Design Manual for Roads and Bridges

Road Layout
Design

CD 192
The design of crossovers and changeovers

(formerly TA 92/03)

Revision 1

Summary
This document contains the requirements for the design of crossovers and changeovers.

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

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

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
1	Jan 2020	Revision 1 (January 2020) update to references only. Revision 0 (September 2019) CD 192 replaces TA 92/03. This full document has been re-written to make it compliant with the new Highways England drafting rules.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes TA 92/03 which is withdrawn.

Contractual and legal considerations

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

Introduction

Background

The design of temporary traffic management differs from the design of permanent features. While requirements and advice documents (RADs) relating to the latter identify an end requirement which needs to be met, aspects relating to temporary traffic management identify aspects which need to be considered within the scheme specific risk assessment along with an indication of what is considered reasonably practicable on the majority of the UK network.

TSM Chapter 8 [Ref 4.N] includes basic requirements for changeovers and crossovers design; however, feedback from designers and contractors has highlighted the need for additional advice to provide consistency in the design and layout of crossovers on dual carriageway all-purpose roads and motorways. The application of the recommended design rules should ensure appropriate locations, and satisfactory horizontal and vertical design. A requirement of TSM Chapter 8 [Ref 4.N] is that crossover location, and more particularly crossover length, is not to be dictated by using an existing central reserve gap that is too short for the design speed. A well-designed crossover will minimise vehicle braking and queuing, therefore reducing the risk of nose-to-tail accidents upstream.

The current drafting rules for RADs require the removal of information and advice not related to a requirement. This has led to the omission of advice currently in TA 92/03. Until this can be incorporated into other documents, such as TSM Chapter 8 [Ref 4.N], TA 92/03 will be available in the DMRB archive.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 3.N] apply to this document.

Abbreviations

Abbreviations

Abbreviation	Definition
ALARP	As Low as Reasonably Practicable
CDM	Construction (Design and Management)
RAD	Requirements and Advice Document
SSD	Stopping Sight Distance
TSM	Traffic Signs Manual
TTM	Temporary Traffic Management

Terms and definitions

Terms

Term	Definition
Bend	A horizontal radius in the existing road alignment.
Changeover	A change of lanes introduced to divert traffic within an existing carriageway, including the hard shoulder. A changeover is normally associated with temporary works where one or more lanes are closed. NOTE: Changeover may occur after the traffic has been merged into fewer lanes than the permanent situation.
Crossover	Where one or more lanes on a dual carriageway or motorway are diverted onto the opposing carriageway. This is normally where a contraflow situation is required to carry out works on the primary carriageway. NOTE 1: Crossover length is shown in Figure A.1. NOTE 2: A second crossover is needed to return to the primary carriageway. Crossover site is the paved area within the central reserve used as part of the crossover.
Curve	The crossover "S" shape.
Entry curve	The first curve of the "S" shape.
Exit curve	The second curve of the "S" shape.
Non-assisting	Superelevation that assists traffic in the non-works situation but adversely affects traffic through a crossover curve.
Road works scheme	Any planned maintenance, construction or inspection activity which requires the placing of temporary traffic management equipment on a road. It also covers street works. NOTE: Temporary layouts not relating to construction etc; activities, in place for up to six months use temporary signs which are within scope of TSM Chapter 8 [Ref 4.N]; temporary layouts in place for more than six months are signed using design rules for permanent signs
Traffic Signs Manual Chapter 8	Traffic Signs Manual Chapter 8 (TSM Chapter 8 [Ref 4.N]) consists of three parts; design, operation and update. Any reference to Chapter 8 without the inclusion of a part number is a reference to all parts.

1. Scope

Aspects covered

1.1 This document shall be used for the design of crossovers and changeovers on motorways and dual carriageway all-purpose trunk roads where a more detailed quantified design is required than normally identified in TSM Chapter 8 [Ref 4.N].

Implementation

1.2 This document shall be implemented forthwith on all schemes involving road works crossovers and changeovers on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 3.N].

