideration of the local demand taking into account the existing road network so as to ensure the optimal degree of access is provided to the national road.

### 4.2 Selection of Junction Type

The flow chart shown in Figure 4.1 illustrates the typical stages involved in the selection of a suitable junction on a national road scheme. As these stages are being completed, the Designer shall complete the junction analysis procedure form included in Figure 4.3.

If, at any point in the design procedure, the junction design is unsatisfactory, then the designer should return to the previous stage in the procedure to refine the design. In certain cases, this process could result in a change in junction type or form.

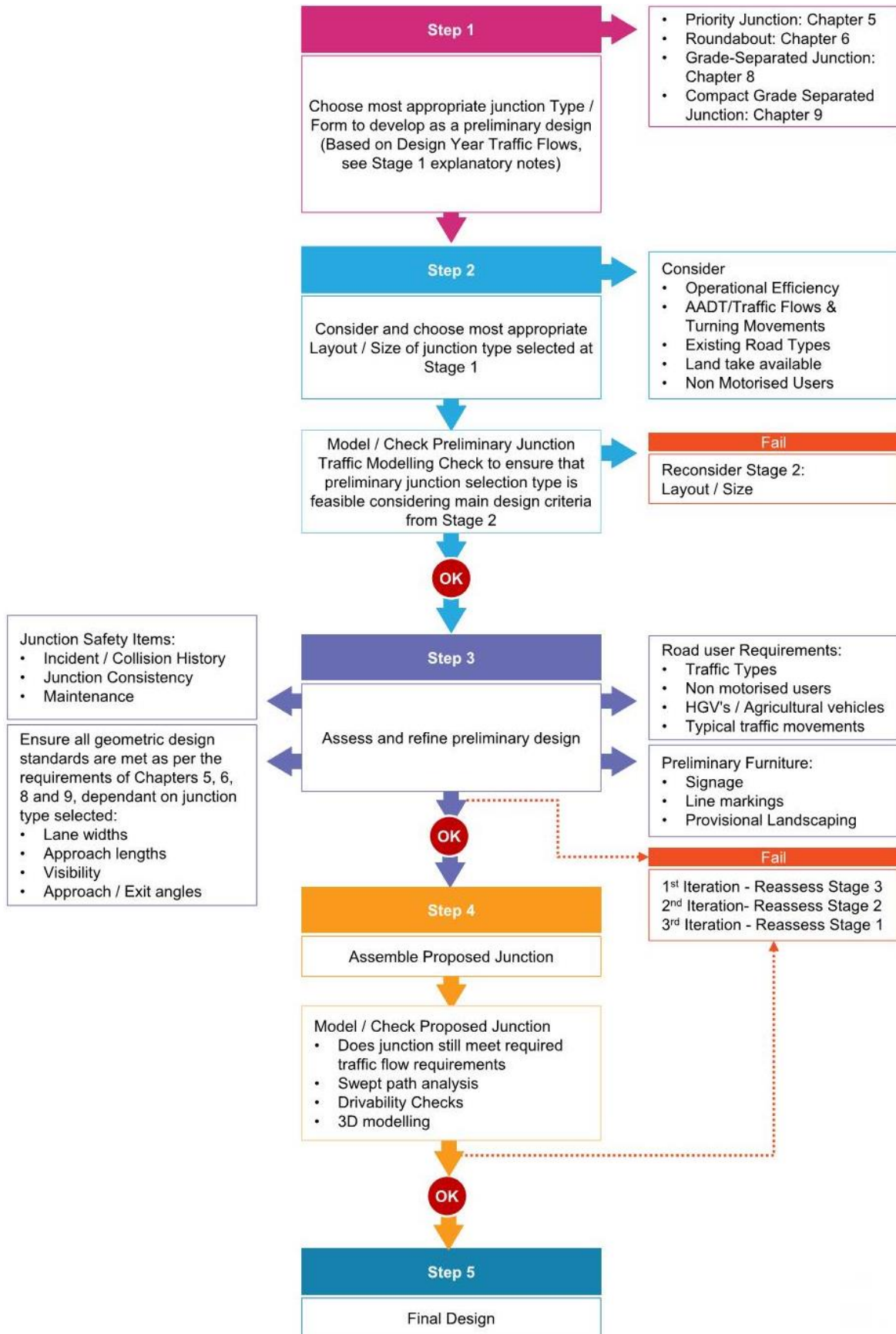


Figure 4.1 Flow Chart Outlining Junction Selection Procedure (Paragraphs 4.2.1 to 4.2.5)



## 4.2.2 Step 1 – Initial Choice of Appropriate Junction Form

The most appropriate type of junction to be used depends on a number of factors but primarily safety and operational performance, and will be subject to the evaluation of design year traffic movements at the junction, the nature and proportions of large vehicles and a road safety audit. The following section presents the most appropriate junction types based on projected traffic flows on both the major road and minor road. These values can be used for an initial assessment of the most appropriate junction type; however, the final junction type will be subject to traffic analysis by the designer to assess the capacity based on the projected turning movements at the junction.

### 4.2.2.1 Priority Junctions

Simple priority junctions are typically the most appropriate junction type for all local accesses on single carriageway roads. On dual carriageways, simple junctions must be restricted to left in/left out only with the exception of single lane sections of Type 3 Divided Roads where right turns off the major road are permitted. Further guidance in relation to simple junctions on Type 3 Divided Roads is given in Chapter 5.

For junctions with a lightly trafficked minor road, the provision of a simple priority junction is the most appropriate junction type where the projected traffic flows (2-way Annual Average Daily Traffic - AADT) are less than those presented in Table 4.1 for both the major road and the minor road. Where traffic flows fall within the ranges outlined in Table 4.1, the provision of a ghost island junction is the most appropriate junction type. The final junction type will be subject to traffic analysis by the designer to assess the capacity based on the projected turning movements at the junction.

**Table 4.1 Flow Ranges – Ghost Island junctions**

| Major road AADT | Minor road AADT |         |
|-----------------|-----------------|---------|
| < 5,000         | > 600           | < 5,000 |
| 5,000 - 10,000  | > 450           | < 3,000 |
| > 10,000        | > 300           | < 1,500 |

*Note: AADT values provided should only be used as an initial assessment of the most appropriate junction type, the final junction arrangement shall be informed by a detailed analysis of peak hour flows (see Appendix D).*

On Type 2 and Type 3 Single Carriageway schemes, nearside passing bays shall be provided at all simple priority junctions that do not warrant a ghost island right turn lane.

At traffic flows greater than those noted in Table 4.1, the provision of an alternative junction design such as a roundabout, compact grade or full grade separated junction should be considered.

### 4.2.2.2 Roundabouts

Roundabouts work most efficiently when vehicular flows are reasonably balanced between the arms, but they may also be the optimum choice in other cases subject to traffic analysis by the designer based on the projected turning movements at the junction. Roundabouts should be designed to match forecast peak hourly flows. The capacity of roundabouts is determined by a number of factors such as their geometric design and whether they are single or multi-lane roundabouts. Entry width and sharpness of flare, as described in Chapter 6, are the most important geometric parameters that determine capacity.

### 4.2.2.3 Grade Separated Junctions

Grade separated junctions to the standards contained in Chapter 8 of this document are reserved for routes serving a high mobility function. As indicated in Table 6.1 of DN-GEO-03031, they are mandatory on Motorways. Full grade separation is generally also required on rural Type 1 Dual Carriageways where the turning volumes warrant such provision.

### 4.2.2.4 Compact Grade Separated Junctions

Compact grade separation, as discussed in Chapter 9, may be considered for lower traffic flow situations on the major road and effectively extends downwards the range of flows and conditions over which grade separation could be justified economically to around 12,500 AADT on the major road. They appear to be suitable for use for mainline flows between approximately 12,500 AADT and 30,000 AADT. They are normally associated with very low flows (generally below 10% of mainline flow) on the minor road with the majority of traffic on both the major road and minor road being through traffic. Compact grade separated junctions can provide a suitable solution over a roundabout where through traffic on both the major and minor road is relatively high and turning traffic is relatively low.

## 4.2.3 Step 2 – Consider Layout/Size of Junction Type

Ordinarily, the 2-way AADT design year flows are used to consider the junction layout to be provided. However, if there is evidence in the area of the junction of high seasonal variations, or if short, intense peaks in the traffic flows are likely, then the designer shall consider using the appropriate seasonal or peak hour flows in the initial capacity assessment to select a junction layout. A traffic study may be required to confirm that the selected junction type is appropriate at the discretion of TII. Traffic studies shall be conducted as per the guidance in the TII Project Appraisal Guidelines.

Computerised methods shall be used by the designer to assess capacity and demonstrate that the particular junction layout chosen is appropriate for the traffic flows and turning movements. It is not realistic to calculate queue lengths and delays manually, reference should be made to PE-PAG-02015 Project Appraisal Guidelines for National Roads Unit 5.1.

The range of reference flows developed should be used to produce trial designs for assessment. A flow to capacity ratio (RFC) of not greater than 75% is generally required when considering carriageways with design speeds of greater than 60 km/h.

The selection of the junction type should be based on a consideration of the particular site characteristics and should be consistent with adjacent junctions upstream and downstream.

## 4.2.4 Step 3 – Assess and Refine Preliminary Design

Step 3 involves addressing all of the relevant safety issues to ensure as safe a design as possible including consideration of the following:

- Road users' specific requirements.
- A preliminary signing, street furniture, vehicle restraint system, and landscape design within the junction.

At this point, the key geometric parameters of the junction design should be assessed and a geometric layout developed in accordance with this standard. The swept path of vehicles likely to use the junction shall then be checked using a computer based programme to ensure safe movements through the intersection.

## 4.2.5 Step 4 – Assemble and Model/Check Proposed Design

Having established the various components of the junction design, the Designer shall check that the capacity of the junction is still adequate.

This includes examining if the junction is located on a route with a wide variation in flow and turning movements, particularly those having prolonged daily peak periods. The check should be undertaken prior to assembling the component parts to form a complete junction.

At this stage a swept path analysis shall be undertaken to confirm driveability using an appropriate software programme. The swept path of vehicles likely to use the junction shall be checked using a computer based swept path analysis programme by the Designer to ensure that all vehicle movements can be accommodated. The swept path analysis shall be appropriate for the vehicle using the junction. See Appendix A for details of approved Design Vehicles.

Heavy Goods Vehicles (HGVs) may be selected as the Design Vehicle, in which case they should enter and depart from the junction in the correct lane(s). However, where these vehicles and other vehicles operating under restricted access conditions only use the junction occasionally, it may be acceptable for the design to be based on them encroaching into other traffic lanes. This may cause some inconvenience to other road users, but may be acceptable where there is a low frequency of occurrence.

Both the tracking width and swept path width shall be considered in the design of the road for use by the Design Vehicles. Tracking width lines delineate the path of the vehicle tyres as the vehicle moves through the turn. Swept path width lines delineate the path of the vehicle body as the vehicle moves through the turn and will therefore always exceed the tracking width. Refer to Figure 4.2.

Before proceeding to final design, a driveability check should be performed, to assess firstly the smooth assembly of the components of the junction design. This should include a computer generated visual assessment of the junction on all approaches from the road user's eye view. Secondly, the junction should be considered within the context of its adjacent links and those adjacent junctions on the particular route. As a whole, the layout should be designed to suit the anticipated traffic pattern, with the principal movements following smooth vehicular paths.

#### **4.2.6 Step 5 – Final Design**

A design shall be developed for the junction layout in accordance with the relevant sections of this standard.

### **4.3 Design Vehicle**

The use of computer software to predict the swept path of large vehicles is mandatory in the design of all junction types. The vehicle type used shall be appropriate to the predicted use of the junction or direct access. The vehicle tracking software should be capable of allowing vehicle speed to be measured. The Designer shall ensure that the junction design can accommodate a driver negotiating the junction at a minimum speed of 5km/hr for direct accesses and 15km/hr for priority junctions. At all other junctions, Designers shall demonstrate using tracking software that the design vehicles included in Appendix A can travel at the design speed set out in this standard.

All of the geometric parameters outlined in this standard for the design of priority junctions have been developed to cater for a 16.5m long articulated vehicle, whose turning width is greater than the vehicle dimensions permitted in the existing Road Traffic (Construction, Equipment and Use of Vehicles) Regulations, or likely to be permitted in the near future. In cases where hard strips are present, the design vehicle may encroach on these while turning, and at some simple junctions with local roads, the design vehicle may encroach into opposing traffic lanes.

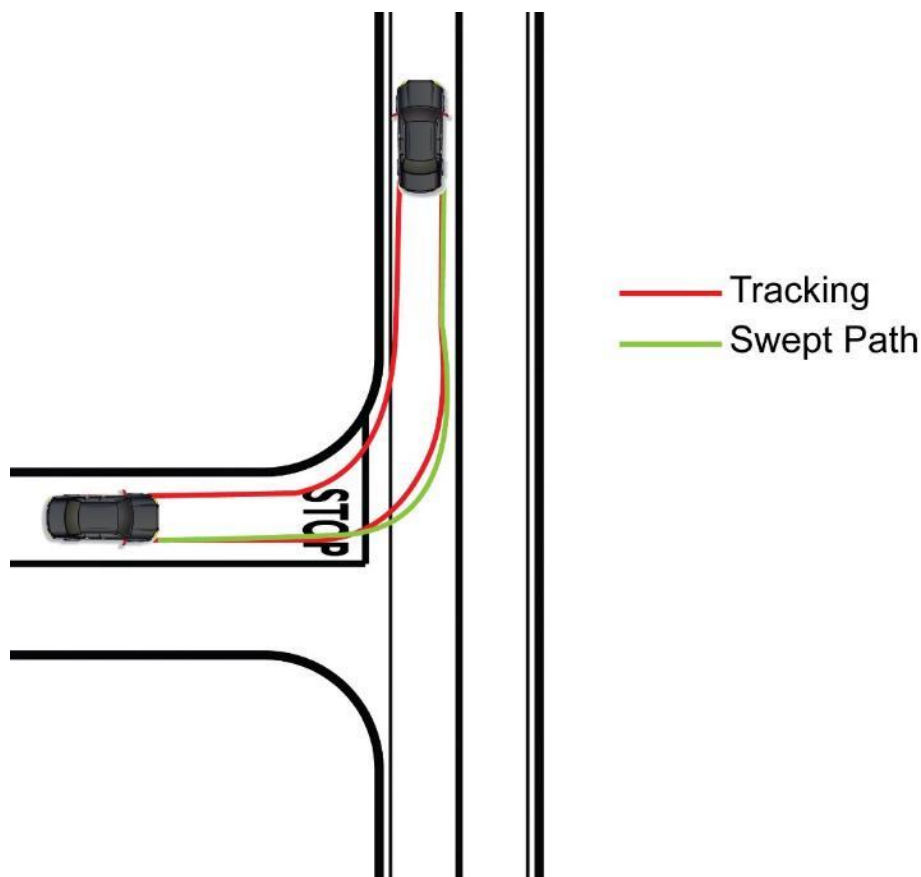


Figure 4.2 Tracking Width and Swept Path of Vehicle

#### 4.4 Improvement of Existing Junctions

Junctions may be improved to enhance safety and efficiency where road user requirements and/or volumes change over time.

For junctions where flow patterns have changed since design, an assessment of the existing and anticipated traffic flows and ATU movements should be conducted as per the current TII Project Appraisal Guidelines. Improvements could include an alteration of junction form/type, change in traffic control, enhancements for active travel etc.

For junctions where flow patterns have changed since design but geometric improvements are not justified based on the traffic assessment, additional road markings may be appropriate. Road markings may help to:

- a) improve throughput at high levels of traffic flow;
- b) cater for particularly high turning movements;
- c) smooth the flow at junctions with irregular geometry;
- d) improve safety;
- e) improve junction efficiency;
- f) increase clarity to road users of the junction layout.

#### **4.4.1 Existing Priority Junctions**

At existing rural priority junctions, the cost of upgrading a simple junction to provide a right turning facility will vary from site to site. However, upgrading should always be considered where the right turning flow into the minor road exceeds 120 vehicles per day, a right turning collision problem is evident, or where vehicles waiting on the major road to turn right inhibit the through flow and create a hazard.

For existing roads where the flow levels are not great enough to justify the provision of a ghost island or roundabout and a right turning problem remains, consideration may be given to the use of other low cost measures. This may include provision of a nearside passing bay where the road width allows through vehicles to pass drivers waiting in the centre of the major road to turn right, albeit at a reduced speed. Where there is not enough road width for a passing bay, then warning arrow markings may be used, with two directional arrows on one stalk. Such measures shall require a Departure from Standards.

#### **4.4.2 Existing Grade Separated Junctions**

At existing grade separated junctions where significant delay is incurred during peak periods as a result of high exit or entry flows, it may be appropriate to convert existing merge/diverge layouts to ghost island or lane gain layouts, where justified based on the results of traffic modelling and appraisal.


|  <b>Junction Analysis Procedure</b> |  | Date:                        |   |                     |                     |
|--|--|------------------------------|---|---------------------|---------------------|
|  |  | Project:                     |   |                     |                     |
|  |  | Location:                    |   |                     |                     |
| Data Collection  | Classification and Name  | AADT                         |   | Design Speed (Km/h) | Posted Speed (Km/h) |
|  |  | Current Year ( )             | Design Year ( )                           |                     |                     |
| Major road   |  |                              |   |                     |                     |
| Intersecting Road  |  |                              |   |                     |                     |
| Junction Type  | New <input type="checkbox"/> Existing <input type="checkbox"/>   |                              |   |                     |                     |
| Site Visit   | Yes: <input type="checkbox"/>  | No: <input type="checkbox"/> | Date of Site Visit (if applicable): _____ |                     |                     |
| <b>Functional Characteristics</b>  | Part 1 (General Information for all Intersections)   |                              |   |                     |                     |
| Collision Analysis   |  |                              |   |                     |                     |
| Access Requirements (Including ATU Requirements and Level of Usage)  |  |                              |   |                     |                     |
| Access Control   |  |                              |   |                     |                     |
| Future Development   |  |                              |   |                     |                     |
| Vehicle Design Type (Include any Special Design Vehicle Details)   |  |                              |   |                     |                     |
| % HGV's  |  |                              |   |                     |                     |
|  | Part 2 (Specific Information for More Detailed Analysis)   |                              |   |                     |                     |
| Junction Layout & Turning Movement Diagram   | Include Layout with all approaches clearly labelled.<br>Direction of flow and flow ratios to be clearly identified.<br>Worked example included in Appendix D to this document. |                              |   |                     |                     |
| Notable Constraints due to Upstream/Downstream Junction  | Yes: _____   | No: _____                    | Notes: _____                              |                     |                     |
| Proposed Improvements to Other Roads (that would impact the traffic movement at this location)                       |  |                              |   |                     |                     |
| <b>Geometric Characteristics</b>   |  |                              |   |                     |                     |
| Road Geometry on all approaches  | To be attached in an appendix to this document.  |                              |   |                     |                     |
| Is design compliant with the standards   | Yes: _____   |                              |   |                     |                     |
| Desirable Stopping Sight Distances   |  |                              | Achievable Stopping Sight Distances       |                     |                     |
| Mainline Horizontal Curvature  |  |                              |   |                     |                     |
| Profile gradient on mainline   | _____ %  | Intersecting Roadway         |   | _____ %             |                     |
| <b>Other Characteristics</b>   |  |                              |   |                     |                     |
| Traffic Management Measures  |  |                              |   |                     |                     |
| Impact on Utilities  |  |                              |   |                     |                     |
| Impact on Right of Way   |  |                              |   |                     |                     |
| Recommendation of Type of Junction Treatment based on Functional, Geometric and Other Characteristics                |  |                              |   |                     |                     |
| Scope of Modelling Required  | Local Junction Modelling <input type="checkbox"/> Micro-simulation Modelling <input type="checkbox"/>  |                              |   |                     |                     |
| Designer: _____  |  | Date: _____                  |   |                     |                     |
| Approved: _____  |  | Date: _____                  |   |                     |                     |

Figure 4.3 Junction Analysis Procedure Form

Worked example included in Appendix D.

## 5. Geometric Design of Priority Junctions & Vehicular Access to National Roads

### 5.1 General

This Chapter describes the geometric design of priority junctions and direct accesses for application to new and improved junctions on national roads (including dual and single carriageway and divided roads).

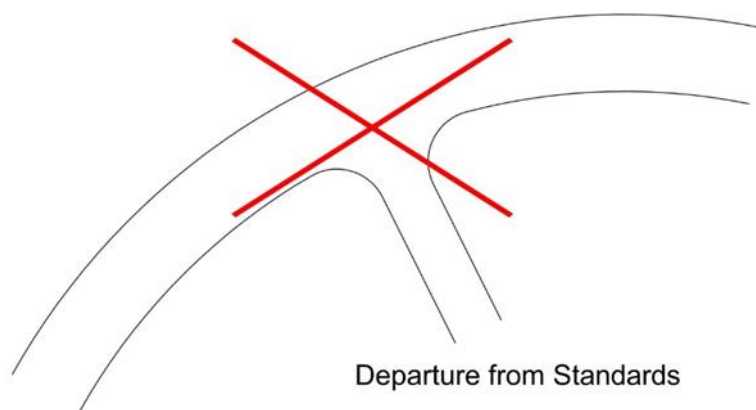
### 5.2 Siting of Priority Junctions and Direct Access to National Roads

#### 5.2.1 General

A saving in collisions may be achieved, and an improvement made in operational performance, by reducing the number of lightly trafficked minor road connections onto major roads. The cost effectiveness of connecting such routes together with a link road before they join a new major road should always be investigated.

#### 5.2.2 Horizontal Alignment

Ideally, priority junctions and direct accesses onto national roads shall not be sited where the major road is on a sharp curve, which is defined as anything below Desirable Minimum radius in accordance with DN-GEO-03031. However, where the siting of a priority junction or access on a curve is unavoidable, T-junctions should be sited with the minor road on the outside of the curve, and where desirable minimum Stopping Sight Distance (SSD) in accordance with DN-GEO-03031 can be achieved for a vehicle on the major road approaching the junction. Junctions or accesses shall not be sited on the inside of sharp curves.

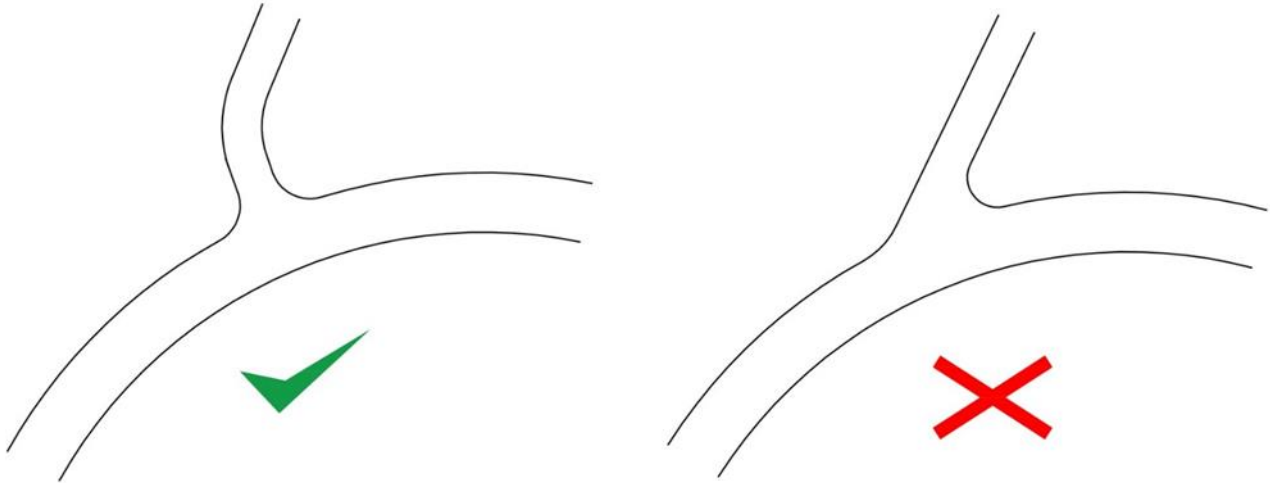


**Figure 5.1 Junction located on the inside of a sharp curve**

New or altered direct accesses or priority junctions shall not be sited at any location where the desirable minimum SSD envelope of the national road falls outside the paved surface of the road. The paved surface includes hard strips and the hard shoulder if present.

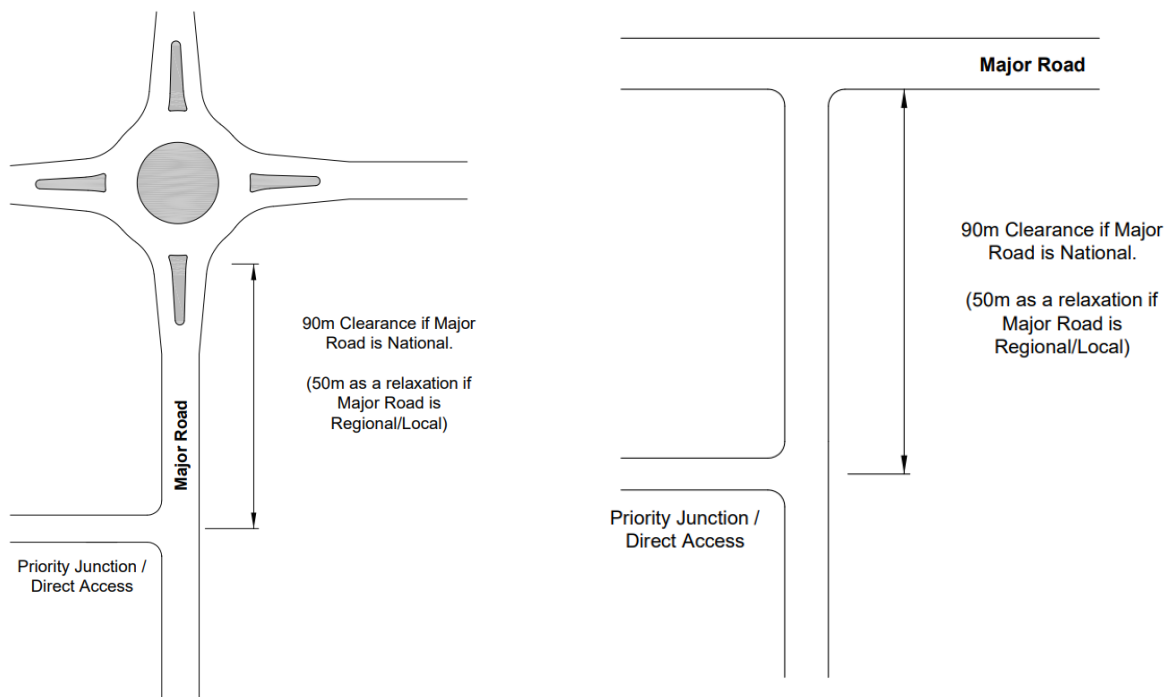
Direct accesses shall not be sited within overtaking sections of single carriageway roads or on either side of a single carriageway where a climbing lane has been provided as defined in DN-GEO-03031.

Problems have been experienced with priority junctions where the major road is on a curve and the minor road is at an acute angle, which can be misleading to drivers who perceive that the minor road retains priority. In such circumstances, the minor road approach should be re-aligned to connect to the major road at 90° in order to eliminate any driver confusion as to which route has priority.



**Figure 5.2** Examples of minor road alignment at junctions

The provision of new priority junctions or direct accesses shall not be permitted within 90m of a roundabout or priority junction on National Roads. This may be reduced to 50m as a relaxation when the road is a Regional / Local Road. See Figure 5.3.



**Figure 5.3** Clearance to minor road/junction at roundabout or priority junction



### 5.2.3 Vertical Alignment

New or altered junctions and accesses at or near crests should be avoided where the shape of the junction or access would not be immediately apparent to the driver on the national road, or where there is restricted forward visibility.

Care should be taken not to provide visibility on minor roads much in excess of the desirable minimum as this can divert the driver's attention away from road users on the major road in the immediate vicinity towards those approaching in the far distance.

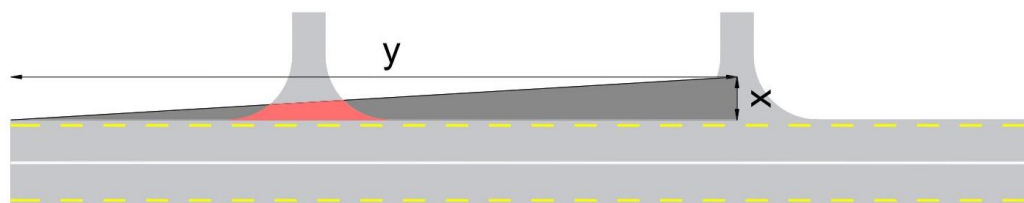
It is also essential that other road users can equally see oncoming vehicles; particularly where vehicles cross the raised footway in front of pedestrians/cyclists.

### 5.2.4 Visibility

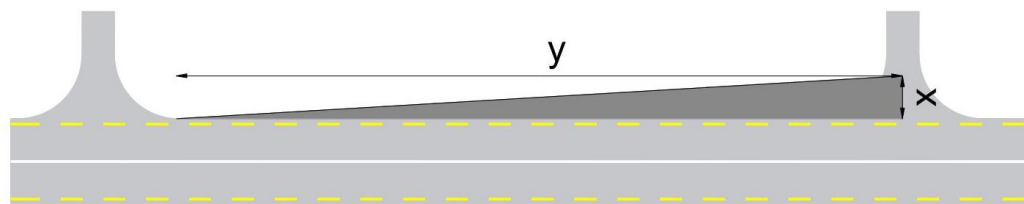
At driver's eye level, there shall be a clear view from the junction or access over the immediate area of the junction or access and its connection to the national road.

Direct accesses shall only be sited where they do not encroach on the visibility requirements of adjoining direct accesses or junctions in regular use – see Figure 5.4. This will determine the minimum spacing of new accesses. However, a minimum staggered distance of 20m shall be always provided.

Signs, street furniture and planting should be located and designed so as not to obstruct visibility.



Direct Access located within the visibility envelope of the adjacent access



Wider spacing of accesses results in unobstructed sight distance from the adjacent access

**Note:**

'x' distance is given by Table 5.4







'y' distance is given by Table 5.5




Figure 5.4 Examples of minor road alignment at junctions

## 5.3 Priority Junction Layouts

Table 5.1 shows the priority junction forms permissible for various major road carriageway types in rural situations. This table should be used as a starting point in choosing the most appropriate type of priority junction to use at a particular site.

**Table 5.1 Possible priority junction types for different major road carriageway types**

| Carriageway Type   | Junction Type   |   |   |   |   |   |
|--------------------|---|---|---|---|---|---|
|                    | Simple (Fig. 2/1)   |   |   | Ghost Island (Fig. 2/4)   |   |   |
| Standard           |  |  |  |  |  |  |
| Single Carriageway | Yes   | Yes   | No  | Yes   | Yes   | No  |
| Type 1 Dual        | Yes†  | No  | No  | No  | No  | No  |
| Type 2 Divided     | Yes†  | No  | No  | No  | No  | No  |
| Type 3 Divided     | Yes†  | No  | No  | Yes   | No  | No  |
| Motorway           | No  | No  | No  | No  | No  | No  |

 T-Junction     Staggered Junction     Crossroads

† Left-in/left-out junctions only (see DN-GEO-03031 for more details by road type)

Simple junctions (such as the simple T-Junctions) are appropriate for most minor junctions on single carriageway roads but left-in/left-out junctions are the preferred option as they reduce conflicts on the national road network. On dual carriageways and divided roads, simple junctions shall be restricted to left in/left out only.

The decision to provide a ghost island right turning facility shall be made in accordance with the guidance contained in Chapter 4. The choice of type of right turn facility to be used, however, will depend on the particular site characteristics and results of traffic modelling of the turning movements at the junction.

On single lane sections of Type 3 Divided Roads, a ghost island right turning facility off the major road may be provided as a Departure from Standards. Right turn manoeuvres onto the major road from the minor road shall not be permitted in such cases (see Figure 5.25 to Figure 5.27).

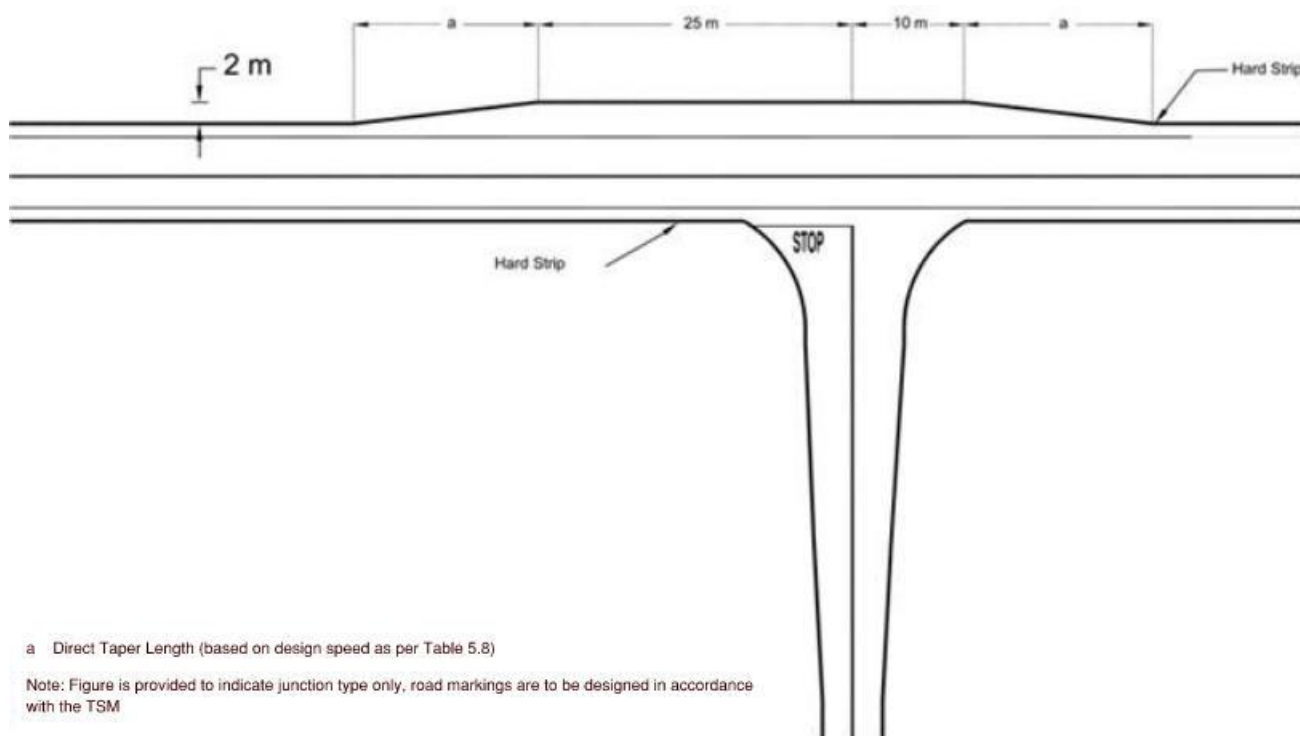
### 5.3.1 Simple Priority Junction

Where a simple priority junction is provided on a Type 2 or Type 3 Single Carriageway, a nearside passing bay as detailed in Figure 5.5 shall be provided to allow through traffic on the major road pass a vehicle waiting to turn right. The total length of the nearside passing bay may need to be increased where it is anticipated that HGVs will be turning off the major road.

On single carriageway roads where overtaking opportunity is limited, simple priority junctions should be sited on non-overtaking sections, as defined in DN-GEO-03031.

The use of simple priority junctions with a nearside passing bay on rural single carriageway roads can, in certain circumstances, pose safety problems. In situations where overtaking opportunity on the major road on either side of the junction is restricted, the presence of a widened carriageway, could result in overtaking manoeuvres which may conflict with right turning movements into and out of the minor road.

Considering the above, designers should avoid providing simple priority junctions in locations where overtaking sections are restricted upstream and downstream of the junction.



**Figure 5.5 Priority Junction with Nearside Passing Bay for Roads without Hard Shoulders**

### 5.3.2 Ghost Island

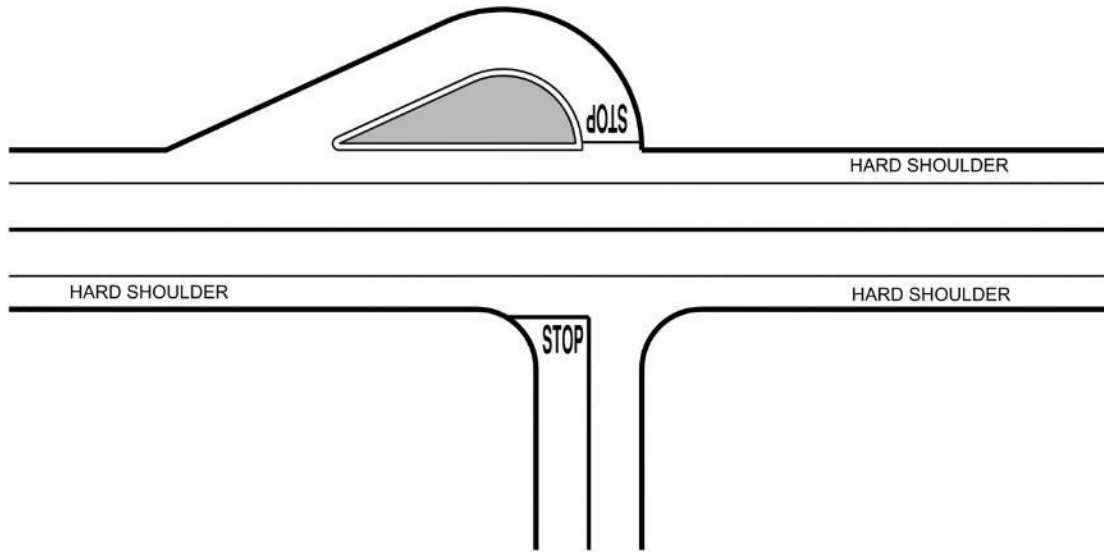
Ghost island junctions may be used on new single carriageway roads, or in the upgrading of existing junctions to provide right turning vehicles with a degree of shelter from the through flow. They are highly effective in improving safety for turning traffic on the major road.

The use of ghost island junctions on rural single carriageway roads can, in certain circumstances, pose safety problems. In situations where the opportunity for overtaking on the major road on either side of the junction is restricted, the presence of a widened carriageway, albeit with hatch markings, could result in overtaking manoeuvres which may conflict with right turning movements into and out of the minor road.

On single carriageway roads where overtaking opportunities are limited, the Designer should consider the provision of raised medians on the approaches to the junction as outlined in Section 5.6.10.

### 5.3.3 Left Diverge Loops

For right turning movements of low volume where signing is not required, an alternative measure is a left hand diverging lane loop as shown in Figure 5.6. This type of junction should only be used where the minor road is providing local access only i.e. very low turning movements with users who are familiar with the layout and where the road layout may lead to overtaking through a simple priority junction if provided.



Note: Figure is provided to indicate junction type only, road markings are to be designed in accordance with the TSM

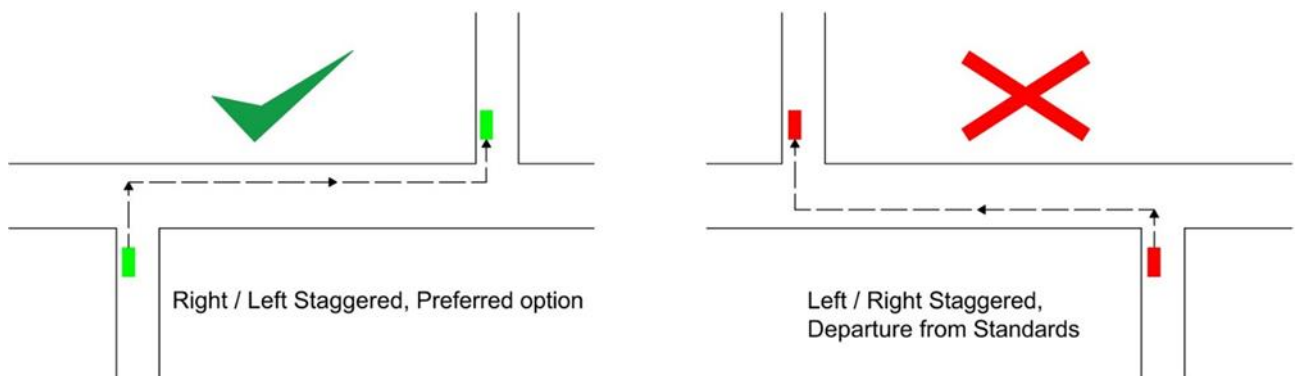
**Figure 5.6 Priority Junction with Left Hand Diverging Lane Loop for Right Turning movements**

### 5.3.4 Crossroads

The use of a crossroads is not allowed on rural national roads and shall be regarded as a Departure from Standard.

### 5.3.5 Staggered Junctions

A staggered junction with a right/left stagger, where minor road traffic crossing the major road first turns right, proceeds along the major road and then turns left, is preferred to left/right staggers because traffic turning between the minor roads is less likely to have to wait in the centre of the major road. The use of left/right staggered junctions is a Departure from Standard.



**Figure 5.7 Staggered junctions**

The stagger distance is the distance along the major road between the centrelines of the two minor roads.

For all staggered priority junctions, the minimum stagger distance between the centreline of the junctions shall be 50m. It shall be provided on all new staggered junctions, including the upgrade of rural crossroads. The maximum stagger distance between centreline of the priority junctions (excluding residential and agricultural accesses) is listed in Table 5.2 below. Junctions with distances exceeding these values shall be treated as two separate junctions.

**Table 5.2 Maximum Stagger Distances for Junctions per Road Speed Limit**

| Speed (km/h) | Maximum Distance Between Centres of Staggered Junctions (m) |
|--------------|---|
| 30           | 70  |
| 50           | 90  |
| 60           | 110   |
| 80           | 160   |
| 100          | 200   |

## 5.4 Provision for Active Travel Users

Provision must be made for the specific requirements of Active Travel users in the design of priority junctions providing access to National roads. Where dedicated active travel facilities are provided, the specific requirements are presented within Section 7.3 of this Standard.

Where dedicated active travel facilities are not provided along all-purpose national roads, the road space shall nonetheless be designed with cycle friendly principles in mind, such that competent cyclists feel comfortable travelling alongside other traffic. Examples of cycle friendly design principles may include:

- Ensuring no abrupt reduction in the hard shoulder width (where the hard shoulder provides the only refuge for cyclists within the road space);
- Ensuring that the setback of channelising islands and design of road markings at junctions and accesses do not obstruct the path of cyclists through the junction (refer to Figures 5.10 and 5.14); and
- Ensuring that any localised narrowing of the hard shoulder at ghost island junctions or climbing lanes considers the position of cyclists on the road.



## 5.5 Direct Accesses

The overriding principle is that direct vehicular access onto national roads shall be avoided as far as practicable.

In particular, National Primary Roads and rural dual carriageways are intended to perform a mobility function, providing for the safe and efficient movement of people and freight. Land access is considered a secondary consideration on these roads, and the provision of direct accesses onto such roads can result in an unacceptable risk of high-speed collisions. Accordingly, Direct vehicular accesses shall not be provided onto a National Primary Road or rural dual carriageway.

Where direct vehicular access onto national primary roads cannot be avoided, a Departure from Standards with justification shall be required where a direct access is proposed.

In all cases, the number of accesses on to the national road should be minimised, either by consolidating them into a single access point, or connecting them to existing side roads.

### 5.5.1 Existing Direct Accesses

Where an existing national road is to be improved on-line, there are likely to be existing accesses. Where possible, these accesses should be relocated to connect to an existing regional or local road and accesses combined as described above.

Where this is not practicable, the layout of the access onto the new road shall be designed in accordance with the geometric standards for a new or altered access described in the following sections. The retention of any existing direct access on to a National Primary Road shall require a Departure from Standard.

Any such layout which does not achieve the geometric standards for a new or altered access shall require a Departure from Standard.

Any application which results in a material increase in the volume of traffic or a material change in the type of traffic entering or leaving a national road shall be carefully considered. Generally, a material increase is considered to be if the turning traffic flows would increase by 5% or more, although there may be cases when it is important to consider smaller increases.

### 5.5.1.1 Geometric Layouts of Direct Accesses

Table 5.3 gives a number of basic direct access layout types and their associated approximate levels of use. Three layouts are presented, as follows:

- a) Layout 1: Field access
- b) Layout 2: Access to dwellings
- c) Layout 3: Left in/Left out

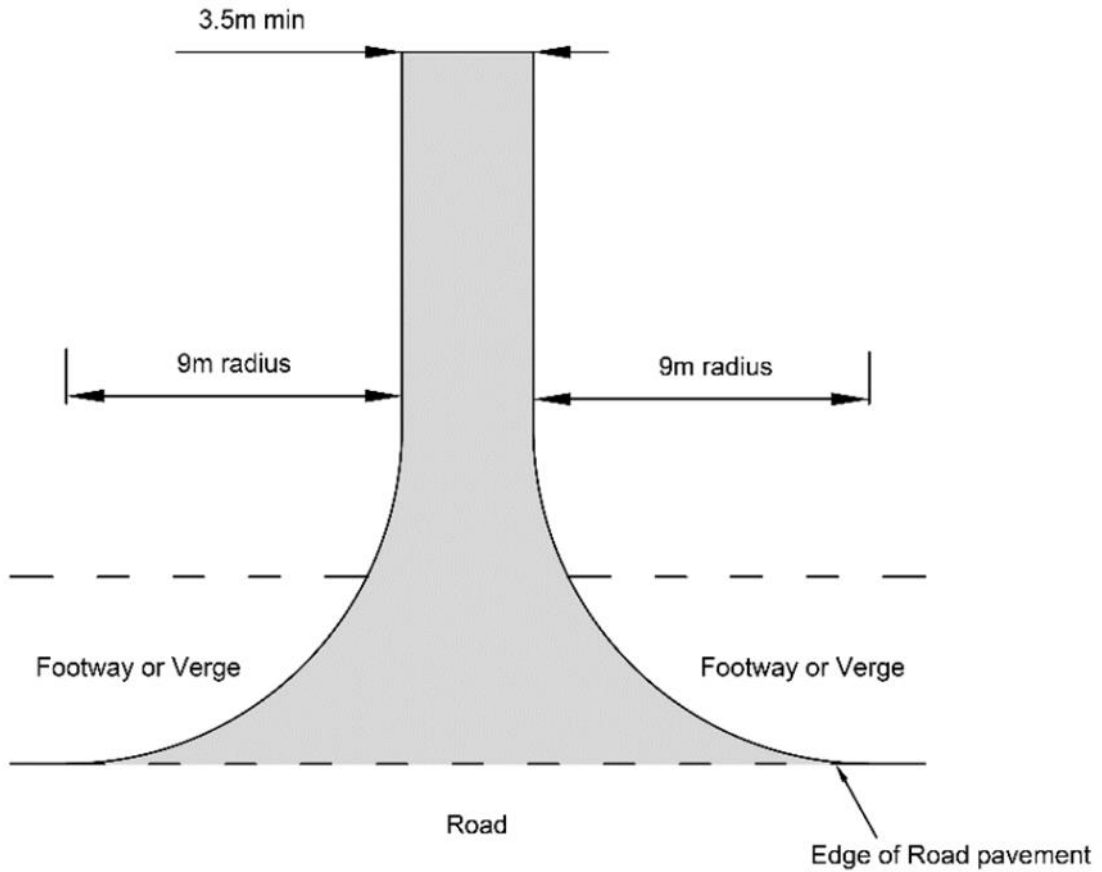
These are illustrated in Figures 5.8, 5.9 and 5.10. Where traffic movements are predicted to exceed the values in Table 5.3, the access shall be designed as a priority junction in accordance with this Standard.

**Table 5.3 Direct Access layouts**

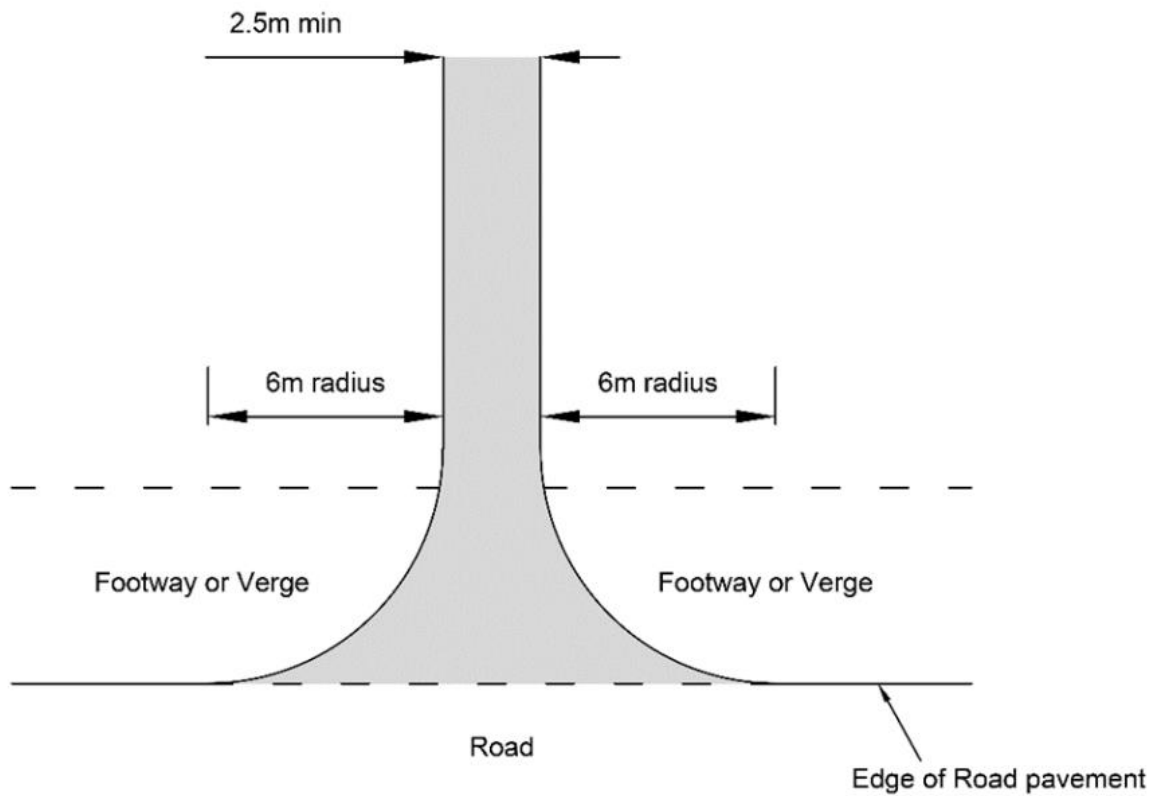
|                             | <b>Field Access<sup>1</sup></b> | <b>Access to Dwellings</b>     | <b>Left in/Left Out</b>        |
|-----------------------------|---------------------------------|--------------------------------|--------------------------------|
| Direct Access Layout        | 1                               | 2                              | 3                              |
| Predicted Traffic Movements | Less than 10 movements a week   | Less than 150 movements a week | Less than 150 movements a week |

<sup>1</sup> May be used on Type 1 Dual Carriageways where maintenance access to attenuation ponds and pollution control areas are taken directly off the mainline.

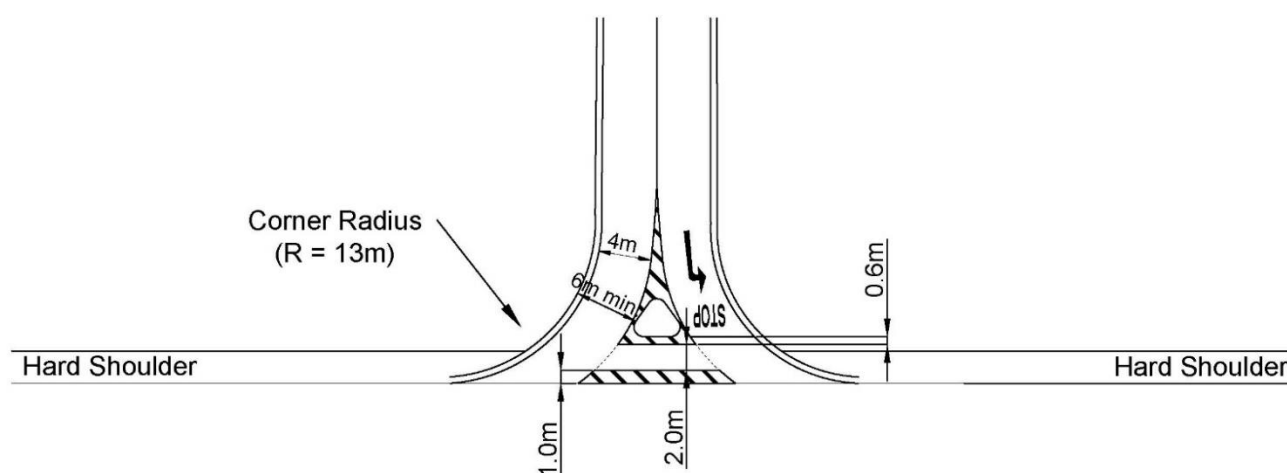
Note: These figures are recommendations and indicate the approximate level at which alternatives for connections should be considered. Designers should look carefully at the safety implications involved in providing the alternative connection.



**Figure 5.8 Direct Access Layout 1 – Field Access**



**Figure 5.9 Direct Access Layout 2 – Access to Dwellings**



Notes: Stop line should be positioned in line with the edge of channel island.  
All road markings are to be designed in accordance with the TSM

Figure 5.10 Access Layout 3 – Left In/Left Out

### 5.5.2 Entrance Gates Across Direct Access

Entrance gates across a direct access shall be set back to accommodate one vehicle in the access, clear of the carriageway and any adjacent footway/cycle facility. The vehicle to be accommodated should be of the largest type to use the access on a regular basis, (which in the case of agricultural vehicles may include a trailer). Gates shall open away from the road.



### 5.5.3 Active Travel Users at Direct Accesses

In rural situations, an Active Travel facility will need to cross direct accesses such as farm and house entrances. The design for Active Travel users at these conflict points is an important consideration, and these requirements are presented within Section 7.4 of this Standard.



## 5.6 Geometric Design of Priority Junctions on Single Carriageways, Dual Carriageways and Divided Roads

### 5.6.1 Design Speed

Geometric standards for junctions are related to the traffic speed of the major road, and for new roads this is the design speed as defined in DN-GEO-03031.

### 5.6.2 Visibility

#### 5.6.2.1 General

Traffic from either a minor road or direct access has to join or cross the major road when there are gaps in the major road traffic streams. It is therefore essential that drivers emerging from a minor road or direct access shall have adequate visibility in each direction to see the oncoming major road traffic in sufficient time to permit them to make their manoeuvres safely. The visibility requirement for drivers emerging from a minor road or direct access is to the high object (1.05m) on the major road as defined in DN-GEO-03031. This concept also applies to major road traffic turning right into the minor road or direct access.



For Dual Carriageways, Divided Roads or a one-way major road, a single visibility envelope in the direction of approaching traffic will suffice. If the minor road serves as a one way exit from the major road, no visibility envelopes will be required, provided that forward visibility for turning vehicles is adequate.

### 5.6.2.2 Minor Road/Direct Access

The required visibility parameters to be determined by the designer for drivers or cyclists approaching a junction with a single or dual carriageway road from a minor road, direct access or cycle route are outlined in Figure 5.11a and Figure 5.11b.

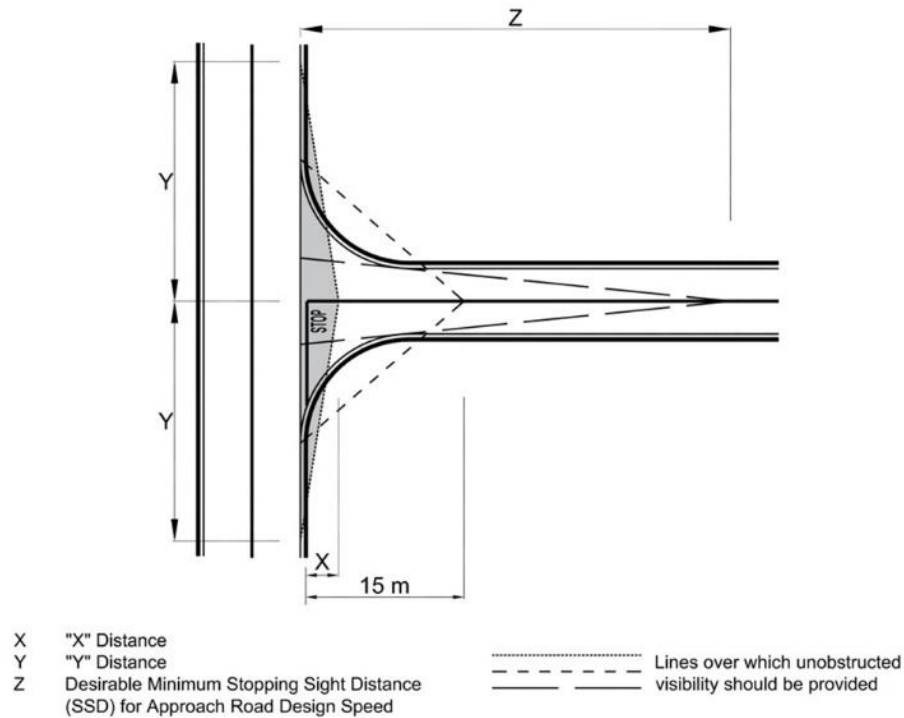
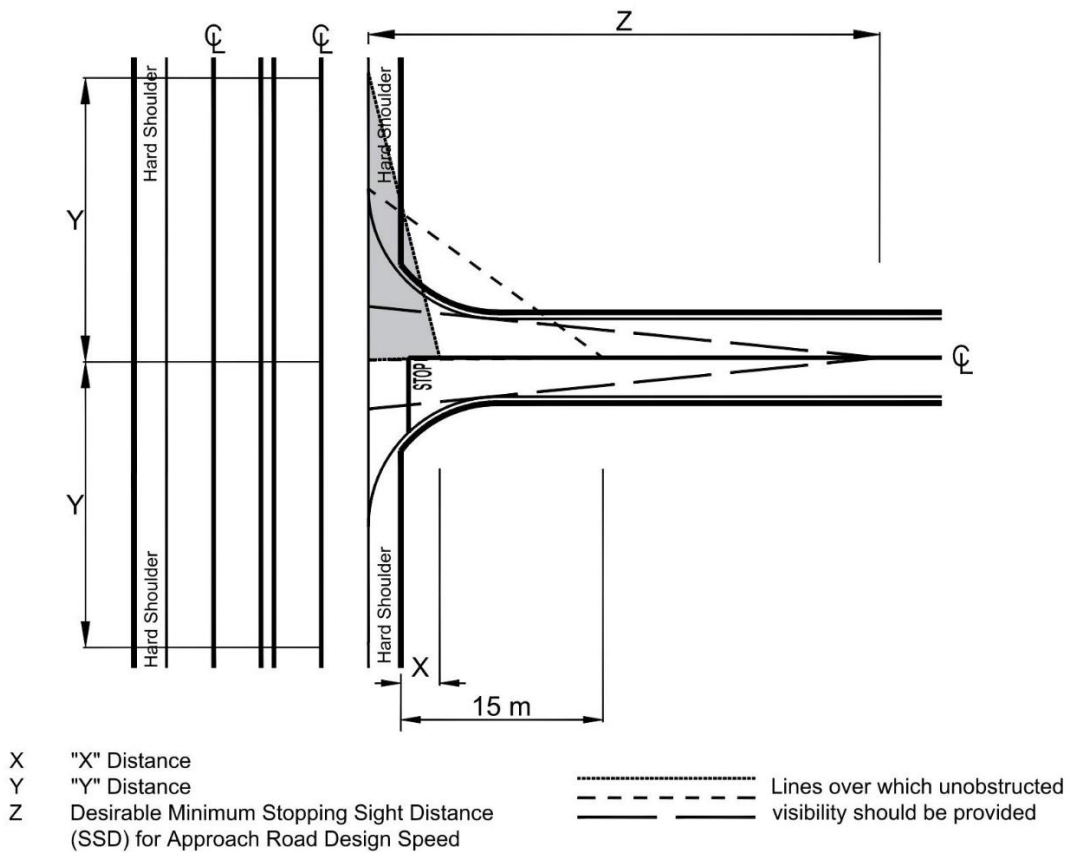


Figure 5.11a Visibility Standards (single carriageway)



**Figure 5.11b Visibility Standards (dual carriageway / divided road)**

The designer shall ensure drivers approaching the junction from the minor road or direct access shall have unobstructed visibility of the junction from a distance corresponding to the desirable minimum SSD for the design speed of the minor road, as described in DN-GEO-03031. This corresponds to the 'z' distance as shown on Figures 5.11a and 5.11b. This allows drivers time to slow down safely and stop. The visibility envelope shall be widened to include any "Yield" or "Stop" sign.

From a point measured 15m along the centreline of the minor road or direct access from the continuation of the line of the nearside edge of the paved surface (including hard strip or hard shoulder) of the major road, the designer shall ensure an approaching driver shall be able to see clearly the junction form, and those peripheral elements of the junction layout as shown in Figures 5.11a and 5.11b. This provides the driver with an idea of the junction form, possible movements and conflicts, and possible required action before reaching the major road.

The distance back along the minor road or direct access from which the full visibility is measured is known as the 'x' distance. It is measured back along the centreline of the minor road or direct access from the continuation of the line of the nearside edge of the paved surface (including hard strip or hard shoulder) of the major road. The 'x' distances on the minor road for visibility measurements shall be as defined in Table 5.4. In difficult circumstances the 'x' distance may be taken as a Relaxation as provided in Table 5.4.

**Table 5.4 'x' Distances on the minor road for visibility measurements**

| Major road use         | Minor road use   | Standard          | 'x' Distance(m) |
|------------------------|--|-------------------|-----------------|
| All roads              | All junctions and accesses, Stop control   | Desirable Minimum | 3.0             |
| All roads              | Cycle Route  | Desirable Minimum | 4.0             |
| National roads         | Simple Junctions, Stop control   | Relaxation        | 2.4*            |
| Regional & Local Roads | All junctions and accesses, Yield control (where there are no relaxations associated with the junction layout) | Desirable Minimum | Max. 9.0        |
| Regional & Local Roads | Accesses, Lightly trafficked   | Relaxation        | 2.0             |
| All roads              | All junctions and accesses   | Desirable Maximum | 9.0             |

From the point "x" metres back from the major road a driver approaching the junction along the minor road shall be able to see clearly points to the left and right on the nearer edge of the major road running carriageway at a distance given in Table 5.5, measured from its intersection with the centreline of the minor road. This is called the 'y' distance and is defined in Figure 5.11a and 5.11b.

