Queensland Good jobs Better services Great lifestyle

Road Planning and Design Manual
Edition 2: Volume 3

Supplement to Austroads Guide to Road Design Part 4C: Interchanges

October 2024

Queensland Government

Relationship with Austroads Guide to Road Design – Part 4C (2023)

The Department of Transport and Main Roads has, in principle, agreed to adopt the standards published in the Austroads *Guide to Road Design* (2023) *Part 4C: Interchanges.*

When reference is made to other parts of the Austroads *Guide to Road Design*, Austroads *Guide to Traffic Management*, Austroads *Guide to Road Safety* or Australian Standard AS 1742 *Manual of Uniform Traffic Control Devices*, the reader should also refer to Transport and Main Roads related manuals:

- *Road Planning and Design Manual* (RPDM)
- Queensland *Guide to Traffic Management* (QGTM)
- Queensland *Guide to Road Safety* (QGRS)
- Queensland *Manual of Uniform Traffic Control Devices* (MUTCD), and
- *Traffic and Road Use Management Manual* (TRUM).

Where a section does not appear in the body of this supplement, the Austroads *Guide to Road Design – Part 4C* criteria is accepted unamended.

This supplement:

1. has precedence over the Austroads *Guide to Road Design – Part 4C* when applied in Queensland
2. details additional requirements, including *accepted with amendments* (additions or differences), *new* or *not accepted*.
3. has the same structure (section numbering, headings and contents) as Austroads *Guide to Road Design – Part 4C*.

The following table summarises the relationship between the Austroads *Guide to Road Design – Part 4C* and this supplement using the following criteria:

Accepted	Where a section does not appear in the body of this supplement, the Austroads *Guide to Road Design – Part 4C* is accepted.
Accepted with amendments	Part or all of the section has been accepted with additions and/or differences.
New	There is no equivalent section in the Austroads Guide.
Not accepted	The section of the Austroads Guide is not accepted.

Relationship table

Section		Title	Queensland application	Department contact
1	**Introduction**			
	1.1	Purpose	Accepted	Road Design
	1.2	Scope of this Part	Accepted	Road Design
	1.3	Road Safety	Accepted	Road Design
	1.4	Road Design Objectives	Accepted	Road Design
	1.5	Traffic Management at Interchanges	Accepted	Road Design
	1.6	Safety Performance of Interchanges	Accepted	Road Design
	1.7	Traffic Capacity of Interchanges	Accepted	Road Design
	1.8	Staged Development of Interchanges	Accepted	Road Design
2	**Design Considerations Process and Principles**			
	2.1	General	Accepted	Road Design
	2.2	Design Considerations	Accepted with amendments	Road Design
	2.3	Design Process	Accepted	Road Design
	2.4	Principles	Accepted with amendments	Road Design
3	**Forms of Interchange**			
	3.1	Traffic Considerations	Accepted	Road Design
	3.2	Other Considerations	Accepted	Road Design
4	**Structures**			
	4.1	General	Accepted	Road Design
	4.2	Form of Structure	Accepted	Road Design
	4.3	Cross-sections on Bridges	Accepted	Road Design
	4.4	Pedestrian / Cyclist Grade Separations	Accepted	Road Design
	4.5	Culverts	Accepted	Road Design
	4.6	Retaining Walls	Accepted	Road Design
	4.7	Wildlife Crossings	Accepted	Road Design
	4.8	Services on Structure	Accepted	Road Design
	4.9	Safety Screens	Accepted with amendments	Road Design
5	**Cross-section**			
	5.1	Major Road and Minor Road	Accepted	Road Design
	5.2	Ramp Cross-section	Accepted with amendments	Road Design
	5.3	Clearances on Major Road	Accepted	Road Design

Section		Title	Queensland application	Department contact
6	**Design Speed**			
	6.1	General	Accepted	Road Design
	6.2	Major Road	Accepted	Road Design
	6.3	Minor Road	Accepted	Road Design
	6.4	Ramps	Accepted with amendments	Road Design
7	**Sight Distance**			
	7.1	General	Accepted	Road Design
	7.2	Stopping Sight Distance on the Major Road and Minor Road	Accepted with amendments	Road Design
	7.3	Exit Ramp Nose	Accepted with amendments	Road Design
	7.4	Entry Ramp Nose	Accepted	Road Design
	7.5	Safe Intersection Sight Distance	Accepted	Road Design
8	**Horizontal Alignment**			
	8.1	Major Road	Accepted	Road Design
	8.2	Minor Road	Accepted with amendments	Road Design
	8.3	Ramps	Accepted	Road Design
9	**Vertical Alignment**			
	9.1	Major Road	Accepted	Road Design
	9.2	Minor Road	Accepted	Road Design
	9.3	Ramps	Accepted	Road Design
10	**Ramp Terminals at Major Roads**			
	10	Ramp Terminals at Major Roads	Accepted with amendments	Road Design
	10.1	Ramp Terminal Locations	Accepted with amendments	Road Design
	10.2	Ramp Alignment at Minor Road Terminals	Accepted	Road Design
	10.3	Ramp Terminal at Minor Road	Accepted	Road Design
11	**Ramp Terminals at the Major Road**			
	11.1	General	Accepted with amendments	Road Design
	11.2	Exit Ramps	Accepted with amendments	Road Design
	11.3	Entry Ramps	Accepted with amendments	Road Design
	11.4	Ramp Traffic Signals	Accepted with amendments	Road Design

Section		Title	Queensland application	Department contact
12	**Ramps on Two-Lane Two-Way Freeways**			
	12	Ramps on Two-Lane Two-Way Freeways	Accepted	Road Design
13	**Pedestrians**			
	13.1	General	Accepted	Road Design
	13.2	Bus Passengers	Accepted	Road Design
14	**Cyclists**			
	14.1	General	Accepted with amendments	Road Design
	14.2	Treatment at Interchanges	Accepted with amendments	Road Design
15	**Pavement Markings, Signs and Lighting**			
	15.1	General	Accepted with amendments	Road Design
	15.2	Key Considerations	Accepted	Road Design
	15.3	Lighting of Interchanges	Accepted with amendments	Road Design
16	**Landscaping and Street Furniture**			
	16.1	General	Accepted with amendments	Road Design
	16.2	Landscape Development	Accepted	Road Design
	16.3	Road Safety	Accepted	Road Design
17	**Other Considerations**			
	17.1	Access in the Vicinity of Interchanges	Accepted	Road Design
	17.2	Service Centres	Accepted	Road Design
	17.3	Oversized Loads and High Wide Load Corridors	Accepted	Road Design
18	**Grade Separated Intersections and Movements**			
	18.1	Grade Separated Intersections	New	Road Design
	18.2	Grade Separated Movements	New	Road Design
	References			
		References	Accepted	Road Design
	Appendices			
	A	Example of Ramp Speed Analysis	Accepted	Road Design
	B	Ramp Terminal Location	Accepted	Road Design
	C	Examples of Ramp Signal Layouts	Accepted with amendments	Road Design
	D	Trapped Lane Exit – EDD Treatment	New	Road Design

Section	Title	Queensland application	Department contact
	Commentaries		
1		Accepted	Road Design
2		Accepted	Road Design
3		Accepted	Road Design
4		Accepted	Road Design
5		Accepted with amendments	Road Design
6		New	Road Design
7		New	Road Design
8		New	Road Design

Departmental contacts

- Director (Road Design), Road Design, Hydraulics, Design and Spatial, Engineering and Technology, Transport and Main Roads email: roaddesignstandards@tmr.qld.gov.au

Contents

Relationship table ii

Departmental contacts v

2 Design considerations process and principles 1

2.2 Design considerations 1

2.2.4 Landscape development 1
2.4.2 Interchange uniformity and spacing 1

4 Structures 1

4.9 Safety screens 1

5 Cross-section 1

5.2 Ramp cross-section 1

5.2.2 Ramp lane widths 1

6 Design speed 2

6.4 Ramps 2

6.4.1 Ramp design speed 2

7 Sight distance 2

7.2 Stopping sight distance on the major road and minor road 2

7.3 Exit ramp nose 2

8 Horizontal alignment 4

8.2 Minor road 4

8.2.1 Curvature 4

10 Ramp terminals at major roads 4

11 Ramp terminals at the major road 4

11.1 General 4

11.2 Exit ramps 12

11.2.1 Single-lane exits 12
11.2.2 Two-lane exits 12
11.2.3 Exits to two high-speed roadways 13
11.2.4 Lane drop at an exit 15
11.2.6 Exit from an arterial road 16
11.2.7 Exit from another ramp 16

11.3 Entry ramps 17

11.3.2 Single-lane entry 17
11.3.3 Entry with auxiliary lane 17
11.3.4 Two-lane entry 19
11.3.8 Entry to an arterial road 19

11.4 Ramp traffic signals 20

14 Cyclists 20

14.1 General 20

14.2 Treatment at interchanges 21

14.2.3 Alternative routes 21

15 Pavement markings, signs and lighting 22

15.1 General 22

15.3 Lighting of interchanges ... 22
16 Landscaping and street furniture ... 22
16.1 General ... 22
18 Grade separated intersections and movements ... 22
18.1 Grade separated intersections ... 22
18.2 Grade separated movements ... 27
References ... 29
Appendix C – Examples of ramp signal layouts ... 30
Appendix D – Trapped lane exit – EDD treatment ... 31
Commentary 5 ... 32
Commentary 6 ... 33
Commentary 7 ... 35
Commentary 8 ... 38

Tables

Table 11.1 – Exit ramp options ... 5
Table 11.3(a) – Acceleration distance Da ... 17
Table 11.3(b) – Correction of acceleration distances as a result of grade ... 18
Table C8 - Using the VEHSIM acceleration curves to establish ramp lengths for ramps with compound grades ... 39

Figures

Figure 7.2 – Sight distance requirements at exit ramps ... 3
Figure 11.2(a) - Example of two-lane exit for a freeway or major divided road ... 12
Figure 11.2(b) – Major exit type 3a ... 13
Figure 11.2(c) – Example of two-lane exit for a freeway or major divided road ... 15
Figure 11.2(d) – Example of exit from an arterial road ... 16
Figure 11.2(e) – Example of exit from a ramp ... 16
Figure 11.3(c) – Entry arrangement NOT to be applied ... 19
Figure 11.3(d) - Entry to an arterial road ... 20
Figure 18.1(a) – Grade separated cross intersection ... 24
Figure 18.1(b) – Grade separated T-junction – Example 1 ... 25
Figure 18.1(c) – Grade separated T-junction – Example 2 ... 26
Figure 18.1(d) – Grade separated cross intersection examples on the network ... 27
Figure 18.1(e) – Grade separated movement examples on the network ... 28

Figure D.1 – Trapped lane exit 31

Figure C6(a) – Average driver deceleration at constant deceleration rate 33

Figure C6(a) – Speed profile of the 85th percentile driver 34

Figure C7 – Example speed profile on a deceleration ramp when vehicle stops for a hazard 35

Figure C8(a) – VEHSIM acceleration speed profiles on an on-ramp 38

Figure C8(b) – Example ramp with multiple grades 39

Figure C8(c) – using the VEHSIM acceleration curves to establish ramp lengths for ramps with compound grades 40

Figure C8(d) – Vehicle speed profile 40

2 Design considerations process and principles

2.2 Design considerations

2.2.4 Landscape development

Additions

Practitioners should refer to the Transport and Main Roads *Road Landscape Manual* for information on landscaping around interchanges.

2.4.2 Interchange uniformity and spacing

Additions

System interchanges desirably do not provide any service level access to nearby local or arterial roads and land use. The interchange elements are typically only motorway – motorway connections.

However, some limited level of service function may need to be tolerated at system interchanges where it is not practical to divert traffic from nearby developments or roads to a service interchange located some distance away. This may particularly be the case where as part of an upgrade project, an existing service interchange, providing access to the nearby road network and/or developments, is upgraded to a system interchange.

4 Structures

4.9 Safety screens

Additions

Refer to the following Transport and Main Roads documents via https://www.tmr.qld.gov.au/business-industry/technical-standards-publications/treatment-of-overhead-structures-objects-thrown-or-dropped:

- Engineering Policy EP177 *Managing the risk of objects thrown from overpasses onto roads*, and
- Technical Guideline *Treatment of overhead structures – objects thrown or dropped*.

5 Cross-section

5.2 Ramp cross-section

5.2.2 Ramp lane widths

Additions

If semi-mountable kerb is used on the outside of loops, the shoulder adjacent to the kerb must be at least 2.0 m wide.

The ramp lane left shoulder width is to transition to the major road left shoulder width from the point at which the painted gore reduces to less than 1.0 m wide.

6 Design speed

6.4 Ramps

6.4.1 Ramp design speed

Additions

Refer to Commentary 6 on design speed of deceleration ramps and Commentary 7 for methods of checking the related sight distance.

The design speed on direct ramps, semi-direct ramps and outer connectors, where the exit terminal is designed as an exit to two high-speed roadways (refer Section 11.2.3), is to be no less than the design speed of the approach on the through-road minus 10 km/h. If this minimum design speed on the ramp cannot be achieved, an alternative two-lane exit geometry (refer Section 11.2.2) is to be applied.

On all ramps, if a speed drop of more than 20 km/h is required, speed reduction measures will be required after leaving the through-roadway. Typically, warning signage and reduced speed limits, together with measures to highlight the alignment of curves, provide sufficient speed reduction. On ramps, it is preferred that alignment features are not used due to the increased crash potential they may introduce, however, in some cases horizontal alignment features may be suitable.

On exit diagonal ramps, the maximum operating speed on the ramp prior to the intersection should be limited to not more than 60 km/h. This should be achieved through appropriate cross-section and horizontal alignment design, combined with signage and pavement markings.

7 Sight distance

7.2 Stopping sight distance on the major road and minor road

Differences

The title of Section 7.2 has been amended to include ramps, reflecting that the guidance in this section of Austroads *Guide to Road Design – Part 4C* also applies to ramps.