Use of GG 101

1.3 The requirements contained in GG 101 [Ref 3.N] shall be followed in respect of activities covered by this document.

2. Design requirements for road works

2.1 The design and operation of all road works and temporary layouts shall meet with the requirements and guidance in Traffic Signs Manual Chapter 8 (TSM Chapter 8 [Ref 4.N]) and relevant legislation.

NOTE 1 Appendix A to D contain supplementary information and guidance for designers to use within scheme specific designs to meet this requirement.

NOTE 2 While the basic principles of crossover and changeover design are covered in TSM Chapter 8 [Ref 4.N] there are locations on the motorway and all purpose trunk road network where designers, including those designing a road scheme being constructed and also temporary traffic management (TTM) designers, need to undertake a more detailed engineering assessment to ensure that a safe crossover or changeover design can be adopted. This document gives details of design parameters and considerations for changeovers and crossovers which would meet the requirements of TSM Chapter 8 [Ref 4.N].

NOTE 3 The safety requirements for road users interacting with the works and road workers involved with the installation of the temporary traffic management or involved with construction activities (including maintenance and inspection activities) are identified in TSM Chapter 8 [Ref 4.N].

NOTE 4 During road works the safety requirements for both road users and road workers are required to be based on the principle of 'As Low as Reasonably Practicable' (ALARP).

2.2 Safety risk assessments shall follow the principles identified in TSM Chapter 8 [Ref 4.N] for all affected populations.

NOTE As the design of temporary traffic management and the identification of a safe method of working is the responsibility of the contractor, no departures from this standard can be granted.

2.3 Any non-compliance with guidance identified in this document shall be supported by a scheme specific risk assessment.

2.3.1 While the responsibility for the design of safe traffic management in association with adopting a safe method of working remains with the contractor, the impact of the proposed TTM on traffic flow or other network affect should be agreed with the Overseeing Organisation (as indicated in TSM Chapter 8 [Ref 4.N]).

3. Normative references

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

Ref 1.N	The National Archives. legislation.gov.uk. CDM 2015, 'Construction (Design and Management) Regulations 2015'
Ref 2.N	Highways England. CD 109, 'Highway link design'
Ref 3.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 4.N	The Stationery Office. TSM Chapter 8, 'Traffic Signs Manual Chapter 8 - Road works and temporary situations'

Appendix A. Crossovers

A1 General

In addition to the maintenance of safety, the design of a crossover is a balance between available locations, economical construction cost, environmental impact and convenience to road users. As crossovers form part of a temporary and often changing situation, attention should be given to the possibility that the exact nature of any design may be affected by unplanned changes or events.

The basis of the design recommendations in this document allows for a reduction in normal driver comfort within the design while maintaining acceptable limits for sideways acceleration. Temporary traffic management arrangements should be prominently signed and consequently road users should be aware of any road layout they are approaching. In this situation drivers are able to tolerate a tighter geometric design than can be accepted in a non-roadworks situation on the assumption that the chosen design speed is consistent with, but not necessarily the same as, any temporary reduced mandatory speed limit.

New construction within the central reserve should normally be retained for future use, unless there is justification for removal at the completion of the works e.g. where retention creates a safety hazard or affects the environment.

A2 Re-use of existing crossover sites

Prior to re-use of an existing crossover site a design assessment is required by TSM Chapter 8 [Ref 4.N], even where it has operated without problems in the past. There is no requirement to assess any existing crossover site until plans arise to re-use it.