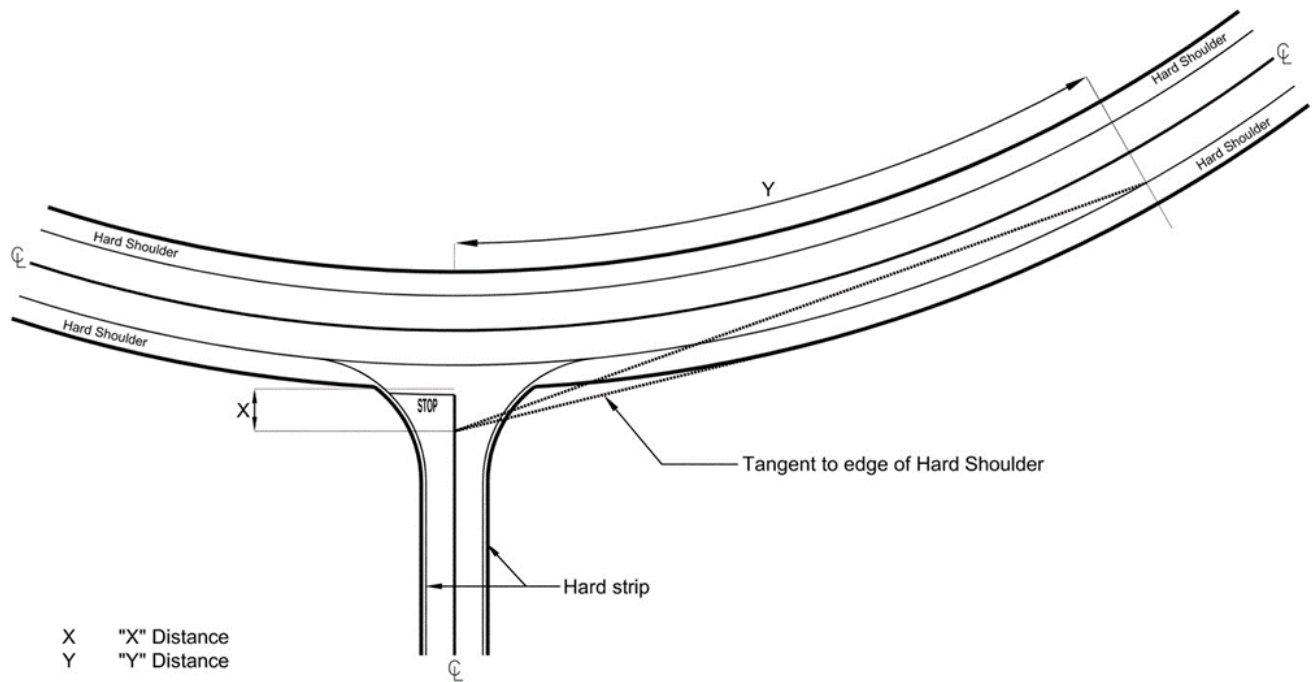
**Table 5.5 'y' Visibility distances from the minor road**

| Design Speed of major road(km/h) | 'y' Distance(m) |
|----------------------------------|-----------------|
| 42                               | 50              |
| 50                               | 70              |
| 60                               | 90              |
| 70                               | 120             |
| 85                               | 160             |
| 100                              | 215             |
| 120                              | 295             |

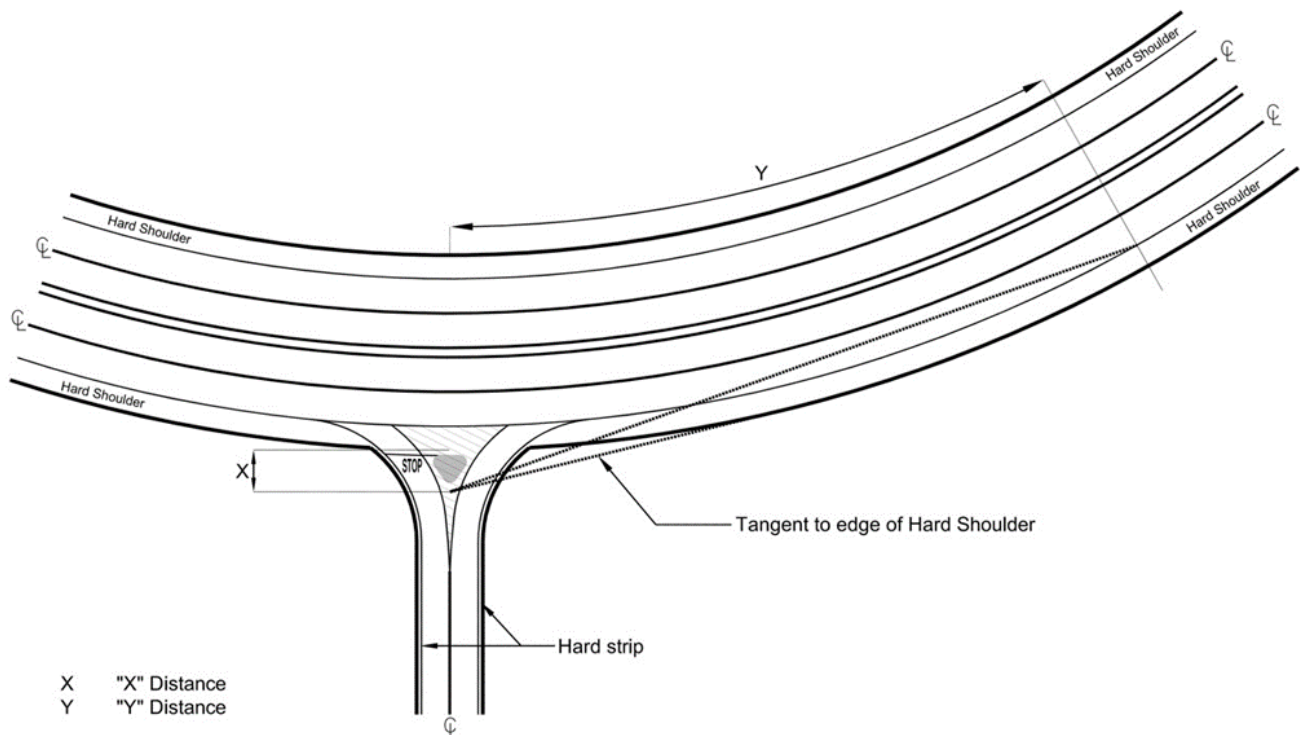
On national roads the full 'y' distance must be achieved to the high object 1.05m.

### 5.6.2.3 Visibility Standards with a Curved Major Road

If the line of vision from the approach road lies partially within the major road paved area, it shall be made tangential to the nearer edge of the major road paved carriageway (including hard shoulder or hard strip), as shown in Figure 5.12a and 5.12b.



**Figure 5.12a** Visibility standards with a curved single carriageway major road



**Figure 5.12b** Visibility standards with a curved dual carriageway / divided road

#### 5.6.2.4 Maximum Visibility Envelope

Although the 'y' distance shall always be provided, there is little advantage in increasing it, as this too can induce high approach speeds and take the attention of the minor road or direct access driver away from the immediate junction conditions. Increased visibility should not be provided to increase the capacities of various turning movements.

### 5.6.2.5 Parking

Dangerous conditions arise if vehicles obstruct visibility by parking within visibility envelopes. Where necessary, parking and access shall be controlled to prevent this. The Designer shall ensure that the positioning of lay-bys, Emergency Refuge Areas, bus stops, traffic signs, environmental barriers, vehicle restraint systems, and other street furniture does not interfere with the drivers' visibility requirements.

It is important to ensure that developments serviced by a new direct access do not lead to parking on the major road in the vicinity of the access, to the detriment of the safe passage of vehicles on both the access and the national road. Where it is considered that unsafe parking may be encouraged, appropriate design measures shall be taken to avoid this.



### 5.6.2.6 Visibility at Active Travel Crossings

The geometric and visibility requirements for Active Travel crossings of National Roads is presented in Chapter 7 of this Standard.



### 5.6.3 Approach Gradients

Gradients on minor roads shall be in accordance with DN-GEO-03031. The gradient on the minor road immediately next to the major road should be considerably less, and a "dwell" area of at least 15m shall be provided immediately adjacent to the major road carriageway. Where site conditions are particularly difficult this area may be reduced to 10m as a Relaxation. In the case of a direct access to dwellings, it may be reduced to 3m as a Relaxation. A combined relaxation in dwell area length and approach gradient is not regarded as a departure.

The gradient for the dwell area shall lie between plus and minus 2.5%. In difficult situations, this may be increased to between plus and minus 4% as a Relaxation.

### 5.6.4 Corner Radii

It is recommended that the minimum circular corner radius at simple junctions in rural areas where no provision is made for HGVs should be 10m. Where there is frequent use by large commercial vehicles (e.g. near a quarry or industry frequently accessed by large vehicles), the minimum circular corner radius shall be as follows:

- a) For vehicles entering the minor road, the corner radii shall be 13m followed by a 1:10 taper for a distance of 25m measured along the line of the minor road from the nearside edge of the major road.
- b) For vehicles entering the major road from the minor road, the corner radii shall be 13m followed by a 1:10 taper for 25m measured along the line of the major road from the corner line of the minor road. This is shown in Figure 5.13.
- c) 13m at ghost island junctions with tapers of 1:6 over a distance of 30m.
- d) 13m at simple staggered junctions, with tapers of 1:8 over a distance of 32m.
- e) 20m radius for left-in/left-out priority junctions, except on Type 2 Divided Roads where the minimum exit radius off the mainline shall be 40m.
- f) 40m exit radius off the mainline and 20m entry radius onto the mainline for left in-left out priority junctions forming part of a compact grade separated junction. Refer to Chapter 8 for details.

The values in a) to d) above are minimum values and a swept path analysis shall be carried out in accordance with Chapter 4 at all at-grade junction locations to establish circular corner radii for the junction appropriate for its use.

Where HGVs comprise a significant proportion of the turning movements (e.g. where a quarry or industry is located on the side road), use of the compound curve is recommended. Details of the design of a compound curve are included in Appendix C of this document.

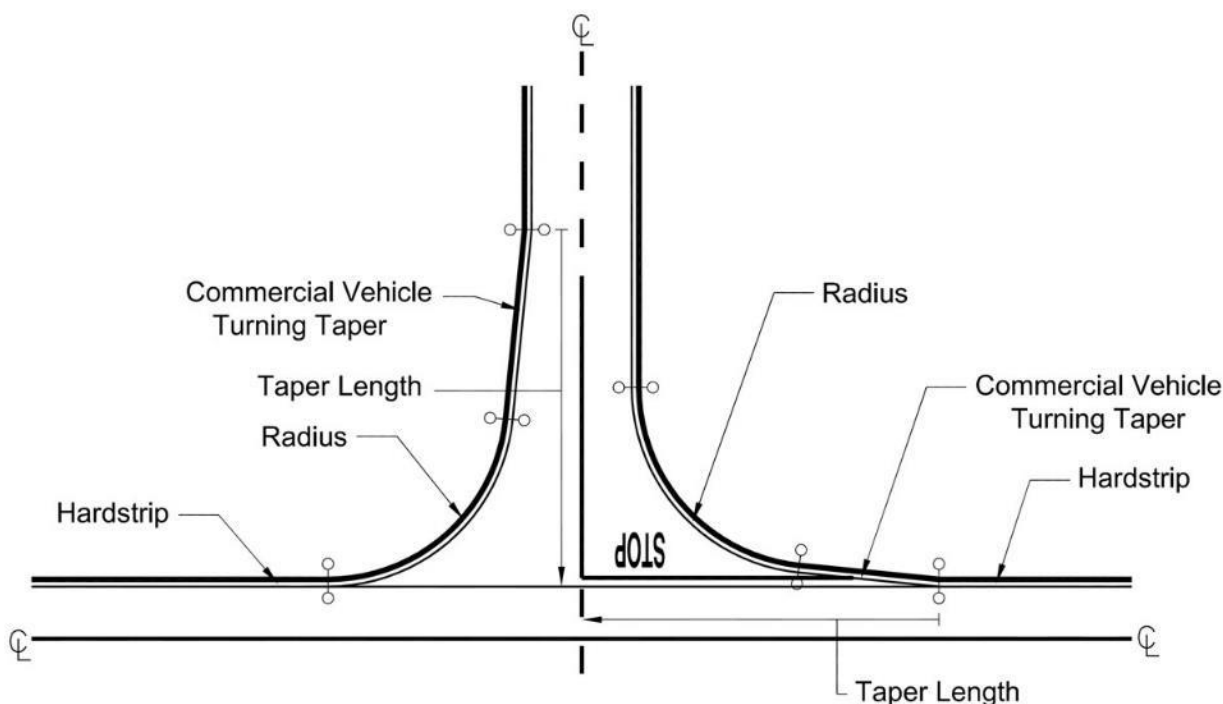


Figure 5.13 Design of Corner Radii for Rural Simple Junctions, Ghost Island Junctions & Simple Staggered Junctions

### 5.6.5 Carriageway Widths

A minimum 0.5 metre hard strip shall be provided throughout all junction layouts, corner radii and associated tapers.

### 5.6.6 Layout at Left In/Left out Priority Junctions

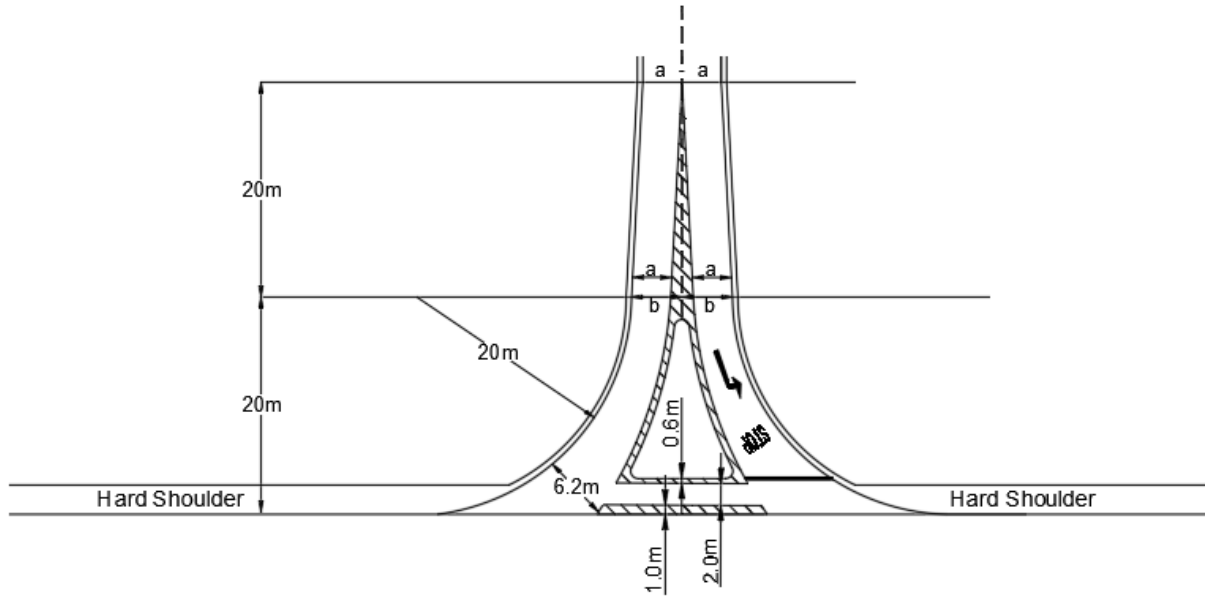
For Left-In / Left-Out priority junctions, the layout shall be as shown in Figure 5.14. On roads with hard shoulders where dedicated on-line off-road active travel facilities are not provided, it is important that setback of the island is designed to be cycle friendly. A clear space of 2.0m shall be allowed for ATUs to navigate through the junction safely as shown.

The setback of the channelising island shall be as follows:

- Where there is a hard shoulder present, a 2.0m wide clear space for cyclists shall be provided in front of the channelising island to delineate cyclists safely through the junction. A hatched separation of 1.0m wide shall be provided between the general traffic lane and the clear space for cyclists. The setback of the channelising island shall be at least 0.6m offset from the clear space for cyclists as shown in Figure 5.14.
- Where there is only a hard strip present, the setback of the channelising island shall be at least 0.6m offset from the back of the hard strip as shown in Figure 5.15.

**Details for Minor Roads**

| Minor Road Width (m) | a (m) | b (m) |
|----------------------|-------|-------|
| < 3.0                | 3.3   | 4.7   |
| 3.0 to 3.65          | 3.65  | 4.7   |
| 3.65                 | 3.65  | 4.7   |

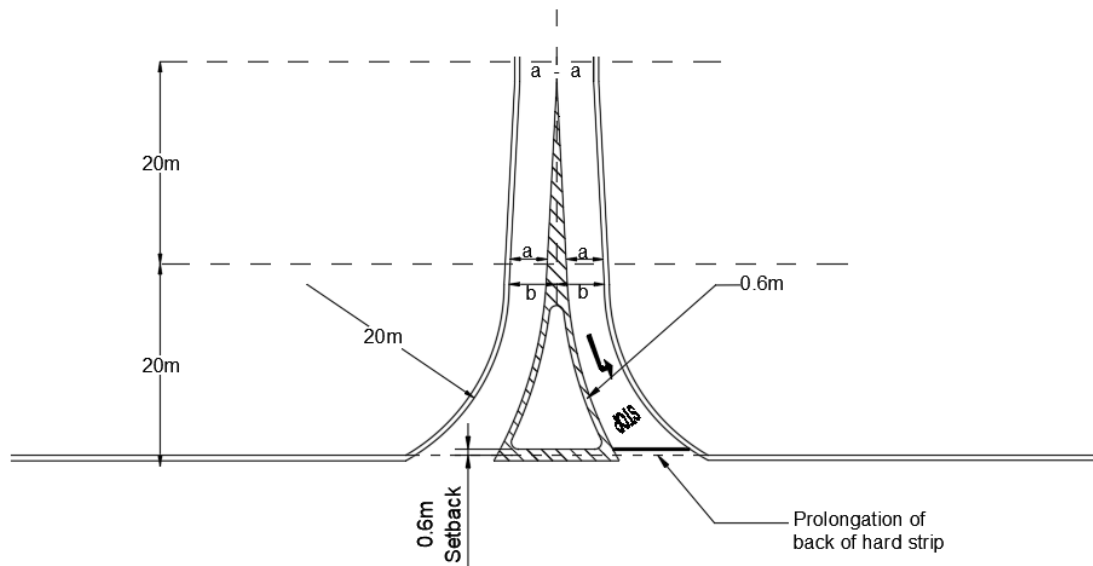


- Notes:
- (1) All corner radii on islands are to be 0.7m to 1m radius
  - (2) The stop line should be positioned in line with the edge of the channel island. All road markings are to be designed in accordance with the TSM
  - (3) See Chapter 9 for Compact Grade Separated junction design

**Figure 5.14 Major/minor road Junction for Left Turn Only Manoeuvres**

**Details for Minor Roads**

| Minor Road Width (m) | a (m) | b (m) |
|----------------------|-------|-------|
| < 3.0                | 3.3   | 4.7   |
| 3.0 to 3.65          | 3.65  | 4.7   |
| 3.65                 | 3.65  | 4.7   |



- Notes:
- (1) All corner radii on islands are to be 0.7m to 1m radius
  - (2) Road markings are to be designed in accordance with the TSM
  - (3) See Chapter 9 for Compact Grade Separated junction design

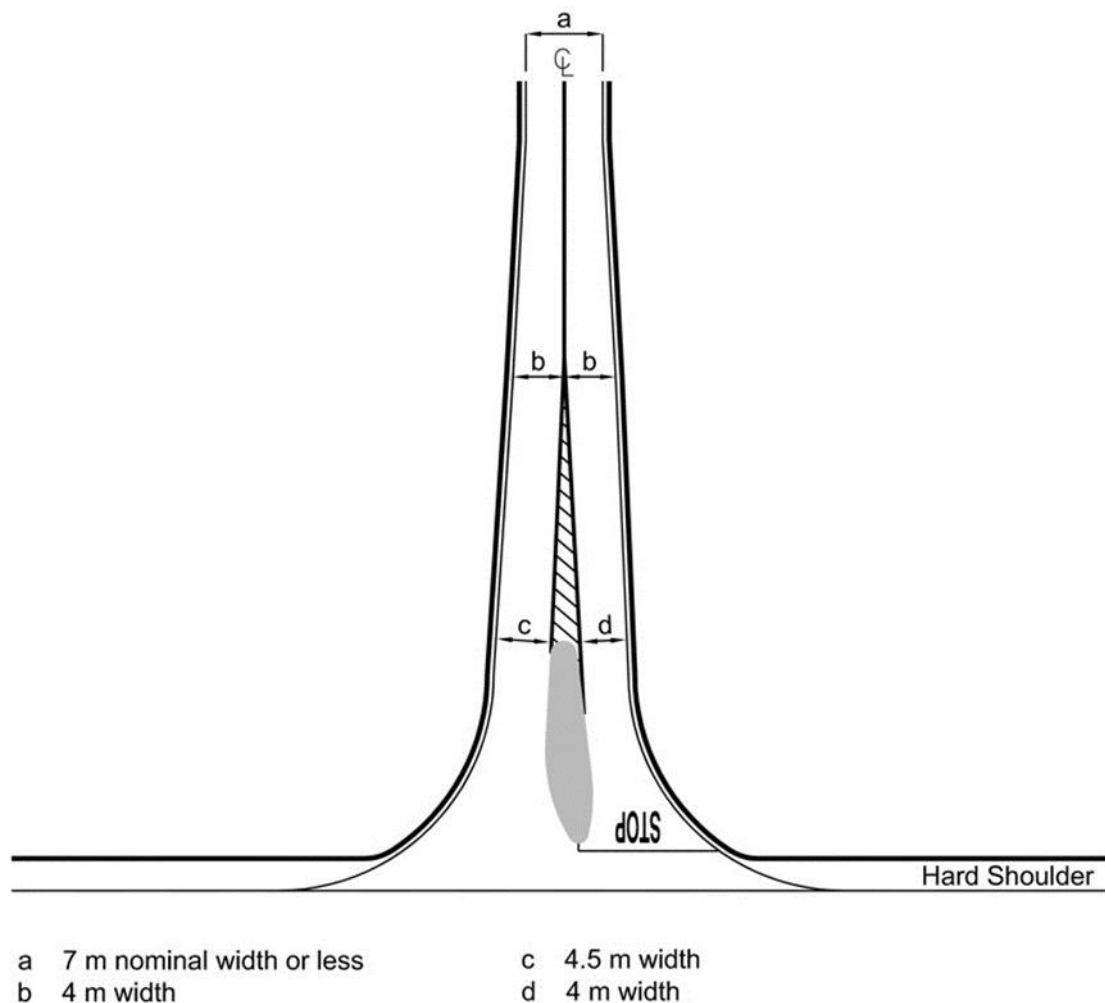
**Figure 5.15 Major/minor road junction for Left Turn Only Manoeuvres with hard strip**

### 5.6.7 Channelising Islands at Priority Junctions

On a minor road approach of nominal width 7.0m or less, where a channelising island is provided on a single carriageway in accordance with 5.6.11, both lanes shall be 4.0m wide at the point where the hatched markings begin. Channelising islands shall be set back 0.6m from the lane marking. At the point where the channelising island commences, the widths on either side of each lane shall be as follows (see Figure 5.16):

- a) 4.0m on the approach to the major road, exclusive of hard strips and 0.6m set back.
- b) 4.5m on the exit from the major road, exclusive of hard strips and 0.6m set back.





**Figure 5.16 Minor road approaches for right and left turning movements**

If there are no channelising islands in the minor road, the nominal approach width should continue up until the tangent point of the corner radii to join the edge of the major road running carriageway.

At skew junctions the centreline of the minor road shall have a minimum radius of 50m that meets the major road nearside channel at right angles. Prior to the 50m radius, the minor road centreline shall be designed in full accordance with DN-GEO-03031 and shall be at an angle of between 50 and 130 degrees to the major road channel. See Figure 5.17.

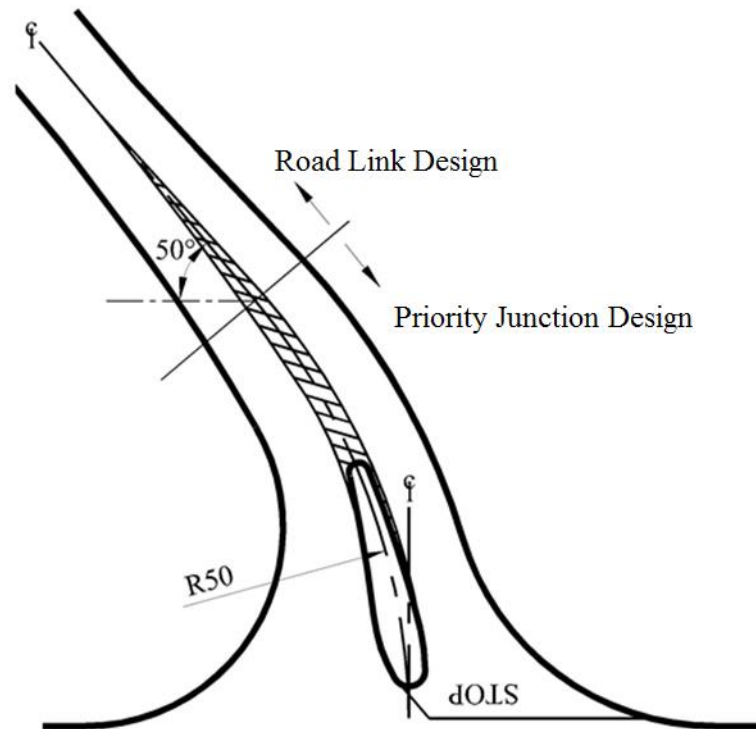


Figure 5.17 Skew Junctions

### 5.6.8 Carriageway Widths around Curves

Around tight radius curves or corners, additional carriageway width shall be provided to cater for the swept path of large vehicles and the "cut in" of trailer units in accordance with Table 5.6.

Table 5.6 Minimum Corner and Curve Radii and Carriageway Widths

| Inside Corner Radius or Curve Radius (m) | Single Lane Width (excluding hard strip provision) (m) | Two Lane Width for One Way or Two Way Traffic (excluding hard strip provision) (m) |              |       |
|--|--|--|--------------|-------|
|  |  | Inside Lane  | Outside Lane | Total |
| 10                                       | 8.4  | 8.4  | 6.5          | 14.9  |
| 15                                       | 7.1  | 7.1  | 6.0          | 13.1  |
| 20                                       | 6.2  | 6.2  | 5.6          | 11.8  |
| 25                                       | 5.7  | 5.7  | 5.2          | 10.9  |
| 30                                       | 5.3  | 5.3  | 5.0          | 10.3  |
| 40                                       | 4.7  | 4.7  | 4.6          | 9.3   |
| 50                                       | 4.4  | 4.4  | 4.3          | 8.7   |
| 75                                       | 4.0  | 4.0  | 4.0          | 8.0   |
| 100                                      | 3.8  | 3.8  | 3.8          | 7.6   |

## 5.6.9 Design of Ghost Island Junctions

### 5.6.9.1 Turning Length

The turning length is provided to allow long vehicles to position themselves correctly for the right turn off the major road. The turning length shall be 10m long irrespective of the design speed or gradient, measured from the centreline of the minor road as shown in Figure 5.18.

Where capacity calculations indicate that for significant periods of time there will be vehicles queuing to turn right from the major road, the turning length shall have a queuing length added to it as a reservoir to accommodate queuing vehicles.

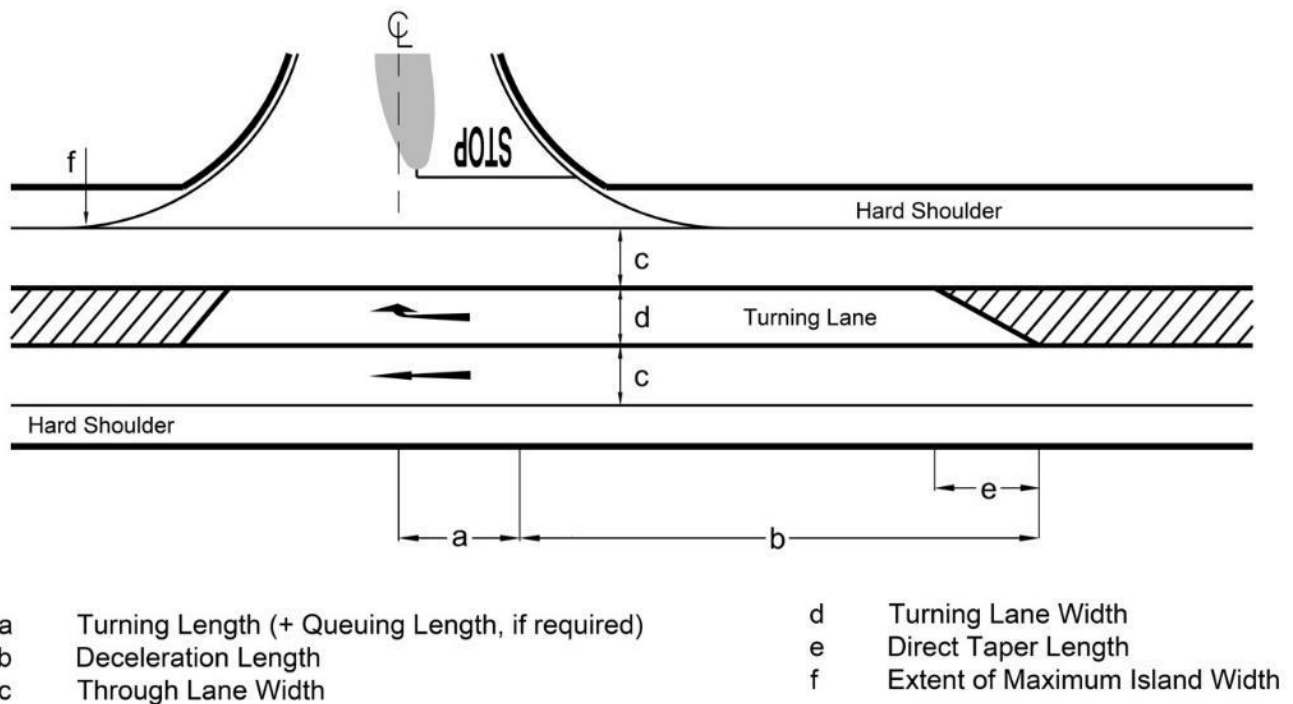
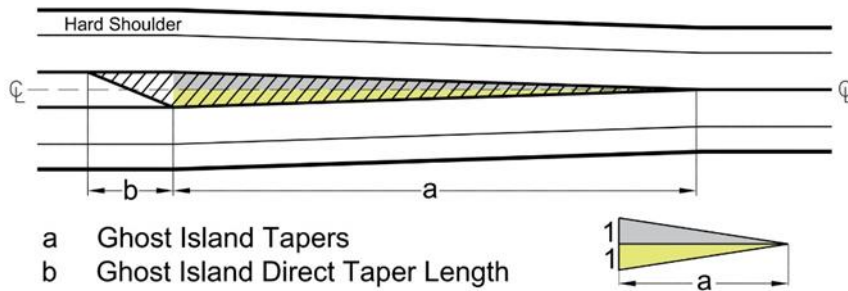


Figure 5.18 Priority Junction with a Ghost Island

### 5.6.9.2 Taper Length

Central islands for ghost islands (Figure 5.19) should normally be developed symmetrically about the centreline of the major road to and from the turning lane width at the tapers shown in Table 5.7. The maximum island width should continue through the junction to the tangent point of the corner radius and the edge of the major road carriageway, downstream of the direction of the right hand turn as shown in Figure 5.18. In difficult circumstances, the Designer may reduce the taper value by one design speed step as a relaxation. Where right turn lanes off the major road are provided at both junctions in a right/left staggered junction, the maximum island width should continue through both junctions as detailed in Figure 5.20.



**Figure 5.19 Ghost Island Development and Taper**

The direct taper length is the length over which the width of a right turning lane is developed. For ghost island junctions, right turning lanes shall be introduced by means of a direct taper whose length is part of the deceleration length, and whole length depends on the design speed. This taper length is given in Table 5.8. In difficult circumstances, the Designer may relax the taper value by one design speed step as a Relaxation.

**Table 5.7 Tapers for Ghost Islands**

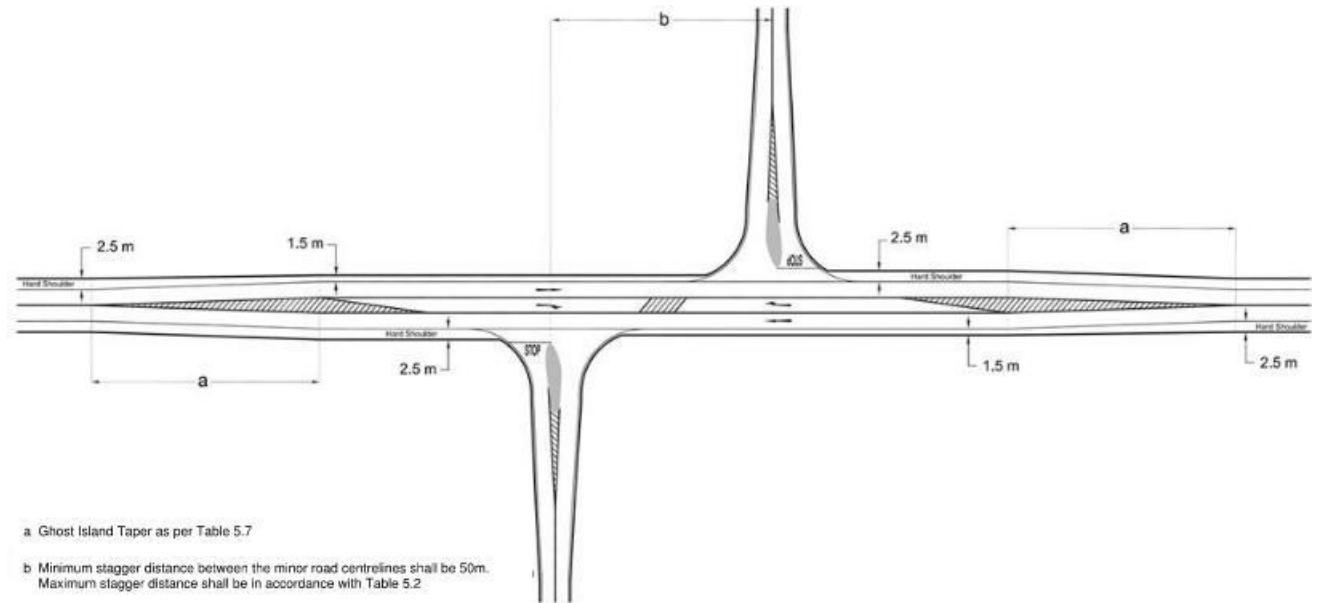
| Design Speed (km/h) | Taper for Ghost Island |
|---------------------|------------------------|
| 50                  | 1:20                   |
| 60                  | 1:20                   |
| 70                  | 1:20                   |
| 85                  | 1:25                   |
| 100                 | 1:30                   |

Note: In difficult circumstances, the Designer may relax the taper value by one design speed step as a Relaxation.

**Table 5.8 Direct Taper Length**

| Design Speed (km/h) | Direct Taper Length (m) |
|---------------------|-------------------------|
| 50                  | 5                       |
| 60                  | 5                       |
| 70                  | 15                      |
| 85                  | 15                      |
| 100                 | 25                      |
| 120                 | 30                      |

Note: In difficult circumstances, the Designer may relax the taper value by one design speed step as a Relaxation.



**Figure 5.20 Ghost Island arrangement at Right/Left Staggered Junction**

### 5.6.9.3 Lane Widths

The width of a ghost island turning lane shall be 3.5m, but a Relaxation to 3.0m is permissible. The through lane width in each direction shall be in accordance with DN-GEO-03036 for the road type, which shall be maintained through the ghost island junction.

### 5.6.9.4 Turning Lanes

The overall length of a turning lane provided at ghost island junctions depends on the major road design speed and the gradient. It consists of the turning length and the deceleration length, and shall be provided in accordance with Table 5.9. The gradient is the average for the 500m length before the minor road. In difficult circumstances, the Designer may relax the deceleration length by one design speed step as a relaxation.

**Table 5.9 Deceleration Length (m) for Ghost Island**

| Design Speed (km/h) | Up Gradient |          | Down Gradient |          |
|---------------------|-------------|----------|---------------|----------|
|                     | 0-4%        | Above 4% | 0-4%          | Above 4% |
| 50                  | 25          | 25       | 25            | 25       |
| 60                  | 25          | 25       | 25            | 25       |
| 70                  | 40          | 25       | 40            | 40       |
| 85                  | 55          | 40       | 55            | 55       |
| 100                 | 80          | 55       | 80            | 80       |

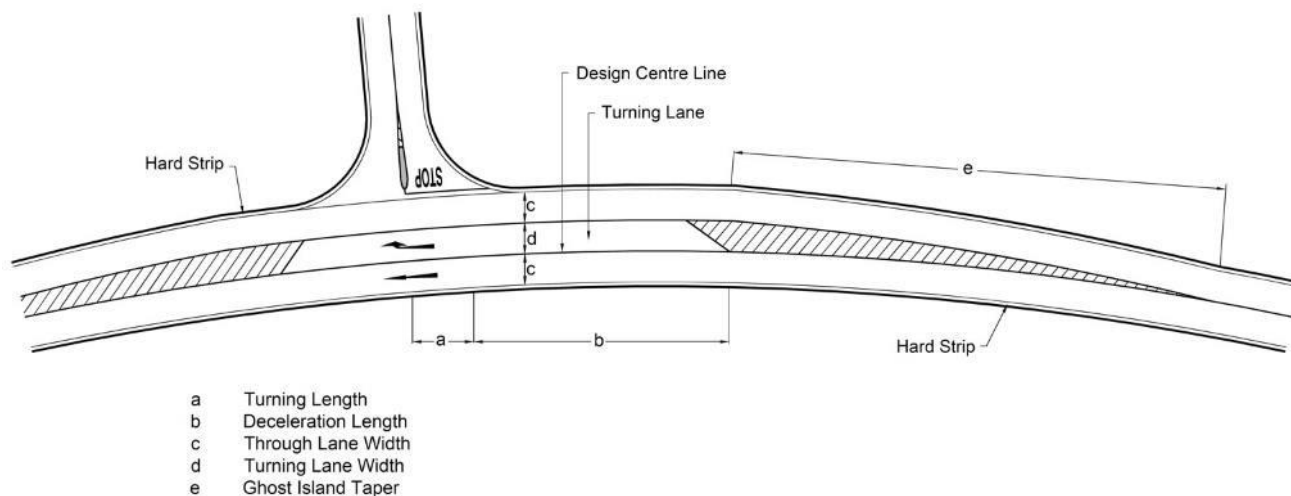
Note: In difficult circumstances, the Designer may relax the deceleration length by one design speed step as a relaxation.

### 5.6.9.5 Ghost Island Junction located on a Curve

Where junctions are located on curves, ghost islands should be introduced asymmetrically on the outside of the curve to suit the circumstances (as indicated in Figure 5.21). It is also appropriate to introduce islands asymmetrically in other circumstances. This can have the benefit of avoiding expense (for example Statutory Undertakers' works). If the widening is developed to the minor road side, through traffic will be deflected where crossing movements at the minor road take place, which may be a benefit.

For asymmetrical ghost islands, the taper ratio will be the same as for a symmetrical island but the taper length will be considerably greater.

Designers shall ensure that with any design whether, with symmetrical or asymmetrical ghost islands; a smooth flowing alignment is achieved.



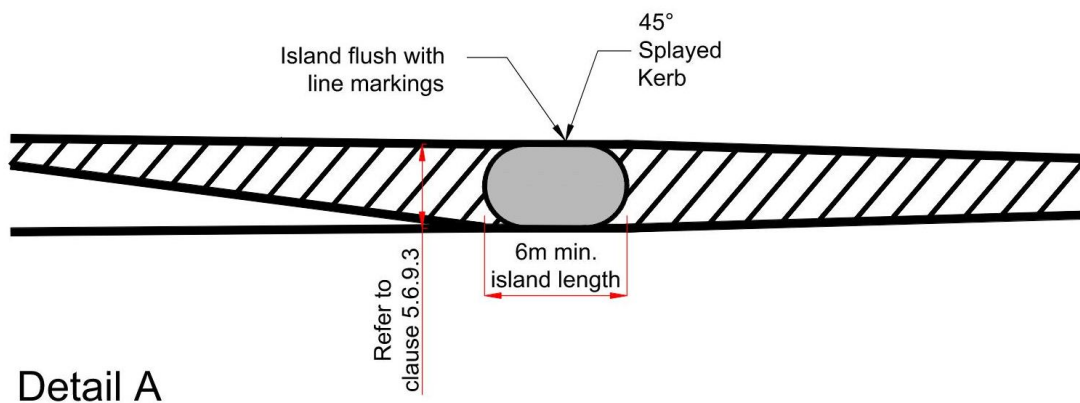
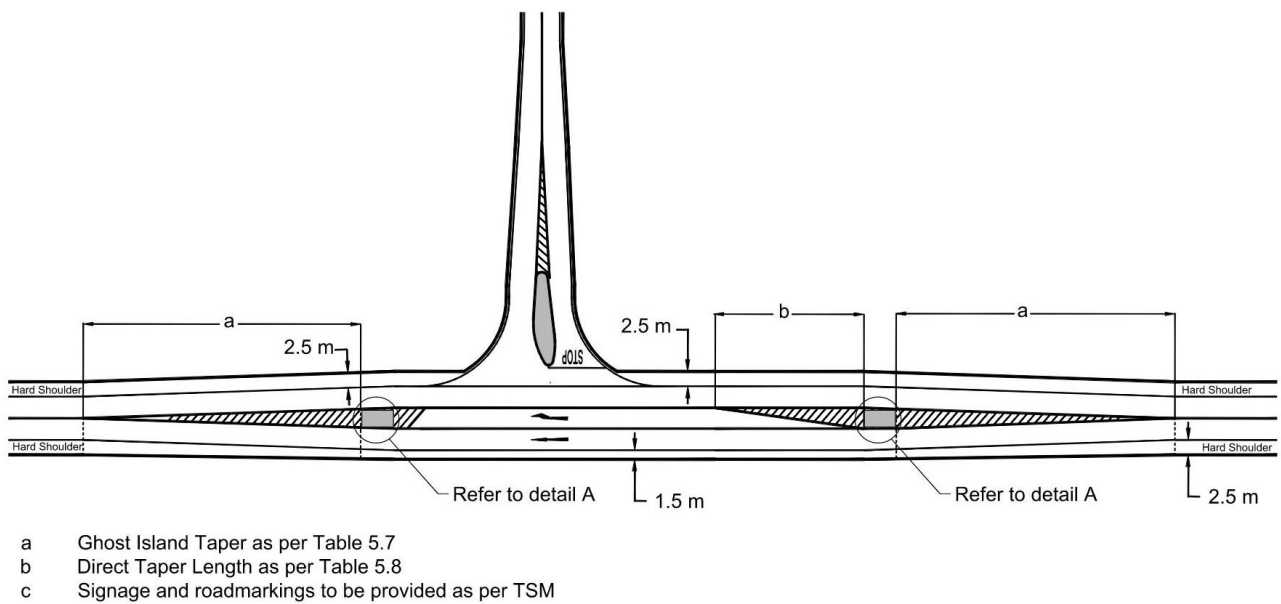
- Note:
- (1) Radius of outside of carriageway varies to accommodate the taper and the horizontal alignment of the major road
  - (2) Right turn lane developed asymmetrically, on the outside of the curve
  - (3) Figure is provided to indicate junction type only, road markings are to be designed in accordance with the TSM

**Figure 5.21 Ghost Island Junction with Curve on major road**

### 5.6.10 Ghost Island Junction where Overtaking is Restricted

As outlined in Section 5.3.2, the provision of ghost island junctions in areas where overtaking opportunities are restricted on either side of the junction has been known to induce unsafe driver behaviour. Following an extended length where overtaking is not possible, the development of a short length of wider road at the junction may be used by frustrated drivers for illegal overtaking, leading to increased collision risks.

In these areas, the Designer shall provide a raised median on each approach to the junction as illustrated in Figure 5.22. At such locations, it is considered important to prevent overtaking through the junction and the islands are intended to physically restrict illegal overtaking manoeuvres. For signage and kerbing details refer to CC-SCD-00051. The inclusion of raised islands will necessitate the provision of road lighting through the junction, details of which shall be developed and agreed with TII via the departure approval procedure.



**Figure 5.22 Ghost Island Junctions with Raised Median on Approaches**

### 5.6.11 Channelising Islands and Refuges

Merging and diverging movements can usefully be separated by channelising islands so that the number of traffic conflicts at any point is reduced (as indicated in Figure 5.14, 5.15, 5.16 and 5.17).

Channelising islands shall be provided in the mouth of the minor road at ghost island junctions, and may be similarly provided at simple junctions, to:

- a) Give guidance to long vehicles carrying out turning movements.
- b) Channelise intersecting or merging traffic streams.
- c) Warn drivers on the minor road that a junction is ahead.
- d) Provide shelter for vehicles / cyclists waiting to carry out manoeuvres such as waiting to turn right.

At rural ghost island junctions channelising islands shall be used in the mouth of the minor road. The recommended layout and step-by-step design approach for channelising islands is shown in Appendix B.

Rural channelising islands shall be raised and kerbed and constructed in accordance with Standard Construction Detail CC-SCD-01110.

Channelising islands shall have a width of at least 2.5 metres and shall be conspicuous in poor lighting conditions.

Rural crossroads are regarded as a Departure from Standards however, details are also included in Appendix B for use if considering upgrading existing rural cross-roads.

## **5.7 Diverging/Merging Tapers and Lanes at Junctions**

Merge and diverge auxiliary lanes and tapers shall not be provided on single carriageway roads.

## **5.8 Drainage and Crossfall**

From considerations of surface water drainage and road user comfort, the road camber on the major road shall be retained through the junction and the minor road graded into the channel line of the major road. Checks shall be made for flat areas at all changes of gradient, superelevation or crossfall in accordance with DN-GEO-03031.

## **5.9 Roads with Hard Shoulders**

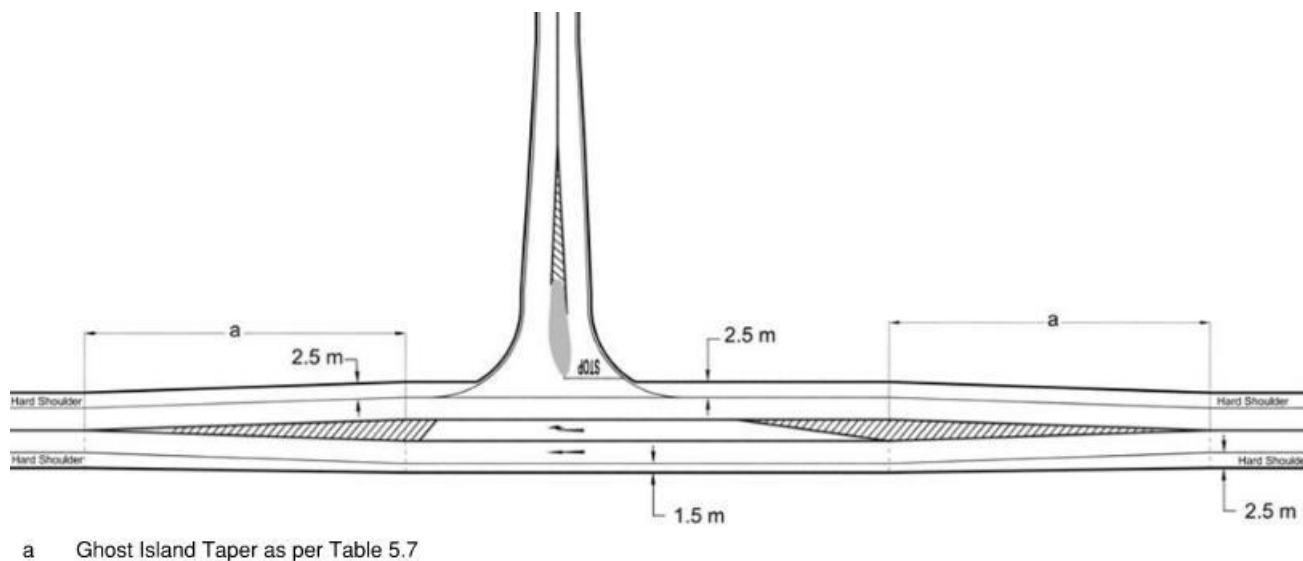
Where hard shoulders are provided on roads with priority junctions, particular care should be taken to ensure safe designs for the junctions. The layouts should be in accordance with the geometric requirements described in the preceding paragraphs of this Chapter, together with the following additional requirements.

### **5.9.1 Major Road Requirements opposite a Junction**

On the side of the major road opposite a simple T- junction, the hard shoulder shall be maintained through the junction.

On the side of the major road opposite a ghost island junction the hard shoulder shall be tapered to form a 1.5m hard strip over the length of the ghost island taper as illustrated in Figure 5.23. On the departure side, the hard shoulder may be reintroduced over the length of the ghost island taper also. The running lane should be a constant width through the junction. Where the required paved width is less than the full paved width away from the junction, the full paved width should be continued through the junction, with any excess area hatched.





**Figure 5.23 Treatment of Hard Shoulders at a Ghost Island Junction**

### 5.9.2 Hard Shoulders on the Minor Road

Where the minor road has a hard shoulder, the hard shoulder approaching the major road should be terminated by tapering to a width of 0.5m to form a hard strip. The taper angle should be 1:30 and the taper should terminate not less than 15m before the start of the entry widening.

The hard shoulder exiting the major road should not start before the end of the exit widening.

Hard Shoulders crossing minor roads shall be terminated at the intersection of the hard shoulder and the hard strip/hard shoulder of the minor road corner radii or taper as appropriate.

### 5.9.3 Stop Line

In accordance with the Traffic Signs Manual, the edge of the stop line nearest to the major road shall not be closer than 0.6m to the line of the back of the paved area of the major road including any hard shoulder or hard strip (see Figure 5.24).

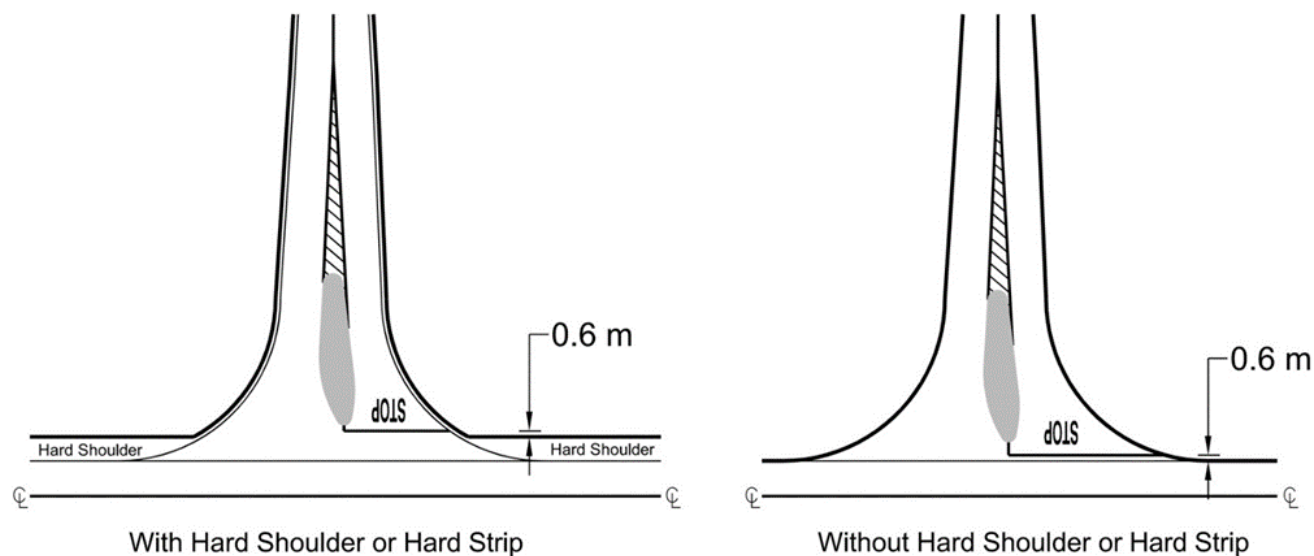


Figure 5.24 Priority Junction Stop Line with and without Hard Shoulder or Hard Strips

## 5.10 Specific Geometric Design Layouts for Dual Carriageways and Divided Roads

### 5.10.1 General

This section outlines additional geometric design properties and features to be considered in the design of priority junctions and accesses associated with dual carriageways and divided roads.

### 5.10.2 Auxiliary Merge and Diverge Lanes

On Type 1 Dual Carriageways and Motorways the merge and diverge auxiliary lanes, where appropriate, shall be detailed in accordance with Chapter 8.

Merge auxiliary lanes and tapers are not permitted on Type 2 Divided Roads. However, diverge auxiliary lanes shall be provided at left-in/left-out priority junctions and compact grade separated junctions on Type 2 Divided Roads. Where auxiliary lanes are provided at left-in/left-out priority junctions for Type 2 Divided Roads, the layout shall be in accordance with the layout as shown in Figure 8.6.1 with an auxiliary taper length of 55m and an auxiliary lane length of 150m which shall terminate at the tangent point of the 40m exit radii.

Merge and diverge auxiliary lanes are not permitted on Type 3 Divided Roads.

### 5.10.3 Dual Carriageway and Divided Roads Priority Junctions

Left-in/left-out priority junctions may be used on Type 1 Dual Carriageways and Type 2 and 3 Divided Roads.

Where junctions are provided on either the one-lane or two-lane side on a Type 3 Divided Road, they shall be restricted to left-in left-out turning movements only, with no crossing of the central reserve. This junction type is only suitable for lightly trafficked minor roads. Such junctions shall not be provided within 100m of a critical changeover as defined in DN-GEO-03031. Where junctions of this type are required on opposite sides of the road, the side roads shall be staggered by a nominal 10m to avoid the appearance of a through road.

On Dual Carriageways and Divided Roads, no permanent crossings of the central reserve are allowed with the exception of single lane sections of Type 3 Divided Roads, where a right turn off the major road may be provided as a Departure from Standard. Right turns onto the major road are prohibited.

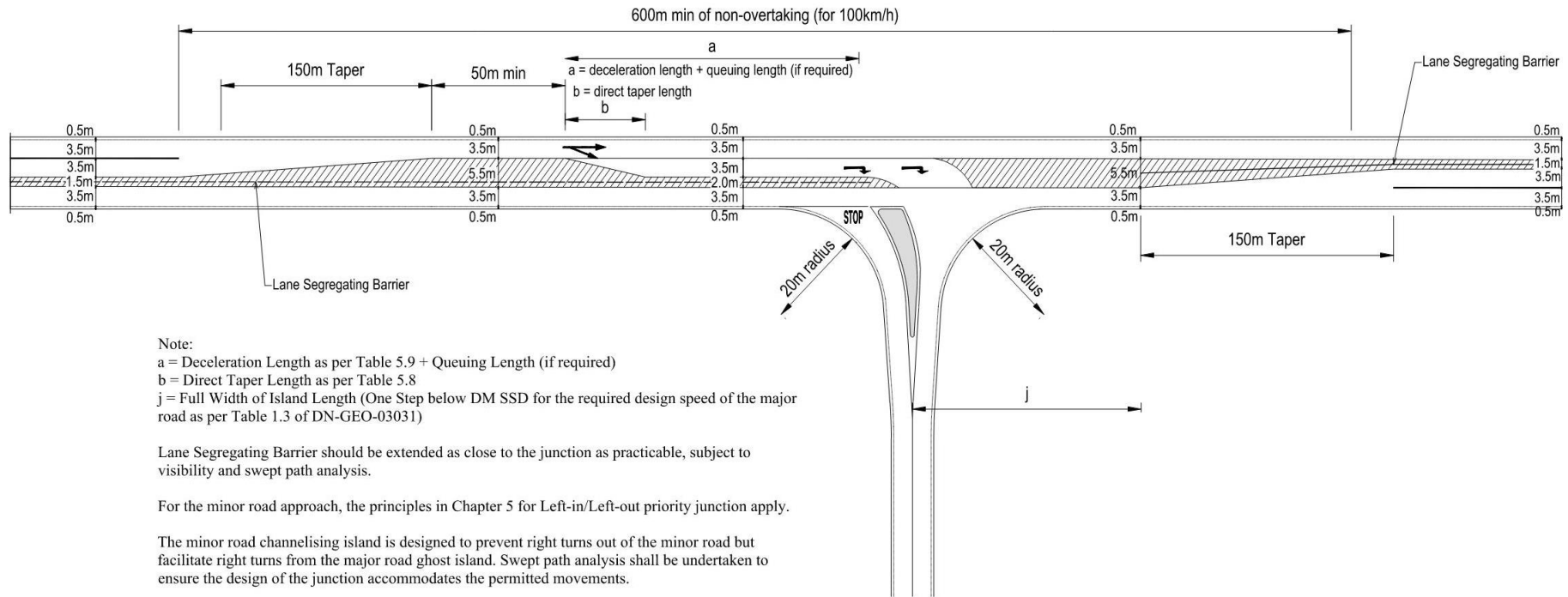
Priority junctions permitting right turns off the major road on Type 3 Divided Roads require a Departure from Standard and when used, shall only be sited at changeovers. Therefore, the passing lanes are terminated either side of the junction, leaving a ghost island at the junction with one 3.5m lane in each direction. Typical layouts are illustrated in Figures 5.25 and 5.26 for a critical changeover and non-critical changeover respectively.

Where there is a change in road type from a motorway or Type 1 Dual Carriageway with full grade separation, to a Type 2 or 3 Divided Road with at-grade priority junctions, a roundabout should always be used at the first major junction in order to emphasise to drivers the changed character of the road.

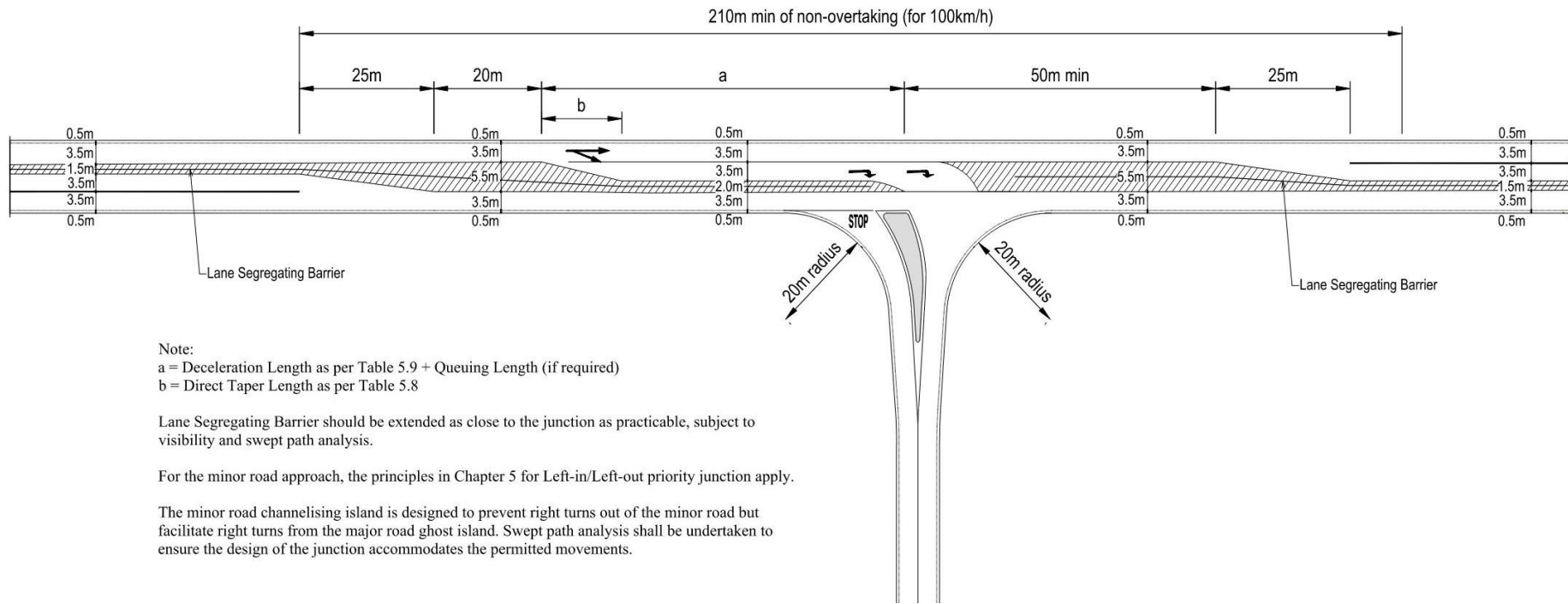
Where it is necessary or desirable to provide a U-turn facility, and a roundabout is not justified, a mainline U-turn loop can be provided at a minor road as a Departure from Standards, as illustrated in Figure 5.27.

Where a U-turn loop is provided at a passing lane length, the loop shall not be provided on the two-lane side, so as to avoid the need for turning traffic to cross two through lanes.

Careful signing will be required on the approaches to all U-turn facilities (except roundabouts) to alert drivers to the U-turn loop.



**Figure 5.25 Junction Layout at Critical Changeover (requires a Departure from Standards)**



**Figure 5.26 Junction Layout at Non-Critical Changeover (requires a Departure from Standards)**

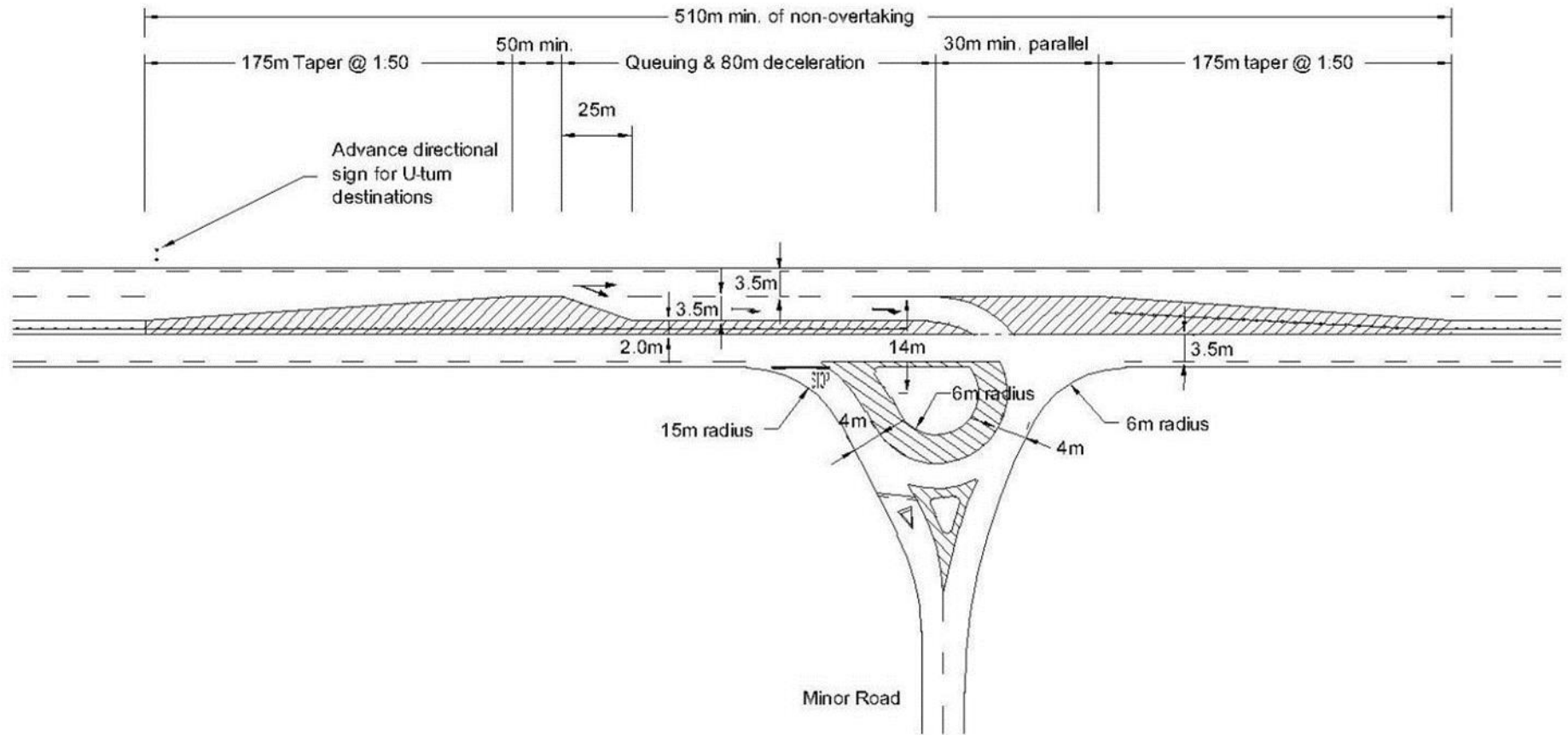


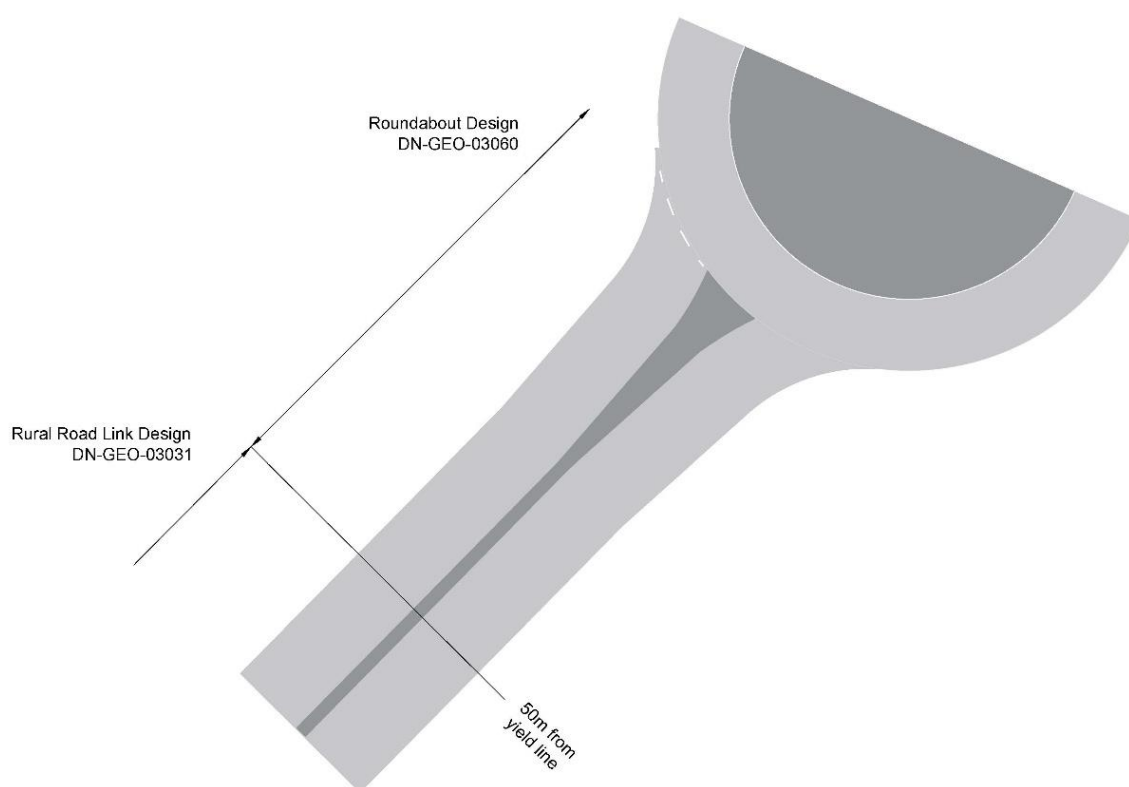
Figure 5.27 Mainline turning loop at minor road (requires a Departure from Standards)

## 6. Geometric Design of Roundabouts

### 6.1 General

This Chapter describes the geometric design of roundabouts for application to new and improved junctions on national roads.