7.3 Exit ramp nose

Additions

Third paragraph of Austroads *Guide to Road Design – Part 4C* is replaced with the following:

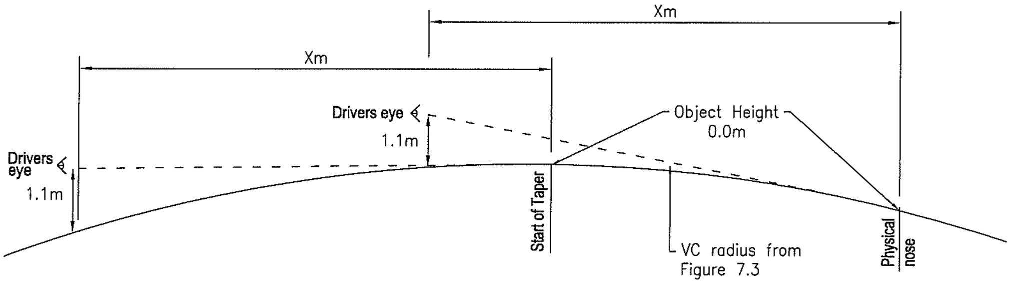
> In the case of a tapered exit treatment (Figure 7.2(b)), the sight distance 'X' measured in metres provided should be at least equivalent to 10 seconds of travel time at the operating speed of the major road. For this exit treatment, the sight distance should be maintained from the start of the taper continuously to the physical nose and desirably maintained to a point 60 m beyond the nose. If the required sight distance is not available to the start of the taper or to the physical nose, an auxiliary lane should be provided.
>
> Where an auxiliary lane is provided (Figure 7.2(c)), the exit is generally more conspicuous, and therefore the sight distance 'X' is based on a minimum of seven seconds of travel time at the operating speed of the major road. The sight distance should be maintained continuously throughout the length of the auxiliary lane and exit ramp to the exit nose and desirably to the point 60 m beyond the physical nose.

If the required sight distance is not available to the calculated location for the start of the auxiliary lane, the auxiliary lane should be extended. The additional auxiliary lane length is determined by firstly finding Point ‘C’ (refer Figure 7.2(d)), located seven seconds of travel time prior to the calculated minimum length of the auxiliary lane (as per Section 11.2). The auxiliary lane is then lengthened so that the exit marking at the start of the lane is visible from Point ‘C’, as shown in Figure 7.2(d).

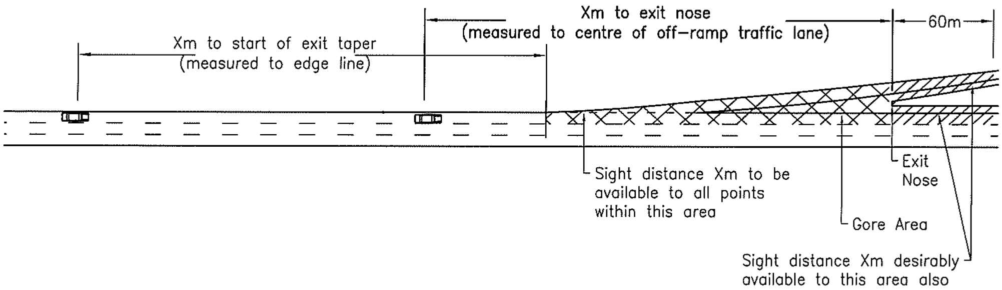
This concession demonstrated in Figure 7.2(d) is the only sight distance concession permitted in the design of exit ramps.

Figure 7.1 in Austroads *Guide to Road Design – Part 4C* is replaced with Figure 7.2. Throughout Section 7.3 of Austroads *Guide to Road Design – Part 4C*, all references to Figure 7.1 are to refer instead to Figure 7.2.

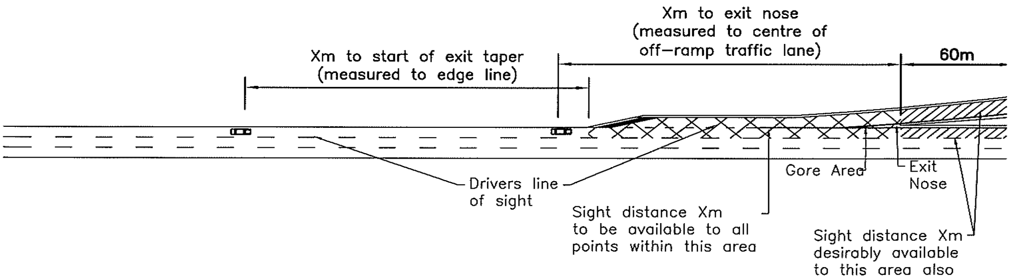
Figure 7.2 – Sight distance requirements at exit ramps



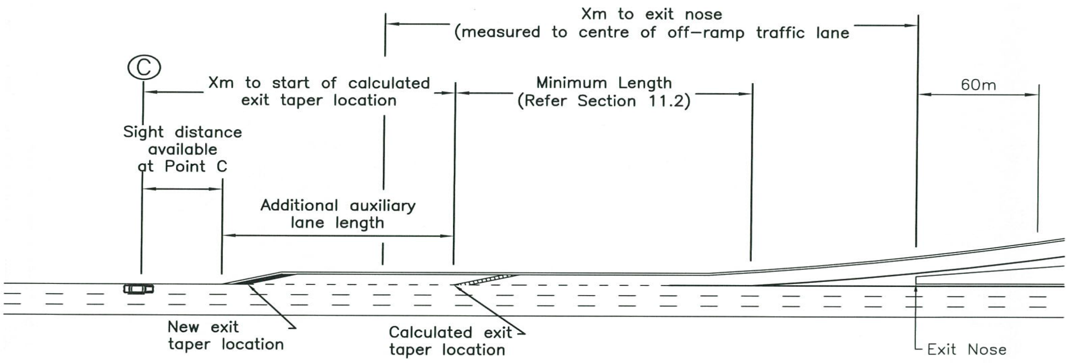
(a) Elevation – exit taper



(b) Plan – exit taper



(c) Plan – auxiliary lane



(d) Plan – auxiliary lane extension where sight distance is constrained

Notes:

In Figures 7.2(a) and (b), the distance X m is based on a minimum of 10 seconds of travel time.

In Figures 7.2(c) and (d), the distance X m is based on a minimum of seven seconds of travel time.

In Figure 7.2(d), sight distance available to the physical nose and beyond are measured in accordance with Figure 7.2(c).

8 Horizontal alignment

8.2 Minor road

8.2.1 Curvature

Additions

The following text is added to the end of this section:

- Safe Intersection Sight Distance (SISD) may be restricted by the bridge parapets and safety barrier at closed diamonds. Where sight distance at the intersection is restricted at either or both of the ramp terminals:
  - The parapets and safety barrier, including any screens or rails, may have to be set back (including appropriate bridge widening) to achieve the required sight distance.
  - Even if visibility over the tops of barriers provides sufficient sight distance, consideration should be made to future additions to the barriers, such as rails or throw screens. In these cases, it is preferred to set back the barrier to achieve the required sight distance, and
  - The intersections may need to be relocated further from the bridge.

10 Ramp terminals at major roads

Differences

Replace title of Section 10 in Austroads *Guide to Road Design – Part 4C* with:

Ramp terminals at the minor road

11 Ramp terminals at the major road

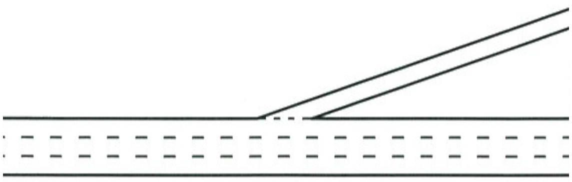
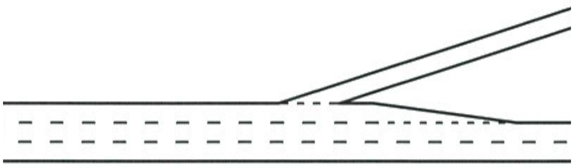
11.1 General

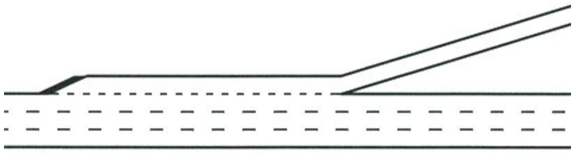
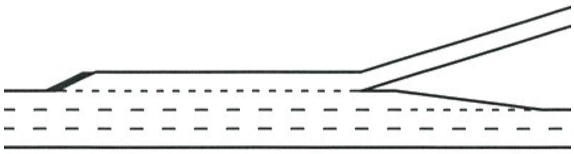
Additions

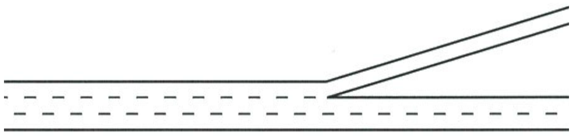
At exits, the ramp crossfall / superelevation should continue as an extension of the major road crossfall / superelevation up to the physical nose between the two sections of pavement. Similarly, at entrances, the ramp crossfall / superelevation should continue as an extension of the major road crossfall / superelevation from the physical nose onwards.

Table 11.1 provides a summary of the various exit ramps options and a discussion on the merits or applicability of each.

Table 11.1 – Exit ramp options

<table>
<tr><td colspan="2">Type 1 – Single lane exit</td></tr>
<tr><td rowspan="3">1a(i) Single lane exit – minimum treatment

Service interchange only – major / minor roads.
Typically only used at low exit volume ramps with good sight distance. This layout is the minimum permissible in low volume constrained situations and most typically to retrofit an additional exit on an existing motorway subject to constraints.</td><td>Refer to Section 11.2.1 for applicable design guidance.</td></tr>
<tr><td>Ramp traffic volume – low:
Total ramp volume typically < 10% of the approaching traffic in the two left nearside lanes of the motorway, and
Peak period ramp volume typically < 50% of ramp capacity ≈ LOS B (refer Austroads Guide to Traffic Management, Part 3: Transport Study and Analysis Methods (2020)).</td></tr>
<tr><td>Basic number of lanes – complies.
Lane balance – complies.</td></tr>
<tr><td rowspan="3">1a(ii) Single lane exit – minimum treatment with lane drop after the exit

Service interchange only – major / minor roads.
Typically only used at low exit volume interchanges with good sight distance. This layout is the minimum permissible in low volume constrained situations and most typically is used to retrofit an additional exit on an existing motorway subject to constraints.
This layout is rarely used in practice except where there are physical constraints, such as existing structures downstream of the exit.</td><td>Refer to Sections 11.2.1 and 11.2.4 for applicable design guidance.</td></tr>
<tr><td>Ramp traffic volume – low:
Total ramp volume typically < 10% of the approaching traffic in the two left nearside lanes of the motorway, and
Peak period ramp volume typically < 50% of ramp capacity ≈ LOS B (refer Austroads Guide to Traffic Management, Part 3: Transport Study and Analysis Methods).</td></tr>
<tr><td>Basic number of lanes – complies.
Lane balance – complies.</td></tr>
</table>

<table>
<tr><th colspan="2">Type 1 – Single lane exit</th></tr>
<tr><td rowspan="3">1b(i) Single lane exit – auxiliary lane

Service interchange – major / minor roads.
System interchange.
Preferred single lane exit ramp configuration.</td><td>Refer to Section 11.2.1 for applicable design guidance.</td></tr>
<tr><td>Ramp traffic volume – low to medium:
• Total ramp volume typically < 20% of the approaching traffic in the two left nearside lanes of the motorway, and
• Peak period ramp volume typically < 75% of ramp capacity ≈ LOS C (refer Austroads Guide to Traffic Management, Part 3: Transport Study and Analysis Methods).</td></tr>
<tr><td>Basic number of lanes – complies.
Lane balance – complies.</td></tr>
<tr><td rowspan="3">1b(ii) Single lane exit – auxiliary lane with lane drop after the exit

Service interchange – major / minor roads.
System interchange.
This layout may be applied where the motorway volume downstream does not require the equal number of lanes as the approach. However, it is preferably only applied where there are existing physical constraints, such as structures, downstream of the exit that prevent the use of layout 1b(i).</td><td>Refer to Sections 11.2.1 and 11.2.4 for applicable design guidance.</td></tr>
<tr><td>Ramp traffic volume – low to medium
• Total ramp volume typically < 20% of the approaching traffic in the two left nearside lanes of the motorway, and
• Peak period ramp volume typically < 75% of ramp capacity ≈ LOS C (refer Austroads Guide to Traffic Management, Part 3: Transport Study and Analysis Methods).</td></tr>
<tr><td>Basic number of lanes – complies.
Lane balance – complies.</td></tr>
</table>

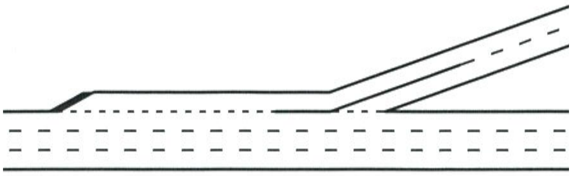
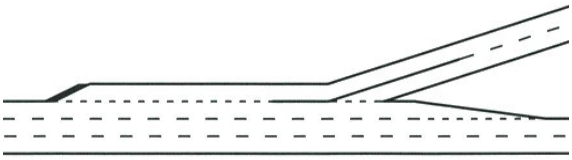
<table>
<tr><td colspan="2">Type 1 – Single lane exit</td></tr>
<tr><td rowspan="3">1c Single lane exit – trapped lane

Service interchange only – major / minor roads.

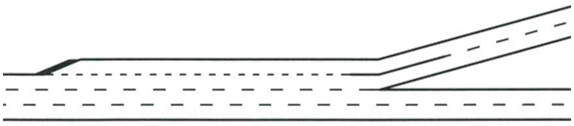
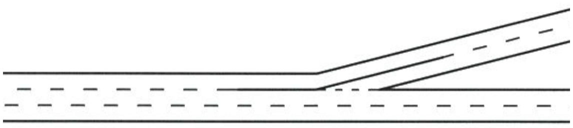
This layout is not preferred and may only be used for application at constrained sites. Motorway downstream volumes do not require the equal number of lanes as the approach.

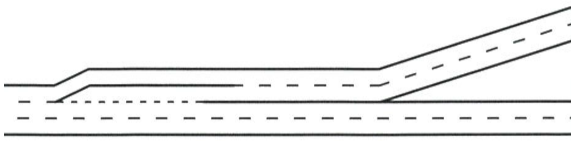
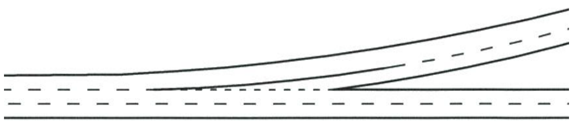
It is most typically located on motorways in inner urban areas or urban arterial roads where the structural design of bridges constrain the number of lanes downstream.

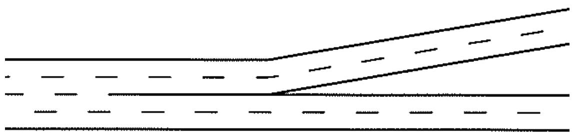
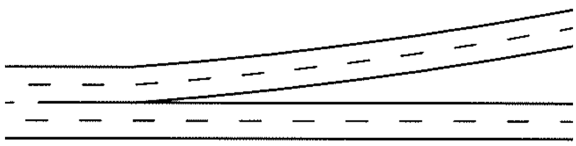
May be applied at sites where an auxiliary lane from a previous interchange is the trapped lane. The previous entry ramp should be close enough that the left lane operates as a weaving lane only and through traffic on the major road typically does not enter the lane.</td><td>Refer to Section 11.2.1 and Appendix D for applicable design guidance.</td></tr>
<tr><td>Ramp traffic volume – low to medium:
• Total ramp volume typically < 20% of the approaching traffic in the two left kerb lanes of the motorway, and
• Peak period ramp volume typically < 75% of ramp capacity ≈ LOS C (refer Austroads Guide to Traffic Management, Part 3: Transport Study and Analysis Methods).</td></tr>
<tr><td>Basic number of lanes – does not comply.

Lane balance – does not comply.</td></tr>
</table>

<table>
<tr><td colspan="2">Type 2 – Two-lane exit</td></tr>
<tr><td rowspan="3">2a(i) Two-lane exit

Service interchange – major / minor roads.
System interchange.
Preferred two-lane exit ramp configuration.</td><td>Refer to Section 11.2.2 for applicable design guidance.</td></tr>
<tr><td>Ramp traffic volume – medium:
Peak period ramp volume greater than 100% of ramp capacity for a single lane, and
The purpose of this arrangement is to provide a ramp capacity close to that of a single lane. Capacity traffic flow for a single lane ramp cannot typically be achieved with a single lane exit.</td></tr>
<tr><td>Basic number of lanes – complies.
Lane balance – complies.</td></tr>
<tr><td rowspan="3">2a(ii) Two-lane exit – lane drop after exit

Service interchange – major / minor roads.
System interchange.
This layout may be applied where the motorway volume downstream does not require the equal number of lanes as the approach. However, it is preferably only applied where existing physical constraints, such as structures, downstream of the exit prevent the use of layout 2a(i).</td><td>Refer to Sections 11.2.2 and 11.2.4 for applicable design guidance.</td></tr>
<tr><td>Ramp traffic volume – medium:
Peak period ramp volume greater than 100% of ramp capacity for a single lane, and
The purpose of this arrangement is to provide a ramp capacity close to that of a single lane. Capacity traffic flow for a single lane ramp cannot typically be achieved with a single lane exit.</td></tr>
<tr><td>Basic number of lanes – complies.
Lane balance – complies.</td></tr>
</table>

<table>
<tr><th colspan="2">Type 2 – Two-lane exit</th></tr>
<tr><td rowspan="3">2b Two-lane exit – trapped lane

Service interchange – major / minor roads.
System interchange.
This layout is not preferred and may only be used for application at constrained sites and where motorway downstream volumes do not require the equal number of lanes as the approach.
It is most typically located on motorways in inner urban areas or urban arterial roads where the structural design of bridges constrain the number of lanes downstream.
May be applied at sites where an auxiliary lane from a previous interchange is the trapped lane. The previous entry ramp should be located close enough that the left lane operates as a weaving lane only, and through traffic on the major road typically does not enter the lane.</td><td>Refer to Section 11.2.2 and Appendix D for applicable design guidance.</td></tr>
<tr><td>Ramp traffic volume – medium:
• Peak period ramp volume greater than 100% of ramp capacity for a single lane, and
• The purpose of this arrangement is to provide a ramp capacity close to, or just above that, of a single lane. Capacity traffic flow for a single lane ramp cannot typically be achieved with a single lane exit.</td></tr>
<tr><td>Basic number of lanes – does not comply.
Lane balance – complies.</td></tr>
<tr><td rowspan="3">2c Two-lane exit – trapped lane

Service interchange – major / minor roads.
System interchange.
This layout is not preferred and may only be used for application at constrained sites. It may be applied at sites where an auxiliary lane from a previous interchange is the trapped lane. The previous entry ramp should be located close enough that the left lane operates as a weaving lane only, and through traffic on the major road typically does not enter the lane.</td><td>Refer to Section 11.2.2 for applicable design guidance.</td></tr>
<tr><td>Ramp traffic volume – medium:
• Peak period ramp volume greater than 100% of ramp capacity for a single lane, and
• The purpose of this arrangement is to provide a ramp capacity close to, or just above that, of a single lane. Capacity traffic flow for a single lane ramp cannot typically be achieved with a single lane exit.</td></tr>
<tr><td>Basic number of lanes – does not comply.
Lane balance – complies if left lane is added at previous interchange. Otherwise, it does not comply.</td></tr>
</table>

Type 3 – Major exits	
3a Major exit to minor roads – ramp geometry	Refer to Section 11.2.2 for applicable design guidance.
	Exiting traffic volume – high: • Ramp exit carries > 30% of the total approaching traffic.
Service interchange – major / minor roads. System interchange. At system interchanges, this ramp arrangement is to be used where the ramp geometry does **NOT** allow for ramp operating speeds to be maintained within 10 km/h of the approach motorway operating speed.	Basic number of lanes – does not comply: trapped left lane. Lane balance – complies.
3b Exit to two major roads – major fork geometry	Refer to Section 11.2.3 for applicable design guidance.
	Diverging traffic volume – high: • Both diverging roads carry > 30% of the approaching traffic.
System interchange only. This ramp arrangement is to be used where the ramp geometry allows for operating speeds on the ramp to be maintained within 10 km/h of the approach motorway operating speed for the full length of the ramp.	Basic number of lanes – does not comply: trapped left lane. Lane balance – complies.

<table>
<tr><td colspan="2">Type 4 – Motorway splits</td></tr>
<tr><td rowspan="3">4a Exit to two major roads – Four lane approach with two lanes exit to each direction – ramp geometry

System interchange.
This arrangement is used where the ramp geometry does NOT allow for ramp operating speeds to be maintained within 10 km/h of the approach motorway operating speed.
This arrangement is only used in circumstances where the approach motorway volume requires four lanes. Extensive mitigation is required due to the presence of two trapped exit lanes. This will typically include overhead gantry signage.</td><td>Refer to Section 11.2.2 for applicable design guidance.</td></tr>
<tr><td>Exiting traffic volume – high: ramp exit carries > 30% of the total approaching traffic.</td></tr>
<tr><td>Basic number of lanes – does not comply: trapped left lanes.
Lane balance – does not comply.</td></tr>
<tr><td rowspan="3">4b Exit to two major roads – Four lane approach with two lanes exit to each direction – major fork geometry

System interchange.
This arrangement is used where the ramp geometry allows for ramp operating speeds to be maintained within 10 km/h of the approach motorway operating speed.
This arrangement is only used in circumstances where the approach motorway volume requires four lanes. Extensive mitigation is required due to the presence of two trapped exit lanes. This will typically include overhead gantry signage.</td><td>Refer to Section 11.2.3 for applicable design guidance.</td></tr>
<tr><td>Diverging traffic volume – high: both diverging roads carry > 30% of the approaching traffic.</td></tr>
<tr><td>Basic number of lanes – does not comply: trapped left lanes.
Lane balance – does not comply.</td></tr>
</table>

11.2 Exit ramps

11.2.1 Single-lane exits

<u>Differences</u>

The first sentence of the fourth paragraph is changed to be replaced with:

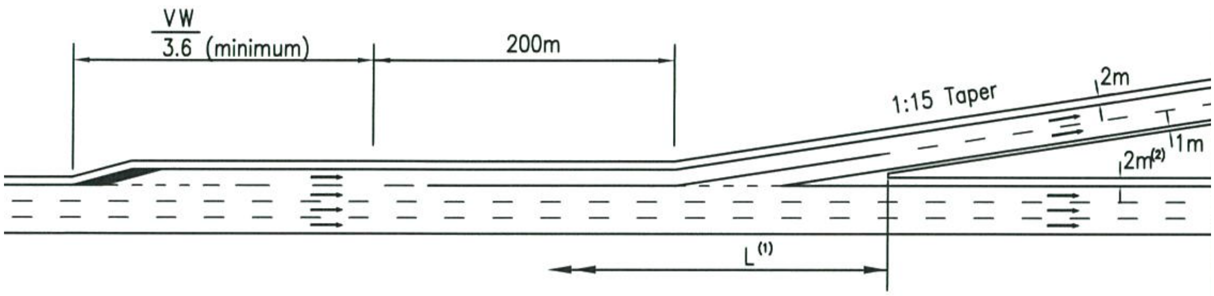
> The gore area of diverges and exits from high-speed roads should be traversable by vehicles for at least 120 m past the nose (i.e. where the pavements separate) (desirable maximum one-way slope of 1 on 10, absolute maximum one-way slope 1 on 6).

11.2.2 Two-lane exits

<u>Differences</u>

Figure 11.3 in Austroads *Guide to Road Design – Part 4C* is replaced with Figure 11.2(a). All references in Austroads *Guide to Road Design – Part 4C* to Figure 11.3 are to refer instead to Figure 11.2(a).

Figure 11.2(a) - Example of two-lane exit for a freeway or major divided road



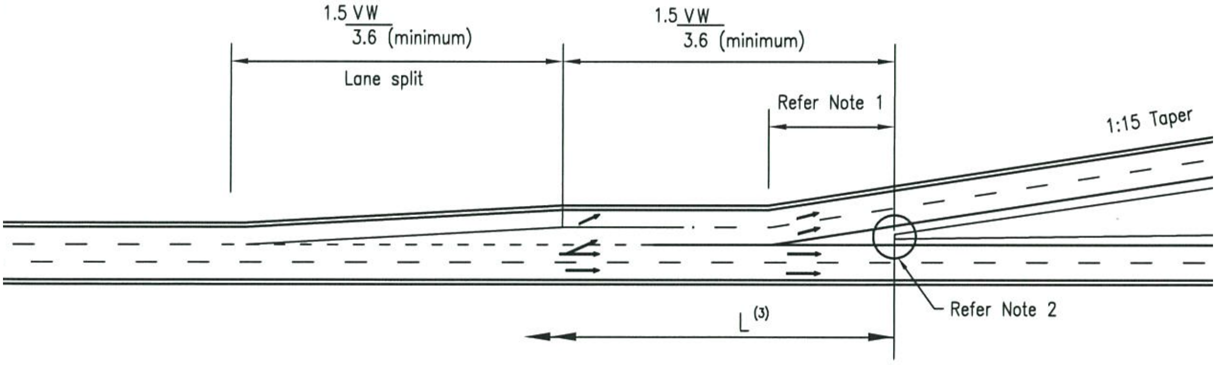
<u>Additions</u>

The gore area of diverges and exits from high-speed roads should be traversable by vehicles for at least 120 m past the nose (i.e. where the pavements separate) (desirable maximum one-way slope of 1 on 10, absolute maximum one-way slope 1 on 6).

Type 3a two-lane exit ramps (refer to Table 11.1) are required when a very high volume of traffic is exiting the motorway at a ramp. The key difference with other two-lane exit ramp types is the second approach lane from the left splits to either the exit at the ramp or continue along the motorway. The leftmost approach lane is an exclusive exit lane. This allows traffic in either of the two left lanes to exit without needing to change lanes.

Figure 11.2(b) shows a major exit from the motorway with a trapped left lane and the split occurring in the second leftmost lane. The dimensions shown represent the minimum dimensions for this exit ramp type. The length of the auxiliary lane can be extended, if desired, by introducing a parallel lane section between the end of the lane split and the start of the painted nose.

Figure 11.2(b) – Major exit type 3a



Notes:
1) Distance between nose of painted island and physical nose is approximately 63 m for the dimensions shown in Figure 11.1 of Austroads *Guide to Road Design – Part 4C*.
2) Refer to Detail B in Figure 11.1 of Austroads *Guide to Road Design – Part 4C*, and
3) L = Distance between the exit ramp and preceding entry ramp (refer to Austroads *Guide to Traffic Management – Part 6: Intersections, Interchanges and Crossings Management* (2020).

11.2.3 Exits to two high-speed roadways

Differences

All text in this section is replaced with the following:

Figure 11.4 in Austroads *Guide to Road Design – Part 4C* is replaced with Figure 11.2(c).

A different type of operation applies where traffic diverges to two high-speed roads that are of similar importance. In this case, either both roadways diverge tangentially from each other or one roadway diverges as a high-speed curve. This is referred to as a 'major fork' and differs to the arrangement where one roadway diverges at an angle as with a normal ramp. The intent of the geometric design of the exit is to convey the message to drivers that they are exiting to another major road.

A key design element for a major fork is that the central lane (or one of the central lanes, in the case of approaching roads with four or more lanes) must allow the traffic in that lane to choose either of the two diverging roads. At least two lanes continue to each of the diverging roadways.

Major forks as described in this section are only to be used when all of the following criteria are satisfied:

- the interchange is a motorway – motorway system interchange with both roads of equal importance
- both motorways have design speeds of 100 km/h or greater
- the split of traffic to each direction must be at least 30 / 70 (i.e. near equal with at least 30% of traffic on each exit), and
- the ramp design speed for both exits must be within 10 km/h of the operating speed of the approach road.

Figure 11.2(c) illustrates the principle of diverging two major roadways, where the layout and alignment is based on achieving a high standard of alignment for both high-speed movements.

Figures 11.2(c)(a) and 11.2(c)(b) show the practice most typically applied in Queensland where one of the diverging roads continues on a near straight alignment as a continuation of the approach road, and the alignment of the other diverging road is curved. The point of the gore is placed:

- in the case of the left diverging road being curved, Figure 11.2(c)(a), in direct alignment with left lane line of the lane to be split, and
- in the case of the right diverging road being curved, Figure 11.2(c)(b), in direct alignment with right lane line of the lane to be split.

The key design elements of these arrangements are as follows:

- the lane split length is to be achieved over the length calculated in the following equation:

  $$Length = \frac{1.5 \times V \times W}{3.6}$$

  where

  V = design speed of the major road approach (km/h)

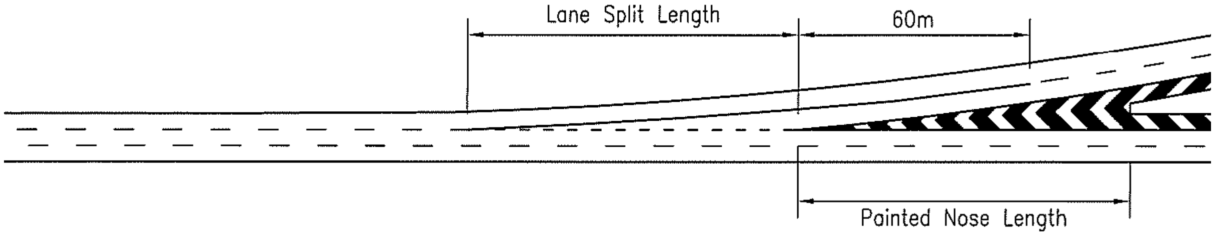
  W = lane width (typically 3.5 m).