The cut-off point between roundabout and link design shall be 50m measured from the yield line which corresponds to the point at which the entry path radius assessment commences. Geometric design in accordance with this chapter shall be undertaken from this point. However, full SSD in accordance with DN-GEO-03031 shall be provided to the yield line on the approach roads to the roundabout.

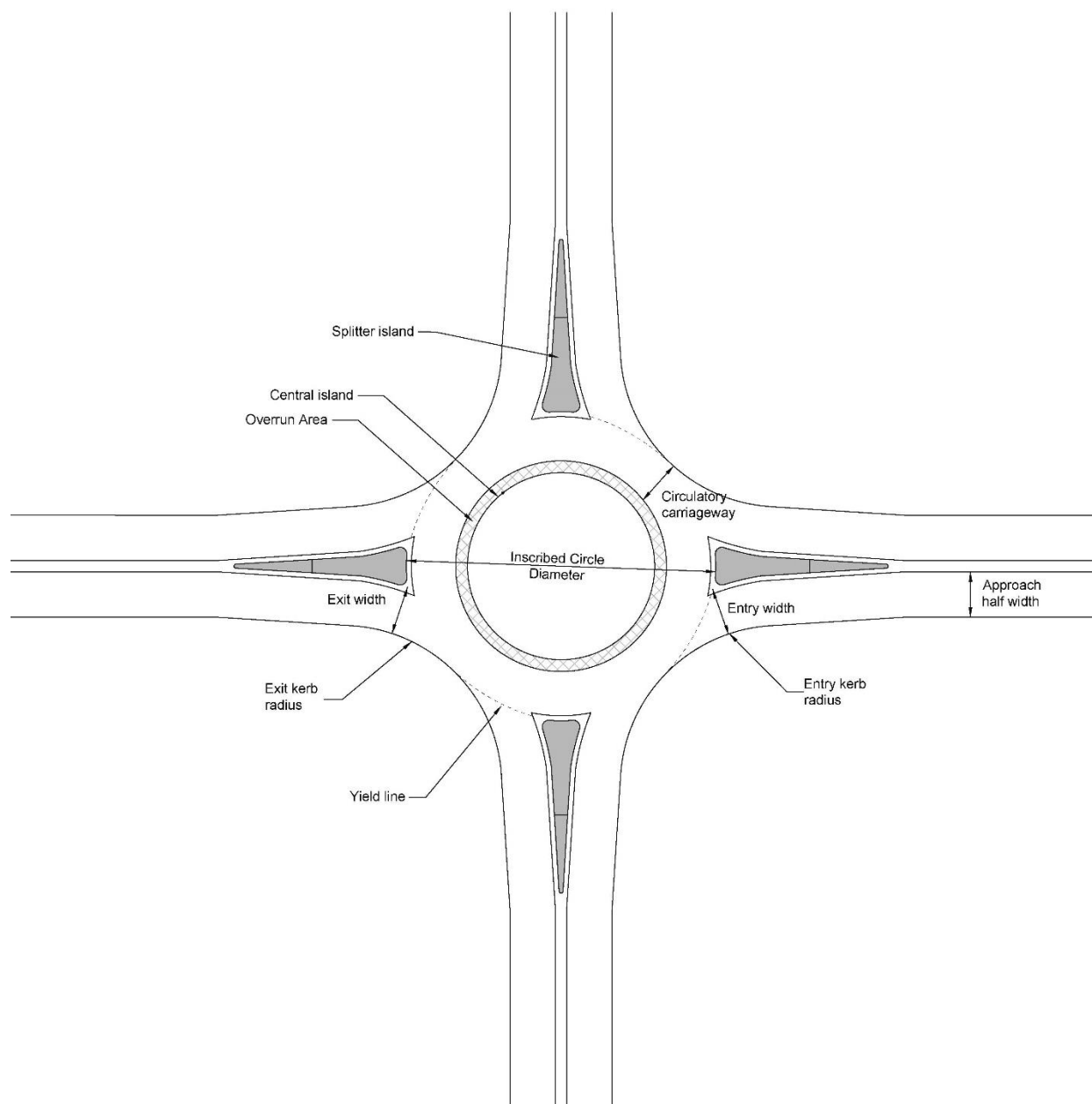


**Figure 6.1 Cut-Off Point between Link Design and Roundabout Design**

Figure 6.2 illustrates the basic geometric elements / terminology associated with roundabouts.

The layout of a roundabout shall be considered by a designer at an early stage in the design process. Items that should be considered that may affect the final geometric layout of a roundabout include:

- The number of approach arms to be incorporated and the number of lanes on the approach arms;
- The angle of approach arms, sharp angles between arms should be avoided by balancing approach arms evenly around the circulatory carriageway edge; and
- Consideration of splitter island requirements at an early stage (including ATU movements and space for required signage and other ancillary infrastructure).



**Figure 6.2 Geometric elements of a roundabout**

The geometric design of roundabouts can be a complex and iterative process that requires the careful assembly of various design elements to achieve a satisfactory final layout. Figure 6.3 provides a general procedure that should be followed for the geometric design of roundabouts.

In principle, the number of roundabout lanes (entry, circulating, and exit lanes) provided should be limited to the minimum number that achieves the desired capacity and operating requirements for the projected future traffic volumes. In this regard, it is important that overprovision in respect of roundabout size and number of lanes is avoided, as this is likely to induce higher vehicular speeds, generate increased potential for conflict (particularly at the exits) and pose operational challenges for active travel users.

As a general rule, the number of circulating lanes from any approach must be equal to or greater than the number of entries on that approach, and the number of exit lanes must be no greater than the number of circulating lanes.



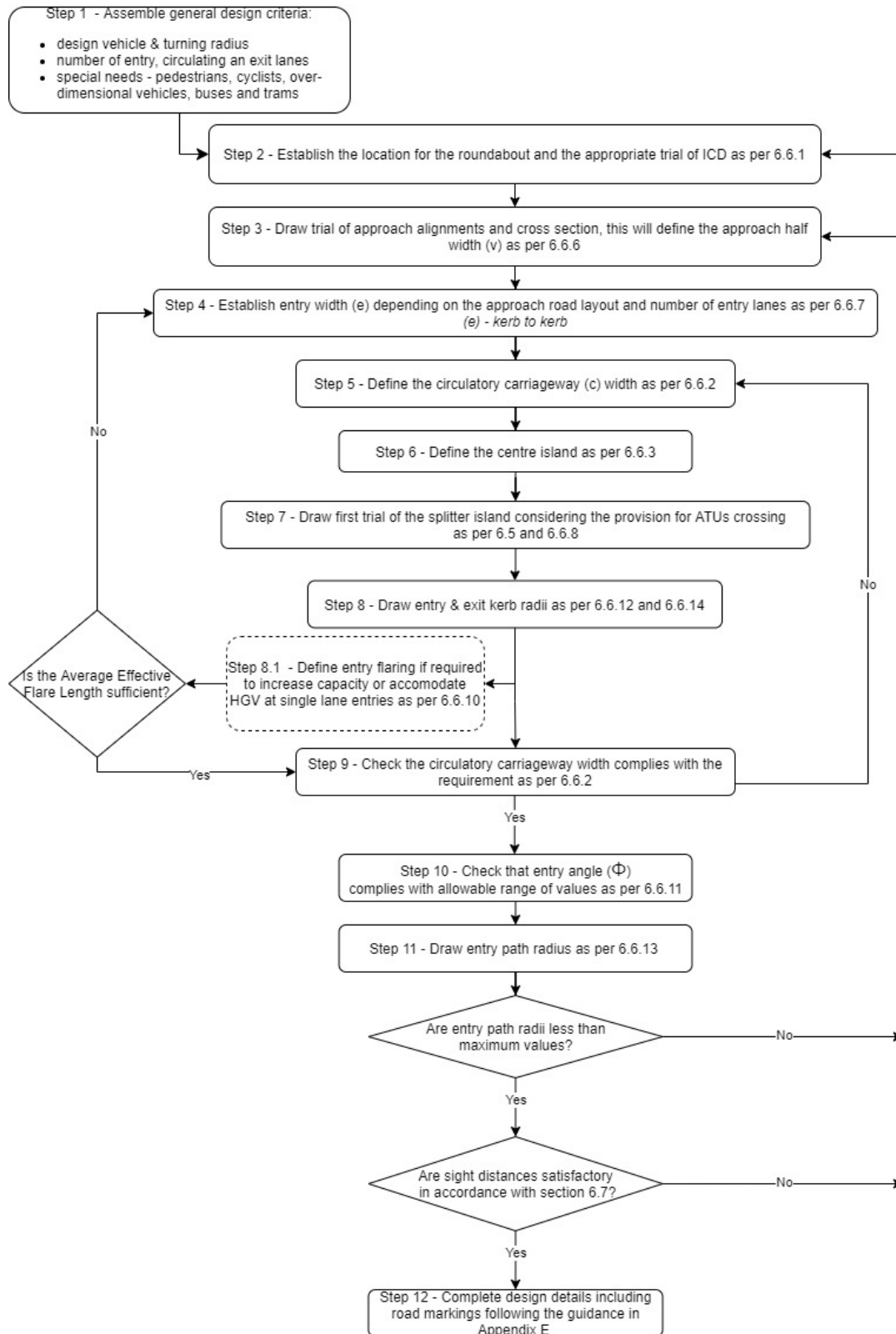


Figure 6.3 Roundabout Design Flowchart

## 6.2 Siting

A project appraisal should be carried out in accordance with TII current practices when considering the optimal siting of roundabouts.

Where several roundabouts are to be installed on the same route, they should be of similar design in the interests of route consistency and safety to the extent that this is possible with the traffic volumes concerned.

In addition to its natural function as a junction, a roundabout may usefully:

- a) facilitate a significant change in road standard, for example, from dual to single carriageway or a sharp change in direction along a route;
- b) facilitate U-turns;
- c) facilitate right turning flows.

The majority of collisions at priority junctions are associated with right turns. The inconvenience of prohibiting right turns and using left-in/left-out junctions can be mitigated by providing a roundabout nearby.

For Type 3 Divided Roads, roundabouts will be appropriate as major junctions. A two-lane section may terminate at a roundabout with the overtaking lane becoming the offside entry lane into the roundabout.

On single carriageway roads where overtaking opportunity is limited, roundabouts may be sited so as to optimise the length of straight overtaking sections along the route (see DN-GEO-03031).

Where a roundabout is proposed, consideration should be given to the location and operational impacts to adjacent junctions. The minimum distance between two roundabouts on a national road shall be 90m measured from the closest points on the inscribed circle diameters.

Where it is proposed to add an arm to an existing roundabout, the effects shall be assessed so that there are no adverse impacts on the capacity, function and safety of the roundabout for all road users.

### **6.3 Landscaping within a Roundabout**

Non-passively safe landscaping and any artwork features constructed on a national road roundabout shall not be provided in the direct line of a potential errant vehicle that overruns the roundabout.

Passively safe landscaping is allowable within a national road roundabout and shall only be provided with TII approval.

Figure 6.4 illustrates the principle for a typical single lane roundabout; non-passively safe landscaping or artwork must not be positioned outside the green shaded area within the roundabout.

Designers must assess the potential path an errant vehicle is most likely to take based on the specific design parameters of the roundabout. Sight lines shall also be considered when landscaping and artwork features are being designed.



**Figure 6.4** Permitted location for non-passively safe landscaping and artwork within a single lane roundabout

## 6.4 Selection of Roundabout Type

The selection of roundabout type will be dictated by the number of entry, circulating and exit lanes. Roundabouts can be Single Lane or Multi-lane, with the choice of roundabout type governed by a combination of factors including:

- a) whether the approach roads are single or dual carriageway / divided roads (or grade separated);
- b) the speed limit on the approach roads;
- c) the level of traffic flow;
- d) the level of ATU flow; and
- e) other constraints such as land-take.

A single lane roundabout (Figure 2.6) has single lane entries and exits on each arm. The width of the circulatory carriageway is designed such that two vehicles are not encouraged to move through the roundabout side-by-side.

Multi-lane roundabouts (Figure 2.7) will have multi-lane entries and/or exits on at least one arm to allow more than one vehicle to enter or leave the roundabout on a given arm at the same time. Multi-lane roundabouts must also have two or more lanes on the circulatory carriageway to allow more than one vehicle to travel side by side on the circulatory carriageway. Approaches to multi-lane roundabouts can be single or dual carriageways / divided roads.

On single carriageway roads, where predicted flows are low and increased lane width is not operationally necessary, a single lane roundabout shall be used. Two-lane roundabouts on single carriageway roads can promote overtaking within the roundabout, especially if there are no overtaking opportunities on the approach of the roundabout. This situation should be avoided where possible by:

- Providing a single lane roundabout until traffic volumes warrant the use of a two-lane facility;
- Providing single-lane only for through movement; or
- Ensuring overtaking opportunities are available prior to the approach or after the exit.



## 6.5 Provision for Active Travel Users (ATUs)

Provision must be made for the specific requirements of ATUs in the design of roundabouts. These requirements are presented in Section 7.5 of this Standard.



## 6.6 Geometric Design of Roundabouts

### 6.6.1 Inscribed Circle Diameter

The Inscribed Circle Diameter (ICD) of the roundabout is the diameter of the largest circle that can be fitted into the junction outline. Figure 6.2 illustrates the ICD for a circular roundabout. Where the outline is non-circular, the ICD in the region of the entry should be used.

The ICD is a critical element in the design of an efficient roundabout and must be large enough to accommodate the swept path of the design vehicle and all entries and exits to the required geometric standards without them overlapping. Excessively large ICDs are undesirable, as these can induce high circulatory speeds which can adversely affect operational safety.

A single lane roundabout shall have an ICD no less than 28m, as this is the minimum value to accommodate the swept path of the design vehicle (Refer to Figure 6.6). The ICD of a single lane roundabout may be increased to accommodate the geometric requirements of this chapter and to facilitate the introduction of splitter islands accommodating the required 3.5m refuge for ATUs on all approaches.

The ICD of a multi-lane roundabout will be dependent on the type of carriageway approaching the roundabout, but shall not exceed:

- 70m when catering solely for single carriageway approaches (with multi-lane entries); and
- 100m when one or more approach arms is a dual carriageway / divided road.

The ICD will also be influenced by the number of arms on the roundabout – the more arms, the larger the ICD. Roundabouts should preferably have four arms, with three arms considered the minimum.

The provision of a five or more arm roundabout is not recommended on national roads and requires a Departure from Standard.

Where consideration is being given to the addition of a fifth arm to a four arm roundabout, it must be shown that the introduction of the fifth arm;

- a) shall not have a negative impact on the operation of the roundabout as a whole;

- b) shall not reduce the ultimate capacity of the roundabout;
- c) shall be designed to ensure that vehicular flows are reasonably balanced between the arms;
- d) shall not result in high circulatory speeds on the roundabout itself;
- e) shall not result in such close spacing of arms that there can be confusion about a driver's intended exit.

Traffic modelling shall be undertaken by the designer to demonstrate this using TII's Project Appraisal Guidelines.

## 6.6.2 Circulatory Carriageway

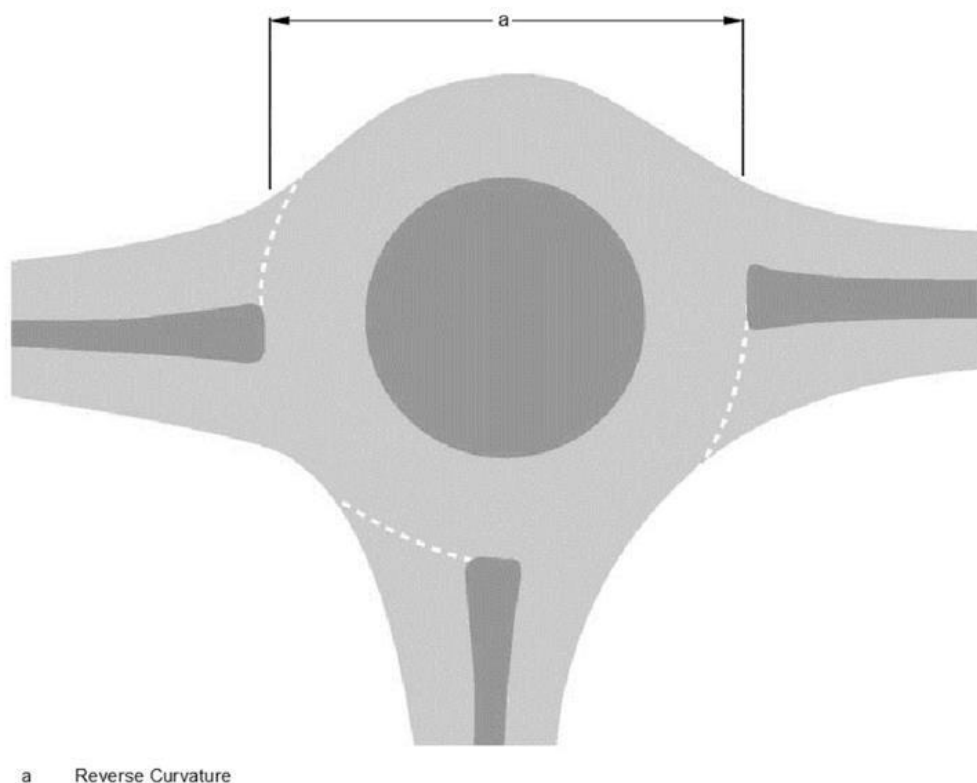
The circulatory carriageway of roundabouts shall generally be circular and of constant width. However, at complex roundabouts, for example where spiral markings are used, the width should be in line with traffic demand.

The width of the circulatory carriageway depends on several factors, including the type of roundabout and the number of circulating lanes. In general, the width of the circulatory carriageway must be between 1.0 and 1.2 times the maximum entry width (refer Section 6.6.7), excluding any overrun area.

At single lane roundabouts, the width of the circulatory carriageway should not exceed 6m, such that two vehicles are not encouraged to move through the roundabout side-by-side. An additional overrun area may be required for small values of ICD, depending on the types of vehicles using the roundabout (see Figure 6.6). At multi-lane roundabouts, the circulatory carriageway width should not exceed 15m.

The appropriate use of circulatory carriageway road markings is an important consideration, particularly for multi-lane roundabouts – advice on designing road markings on the circulatory carriageway is provided in Appendix E. The number of circulating lanes from any particular approach must be equal to or greater than the number of entry lanes on that approach.

Short lengths of reverse curve on the ICD, where two consecutive tangential circular arcs curve in opposite directions, shall be avoided between entry and adjacent exits. This shall be eliminated where possible by reducing the size of the inscribed circle diameter to the minimum allowable by the geometric constraints. Where this does not eliminate the reverse curve the entry and exits may be linked with a short straight section. Where there is a considerable distance between the entry and the next exit, such as at three-arm roundabouts, reverse curvature is acceptable (see Figure 6.5).



**Figure 6.5 Three-arm Roundabout Illustrating Reverse Curvature**

There may be situations where the turning proportions are such that one section of the circulatory carriageway on multi-lane roundabouts has a relatively low flow, resulting in an unused area of carriageway, usually adjacent to a channelising island:

- a) For larger roundabouts, the circulatory carriageway can be reduced in width by extending the channelising island. This method of reducing circulatory width may also be adopted as an interim measure in the early years of a scheme. At the same time, the offside entry lane may be taken out of use, for example, by the use of coloured or textured surfacing or hatched markings.
- b) For smaller roundabouts, increasing the size of the central island is a more appropriate method of interim circulatory carriageway reduction, preferably by physical means but alternatively using coloured surfacing or hatched markings.

Hatching should not be used to reduce the entry width in areas adjacent to pedestrian facilities.

### 6.6.3 Central Island

The central island should be circular and at least 4 metres in diameter.

It should be noted that the swept path for the Design Vehicle may impinge slightly (by up to 0.3m) into either the inner or outer 1m clearance allowance. Given the anticipated frequency of this type of vehicle, this is not considered to be particularly significant and the dimensions in Figure 6.6 and Table 6.1 should not be increased accordingly.

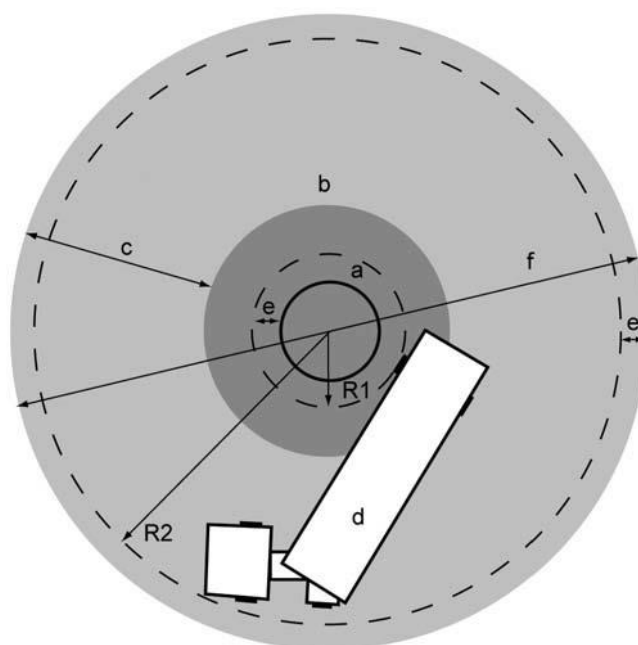
In order to ensure that light vehicles encounter sufficient entry deflection at single lane roundabouts whilst still allowing larger vehicles to circulate, an overrun area (i.e. a raised low profile area around the central island) may be necessary (refer Figure 6.6 and Table 6.1).

It should be capable of being mounted by the trailers of HGVs, but be unattractive to cars e.g. by having a slope and/or a textured surface. Overrun areas must therefore be:

- Constructed of appropriate load-bearing pavement (equivalent to the adjacent carriageway)
- Clearly distinguishable from the general running surface in day and night conditions by having a slope and contrasting surface colour.
- Generally maintenance free and designed so that water runoff will not create ponding issues.
- Free of any street furniture / obstructions.
- Not used on unlit roads.

The profile dimensions of the overrun area are shown in Figure 6.7. The design of the overrun area shall not prevent cyclists crossing it safely, even on an angled approach. If any vertical face is present, the feature will be more difficult and possibly dangerous for cyclists to negotiate.

- (a) = Main central island
- (b) = Central overrun area, where provided
- (c) = Remaining circulatory carriageway width =  
1.0 - 1.2 x maximum entry width
- (d) = Design Vehicle
- (e) = 1m clearance minimum
- (f) = Inscribed Circle Diameter

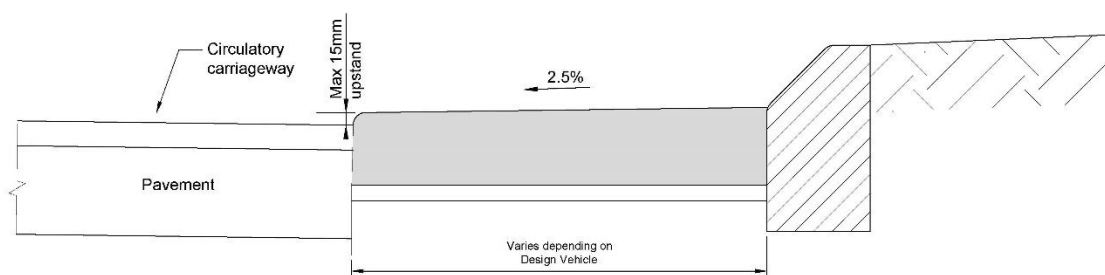


**Figure 6.6 Minimum Turning Widths Required for Single Lane Roundabouts**

**Table 6.1 Centre Island Widths Required for Roundabouts**

| Central Island Diameter (m) | R1(m) | R2(m) | Minimum ICD (m) |
|-----------------------------|-------|-------|-----------------|
| 4.0                         | 3.0   | 13.0  | 28.0            |
| 6.0                         | 4.0   | 13.4  | 28.8            |
| 8.0                         | 5.0   | 13.9  | 29.8            |
| 10.0                        | 6.0   | 14.4  | 30.8            |
| 12.0                        | 7.0   | 15.0  | 32.0            |
| 14.0                        | 8.0   | 15.6  | 33.2            |
| 16.0                        | 9.0   | 16.3  | 34.6            |
| 18.0                        | 10.0  | 17.0  | 36.0            |

In these cases no splitter islands should protrude within the inscribed circle diameter.



**Figure 6.7 Profile of overrun area**

It should be noted that these diagrams show an indicative cross-sectional shape of an overrun area, developed to illustrate the dimensions that must not be exceeded.

### 6.6.4 Splitter Islands

Splitter islands shall be used on each arm, located and shaped so as to separate and direct traffic entering and leaving the roundabout. They shall be raised and kerbed creating a physical restriction that assists in controlling the entry speed and the entry path.

Kerbed splitter islands can act as pedestrian or cyclist refuges provided that they are large enough to give adequate safe standing space for accompanied wheelchair users, and pedestrians with pushchairs or cyclists. Where splitter islands have to accommodate ATUs, they shall be designed in accordance with Section 7.5. When provision for an ATU crossing is made off-line, the splitter island width can be reduced to a minimum of 1.5m. Markings may also be used to extend a splitter island on the approach, the exit or the circulatory carriageway. Signs and other street furniture can be sited on kerbed islands provided that there is sufficient room to maintain the required clearances and they do not obstruct visibility. The provision of directional signage shall be considered when designing the size of splitter islands.

The splitter island length should be carefully designed so that it:

- Gives early warning to drivers that are approaching the junction (especially on high-speed roads and when the approach road is on uphill gradient);
- Prevents traffic exiting the roundabout from encroaching into the opposite traffic lane.



### 6.6.5 Entries

A number of variables need to be considered in selecting an entry design which is safe and has adequate capacity. These variables are:

- a) approach half width ( $v$ );
- b) entry width ( $e$ );
- c) entry flaring ( $F$ );
- d) entry angle ( $\phi$ );
- e) entry kerb radius ( $r$ );
- f) entry path radius (EPR).

These are described below and shown in Figures 6.8 to 6.16.

### 6.6.6 Approach Half Width

The approach half width,  $v$ , is the width of the approach carriageway, excluding any hatching, in advance of any entry flare (see Figure 6.8). It is the shortest distance between the median line, or the edge of the central reserve on dual carriageways / divided roads, and the nearside edge of the road. Where there is white edge lining or hatching, the measurement should be taken between markings rather than kerb to kerb.

### 6.6.7 Entry Width

The entry width, ( $e$ ), is the width of the carriageway at the point of entry. As shown in Figure 6.8, it is measured from the point A at the right hand end of the yield line along the normal to the nearside kerb. For capacity assessment, the measurement should be taken as the total width of the lanes which drivers are likely to use, which is normally between any white edge lining or hatching.

Entry width is a key factor affecting capacity, in conjunction with length and sharpness of flare. One or two extra lanes may be added to the approach at a multi-lane roundabout. However, as a general rule, not more than two lanes should be added and no entry should be more than four lanes wide.

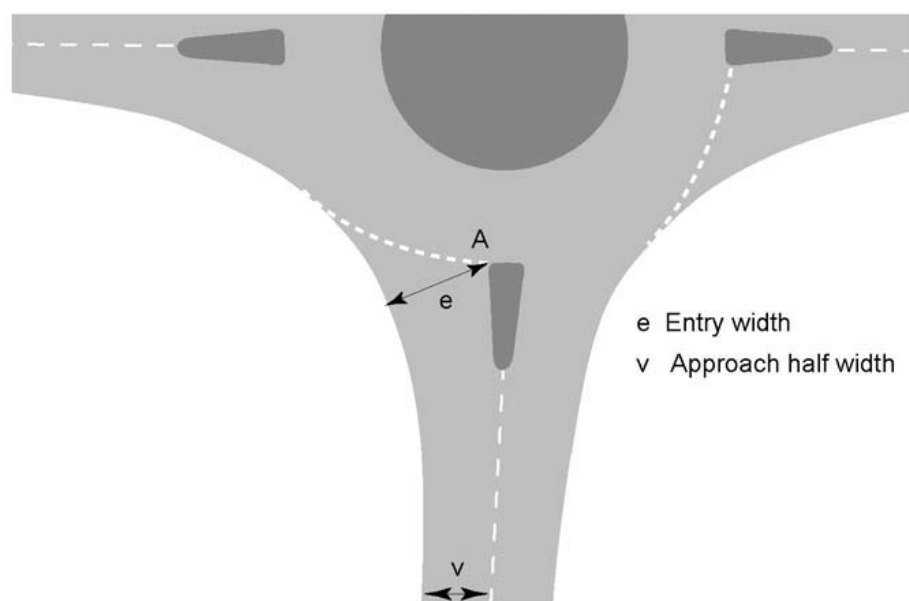


Figure 6.8 Approach Half Width and Entry Width

Lane widths at the yield line (measured along the normal to the nearside kerb, as for entry width) must be not less than 3m or greater than 4.5m, with the 4.5m value appropriate at single lane entries and values of 3 to 3.5m appropriate at multi-lane entries. To avoid introducing undesirable negative flare, potentially reducing capacity, lane widths at the yield line should not be less than the approach width of the same lane.

On a single carriageway approach to a roundabout, the entry width must not exceed 10.5m. On a dual carriageway approach to a multi-lane roundabout, the entry width must not exceed 15m.

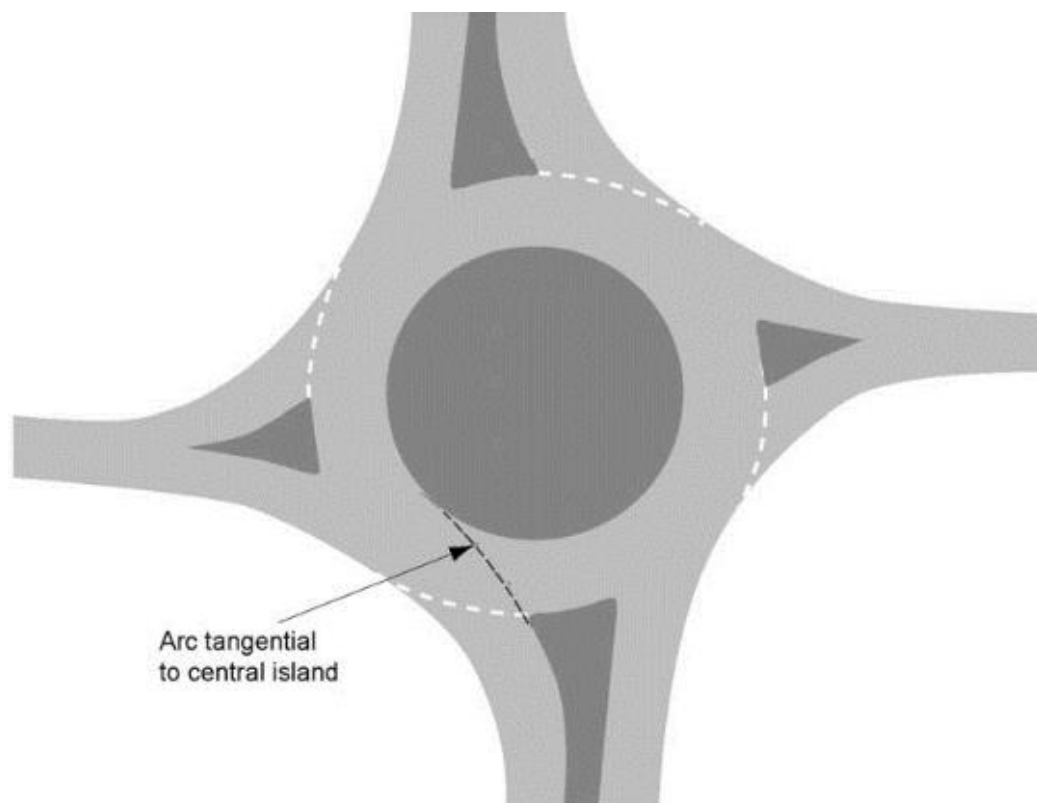
The width of entry shall be able to accommodate the swept path of the entering design vehicle. However, it is important that the entry is not any wider than necessary, as excessive entry width can make it difficult for designers to achieve adequate speed reduction at the entries to the roundabout.

On multi-lane roundabouts, the development of entry lanes must account for the anticipated turning proportions and possible lane bias, since drivers often have a tendency to use the nearside lane. The use of lane bifurcation where one lane widens into two should maximise use of the entry width where traffic analysis indicates that more than one entry lane is required. The use of very short offside lanes is not recommended as they tend to be used infrequently in practice with the result that debris collects on the road surface and forms a safety hazard, particularly for two-wheeled vehicles.

For road improvement schemes on national roads, forecast design year flows sometime after opening will be considered. This can result in roundabout entries with too many lanes for initial flows, subsequently leading to operational problems. A layout based on projected flows will determine the eventual land requirements for the roundabout, but for the early years of operation it may be necessary for the designer to consider an interim layout. This approach can result in reduced entry widths and entry lanes.

### **6.6.8 Alignment of Entry Lanes**

The alignment of entry lanes is critical. The kerb line of the splitter island (or central reserve in the case of a dual carriageway / divided road) should lie on an arc which, when projected forward, meets the central island tangentially (see Figure 6.9).



**Figure 6.9** Arc Projected Forwards from the Splitter Island and Tangential to the Central Island

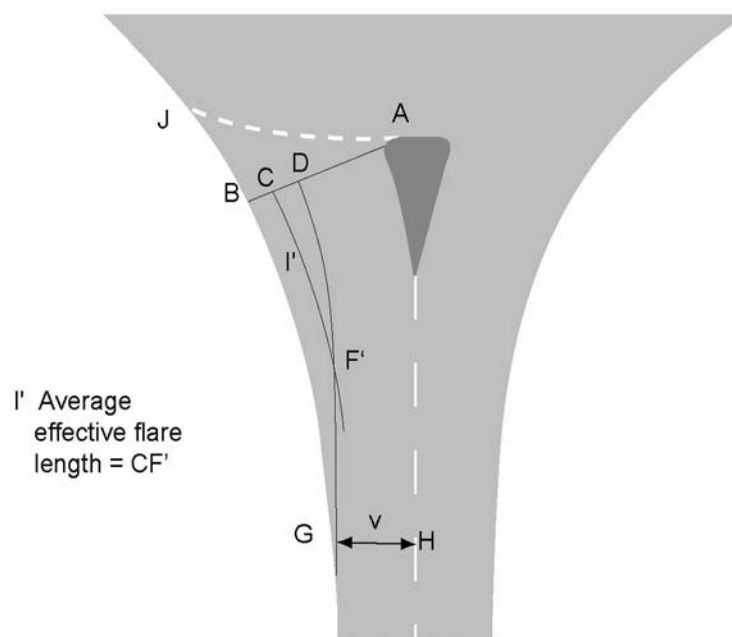
### 6.6.9 Design of Multi-lane Entries

On multi-lane entries, it is important to ensure that entries are configured in order to avoid the situation where some lanes exceed capacity and others are underused. On flared entries, the queue from an overused lane may back up and block access to other lanes.

### 6.6.10 Entry Flaring

Entry flaring is localised widening at the point of entry. Multi-lane roundabouts have flared entries with the addition of one or two lanes at the yield line to increase capacity. Single lane entries should be slightly flared to accommodate the swept path of HGVs. Even a small increase in entry width may increase capacity.

The average effective flare length,  $l$ , is the average length over which the entry widens. It is the length of the curve  $CF'$ , shown in Figure 6.10.



**Figure 6.10 Average Effective Flare Length**

Notes:

$AB = e$  (entry width).

$GH = v$  (approach half width at point G which is the best estimate of the start of the flare).

$GD$  is parallel to  $AH$  and distance  $v$  from  $AH$  ( $v$  is measured along a line perpendicular to both  $AH$  and  $GD$  and, therefore, the length of  $AD$  is only equal to  $v$  if  $AB$  is perpendicular to the median at  $A$ ).

$CF'$  is parallel to  $BG$  and distance  $\frac{1}{2} BD$  from the  $BG$ .

To determine the average effective flare length,  $l'$ :

- construct curve  $GD$  parallel to the median  $HA$  (centre line or edge of central reserve or splitter island) and distance  $v$  from it;
- construct curve  $CF'$  parallel to curve  $BG$  (the nearside kerb) and at a constant distance of  $\frac{1}{2} BD$  from it, with  $F'$  the point where  $CF'$  intersects line  $DG$ ;
- the length of curve  $CF'$  is the average effective flare length  $l'$ .

In cases where the line  $AB$  is not perpendicular to the median, the length  $AD$  will differ slightly from  $v$ .

The total length of the entry widening ( $BG$ ) will be about twice the average effective flare length.

The capacity of an entry can be improved by increasing the average effective flare length. Similar levels of capacity can be obtained with a variety of flare lengths and entry widths. A minimum average effective flare length of 25m in rural areas is desirable, but capacity will be the determining factor.

Effective flare lengths greater than 25m may improve the geometric layout but have little effect in increasing capacity. If the effective flare length exceeds 100m, the design becomes one of link widening. Where the design speed is high, entry widening should be developed gradually with no sudden changes in direction.

The sharpness of flare,  $S$ , is defined by the relationship:

$$S = 1.6 [e-v] / l'$$

It is a measure of the rate at which extra width is developed in the entry flare. The value of S depends on the available land-take and the capacity required. Values of S greater than unity correspond to sharp flares and smaller values ( $0 \leq S \leq 1$ ) to gradual flares. Long gradual flares are most efficient as they make better use of the extra width but sharp flares have a smaller potential of land take. Sharp flares can still give significant increases in capacity and may be appropriate where there is cyclist / pedestrian crossing demand.

The entry width and the average effective flare length are related. The capacity of a wide entry combined with a short flare can be similar to that of a narrow entry combined with a long flare. There are many intermediate combinations of e and l' that will have the same capacity.

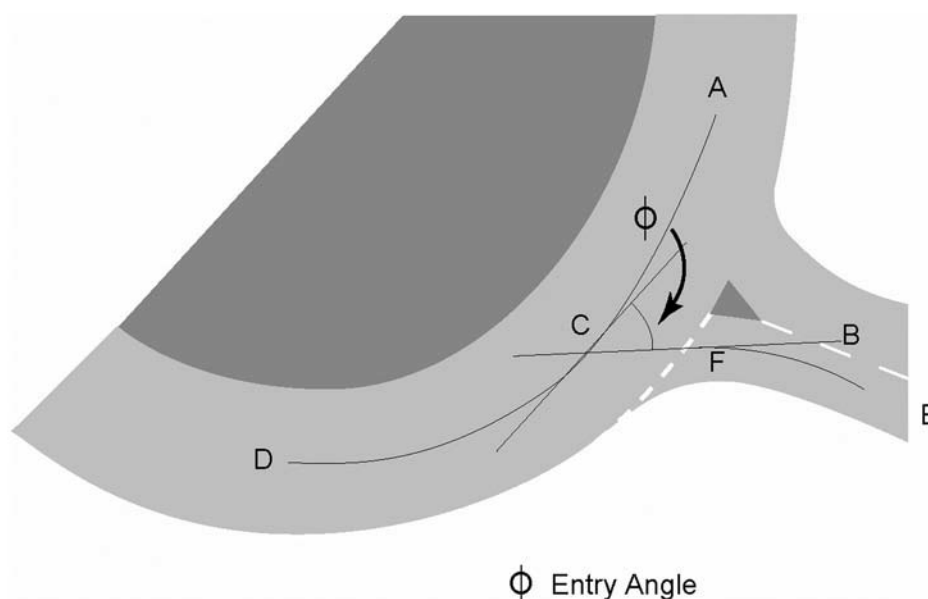
Although entry width and sharpness of flare (which is a function of flare length and widening) have the largest effect on capacity, other variables such as entry angle and entry radius are also important. When capacity is at a premium, small changes in these variables can sometimes provide a bigger increase in capacity than making a large change in a single variable.

### 6.6.11 Entry Angle

The entry angle, ( $\phi$ ), serves as a geometric proxy for the conflict angle between entering and circulating traffic streams. There are two different methods for its measurement, depending on the size of the roundabout.

For a large roundabout where the arms are well separated, the angle measured is in effect that between the projected path of an entering vehicle and the path of a circulating vehicle (see Figure 6.11). To determine the entry angle:

- a) construct the curve EF as the locus of the mid- point between the nearside kerb and the median line (or the edge of any splitter island or central reserve);
- b) construct BC as the tangent to EF at the yield line;
- c) construct the curve AD as the locus of the mid- point of (the used section of) the circulatory carriageway (a proxy for the average direction of travel for traffic circulating past the arm);
- d) the entry angle,  $\phi$ , is the acute angle between BC and the tangent to AD.



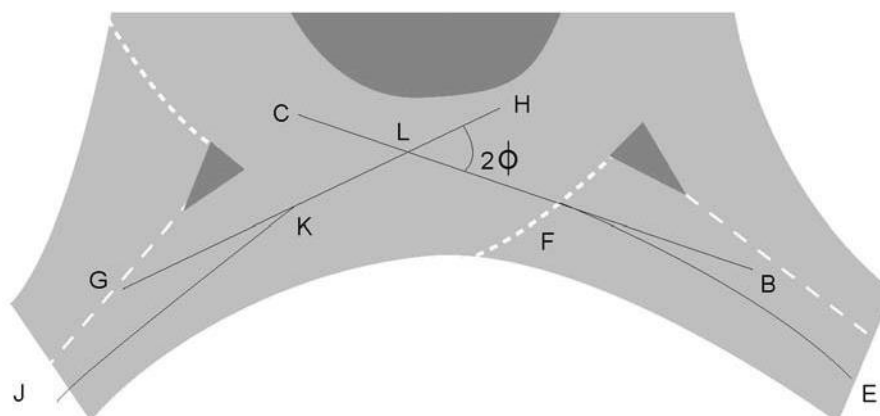
**Figure 6.11 Entry Angle at a Larger Roundabout**

For Single Lane Roundabouts, the entry angle is measured as shown in Figure 6.12. This construction is also used when there is insufficient separation between entry and adjacent exit to be able to define the path of the circulating vehicle clearly. In this case, circulating traffic which leaves at the following exit will be influenced by the angle at which that arm joins the roundabout. The angle between the projected entry and exit paths is measured and then halved to find  $\phi$ :

- construct line BC as in Figure 6.11;
- construct the curve JK in the next exit as the locus of points midway between the nearside kerb and the median line (or the edge of any splitter island or central reserve);
- construct the line GH as the equivalent of line BC i.e. the tangent to the curve JK at the point where JK intersects the border of the inscribed circle;
- the lines BC and GH intersect at L. The entry angle,  $\phi$ , is half of angle HLB.

$$\phi = [\text{angle HLB}]/2$$

Note that if angle GLB exceeds 180 degrees,  $\phi$  is defined as zero.



**Figure 6.12 Entry Angle at a Smaller Roundabout**

If it is not clear which of the two methods should be used, the following procedure should be implemented. All three vehicle paths (entry, exit and circulatory carriageway medians) should be constructed, and the entry and exit paths projected towards the roundabout centre. The choice of construction for  $\phi$  depends on where these projections meet: if the meeting point is closer to the centre of the roundabout than the arc of the circulatory carriageway median, then the construction shown in Figure 6.11 should be used; if they meet outside that area, then the construction illustrated in Figure 6.12 should be used. In the limiting case where all three medians intersect at a point, the circulatory carriageway median approximately bisects the angle between the other two medians, so that the two methods become equivalent.

The entry angle,  $\phi$ , shall lie between 20 and 60 degrees. Low entry angles force drivers to look over their shoulders or use their mirrors to merge with circulating traffic. Large entry angles tend to have lower capacity and may produce excessive entry deflection which can lead to sharp braking at entries, accompanied by shunt collisions, especially when approach speeds are high.

### 6.6.12 Entry Kerb Radius

The entry kerb radius, ( $r$ ), is the radius of curvature of the nearside kerb line over the distance from 25m upstream of the yield line to 10m downstream of it (see Figure 6.13). It is the radius of the best fit circular curve over a length of 25m.

The entry kerb radius should be not less than 10m. At Single Lane Roundabouts, If the approach is intended for regular use by HGVs, the value should be not less than 20m. However, entry kerb radii of 100m or more will tend to result in inadequate entry deflection and should not be used.

Although entry capacity can be increased by increasing the entry kerb radius, once its value reaches 20m, further increases only result in very small capacity improvements. Reducing the entry kerb radius below 15m reduces capacity.

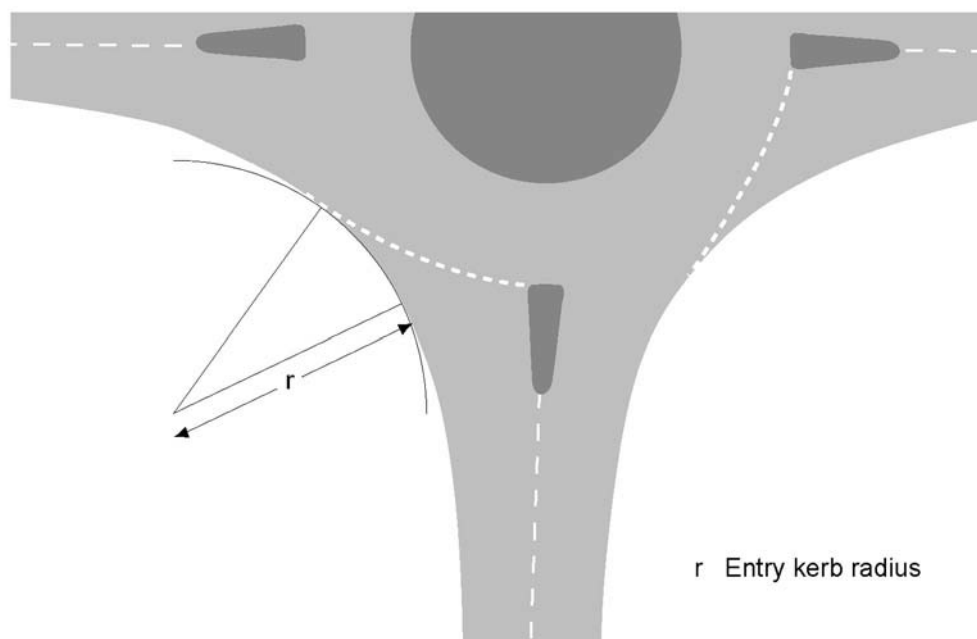


Figure 6.13 Entry Kerb Radius

### 6.6.13 Entry Path Radius

The entry path radius is a measure of the deflection to the left imposed on vehicles entering a roundabout. It is the most important determinant of safety at roundabouts because it governs the speed of vehicles through the junction and whether drivers are likely to yield to circulating vehicles.

To determine the entry path radius, the shortest path allowed by the geometry is drawn. This is the smoothest, flattest path that a vehicle can take through the entry, around the central island and through the exit (in the absence of other traffic) (see Figures 6.14a to 6.15). This path represents the actual vehicle path and must not include instantaneous transitions between circular curves of different radii, including straights.

The path is assumed to be 2m wide so that the vehicle following it would maintain a distance of at least one metre between its centreline and any kerb or edge marking. The path starts 50m in advance of the yield line.

The smallest radius of this path on entry that occurs as it bends to the left before joining the circulatory carriageway is called the entry path radius. Note that this is different to, and should not be confused with, the entry kerb radius as described earlier. It is the radius of the best fit circular curve over a length of 25m.

The entry path radius must be checked for all turning movements on all approaches. For single lane entries, one entry path is drawn (see Figure 6.14a). On multi-lane entries, three entry paths are drawn, as follows:

1. Nearside lane entry (refer Figure 6.14b)
2. Offside lane entry (refer Figure 6.14c)
3. Cutting across lanes entry (refer Figure 6.14d)

The entry path radius must not exceed 100m for all vehicle paths at all roundabout types on rural national roads.



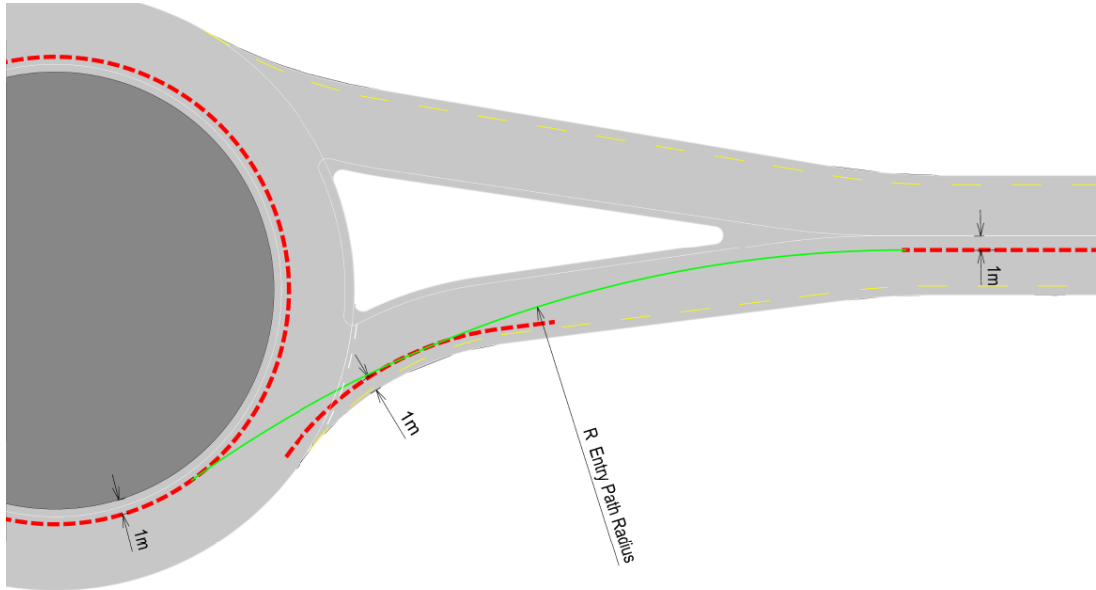


Figure 6.14a Entry Path Radius - Single Lane Entry

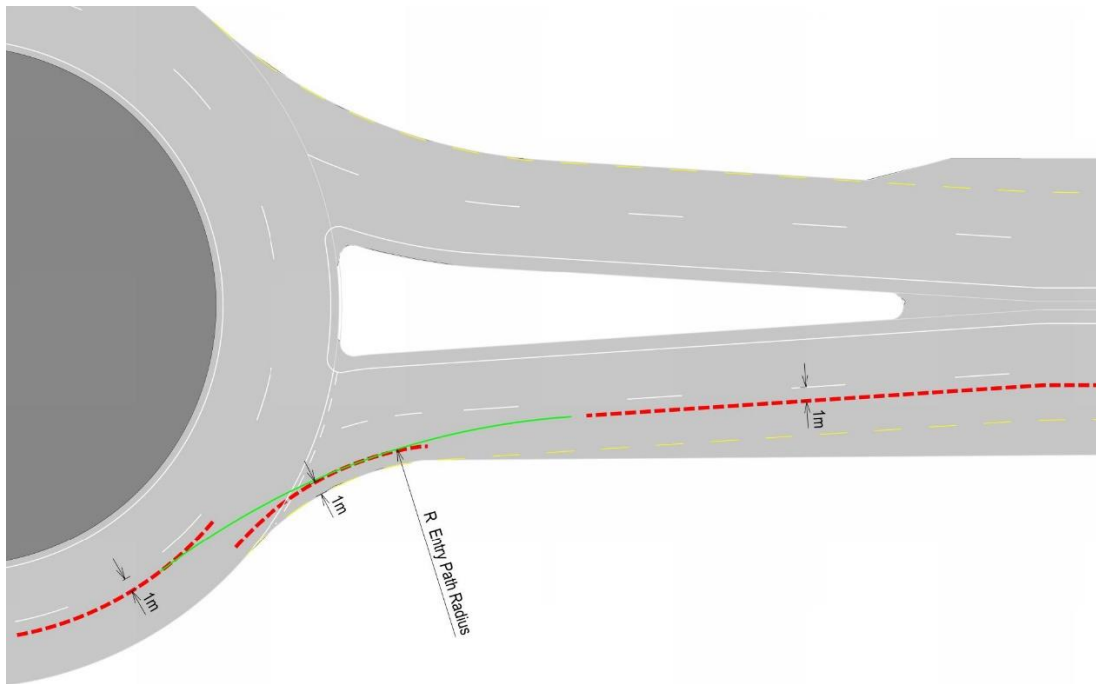


Figure 6.14b Entry Path Radius – Nearside Lane Entry

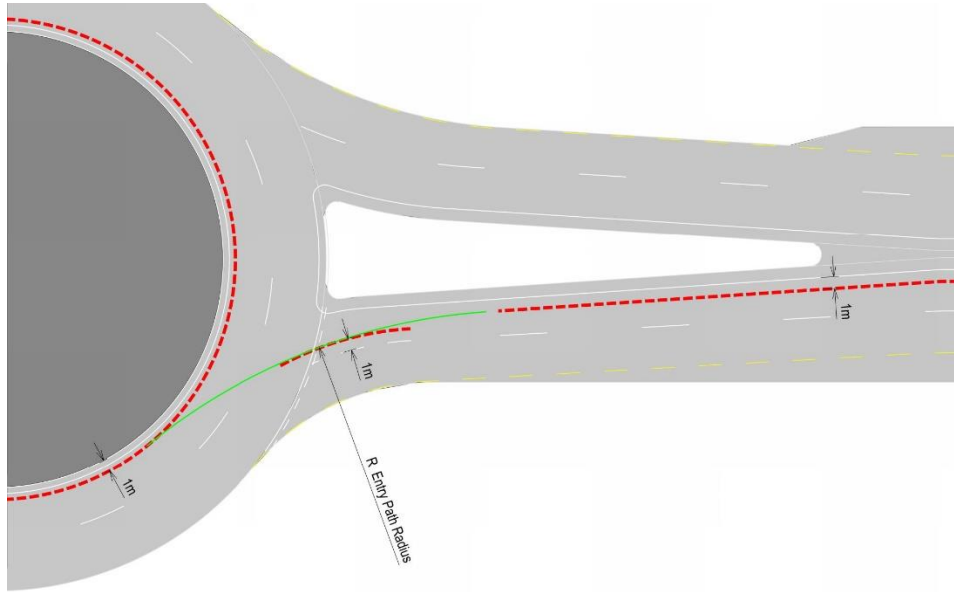


Figure 6.14c Entry Path Radius - Offside Lane Entry

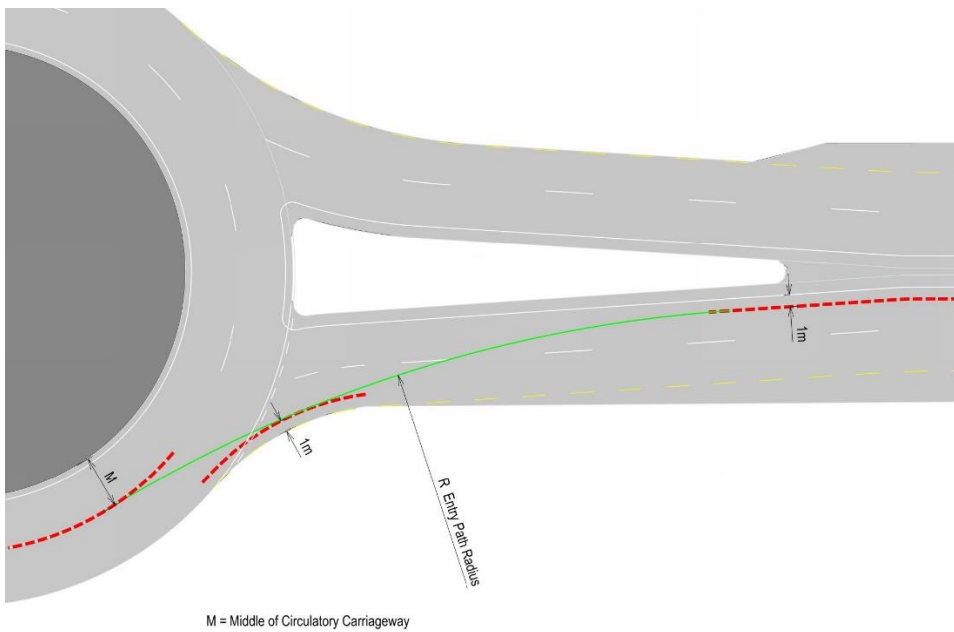
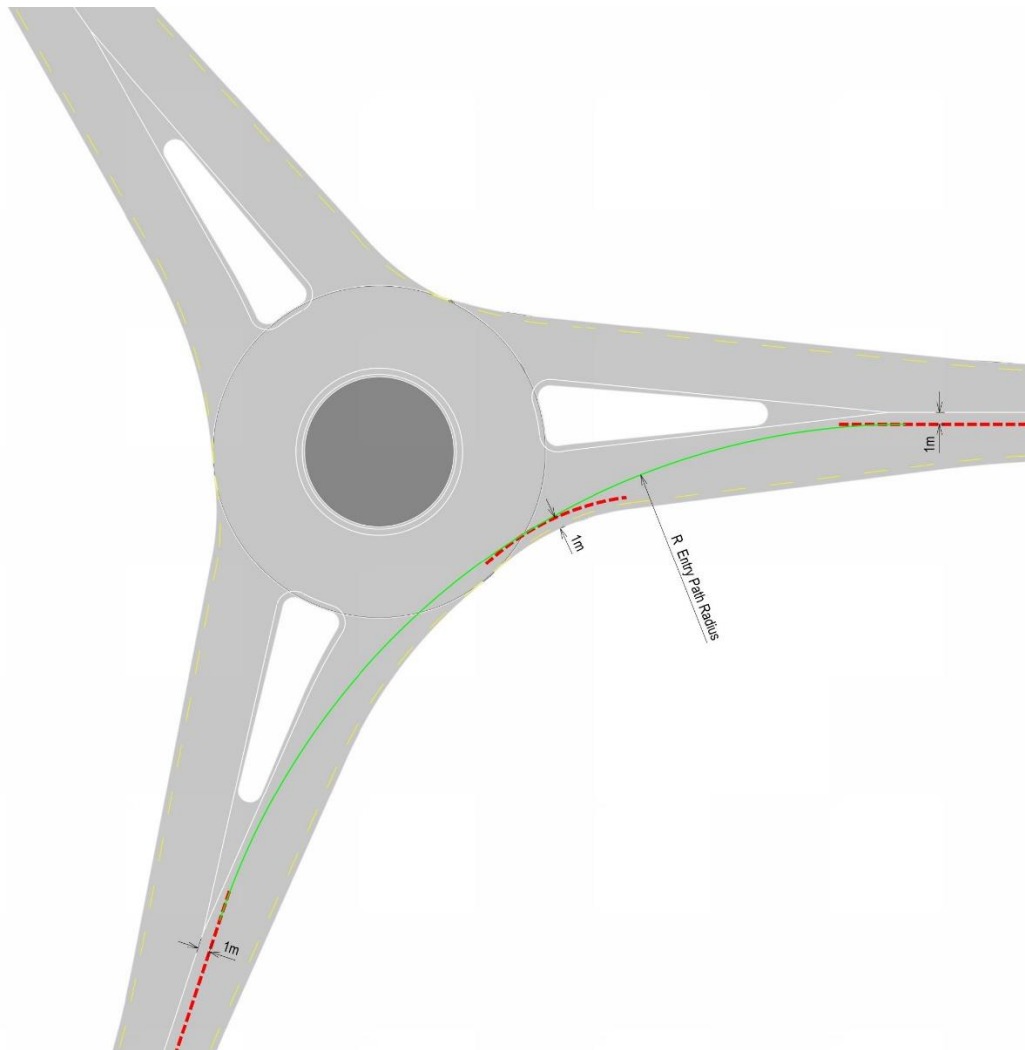


Figure 6.14d Entry Path Radius – Cutting Across Lanes Entry



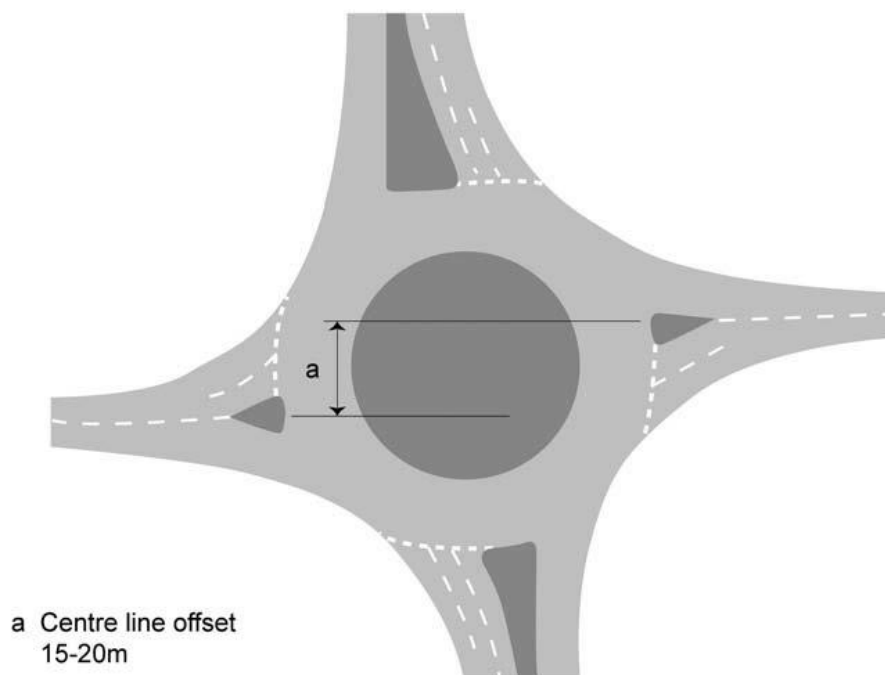
**Figure 6.15** Determination of Entry Path Radius for the Left Turn at a Roundabout at a Y-junction

A method for creating entry deflection at a roundabout is to stagger the arms as shown in Figure 6.16. This will:

- a) reduce the size of the roundabout;
- b) minimise land acquisition;
- c) help to provide a clear exit route with sufficient width to avoid conflicts.

Sharp curves on the link road design should not be introduced to increase entry deflection, although a gentle curve to the right preceding left hand entry deflection may be used.

The design of Single Lane Roundabouts is similar to that for Multi-lane Roundabouts, but the single-lane entries, circulatory carriageway and exits are retained.



**Figure 6.16 Staggering of Arms to Increase Deflection**

## 6.6.14 Exits

### Exit Width

The exit width is the width of the carriageway on the exit and is measured in a similar manner to the entry width. It is the distance between the exit median (or the edge of any splitter island or central reserve) along the normal to the nearside kerb.

The exit width will be dictated by the number of exit lanes which is determined by capacity needs. At a Single Lane Roundabout, the exit width should be similar to the entry width, reducing at a rate of 1:15 to 1:20 to the standard lane width on the downstream link.

At Multi-lane Roundabouts, the exit may accommodate one or more lanes depending on capacity needs and the cross-section of the downstream link. The following approach shall be taken when designing the exit width:

- Where a single lane exit is provided, the exit width shall conform to that of a Single Lane Roundabout (described above).
- Where the downstream link is a single carriageway, but an additional exit lane is required at the roundabout, the exit width should be between 7m and 7.5m and the exit should taper down to a minimum of 6m (see Figure 6.17) at the end of the splitter island, allowing traffic to pass a broken down vehicle. Thereafter, the width shall be reduced at a rate of 1:15 to 1:20 to the standard lane width on the downstream link.
- Where the downstream link is an all-purpose two-lane dual carriageway, the exit width should be between 10m and 11m and the exit should taper down to two lanes wide.

Where the exit is on an up gradient, the exit width may be maintained for a short distance before tapering in. This helps reduce intermittent congestion caused by slowly accelerating HGVs by giving other drivers an opportunity to overtake them.

If the exit road is on an up gradient combined with an alignment which bends to the left, it may be necessary to maintain the exit width over a longer distance to help ensure that overtaking manoeuvres can be completed before the merge is encountered.

As a general rule, the number of exit lanes must be no greater than the number of circulating lanes. Where the number of exit lanes is less than the number circulating lanes, it may be beneficial to include pavement arrows on the approaches to signify that a lane-drop around the circulatory carriageway is approaching. Further advice is provided in Appendix E.

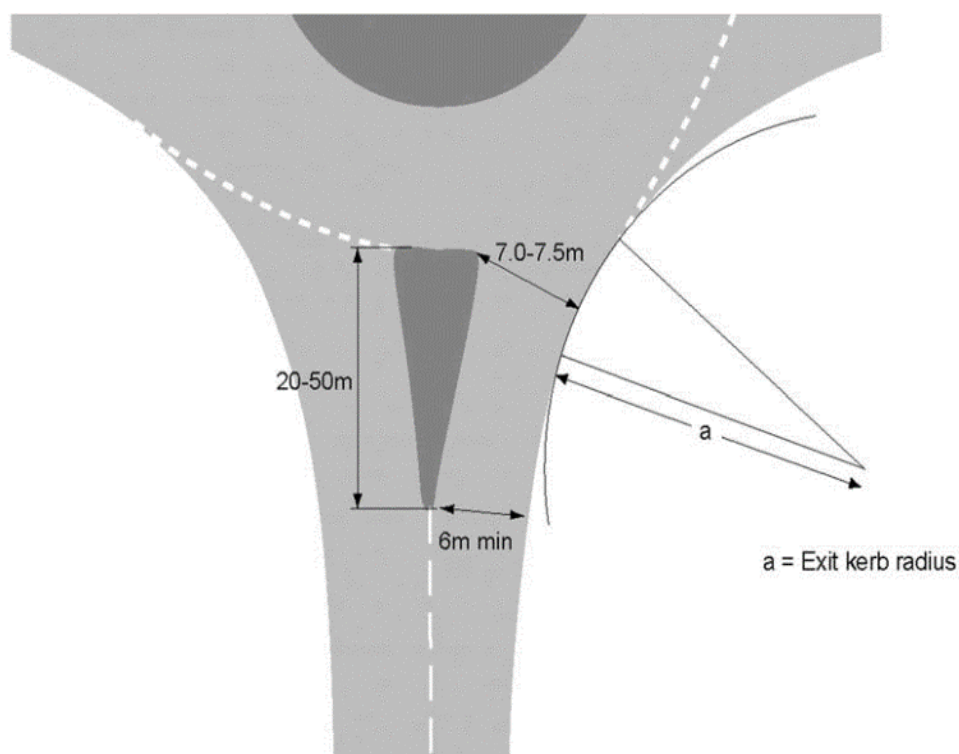


Figure 6.17 Typical Single Carriageway Exit at a roundabout

### Exit Kerb Radius

The exit kerb radius ( $a$ ) is shown in Figure 6.17. Values for the exit kerb radius should exceed the largest entry radius (except at Single Lane Roundabouts, where they should be equal).

At a Single Lane Roundabout, the value of the exit kerb radius should be between 15m and 20m.

At other roundabouts, the exit kerb radius should not be less than 20m or greater than 100m. A value of 40m is desirable, but for larger roundabouts on high speed roads, a higher value may suit the overall junction geometry. A compound curve starting with a 40m radius and developing to a larger radius, of up to 100m, will usually offer the best solution. Larger values of exit radii may lead to high exit speed, which will not be appropriate if there are significant numbers of cyclists using the junction or where pedestrian/cyclist crossing facilities are located immediately downstream.

The shortest distance possible between an entry arm and the next exit is governed by the minimum entry radius (10m) and the minimum exit radius for the type of roundabout in question (15m at a Single Lane Roundabout, otherwise 20m).

If a roundabout is to be modified to include an additional arm, care should be taken to ensure that this does not affect safety at the preceding entry and following exit.

It may be necessary to redesign the whole junction if adequate spacing and deflection between entries and adjacent exits cannot be achieved.

Exits should be checked to ensure that vehicle paths are smooth and vehicles are not directed towards splitter islands. Splitter islands should end at a tangent (or, at least, parallel) to the centre line and be long enough to prevent an exiting vehicle from crossing the centre line into oncoming traffic.

If the peak exit volume approaches the capacity of the downstream link, tapers longer than 1:20 may be needed to merge the traffic as the traffic density in each lane will be high.

If circulatory speeds are high, sharp turns into exits can increase the likelihood of load shedding by HGVs and decrease the traffic capacity of the junction.

## **6.7 Visibility**

### **6.7.1 General**

Except for visibility to the right at entry and across the central island as set out in this Chapter, the envelope of visibility for the measurement of stopping sight distance on the approaches to the roundabout shall be in accordance with DN-GEO-03031.

Where Active Travel crossings are provided at the roundabout, visibility to the crossing shall be in accordance with Section 7.5.1 of this standard.

Where signs are to be erected on a central reserve, verge or splitter island within the envelope of visibility, including to the right, care must be taken to ensure that the signs do not obstruct sight lines. For the mounting height refer to the Traffic Sign Manual.

### **6.7.2 Forward Visibility on Approach (Stopping Sight Distance)**

Visibility on the approach must be measured to an object at the yield line as indicated in Figure 6.18. Visibility shall meet the requirement stated in DN-GEO-03031 corresponding to the Desirable Minimum Stopping Sight Distance for the design speed of the approach road.

For chevron signs on the central island refer to the Traffic Signs Manual.

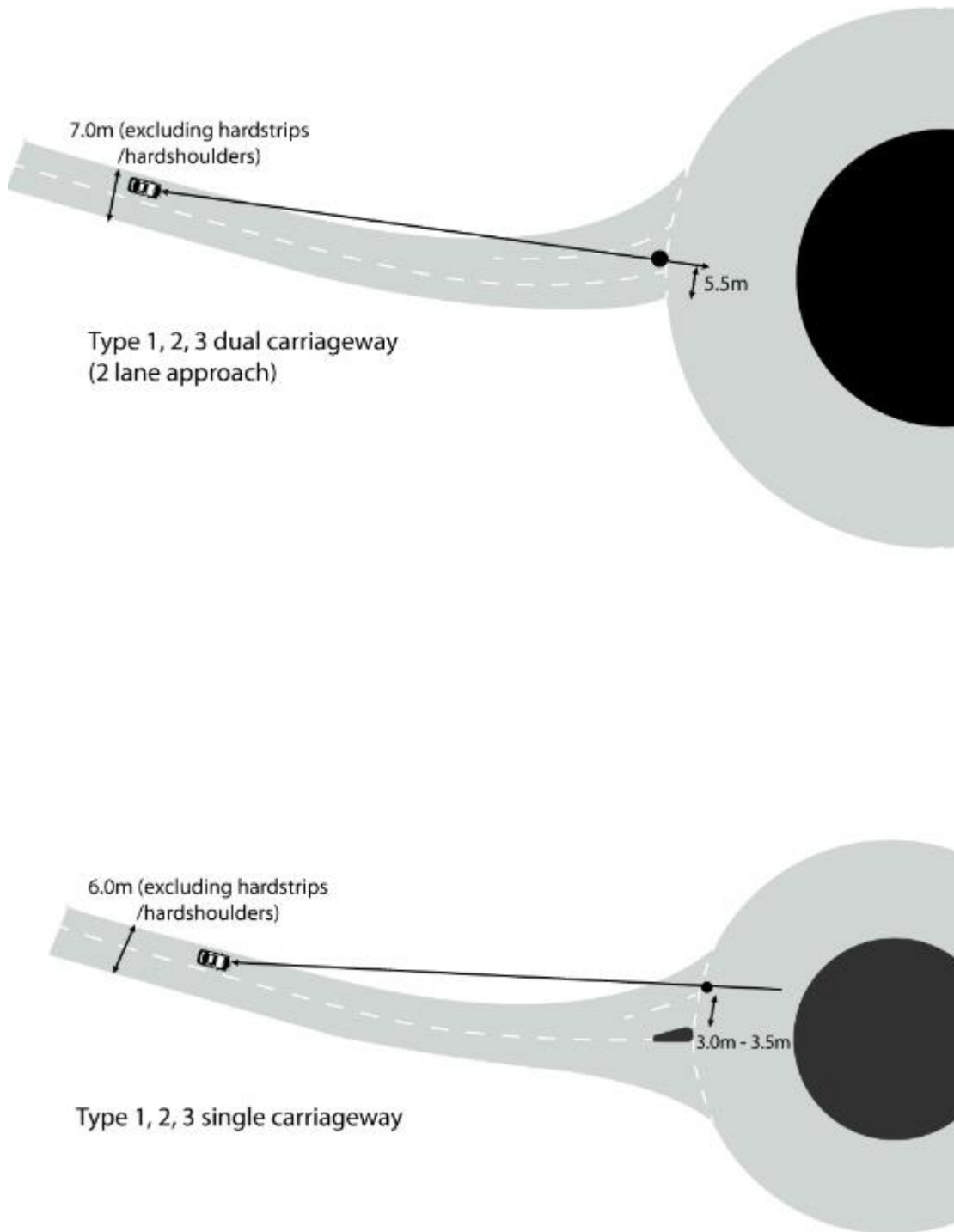


Figure 6.18 Measurement of Stopping Sight Distance on Curved Approach

### 6.7.3 Forward Visibility at Entry

Drivers of all vehicles approaching the yield line must be able to see objects on the roadway for the full width of the circulatory carriageway for the Visibility Distance given in Table 6.2 (measured along the centre of the circulatory carriageway as shown in Figure 6.19). The height of objects shall be consistent with those used for measurement of stopping sight distance as outlined in DN-GEO-03031. The visibility must be checked from the centre of the nearside lane at a distance of 15m back from the yield line, as shown in Figure 6.19.

### 6.7.4 Visibility to the Right

Drivers of all vehicles approaching the yield line must be able to see the full width of the circulatory carriageway to their right, from the centre of the offside lane at the yield line, for the Visibility Distance given in Table 6.2 (measured along the centre of the circulatory carriageway), as shown in Figure 6.20.

**Table 6.2 Roundabout Minimum Visibility Requirement**

| Inscribed Circle Diameter (m) | Visibility Distance (m) ('a' in Figures) |
|-------------------------------|--|
| <40                           | Whole junction                           |
| 40 – 60                       | 40                                       |
| 60 – 100                      | 50                                       |
| >100*                         | 70                                       |

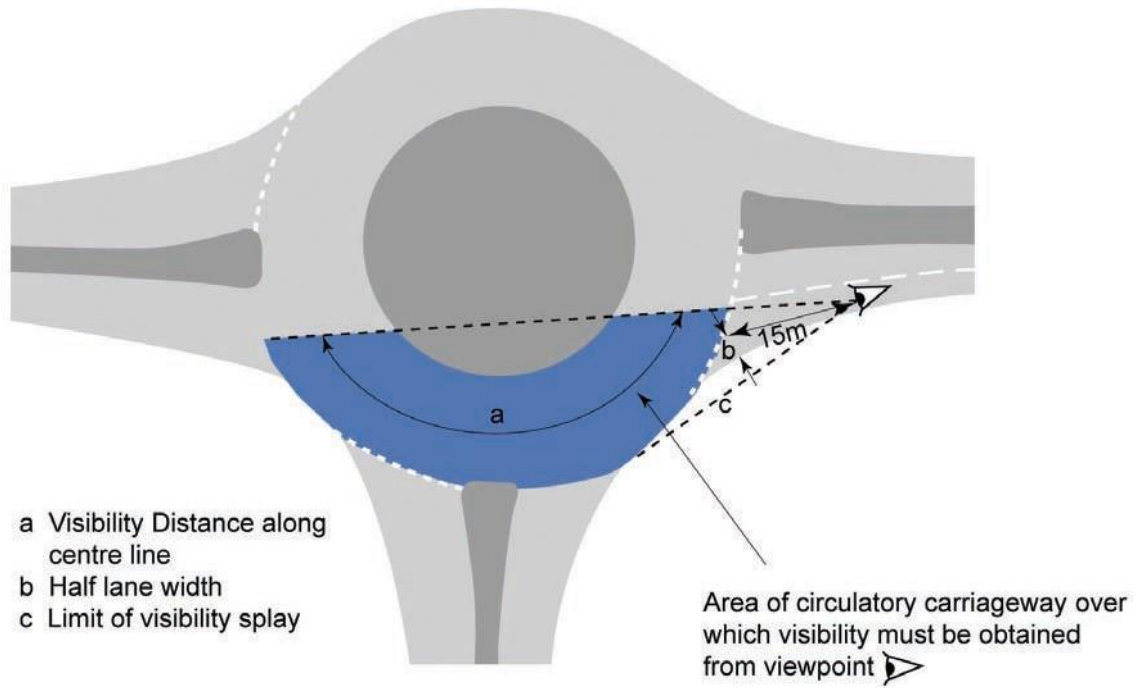
\*ICD >100m shall require a Departure from Standards.

Visibility to the right must also be provided from the centre of the offside lane at a distance of 15m back from the yield line, as shown in Figure 6.21.

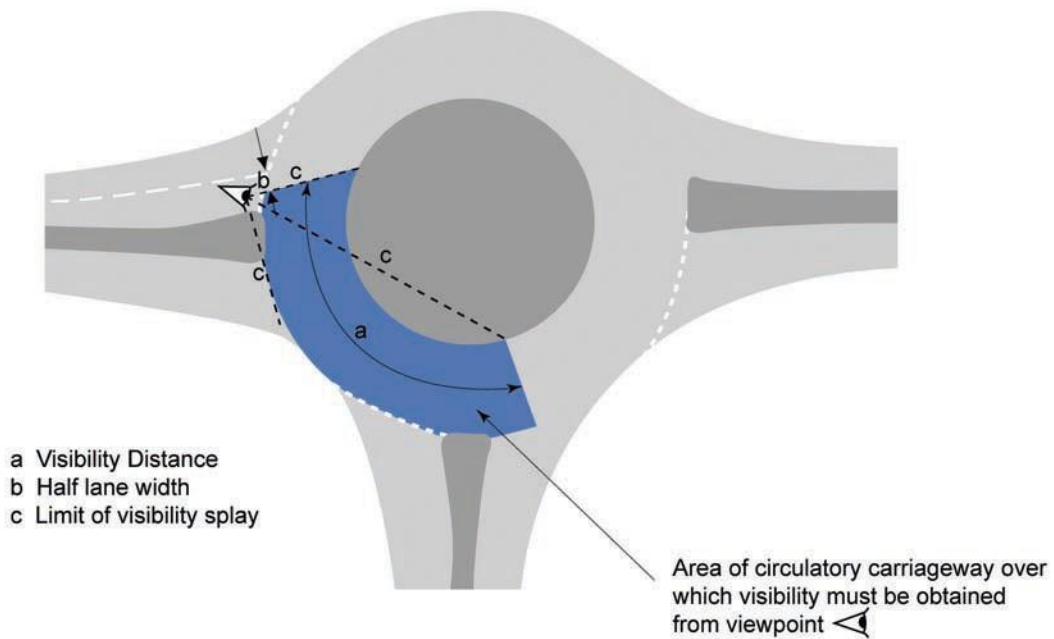
The envelope of visibility to the right must be obtainable from a driver's eye height of between 1.05m and 2m to an object height of between 1.05m and 2m. Object height is adjusted for this visibility check and is expected to be for oncoming traffic and not objects on the roadway.

Excessive visibility to the right can result in high entry speeds, potentially leading to collisions. On dual carriageway / divided road approaches where the speed limit is greater than 60km/h, limiting visibility to the right by screening until the vehicle is within 15m of the yield line can be helpful in reducing excessive approach speeds. The screening should be at least 2m high, in order to block the view of all road users. Screening can also be used on flared approaches on high speed single carriageway roads where there is a long splitter island.

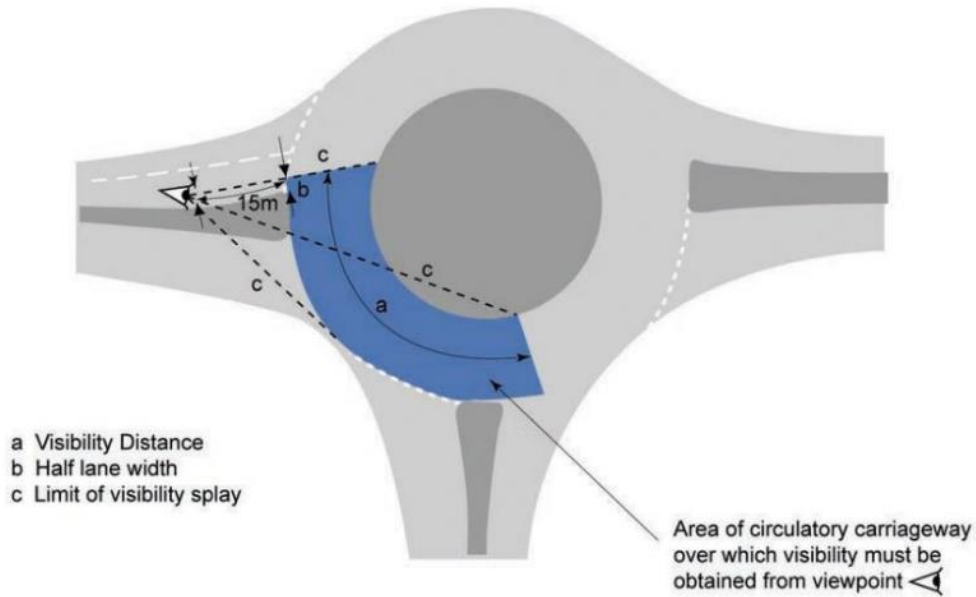




**Figure 6.19 Forward Visibility Required at Entry**



**Figure 6.20 Visibility to Right along Circulatory Carriageway Required at Entry (from Yield Line)**

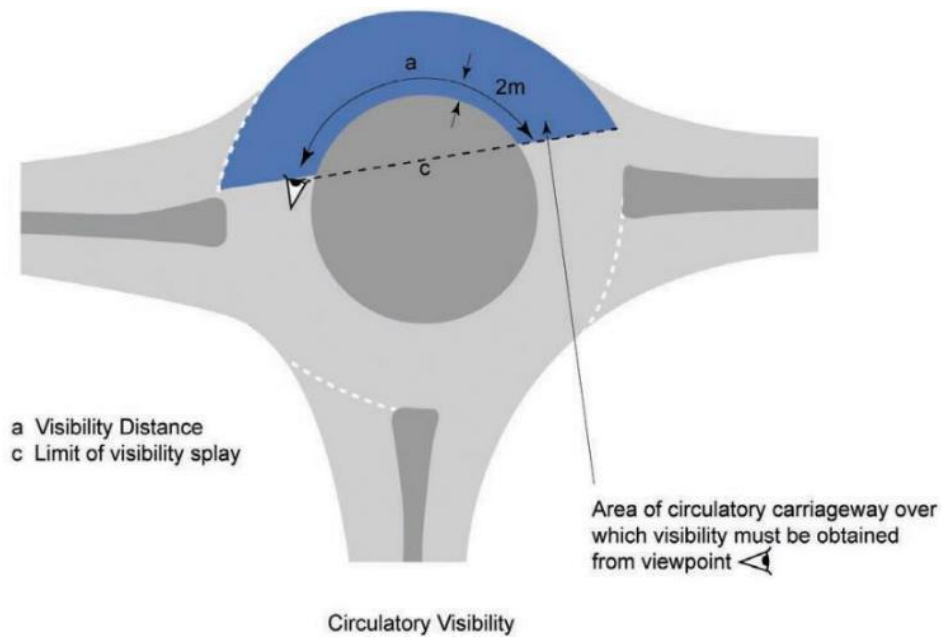


**Figure 6.21** Visibility to Right along Circulatory Carriageway in Advance of Yield Line

### 6.7.5 Circulatory Visibility

Drivers on the circulatory carriageway shall be able to see the full width of the circulatory carriageway ahead of them for the visibility distance given in Table 6.2. This visibility must be provided at a distance of 2m in from the central island, as shown in Figure 6.22. The envelope of visibility must be obtainable from a driver's eye height of between 1.05m and 2m to an object height of between 1.05m and 2m.

The circulatory visibility needs to be checked to ensure it is not obstructed by landscaping or other features. Normally, at least the outer 2m of the central island should be hard standing or planted with grass or similar low level vegetation.



**Figure 6.22** Circulatory Visibility Required

### **6.7.6 Exit Visibility**

On the circulatory carriageway, the exit visibility shall conform to Table 6.2. Once a vehicle has crossed the inscribed circle at the exit from the roundabout, the Stopping Sight Distance shall conform to DN-GEO-03031.

### **6.7.7 Visual Intrusion**

Signs and street furniture should be located and designed so as not to obstruct road users' visibility. However, isolated objects less than 550mm wide such as lamp columns, sign supports or bridge columns within the visibility envelopes are acceptable.

### **6.7.8 Visibility at Grade Separated Junctions**

At roundabouts on grade separated junctions in particular, care is needed to ensure that the yield line is clearly visible to approaching drivers. Visibility at a roundabout can also be impacted by the position of safety barriers, parapets and bridge abutments. Designers shall ensure that the design of safety barriers and parapets does not reduce the visibility requirements outlined in this Chapter.

## **6.8 Crossfall**

### **6.8.1 Crossfall and Longitudinal Gradient**

Steep gradients should be avoided at roundabout approaches or flattened to a maximum of 2% for a minimum distance of 25m before entry. Crossfall and longitudinal gradient combine to provide the necessary slope to drain surface water from the carriageway. The minimum resultant gradient of any part of the road surface within 50m of the roundabout shall be 1% in accordance with DN-GEO-03031. This may be reduced locally to 0.5% at the direct interface between the approaching road and the circulatory carriageway in difficult circumstances.

On the approaches and exits, superelevation can assist drivers in negotiating the associated curves. Its value, when used, should be appropriate to the speed of vehicles, and equal to or greater than those necessary for surface drainage, but should not exceed 5% (1 in 20).

On entries, superelevation should be reduced to 2% at 20m from the yield line, since with adequate advance signing and entry deflection, speeds on approaches should be reducing. At exits, superelevation should be provided where necessary to allow vehicles to accelerate safely away from the roundabout. However, as with entries, crossfall within 20m of the roundabout ICD should not exceed 2%. If the exit leads into a right hand curve, superelevation should be introduced in accordance with DN-GEO-03031.

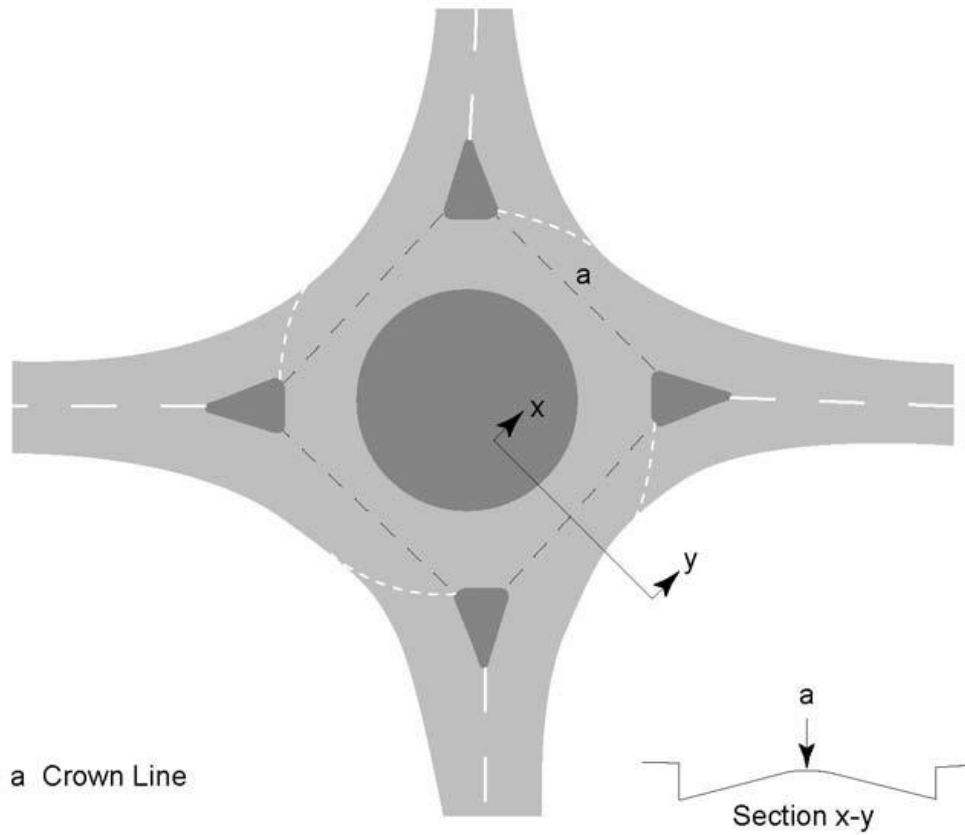
The minimum longitudinal gradient of the circulatory carriageway shall be 0.5%. The maximum longitudinal gradient shall be 2.5%. Gradients outside these limits will require a Departure from Standard.

### **6.8.2 Crossfall on the Circulatory Carriageway**

Crossfall is required to drain surface water on circulatory carriageways. The normal value is 2% (1 in 50). It should not exceed 2.5% (1 in 40). To avoid ponding, longitudinal edge profiles should be graded at not less than 0.67% (1 in 150), with 0.5% (1 in 200) considered the minimum. The design gradients do not in themselves ensure satisfactory drainage, and, therefore, the correct siting and spacing of gullies is critical. Gullies shall not be located at any pedestrian crossing location.

At roundabouts on high speed roads, crossfall shall be arranged to assist vehicles. To do this, a crown line is formed. This line can either join the ends of the splitter islands as shown in Figure 6.23, or divide the circulatory carriageway in the proportion 2:1 internal to external (Figure 6.24).

In some cases, a subsidiary crown line may assist in achieving appropriate values of crossfall without giving excessive changes at the main crown line (Figure 6.25).



**Figure 6.23 Using One Crown Line to Join Splitter Islands**

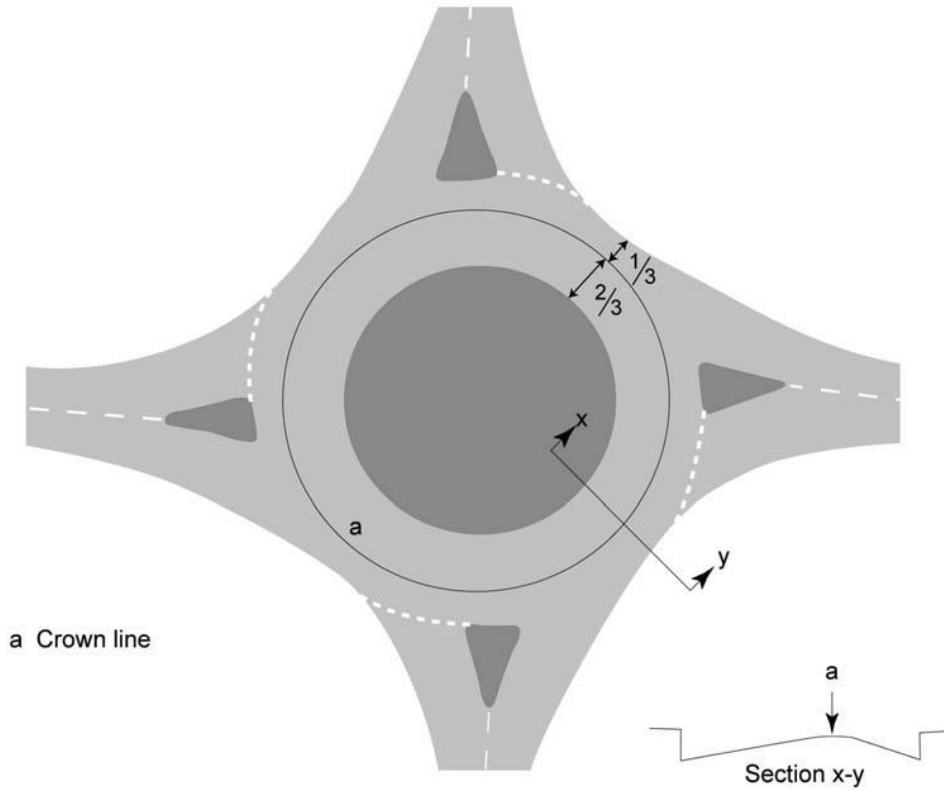


Figure 6.24 Using One Crown Line to Divide the Carriageway in the Ratio 2:1

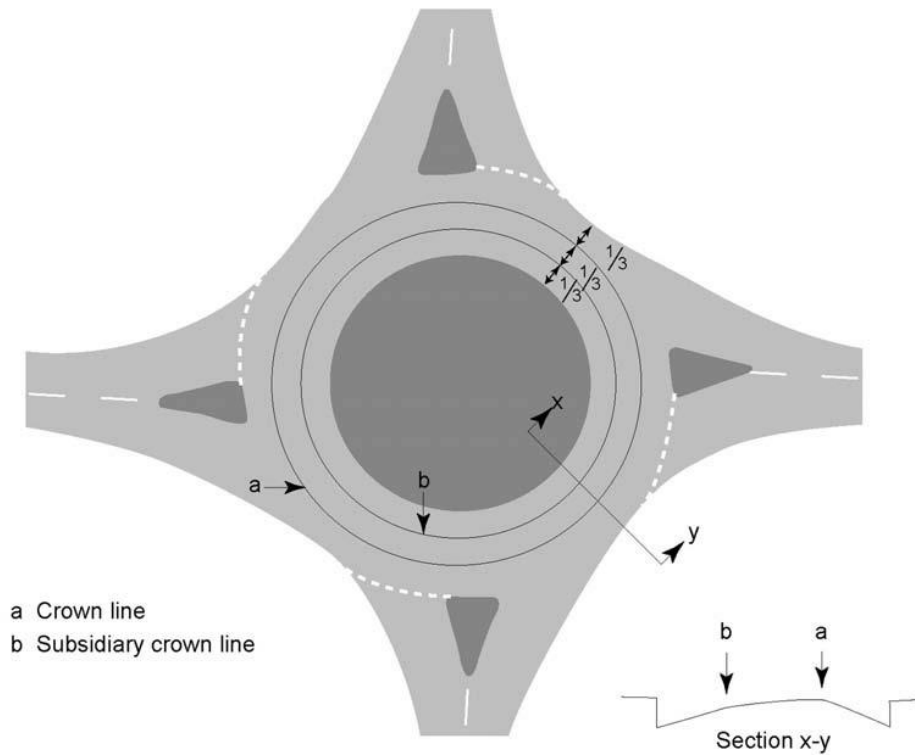


Figure 6.25 Using Two Crown Lines

The conflicting crossfalls at the crown lines have a direct effect on driver comfort and may also be a contributory factor in load shedding and HGV roll-over collisions. Over a given section, the maximum recommended arithmetic difference in crossfall is 5%. Lower values are desirable, particularly for roundabouts with a small inscribed circle diameter. There should be no sharp changes in crossfall and a smooth crown is essential.

At Single Lane Roundabouts, it is more appropriate to apply constant crossfall in one direction across the full width of the circulatory carriageway. This crossfall should slope outwards to ease drainage and help keep speeds down. It also makes the central island more conspicuous.

## 6.9 Road Marking and Signing

Road markings and signing are an integral part of the roundabout design process which are intrinsically related to the geometry, safe operation and capacity of the roundabout. Appendix E provides guidance on the use of road markings aimed at ensuring safe and intuitive layout.

Multi-lane roundabouts and/or roundabouts with high flows and inscribed circle diameters close to the recommended maximum will need careful consideration in terms of signage and marking provision on the approaches and circulatory carriageway.

Turn Left signs should only be used with caution on the circulatory carriageway, to avoid drivers mistakenly turning into roundabout entries. They should be used only on the central island of the roundabout in conjunction with the Chevron board as per Chapter 6 of the TSM.

The Traffic Signs Manual provides guidance on the signs to be used at roundabouts. Where additional road markings are used to designate lanes on the approaches and circulatory carriageways, complementary signs are used. On wide approaches and circulatory carriageways where tall vehicles could obscure post mounted signs, gantry mounted signs are recommended.

Chevron signs can impinge on circulatory visibility, but the effects can be minimised by positioning the signs 2m back from the central island kerb line.

## 6.10 Kerbing and Verge Width

Roundabout entries and exits shall be kerbed. Where kerbs are not present on approach links, the kerbs shall start at the point where the hard strips or hard shoulders terminate as shown in Figure 6.26 and 6.27.

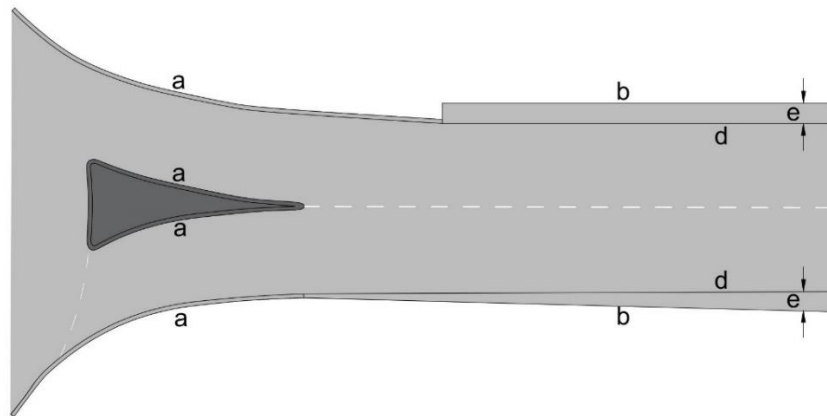
The preferred method of terminating the hard strips or hard shoulders on entry is to taper the edge of pavement towards the edge of carriageway, however, the designer should ensure that no negative flare is introduced if this method is adopted. Alternatively, the edge of carriageway could be tapered to the edge of pavement increasing the entry width.

On the exit, the hard strips or hard shoulders should start where the exit width returns to the nominal value of the approach carriageway, with the edge line continuing along the projected line of kerbing once this is terminated. This avoids situations where vehicles might pull into the hard shoulder on the immediate exit from the roundabout.

The verge width should be at least 2.5m and should generally be consistent around the roundabout. Further advice is given in DN-GEO-03036. Factors that should be taken into account in determining verge width include:

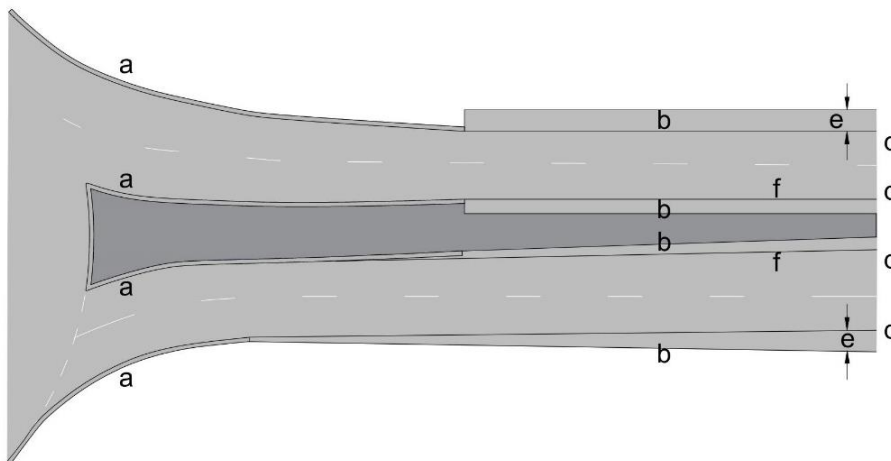
- a) visibility requirements;

- b) space required to accommodate buried services, road signs and other street furniture;
- c) maintenance access;
- d) any likely future traffic increases that could require an increase in carriageway width.
- e) accommodation for active travel facilities



a - Kerbs  
 b - Edge of pavement  
 d - Edge of carriageway  
 e - Hard strip / hard shoulder width

**Figure 6.26 Method of Terminating Edge Strips on a Single Carriageway Approach to a Roundabout**



a - Kerbs  
 b - Edge of pavement  
 d - Edge of carriageway  
 e - Hard strip / hard shoulder width  
 f - Offside hard strip

**Figure 6.27 Method of Terminating Edge Strips on a Dual Carriageway / Divided Road Approach to a Roundabout**

## 6.11 Heavy Goods Vehicles

The problem of HGVs overturning or shedding their loads at roundabouts has no obvious solution in relation to layout geometry. Whilst this type of collision may infrequently cause personal injury, there are considerably more damage only incidents. Load shedding often results in congestion and delay, and is expensive to clear, especially if occurring at major junctions. Experience suggests that roundabouts where these problems persist usually exhibit one or more of the following features:

- a) Inadequate entry deflection leading to high entry speeds;
- b) Long straight sections leading into deceptively tight bends;
- c) Excessive visibility to the right;
- d) Low circulating flow past the entry;
- e) Tightening of the line on circulation;
- f) Sharp turns into exits;
- g) Excessive crossfall changes;
- h) Excessive adverse crossfall on circulatory sections;
- i) Double or reverse curvature.

A problem for some vehicles may be present even if speeds are not high. Research has shown that an articulated HGV with a centre of gravity height of 2.5m above the ground can overturn on a 20m radius bend at speeds as low as 25 km/h. Layouts designed in accordance with the recommendations in this standard should avoid the problems listed above. However, designers should recognise that each site will be different and designs should be specifically checked to ensure that such problems are avoided. During construction, particular attention should be paid to ensure that pavement surface tolerances are complied with and that abrupt changes in crossfall are avoided.

## 6.12 Segregated Left Turn Lanes at Roundabouts

The provision of a Segregated Left Turn Lane at roundabouts requires a Departure from Standard. Where considered necessary and justified, these shall be designed in accordance with Appendix F.





## **7. Active Travel Facility Junctions and Crossings**

### **7.1 General**

This Chapter describes the requirements for Active Travel crossing treatments on National Roads remote from a junction and crossing treatments at At-Grade junctions such as priority junctions, vehicular accesses, and roundabouts.

As outlined in Section 6.3 of DN-GEO-03031, the requirement for Active Travel facilities on a particular scheme shall be based on the planning and design principles as outlined in PE-PMG-02045. This approach requires the Designer to appraise and define the most appropriate Active Travel facility to be provided based on the need for intervention for a particular scheme.

Online, off-road Active Travel facilities are provided adjacent to a road and these facilities shall comply with the requirements of this standard, DN-GEO-03031 and DN-GEO-03036. The interaction between ATUs and road users is an important component of the overall design of such facilities. Appropriate control measures shall be in place when these users are required to interact, and layouts which are simple to understand and allow for appropriate visibility for both ATUs and motorists is of critical importance.

Where the planning / appraisal process has determined the need for an on-line, off-road Active Travel facility, the design shall seek to minimise direct user conflicts between ATUs and motorists. For example, a two-way facility should be provided on the side of the road which maximises the opportunity for connectivity and minimises the need for crossings and potential conflict points with National Roads.

Notwithstanding the above, there may be areas where crossings / conflicts cannot be avoided, for example remote from a junction in order to provide access to amenities / destinations and across road junctions to facilitate continuity of the facility. In these instances, the requirements outlined in the following sections shall be adopted.

### **7.2 Active Travel Crossing Facilities Remote from a Junction**

Grade separation is preferred where an on-line off-road active travel facility crosses a national road remote from a road junction. At-grade crossings are prohibited on all Motorways, Dual Carriageways and Divided Roads.

On single carriageways, uncontrolled at-grade crossings (with vehicular priority) may be considered where the speed limit is 80km/h or less, the AADT is less than 10,000 and the maximum peak hour volume is less than 1,400vph (two-way). In all other circumstances, grade separated crossings shall be provided.

#### **7.2.1 Grade Separation**

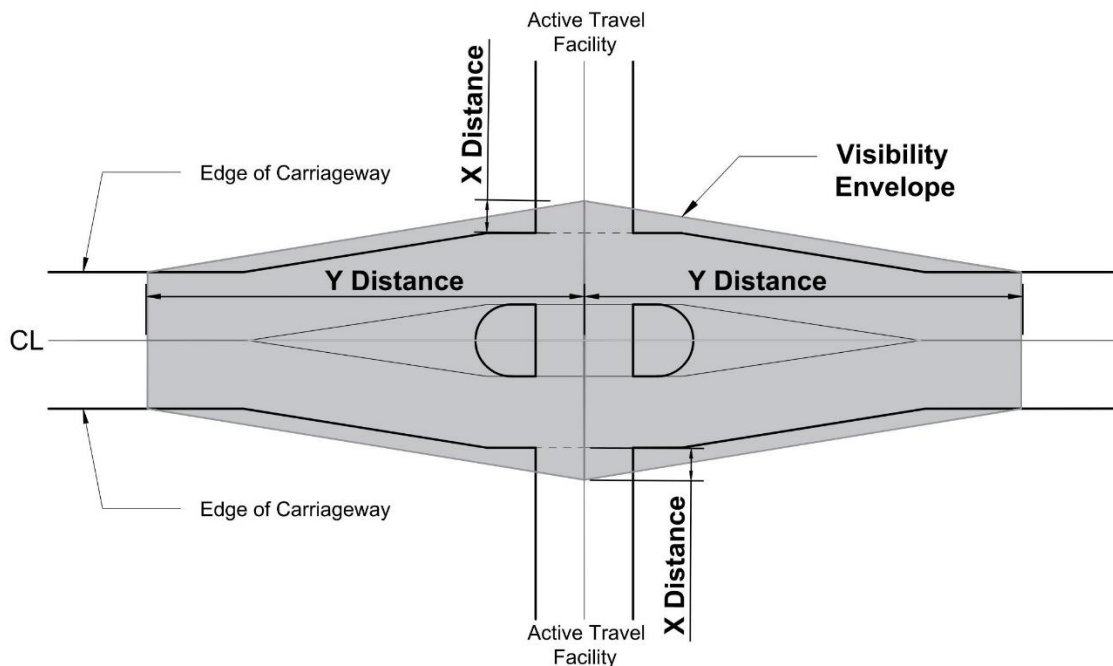
The design of any grade separated Active Travel facility shall be in accordance with DN-GEO-03036 – Cross Sections and Headroom, DN-STR-03005 – Design Criteria for Footbridges, DN-GEO-03040 – Subways for Pedestrians and Pedal Cyclists Layouts and Dimensions, and the requirements of this Standard.

#### **7.2.2 At Grade (Vehicular Priority)**

Where an at-grade Active Travel crossing of a National Road is proposed (as permitted under paragraph 7.2), priority at these crossings is with vehicular traffic on the road.

The at-grade crossing treatment shall be designed in accordance with CC-SCD-00051 and shall provide a central island in order to allow for a safe refuge and two-stage crossing for ATUs. Appropriate traffic calming and speed reduction measures are essential to ensure safety through the crossing for all road users.

Visibility from the active travel facility shall be provided in accordance with Figure 7.1. The required 'X' distance on the active travel facility on the approach to a road shall be 4.0m. The appropriate 'Y' distance depends on the design speed of the road, as set out in Table 5.5.



**Figure 7.1** Visibility envelopes for at-grade active travel crossing of National Roads (remote from a junction)

Where an active travel facility intersects with another active travel facility, the required visibility envelope is dependent on the design speed for cyclists and the 'Y' distance is that presented under in Table 7.1 for Minimum Stopping Sight Distance. The required 'x' distance shall be 4.0m.

**Table 7.1** Stopping Sight Distances

| Design Speed (km/h)                 | 50km/h | 30km/h | 10km/h |
|-------------------------------------|--------|--------|--------|
| Minimum Stopping Sight Distance (m) | 60     | 35     | 15     |

### 7.3 Provision for Active Travel Users at Priority Junctions

The design of Priority Junctions providing access to National Roads is discussed in Chapter 5 of this standard. Active Travel users are an important consideration in the design of these junctions. Provision must be made for the specific requirements of Active Travel users in the design of priority junctions providing access to National roads, and the requirements for Active Travel users is discussed in the following sections.

#### 7.3.1 Priority Junctions with MINOR ROAD AADT <4,000

At priority junctions where the AADT of the minor road is less than 4,000 vehicles, crossing facilities shall be a bend-out crossing as presented in Figure 7.2.

The priority at these junctions should lie with vehicular traffic. Signs should be provided on the road warning motorists of the upcoming crossing facility. This type of facility can be used for both one-way and two-way off-road Active Travel facilities.

The bend-out crossing junction increases the space between the Active Travel facility crossing point and the main carriageway. This allows space for motorised vehicles turning off the major road before they encounter the Active Travel facility. The distance between the edge of the main carriageway and the crossing facility shall be between 10 and 15 metres.

The bend-out junction treatment includes a straight approach for cyclists to ensure that cyclists are provided with full visibility on entry to the junction treatment. The horizontal radii of 10 metres on the active travel facility shall be introduced to encourage lower cycle speeds on approach to the junction. A colour contrast treatment should be provided along the route warning cyclists of the upcoming conflict with motorised traffic as illustrated in Figure 7.2.

For visibility, the required 'x' distance on the active travel facility on the approach to the bend-out crossing shall be 4.0m as illustrated in Figure 7.2. The appropriate 'y' distance depends on the design speed of the minor road, as set out in Table 5.5.

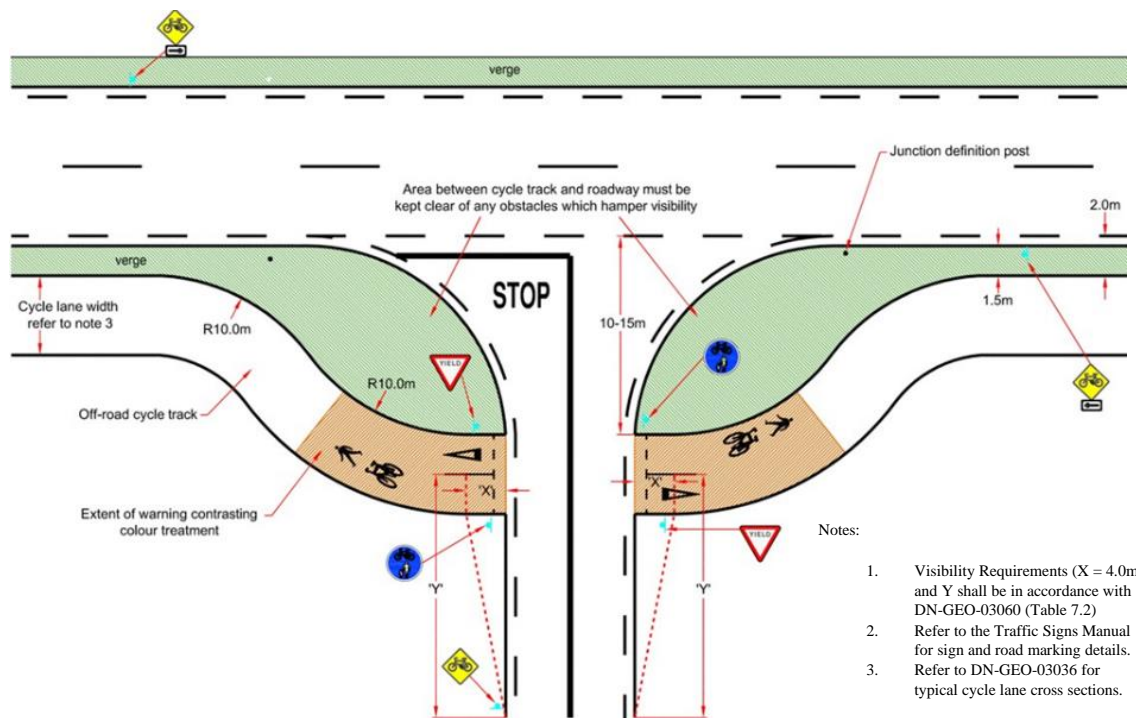


Figure 7.2 Bend Out Crossing (minor road AADT <4,000)

### 7.3.2 Priority Junctions with Minor Road AADT > 4000

At priority junctions, where the AADT of the minor road is greater than 4,000 vehicles, crossing facilities shall be a bend-out crossing with a central island. This type of facility can be used for both one-way and two-way off-road Active Travel facilities. The priority at these junctions is with vehicular traffic. Road markings and signs should be provided on the road to warn motorists of the upcoming crossing facility.

The provision of a central island will allow active travel users to cross the side road in two stages improving safety and convenience for cyclists. The central island shall be a minimum of 3.5 metres in width to accommodate a waiting ATUs safely.

The distance between the edge of the major road carriageway and the crossing facility for a bend-out junction shall be between 10 and 15 metres.

The bend-out junction treatment shall include a straight approach for ATUs to ensure that they are provided with full visibility on entry to the junction treatment. The horizontal radii of 10 metres on the active travel facility shall be introduced to encourage lower cycle traffic speeds on approach to the junction treatment. A colour contrast treatment should be provided along the active travel route warning ATUs of the upcoming conflict with motorised traffic. Figure 7.3 demonstrates a bend-out crossing with a central island.

For visibility, the required 'x' distance on the active travel facility on the approach to the bend-out crossing shall be 4.0m as illustrated in Figure 7.3. The appropriate 'y' distance depends on the design speed of the minor road, as set out in Table 5.5.

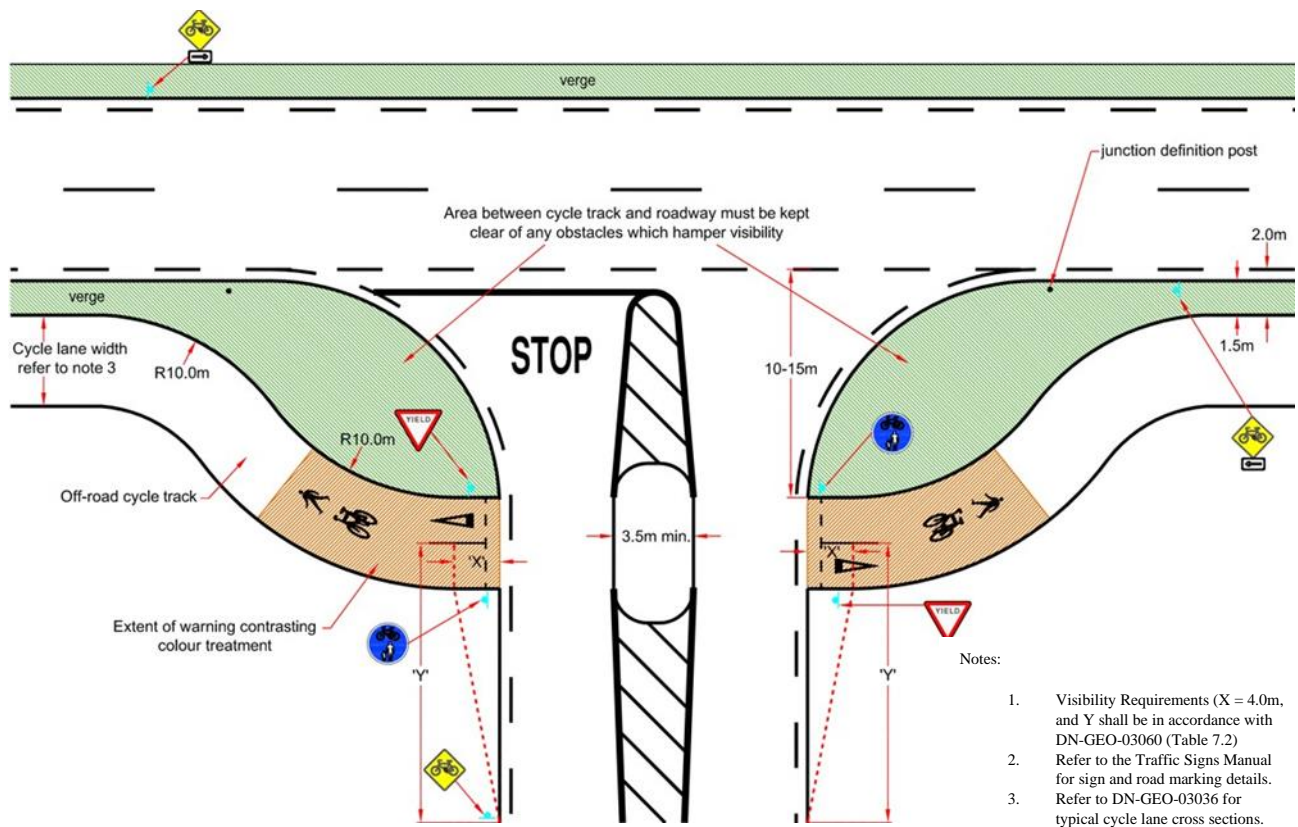


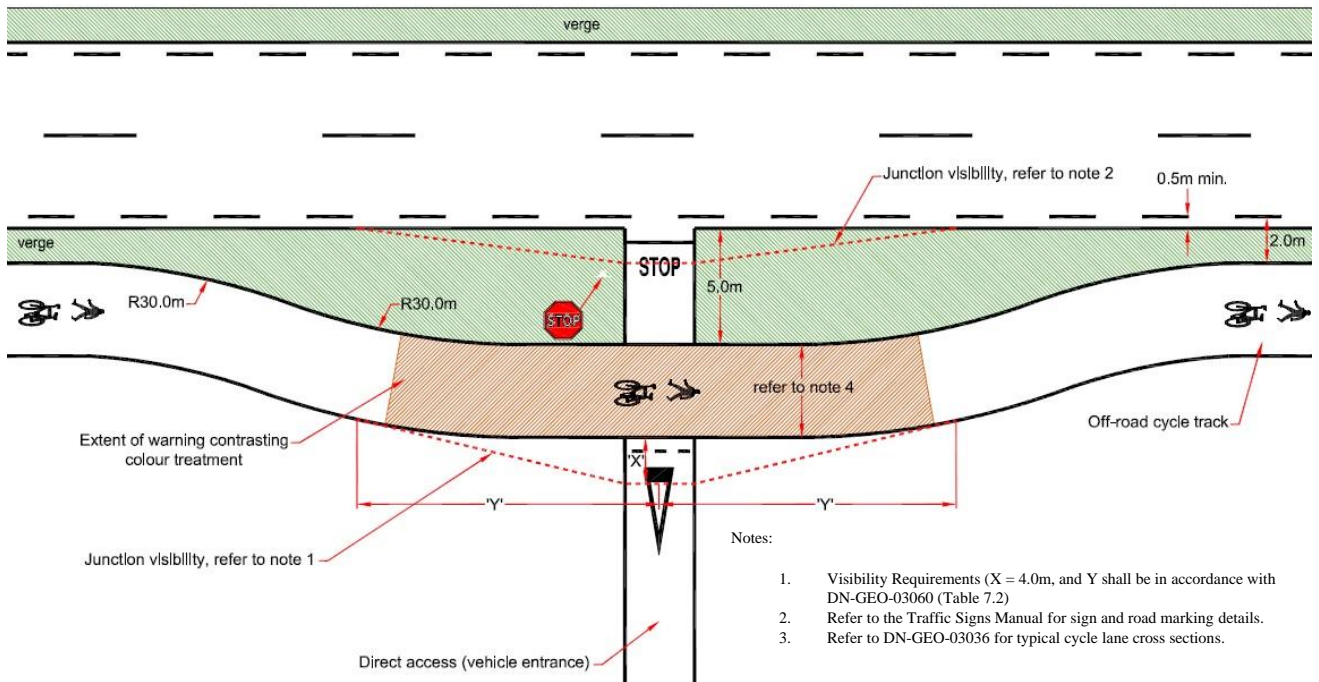
Figure 7.3 Bend-Out Crossing with a Central Island

## 7.4 Provision for Active Travel Users at Vehicular Accesses

In rural situations, an Active Travel facility may need to cross direct accesses such as farm and house entrances. As a general rule, the priority at these crossings should lie with the active travel users and it is preferable that the alignment of the Active Travel facility is retained through and past the access.

The provision of a bend-out Active Travel facility requires sufficient set back to allow a single vehicle to wait between the main carriageway and the Active Travel crossing point. This distance will be based on the maximum size of the vehicle using the direct entrance and shall be 5.0 metres if the direct entrance serves a private house and 15.0 metres if serving a farm entrance. Figure 7.4 illustrates a bend-out crossing associated with a direct entrance on the public road.

Additionally, the access will require a visibility envelope setback of 2.0m ('X' distance) from the cycle facility with a stopping sight distance based on the design speed of the cycle facility as set out in Table 5.5.



**Figure 7.4 Direct Access Bend-Out Crossing**

The Active Travel facility's pavement construction must be carried across the private entrance to clearly indicate priority to cycle traffic and the road entrance should be at the same level as the Active Travel facility. Cycle symbol road markings should be provided at the crossing to reinforce the arrangement and a colour contrast treatment should be provided along the facility warning cyclists of the upcoming conflict with motorised traffic.

## 7.5 Provision for Active Travel Users (ATUs) at Roundabouts

Roundabouts are one of the safest forms of at grade junctions for general motorised traffic, however they can pose safety concerns for cyclists due to high vehicular speeds, particularly leaving the roundabout. Provision must be made for the specific requirements of ATUs in the design of roundabouts.

At-grade crossings shall only be provided at single lane entries and exits to reduce the width of crossing and the interaction with motorised traffic. In such cases, the preferred crossing facility is a bend-out crossing of the minor road located between 10 and 15 metres from the circulatory carriageway of the roundabout. A splitter island shall be provided on the minor road, and the island shall be a minimum of 3.5 metres in width.

Where the active travel facility crosses minor roads with flows greater than 10,000 AADT, grade separation shall be required.

Figure 7.5 illustrates the design requirement associated with the provision of on-line, off-road Active Travel facilities at a roundabout. The indicative layout shown is for a two-way Active Travel facility provided along one side of the major road, crossing the minor road with a splitter island provided.

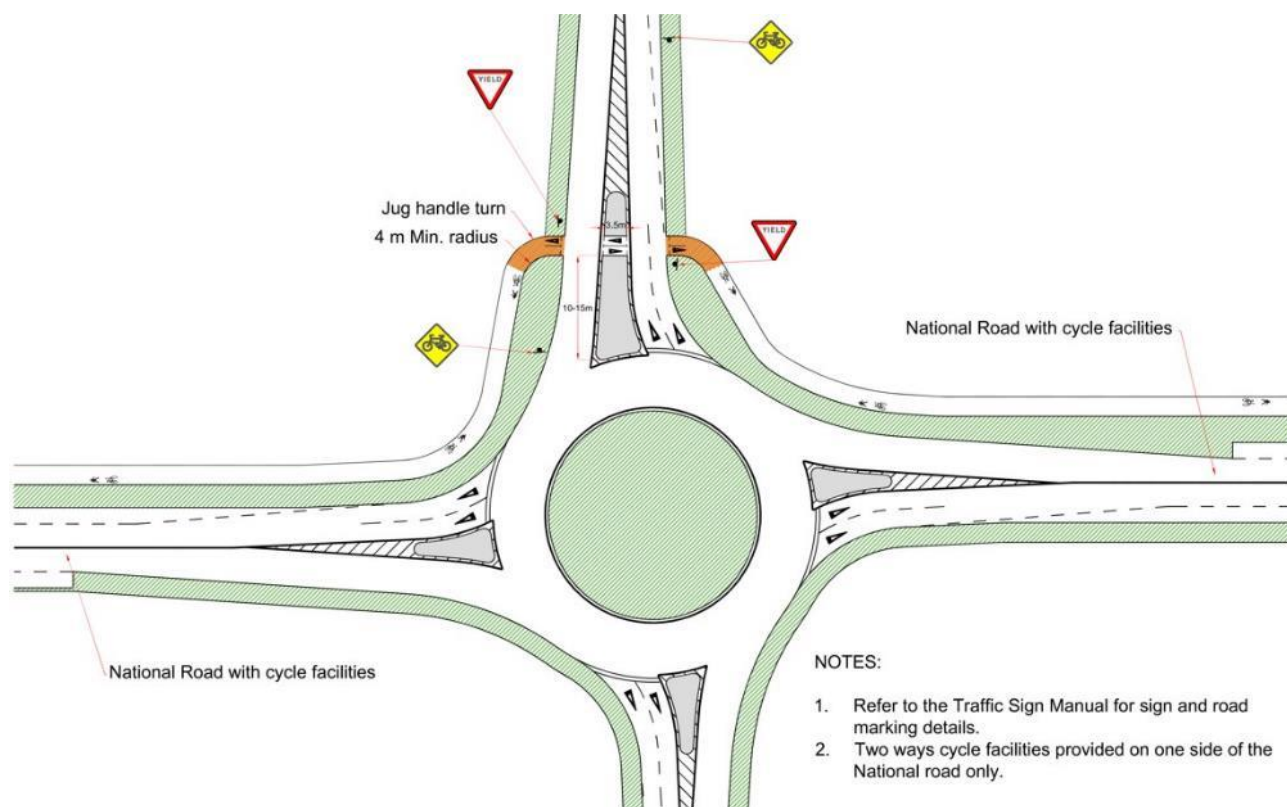


Figure 7.5 Roundabout Junction

### 7.5.2 Visibility Requirements for Active Travel Crossings at Roundabouts

Drivers approaching a roundabout with an Active Travel crossing across the entry shall be able to see the full width of the crossing so that they can see whether there are ATUs wishing to cross. The visibility required is the Desirable Minimum Stopping Sight Distance for the design speed of the link included in DN-GEO-03031.

ATUs must be able to see and be seen by the approaching traffic. The visibility should not be obscured or restricted by parked vehicles, trees or street furniture etc. (see Figure 7.6).

At the yield line, drivers must be able to see the full width of a crossing across the next exit if it is within 15m of the yield line on that arm.

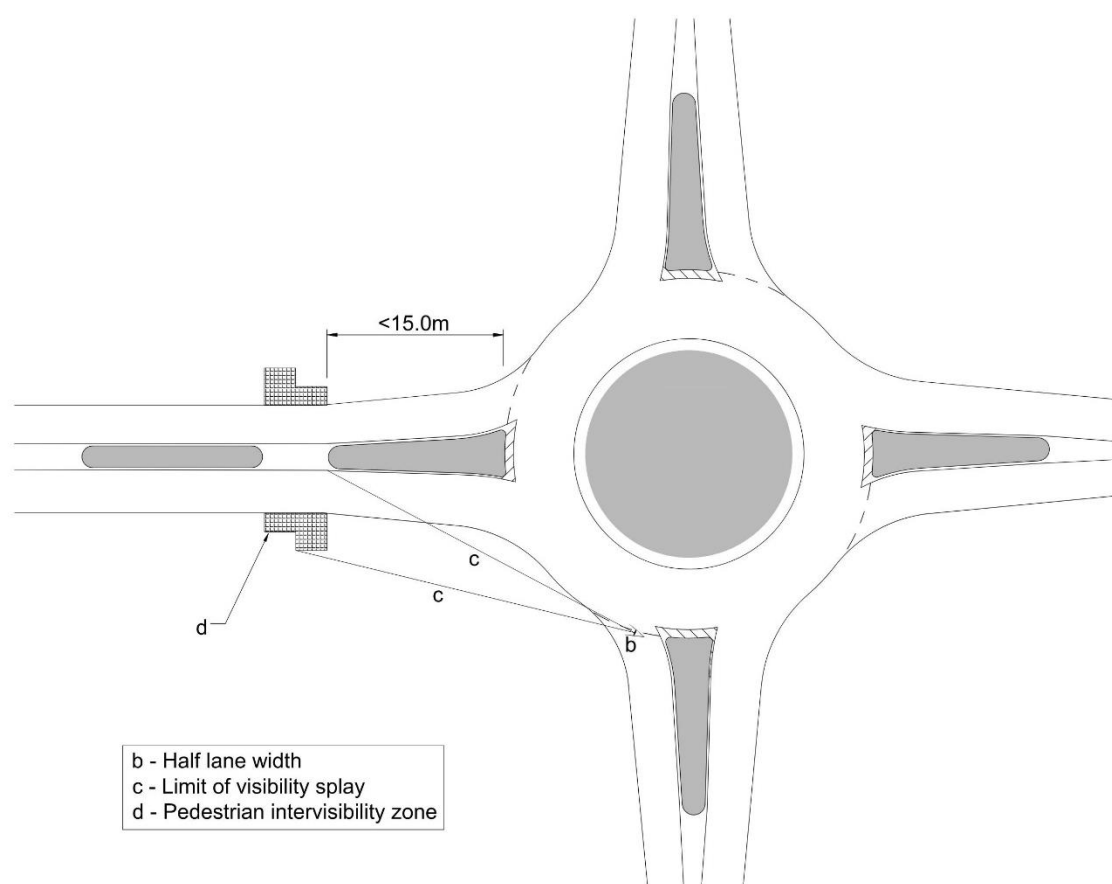


Figure 7.6 Visibility Requirements at Active Travel Crossing of Roundabout Approach Arm

## 7.6 Termination of Active Travel Facilities

As outlined in Section 7.2, the design of Active Travel facilities adjacent to National Roads shall seek to minimise direct user conflicts between ATUs and motorists. In this regard, it is recommended that continuous facilities are provided where possible, with an appropriate termination point that provides safe access / connectivity to key locations such as town centres.

Where a continuous facility cannot be provided, the safety of ATUs and the transition back on road is an important consideration at the termination of the facility. A crossing facility with a refuge island shall be provided to allow for a safe refuge and two-stage crossing for ATUs. Appropriate traffic calming, speed reduction measures and appropriate visibility are essential to ensure safety through the crossing for all road users.

Where an Active Travel facility terminates on a Type 1 Single Carriageway with a hard shoulder, the design shall comply with the requirements specified in CC-SCD-00053.

Where an Active Travel facility terminates on a Type 2 or Type 3 Single Carriageway with a hard strip only, the layout shall comply with CC-SCD-00054.



## 8. Layout of Grade Separated Junctions

### 8.1 General Principles

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 shall not be used.

These are:

- a) grade separated junctions on single carriageways, Type 2 and 3 Divided Roads (see DN-GEO-03031 and Chapter 9 of this standard dealing with compact grade separated junctions);
- b) grade separation on dual carriageways within 0.5 km of a changeover to a single carriageway, 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 and Chapter 5 of this standard);
- c) offside merges and diverges;
- d) priority junctions, particularly those with right turning movements, on an otherwise grade separated route.