  This equation results in a length of approximately 160 m for design speed of 110 km/h (posted speed of 100 km/h).

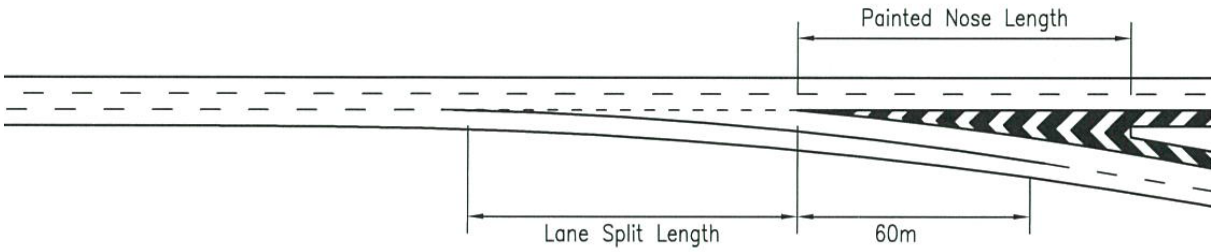
- The length of the painted gore to the nose between the two diverging roads is to be at least the same as the lane split length to allow for driver error. Shorter lengths do not make sufficient allowance for driver error, while longer lengths may encourage additional unsafe carriageway lane changes, and
- The lane line between the diverging outside lane and the lane being split shall be a continuous lane line for the full length of the lane split and should extend 60 m past the physical nose where lane changing movements are undesirable.

Figure 11.2(c)(c) shows an arrangement where both roads diverge tangentially. In this situation, the nose should be placed in direct alignment with the centre of the central lane to be split. A continuity line is to be marked extending from the nose on an alignment parallel to the lane line for the diverging road with the higher traffic volume. The pavement marking arrangement shown in Austroads *Guide to Road Design – Part 4C* is not to be applied as it results in an excessive area on the approach to the nose that does not provide sufficient driver guidance.

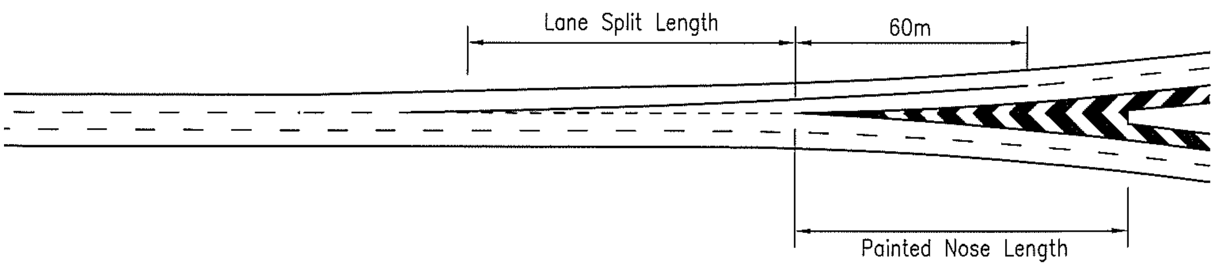
Figure 11.2(c) – Example of two-lane exit for a freeway or major divided road



(a) Left road diverge



(b) Right road diverge



(c) Both roads diverge

In all cases, sight distance to the physical nose is to be at least 440 m measured from an eye height of 1.1 m to zero object height.

The operating conditions at locations of major forks are different from those at other interchanges, and some stringent controls are required to ensure their safe operation. Austroads *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings Management* (2020) identifies a number of aspects important to the traffic operation of major forks.

11.2.4 Lane drop at an exit

Additions

The lane drop must be located on a uniform grade or in a sag and preferably on straight alignment so that drivers can see the full length of the taper.

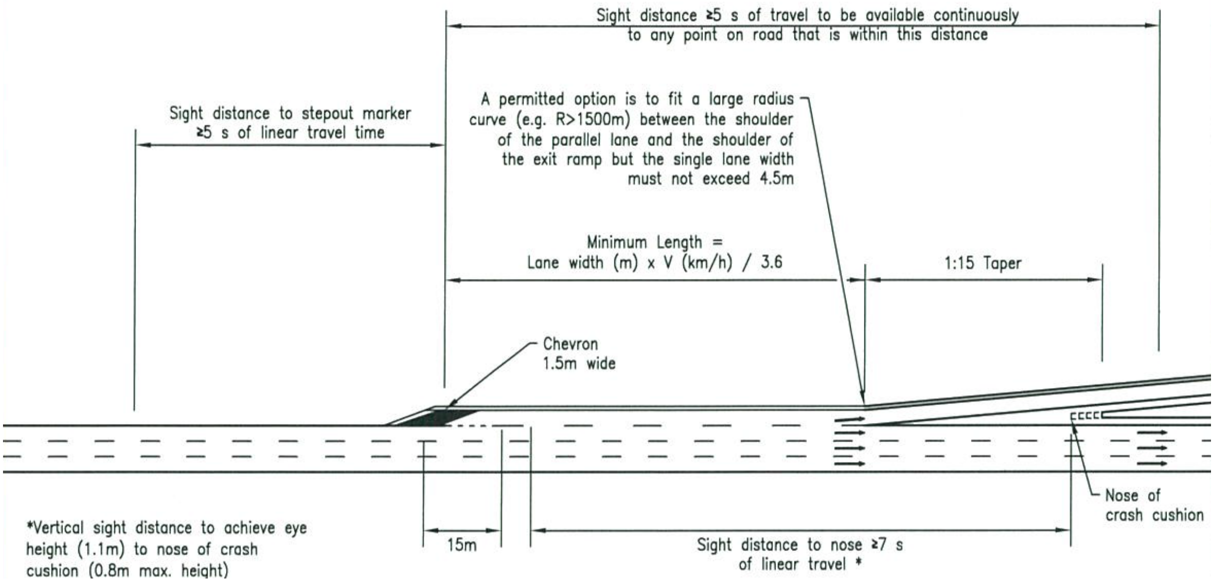
11.2.6 Exit from an arterial road

There is no equivalent Section 11.2.6 in Austroads *Guide to Road Design – Part 4C.*

New

Ramp exits from an arterial road can be used in place of at-grade intersections to provide a higher level of service and to maintain higher operating speeds on the arterial road. Figure 11.2(d) shows a typical single lane exit for a ramp exit from an arterial road.

Figure 11.2(d) – Example of exit from an arterial road



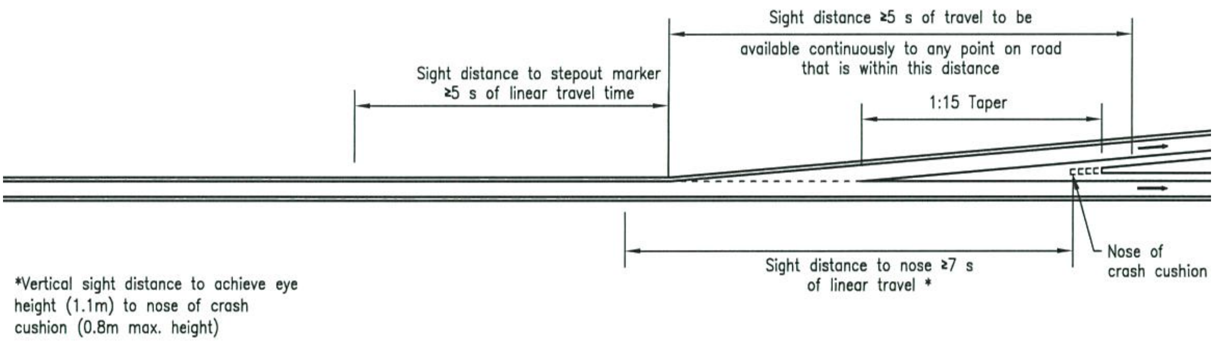
11.2.7 Exit from another ramp

There is no equivalent Section 11.2.7 in Austroads *Guide to Road Design – Part 4C*.

New

At some interchanges, it may be necessary for a single ramp exit to carry traffic to be split onto multiple ramps. In these cases, it will be necessary for a ramp exit on the ramp to be provided. Due to the generally lower operating speed on the ramp and higher level of driver awareness, the design requirements for the ramp exit from the ramp are not to the same level as a ramp exit from a motorway. Figure 11.2(e) shows a typical ramp exit from another ramp.

Figure 11.2(e) – Example of exit from a ramp



11.3 Entry ramps

11.3.2 Single-lane entry

<u>*Additions*</u>

The zip merge without the continuity line is not used for entry ramps to motorways in Queensland.

11.3.3 Entry with auxiliary lane

<u>*Differences*</u>

Delete the following part of the last sentence in the first paragraph in Austroads *Guide to Road Design – Part 4C:*

> "*in* Austroads *Guide to Road Design – Part 4A (*Austroads 2017c*) should be used to assess the length of ramp required for acceleration to the design speed of the through-road."*

Delete the reference to Table 11.2 in Austroads *Guide to Road Design – Part 4C* in the second paragraph and replace it with Table 4C-3 and 4C-4.

Replace '*Table 11.2: Acceleration Distance $D_{a'}$* and '*Table 11.3: Correction of acceleration distances as a result of grade'* in Austroads *Guide to Road Design – Part 4C* with Tables 11.3(a) and 11.3(b) respectively.

<u>*Additions*</u>

The design speed of the through-road for the purpose of calculating the acceleration distance for the entry ramp is usually made equal to the mean free speed of the through-road (which is often approximately equal to the speed limit).

Where very long entry lanes (> 1000 m) are required from the processes in this section, the entry lane is to be treated as an added lane which may become a climbing lane for slow moving vehicles. The end of the lane is to be treated as a lane drop at the appropriate location.

Table 11.3(a) – Acceleration distance Da

Design speed of through-road (km/h)	Acceleration Distance D_a (m) – for flat grade							
	Where design speed of curve A (km/h)							
	0	20	30	40	50	60	70	80
70	140	135	125	105	75	45	-	-
80	215	205	195	175	150	115	75	-
90	300	295	280	265	235	200	160	90
100	405	395	385	365	340	305	265	195
110	600	590	580	560	535	500	460	385
120	860	850	840	820	795	760	720	645

Notes:

1. This table applies to situations where a curve having a design speed less than the design speed of the through-road is provided prior to the ramp nose (refer to Section 11.3.3).
2. Where ramp traffic signals (refer to Section 11.4) are provided near the nose, the acceleration distance required (from a stopped condition) should be based on a design speed of Curve A of 0 km/h.
3. The design speed of the through-road for the purpose of calculating acceleration distance is usually made equal to the mean free speed (which is often approximately equal to the speed limit), and
4. D_a values shown in table are for level grade. Adjust for grade using Table 11.3(b). Flat grade is any ramp with a grade given by 1% downgrade ≤ grade ≤ 1% upgrade.

Table 11.3(b) – Correction of acceleration distances as a result of grade

Design speed of through-road (km/h)	Ratio of length on grade to length on level (Table 4C-1)															
	Where design speed of curve A (km/h)															
	1% < upgrade ≤ 3%								1% < downgrade ≤ 3%							
	0	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**0**	**20**	**30**	**40**	**50**	**60**	**70**	**80**
70	1.15	1.15	1.15	1.15	1.15	1.15	-	-	0.95	0.95	0.90	0.90	0.90	0.90	-	-
80	1.15	1.15	1.15	1.15	1.15	1.15	1.15	-	0.90	0.90	0.85	0.85	0.85	0.85	0.80	-
90	1.20	1.20	1.20	1.20	1.20	1.25	1.25	1.30	0.90	0.85	0.85	0.85	0.85	0.85	0.80	0.80
100	1.20	1.20	1.20	1.20	1.20	1.25	1.25	1.30	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.80
110	1.40	1.40	1.40	1.45	1.45	1.45	1.50	1.55	0.80	0.80	0.80	0.80	0.80	0.75	0.75	0.75
120(1)									0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	3% < upgrade ≤ 5%								3% < downgrade ≤ 5%							
70	1.25	1.25	1.30	1.30	1.30	1.30	-	-	0.90	0.85	0.85	0.80	0.80	0.80	-	-
80	1.35	1.40	1.40	1.45	1.45	1.50	1.60	-	0.80	0.80	0.75	0.75	0.75	0.75	0.65	-
90	1.45	1.45	1.50	1.50	1.55	1.60	1.70	1.70	0.80	0.75	0.75	0.75	0.75	0.75	0.70	0.70
100	1.55	1.55	1.55	1.60	1.60	1.65	1.70	1.70	0.75	0.75	0.75	0.75	0.75	0.70	0.70	0.70
110(1)									0.70	0.70	0.65	0.65	0.65	0.65	0.65	0.60
120(1)									0.65	0.65	0.60	0.60	0.60	0.60	0.60	0.55
	5% < upgrade ≤ 6%								5% < downgrade ≤ 6%							
70	1.45	1.45	1.45	1.50	1.55	1.55	-	-	0.80	0.80	0.80	0.80	0.80	0.80		
80	1.75	1.80	1.80	1.90	1.95	2.10	2.40	-	0.75	0.75	0.70	0.70	0.70	0.65	0.60	
90	2.00	2.00	2.10	2.10	2.20	2.35	2.55	2.55	0.70	0.70	0.70	0.70	0.65	0.65	0.60	0.60
100	2.15	2.20	2.20	2.25	2.30	2.40	2.55	2.55	0.70	0.70	0.70	0.65	0.65	0.65	0.60	0.60
110(1)									0.60	0.60	0.60	0.60	0.55	0.55	0.55	0.55
120(1)									0.55	0.55	0.55	0.50	0.50	0.50	0.50	0.50

Notes:

1. Empty cells at these speeds indicate that the modelled ramp is longer than 1 km in length. Ramps greater than 1 km in length are not supported and alternative ramp geometry should be selected.