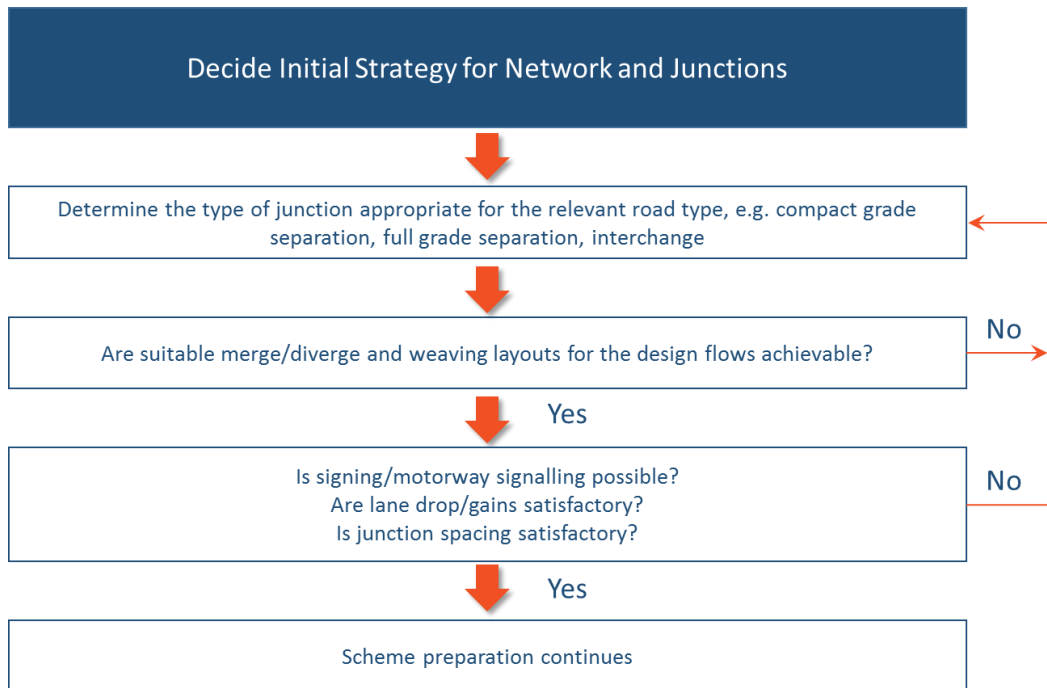
Full grade separation is not permitted on single carriageway roads and Type 2 and 3 Divided Roads due to driver perception and therefore reduced safety and shall be avoided in design. However, DN-GEO-03031 permits the introduction of compact grade separation on these road types. Refer to Table 6.1 of DN-GEO-03031.

Junction and Interchange design is an iterative process which is a key part of the overall design process for schemes. Figure 8.1 is a flowchart for junction and interchange design. Figure 8.2 outlines the connector road design process.

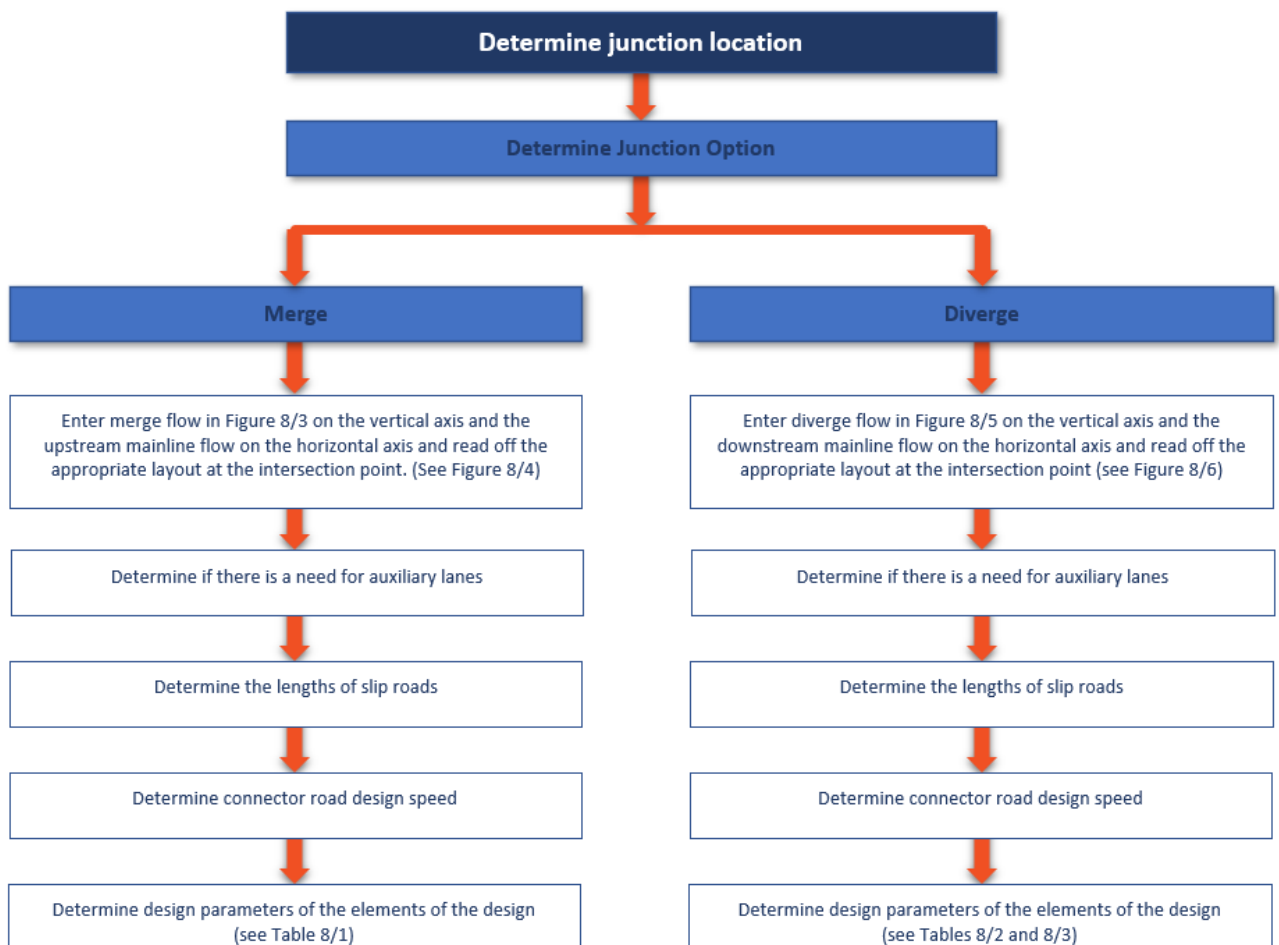
#### 8.1.1 Urban/Rural Grade Separated Junctions

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 a Type 1 Dual Carriageway National Road 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 offsets the increased risks caused by reductions in standards. For example, lighting and speed limits would 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 8.1 and Table 8.2).





**Figure 8.1** Flow Chart Showing the Junction/Interchange Design Process



**Figure 8.2** Flow Chart Showing the Connector Road Design Process

## 8.2 Design Process

The first stage is to decide on an initial network strategy, fix a design year, and decide whether rural design standards apply or if urban standards should be used; for example, in the case of an urban motorway. A junction strategy shall also be determined, including the connections to be made, for example whether the junction should be omni-directional.

Having made those starting decisions, it is possible to derive hourly flows to be used in the design process following the guidance in the TII Project Appraisal Guidelines. 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 national road. Reference to DN-GEO-03036 will give a starting point on the level of carriageway provision for the links on the network assumed.

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 junctions or using parallel link roads. Parallel link roads reduce the frequency of direct access points along the mainline to eliminate sub-standard weaving lengths, thus promoting free flow to minimise the potential for collisions and to preserve the 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. Refer to Section 8.9.3 for detail on the provision of parallel link roads.

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.

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 8.2 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 DN-GEO-03036. Interchanges may be also be justified and where required shall be designed in accordance with DN-GEO-03041.

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 8.1. With the exception of interchanges, these junctions have merge and diverge slip roads which, where absolutely necessary, may be signalised at their junction with the side road or roundabout.

## 8.3 Layout Options

### 8.3.1 General

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. On all purpose routes, provision for ATUs must also be a key consideration during the planning and design stages, particularly given the relative vulnerability of cyclists and pedestrians to fast moving traffic. Additionally, on a Motorway or Type 1 Dual Carriageway national 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 road authorities.

### 8.3.2 Siting

The siting of a grade separated junction on a hilltop should be avoided if possible as approach gradients can cause operational problems in the diverge area, even when the percentage of HGVs 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.

### 8.3.3 Recommended Layouts for Grade Separated Junctions

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

- a) dumb-bell roundabout – junctions with the minor road are provided by two roundabouts which are connected by a central link road either under or over the mainline;
- b) half clover-leaf – use of two quadrants and roundabout junctions with the minor road;
- c) interchange – a junction between major roads with all movements catered for by free flowing connector roads (Refer to DN-GEO-03041).

### 8.3.4 Dumb-Bell Roundabout

The dumb-bell roundabout layout is typically the most common form of rural grade separation and involves the construction of one bridge crossing the major road.

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 yield 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.

### 8.3.5 Half Cloverleaf

A half-cloverleaf is used where site conditions are difficult and the use of all four quadrants is not possible (see Figures in Chapter 2). A roundabout junction shall be provided at the junctions with the minor road.

### 8.3.6 Variants

Variants on the two basic types of grade separated junctions (half cloverleaf and dumb-bell roundabout) can be provided if:

- a) the junction is 3 way i.e. a T junction;
- b) not all movements need catering for; or
- 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.



### 8.3.7 Provision for Active Travel Users

Generally, Active Travel road users do not need to be catered for along the mainline of a grade separated interchange, as it is preferable to provide alternative facilities away from high-speed traffic, where warranted. However, should ATU facilities be required to cater for a particular demand, the ATUs are to be directed to the at grade junction and away from both the merge and the diverge lanes serving the grade separated interchange from the mainline.



## 8.4 Design Principles

### 8.4.1 General

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 the Traffic Signs Manual. These principles have been incorporated in the recommended layouts.

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 tall vehicles. 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 should take the siting of the gantries into account.

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

Correction factors to take account of gradients and proportion of HGVs, as detailed in Table 8.5, may need to be made to the flows to be entered in Tables 8.4, and Figures 8.3 and 8.5.

## 8.5 Merges – General Principles

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.

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.

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 shall be provided by auxiliary lanes. By providing auxiliary lanes at merge locations, the conditions and opportunities for merging are improved.

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.

### 8.5.1 Choosing a Merge Layout (Refer to Figure 8.3)

Hourly flows for the merge and the mainline upstream must be inserted in Figure 8.3 to select a merge layout as shown in Figures 8.4.1 to 8.4.5. 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 8.3 is a Departure from Standard, whether the proposed design is an under or over provision.

Figure 8.3 provides a number of layouts to cater for anticipated flows. Layout A (Figure 8.4.1) provides a basic parallel merge. Layout B (Figure 8.4.2), Layout C (Figure 8.4.3) and Layout D (Figure 8.4.4) are required where flows justify a lane gain arrangement. Layout E (Figure 8.4.5) may be considered as a Departure from Standard where it is not possible to use Layout C (see also Section 8.9).

Ghost island road markings at merges should be designed in accordance with Chapter 7 of the Traffic Signs Manual.

The minimum width of a ghost island at a merge lane is 2.0 m at its widest point and the minimum width of a chevron is 0.5m. 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 lengths to comply with the standard and this may be reflected in the land requirement especially where the layout is being provided within an existing road boundary.

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 8.1 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.

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.

In circumstances where traffic modelling shows significant delays incurred during peak periods as a result of high entry flows, it may be appropriate to use non-standard layouts that are not included in this Standard. Use of layouts not included in this Standard shall require a Departure from Standards.

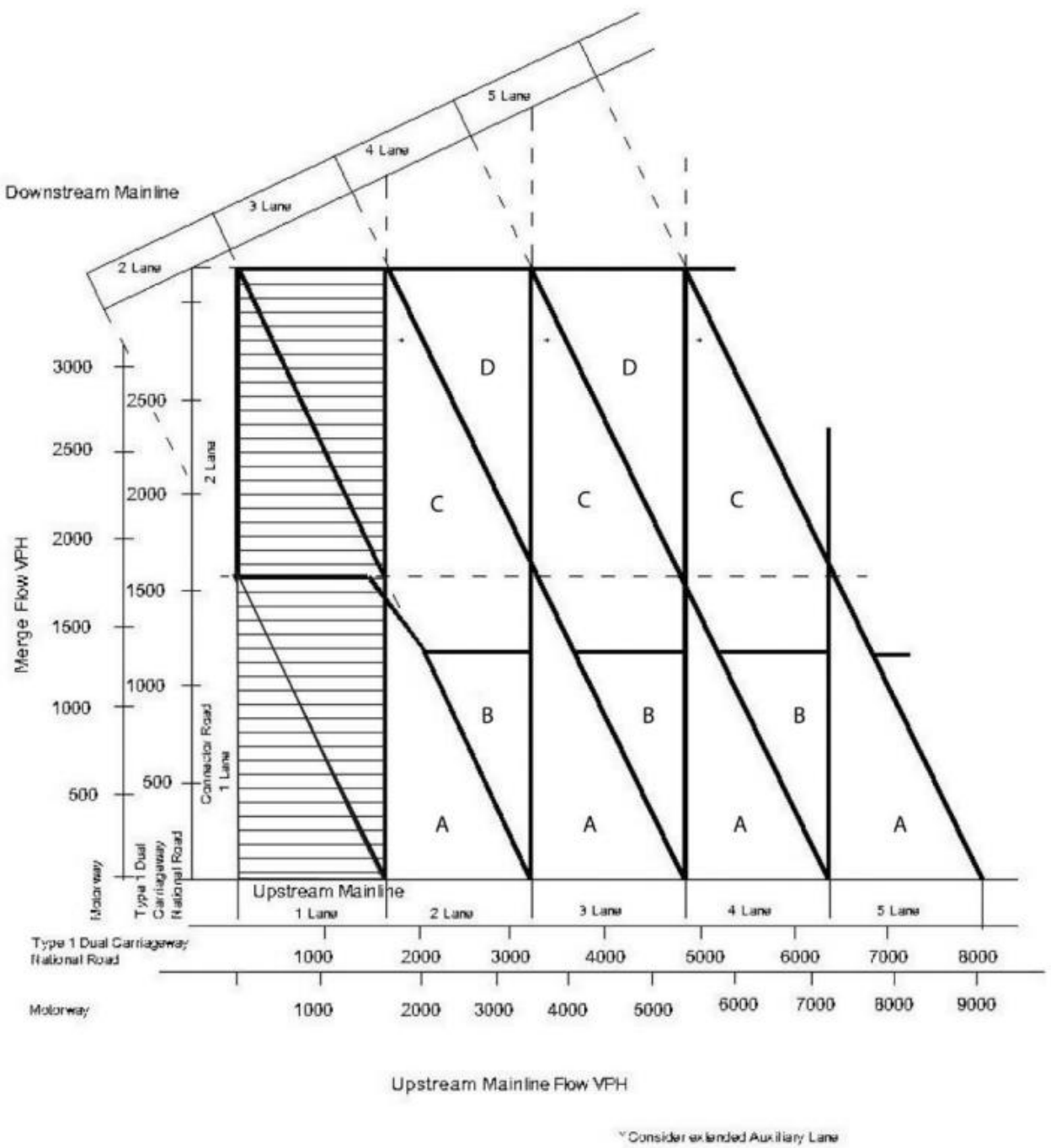
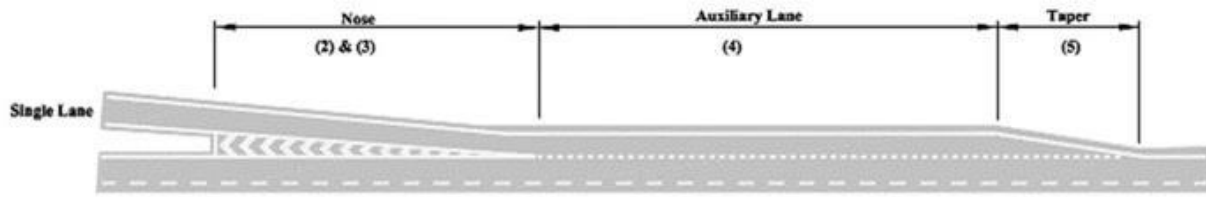
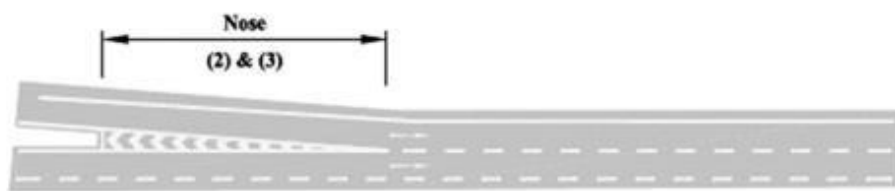


Figure 8.3 Merging Diagram



A - Parallel Merge

Figure 8.4.1 Merge Lane Layouts for use with Figure 8.3 (Layout A)

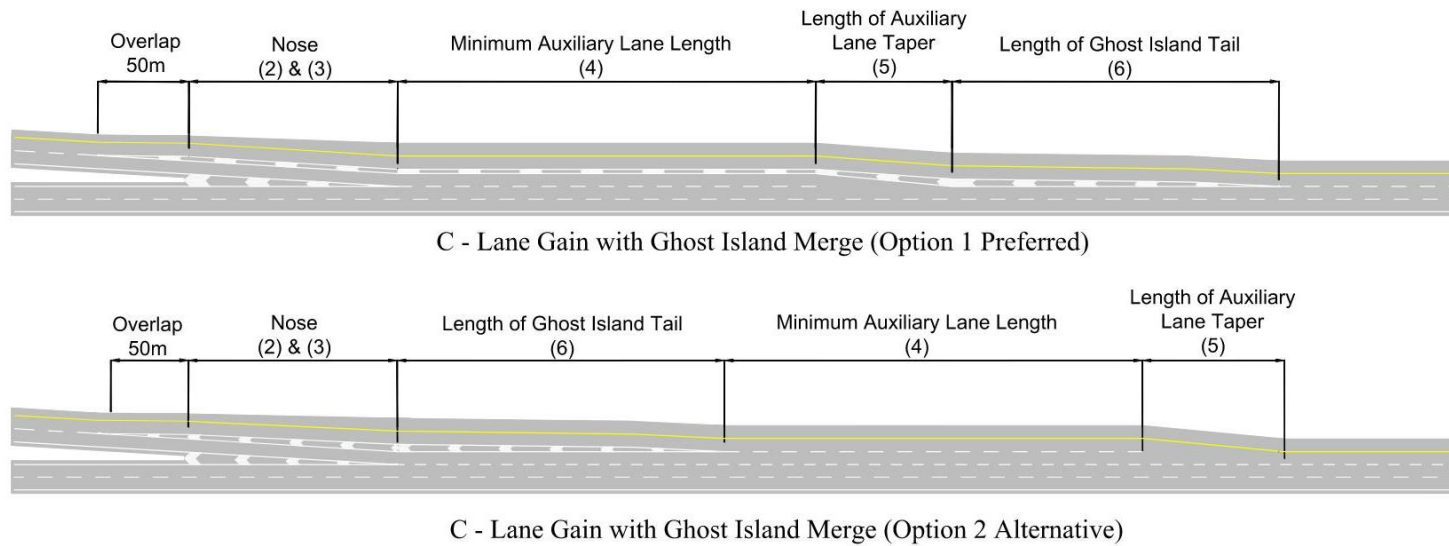


B - Lane Gain

Figure 8.4.2 Merge Lane Layouts for use with Figure 8.3 (Layout B)

Notes to Figures 8.4.1 and 8.4.2:

1. Figures in brackets refer to columns in Table 8.1.

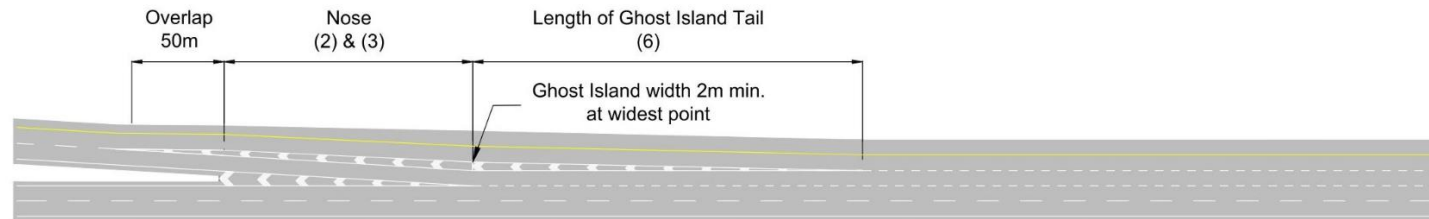


**Figure 8.4.3 Merge Lane Layouts for use with Figure 8.3 (Layout C)**

Notes to Figure 8.4.3:

1. Figures in brackets refer to columns in Table 8.1.
2. Option 1 is preferred 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 may be used in circumstances where traffic modelling indicates it is appropriate.



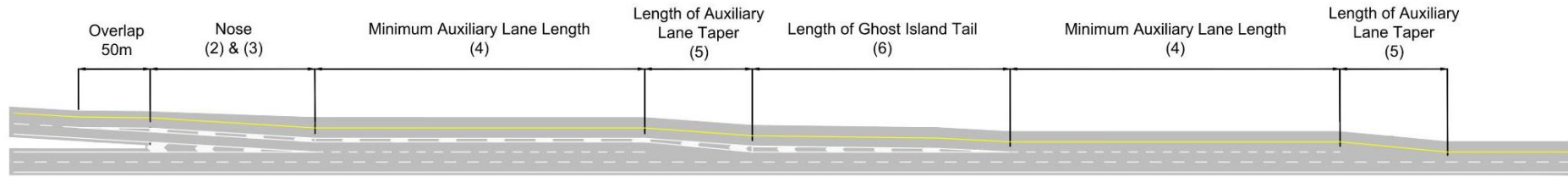


#### D - 2 Lane Gain with Ghost Island

**Figure 8.4.4 Merge Lane Layouts for use with Figure 8.3 (Layout D)**

Notes to Figure 8.4.4:

1. Figures in brackets refer to columns in Table 8.1.



E - Alternative Ghost Island Merge with Auxiliary Lane

**Figure 8.4.5 Merge Lane Layouts for use with Figure 8.3 (Departure from Standard)**

Notes to Figure 8.4.5:

1. Figures in brackets refer to columns in Table 8.1.
2. This layout is for use where Layout C would be used but is not possible to implement because of site restraints. To use requires approval as a Departure from Standards.

## 8.6 Diverges – General Principles

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

There is the potential for collisions 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 DN-GEO-03036) and junctions 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.

### 8.6.1 Choosing a Diverge Layout (Refer to Figure 8.5)

Hourly flows, as determined from the traffic flows section of this Chapter, for the diverge and the mainline downstream of the back of the diverge nose must be inserted in Figure 8.5 to select a diverge layout as shown in Figures 8.6.1 to 8.6.4. 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 8.5 is a Departure from Standard, whether the proposed design is an under or over provision.

The minimum length of a diverge slip road to be provided will normally be dictated by the requirements in the preceding paragraphs in relation to capacity and the topographical layout of a junction, however, in all cases, the minimum length of a diverge slip from a motorway or Type 1 Dual Carriageway shall be equal to the Desirable Minimum Stopping Sight Distance (SSD) for the mainline from the tip of the diverge nose to the stop or yield line at the end of the connector road.

For all connector roads, a near straight at least equal in length to the nose length given in Table 8.2 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.

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.

For diverges, the layout of the edge line must incorporate the radii shown on Figures 8.6.1 to 8.6.4.

In circumstances where traffic modelling shows significant delays incurred during peak periods as a result of high exit flows, it may be appropriate to use non-standard layouts that are not included in this Standard. Use of non-standard layouts shall require a Departure from Standards.

### 8.6.2 Single Lane Parallel Diverge

The single lane parallel diverge is only applicable to diverging lane cross-sections of 1 x 4.0m or 2 x 3.0m lanes, as shown in Table 8.2.

The layout of the single lane parallel diverge is shown in Figure 8.6.1 (Layout A) and Figure 8.6.2 (Layout B). This layout is a Taper Diverge incorporating a single auxiliary lane. Point A is the intersection between the single lane parallel diverge and the taper diverge.

The method of construction for the single lane parallel diverge (as described above and shown in Figure 8.6.2) will be the same for all applicable Road Classes.

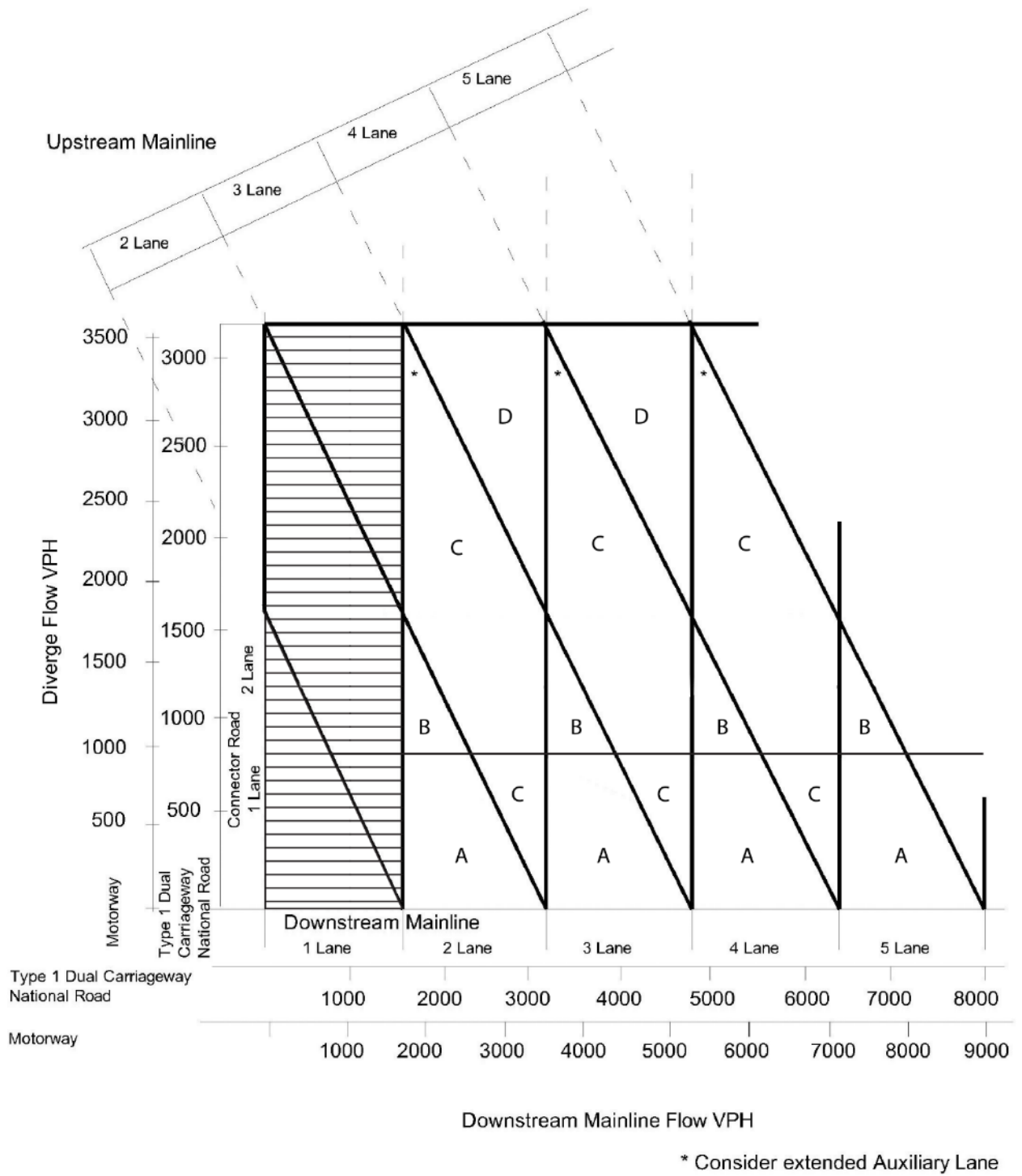
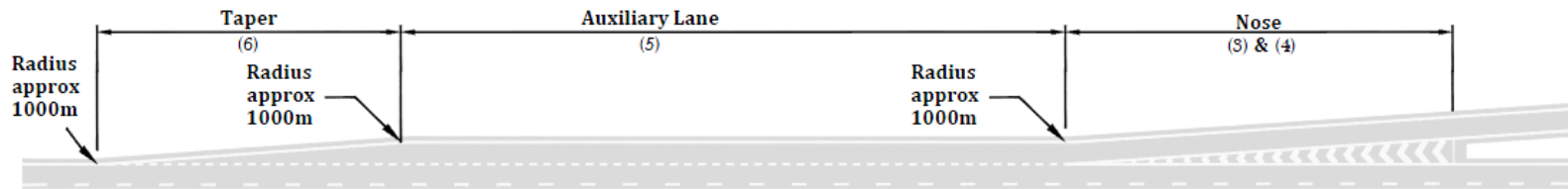
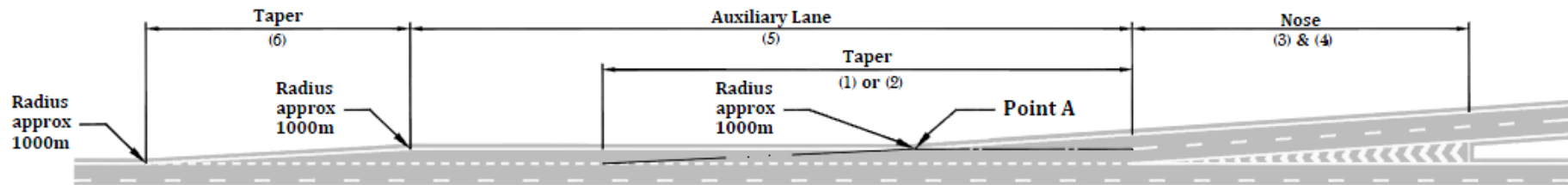


Figure 8.5 Diverging Diagram



A - Single Lane Parallel Diverge

Figure 8.6.1 Diverge Lane Layouts for use with Figure 8.5 (Layout A)



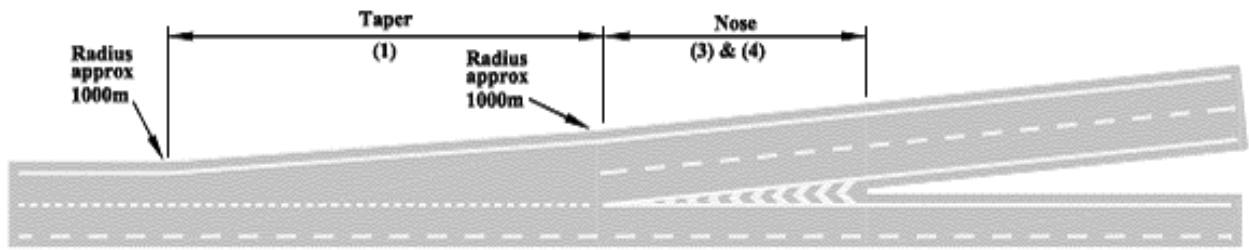
B - Single Lane Parallel Diverge showing  
 2 x 3.0m Diverging Lane Connector Road

Construction Lines for Taper Diverge and Parallel Diverge  
 (Single Auxiliary Lane) to determine Point A

Figure 8.6.2 Diverge Lane Layouts for use with Figure 8.5 (Layout B)

Notes to Figures 8.6.1 and 8.6.2

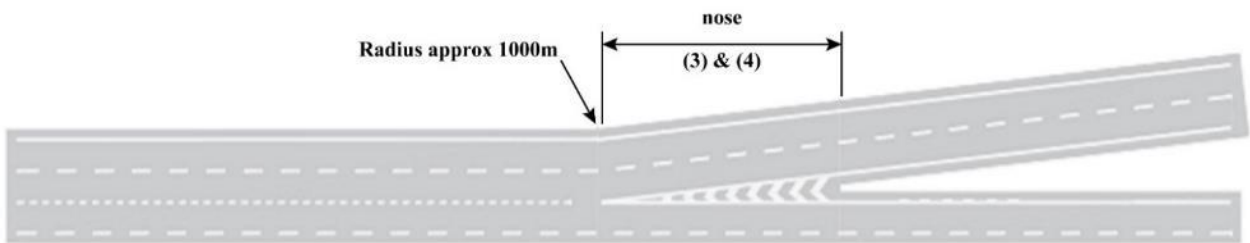
1. Figures in brackets refer to columns in Table 8.2.
2. Point A for the 1 x 4.0m diverging lane is generally located close to the tip of the nose.
3. Point A for the 2 x 3.0m diverging lane generally occurs 2/3 of the way along the auxiliary lane.
4. The extent of the single lane parallel diverge carriageway will always encompass the full extent of a Taper Diverge.



The edge line must be laid to the radii indicated

C - Lane Drop at Taper Diverge

Figure 8.6.3 Diverge Lane Layouts for use with Figure 8.5 (Layout C)



The edge line must be laid to the radii indicated

D - 2 Lane Drop

Figure 8.6.4 Diverge Lane Layouts for use with Figure 8.5 (Layout D)

Notes to Figures 8.6.3 and 8.6.4

1. Figures in brackets refer to columns in Table 8.2.

## 8.7 Geometric Design Parameters

The geometric parameters applicable to merges and diverges must be those in Tables 8.1 and 8.2 respectively. Figures 8.4 and 8.6 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 8.4 does not require the use of larger radii. For diverges, the layout of the edge line should incorporate the radii shown on Figure 8.6.

**Table 8.1 Geometric Design Parameters for Merging Lanes**

| Road Class                                    | Length of entry taper (m) (1) |            | Nose Ratio (see Note 1) (2) | Nose Length (see Note 1) (3) | Minimum auxiliary lane length (m) (4) | Length of auxiliary lane taper (m) (5) | Length of Ghost Island Tail (m) (6) |
|---|-------------------------------|------------|-----------------------------|------------------------------|---------------------------------------|--|-------------------------------------|
|   | 4m lane                       | 3.65m lane |                             |                              |                                       |  |                                     |
| <b>Motorway</b>                               |                               |            |                             |                              |                                       |  |                                     |
| <b>Rural Motorway</b>                         |                               |            |                             |                              |                                       |  |                                     |
| Mainline                                      | 220                           | 205        | 1:40                        | 115                          | 230                                   | 75                                     | 180                                 |
| Within Interchange                            | 150                           | 130        | 1:25                        | 75                           | 160                                   | 55                                     | 150                                 |
| <b>Urban Motorway</b>                         |                               |            |                             |                              |                                       |  |                                     |
| Design Speed 100 km/h                         | 105                           | 95         | 1:15                        | 50                           | 125                                   | 40                                     | 150                                 |
| <b>Type 1 Dual Carriageway National roads</b> |                               |            |                             |                              |                                       |  |                                     |
| 120 km/h                                      | 160                           | 150        | 1:30                        | 85                           | 190                                   | 55                                     | 150                                 |
| 100 km/h                                      | 140                           | 130        | 1:25                        | 75                           | 160                                   | 55                                     | 150                                 |
| Urban 80 km/h speed limit                     | 80                            | 75         | 1:12                        | 40                           | 100                                   | 40                                     | n/a                                 |
| Urban 60 km/h speed limit or less             | 70                            | 65         | 1:12                        | 35                           | 80                                    | 40                                     | n/a                                 |

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 Table to be read in conjunction with Figures 8.4.1 to 8.4.5

**Table 8.2 Geometric Design Parameters for Diverging Lanes**

| Road Class                                    | Length of exit taper (m) |                     |                     | Nose Ratio<br>(See Note<br>1)<br>(3) | Nose<br>length (m)<br>(4) | Minimum<br>auxiliary<br>lane length<br>(m) (5) | Length of<br>aux lane<br>taper (m)<br>(6) |
|---|--------------------------|---------------------|---------------------|--------------------------------------|---------------------------|--|---|
|   | 4.00m lane<br>(1)        | 2x3.65m<br>lane (2) | 2x3.00m<br>lane (2) |                                      |                           |  |   |
| <b>Motorways</b>                              |                          |                     |                     |                                      |                           |  |   |
| Rural Motorway                                |                          |                     |                     |                                      |                           |  |   |
| Mainline                                      | 180                      | 185                 | 150                 | 1:15                                 | 80                        | 200  | 75  |
| Within<br>Interchange                         | 130                      | 130                 | 110                 | 1:15                                 | 70                        | 150  | 55  |
| <b>Urban Motorway</b>                         |                          |                     |                     |                                      |                           |  |   |
| Design Speed<br>100 km/h                      | 130                      | 130                 | 110                 | 1:15                                 | 70                        | 150  | 55  |
| <b>Type 1 Dual Carriageway National roads</b> |                          |                     |                     |                                      |                           |  |   |
| 120km/h                                       | 150                      | 150                 | 120                 | 1:15                                 | 70                        | 170  | 55  |
| 100 km/h                                      | 130                      | 130                 | 110                 | 1:15                                 | 70                        | 150  | 55  |
| Urban 80<br>km/h speed<br>limit               | 80                       | 90                  | 75                  | 1:12                                 | 40                        | 100  | 40  |
| Urban 60<br>km/h speed<br>limit or less       | 70                       | 80                  | 65                  | 1:12                                 | 35                        | 80   | 40  |

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 Table to be read in conjunction with Figures 8.6.1 to 8.6.4

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 8.1) to 370 m. As a guide, this should be considered when connector road and mainline flows reach 85% of capacity, as defined in the Traffic Flows section later in this chapter, for more than 1,000 hours per year. Figure 8.7 shows an example for the layout of a ghost island merge with lane gain. Within larger interchanges, the length may be increased to 500m. 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.

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:

- a) the uphill section of road would be sufficiently steep to require a climbing lane; or
- b) the proportion of HGVs is greater than 10% and the uphill mainline gradient is in excess of 2% and within 0.5 km of the crest.

For extended auxiliary lanes in merges, of length greater than that given in column (4) of Table 8.1, a sign showing the number of lanes ahead, also that traffic in the slip road must merge into the mainline nearside lane with a distance plate '200m', should be placed 200m from the start of the taper. For very long auxiliary lanes in merges consideration should be given to additional signs with the appropriate distance plates, see the Traffic Signs Manual.

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

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



## **8.8 Successive Merges or Diverges Within Interchanges**

Where there are closely spaced successive merges or diverges on mainlines and connector roads within a junction or interchange (Figure 8.8), the minimum spacing between the tips of noses must be  $3.75V$  m, where  $V$  is the design speed in km/h, 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).

At a fork within an interchange link, the taper must be developed as shown in Table 8.3 and Figure 8.9.

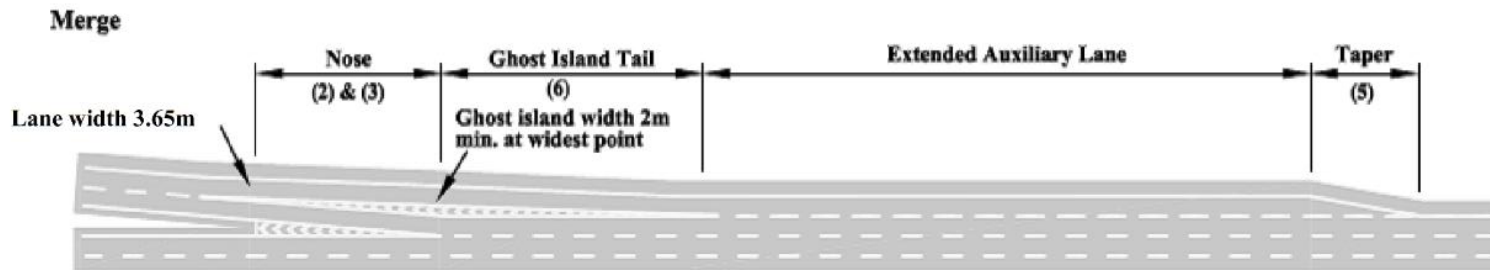


Figure in Brackets refer to Table 8.3

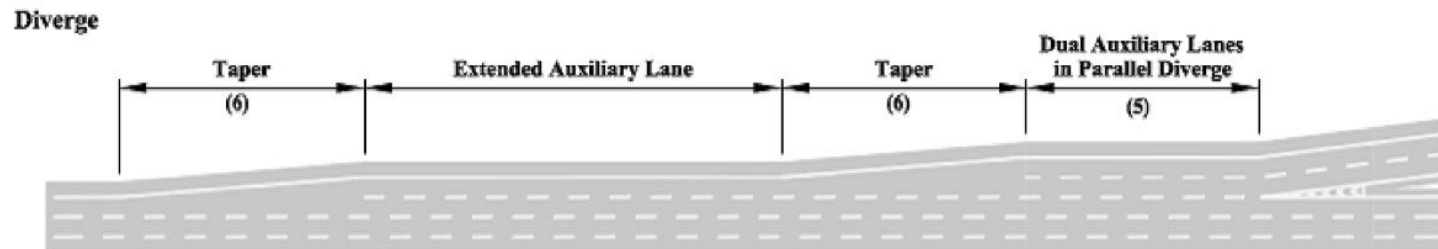


Figure in Brackets refer to Table 8.3

Figure 8.7 Extended Auxiliary Lanes for Rural Motorways

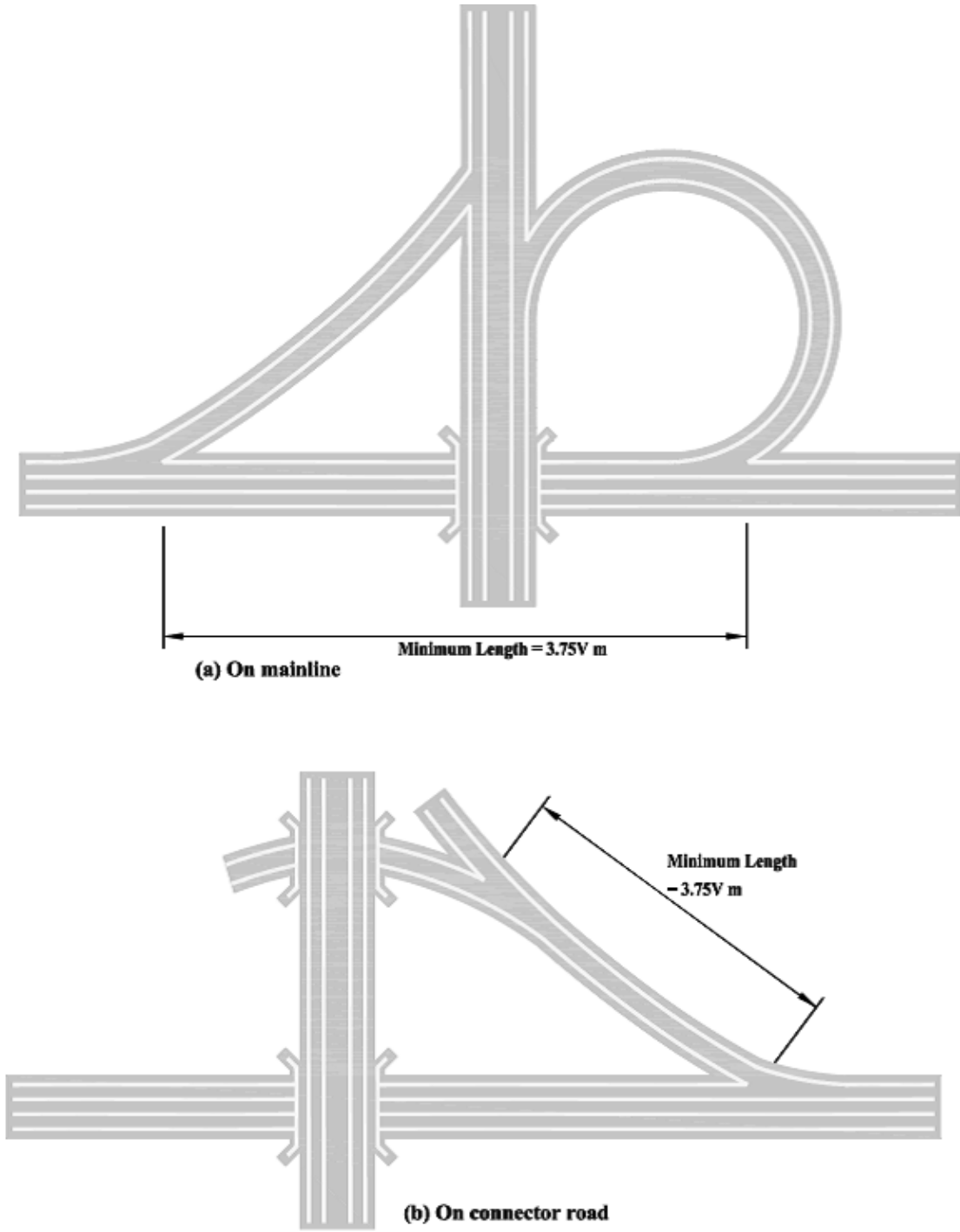


Figure 8.8 Example of Successive Merges/Diverges

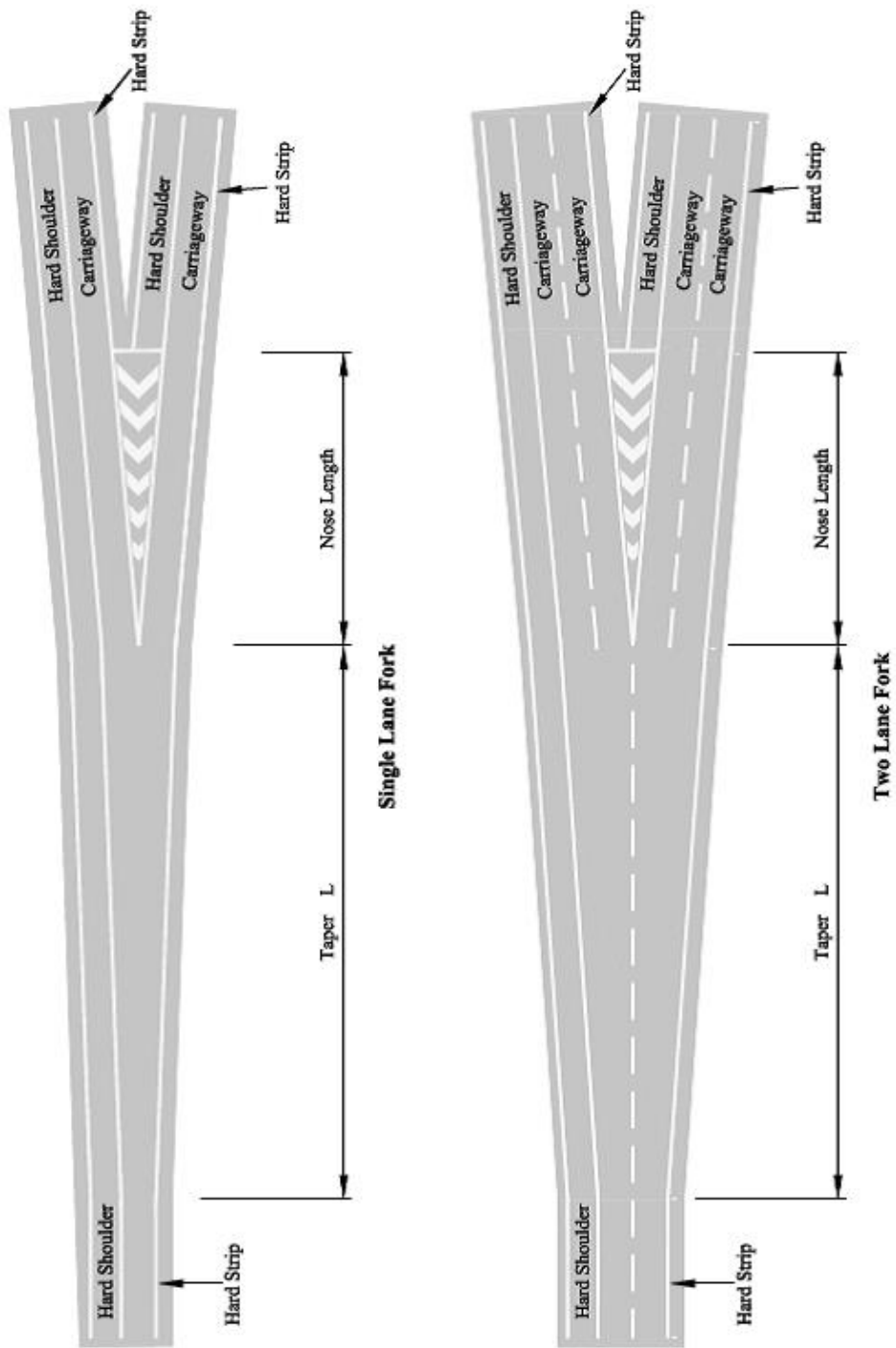


Figure 8.9 Development of Taper at Fork

**Table 8.3 Geometric Design Parameters for a Fork within an Interchange Link**

| Interchange Link<br>Design Speed | Length of Taper, L (metres) |        | Nose Ratio | Nose Length<br>(metres) |
|----------------------------------|-----------------------------|--------|------------|-------------------------|
|                                  | 1 lane                      | 2 lane |            |                         |
| 70/85km/h                        | 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.

## 8.9 Grade Separated Junctions: Weaving and Spacing

### 8.9.1 General

On Rural Motorways and Type 1 Dual Carriageways, the minimum length between a grade separated junction designed to this standard and an at-grade junction shall be 1km.

On Rural Type 2 Divided Roads, a minimum spacing of 1km should be provided between junctions, service areas and Emergency Refuge Areas (ERAs).

On Urban Motorways and Urban Type 1 Dual Carriageways, the minimum length between a grade separated junction designed to this standard and an at-grade junction (including roundabouts), service area or Emergency Refuge Area (ERA) must be the desirable minimum weaving length as derived from Figure 8.16.

A weaving section shall be assessed using the weaving section formula (presented in 8.9.4) where successive grade separated junctions are spaced less than 3km apart.

A Departure from Standard is required where the minimum weaving length or spacing between junctions is less than Desirable Minimum.

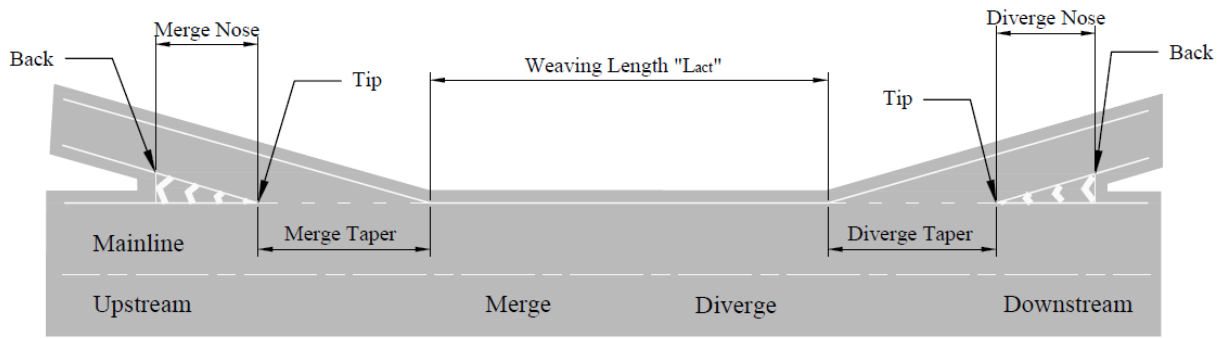
### 8.9.2 Weaving Section Lengths

For Rural Motorways and Type 1 Dual Carriageways, weaving lengths must be measured as shown in Figures 8.10 to 8.14.

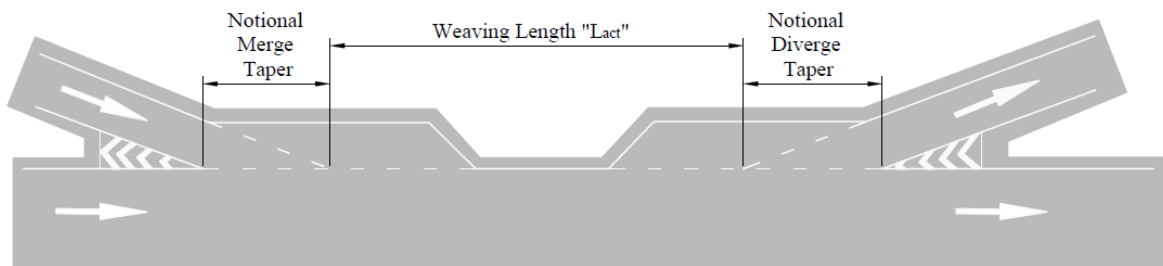
Where taper merge and diverge layouts are encountered on existing schemes, the weaving length can be measured between the end of the merge and start of the diverge as per Figure 8.10A.

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 8.10B. In the case of lane gains and lane drops, the methods set out in Figures 8.11, 8.12 and 8.13 must be used.

In the case of ghost island merges and diverges, the examples in Figure 8.14 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.



A - Merge, Weaving Length and Diverge



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

\* Note that Figure 8.10A may be used for measuring weaving length provision on existing taper layouts only. Taper merge / diverge layouts are no longer permitted.

**Figure 8.10 Definition of Terms used in Weaving and Measurement of Weaving Length for Taper and Auxiliary Lane Layouts**

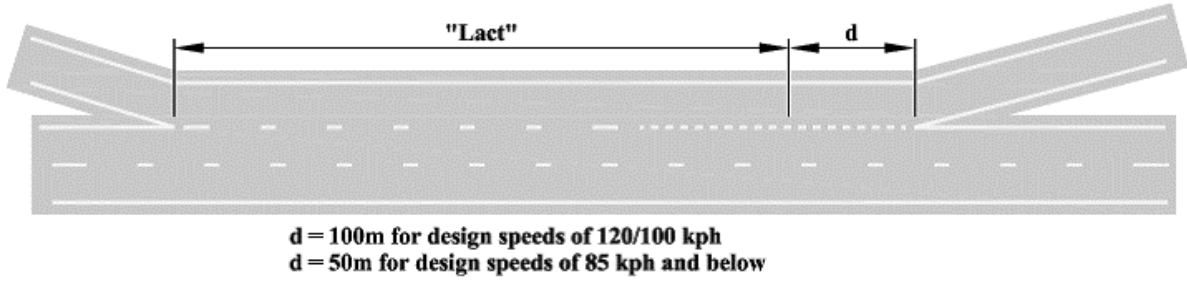


Figure 8.11 Lane Gain/ Lane Drop

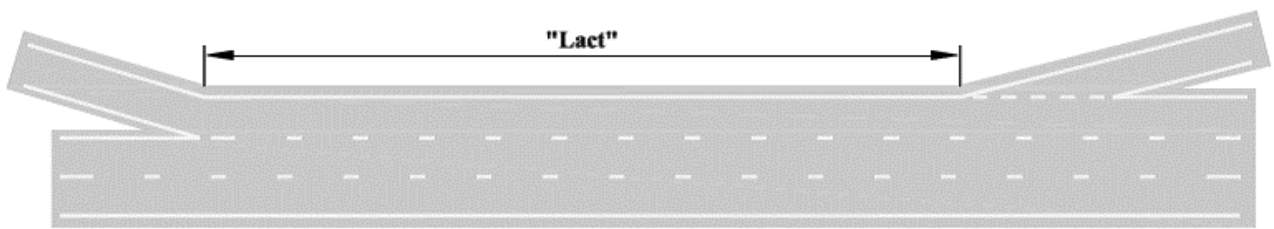


Figure 8.12 Lane Gain only

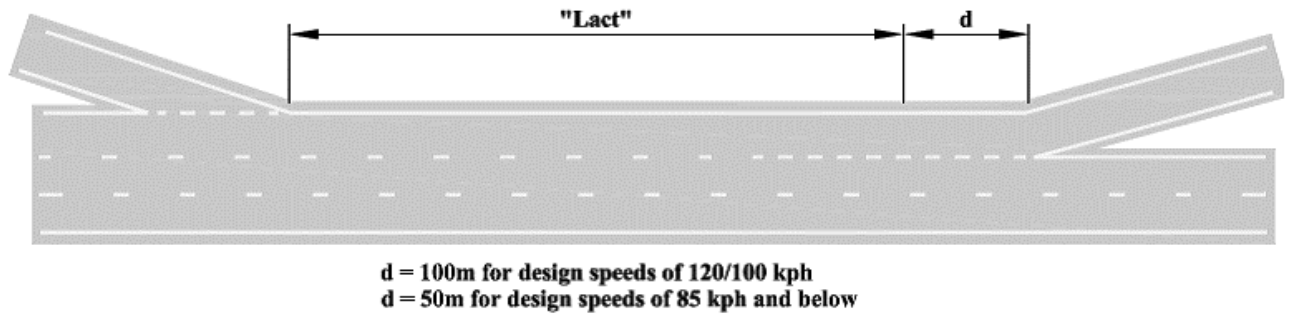
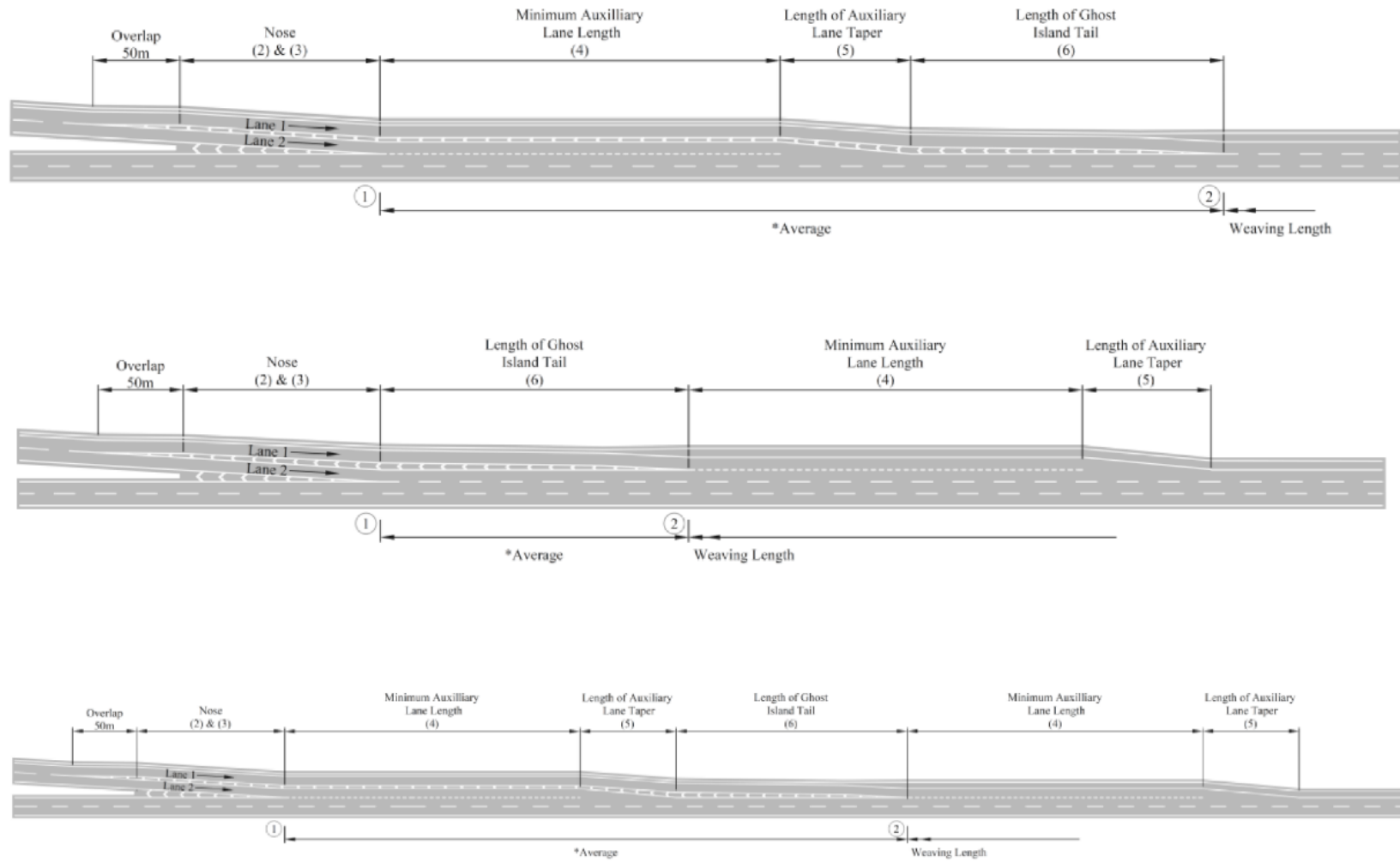


Figure 8.13 Lane Drop Only



**Figure 8.14 Measurement of Weaving Length for Ghost Island Layouts**

Total Weaving Length  $L_{act}$  is the distance to point 2 plus half the distance between 1 and 2. Figures in brackets refer to Table 8.1



### 8.9.3 Minimum Length of Weaving Sections

On Rural Motorways and Type 1 Dual Carriageway National Roads, the Desirable Minimum weaving length between grade separated junctions shall be 2km. The requirements for Motorway Service Areas (MSAs) on rural motorways are as for rural motorway junctions.

A Departure from Standard is required where the weaving length provided on Rural Motorways and Type 1 Dual Carriageways is less than the Desirable Minimum.

In this scenario, if junction spacing cannot be increased, the inclusion of parallel link roads between the two junctions should be considered. As shown in Figure 8.15, the provision of parallel link roads may be combined with the closure of the Junction #1 merge and the Junction #2 diverge, to eliminate the need for the weaving section.

Parallel link roads can take local traffic off the mainline thus improving mainline flow conditions. A parallel link road running adjacent to the mainline can be either one-way or two-way and run either side of the carriageway. The parallel link road shall be designed to a 60km/h Design Speed. For cross-sectional requirements of parallel link roads, refer to Table 4.1 – 4.4 of DN-GEO-03036.

Where a two-way parallel link road is proposed, a single lane dualling cross-section shall be implemented.

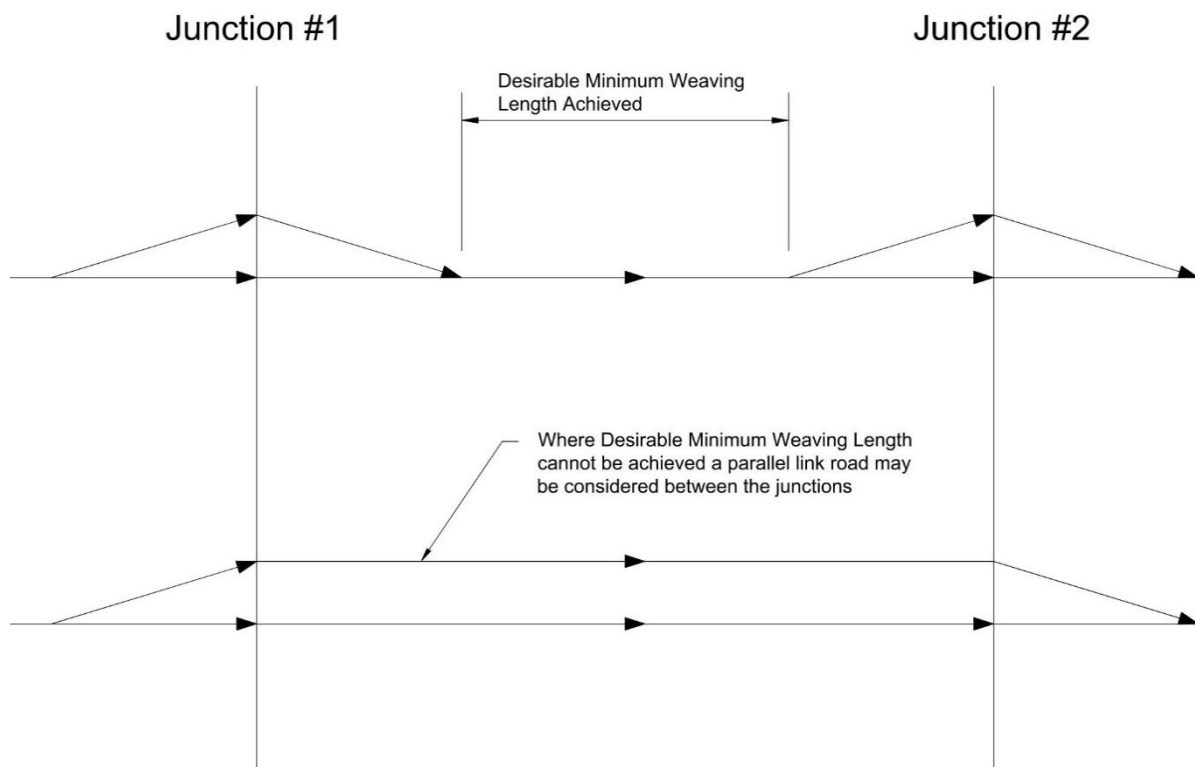
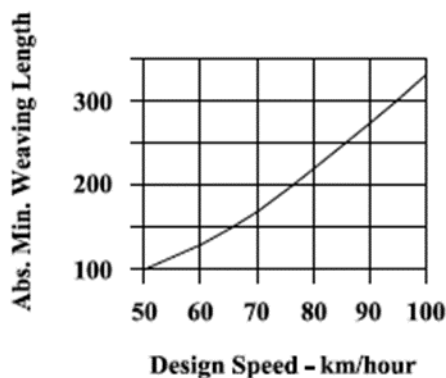
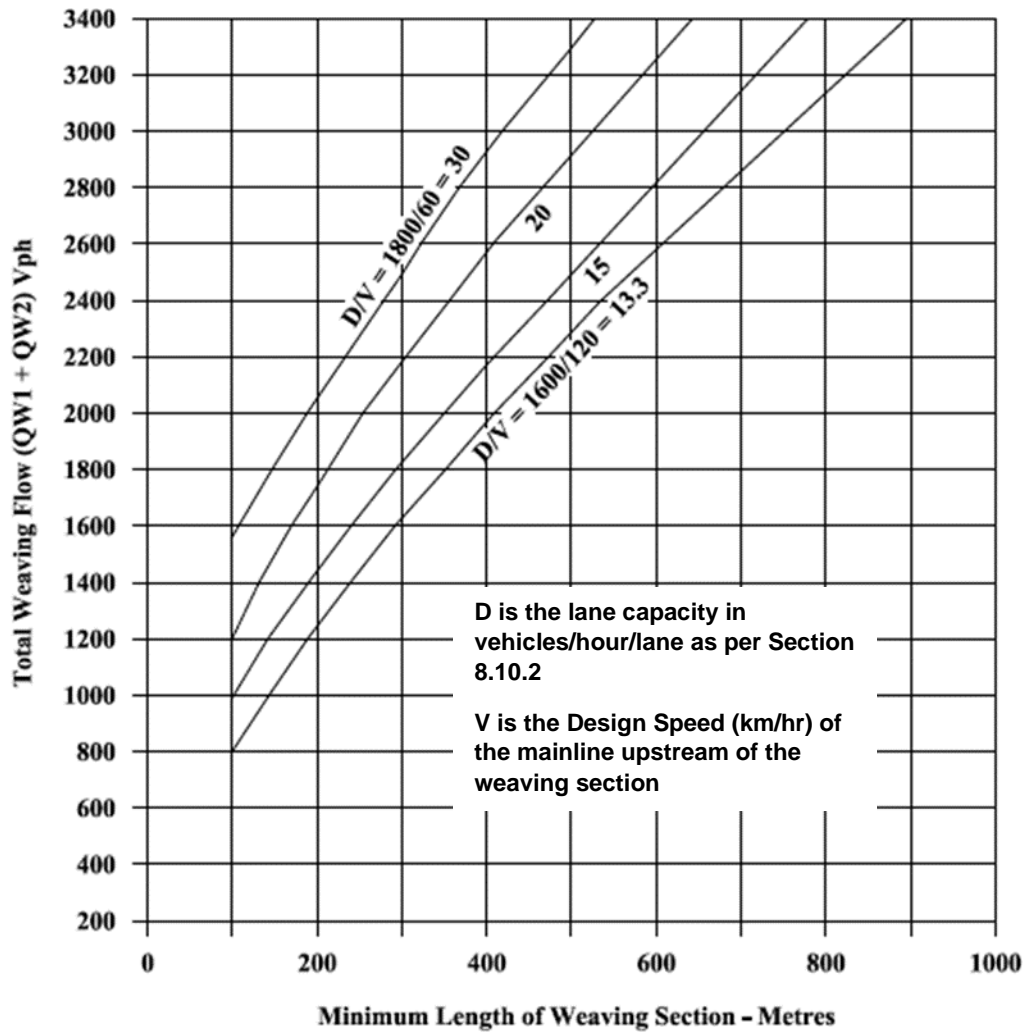


Figure 8.15 Indicative Parallel Link Road Layout

For Urban Motorways and Urban Type 1 Dual Carriageways, the design flows must be inserted in Figure 8.16 to obtain a minimum weaving length ( $L_{min}$ ). This must then be compared to the Design Speed related Absolute Minimum weaving length in Figure 8.16 and the greater of the two lengths taken as the minimum length of weaving section, provided that signing requirements can be met.



To determine the minimum length of weaving section ( $L_{min}$ ) for use with the formula for calculating weaving

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 8.16 Weaving Length Diagram for Urban Roads

### 8.9.4 Weaving Section Lanes Calculation

The principle of calculating weaving sections is that the length is fixed using Section 8.9.3 and the number of lanes is calculated using the weaving formula. This determines the total number of lanes within the weaving section and may indicate the addition of one or two lanes between the junctions. The formula shows that the minor weaving flow has an impact on the traffic demand of up to 3 times its numerical value.

An actual weaving length  $L_{act}$  less than the desirable minimum must not be entered into the formula.

For weaving sections on motorways and dual carriageway roads, design flows must be calculated as per this Chapter. 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:

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

Where:

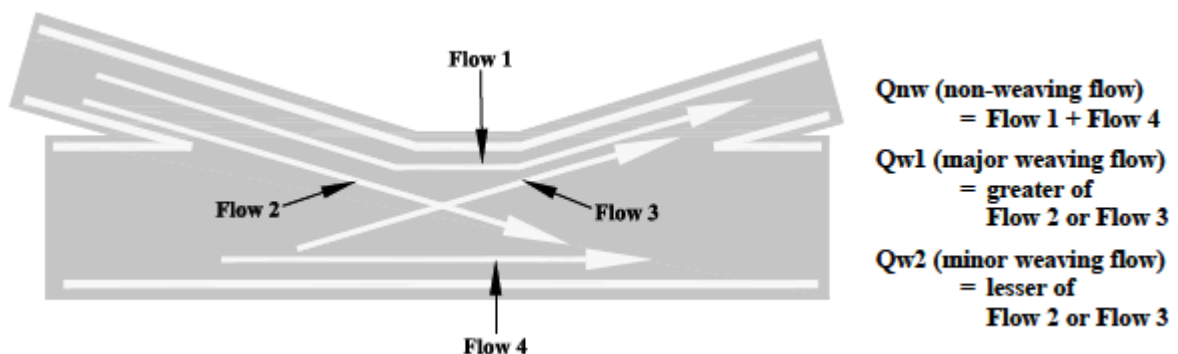
- N = Total number of traffic lanes within the weaving section
- $Q_{nw}$  = Total non-weaving flow in vph
- $Q_{w1}$  = Major weaving flow in vph
- $Q_{w2}$  = Minor weaving flow in vph
- D = Maximum mainline flow from Section 8.10 in vph per lane
- $L_{min}$  = Desirable Minimum weaving length for the road
- $L_{act}$  = Actual (measured) weaving length available

The flows  $Q_{nw}$ ,  $Q_{w1}$  and  $Q_{w2}$  shall be determined with reference to Figure 8.17.

In calculating the number of traffic lanes required 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:

- a) the number of lanes required for merging and diverging (Sections 8.7 and 8.8);
- b) when the fractional part is about 0.5 the number of lanes shall be rounded up;
- c) 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;
- d) the consequences of under provision should be borne in mind, as the acquisition of land at a later date could be costly or impossible;
- e) relevant environmental factors should be taken into account.



- $Q_{nw}$  (non-weaving flow) = Flow 1 + Flow 4
- $Q_{w1}$  (major weaving flow) = greater of Flow 2 or Flow 3
- $Q_{w2}$  (minor weaving flow) = lesser of Flow 2 or Flow 3

Figure 8.17 Flow Terms used in Weaving

## 8.10 Traffic Flows

### 8.10.1 Hourly Design Flow

Hourly Design Flows shall be calculated using an appraisal method agreed with TII. For roads of the Main Urban Type, junction and weaving area design shall be based on the 30<sup>th</sup> highest hourly flow. For Inter-Urban road types, the 50<sup>th</sup> and 200<sup>th</sup> highest hourly flows respectively shall be used. The highest value of the total design flow, corrected for HGVs and gradient as described later in this Section, projected to the 15<sup>th</sup> year after opening, shall be taken as the basis of design for merges, diverges, and weaving sections.

### 8.10.2 Mainline Traffic Capacity

For the purpose of designing junctions and interchanges, the maximum lane capacity for Type 1 Dual Carriageway national roads should be taken as 1,600 vehicles per hour (vph) and for Motorways as 1,800 vph. These values have been used in Figures 8.3 and 8.5 in this Standard. If higher values have been used in the design of the mainline carriageways, then the equivalent number of lanes should be used, instead of design flows, for that part of Figures 8.3 and 8.5 that relate to the mainline.

### 8.10.3 Design Flows and Connector Road Cross-sections

Connector road cross-sections corresponding to design traffic flow ranges are given in Table 8.4. Further details of the cross-sections are given in Section 8.11.

**Table 8.4 Connector Road Cross-sections for Design Flows**

|  | For Mainline Road Type |                                       | Connector Road Cross-section for: |                             |                                 |
|--|------------------------|---------------------------------------|-----------------------------------|-----------------------------|---------------------------------|
|  | Motorway               | Type 1 Dual Carriageway National road | Slip Road                         |                             | Interchange Link/Loop           |
|  |                        |                                       | Merge                             | Diverge                     | Merge/Diverge                   |
| Peak Corrected Design Flow on Connector Road:<br>Vehicles per hour | 0-900                  | 0-800                                 | Single Lane - 4.00m Carriageway   |                             | Single Lane - 4.00m Carriageway |
|  | 900-1350               | 800-1200                              | Single Lane - 4.00m Carriageway   | Two Lane - 6m Carriageway   |                                 |
|  | 1350-2700              | 1200-2400                             | Two Lane - 7.3m carriageway       | Two Lane - 7.3m carriageway | Two Lane - 7.3m carriageway     |
|  | 2700-3600              | 2400-3200                             |                                   |                             |                                 |

Notes:

Cross-sectional details for Connector Road verges and hard strips are given in the relevant tables of DN-GEO-03036.

### 8.10.4 Flow Corrections for Uphill Gradients and for LCVs

Corrections for uphill gradients and for the presence of HGVs as set out in Table 8.5 shall be made to the predicted hourly flows before corresponding values are read off from Table 8.4 and from Figures 8.3 and 8.5.

To establish the mainline gradient a one kilometre section shall be used, 0.5 km either side of the merge or diverge nose tip, and the average gradient determined. The merge connector road gradient shall be based on the average of the 0.5 km before the nose tip.

**Table 8.5 Percentage Correction Factors for Gradients and the presence of HGVs**

| %HGV | Mainline Gradient |     | Merge Connector Gradient |       |     |
|------|-------------------|-----|--------------------------|-------|-----|
|      | <2%               | >2% | <2%                      | 2%-4% | >4% |
| 5    | -                 | +10 | -                        | +15   | +30 |
| 10   | -                 | +15 | -                        | +20   | +35 |
| 15   | -                 | +20 | +5                       | +25   | +40 |
| 20   | +5                | +25 | +10                      | +30   | +45 |

## 8.11 Geometric Standards

### 8.11.1 Cross-Sections

For the purpose of designing grade separated junctions, Table 8.4 gives the required number of lanes and widths for the running carriageway for a range of design flows and road types. Details of other components such as hard shoulders, hard strips and verges that make up the cross-section for slip roads and interchange links are detailed in DN-GEO-03036. Values for the appropriate widths of such components can be found in the relevant tables of DN-GEO-03036.

### 8.11.2 Maximum Lengths of Slip Roads and Interchange Links

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

Single Lane Interchange Links must only be provided:

- a) 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
- b) where their length does not exceed 0.5 km and they are on an average uphill grade of 3% or steeper.

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.

### 8.11.3 Design Speed

Design speeds for the mainline must be determined from DN-GEO-03031. The design speeds of connector roads must be as given in Table 8.6. The design speed for link roads should normally be one design speed step below that of the mainline, as shown in Table 8.6 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.

**Table 8.6 Connector Road Design Speed**

| Mainline Design Speed                        |                        | Rural Motorway<br>120km/h | Urban Motorway<br>100km/h | Rural Type 1<br>Dual<br>Carriageway<br>120km/h | Rural Type 1<br>Dual<br>Carriageway<br>100km/h | Urban Type 1<br>Dual<br>Carriageway<br>85km/h | Urban Type 1<br>Dual<br>Carriageway<br>70km/h |
|--|------------------------|---------------------------|---------------------------|--|--|---|---|
| Connector<br>Road<br>Design<br>Speed<br>km/h | Interchange<br>Link    | 85                        | 70                        | 85   | 85   | 70  | 60  |
|  | Slip Road              | 70                        | 60                        | 70   | 70   | 60  | 60  |
|  | Link Road              | 120 or 100                | 100 or 85                 | 120 or 100                                     | 100 or 85                                      | 85 or 70                                      | 70 or 60                                      |
|  | Dumb-bell Link<br>Road | 70                        | 70                        | 70   | 70   | 70  | 60  |
|  | Loops                  | 50                        | 50                        | 50   | 50   |   |   |

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

#### 8.11.4 Horizontal and Vertical Alignment

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 DN-GEO-03031. The maximum gradient for connector roads shall be 6%.

Low radius connector roads must be widened on curves in accordance with DN-GEO-03031.

#### 8.11.5 Vertical Alignment for Merges and Diverges

Vertical design of merges and diverges (see Figure 8.18) shall provide:

- a) At the start of nose, a constant crossfall shall be maintained across the main carriageway, the tip of the nose and the slip road carriageway (Section A-A on Figure 8.18).
- b) At the back of the nose either:
  - i) a constant crossfall across the main carriageway, the back of the nose and the slip road carriageway (Section B-B on Figure 8.18) or;
  - ii) a separate crossfall for the mainline and the slip road with a single change in crossfall by a maximum of 3%, located on either edge of the nose or within the nose (Section B-B on Figure 8.18).
- c) From the back of the nose to the point where both slip road and mainline verge widths have been fully developed (shown as point V on Figure 8.18), the crossfall of the un-paved verge shall be a maximum of 5% (Section C-C on Figure 8.18).

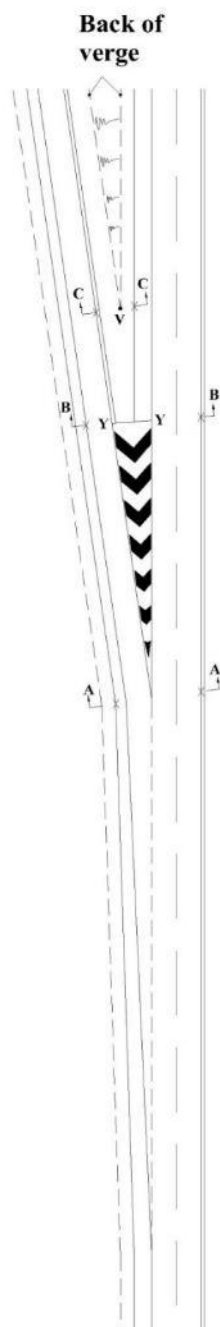


Figure 8.18 Vertical Alignment for Merges and Diverges

## 8.12 Loops

In the case of the horizontal curvature and superelevation for loops (as defined in Chapter 1), there is evidence to suggest that the radii of loops 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 8.7 appropriate to the mainline design speed. Within the loop, successive radii of the same hand must not reduce in radius. The standards for superelevation for loops are set out in DN-GEO-03031. Superelevation greater than 7% and up to 10% may be provided as shown in DN-GEO-03031 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 DN-GEO-03031. Widening on loops must be as set out in DN-GEO-03031, Section 3.9.

**Table 8.7 Minimum Loop Radii – (m)**

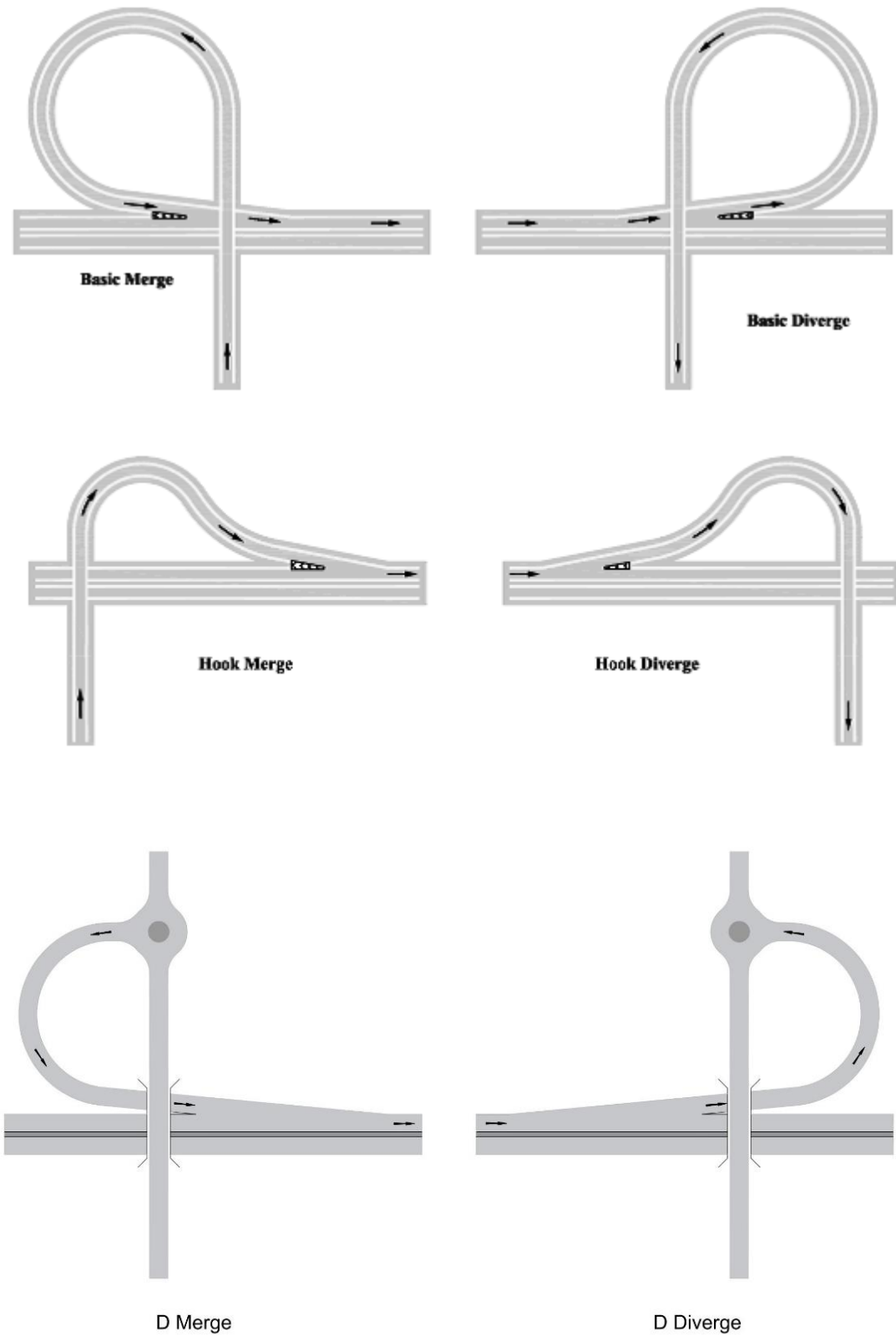
| Design Speed 120 km/h<br>On/Off Mainline | Design Speed 100 km/h or less |              |
|--|-------------------------------|--------------|
|  | On to Mainline                | Off Mainline |
| 75                                       | 40                            | 50           |

Research into loops carried out from 1985 to 1994 did not reveal any systemic safety problems. Collision levels at sites surveyed were generally low with approximately a third of the sites having no personal injury collisions over the study period.

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 8.19:

|   |
|---|
| <b>Basic merge</b>  |
| 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 8.19a.   |
| <b>Basic diverge</b>  |
| 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 8.19b. |
| <b>D merge</b>  |
| The loop commences at a T-junction or roundabout and merges with the mainline flow. The angle turned is typically approximately 180°.   |
| <b>D diverge</b>  |
| 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°.                                      |
| <b>Hook merge</b>   |
| 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 8.19c.   |
| <b>Hook diverge</b>   |
| 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 8.19d.   |





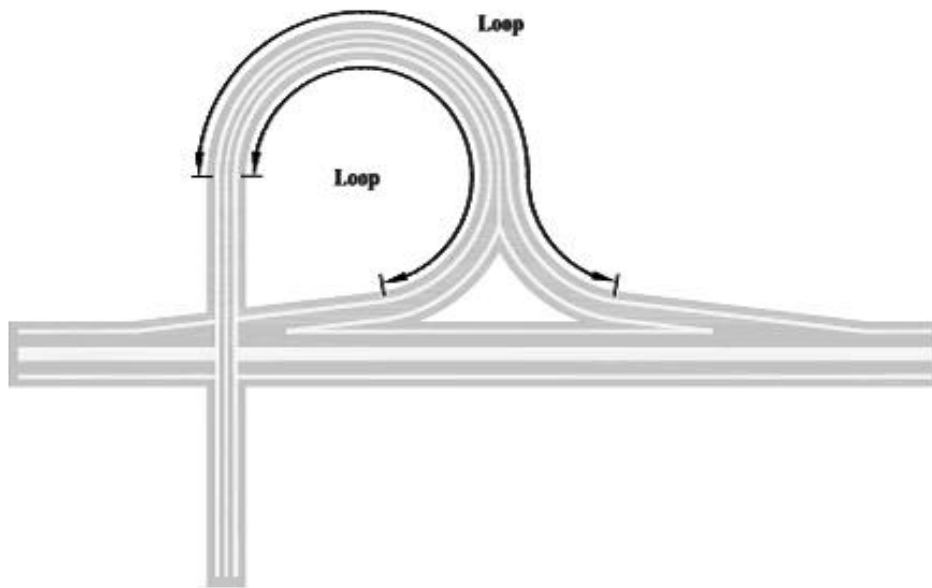
**Figure 8.19** Types of Loop

*Note: A near straight is required beyond the back of each nose (see Sections 8.7 and 8.8)*

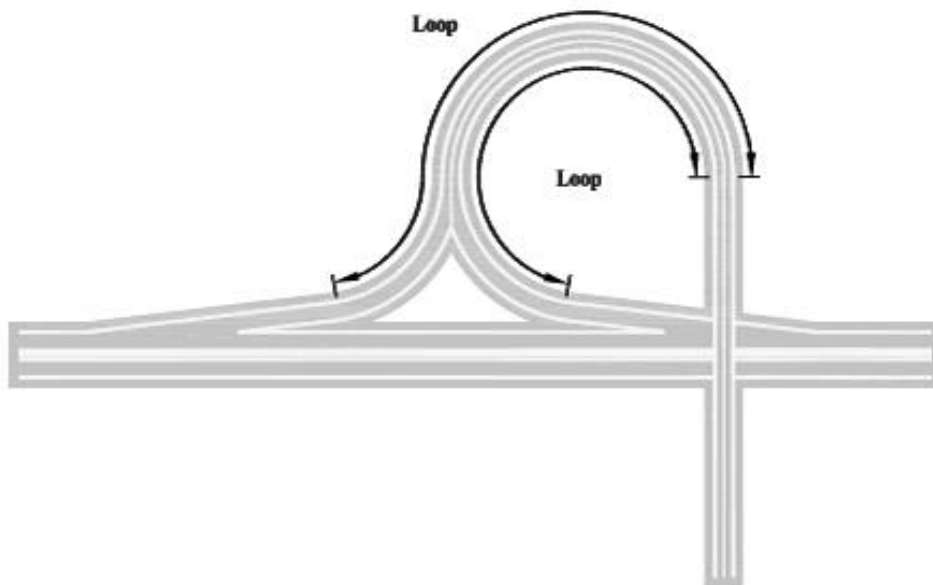
The average speed of approach to a loop may have an impact on its safety record. It is possible that the higher speeds on motorways on the approach to loops may be a contributory factor to collisions, particularly on diverge loops. Measures to maintain safety are necessary, and measures to consider include:

- a) provision and maintenance of clear visibility over the whole of the loop on the approaches, especially beyond an underbridge (see Paragraph 8.13.3);
- b) advisory speed limits and/or bend signs and “chevron” warning signs;
- c) widening of lanes on the loops as appropriate for lower radii in accordance with DN-GEO-03031, Section 3.9;
- d) the provision of vehicle restraint systems on the outside of the curve;
- e) physical separation of opposing traffic streams (see Section 8.17 Connector Roads for mandatory requirements);
- f) lighting;
- g) high skid resistant surfacing.

The provisions for loops in this document must apply only to the layouts shown in Figure 8.19, which may be used in combination as shown in Figure 8.20.



**a) Basic diverge plus hook merge**



**b) Basic merge plus hook diverge**

**Figure 8.20 Examples of Combinations of Different Types of Loop**

*Note: A near straight is required beyond the back of each nose (see Sections 8.7 and 8.8)*

## 8.13 Sight Distances

### 8.13.1 Merges

The Stopping Sight Distance on the connector road must be that related to the design speed selected for that road (see Table 8.6). This will apply until the driver reaches the Stopping Sight Distance from the back of the merge nose. From that point forward, the Stopping Sight Distance must be that for the mainline design speed as illustrated in Figure 8.21A. 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. 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 (Section 8.7). The width of the back of the nose must be sufficient to accommodate the mainline hard shoulder/hard strip and the connector road offside hard strip.

### 8.13.2 Diverges

The Desirable Minimum Stopping Sight Distance for the mainline design speed shall be maintained until the driver reaches the tip of the diverge nose. The stopping sight distance can then be reduced to the Desirable Minimum for one design speed step below the mainline design speed (but not below 70km/h). When the driver reaches the back of the diverge nose, the stopping sight distance can then be reduced to the Desirable Minimum for the design speed of the connector road as illustrated in Figure 8.21B. On lengths where two sight distances overlap, the requirements of the longer Stopping Sight Distance shall be met. If the length of the connector road between the back of the nose and the stop or yield 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 stop or yield line must be visible from a distance equal to the mainline Stopping Sight Distance from either the connector road or the mainline carriageway. See Figure 8.21C.

### 8.13.3 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 8.20. 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.

At connections to the local road system and where at-grade junctions form part of the grade separated junction, the sight distance requirements for various junction types as outlined in this standard shall be adopted for roundabouts, traffic signals and priority junctions respectively. Approaching drivers shall have unobstructed visibility of the at-grade junction from a distance corresponding to the relevant Stopping Sight Distance on the approach road.

## 8.14 Hard Strip and Hard Shoulder

For merge configurations as shown in Figures 8.4.1 to 8.4.5, the width of the connector road hard strip shall change to the width of the mainline hard shoulder or hard strip over the full length of the nose.

For diverge configurations as shown in Figures 8.6.1 to 8.6.4, the width of the mainline hard shoulder or hard strip shall be maintained to the tip of the diverge nose. The width of the mainline hard shoulder or hard strip shall change to the width of the connector road hard strip over the full length of the nose.

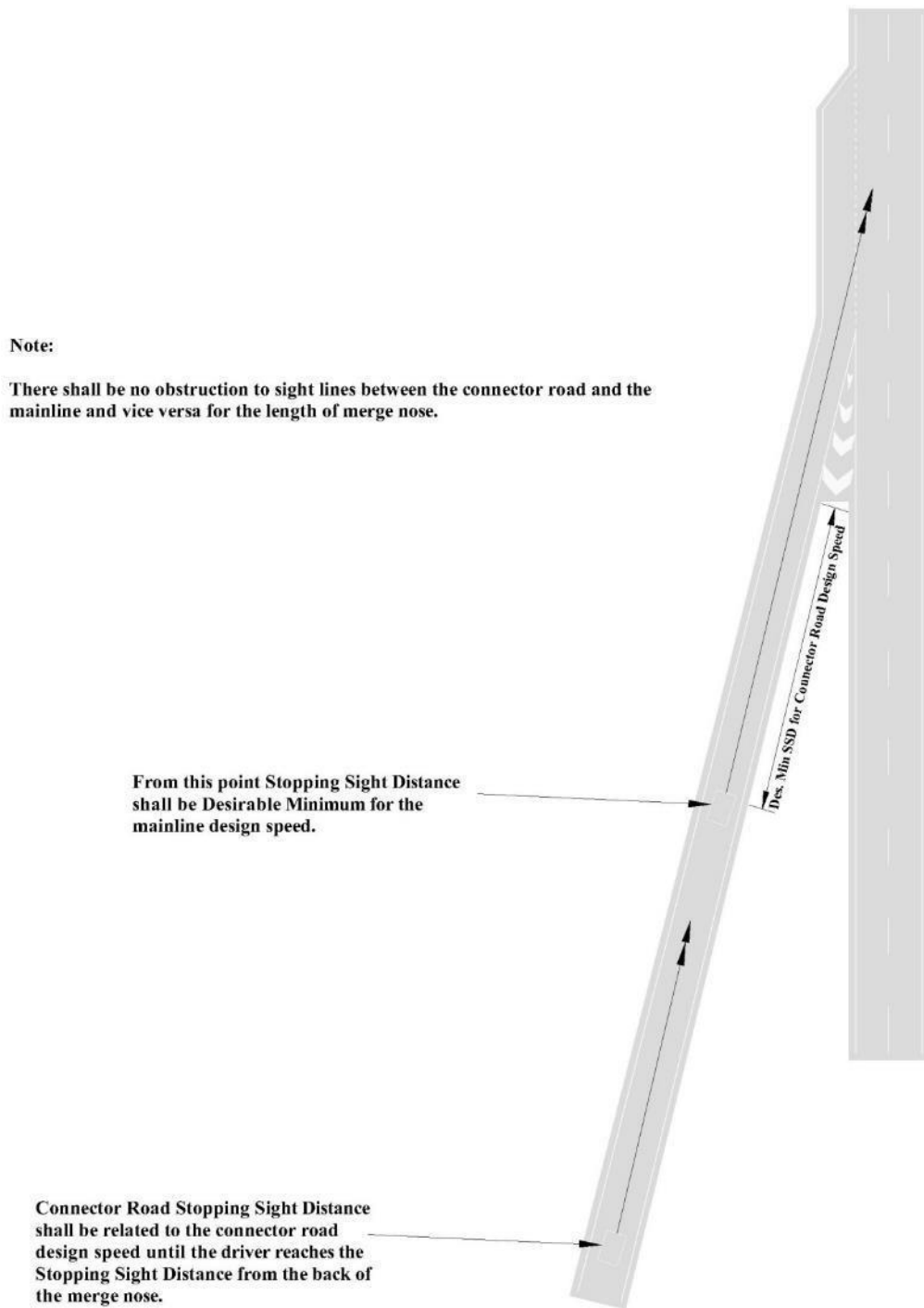


Figure 8.21a Illustration of Stopping Sight Distance on Merge Slip Road

**Notes:**

1. This Figure shows the situation when the distance from the back of the nose to any stop or yield line exceeds the Desirable Minimum Stopping Sight Distance for the mainline (SSD1).
2. On lengths where two sight distances overlap, the requirements of the longer Stopping Sight Distance shall be met.
3. This Figure does not apply to loops of low radius.

At the back of the nose, the SSD can then be reduced to the Desirable Minimum for the design speed of the connector road (SSD3),

subject to Note 2 above.

Immediately after the tip of the nose, the SSD can be reduced to Desirable Minimum for one design speed step below that of the mainline (but not below 70km/h), i.e. SSD2.

Desirable Minimum SSD (SSD1) for the mainline design speed shall be maintained until the driver reaches the tip of the diverge nose.

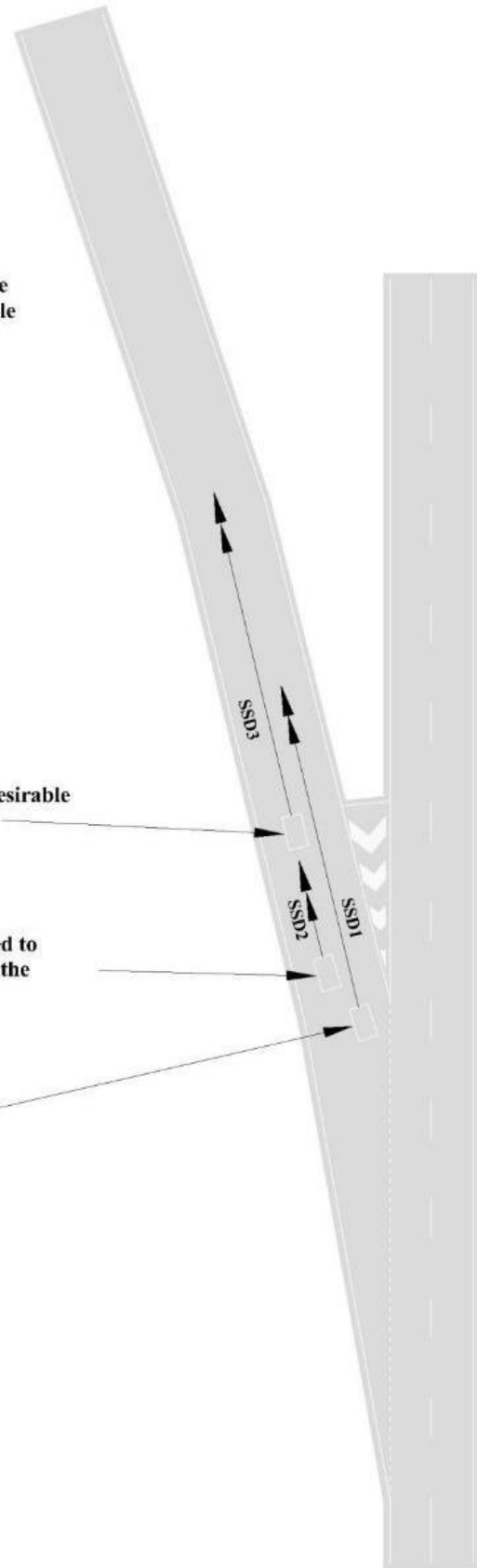
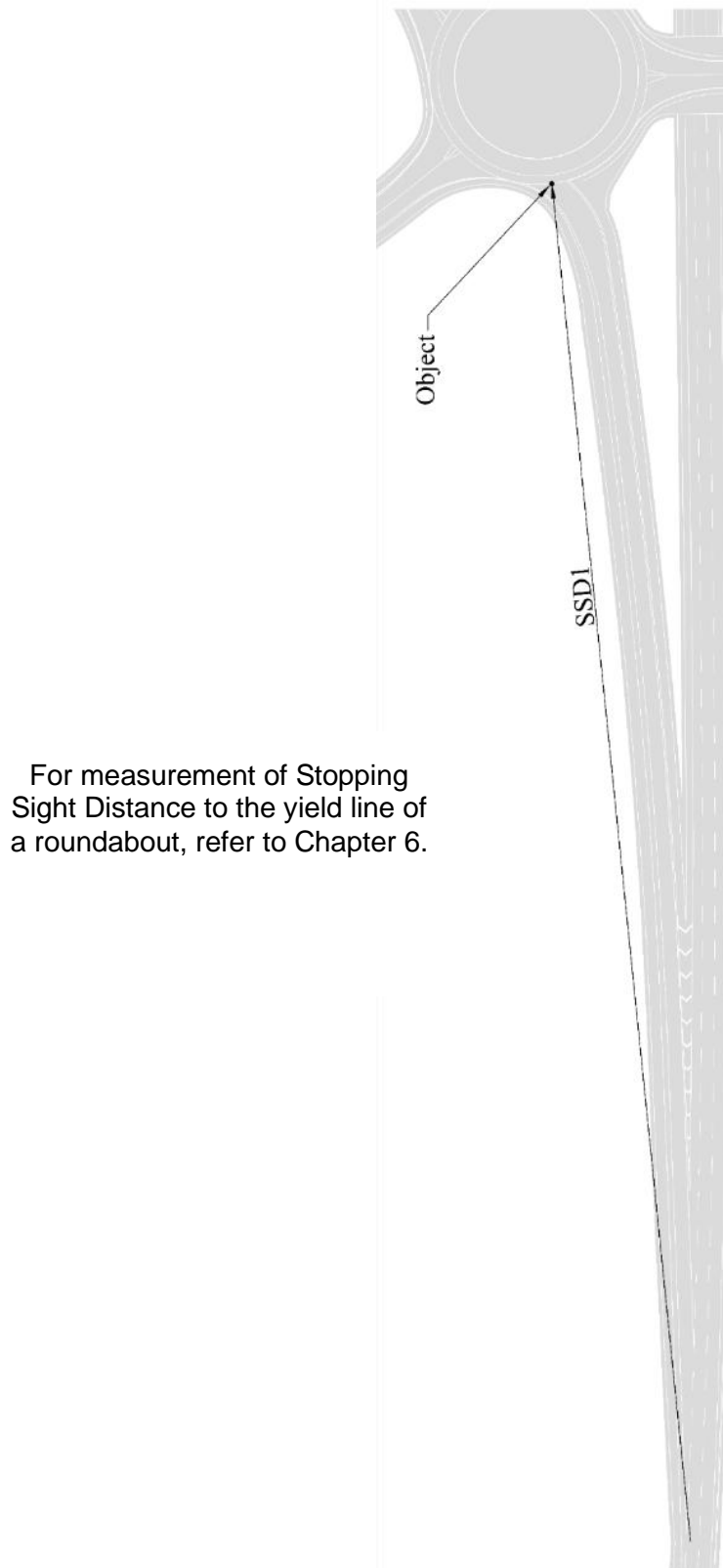


Figure 8.21b Illustration of Stopping Sight Distance on Diverge Slip Road



**Figure 8.21c Illustration of Stopping Sight Distance on Slip Road**

*Notes:*

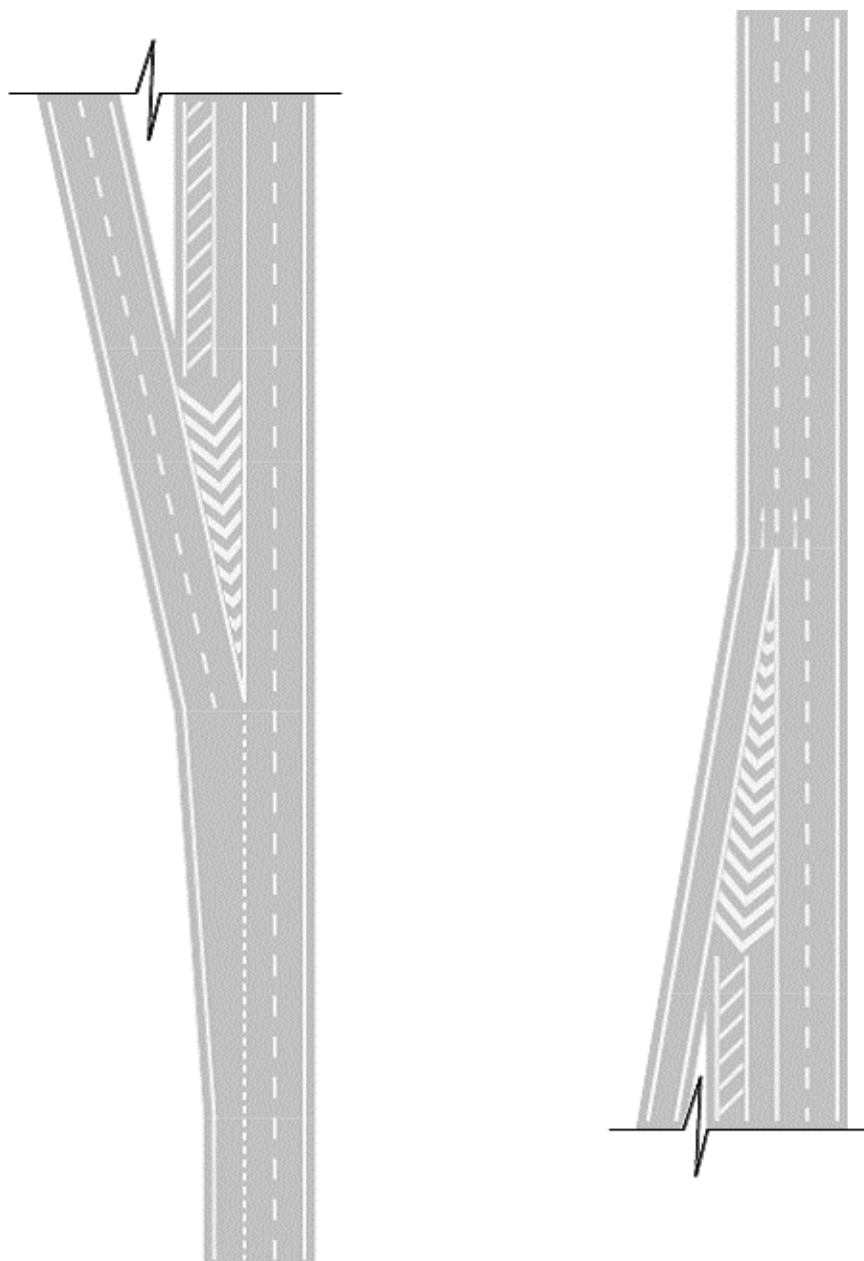
*This figure shows the situation when the distance from the back of the nose to any stop or yield line is less than the Desirable Minimum Stopping Sight Distance for the mainline (gradient 1).*

*This figure does not apply to loop roads.*

## 8.15 Lane Drop/Lane Gain and Through Carriageway

Where a 3-lane carriageway is reduced to 2 lanes by means of a lane drop at a junction as shown in Figure 8.22, provision must be made on the link between the lane drop and a 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 hard shoulder if a motorway) and the pavement adjacent to the nearest paved edge must be hatched out to leave a normal width of hard strip (or hard shoulder if a motorway) adjacent to the running lane as shown in Figure 8.22. 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.

Advice on the signing of lane gains and lane drops is given in the Traffic Signs Manual.



**Figure 8.22 Lane Drop to Two Lanes and Subsequent Lane Gain Showing Hatched Pavement for Maintenance and Traffic Management**



## 8.16 Interchanges

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 below:

- a) efficiency;
- b) safety;
- c) consistency;
- d) location;
- e) maintenance;
- f) environmental effects;
- g) land take;
- h) capital cost;
- i) economic assessment;
- j) provision for Active Travel users (crossing the junction)

Figure 8.23 shows three different 4 way interchanges.

- a) 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 8.23.1a.
- b) 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 8.23.1b.

A variant of Figure 8.23.1b is shown at Figure 8.24 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.

The three way 'trumpet' interchange (Figure 8.23.2c) should be designed to enable future conversion to a four way. It has a 2 way slip road which requires careful design for safety. Figure 8.23.2d shows a three way interchange with restricted movement. This enables high vehicle speeds to be maintained with low land take, but it requires a skew structure and prohibits any future conversion.

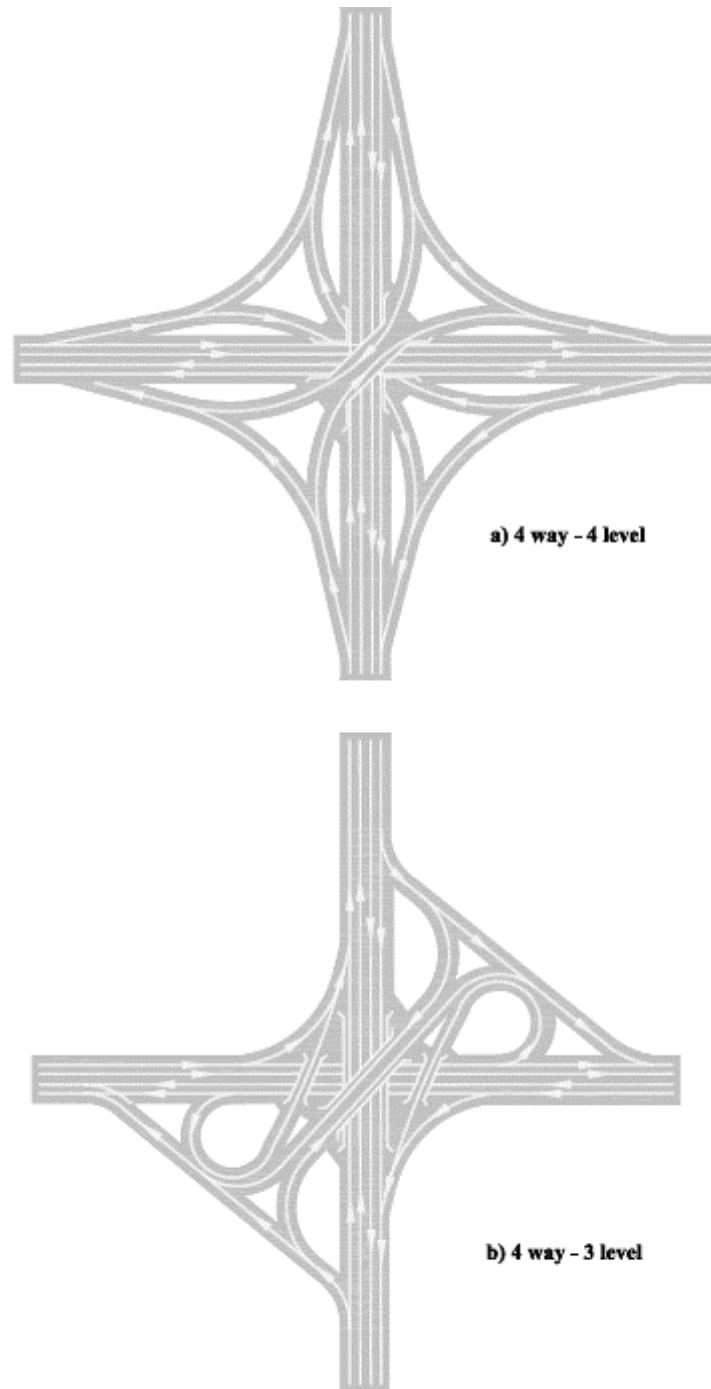


Figure 8.23.1 Typical Layouts of Interchanges

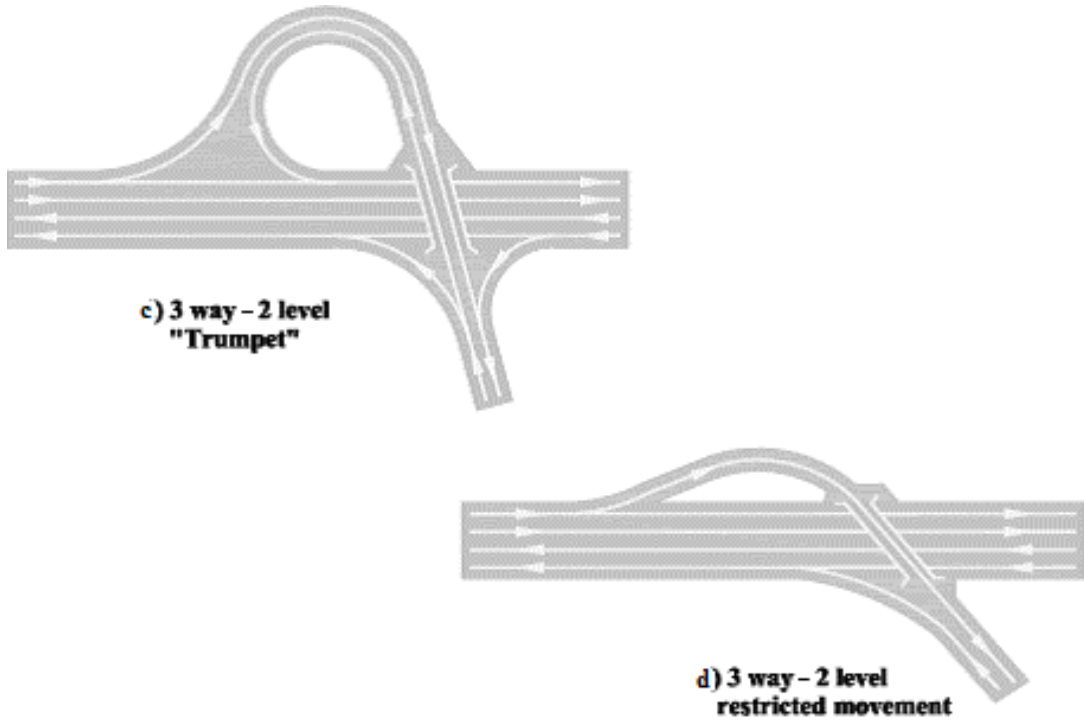


Figure 8.23.2 Typical Layouts of Interchanges



Figure 8.24 Variant of Figure 8.23.1b Restricted in Height to Reduce Environmental Impact

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. HGVs 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.

Loops and certain links may require advisory speed limits (which should be discussed and agreed with TII) 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.

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 (Table 8.4) 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.

## **8.17 General**

### **8.17.1 Maintenance**

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. They should be located on straights or right hand curve sections with at least desirable minimum radius.

### **8.17.2 Connector Roads**

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 collisions.

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. They should be located on straights or right hand curve sections with at least desirable minimum radius.

The collision 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.

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

### **8.17.3 Merging and Diverging Lanes**

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 Section 8.15 should be followed.

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 8.6.3 (Layout C) and Figure 8.4.2 (Layout B). Removal of a lane (excluding climbing lanes) must not take place on the link between junctions.

### **8.17.4 On-line Service Areas**

On-line Service Areas should be provided in accordance with the guidance in DN-GEO-03028, The Location and Layout of Service Areas. Generally, all vehicle types are permitted to enter an On-line Service Area via a connector road directly from the mainline or as an integral part of a grade separated junction. On-line Service Areas shall be designed in accordance with the merge and diverge layout designs, including minimum length of diverge slips, and junction spacing parameters in this chapter. Measures must be taken to reduce any 'see-through' effects when looking from a diverge slip to the merge such as slip or internal road system of the On-line Service Area.

### **8.17.5 Other Service Areas**

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 this Chapter or Chapter 5 of this Standard, as appropriate for each site.

### **8.17.6 Emergency and Maintenance Accesses**

Where an emergency or maintenance access is required, a suitable layout must be chosen from Chapter 5 of this standard. The preferred layout is that shown as Direct Access 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 hard strip or hard shoulder, 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 Chapter 5 of this standard with respect to avoiding steep gradients on the access road in the immediate vicinity of its connection to the national road.

## **8.18 Safety**

The consequences of an incident can be severe if hazards are present within the verge area immediately downstream of the diverge nose at a junction. 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. 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, if a safety barrier is required to protect errant vehicles from any hazards, including height differences between adjacent carriageways, the use of full height terminals or crash cushions with appropriate performance levels is recommended as end treatments to barriers. Sufficient space should be allowed for any safety barriers and end treatments.

## 9. Layout of Compact Grade Separated Junctions

### 9.1 Design Procedure

#### 9.1.1 General Principles

The introduction of design standards for compact grade separation is primarily aimed at improving safety for all road users. At all stages in the design and construction of the junction it is of paramount importance that safety aspects are fully investigated and considered.

Compact grade separation can be used on Type 1 and 2 Single Carriageways and Type 2 and 3 Divided Roads as defined in Table 6.1 of DN-GEO-03031.

This Chapter sets out the level of provision to be considered for low traffic flow situations on the minor road and effectively extends downwards the range of flows and conditions over which grade separation could be justified economically to around 12,500 AADT on the major road.

On existing dual carriageways, the provision of compact grade separation may be applied to a route which consists of a number of grade separated junctions and roundabouts interspersed with at grade priority junctions. The introduction of compact grade separation on a route such as this is intended to remove all the right turn manoeuvres associated with the mainline resulting in a fully grade separated route. Some left-in/left-out junctions may be retained or introduced.

Where a compact grade separated junction or junctions are being considered the following shall be taken into account:

- a) the closure of certain minor road junctions which have very low flows and for which there are alternative routes. The additional journey length, delay and inconvenience resulting from the closure of a route must be considered in the context of the improved safety which will be achieved by the removal of all the right turn manoeuvres;
- b) limiting remaining at grade junctions to left-in/left-out only;
- c) where there is no alternative route it may be necessary to reconsider the location and number of junctions;
- d) improvements to the network to assist the closure of certain junctions;
- e) the provision of accommodation roads, and ATUs facilities;
- f) the removal of direct accesses from the mainline;
- g) collecting a number of minor roads into a single compact grade separated junction;

On single carriageways, compact grade separated junctions shall only be adopted where the mainline cross-section includes a length of single lane dualling (with physical central reserve) through the junction, to prevent illegal right turn movements out of the minor road junctions as outlined in Section 9.2.11.

#### 9.1.2 Provision on Type 3 Divided Roads

On Type 3 Divided Roads with relatively high traffic flows, it may be appropriate to provide compact grade separated junctions. On a length of Type 3 Divided Road with compact grade separated junctions there shall be no breaks in the central reserve. All major junctions shall be compact grade separated, or roundabout, while minor ones shall be left-in/left-out only. U-turns will only be possible at the compact grade separated junctions, or at roundabouts. Accesses should be severely limited or avoided altogether.

Where practicable, layouts should be designed so that merging occurs on two-lane sections, thereby avoiding the problems of merging into a single lane. This can be achieved if the junction is at a non-critical changeover.

Analysis indicates that for the improvement of an existing priority junction to compact grade separation standards an increase in capacity of 70% for some movements can be achieved at the mainline junctions.

The layout of the compact grade separation should be chosen to suit the traffic movements. In certain conditions, the redistribution of the turning traffic can result in significant turning flows at the minor road junction entry and exits. It is important therefore to assess the capacity of these junctions when considering the layout to be adopted.



### 9.1.3 Cycle Friendly Design

In general, it is preferable to provide alternative facilities away from high-speed traffic, where warranted. Notwithstanding, cycle friendly design principles should be adopted in the design of compact grade separated junctions.

To assist cyclists, gradients should ideally be limited to 5%, however the objectives of compact grade separations will in many instances prevent this being achieved. Gradients should only be increased above this figure with careful consideration of all factors in accordance with Section 9.2.6.

At junctions, where the active travel facility along the mainline crosses a connector road, the geometric requirements as prescribed for major priority junctions should be provided for ATU's, including the provision of a 3.5 metre central island if traffic flows warrant it.



## 9.2 Geometric Standards

### 9.2.1 General

This standard provides a geometric standard for compact grade separation incorporating established design standards for priority junctions.

The geometric standards for the mainline and for those minor roads which pass directly through a compact grade separated junction shall be provided in accordance with DN-GEO-03031.

The standards for compact grade separation in this standard have been set in order to minimise the variation in designs to prevent confusion for the road user. Those items which do permit a degree of variation at the discretion of the designer are:

- a) Junction configurations;
- b) Horizontal radii on compact connector road (desirable minimum radius with a relaxation of one design speed step);
- c) Vertical Curvature (desirable minimum radius with a relaxation of one design speed step);
- d) Carriageway Width (three options and a one step relaxation);
- e) Curve Widening (three options are permitted for each radius).

### 9.2.2 Design Speed

Design speeds for the mainline and the minor road shall be determined from DN-GEO-03031.



As a general principle, it is intended that the speed of a vehicle through the compact connector road shall be limited by its speed through the entry and exit junctions with the mainline and the minor road. For this reason, long straight sections within the compact connector road shall be avoided.

The design standards for compact grade separated junctions relate to a single design speed of approximately 30km/h. Junctions shall only be designed to this design speed, higher or lower standards shall not be used. A range of standards would result in driver confusion and uncertainty and problems of perception of the junction with consequent safety implications.

If speeds markedly in excess of this do occur or are anticipated, then speed limits within the junction may need to be considered.

### 9.2.3 Compact Connector Road

Compact connector roads shall be designed in accordance with Table 9.1 except for the special conditions when the stopping sight distance may be relaxed further as outlined in Section 9.2.5. The stopping sight distances in Table 9.1 are not related to the design speed but are based upon the requirements to provide adequate stopping sight distance through the compact connector road to show the shape of the junction clearly to the driver leaving the mainline. The design parameters provided in this section are for the compact connector road only, junctions either end of the connector road shall be designed in accordance with the relevant chapter of this standard and DN-GEO-03031.

**Table 9.1 Design Standards for Compact Connector Roads**

|   |     |
|---|-----|
| <b>Stopping Sight Distances</b>                               |     |
| Desirable Minimum (m)   | 70  |
| Relaxation of One Design Speed Step (m)                       | 50  |
| <b>Horizontal Curvature</b>                                   |     |
| Desirable Minimum Radius (m) with 5% Superelevation           | 40  |
| Relaxation of One Design Speed Step(m) with 5% Superelevation | 32  |
| <b>Vertical Curvature</b>                                     |     |
| Desirable Minimum Crest K                                     | 3.3 |
| Relaxation of One Design Speed Step Crest K                   | 2.3 |
| Absolute Minimum Sag K with lighting                          | 2.3 |
| Absolute Minimum Sag K without lighting                       | 3.2 |

### 9.2.4 Horizontal and Vertical Alignment

Horizontal radii shall comply with Table 9.1. In normal circumstances the Desirable Minimum Radius should be used, however in difficult circumstances e.g. space constraints or environmental issues exist, a Relaxation of one design speed step may be used at the discretion of the Designer.

Given the low design speed and the nature of the compact connector road, transition curves are not required within the compact grade separated junction.

In the design of vertical curves consideration is given to stopping sight distance and driver discomfort, which requires the vertical rate of change of grade to be kept within tolerable limits. For the low design speed adopted for compact connector roads the stopping sight distance criterion over the summit is not critical because larger changes of grade do not obstruct stopping sight distance and the comfort criterion overrides. Wherever possible, vertical curvature on bridge decks should be avoided.

### 9.2.5 Sight Distances

For Compact Connector roads of low radii where it is necessary to provide for vehicle restraint systems, an obstruction in Stopping Sight Distance to the 0.26m object height may occur. In this case a relaxation to Stopping Sight Distance to the 0.26m object may be provided but SSD shall be maintained above the vehicle restraint system to the 1.05m object height.

Guidance on sight distance and visibility standards are given in Chapter 5 of this standard for the connections to the major and minor roads. In the case of compact grade separation these shall be taken as mandatory.

Where minor roads or accommodation roads are connected to the compact connector road then the visibility standards at the junction shall be in accordance with Chapter 5 and Table 9.1 of this standard.

### **9.2.6 Gradients**

The desirable maximum gradient for compact connector roads shall be 8%, although a relaxation to 10% shall be permitted in difficult locations. In selecting the gradient, the needs of cyclists should be considered and the risk of occurrence of icy conditions.

### **9.2.7 Superelevation**

Normal standards for superelevation, set out in DN-GEO-03031, would require excessive superelevation for all compact grade separations. Icy conditions can cause slow moving vehicles to slide to the inside of the curves with excessive superelevation, this effect can be exacerbated by steep gradients.

The geometric layout of the compact connector road will require successive application and removal of the superelevation between the connector road and the junction mouths. The need to maintain consistent steering requirements through the compact connector road is an important design consideration which shall be taken into account in the application of superelevation.

Superelevation on compact connector roads shall be limited to 5%.

Designers shall ensure that adverse camber is avoided at the entry to and exit from compact junctions. Accordingly, where practical, compact grade separated junctions should not be located on mainline transition curves, as this can result in difficulty in the avoidance of adverse camber.

### **9.2.8 Drainage**

All drainage within the compact grade separated junction should be of a positive nature via kerbs and gullies to facilitate the removal of surface water. Factors to consider and which may influence the decision are:

- a) the geometric standards for the junction are likely to result in steep gradients combined with successive application and removal of superelevation up to 5%;
- b) surface water from the compact connector road should be prevented from flowing onto or across the major and minor carriageways.

### **9.2.9 Cross-Sections and Curve Widening**

For the purpose of designing junctions and interchanges, cross-sections for the mainline and typical connector roads are given in DN-GEO-03031 and Chapter 8 of this standard. Different lane marking details and widths of construction for connector roads are specified in this Standard. Compact connector roads may be widened on curves in accordance with Table 9.2, the widening shall be applied in the form of central hatched markings as illustrated in Figure 9.1.

The width of curve widening shall be chosen to suit the anticipated level of usage by HGVs. Designers shall take into account the probability of HGVs regularly meeting on the curve.

Where no curve widening is applied, HGVs will cut across into the oncoming lane, where the minimum curve widening is applied HGVs will cut across into the whole of the hatched area.

Where the normal curve widening is provided there will be sufficient width for two large vehicles to pass in opposite directions. Regulatory signs shall be provided when appropriate in accordance with the requirements detailed later in this Chapter.

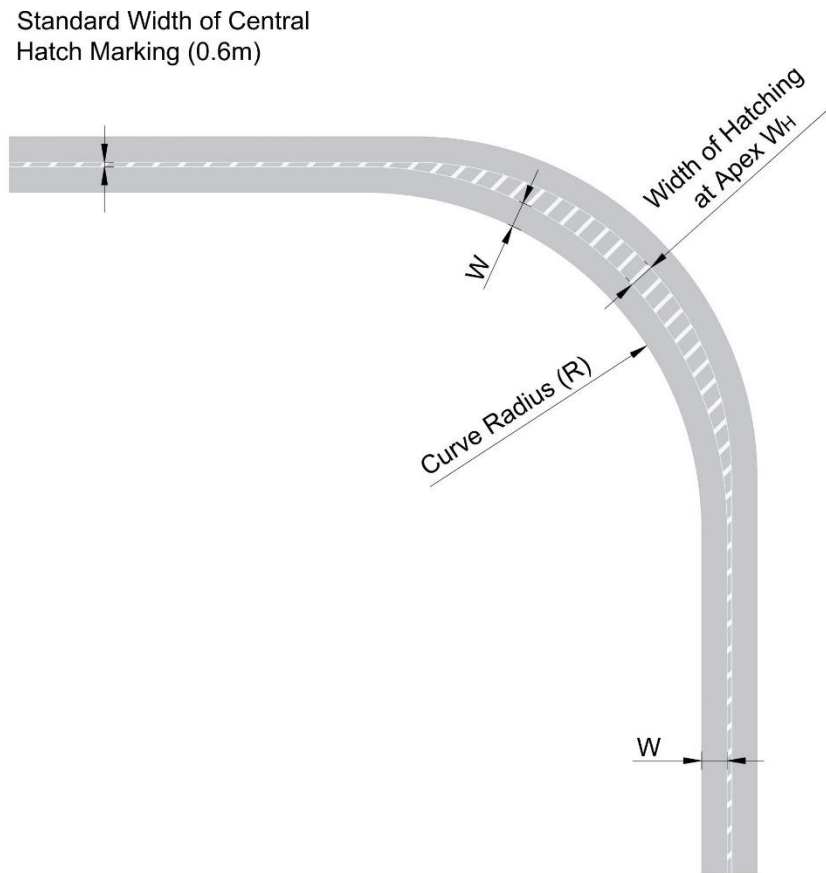


Figure 9.1 Application of Curve Widening

Table 9.2 Curve Widening on Compact Connector Roads

| Inner Channel Radius (m) | Width W <sub>H</sub> of Hatching at Apex on Curve (m) |                        |                       |
|--------------------------|---|------------------------|-----------------------|
|                          | No Curve Widening                                     | Minimum Curve Widening | Normal Curve Widening |
| 40                       | 0.6   | 1.90                   | 3.40                  |
| 32                       | 0.6   | 2.54                   | 3.74                  |

Carriageway widths for the compact connector road shall be such that they provide a transitional change in standards from the major carriageway width to the minor carriageway width in accordance with Table 9.3.

The minimum width of carriageway for a compact connector road shall be 6.6m and the maximum shall be 7.9m, excluding curve widening. Where the traffic volumes are particularly low and the proportion of HGVs is correspondingly low a relaxation to 6m may be permitted, by either reducing the carriageway width or omitting the central hatched markings.

**Table 9.3 Compact Connector Road Widths**

| Major Carriageway | Compact Connector Road                  |  | Minor Carriageway |
|-------------------|---|--|-------------------|
| Lane Width (m)    | Lane Width (W) (excluding hatching) (m) | Standard Width of Central Hatch Markings (m) | Lane Width (m)    |
| All Widths        | 3.0                                     | 0.3 per lane                                 | < 3.0             |
|                   | 3.3                                     | 0.3 per lane                                 | 3.0 to 3.65       |
|                   | 3.65                                    | 0.3 per lane                                 | 3.65              |

### 9.2.10 Hard Strips

The use of hard strips is associated with high speed roads, they shall not be used within the compact connector road. Where hard strips are included on the mainline they shall be terminated within the junction.

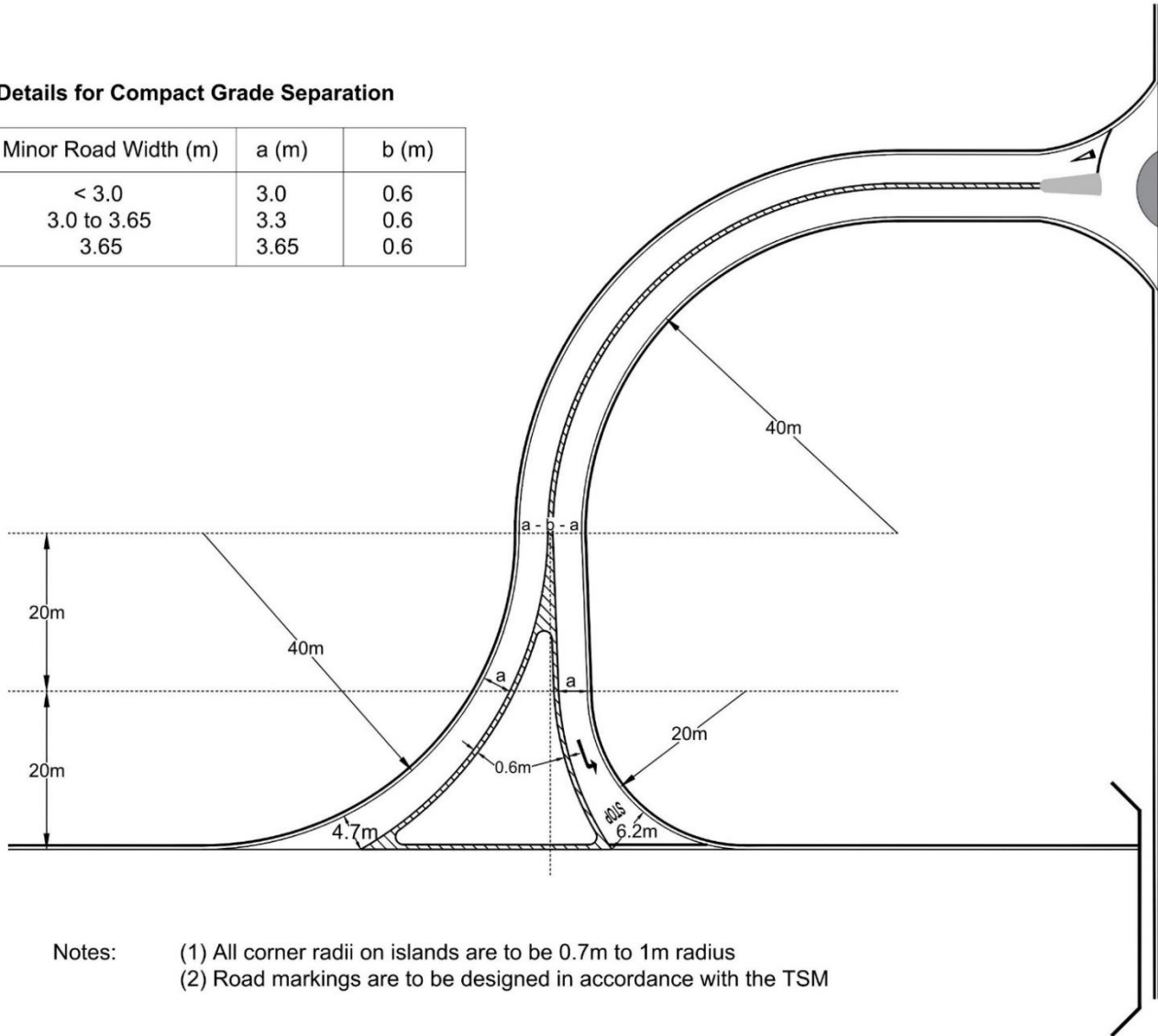
### 9.2.11 Junctions

Priority Junction entries and exits with the mainline shall be in accordance with Chapter 5 of this standard with the exception that diverge auxiliary lanes shall be provided at compact junctions on Type 2 and Type 3 Divided Roads.