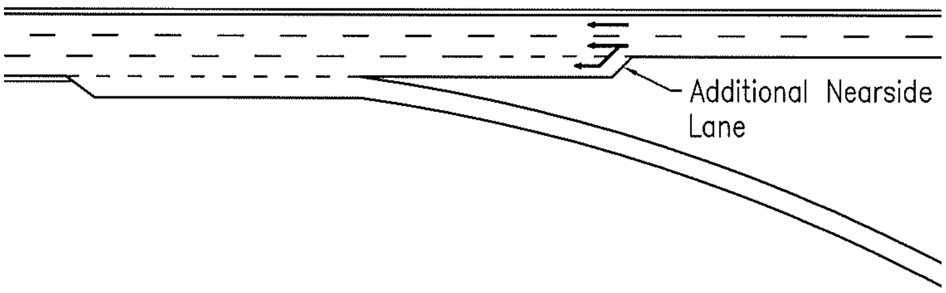
Additions

The values in Tables 11.3(a) and 11.3(b) have been generated from VEHSIM acceleration curves for a typical car. The VEHSIM curves are reproduced in Commentary 8.

In practice, the vertical profile of a ramp may consist of sections of varying grade due design issues such as the natural topography, tie in grades at the minor and major roads, or other constraints. In these situations, the overall length of ramp required can be established by determining the vehicle speed at the end of each section of grade moving along the ramp. Once the entry speed to the final section of grade which merges with the motorway is determined, the remaining length required for vehicles to meet the required design speed can be determined. A worked example on determining ramp lengths on compound grade ramps is included in Commentary 8.

It is not uncommon for the entry ramp to form an added lane at the entry merge. The arrangement where an additional nearside lane is created on the motorway mainline immediately prior to the entry ramp, as depicted in Figure 11.3(c), is not to be adopted.

Figure 11.3(c) – Entry arrangement NOT to be applied



11.3.4 Two-lane entry

<u>Differences</u>

Delete the reference to Table 11.2 in Austroads *Guide to Road Design – Part 4C* in the first paragraph and replace it with Table 11.3(a) and 11.3(b).

Delete the last sentence in the first paragraph in Austroads *Guide to Road Design – Part 4C:*

> *"*Austroads *Guide to Road Design – Part 4A (*Austroads 2017c*) should be used to assess the length of ramp required for acceleration to the design speed of the road".*

11.3.8 Entry to an arterial road

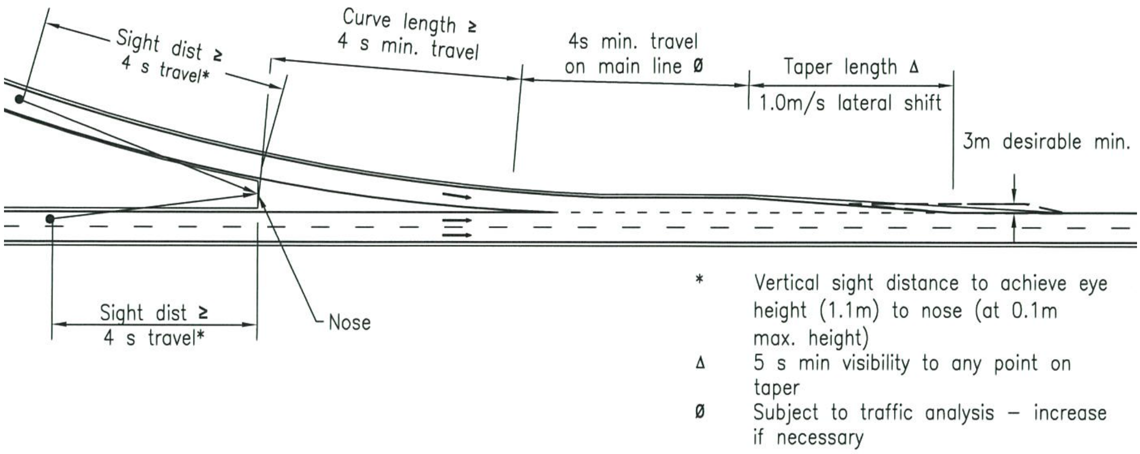
There is no equivalent Section 11.3.7 in Austroads *Guide to Road Design – Part 4C*.

<u>New</u>

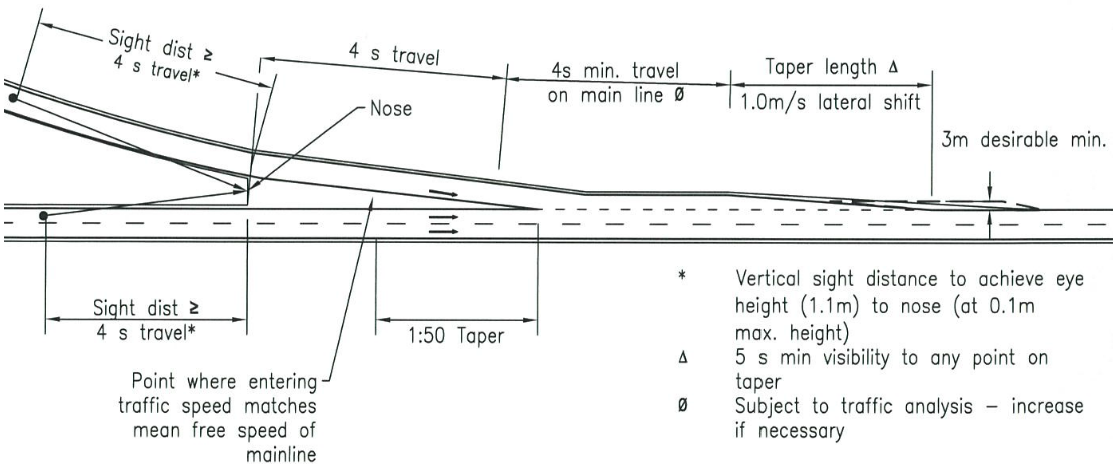
Ramp entries to an arterial road can be used in place of at-grade intersections to provide a higher level of service and to maintain higher operating speeds on the arterial road. Figure 11.3(d) shows options for a typical ramp entry to an arterial road.

Figure 11.3(d) - Entry to an arterial road

(a) Standard arrangement – where ramp design speed on entrance curve is less than mainline design speed.



(b) Tangential option permissible when entrance curve suitable for mainline design speed and ramp speed matches mainline design speed.



11.4 Ramp traffic signals

Differences

The guidance in Section 11.4 of Austroads *Guide to Road Design – Part 4C* is to be considered informative only. Guidance for application in Queensland is provided in the Transport and Main Roads *Design guidelines for the provision of managed motorway ramp signalling.* This can be found in Queensland *Guide to Traffic Management* Part 9: *Transport Control Systems - Strategies and Operations (2020)* (QGTM).

14 Cyclists

14.1 General

Additions

The policy position with respect to cyclists using freeways in Queensland is given in the Transport and Main Roads *Cycling Infrastructure Policy*.

In general, cycling will only be permitted on the shoulders of rural motorways and will not be permitted on the shoulders of new urban motorways. Any new motorway projects and upgrades should aim to achieve a high level of safety and service for cyclists.

In determining the suitability of the motorway for on-road cycling, detailed consideration should be given to the following factors at the interchanges:

- volume of motor vehicles using the ramps
- sight distances to cyclists crossing the ramps, and
- existence of multi-lane ramps.

The suitability of the motorway as an on-road cycle facility and general cross section details for accommodation of cyclists on motorway shoulders are considered in RPDM Volume 3, Part 3.

14.2 Treatment at interchanges

Additions

The principles to be applied in allowing cyclists to cross the motorway ramps as shown in Figure 14.1(a) in Austroads *Guide to Road Design – Part 4C* include:

- cyclists must have sufficient advance awareness that they must cross high-speed motor vehicle traffic, and
- motorists exiting or entering the motorway are expecting to merge / diverge smoothly without being interrupted by bicycle crossing facilities.

The facility for cyclists to cross the ramp must clearly communicate that all cyclists must give way to approaching traffic on the ramp and can do so safely.

In addition to the guidance in Austroads *Guide to Road Design – Part 4C* with regards to cyclist delays, if motor vehicle volumes do not exceed 800 vehicles per hour at any time during the day, the cyclist path through the interchange as shown in Figure 14.1(a) in Austroads *Guide to Road Design – Part 4C* is encouraged (refer Commentary 5).

Where cyclists are permitted to ride on the motorway shoulder on a marked cycle route, additional signage is necessary if the cycle route is marked. The signs at the interchange are required in accordance with the Queensland MUTCD:

- at entry and exit ramps, warning motorists that they might encounter cyclists crossing ramps
- at all interchanges to guide cyclists safely across the ramps or via an alternative route, and
- to advise cyclists of a requirement to leave the motorway (e.g. at 'squeeze points', such as narrow shoulder on bridges) or to cross a ramp.

14.2.3 Alternative routes

Additions

The alternative route should aim to provide cyclists with a facility of a similar standard to that of the motorway, and with minimum deviation or added distance.

15 Pavement markings, signs and lighting

15.1 General

Additions

Queensland MUTCD is the primary reference with regards to pavement markings and signs in Queensland.

15.3 Lighting of interchanges

Additions

Practitioners should refer to the Volume 6 – *Lighting* of this RPDM for information on lighting around interchanges.

16 Landscaping and street furniture

16.1 General

Additions

Practitioners should refer to the Transport and Main Roads *Road Landscape Manual* for information on landscaping around interchanges.

18 Grade separated intersections and movements

There is no equivalent Section 18 in Austroads *Guide to Road Design – Part 4C*.

New

18.1 Grade separated intersections

On roads other than motorways, grade separated intersections may be considered as an alternative to a full interchange. These intersection types are used more extensively in the UK and are referred to as “Compact grade separated junctions”. Grade separated intersections in Queensland are characterised by:

- Left in, left out treatments on the major road:
  - Left in treatment – Deceleration Lanes
    - The warrant for a left-turn deceleration lane AUL(S), AUL or CHL is determined in accordance with the warrants for turn treatments contained in RPDM Volume 3, Part 4A. It is expected in these cases that the minimum treatment will be an AUL(S).
    - Where an AUL / CHL treatment is provided, the length of the deceleration lane is to be designed in accordance with RPDM Volume 3, Part 4A.
  - Left out treatment
    - The need for an acceleration lane is to be determined based on a capacity and delay assessment for the movement, sight distance and other sight constraints.
    - The left-turn treatment and any associated acceleration lanes are to be designed in accordance with RPDM Volume 3, Part 4A, and
    - Where acceleration lanes are appropriate for this type of interchange, the length and cost will generally be significantly less than that associated with a conventional ramp.

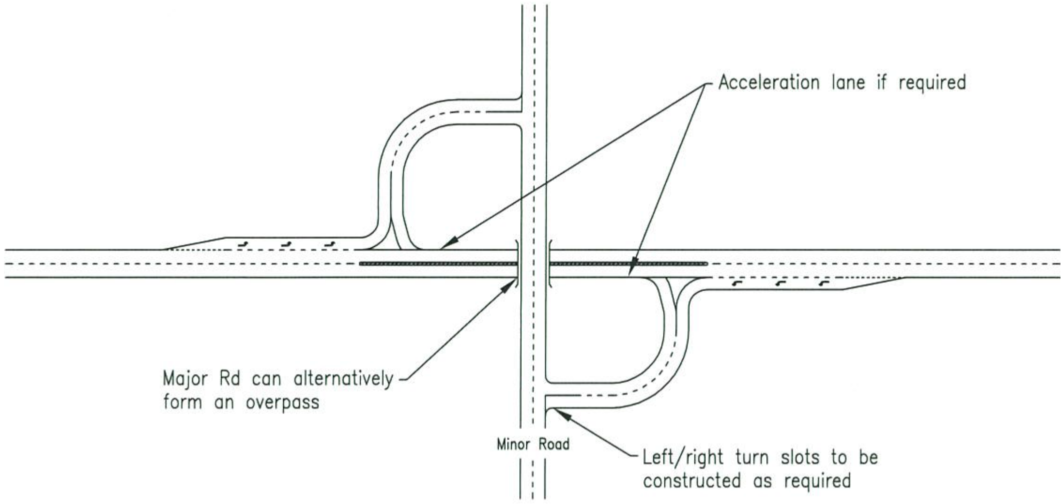
- No right-turns or through movements across the major road at grade. These are restricted by physical measures such as median barrier, and
- Possibility to upgrade to dual carriageway on the major road or full interchange in the future. The intersections on the major and the minor roads and the interconnecting road should be designed considering the location of any dual carriageway upgrade and/or ultimate ramps as part of a full interchange upgrade.

The advantage of grade separated intersections is that they provide most of the safety benefits from grade separation without full entry and exit ramps. There is also an increased flexibility at grade separated intersections to vary the quadrants of the intersection where the connecting roads are based to avoid high cost constraints. This reduces the cost and land requirement.

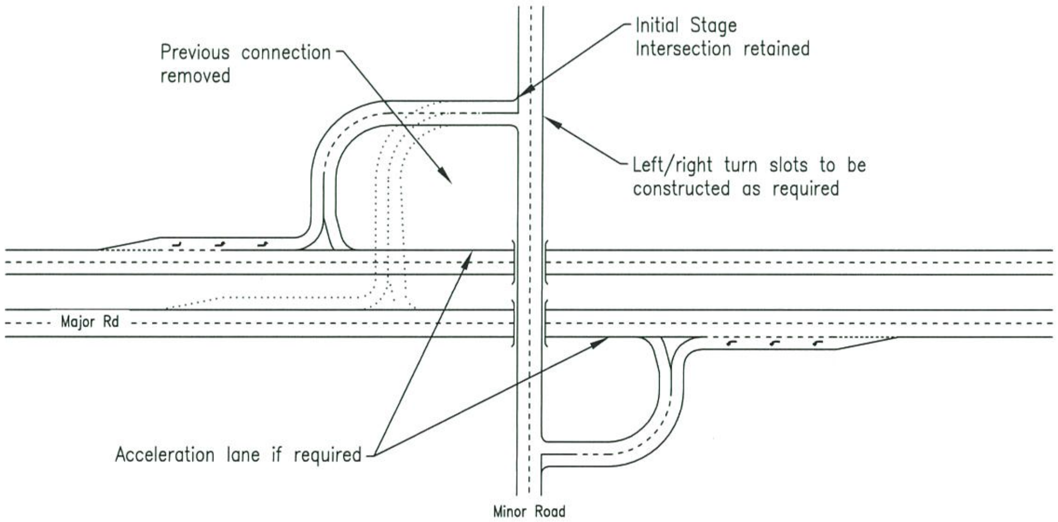
Grade separated intersections may be considered for high-speed rural intersections with high crash rates where other intersection types are not appropriate. Grade separated intersections can also be used in urban areas. Motorways will still require full interchange design.

Examples of grade separated intersections are shown in Figures 18.1(a) to 18.1(c), illustrating the conceptual layouts for cross intersections and T junctions, and in Figure 18.1(d), showing existing examples of grade separated intersections.

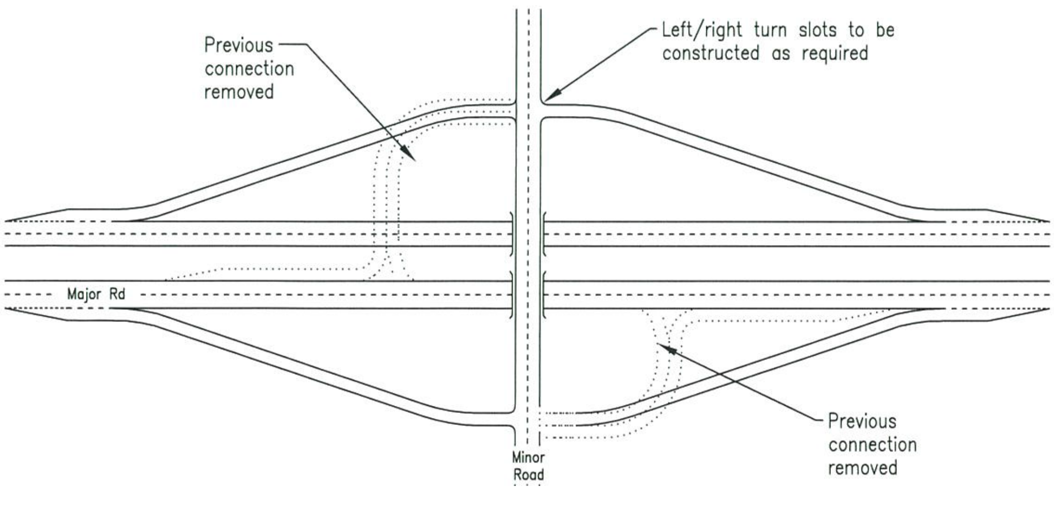
Figure 18.1(a) – Grade separated cross intersection



(a) Initial Stage

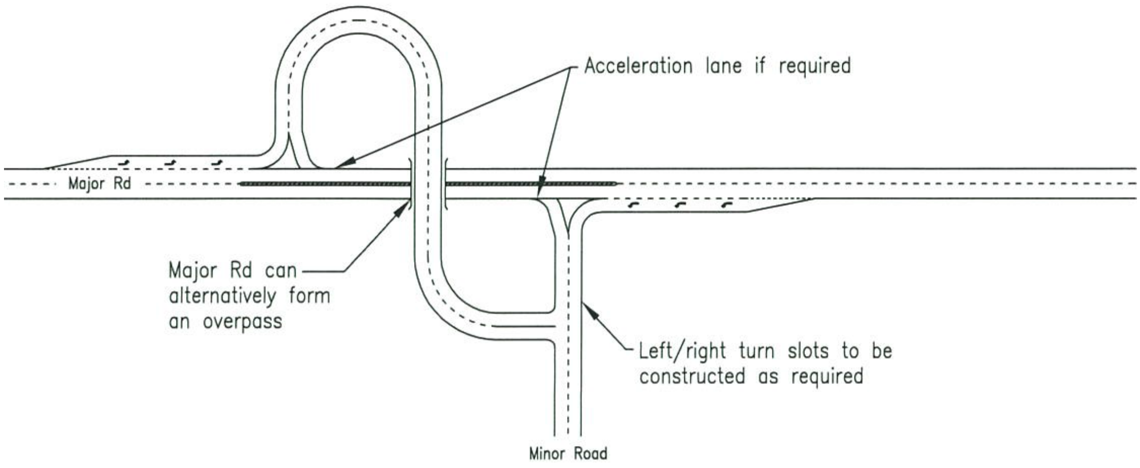


(b) Stage 2 Option A – upgrade to dual carriageway with grade separated intersection

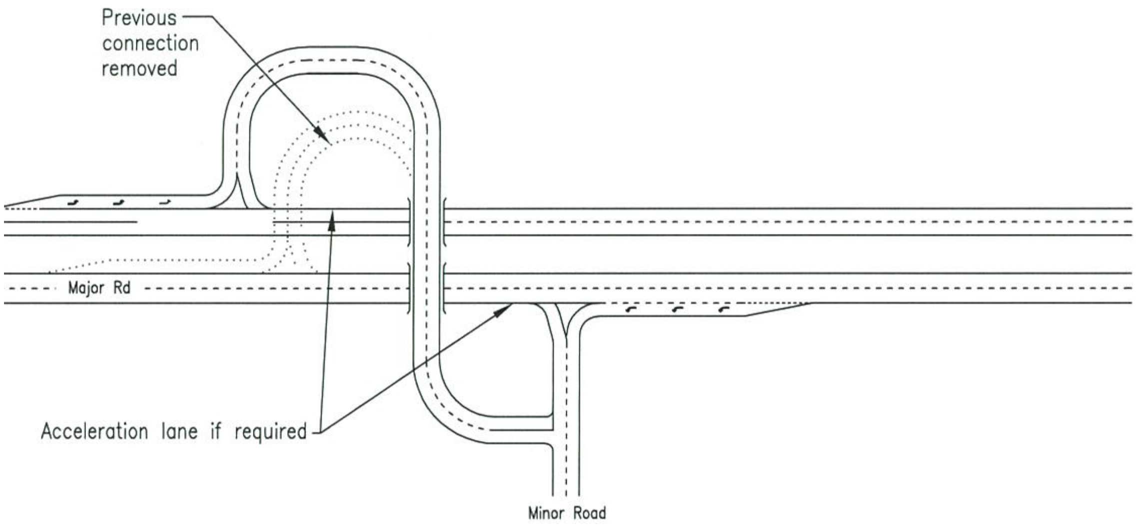


(c) Stage 2 Option B – upgrade to full interchange

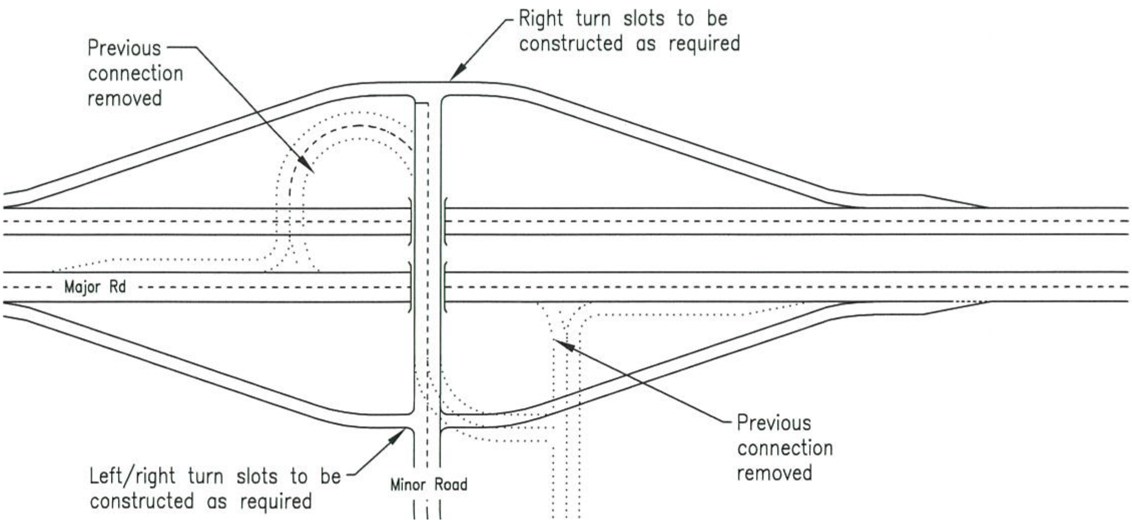
Figure 18.1(b) – Grade separated T-junction – Example 1



(a) Initial Stage

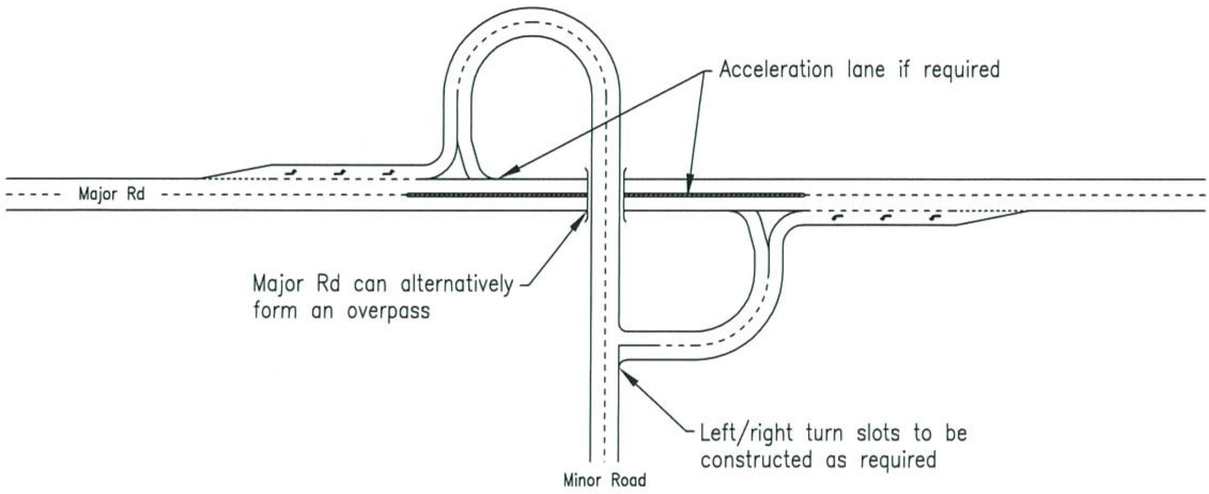


(b) Stage 2 Option A – upgrade to dual carriageway with grade separated intersection

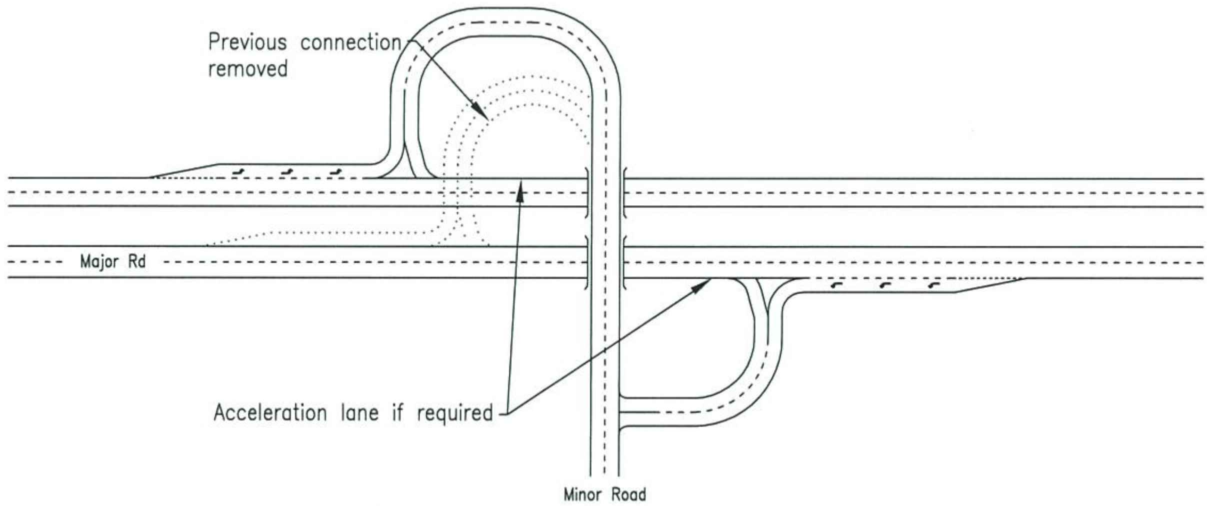


(c) Stage 2 Option B – upgrade to full interchange

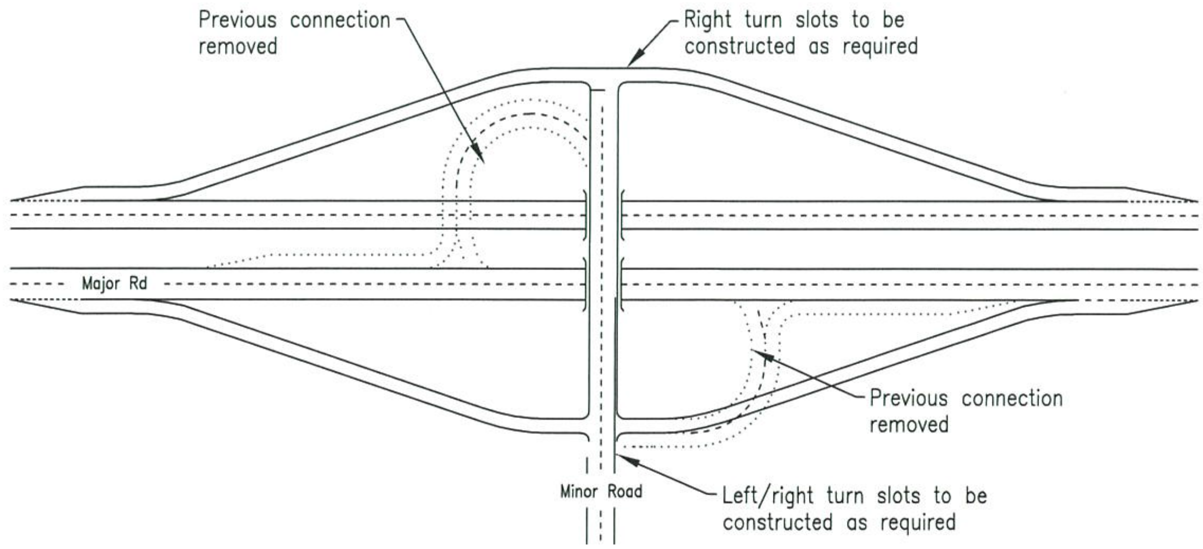
Figure 18.1(c) – Grade separated T-junction – Example 2



(a) Initial Stage



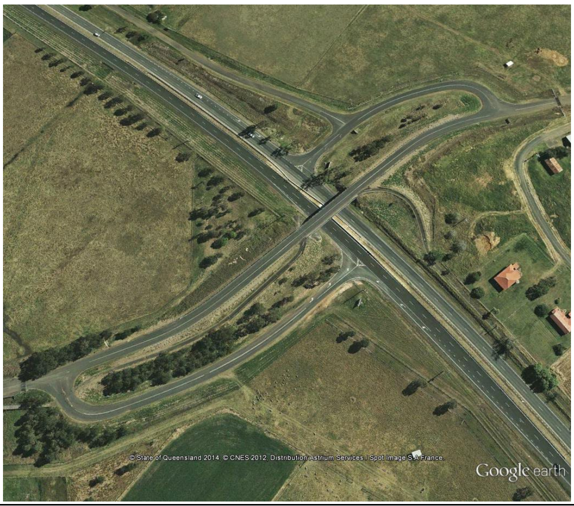
(b) Stage 2 Option A – upgrade to dual carriageway with grade separated intersection



(c) Stage 2 Option B – upgrade to full interchange

Figure 18.1(d) – Grade separated cross intersection examples on the network

(a) Warrego Highway – Gatton Outer Ring Road



b) Kiel Mountain Road-Nambour Connection Road

18.2 Grade separated movements

When at-grade intersections are near capacity, it may not always be economically practicable to further widen the intersection or to grade separate the entire intersection. A capacity analysis may reveal that removing a single movement, typically a right-turn or through movement, through provision of a single movement ramp, can provide a substantial extension to the design life of the existing at-grade intersection. In some cases, intersections have had a second movement subsequently grade separated.