Where auxiliary lanes are provided, the layout shall be in accordance with the layout as shown in Figure 8.6.1 with an auxiliary taper length of 55m and an auxiliary lane length of 150m which shall terminate at the tangent point of the 40m exit radii. No nose shall be provided in compact grade separated auxiliary lane diverges. At compact grade separated junctions the exit radius off the mainline as detailed in Chapter 5 shall be increased to 40m for left in-left out junctions. Further design details specific to left in-left out junctions forming part of compact grade separated junctions are provided in Figure 9.2. Channelising islands shall be set back at least 0.6m from the back of the 2.0m wide clear space allowed for ATUs to ensure the junction is cycle friendly.

**Details for Compact Grade Separation**

| Minor Road Width (m) | a (m) | b (m) |
|----------------------|-------|-------|
| < 3.0                | 3.0   | 0.6   |
| 3.0 to 3.65          | 3.3   | 0.6   |
| 3.65                 | 3.65  | 0.6   |

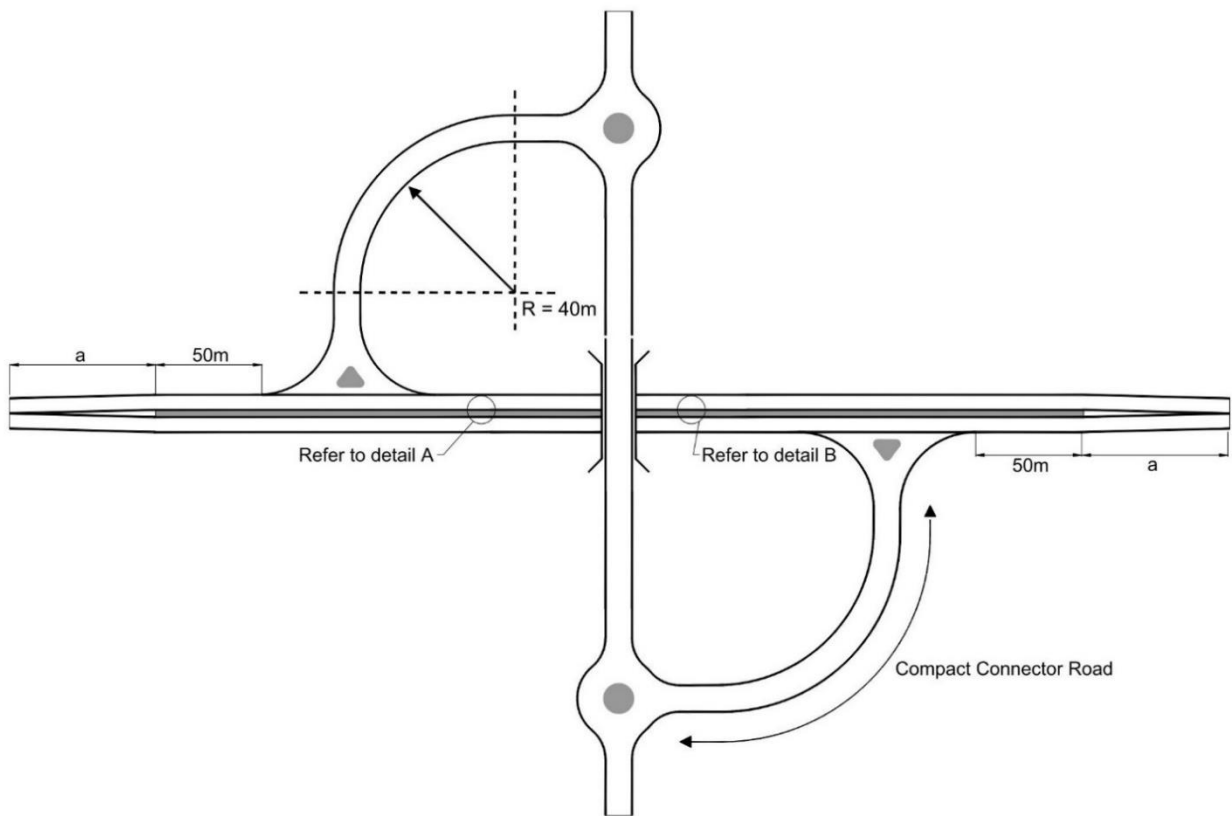


**Figure 9.2 Left in-left out Junction forming part of a Compact Grade Separated Junction**

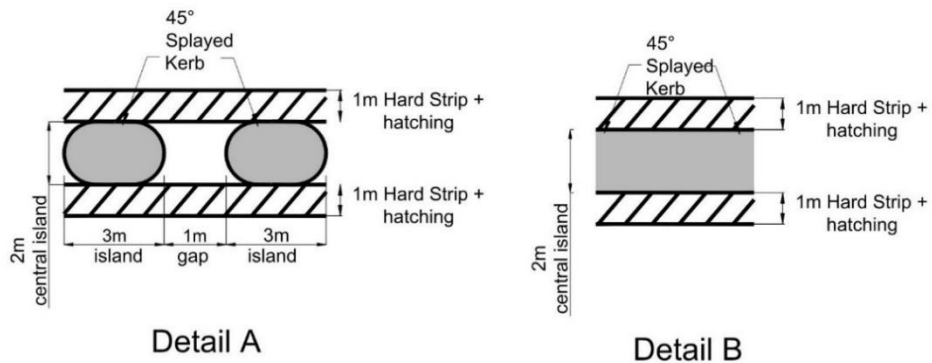
On single carriageways, compact grade separated junctions shall only be adopted where the mainline cross-section includes a physical central reserve, to prevent illegal right turn movements out of the minor road junctions. The physical central reserve shall commence / terminate at a minimum spacing from the minor road junctions as illustrated in Figure 9.3.

The Designer should consider the crossfall of the mainline and drainage requirements when selecting the appropriate raised median detail.

- Where one-way crossfall is provided on the mainline, breaks will be required in the raised median to allow surface water to drain across the carriageway, as illustrated in Figure 9.3 – Detail A.
- Where two-way crossfall is provided on the mainline, a continuous raised median shall be adopted as illustrated in Figure 9.3 – Detail B.



- Notes: (1) The value of 'a' is equal to the taper length as per Table 5.7 of DN-GEO-03060  
 (2) Gap in central island required when carriageway is superelevated



**Figure 9.3 Single Lane Dualling – Compact grade Separated Junctions on Single Carriageways**

Slip roads shall not be used at compact grade separation since compact connector roads are 2 way.

## 9.3 Layout Options

### 9.3.1 General

In some cases, underbridges could be considered as an alternative where they may prove practical and justifiable economically.

There may be situations, where, due to local topography, this would be preferable in landscape terms. In level and treeless landscapes, overbridges can be visually intrusive and planting may be out of character. Environmental Design is addressed further in the TII Environmental Planning Guidelines.

Detailed examples of alternative layouts for junctions are indicated in Figures 9.4 to 9.6. Schematic representations of other layouts are indicated in Figures 9.6 to 9.9.

Compact grade separation can be used effectively on a section of carriageway which has a series of priority junctions in close proximity to remove right turn manoeuvres. For example, where a compact junction is incorporated, the junctions adjacent to the compact grade separation can be restricted to left in left out requiring right turning traffic from these junctions to divert to the compact grade separation to complete their manoeuvre. Another option may be to close the adjacent priority junctions and divert these routes to connect into the compact grade separated junction.

The preferred locations for the junction of the compact connector road to the mainline are in the 1st and 3rd quadrants as indicated in Figure 9.4 as this facilitates the provision of required visibilities without the need to widen under the structure.

### 9.3.2 Typical Sketch Layouts

**Figure 9.4:** Detailed layout of 4 arm compact junction with compact connector roads in preferred location. Diverges and merges are to be designed in accordance with Chapter 5 for priority junctions. Layout suitable for junctions with substantial minor road through traffic. At grade junctions with a single carriageway mainline must be staggered to avoid “see through” issues.

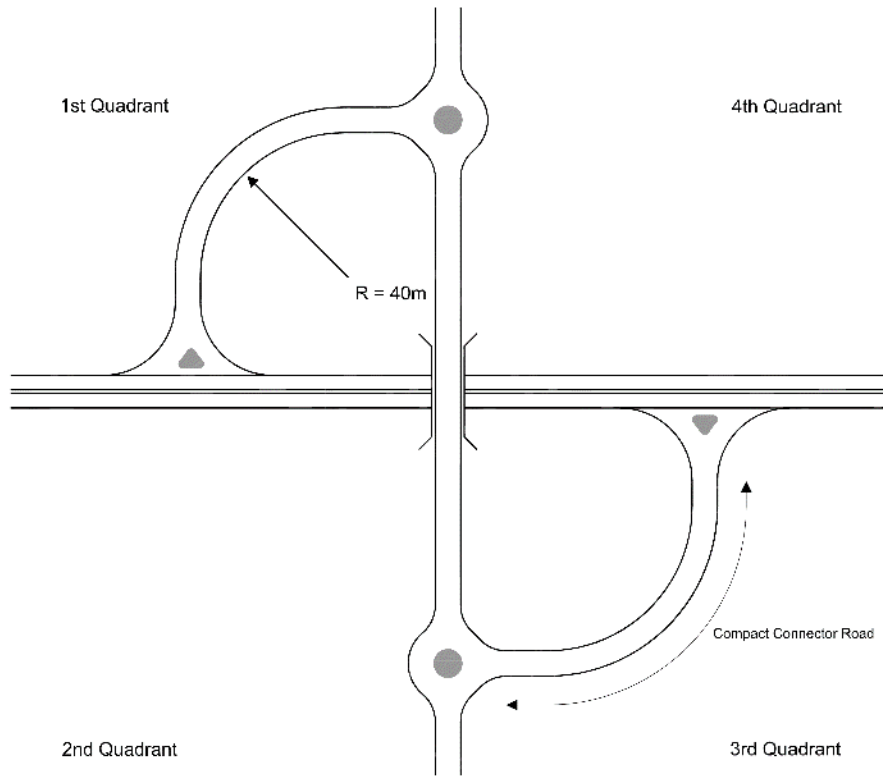
**Figure 9.5:** Detailed layout of 3 arm compact junction with compact connector roads in preferred location. Diverges and merges are to be designed in accordance with Chapter 5 for priority junctions. At grade junctions with a single carriageway mainline must be staggered to avoid “see through” issues.

**Figure 9.6:** A selection of schematic layouts indicating 4 arm compact grade separations on all-purpose divided roads.

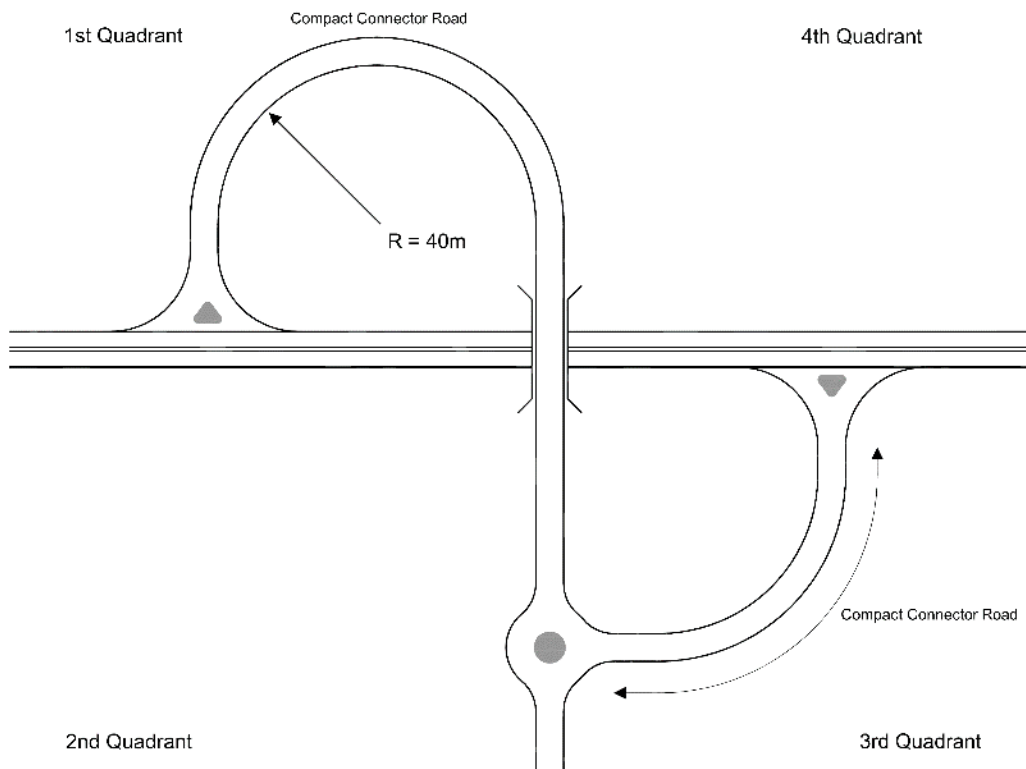
**Figure 9.7:** A schematic example layout indicating 4 arm compact grade separations on all-purpose single carriageways.

**Figure 9.8:** A schematic example layout indicating 3 arm compact grade separations on all-purpose divided roads.

**Figure 9.9:** A schematic example layout indicating 3 arm compact grade separations on all-purpose single carriageways.

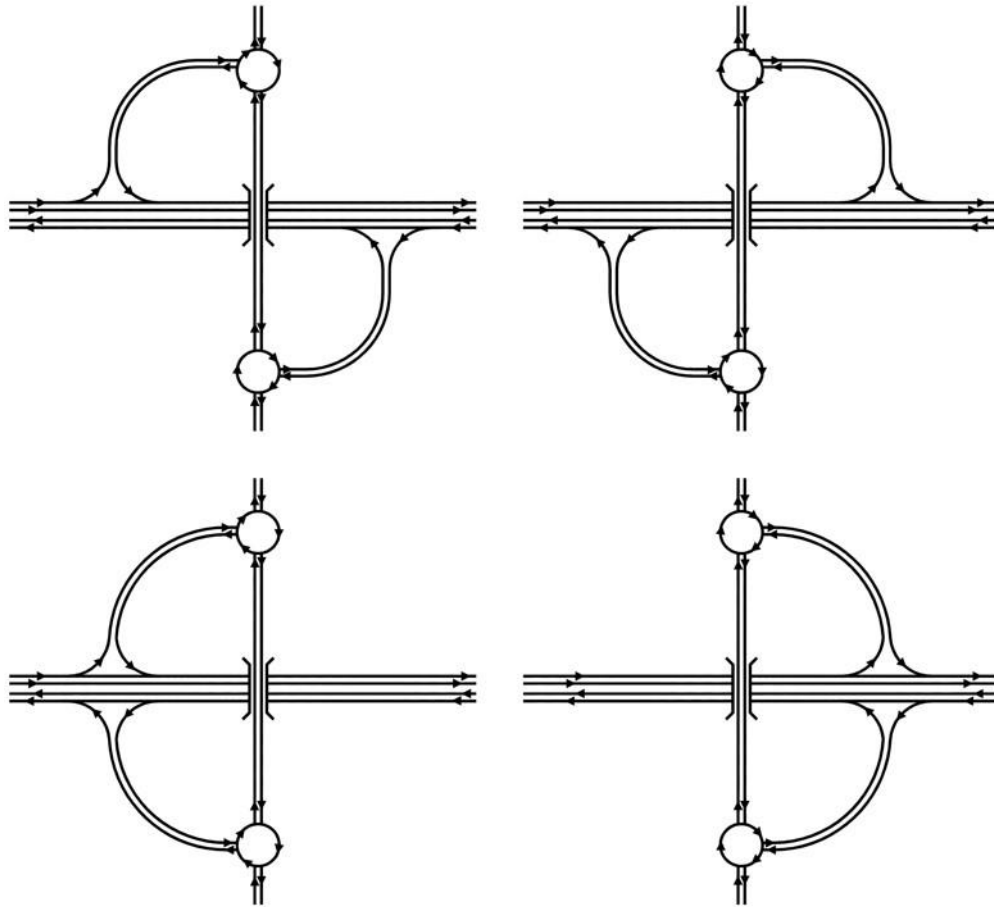


**Figure 9.4 Example of Compact Grade Separation for 4 Arm Junction**

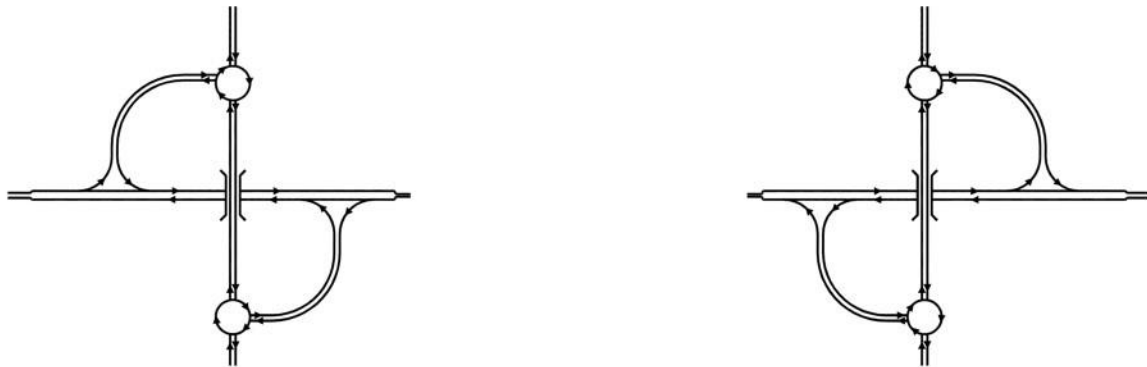


**Figure 9.5 Compact Grade Separation for 3 Arm Junction**





**Figure 9.6 Schematic Examples of 4 Arm Compact Grade Separation on Divided Roads**



**Note:** At grade junctions between the connector loop and the mainline are staggered to avoid the creation of the "see through" effects.

**Figure 9.7 Schematic Example of a 4 Arm Compact Grade Separation Single Carriageway**

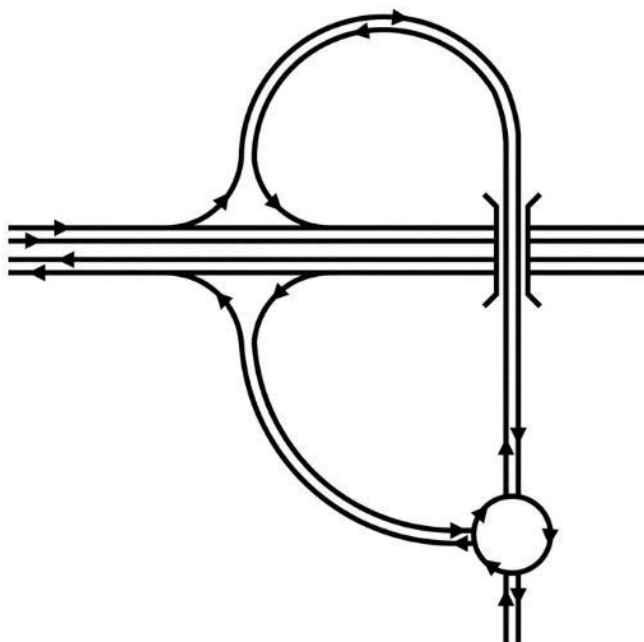


Figure 9.8 Schematic Example of 3 Arm Compact Grade Separation on Divided Roads

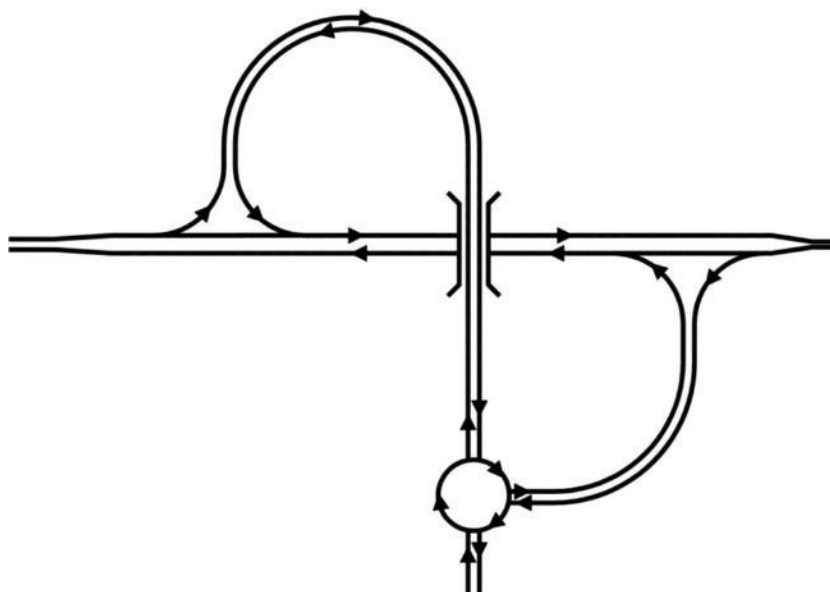


Figure 9.9 Schematic Example of 3 Arm Compact Grade Separation on Single Carriageways

## 9.4 Safety

### 9.4.1 General

One of the principal objectives of compact grade separated junction design is to improve safety by the elimination of right turn manoeuvres between the mainline and the side road, by providing left-in/left-out turn only priority junctions and the closure of central reserve gaps.

It is intended that compact grade separation shall be used to provide a safe means of crossing high speed routes for all road users.

The geometrical standards for the compact connector road have been established at a level of provision intended to maintain slow vehicular speeds through their length thereby improving safety for other road users.

Other positive factors which improve safety as a result of compact grade separation are;

- a) removing the possibility of large vehicles which cross central reserve gaps protruding into the offside lane;
- b) removal of U turns on the mainline.

#### **9.4.2 Collisions**

Collision statistics for 3 arm priority junctions indicate that the severity of collisions is dependent upon the classification of the mainline and the mainline speed limit and that generally collision severity decreases as speed decreases. Compact grade separation will transfer the right turn manoeuvres from the higher speed, higher classification road to the lower speed, lower classification road. The effect of this should be to reduce the number of fatal and serious collisions. There may be a corresponding increase in minor injury collisions at the minor road junction, however the use of roundabouts at the junctions between the minor road and compact connector road may reduce the number of collisions at these locations also.

#### **9.4.3 Traffic Signs**

On the approach to the junction from the major road, the junction must be clearly defined by means of appropriate signing indicating the junction as a priority T junction and not as a slip road.

Within the compact connector road, it is recommended that signing be restricted to warning signs indicating the nature of the alignment, and the proximity of junctions.

#### **9.4.4 Road Markings**

The application of special surface treatments may be provided as an additional means of highlighting the nature of the geometrical standards for the compact connector road. This can be achieved by the application of a contrasting surface colour (red) within the hatch markings to emphasise the nature of the curve, this should reinforce the meaning and presence of the markings to the driver.

## 10. References

### 10.1 TII Publications (Standards & Technical)

- a) DN-STR-03005, Design Criteria for Footbridges
- b) DN-GEO-03030, Guidance on Minor Improvements to National Roads
- c) DN-GEO-03031, Rural Road Link Design
- d) DN-GEO-03040, Subways for Pedestrians and Pedal Cyclists – Layout and Dimensions
- e) DN-GEO-03041, The Design of Major Interchanges
- f) DN-GEO-03044, The Geometric Layout of Signal-Controlled Junctions and Signalised Roundabouts
- g) DN-REQ-03034 Safety Barriers
- h) DN-GEO-03036, Cross-sections and Headroom
- i) DN-GEO-03046, The Location and Layout of Lay-bys and Location Markers
- j) DN-GEO-03047, Rural Cycleway Design (Off-line)
- k) DN-LHT-03038, Design of Road Lighting for National Roads
- l) AM-PAV-06045, Management of Skid Resistance
- m) DN-PAV-03023, Surfacing Materials for New and Maintenance Construction, for Use in Ireland
- n) PE-PMG-02041 Project Management Guidelines
- o) PE-PMG-02042 – Project Manager’s Manual for Major National Projects
- p) PE-PMG-02043 – Project Manager’s Manual for Minor National Projects

### 10.2 Other TII Publications

- a) TII Project Appraisal Guidelines (Available at:  
<https://www.tiipublications.ie/downloads/>)

### 10.3 Traffic Sign Regulations

- a) Traffic Signs Manual. Department of Transport.

### 10.4 UK, Design Manual for Roads and Bridges

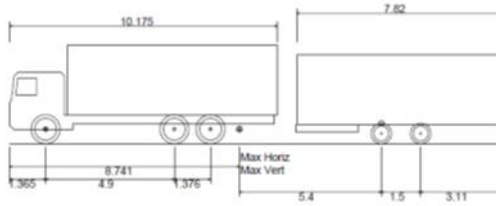
- a) CD 109 Highway Link Design
- b) CD 116 Geometric Design of Roundabouts
- c) CD 122 Geometric Design of Grade Separated Junctions
- d) CD 123 Geometric Design of at-grade Priority and Signal-Controlled Junctions
- e) CD 127 Cross-sections and Headroom

## **10.5 Other Documents & Sources**

- a) Austroads, Guide to Road Design Part 4B (Roundabouts), Sydney 2021.
- b) <https://www.google.ie/maps>

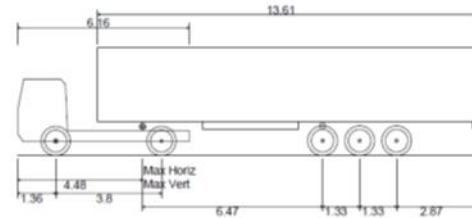
## **Appendix A:**

### Design Vehicles



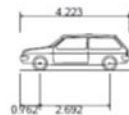
FTA Design Drawbar Vehicle (1998)

|                             |         |
|-----------------------------|---------|
| Overall Length              | 18.751m |
| Overall Width               | 2.550m  |
| Overall Body Height         | 3.745m  |
| Min Body Ground Clearance   | 0.450m  |
| Max Track Width             | 2.470m  |
| Lock to Lock Time           | 3.00s   |
| Curb to Curb Turning Radius | 10.000m |



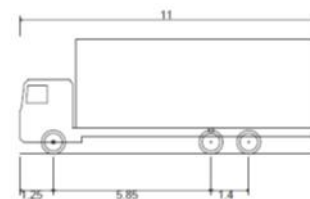
FTA Design Articulated Vehicle (1998)

|                             |         |
|-----------------------------|---------|
| Overall Length              | 16.480m |
| Overall Width               | 2.550m  |
| Overall Body Height         | 3.870m  |
| Min Body Ground Clearance   | 0.515m  |
| Max Track Width             | 2.470m  |
| Lock to Lock Time           | 3.00s   |
| Curb to Curb Turning Radius | 6.550m  |



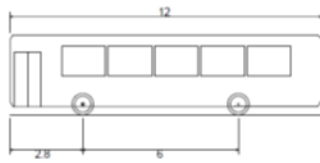
DB32 Private Car

|                             |        |
|-----------------------------|--------|
| Overall Length              | 4.223m |
| Overall Width               | 1.715m |
| Overall Body Height         | 1.392m |
| Min Body Ground Clearance   | 0.233m |
| Max Track Width             | 1.629m |
| Lock to Lock Time           | 4.00s  |
| Curb to Curb Turning Radius | 5.780m |

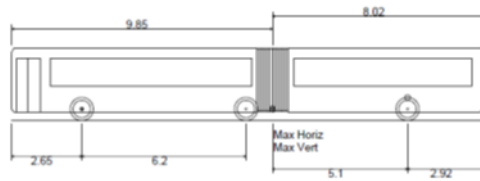


11m (Large) Rigid Truck (12.5m min. radius)

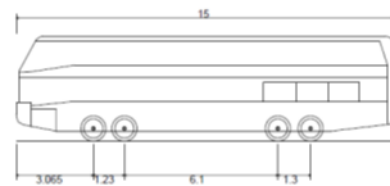
|                             |         |
|-----------------------------|---------|
| Overall Length              | 11.000m |
| Overall Width               | 2.500m  |
| Overall Body Height         | 4.250m  |
| Min Body Ground Clearance   | 0.427m  |
| Track Width                 | 2.500m  |
| Lock to Lock Time           | 6.00s   |
| Wall to Wall Turning Radius | 12.500m |



|                             |         |
|-----------------------------|---------|
| <b>'Standard' Rigid Bus</b> |         |
| Overall Length              | 12.000m |
| Overall Width               | 2.550m  |
| Overall Body Height         | 3.069m  |
| Min Body Ground Clearance   | 0.309m  |
| Track Width                 | 2.350m  |
| Lock to Lock Time           | 4.00s   |
| Wall to Wall Turning Radius | 10.771m |



|                             |         |
|-----------------------------|---------|
| <b>Bendi-Bus</b>            |         |
| Overall Length              | 17.870m |
| Overall Width               | 2.500m  |
| Overall Body Height         | 2.751m  |
| Min Body Ground Clearance   | 0.337m  |
| Track Width                 | 2.500m  |
| Lock to Lock Time           | 6.00s   |
| Curb to Curb Turning Radius | 11.500m |



|                             |         |
|-----------------------------|---------|
| <b>15m 6WS Luxury Coach</b> |         |
| Overall Length              | 15.000m |
| Overall Width               | 2.500m  |
| Overall Body Height         | 4.157m  |
| Min Body Ground Clearance   | 0.397m  |
| Track Width                 | 2.500m  |
| Lock to Lock Time           | 5.00s   |
| Wall to Wall Turning Radius | 12.490m |



## **Appendix B:**

### Design of Channelising Islands

## Design of Channelising Islands

This appendix outlines the methodology for designing channelising islands at priority junctions and is subdivided into:

- T-Junctions or staggered junctions;
- Skew junctions; and
- Rural Crossroads.

### T-Junctions or Staggered Junctions

The recommended layout for T-junctions or staggered junctions, where the minor road centreline is inclined to the major road at an angle of between  $70^\circ$  and  $110^\circ$ , is shown in Figure B.1. This figure should be read in conjunction with Tables B.1 and B.2.

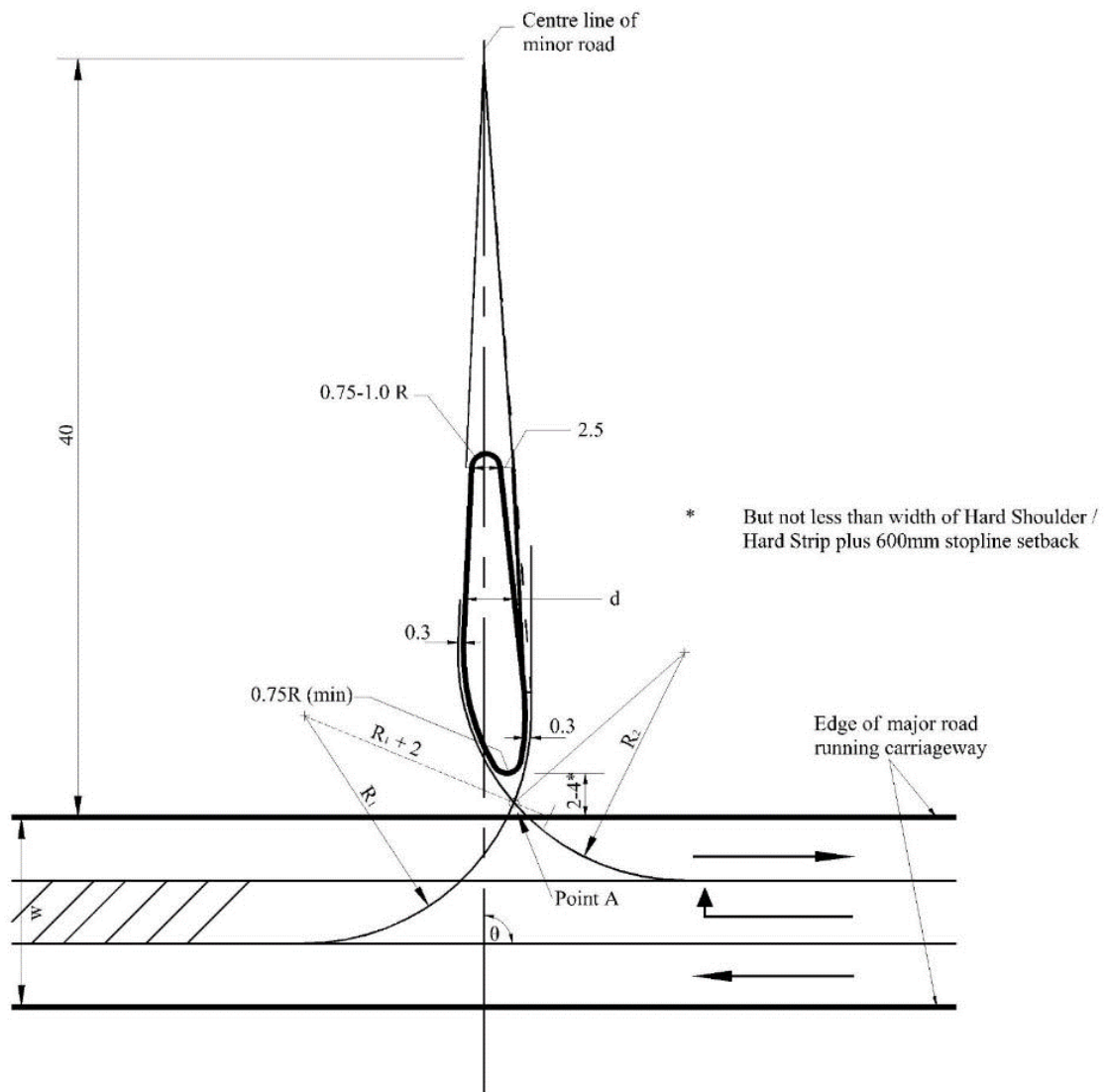


Figure B.1 Design of Rural Channelising Island (Dimensions in Metres)

**Table B.1 Channelising Island Offset**

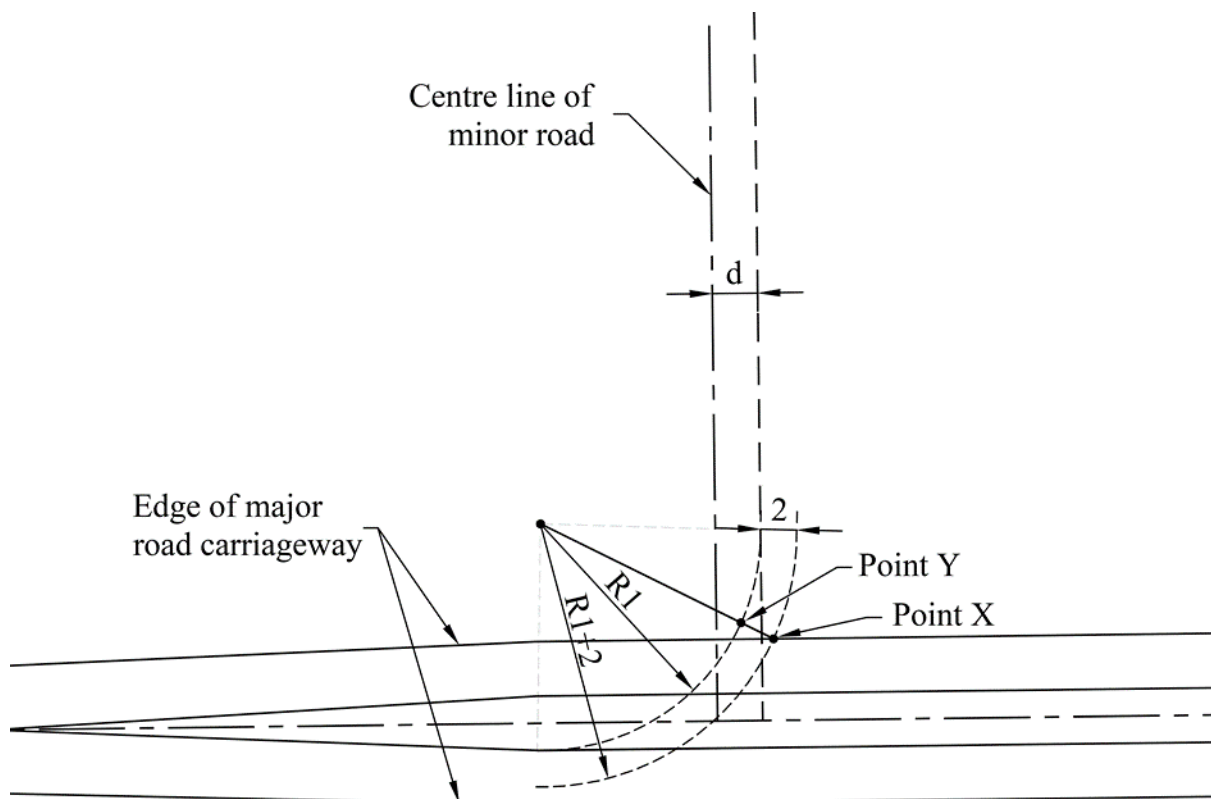
| Minor road inclination (°) | Offset d (m) |
|----------------------------|--------------|
| 70                         | 1.5          |
| 80                         | 2.0          |
| 90                         | 2.5          |
| 100                        | 2.0          |
| 110                        | 1.5          |

**Table B.2 Design of Radius R1**

| Width of major road carriageway at junction (m) | Radius R1 (m) |
|---|---------------|
| 9.5   | 12            |
| 10.0  | 12            |
| 11.0  | 14            |

Note: Radius R2 is normally the same value as R1 but should be designed to ensure that the channelising island nose is positioned between 2m to 4m from the edge of the main carriageway and that the width of the island lies between 2m and 5m.

The methodology for designing channelising islands of this type is described in the following sections and represented in Figures B.2a to B.2f.



**Figure B.2a Channelising Island Development Steps 1 to 4**

1. Draw an offset, d, from the centreline of the minor road. Values for d are given in Table B.1.
2. Draw circular arc, R1, tangential to the offset d from the minor road centreline and tangential to the offside edge of the through traffic lane on the major road into which right turning traffic from the minor road will turn. Values for Radius R1 can be found in Table B.2.

3. By striking a circular arc of radius  $(R1 + 2)$  metres from the same centre point as arc R1 to intersect the edge of the major road carriageway, Point X is established.
4. Point Y is located where a straight line drawn from the centre point of arc R1 to Point X crosses arc R1.

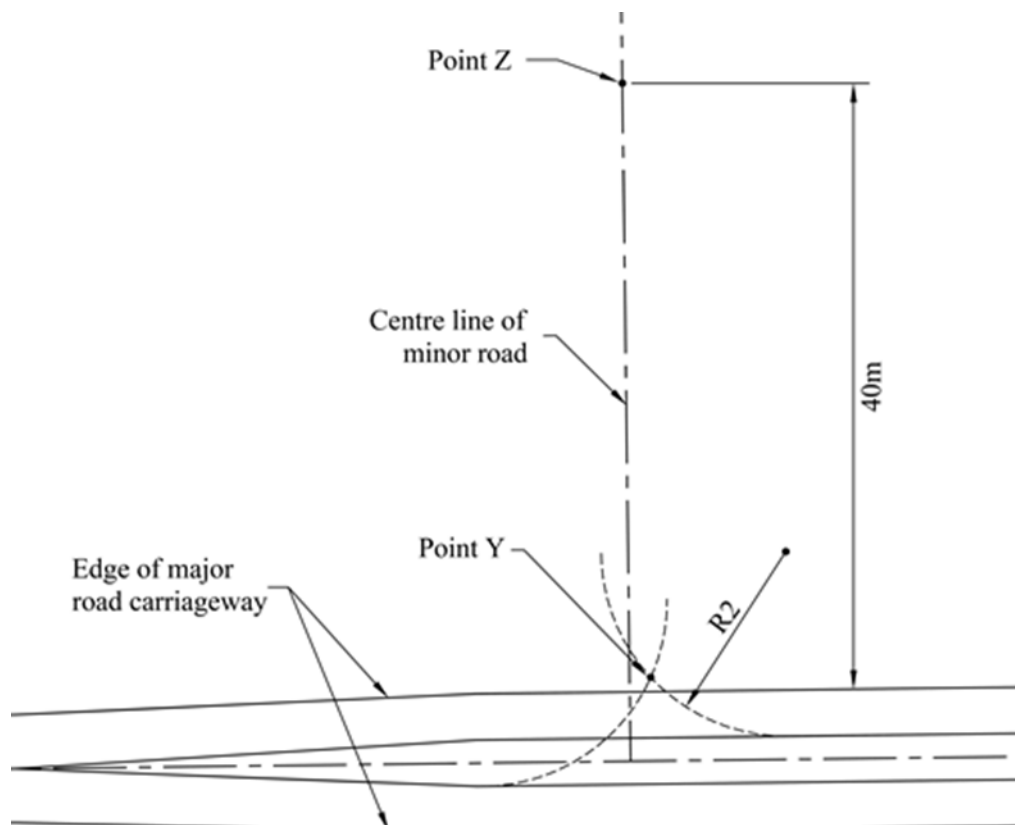
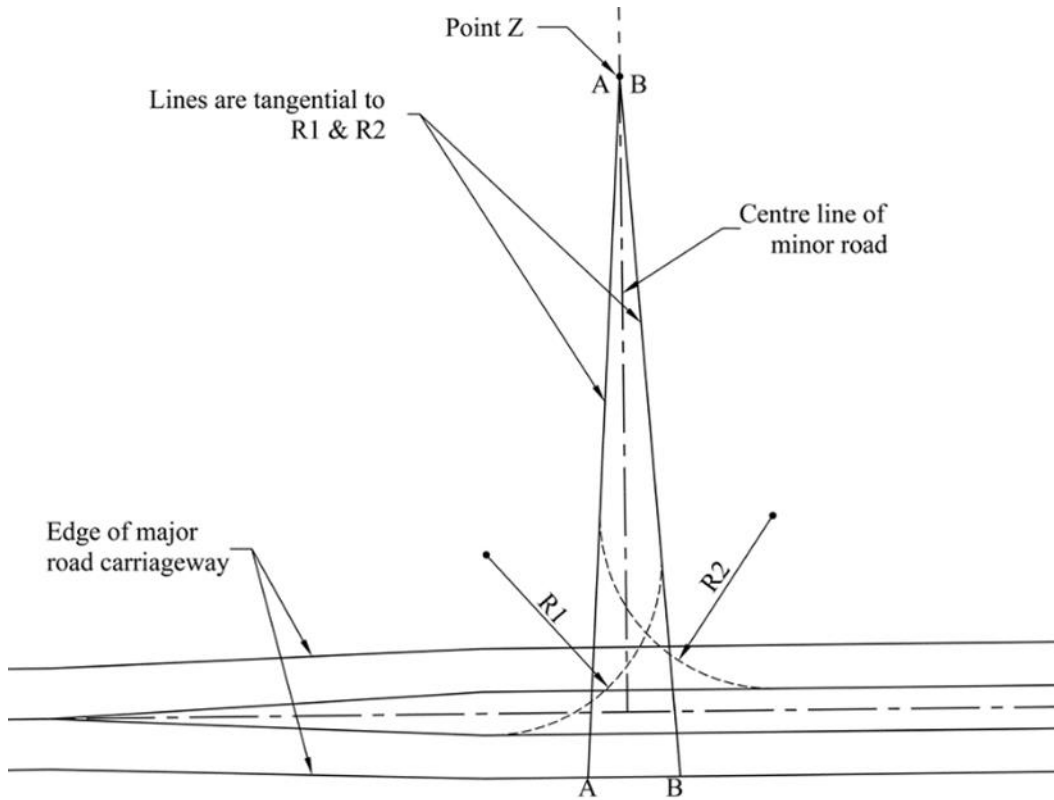


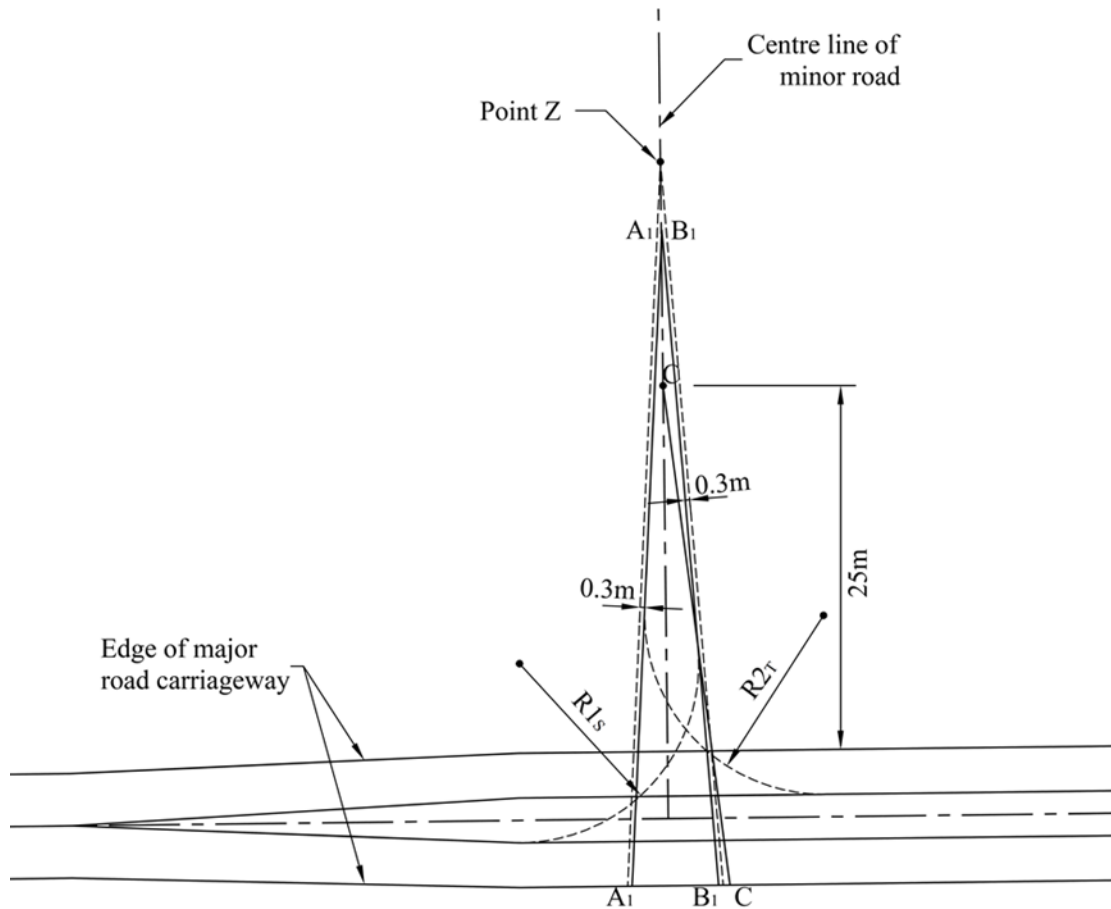
Figure B.2b Steps 5 and 6

5. Draw an arc, R2, through Point Y and tangential to the offside edge of the major road offside diverging lane and of an equal radius to R1. (Note: Radius R2 is typically the same size as R1 but should be designed to ensure that the channelising island nose is positioned between 2 to 4m s from the edge of the main carriageway and that the overall width of the channelising island is between 2m to 5m.)
6. Draw a point, Z, 40m from the edge of the major road on the centreline of the minor road.



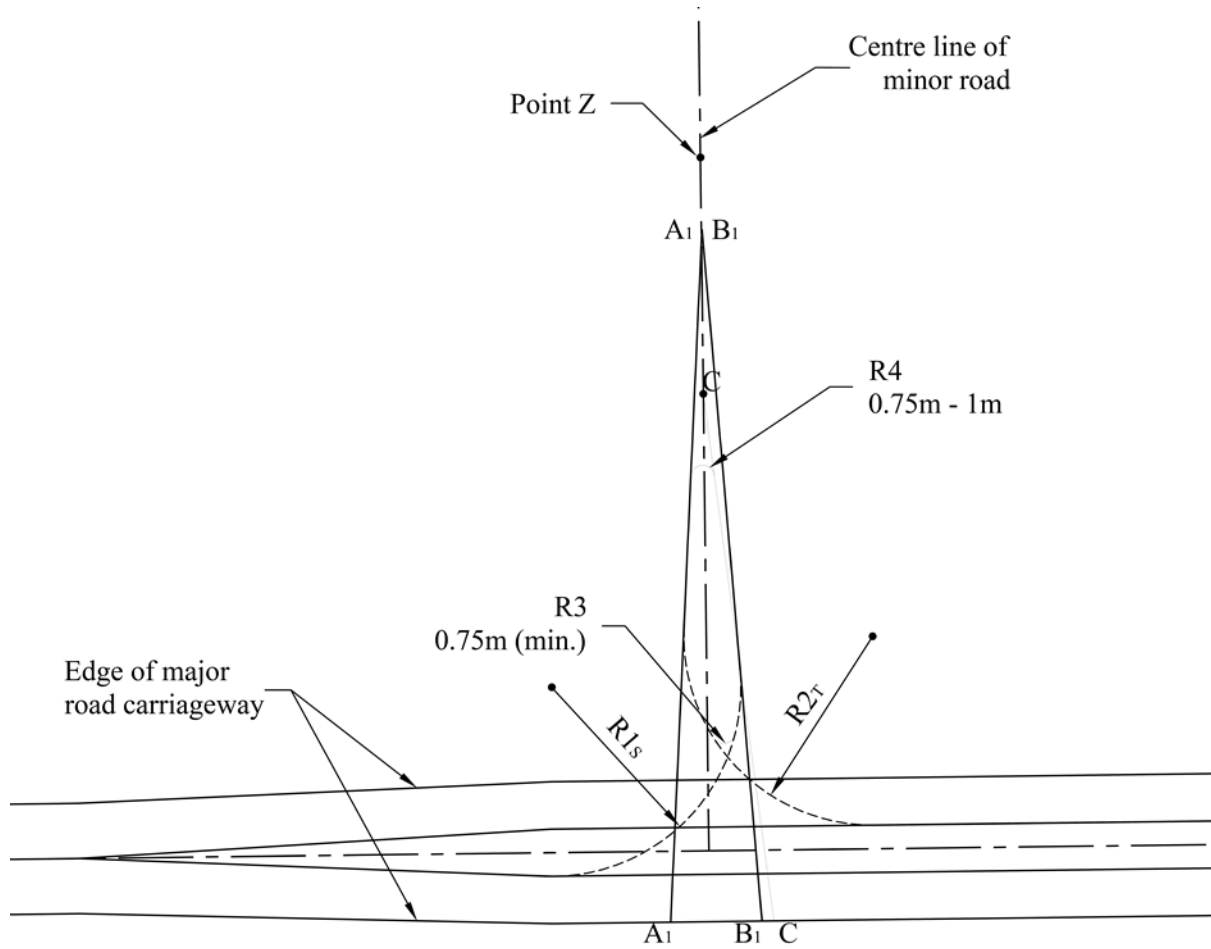
**Figure B.2c Step 7**

7. Draw 2 lines, A-A & B-B, from this point, Z, which are tangential to the Arc's R1 and R2.



**Figure B.2d Steps 8 to 10**

8. Offset these lines A-A and B-B by 0.3m inwards creating A1-A1 and B1-B1.
9. R1s and R2t are then created tangential to these offset lines A1-A1 and B1-B1.
  - a) Arc R1s is created with radius equal to R1 and is tangential to B1-B1 along the minor road and the through traffic lane on the major road into which right turning traffic from the minor road will turn
  - b) Arc R2t is created with radius equal to R2 and is tangential to A1-A1 and the offside edge of the major road offside diverging lane.
10. Draw another line, C-C, which starts at a distance 25m up from the edge of the carriageway on the centre line of the minor road and is tangential to the Arc R1s.



**Figure B.2e Steps 11 to 12**

11. Draw a 0.75m radius, R3, where R1<sub>s</sub> and R2<sub>t</sub> intersect near the major carriageway. This is the bottom of the channelising island. R3 will be tangential to R1<sub>s</sub> and R2<sub>t</sub>.
12. Draw another 0.75m to 1m radius, R4 between line A<sub>1</sub>-A<sub>1</sub> and line C-C. R4 will be tangential to the Line A<sub>1</sub>-A<sub>1</sub> and C-C.

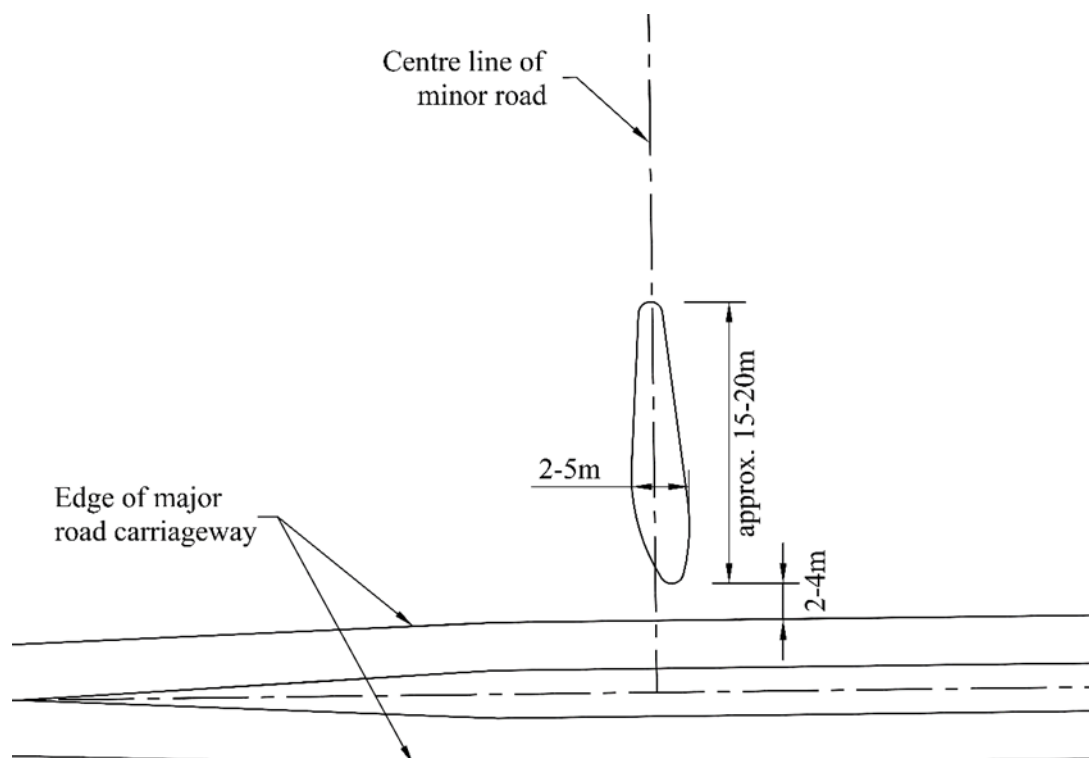


Figure B.2f Finalised design

## Skew Junctions

The design of channelising islands for skew junctions is similar to that outlined above, but the following points should be noted:

- The centreline of the minor road is turned with a radius of at least 50m to meet the edge of the major road at right angles.
- For left hand envelope junctions, the channelising island should be about 15m long. The right hand side of its tail (viewed from the minor road approach) should touch the curved minor road centreline and be rounded off at a radius of 0.75m to 1.00m.
- The offset,  $d$ , for left hand envelope junctions is 4.5m.
- For right hand envelope junctions, the circular arc  $R1$  touches the curved minor road centreline and is tangential to the offside edge of the through traffic lane on the major road into which right turning traffic from the minor road will turn.
- The channelising island should be about 15m long. The tail is offset about 1m to the right of the curved minor road centreline (viewed from the minor road approach) and rounded off with a radius of 0.75m to 1.00m.

## Crossroads

The use of rural crossroads is regarded as a Departure from Standard. However for upgrading of rural cross-roads the following details may be used.



The recommended layout of channelising islands at rural crossroads where long vehicles are predicted, and where the minor road centreline is inclined to the major road at an angle between  $70^\circ$  and  $110^\circ$ , is shown in Figure B.3.

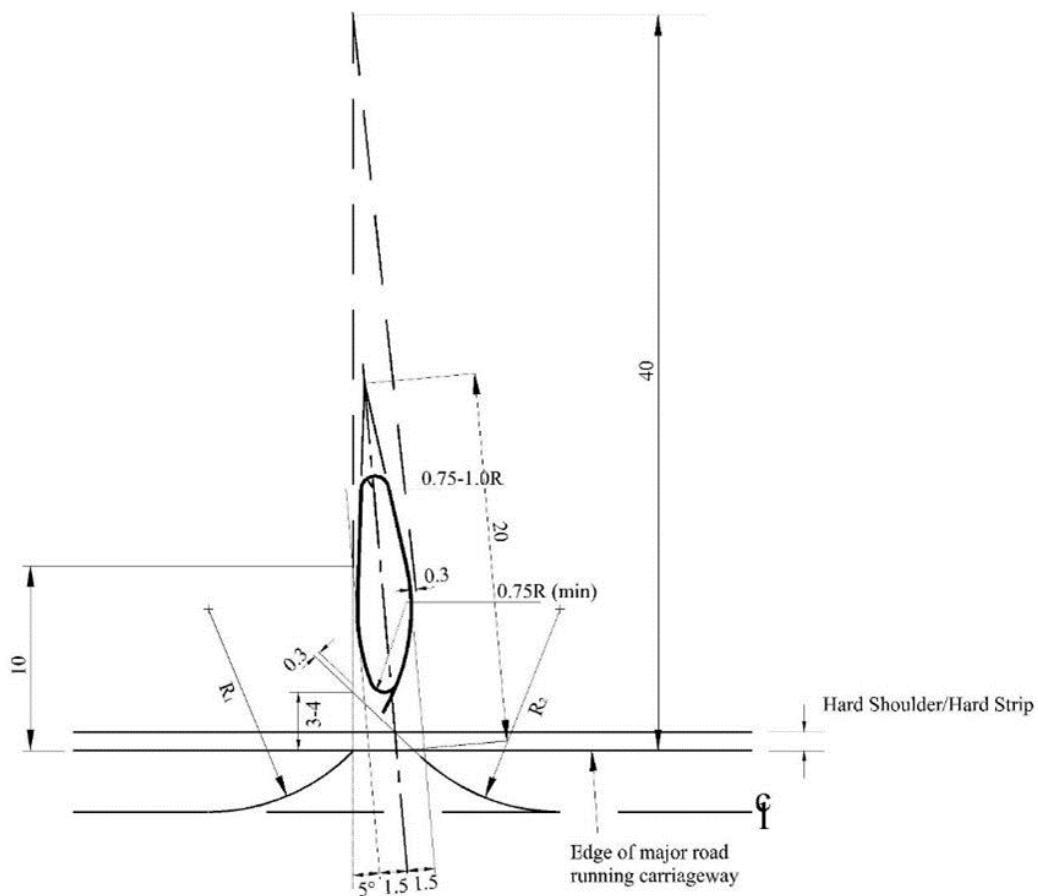
There are similarities in the design to that outlined previously, but the following points should be noted:

- a) The long axis of the channelising island is inclined at  $5^\circ$  to the minor road centreline and the island is always 3m wide.
- b) The circular arc R1 has a radius of 11m and is tangential to the left hand side of the channelising island (viewed from the minor road approach) and the centreline of the major road. (In some cases where the minor road is inclined to the major road at angles between  $100^\circ$  and  $110^\circ$ , R1 will have to be reduced to 8m to create a suitable island.)
- c) The circular arc R2 has a radius of 11m and is tangential to the major road centreline and the minor road centreline.

Where the minor road centreline is inclined to the major road at angles less than  $70^\circ$ , R1 will normally be 12m and R2 8m.

Where the minor road centreline is inclined to the major road at angles greater than  $110^\circ$ , R1 will normally be 8m and R2 12m.

Where two envelope minor roads meet at a crossroads, the minor road centrelines should be offset relative to one another by approximately the width of one channelising island.