Grade separated right-turn ramps can also be used where an additional intersection accommodating right-turns is impracticable or undesirable. This may be due to proximity to other intersections or a desire not to introduce additional right-turn conflicts on a major road. In these cases, the right-turn ramp can allow for right-turn movements to be accommodated at an otherwise left-in, left-out intersection.

At these intersections, the grade separated right-turn ramps can be a direct, semi-direct A or semi-direct B ramp. Other ramp types, such as a loop or semi-direct C, are typically not economical. The semi-direct A or direct ramp are acceptable for right-turn movements only where the ramp is provided with its own dedicated lane on joining the exiting road.

The ramp diverge can be designed as a minimum treatment single lane exit.

- Length of diverge to be based on:
  - Diverge Length $L = V\,W/3.6$, or
  - Meeting the deceleration length requirements based on design speed of any curves on the ramp.
- Location of the physical nose is to be based on the provision of at least seven seconds of visibility to the nose. The physical nose will require appropriate crash attenuation devices where a barrier is required in the nose due to the grade separation of the movements. An object height of 0.8 m is to be applied to crash cushions.

Ramps for through movements can be a flyover or underpass. Examples of grade separated movements are shown in Figure 18.1(e).

Figure 18.1(e) – Grade separated movement examples on the network

(a) Bundaberg Ring Road – Fe Walker Street

(b) Coronation Drive – Hale Street

(c) Frederick Street – Milton Road

(d) Moggill Road – Musgrave Road

References

Transport and Main Roads publication references refer to the latest published document on the departmental website (www.tmr.qld.gov.au).

Additions

Austroads (2023) *Guide to Road Design Part 4C, Interchanges*, Austroads, Sydney, NSW

Austroads (2020) *Guide to Traffic Management Part 3, Transport Study and Analysis Methods,* Austroads, Sydney, NSW

Austroads (2020) *Guide to Traffic Management Part 6, Intersections, Interchanges and Crossings Management*, Austroads, Sydney, NSW

Transport and Main Roads *Cycling Infrastructure Policy*, Brisbane, QLD

Transport and Main Roads *Road Landscape Manual*, Brisbane, QLD

Transport and Main Roads *Road Planning and Design Manual* (RPDM), Brisbane, QLD

Transport and Main Roads Queensland *Manual of Uniform Traffic Control Devices* (MUTCD), Brisbane, QLD

Transport and Main Roads *Traffic and Road Use Management Manual* (TRUM), Brisbane QLD

Appendix C – Examples of ramp signal layouts

Additions

Additional guidance for Motorway Ramp Signalling can be found in Queensland *Guide to Traffic Management* Part 9: *Transport Control Systems - Strategies and Operations (2020)* (QGTM).

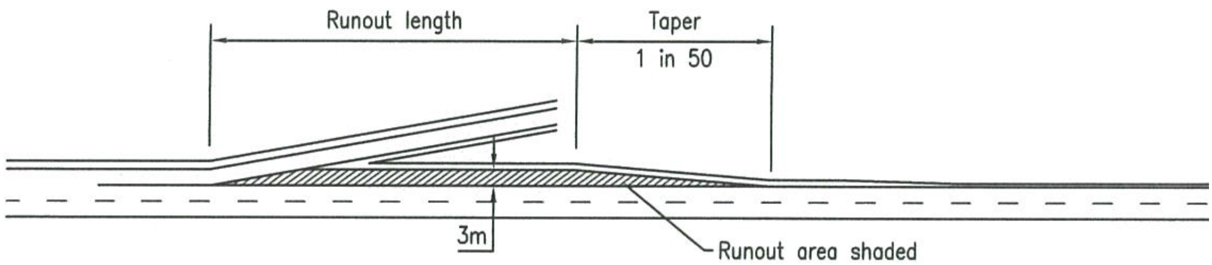
Appendix D – Trapped lane exit – EDD treatment

There is no equivalent Appendix D in Austroads *Guide to Road Design – Part 4C*.

New

Specialists in VicRoads have re-line marked a small number of existing lane drops past the exit to trapped lane exits or 'Exclusive lane exits', using their terminology. This is based on information that a trapped lane exit has a higher capacity than the exit where the lane drop occurs after the exit. There is anecdotal evidence that safety is not compromised. Therefore, when a lane drop after an exit is identified as a critical bottleneck, it has been converted to a trapped lane exit as shown in Figure D.1.

Figure D.1 – Trapped lane exit



In these situations, a generous run-out area should be provided. The runout length should be 180 m minimum in length with the runout area similar to a pavement area for a lane drop as per Figure 11.5 in Austroads *Guide to Road Design – Part 4C*. Further signage and line marking is required before the exit to ensure that the trapped lane layout is very obvious to drivers.

Designers in Queensland may consider an EDD design based on this experience at critical bottlenecks. Specialist advice should be sought.

Commentary 5

Additions

The 1989 study on 'Urban Freeway Cycling' estimated that a cyclist requires a gap of seven seconds in order to cross the ramp safely. It states that a maximum average delay of 15 seconds for cyclists is appropriate. This corresponds to a random traffic flow of 1000 vph, however, traffic counts for peak hours are an average, and volumes are higher at various times during the middle of this peak period. Consequently, an hourly peak traffic flow of 800 vehicles per hour is more appropriate to allow for peak flows of 1000 vph in any part of the hour.

Commentary 6

There is no equivalent Commentary 6 in Austroads *Guide to Road Design – Part 4C*.

New

Determining the speed profile on deceleration ramps

This commentary can be used to determine the deceleration profile for an average and 85th percentile driver.

Speed profile for an average driver

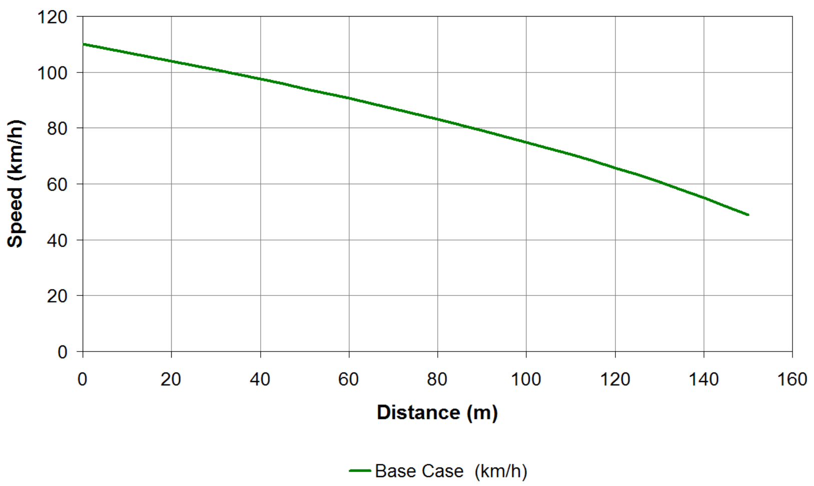
Deceleration rates on exit ramps are modelled using a constant rate of deceleration, as shown in Figure 1, for an average driver. The speed profile is modelled by using the following equation of motion (Equation 1).

Equation 1: $v^2 = u^2 + 2a_{accel}s$

Where:

- v = final speed (m/s), u = initial speed m/s
- a_{accel} = acceleration (m/s/s) (negative for deceleration). The deceleration rate of an average driver can be taken as -2.5 m/s/s. Note that this variable is normally represented as 'a', however, a subscript has been added to differentiate it from the grade variable.
- s = distance (m)

Figure C6(a) – Average driver deceleration at constant deceleration rate



Grade correction can be achieved by modifying Equation 1, by using the following relationship. This underlying principle of the relationship presented in Equation 2 is that the deceleration rate and impact of grade is represented as a proportion of acceleration due to gravity.

Equation 2: $a_{accel} = -9.81(d + 0.01a)$

Where:

- 9.81 = acceleration due to gravity (m/s^2).
- d = deceleration coefficient (positive for deceleration) The deceleration coefficient for an average driver is 0.25.
- a = grade of the ramp (%); negative for downgrades, positive for upgrades.

Substituting Equation 2 into Equation 1, and making adjustments to convert the speeds into km/h, gives:

Equation 3: $$V^2 = \sqrt{U^2 - 254s(d + 0.01a)}$$

Where:

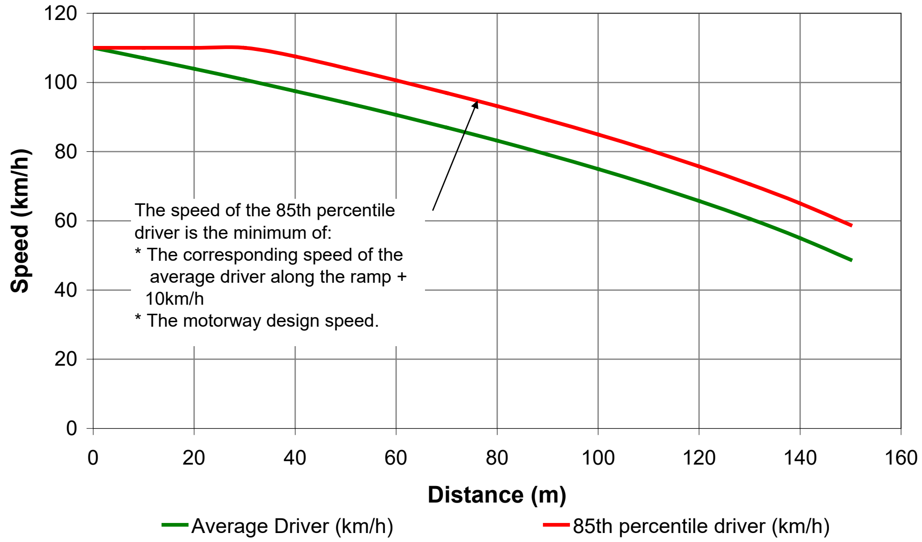
- V = final speed (km/h), U = initial speed (km/h).

Speed profile for an 85th percentile driver

The speed profile of the 85th percentile driver is determined by finding the minimum value of:

- the corresponding speed of the average driver along the ramp plus 10 km/h, and
- the motorway design speed.

Figure C6(a) – Speed profile of the 85th percentile driver



Commentary 7

There is no equivalent Commentary 7 in Austroads *Guide to Road Design – Part 4C*.

<u>*New*</u>

This commentary item aims to find a stopping sight distance equation which accounts for the fact that a driver is already decelerating on a deceleration ramp.

Before applying this equation, a designer must firstly establish the speed profile of an average and 85th percentile driver for normal exit ramp deceleration (refer to Commentary 6).

After this, the designer is required to check sight distance to a hazard that might appear along the ramp. A designer may choose to use the conventional Stopping Sight Distance (SSD) equation (refer to Equation 4). For constrained cases, this commentary shows the derivation of an alternative SSD equation which may be used during deceleration (refer to Figure C7).

It is necessary to ensure that a driver travelling at the average speed has sight distance to a 0.2 m object. As a check, it is also necessary to ensure that a driver travelling at the 85th percentile speed has sight distance to a 0.8 m object.

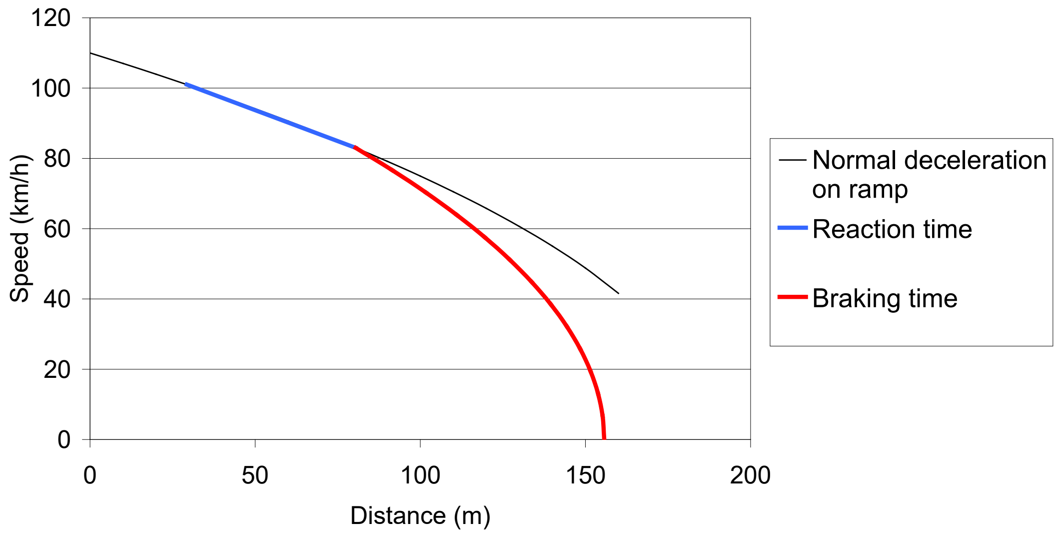
SSD = distance travelled during reaction time + distance travelled during braking.

$$SSD = \frac{R_T V}{3.6} + \frac{V^2}{254(d + 0.01a)}$$

Where:

- R_T = Reaction time (sec)
- V = Operating speed (km/h)
- d = coefficient of deceleration (longitudinal friction factor)
- a = longitudinal grade (%, + for upgrades & - for downgrades)

Figure C7 – Example speed profile on a deceleration ramp when vehicle stops for a hazard



Notes:

1. In this example, the normal deceleration on the ramp assumes that vehicles must decelerate from a mainline design speed of 110 km/h to a curve A speed of 44 km/h. Deceleration is constant and typically at a comfortable deceleration rate of -2.5 m/s².
2. A hazard appears at a distance of approximately 30 m. Then a perception reaction time passes, while still continuing at the comfortable deceleration rate. Once the perception reaction time passes, the driver will begin to decelerate.

Derivation

Firstly, isolate the reaction part of the equation:

- Prior to seeing an object on the road, drivers will be decelerating at a constant comfortable deceleration rate (typically 2.5 m/s²). Once the hazard appears on the road, drivers will need time to perceive and react. During this reaction time, drivers will continue to decelerate at their comfortable deceleration rate (again typically 2.5 m/s²).
- The speed at the beginning of the reaction time is V_1.
- The speed at the end of the reaction time (and beginning of braking time) is V_2.
- Since the deceleration is constant, the average of V1 and V_2 may be taken as the speed during the reaction time.
- In the above equation (Equation 4), substitute for the average, $V = \frac{V_1 + V_2}{2}$ in the reaction time part of the equation:

$$SSD = \frac{R_T \times 0.5(V_1 + V_2)}{3.6} + \text{Distance travelled during braking}$$

Now isolate the braking part of the equation:

- According to our definitions from above, braking begins at a speed of V_2 – giving the following equation

$$SSD = \text{Distance travelled during reaction time} + \frac{V_2^{\,2}}{254(d + 0.01a)}$$

Now consider the entire equation together:

$$SSD = \frac{R_T \times 0.5(V_1 + V_2)}{3.6} + \frac{V_2^{\,2}}{254(d + 0.01a)}$$

- Derived from the following equation of motion ($v = u + a_{accel}t$), where “a” is acceleration (negative for deceleration). Note a subscript has been added to the acceleration variable to differentiate it from the grade variable.

$$\tfrac{V_2}{3.6} = \tfrac{V_1}{3.6} + a_{accel}R_T$$

$$V_2 = V_1 + 3.6 \times a_{accel}R_T$$

- Now substitute V2 from the previous equation and simplify to give Equation 5:

$$SSD = \frac{R_T \times 0.5(V_1 + V_1 + 3.6 \times a_{accel}R_T)}{3.6} + \frac{(V_1 + 3.6 \times a_{accel}R_T)^2}{254(d + 0.01a)}$$

Equation 5:

$$SSD = \frac{R_T V_1}{3.6} + 0.5 a_{accel} R_T{}^2 + \frac{\left(V_1 + 3.6 \times a_{accel} R_T\right)^2}{254(d + 0.01a)}$$

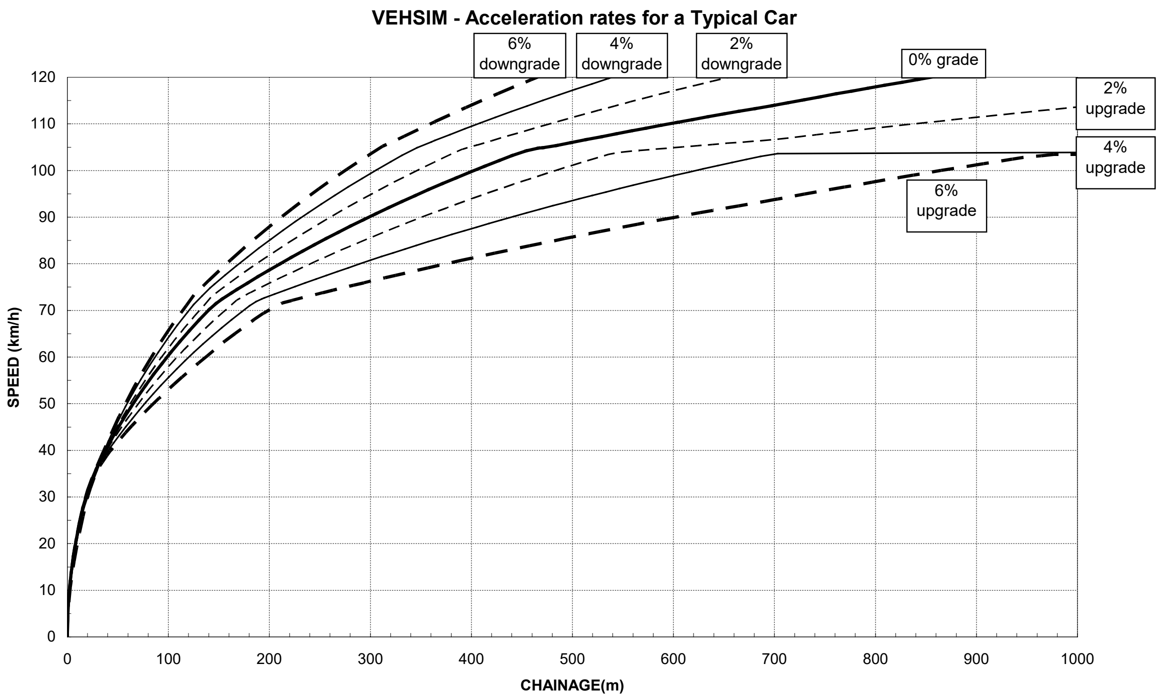
Commentary 8

There is no equivalent Commentary 8 in Austroads *Guide to Road Design – Part 4C*.

New

The tables for determining the acceleration length required on motorway entry ramps are based on the results from VEHSIM modelling for a typical car. The output acceleration profiles from this modelling are shown graphically in Figure C8(a).

Figure C8(a) – VEHSIM acceleration speed profiles on an on-ramp



The curves shown in Figure C8(a) can be used to determine acceleration lengths for ramps with characteristics not covered by the Tables in Section 11.3.3.

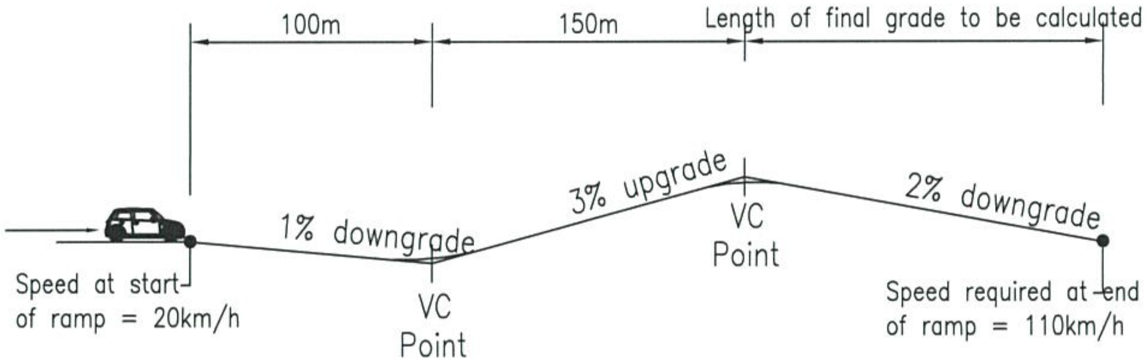
These curves can also be used to determine the acceleration profile on ramps with compound grades (i.e. ramps consisting of sections of varying grade). These are determined by tracking the acceleration profile along each grade curve for the length of each section of grade as demonstrated in the following example.

Example calculation for a ramp with multiple grades

In this example, the features of the ramp entry to a motorway are as follows and as shown in Figure C8(b):

- Entry curve at the start of the ramp restricts traffic speeds to 20 km/h.
- Immediately following the curve, the ramp is a 1% downgrade for a length of 100 m. The ramp then continues as a 3% upgrade for a length of 150 m and finishes as a 2% downgrade to merge with the motorway.
- The design speed at the merge with the motorway is 110 km/h.

Figure C8(b) – Example ramp with multiple grades

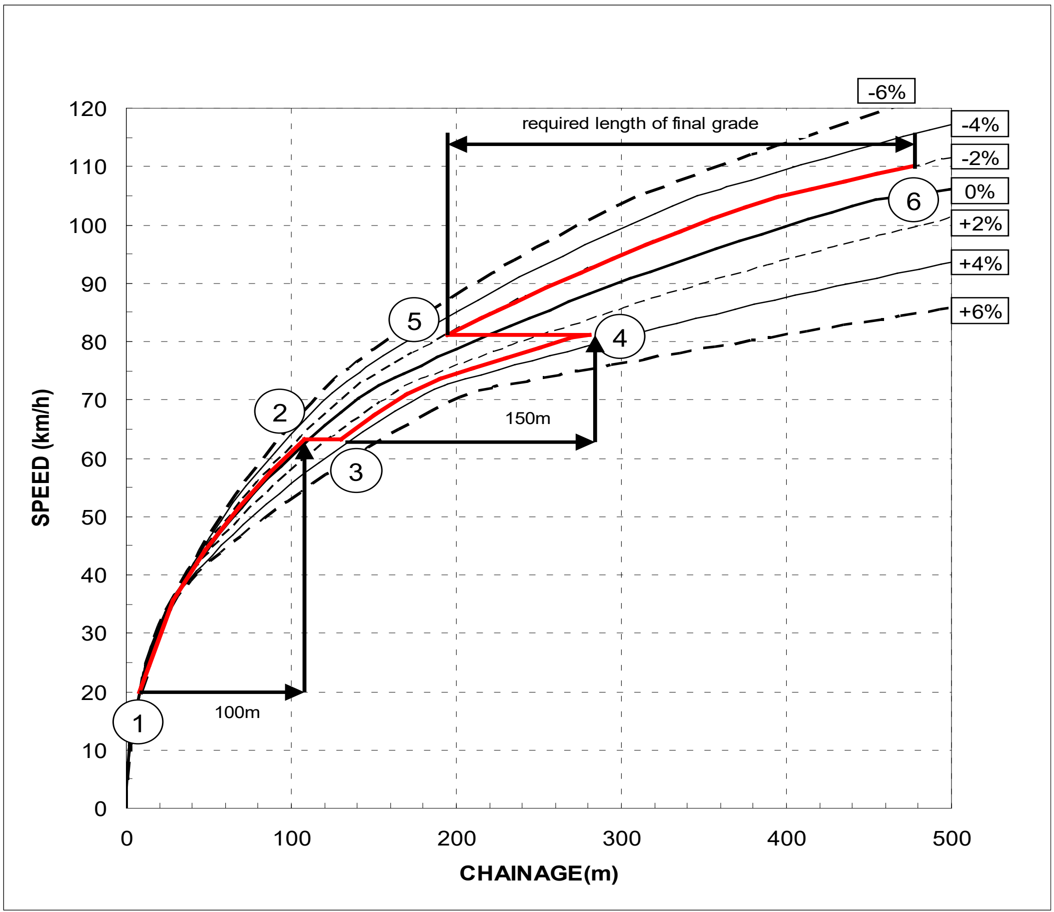


The process to determine the required length of the entry ramp is as follows. Each point in the table below refers to the circled number on Figure C8(c).

Table C8 - Using the VEHSIM acceleration curves to establish ramp lengths for ramps with compound grades

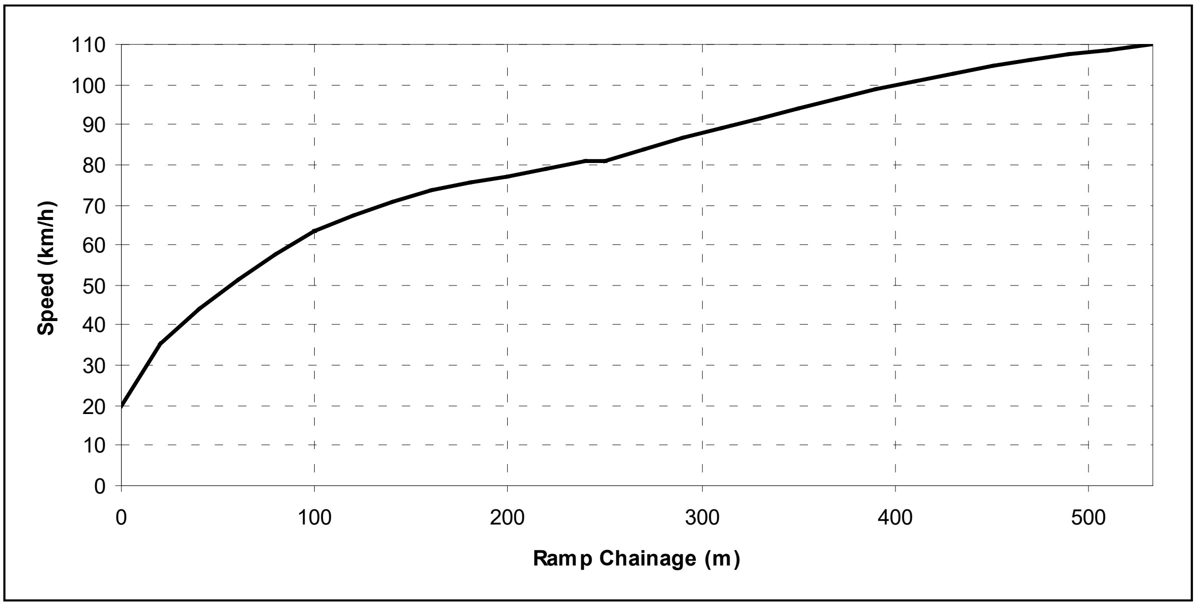
Point	Input	Calculation / comment
1	Entry speed at the start of grade 1 = 20 km/h	Identify the chainage at 20 km/h on 1% downgrade line = 8 m.
2	The length of grade 1 = 100 m	Chainage at end of grade 1 on 1% downgrade line = 8 m + 100 m = 108 m. Find the speed at chainage 108 m on the 1% downgrade line = 63 km/h.
3	Entry speed at the start of grade 2 = 63 km/h	Find the chainage at 63 km/h on 3% upgrade line = 130 m.
4	The length of grade 2 = 150 m	Chainage at end of grade 2 on 3% upgrade line = 130 m + 150 m = 280 m. Find the speed at chainage 280 m on the 3% upgrade line = 81 km/h.
5	Entry speed at the start of grade 3 = 81 km/h	Find the chainage at 81 km/h on 2% downgrade line = 195 m.
6	Design speed required at end of grade 3 = 110 km/h	Find the chainage where 3% downgrade line crosses 110 km/h speed = 477 m. Length of grade 3 = 477 m – 195 m = 282 m.

Figure C8(c) – using the VEHSIM acceleration curves to establish ramp lengths for ramps with compound grades



The results of this analysis indicate that the final section of the ramp should be at least 282 m in length to ensure that vehicles on the ramp can enter the motorway at the design speed of 110 km/h. The speed profile along the ramp is shown in Figure C8(d).

Figure C8(d) – Vehicle speed profile



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