**Figure B.3 Design of Rural Crossroads Channelising Island (Dimensions in metres)**

## **Appendix C:**

### Design of a Compound Curve

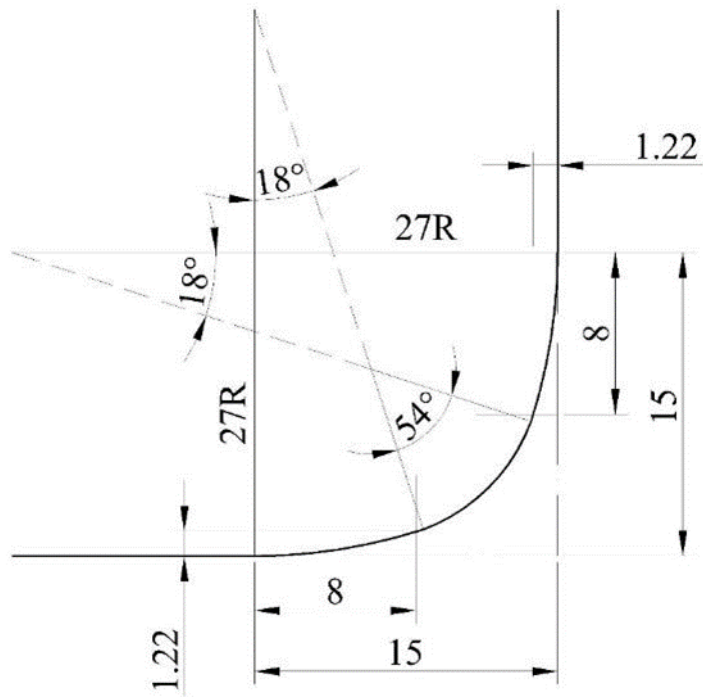




Figure C.1 Design of a Compound Curve

## **Appendix D:**

### Junction Analysis Procedure Worked Example

**Table D.1 Junction Analysis Procedure Worked Example**

|  <b>Junction Analysis Procedure</b> |  | Date: 01/04/17                                 |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
|--|--|--|-------------------|--|---------------------|--------|---------------|------|----------|-------------|----------|---|------|----------------|---------|---|-------|---|------|--------------|-----------|---|-------|---|------|----------------|----------|--|-------|---|------|---------------|-----------|--|-------|---|------|----------------|----------|---|-------|---|------|--------------|-----------|--|---------|
|  |  | Project: N200 Junction Upgrade                 |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
|  |  | Location: N200 / R999 Junction                 |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| Data Collection  | Classification and Name  | AADT   |                   | Design Speed (Km/h)                                    | Posted Speed (Km/h) |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
|  |  | Current Year (2016)                            | Design Year (N/A) |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| Major Road   | National Secondary Road N200   | 4,000  | 6,000             | 100  | 100                 |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| Intersecting Road  | Regional Road R999   | 3,200  | 4,500             | 100  | 80                  |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| Junction Type  | New <input type="checkbox"/> Existing <input checked="" type="checkbox"/>  |  |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| Site Visit   | Yes: <input checked="" type="checkbox"/> No: <input type="checkbox"/>  | Date of Site Visit (if applicable): 01/10/2017 |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| Functional Characteristics   | Part 1 (General Information for all Intersections)   |  |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| Collision Analysis   | Table 1 presents a summary of the accidents which have occurred at the N200/R999 Junction. This information is also shown graphically in Figure 1.   |  |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
|  | <b>Table 1 N200/R999 Junction Collision Data</b>   |  |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
|  | <table border="1"> <thead> <tr> <th>Number</th> <th>Accident date</th> <th>Time</th> <th>Location</th> <th>Description</th> <th>Severity</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2010</td> <td>11:30 Saturday</td> <td>R99 (S)</td> <td>80 kph zone, Car, Rear end, straight, Dry</td> <td>Minor</td> </tr> <tr> <td>2</td> <td>2010</td> <td>15:35 Friday</td> <td>N200/R999</td> <td>100 kph zone, Goods vehicle, Other circumstances, Dry</td> <td>Minor</td> </tr> <tr> <td>3</td> <td>2009</td> <td>01:05 Thursday</td> <td>R999 (S)</td> <td>80 kph zone, Car, Single vehicle only, Dry</td> <td>Minor</td> </tr> <tr> <td>4</td> <td>2008</td> <td>18:00 Tuesday</td> <td>N200/R999</td> <td>100 kph zone, Bus, Head-on right turn, Wet</td> <td>Minor</td> </tr> <tr> <td>5</td> <td>2007</td> <td>16:00 Saturday</td> <td>N200 (W)</td> <td>100 kph zone, Car, Single vehicle only, Dry</td> <td>Minor</td> </tr> <tr> <td>6</td> <td>2005</td> <td>16:30 Friday</td> <td>N200/R999</td> <td>100 kph zone, Other vehicle, Angle, both straight, Dry</td> <td>Serious</td> </tr> </tbody> </table> |  |                   |  |                     | Number | Accident date | Time | Location | Description | Severity | 1 | 2010 | 11:30 Saturday | R99 (S) | 80 kph zone, Car, Rear end, straight, Dry | Minor | 2 | 2010 | 15:35 Friday | N200/R999 | 100 kph zone, Goods vehicle, Other circumstances, Dry | Minor | 3 | 2009 | 01:05 Thursday | R999 (S) | 80 kph zone, Car, Single vehicle only, Dry | Minor | 4 | 2008 | 18:00 Tuesday | N200/R999 | 100 kph zone, Bus, Head-on right turn, Wet | Minor | 5 | 2007 | 16:00 Saturday | N200 (W) | 100 kph zone, Car, Single vehicle only, Dry | Minor | 6 | 2005 | 16:30 Friday | N200/R999 | 100 kph zone, Other vehicle, Angle, both straight, Dry | Serious |
| Number   | Accident date  | Time   | Location          | Description  | Severity            |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| 1  | 2010   | 11:30 Saturday                                 | R99 (S)           | 80 kph zone, Car, Rear end, straight, Dry              | Minor               |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| 2  | 2010   | 15:35 Friday                                   | N200/R999         | 100 kph zone, Goods vehicle, Other circumstances, Dry  | Minor               |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| 3  | 2009   | 01:05 Thursday                                 | R999 (S)          | 80 kph zone, Car, Single vehicle only, Dry             | Minor               |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| 4  | 2008   | 18:00 Tuesday                                  | N200/R999         | 100 kph zone, Bus, Head-on right turn, Wet             | Minor               |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| 5  | 2007   | 16:00 Saturday                                 | N200 (W)          | 100 kph zone, Car, Single vehicle only, Dry            | Minor               |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
| 6  | 2005   | 16:30 Friday                                   | N200/R999         | 100 kph zone, Other vehicle, Angle, both straight, Dry | Serious             |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
|  |    |  |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |
|  | <b>Figure 1 Accident statistics at the N200/R999 junction</b>  |  |                   |  |                     |        |               |      |          |             |          |   |      |                |         |   |       |   |      |              |           |   |       |   |      |                |          |  |       |   |      |               |           |  |       |   |      |                |          |   |       |   |      |              |           |  |         |

|   |   |
|---|---|
| Access Requirements (Including ATU Requirements and Level of Usage) | No pedestrian or cycle facilities required at the junction.   |
| Access Control  | Priority controlled junction  |
| Future Development  | No planned future development in the area. Surrounding lands are zoned agricultural.                |
| Vehicle Design Type (Include any Special Design Vehicle Details)    | Junction designed to accommodate a maximum vehicle size equating to a standard articulated vehicle. |
| % HGV's   | 4%  |

Part 2 (Specific Information for More Detailed Analysis)

Junction Layout & Turning Movement Diagram

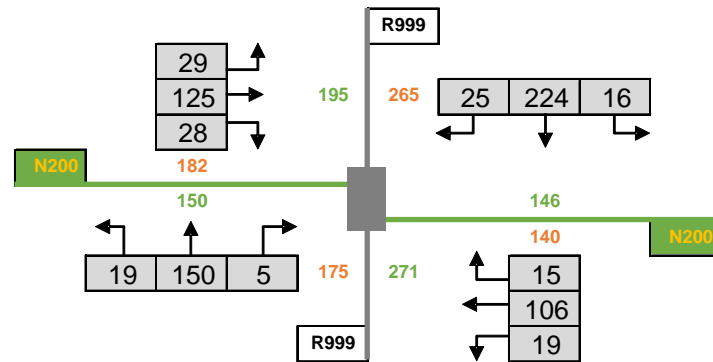


Figure 2 Friday morning peak hour junction turning movements

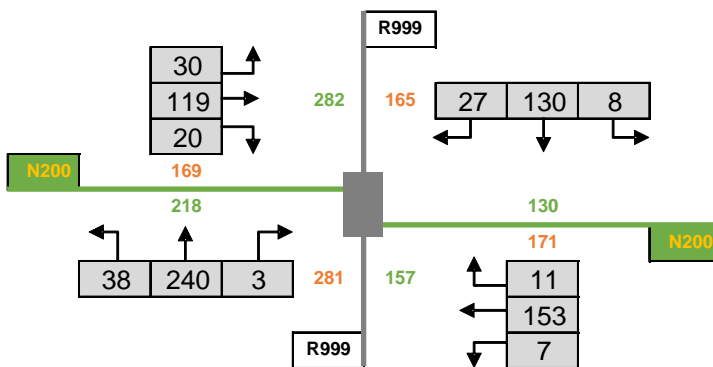



Figure 3 Friday evening peak hour junction turning movements

|  |  |        |
|--|--|--------|
| Notable Constraints due to Upstream/Downstream Junction  | Yes: ___ No: <input checked="" type="checkbox"/> ___ | Notes: |
| Proposed Improvements to Other Roads (that would impact the traffic movement at this location) | None   |        |
| <b>Geometric Characteristics</b>   |  |        |
| Road Geometry on all approaches  | To be attached in an appendix to this document.      |        |
| Is design compliant with the standards   | Yes: ___ <input checked="" type="checkbox"/> ___     |        |

|   |   |                                     |  |
|---|---|-------------------------------------|--|
| Desirable Stopping Sight Distances  | 200m  | Achievable Stopping Sight Distances | 300m   |
| Mainline Horizontal Curvature   |   |                                     |  |
| Profile gradient on mainline  | 2%  | Intersecting Roadway                | 2%   |
| <b>Other Characteristics</b>  |   |                                     |  |
| Traffic Management Measures   | n/a   |                                     |  |
| Impact on Utilities   | n/a   |                                     |  |
| Impact on Right of Way  | n/a   |                                     |  |
| Recommendation of Type of Junction Treatment based on Functional, Geometric and Other Characteristics |  <p>The option to introduce a roundabout at the N200/R999 junction is considered to be the emerging preferred option at this location. The assessment shows that this upgrade would operate well within capacity, and is appropriate considering the relatively balanced flows along each of the N200 and R999. In particular, this option allows for the safe movement of vehicles along the R999 travelling across the, which in the staggered arrangements would be required to undertake two movements to pass through the junction. A roundabout option would also provide safety improvements.</p> |                                     |  |
| Scope of Modelling Required   | <b>Local Junction Modelling</b> <input checked="" type="checkbox"/>   |                                     | <b>Micro-simulation Modelling</b> <input type="checkbox"/> |
|   | Designer: Jane Smith  |                                     | Date: 01/04/17   |
|   | Approved: _____   |                                     | Date: _____  |

## **Appendix E:**

### Additional Advice on Road Markings



This appendix provides additional advice regarding the design of road markings on roundabouts, to give a better understanding of the design principles and to enable safe design. The advice is particularly applicable to multi-lane roundabouts, where the potential for conflicts between circulating and exiting vehicles is greater.

## General Principles

As a general principle, the associated road markings can significantly affect the safety and capacity of a roundabout. Consequently, the need for and layout of road markings is an integral part of the design process. As with the geometric design, the design of road markings is an iterative process.

Road markings may be used on multi-lane roundabouts to help reduce driver confusion by channelising traffic into the correct lane for the particular manoeuvre it needs to make. While the use of such markings may reduce flexibility of lane use for variable traffic conditions, they can be highly beneficial from a safety perspective by reducing the potential for side-to-side collisions and conflicts at the exits.

Roundabout road markings may comprise the use of lane indication arrows on the approaches together with the use of markings on the circulatory carriageway. The basic objectives of road markings at multi-lane roundabouts are to:

- Afford a smooth path onto the junction and guide drivers around the circulatory carriageway in a flowing path for all movements;
- Provide a smooth alignment from the circulatory carriageway to the roundabout exit;
- Minimise conflicts by ensuring that vehicles entering the correct lane can exit without having to change lanes within the roundabout (in the case of spiral markings); and
- Achieve the best balance of queuing traffic over the roundabout entries (during periods of heavy flow).

The application of approach and circulatory markings on multi-lane roundabouts will be most effective when the roundabout geometry aligns with the desired layout, with a maximum of four approach arms evenly balanced around the circulatory carriageway. Appropriate lane choice can be difficult to determine on multi-lane roundabouts when some or all approach arms are aligned at angles substantially more or less than 90 degrees.

## Circulatory Carriageway Road Markings

As discussed in Section 6.4, multi-lane roundabouts must have two or more lanes on the circulatory carriageway to allow more than one vehicle to travel side by side on the circulatory carriageway. Accordingly, circulatory carriageway road markings are necessary to channelise traffic and avoid the confusion associated within an excessively wide un-marked carriageway.

The markings should be positioned so that the circulating lanes are visible from each entry to offer drivers a clearly defined position on the circulatory carriageway to which to direct their vehicle.

There are four basic configurations of road markings which may be used on the circulatory carriageway:

- a) Concentric markings (see Figure E.1) are useful to encourage drivers to enter and circulate in two or more adjacent lanes. The basic form of concentric markings divides the carriageway into a number of circulating lanes, tracing a complete path around the circulatory carriageway and guiding vehicles around the roundabout.

However, on wide circulatory carriageways, these may have limited effect in reducing conflicts at single lane exits, as drivers may deviate across other circulating movements in order to leave the roundabout.

- b) Partial concentric markings (see Figure E.2) can assist on wide circulatory carriageways by presenting drivers with clearly defined lanes within which to pass around the junction, and reduce the likelihood of drivers in the offside entry lane being forced towards the central island. The breaks in marking continuity allow vehicles to change lanes in advance of the exits.
- c) Concentric-spiral markings (see Figure E.3) are similar to concentric markings except that the outermost circulating lane or lanes guide traffic to the next exit by means of a lane-drop. This is effected by running the circulatory markings directly into the existing road markings at the exit. These types of markings are useful in reducing conflicts between vehicles at the exits, where more than one exit lane is provided and can be used with any number of circulating lanes.
- d) Spiral markings (see Figures E.4 and E.5) involve a series of lane-gains and lane-drops around the circulatory carriageway so that drivers enter in the lane appropriate for their desired exit. The markings can also cater for heavily biased turning proportions, since the circulatory width may be divided according to traffic demand.

As discussed in Section 6.6.2, it is not always essential to provide the same number of circulating lanes for the entire length of the circulating carriageway. This may be appropriate in situations where the turning proportions are such that one section of the circulatory carriageway has a relatively low flow.

Reducing the number of lanes on the circulatory carriageway can be achieved by extending the splitter island (permanent reduction) or by hatching the pavement in front of the splitter island (temporary reduction) to one circulating lane prior to the exit. See Figure E.6.

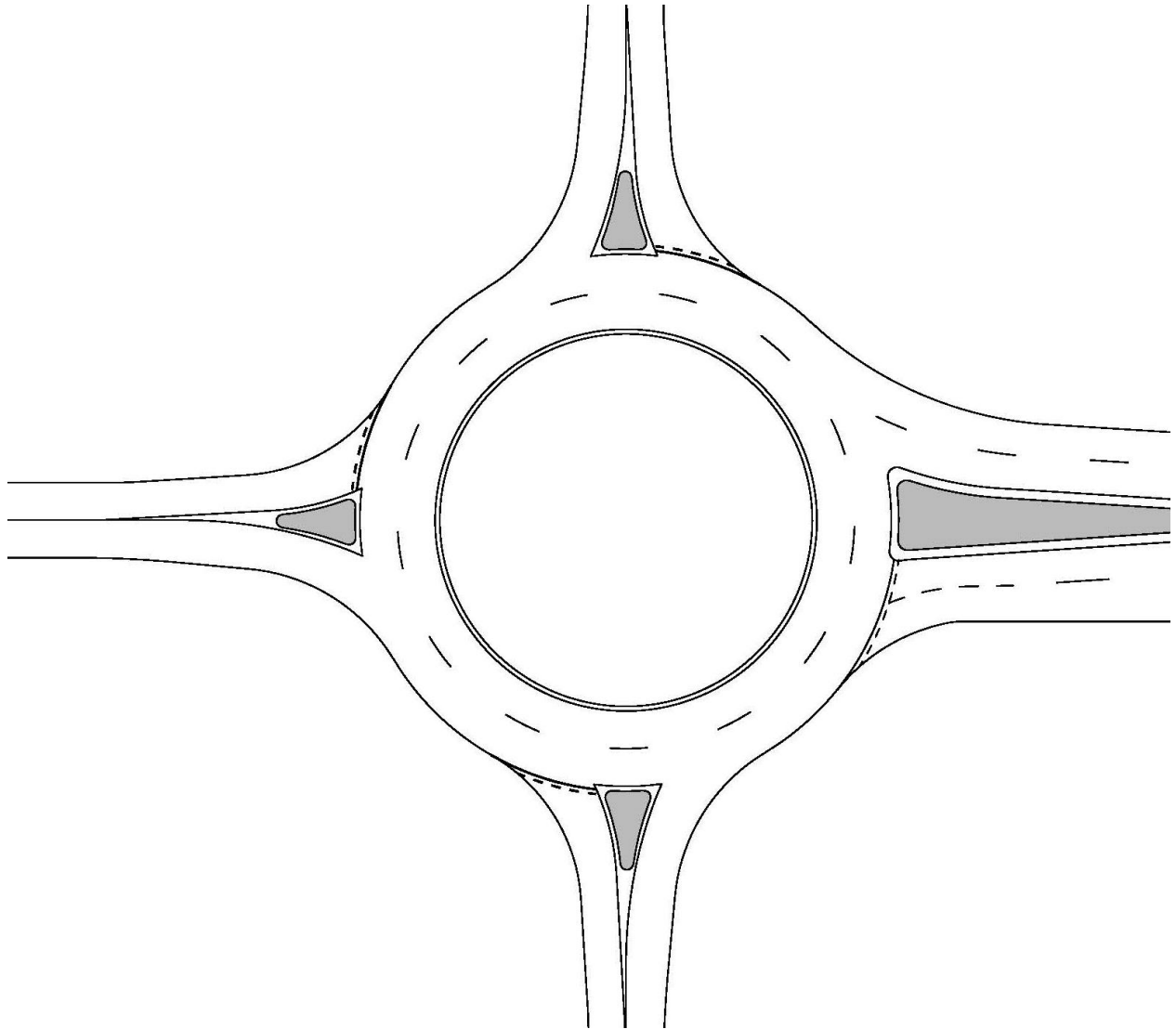
### **Lane Indication Markings and Arrows**

Lane directional arrows should be used on the approaches to multi-lane roundabouts to direct motorists into the correct lane for the movement they need to make when:

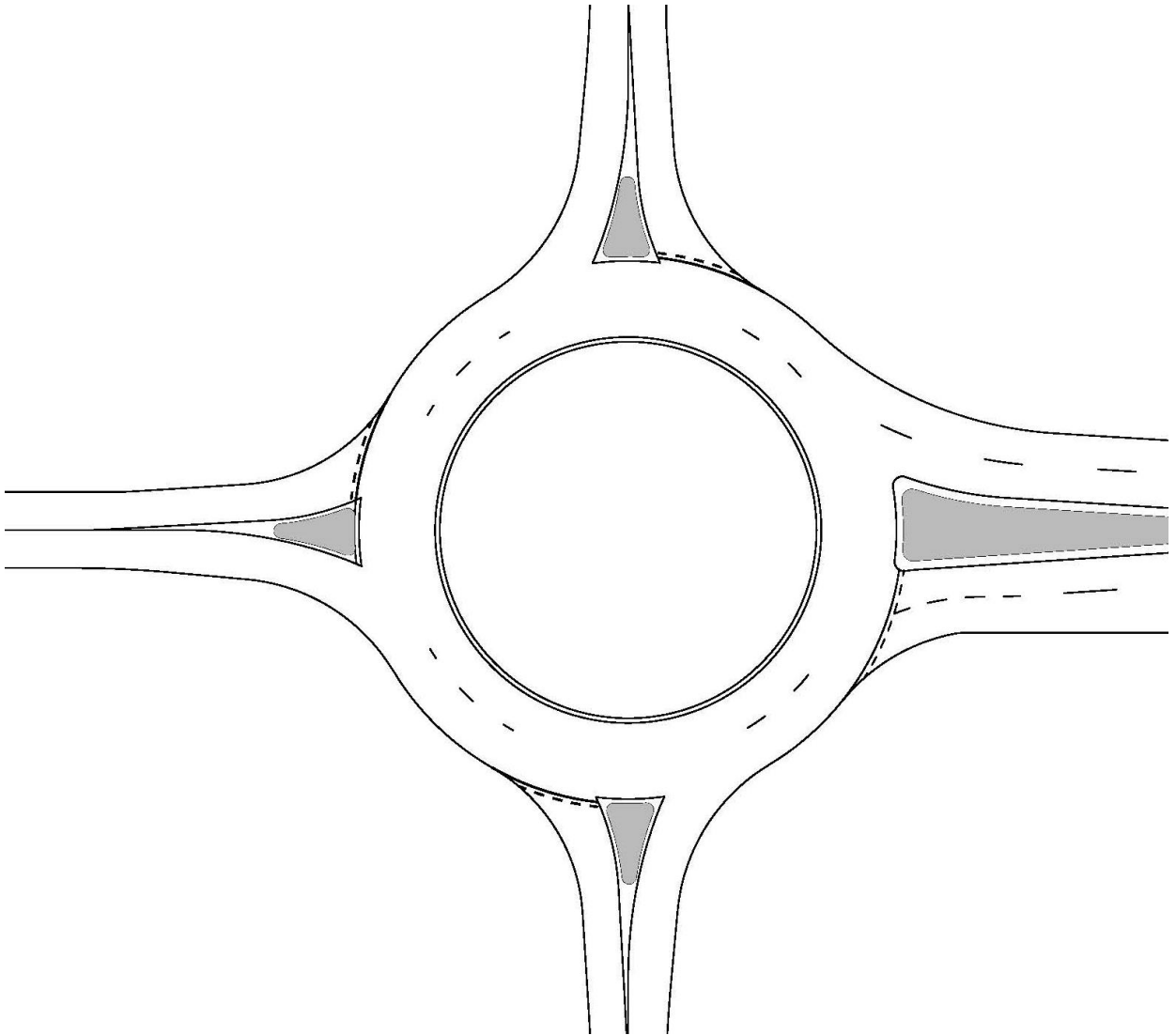
- there is more than one lane on an approach;
- the number of lanes reduces from entry to exit. (see Figure E.6)

Lane directional arrows may increase the capacity of a roundabout and improve safety, but will only be successful if directional markings complement circulatory markings and are easily understood by motorists. Careful judgment is needed to ensure that such markings are not used inappropriately, as the reduction in flexibility may adversely affect the capacity of the roundabout.

Where a right-hand lane is dedicated to right turning traffic, a right-turn arrow will ensure appropriate use of the lane. On multi-lane roundabouts, the number of exit lanes will be determined by capacity needs. Where no lane indication arrows are shown on approach, the number of exit lanes should equal the number of circulating lanes prior to the exit.



**Figure E.1**      **Concentric Markings**



**Figure E.2 Partial Concentric Markings**

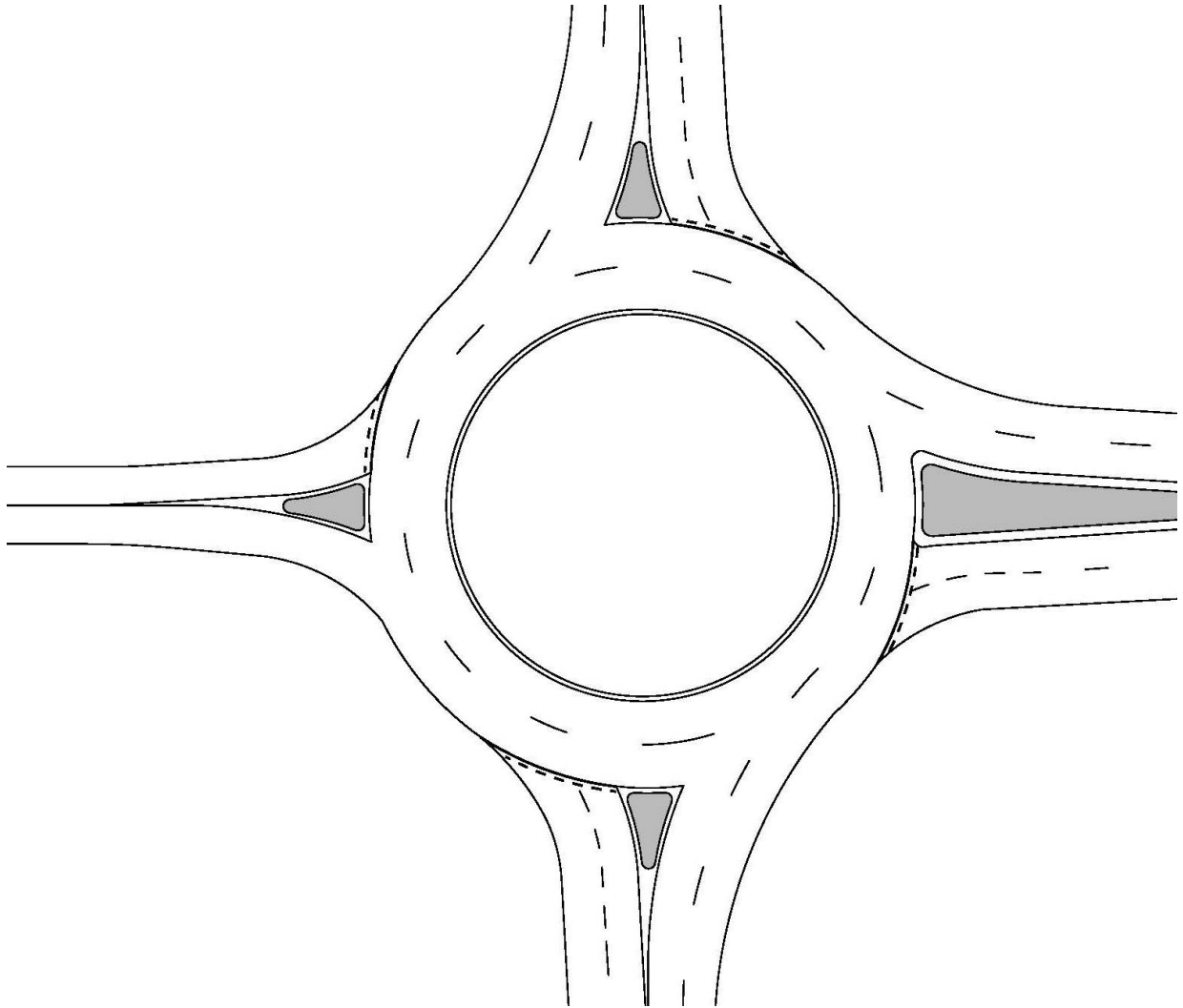


Figure E.3 Concentric-Spiral Markings

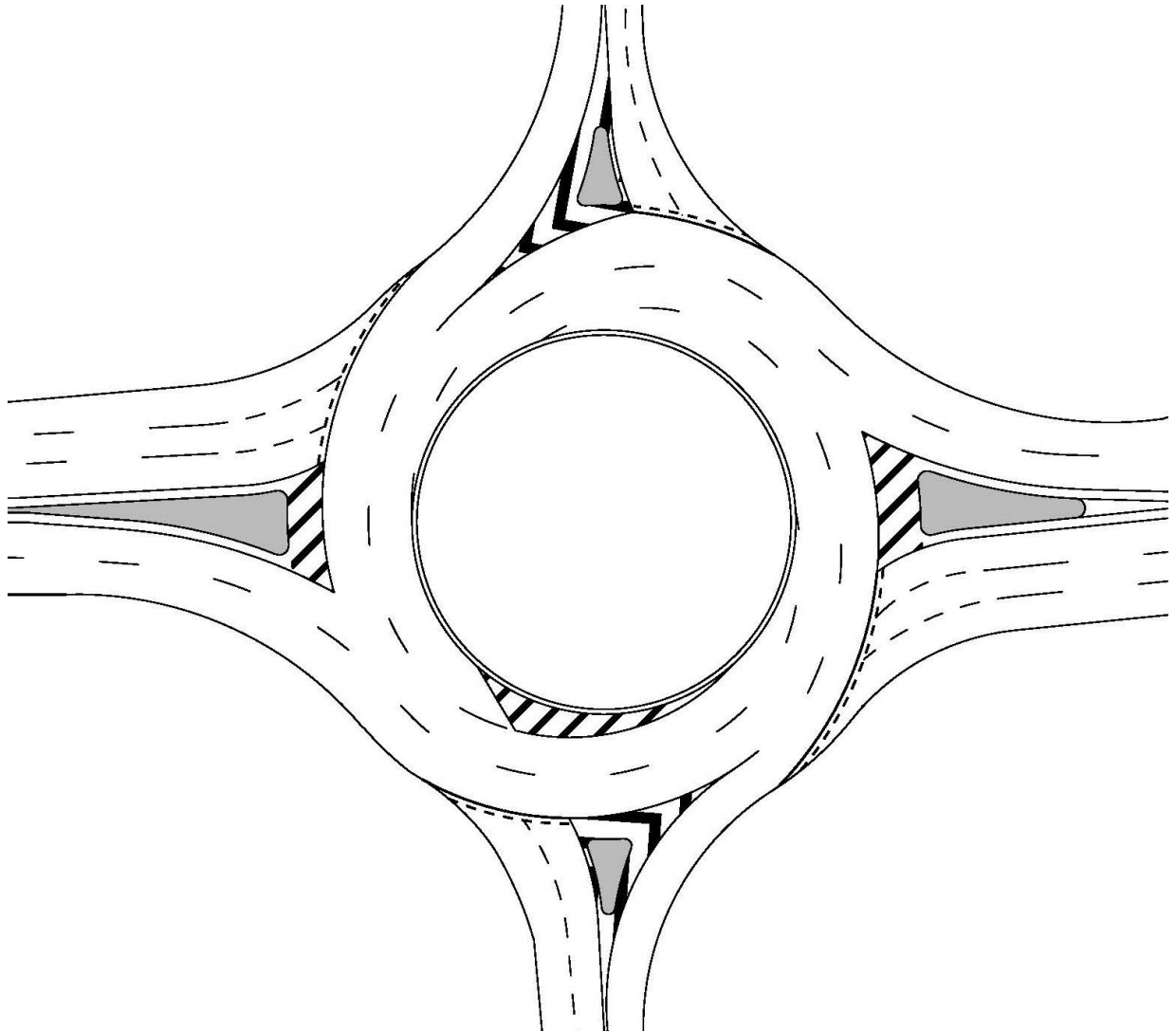


Figure E.4 Spiral Markings

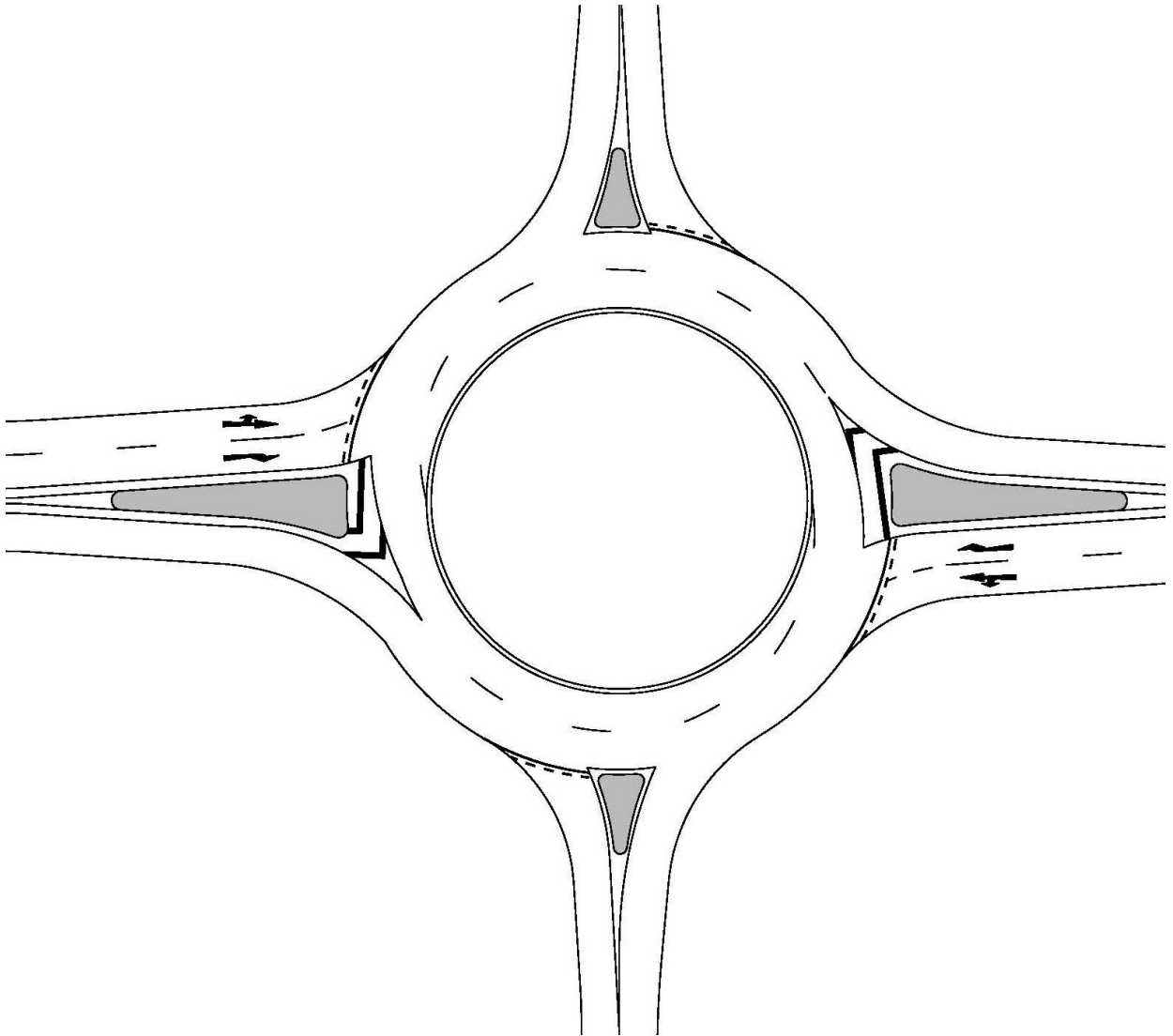
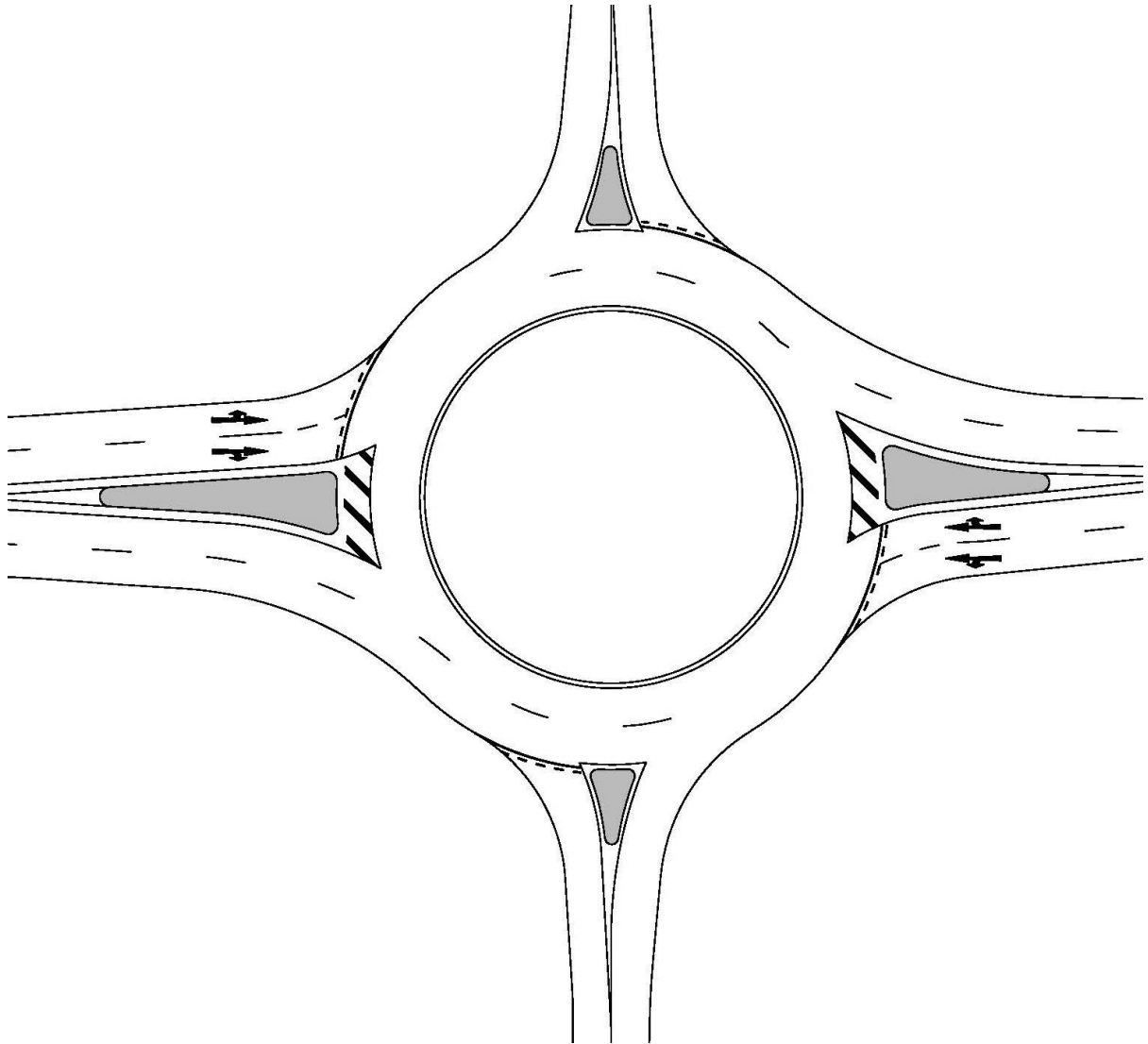


Figure E.5 Spiral Markings



**Figure E.6**      **Reduction to one lane circulating on multi-lane roundabout**



## **Appendix F:**

### Segregated Left Turn Lanes

This appendix outlines the criteria for the provision of Segregated Left Turn Lanes (SLTL) at roundabouts and the geometric features to be considered. The implementation of SLTL requires a Departure from Standard.

### General Principles

A SLTL should only be implemented if:

- There is a significant left turn movement at a particular entry;
- It improves the overall operational efficiency of the junction, to a greater extent than other design options; and
- It improves road safety of the junction for all users (including ATUs).

The use of two-lane SLTLs is not permitted, as these can result in high vehicle speeds and potential conflicts at the exit or merge point. Where left turn flows are very high, alternative junction forms or methods of junction control shall be considered.

Accesses, junctions, lay-bys and bus stops shall not be located within SLTLs.

The use of SLTLs at unlit junctions is not permitted.

SLTLs should not be designed to induce high speeds. Any desirable speed reduction should be achieved on the approach to the lane rather than within it.

Segregation shall be provided by physical separation as shown in Figure F.1 and Figure F.2. Vehicles are channelled into the left-hand lane by road markings, supplemented by advance direction signs. They proceed to the first exit without having to yield to other vehicles at the entry onto the roundabout. As physical segregation is to be provided, this shall permit a left turn at the roundabout in the normal way from the non-segregated part of the approach as shown on Figure F.1.

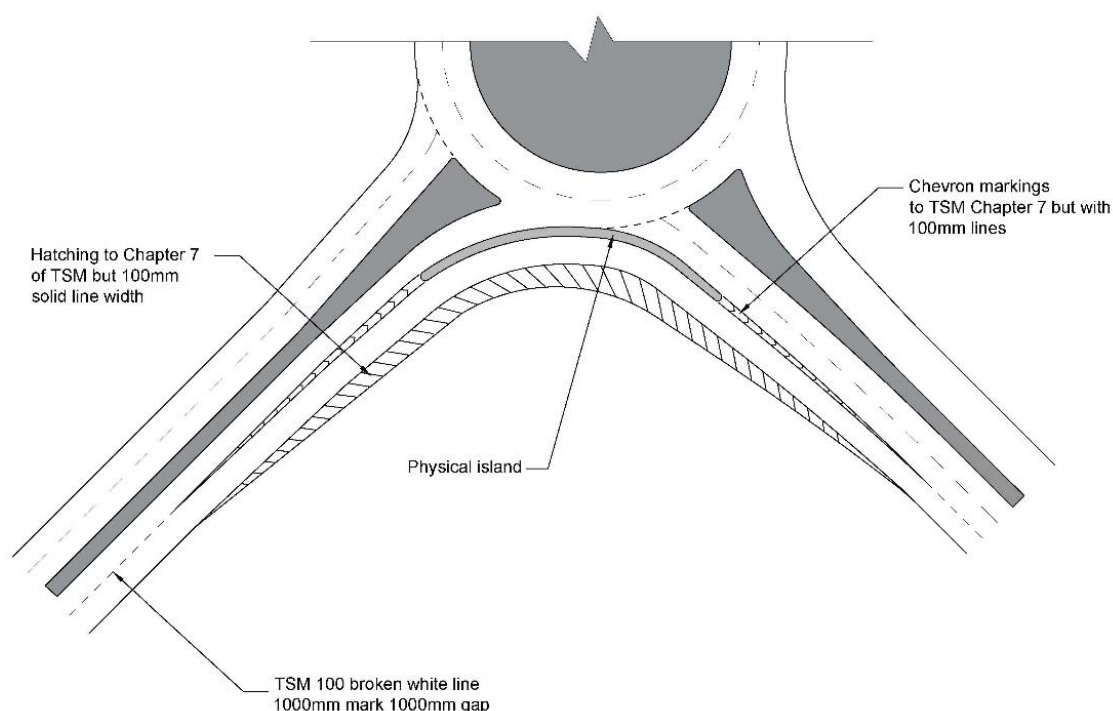
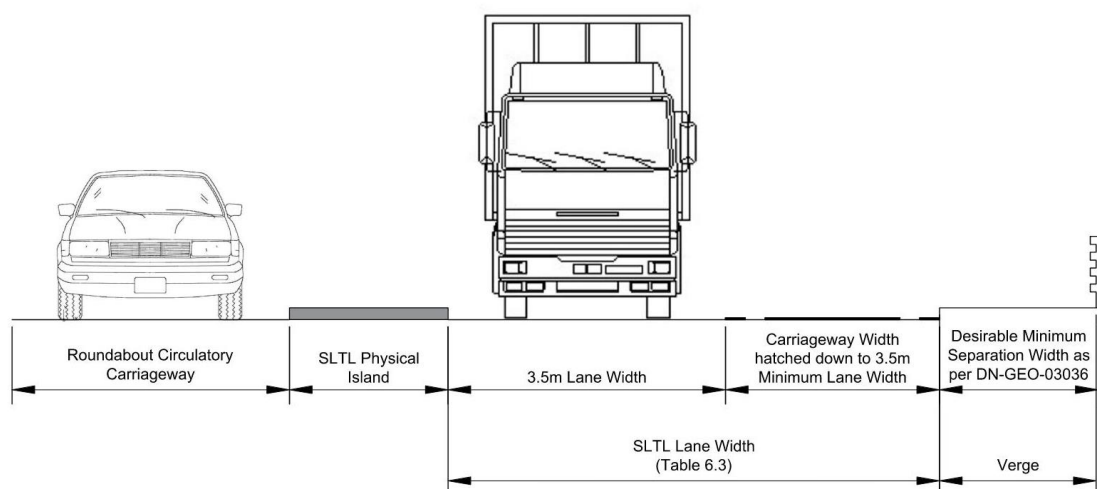


Figure F.1 Generic SLTL with Physical Island



**Figure F.2 Indicative cross-section for SLTL island less than 50m in length**

### Traffic Flows and Capacity of Segregated Left Turn Lanes

When considering the use of SLTLs, vehicle composition and the total inflow at the roundabout entry, the proportion of left turning vehicles and the number of entry lanes should all be examined. The following procedure can be used as an initial assessment to determine whether the provision of a segregated left turn lane merits further consideration.

The inclusion of a SLTL should be considered if:

$$L \geq \frac{F}{E}$$

Where:

**L** is the flow of left turning vehicles;

**F** is the total entry arm inflow in vehicles per hour;

**E** is the number of proposed entry lanes onto the roundabout including the segregated left turn lane.

The following examples illustrate the use of this initial assessment process. In Example 1, a segregated left turn lane is being considered at an existing roundabout and in Example 2, as an addition to a new roundabout layout.

#### Example 1

An existing roundabout currently has a 3-lane entry, a left turn flow of 500 vehicles per hour and a total entry inflow of 1200 vehicles per hour. The provision of a left turn lane will result in the loss of one entry lane onto the circulatory carriageway. **L** is 500, which is greater than **F/E** ( $1200/3 = 400$ ), indicating that further examination is worthwhile.

#### Example 2

A new roundabout is proposed, the left turn flow is 250 vehicles per hour, the total inflow is 1000 vehicles per hour and the left turn lane can be provided in addition to two entry lanes.

L is 250, which is less than F/E ( $1000/3 = 333$ ), indicating that a SLTL may not improve the capacity of the roundabout entry. Designers should therefore consider alternative measures such as additional entry width (i.e. a three lane entry) or a longer flare length.

For marginal cases where the value of F/E is close to L, the provision of a SLTL may merit further consideration where other factors such as safety need to be considered.

The composition of the turning proportions at the entry, the number of exit lanes and the capacity of the approach road should also be examined when considering the provision of a SLTL.

The capacity of a SLTL is dependent on the entry and exit treatments and lane width. To ensure maximum capacity, a dedicated lane on the approach and exit shall be provided with a lane width of 3.5m.

The impact of introducing a SLTL should be assessed taking into account the entry and exit treatments. A traffic micro-simulation program shall be used by the designer to assess the impact of introducing a segregation.

The relevant peak periods for the junction being analysed should be used, and should include forecast commuter, development usage and other peak periods. The effect of the lane on traffic flows at different periods of the day should also be considered. The results of any assessment should be carefully examined to ensure that the provision of a SLTL is the most appropriate form of improvement, compared with alternatives such as modifications to flare lengths or entry widths.

The use of SLTLs on roundabouts forming part of grade separated junctions should be considered where queuing at roundabout entries becomes a problem.

### **Geometric Design of Segregated Left Turn Lanes**

The curve radius used for the SLTL will be dependent on both the design speed of the approach road and site constraints. The driver's perception of the approach and SLTL radii will be a determining factor in their approach speed. The designer should therefore consider the need for speed reduction measures on the approach depending on the minimum curve radii used. Inside curve radii of less than 10m are not recommended. The exit radius used should be greater than, or equal to, the entry radius.

Where SLTLs are considered on grade separated junctions, designers shall provide a  $3.75V$  m distance between the mainline and the segregated lane diverge noses, where V is the design speed in km/h. Refer to Chapter 8 for further information.

SLTLs shall not be used at the end of steep downhill gradient approaches, this being defined as a longitudinal gradient in excess of 4% within the immediate approach to the junction as defined in DN-GEO-03031, applicable to the design speed of the approach measured back from the start of the entry taper, see Figure F.3 for definition of entry taper. The longitudinal gradient along the SLTL shall not exceed 4%.

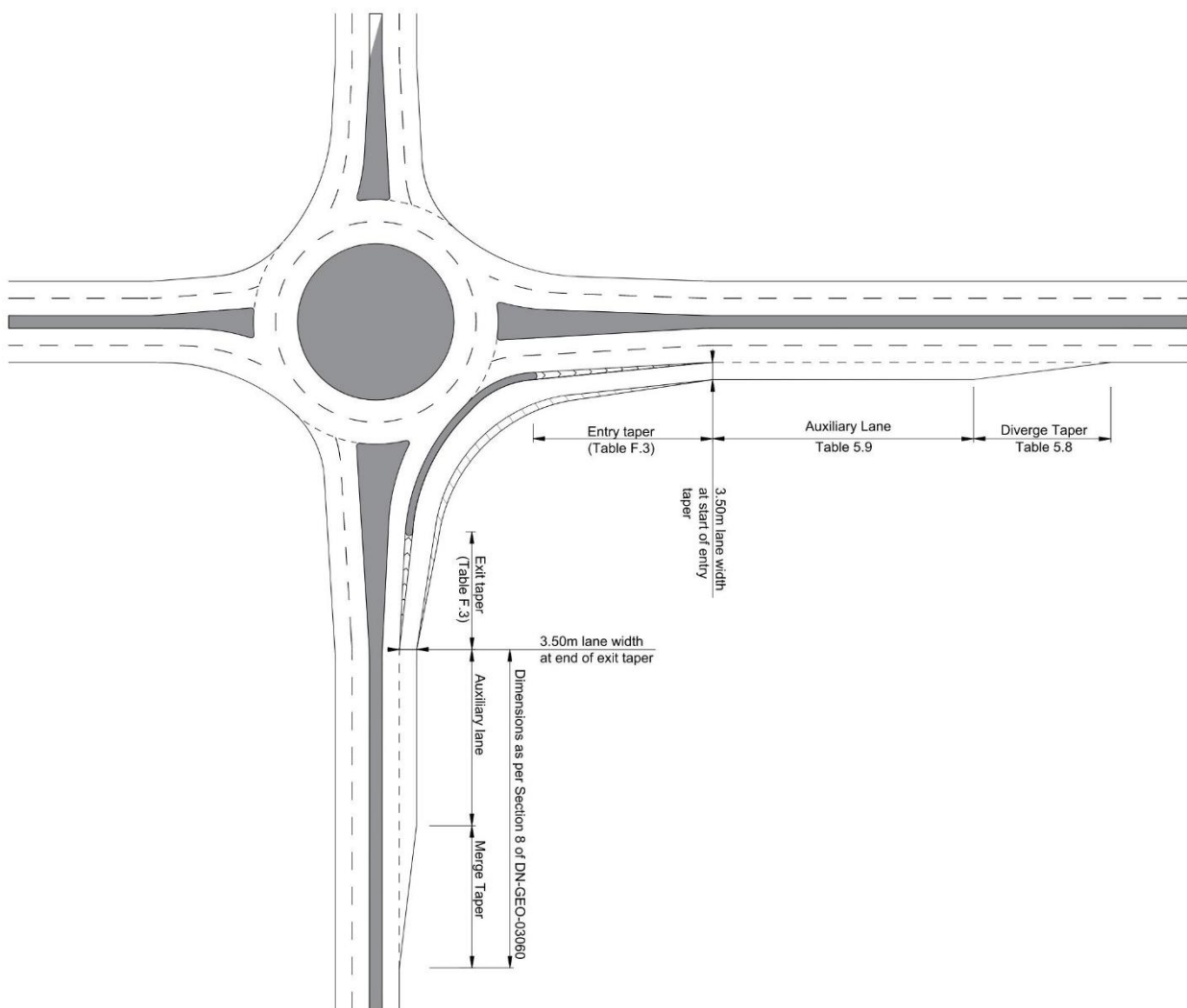
Superelevation along the SLTL shall be applied in accordance with Table 1.3 of DN-GEO-03031 subject to a maximum value of 5%.

The Desirable Minimum Stopping Sight Distance (SSD) on the SLTL shall be the lesser of (a) the SSD obtained from DN-GEO-03031 Table 1.3 for the design speed of the approach or (b) the SSD given in Table F.1 in this standard appropriate to the maximum nearside curve radius. The Desirable Minimum SSD shall be applied to the section of SLTL between the end of the entry taper and the start of exit taper.

The maximum curve radius used to determine the SSD from Table F.1, shall be the greater of either the entry or exit radius of the SLTL, these being defined as the radius that occurs immediately after the entry taper and immediately before the exit taper in the direction of travel. See Figure F.3 for definition of entry and exit tapers.

**Table F.1 Desirable Minimum Stopping Sight Distances**

| Maximum Curve Inner Radius (m) | Desirable Minimum Stopping Sight Distance (m) |
|--------------------------------|---|
| less than or equal to 20       | 35  |
| 21 to 40                       | 70  |
| 41 to 80                       | 90  |
| 81 to 100                      | 120   |
| Greater than 100               | 215   |



**Figure F.3 Auxiliary Lane Approach and Exit for Segregated Left Turn Lane**

The width of the SLTL carriageway is dependent on the curve radii used as well as the length of the SLTL physical island and overall roundabout ICD.

For short SLTLs with a physical island length less than 50m, the carriageway width specified in column 2 of Table F.2 shall be applied.

This width will be sufficient to accommodate the swept path of a HGV, however, hatch marking shall be provided on the inside of the curve to reduce the marked lane to 3.5m, as shown in Figure F.4.

For longer SLTLs with a physical island length in excess of 50m, the carriageway widths specified in column 3 of Table F.2 shall be used to accommodate the swept path and to make allowance for passing broken-down vehicles. However, hatch marking shall be provided on the inside of the curve to reduce the marked lane to 3.5m, as shown in Figure F.4.

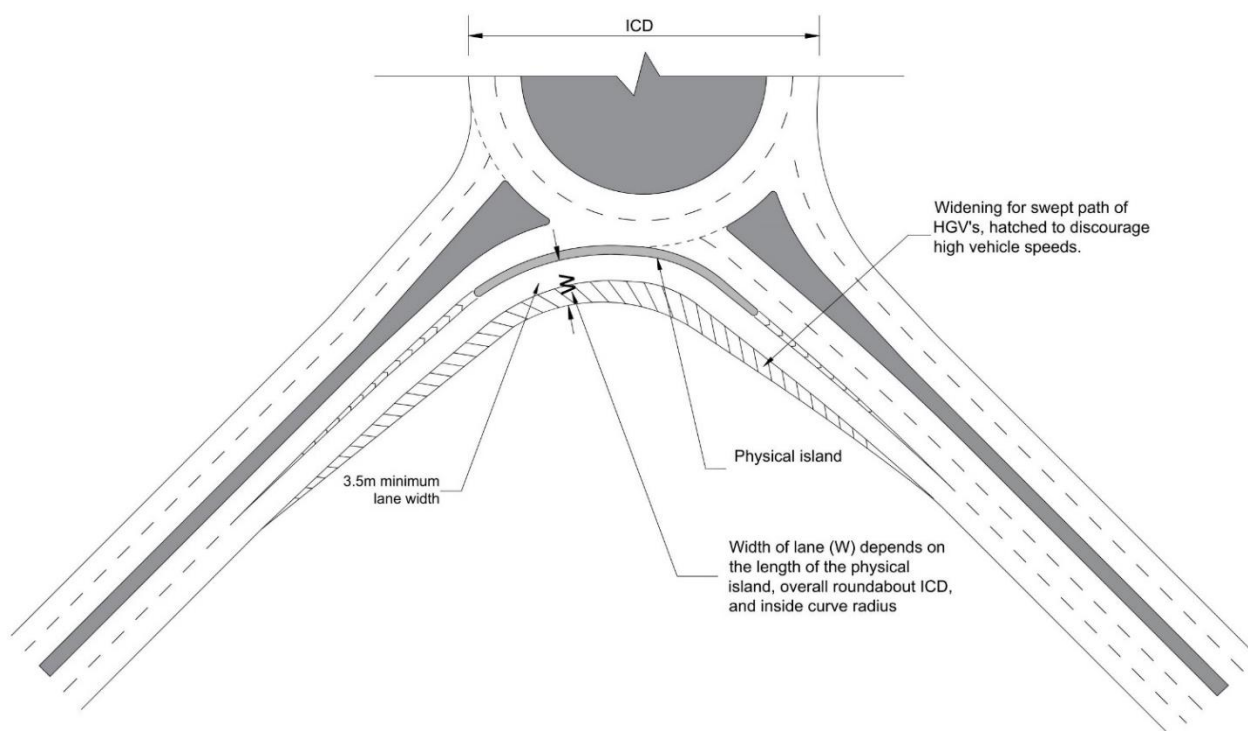
For roundabouts with an inscribed circle diameter  $\leq 50\text{m}$ , the SLTL width shall be based on the minimum curve radius on the entry or exit and shall be constant over the length of the SLTL, as shown in Figure F.4.

For roundabouts with an inscribed circle diameter  $> 50\text{m}$ , the designer shall have discretion to reduce the SLTL width on the section of SLTL between the entry and the exit, depending on the radius used on that section. The widths, depending on the length of the physical island, specified in Table F.2 shall be used.

Hard strips shall not be provided on SLTLs. They shall be terminated at the start of the entry taper and recommenced at the end of the exit taper.

**Table F.2 Minimum Corner and Curve Radii and Carriageway Widths**

| <b>Minimum Inside Corner Radius or Curve Radius (m)</b><br><b>(1)</b> | <b>SLTL Carriageway Width (for channelising island lengths <math>\leq 50\text{m}</math>) (m)</b><br><b>(2)</b> | <b>SLTL Carriageway Width (for channelising island lengths <math>&gt; 50\text{m}</math>) (m)</b><br><b>(3)</b> |
|---|--|--|
| 10  | 8.4  | 10.9   |
| 15  | 7.1  | 9.6  |
| 20  | 6.2  | 8.7  |
| 25  | 5.7  | 8.2  |
| 30  | 5.3  | 7.8  |
| 40  | 4.7  | 7.2  |
| 50  | 4.4  | 6.9  |
| 75  | 4.0  | 6.5  |
| 100   | 3.8  | 6.3  |
| $> 100$   | 3.5  | 6.0  |



**Figure F.4 Width of SLTL for varying ICD and physical island**

Where ATUs are not expected to cross the junction (for example, where off-line or grade separated crossing facilities are provided), the physical island shall be a minimum width of 1.5m and it shall extend a minimum of 1.5m and 6m into the entry and exit roads respectively, as shown on Figure F.5.

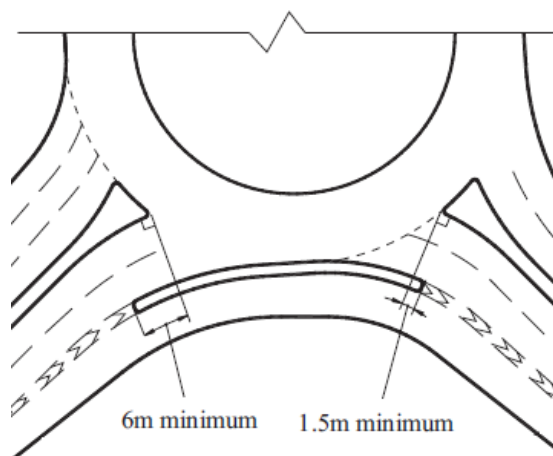
Where ATUs are permitted to cross the SLTL, the physical island shall be a minimum width of 4m, to facilitate safe crossing and any requirements for bollards and signs.

The kerb height above the carriageway for raised and kerbed channelising islands should be 125mm.

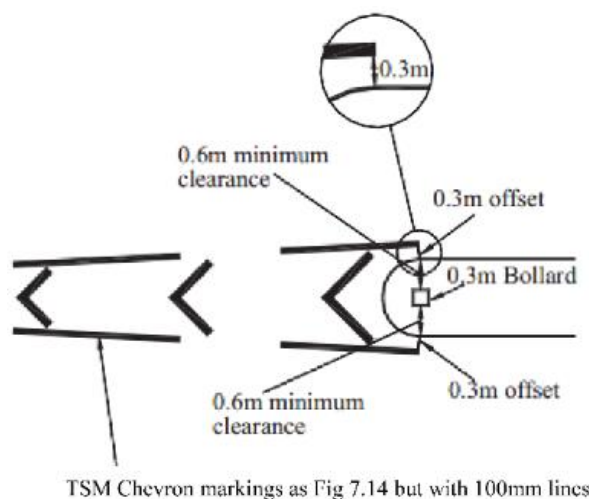
Traffic signs and street furniture may be placed on channelising islands. Their number should be limited however, as proliferation can create confusion, reduce visibility, add to sign clutter and have significant maintenance implications. Reference should be made to DN-REQ-03034 for vehicle restraint system details for protection from roadside hazards.

A retroreflective or transilluminated bollard shall be installed at the start of the physical island. A minimum clearance of 0.6m between the edge of the sign or bollard and edge of the island shall be provided, as shown in Figure F.6.

The taper for the hatching shall be developed asymmetrically on the SLTL side of the entry and exit taper as shown on Figure F.7 and shall terminate in a position offset 0.3m from the edge of a channelising island as shown on Figure F.6. The 0.3m offset may be reduced to 0.15m where the speed limit is 70 km/h or less.



**Figure F.5** Generic Physical Left Turn Lane with no provisions made for Active Travel Users



**Figure F.6** Termination of Taper Hatching at Physical Island

### Approach and Exit Layout of Segregated Left Turn Lanes

The approach arrangements shall consist of a taper diverge with auxiliary lane deceleration length as shown on Figure F.3. The auxiliary lane diverge layout is preferred because it minimises driver confusion at the junction and is more cycle friendly than dedicated lanes (in the form of a lane drop).

An entry taper is provided at the end of the deceleration lane. The SLTL width shall be a minimum of 3.5m at the start of the entry taper, as shown on Figure F.3. Any widening required to accommodate the swept paths of HGVs shall be developed along the length of the entry taper.

The length of the entry taper shall be dependent on the widening required to accommodate either the SLTL channelising island width, subject to a minimum width of 2.1m (1.5m island width plus 0.3m marking offset on each side), or the widening required to accommodate the swept path of a HGV (Table F.2). The larger of the two values shall be used to calculate the entry taper length using the factors contained in Table F.3.

Figure F.7 shows an example of how to calculate the entry taper length for a 1.5m wide physical island less than 50m in length, for a 70km/h single carriageway approach and 85 km/h single carriageway on exit.



**Table F.3**      **Desirable Minimum Entry/Exit Taper Length Factors**

| <b>Design Speed (km/h)</b> | <b>Entry/Exit Taper Length Factor</b> |
|----------------------------|---------------------------------------|
| 50                         | 20                                    |
| 60                         | 20                                    |
| 70                         | 20                                    |
| 85                         | 25                                    |
| ≥100                       | 30                                    |

The exit layout from a SLTL shall be either an auxiliary lane merge or a dedicated lane. The auxiliary lane merge layout shall be designed in accordance Figure F.3. The dedicated exit lane provides a free running exit for traffic from the SLTL in the form of a lane gain.

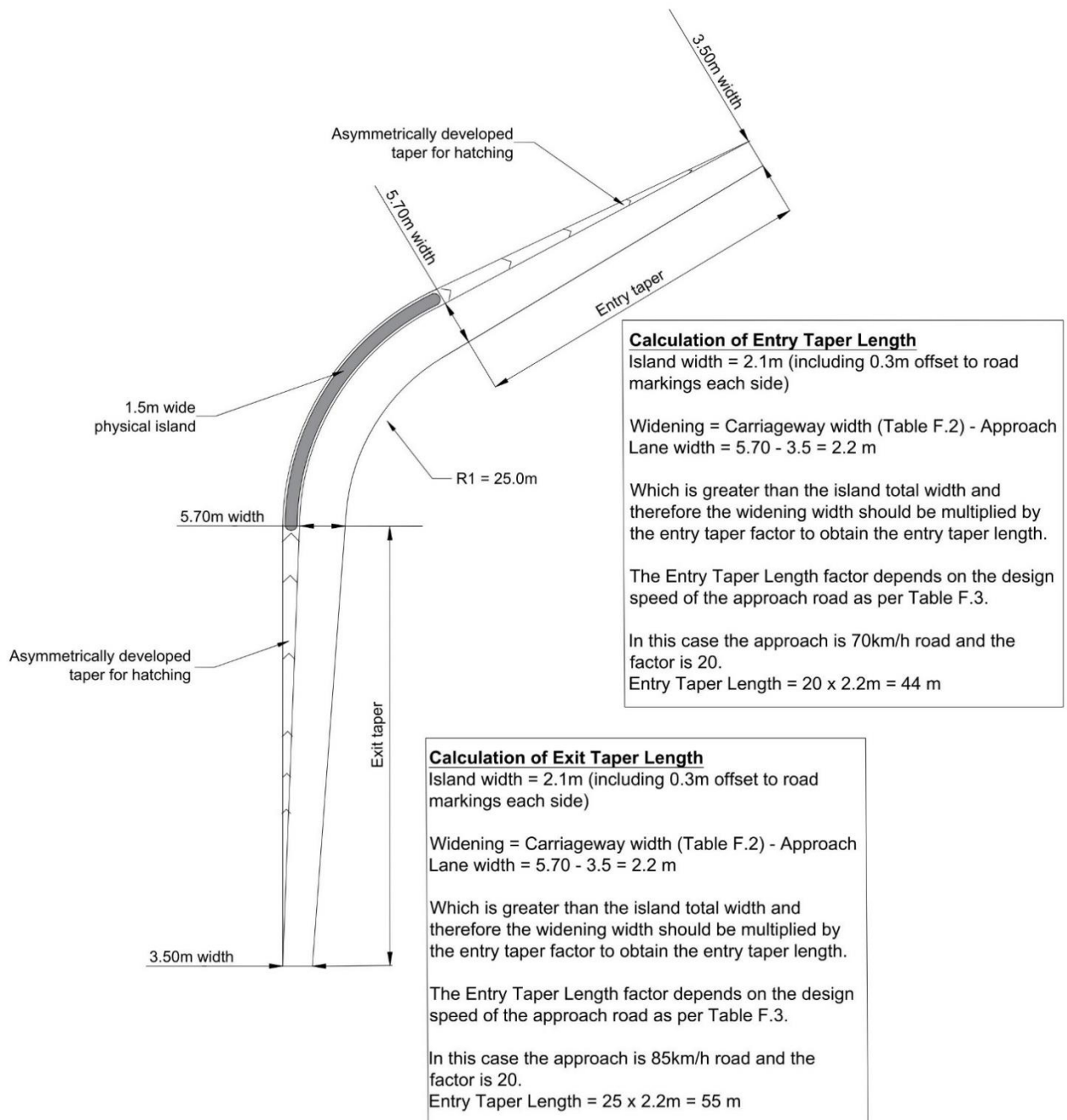
The exit arrangements consist of an exit taper as shown on Figure F.3. As with the entry taper, the length of the exit taper shall be calculated by using the larger value when comparing the width of the SLTL island (including road marking offset on each side) with the width reduction required between the start and end of the exit taper, as shown on Figure F.7. The larger of the two values shall be used to calculate the exit taper length using the factors contained in Table F.3.

The SLTL width shall be 3.5m at the end of the exit taper, as shown on Figure F.3. Any widening required to accommodate the swept paths of HGVs through the SLTL shall be removed along the length of the exit taper.

The taper for the hatching shall be developed asymmetrically on the SLTL side of the exit taper as shown on Figure F.7 and shall terminate in a position offset from the edge of a channelising island in accordance with the details provided in Figure F.6.

Any additional width provided at the beginning of the roundabout exit (refer Section 6.6.14), shall be reduced on the nearside and the exit width reduction shall be completed upstream of the end of the SLTL exit taper. This may require extending the SLTL exit taper to accommodate the roundabout exit width reduction.

Where signs and street furniture are placed on the channelising island in the vicinity of the exit, they should be located so as not to obstruct intervisibility between the SLTL exit and adjacent roundabout exit lane.



**Figure F.7 Entry/Exit Taper Length Example Calculation**

**Traffic Signs and Road Marking of Segregated Left Turn Lanes**

All traffic signs and road markings shall be designed in accordance with the Traffic Signs Manual (TSM).

The presence of a SLTL shall be signed on the approach using an advance direction sign in accordance with TSM Chapter 2. The use of road markings to supplement advance directional signs may also be considered.

Countdown markers in accordance with TSM Chapter 4 should only be provided on the approach to the roundabout when there is no risk of confusion between the distance to the commencement of the SLTL and the distance to the roundabout yield line.

Where the SLTL follows a tight radius relative to the approach speed, the use of “slow” road markings to TSM Chapter 7 is recommended in conjunction with associated ‘Sharp Bend’ warning signs (W 051L) to TSM Chapter 6, plated with a Max Speed (RUS 041, RUS 042, RUS 043 or RUS 044) per Chapter 5 of the TSM. Care should be taken to ensure that these signs are located to avoid “sign clutter” or confusion to drivers not using the SLTL.

The layout of the approach and departure to and from the physical SLTL islands shall be marked using chevron markings detailed for the particular road type in Chapter 7 of the TSM but with 100mm boundary line width.

Where the SLTL has been widened to accommodate the swept path of a HGVs, the designer should ensure that the widened lane does not encourage high vehicular speeds or two vehicles to attempt to use the lane side by side. The operational lane shall be narrowed down to 3.5m through the use of suitable hatch markings on the inside of the curve in accordance with TSM Chapter 7 but with 100mm boundary line width. The diagonal hatching line width shall be a minimum width of 1.0m.

Reflecting road studs shall comply with TSM Chapter 7.





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