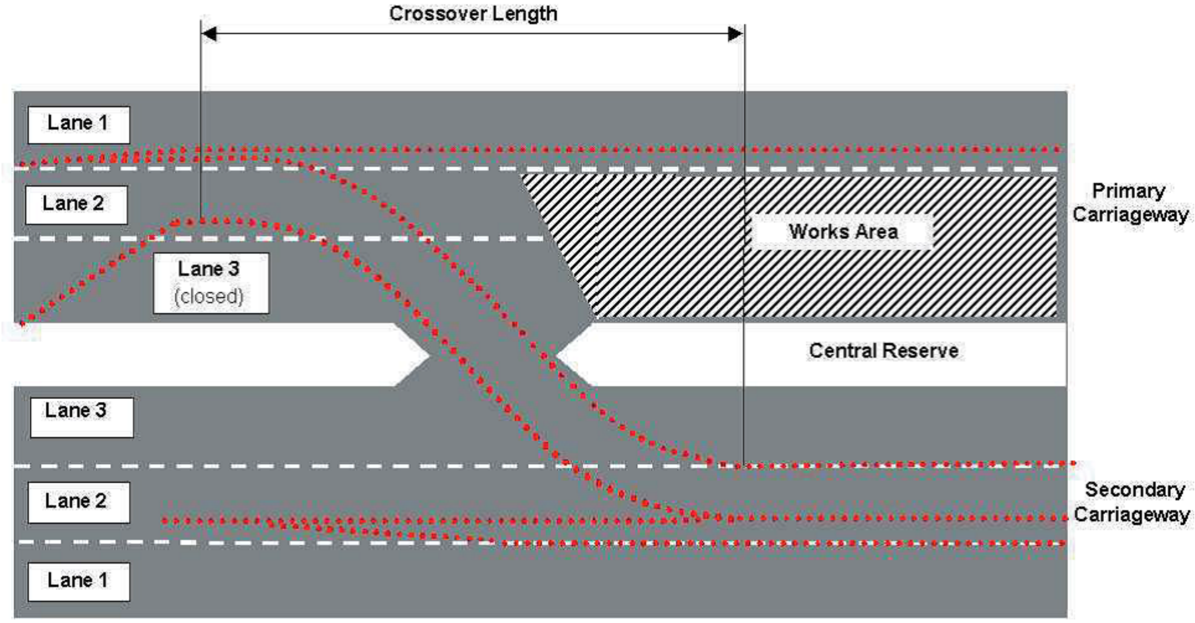
A3 New roads and network improvement schemes

The design of new roads or network improvement schemes would not normally provide crossover sites for the purposes of future maintenance works. However, part of the design process for a new road or improvement scheme assesses future maintenance needs. This document should be used when identifying lengths of central reserve which could be designed to contain the minimum of equipment to allow for the construction of crossovers, at a later date. In all cases the maintaining organisation should be consulted.

A4 Construction records

As-built drawings for the works should indicate the assumed design speed used in the design of a crossover. This will assist at a later date when crossover sites are assessed for potential re-use. These should be included in the Health and Safety file (see relevant CDM Regulations CDM 2015 [Ref 1.N]) plus any as-built data requirements for the relevant Overseeing Organisations.

Figure A.1 Typical crossover layout



Appendix B. Geometric design

B1 Design speed and speed limits

Any temporary mandatory speed limit to be used for a scheme should be determined by reference to TSM Chapter 8 [Ref 4.N]. The design speed to be adopted for a crossover is related to either the temporary reduced mandatory speed limit or the nature of the works which would naturally reduce the speed of traffic passing through a crossover.

The selection of design speed is not affected by the status of the crossover site as permanent or temporary.

It is not acceptable to attempt to reduce costs by selecting a crossover design speed and corresponding temporary speed limit lower than TSM Chapter 8 [Ref 4.N] identifies as being required. In the case of pre-existing crossover sites, shown by assessment to be sub-standard, the cost implications of enhancement to that required given the likely future use should be assessed as part of the design.

It is recommended that the speed limit at crossovers reflect any mandatory reduced speed limit in place throughout the works; however, TSM Chapter 8 [Ref 4.N] identifies that it is undesirable to set the speed limit along the whole length of the schemes based on the conditions along only a short length of the schemes. If a crossover cannot be designed for the prevailing temporary reduced mandatory speed limit it should be designed for an appropriate lower design speed and if needed for road user safety the temporary reduced mandatory speed limit may be further reduced at the crossover.

Reducing the design speed by one step (Table D.1) is preferable to two steps, and a two-step reduction should only be permitted in extreme cases where the costs of adopting a one-step reduction remain disproportionately high. Reductions of more than two steps are not suitable as the reduced standard will be insufficiently conspicuous to approaching traffic to transit the crossover safely or adjust their speed to obey such low speed limits without unacceptably reduction in capacity.

The advice of TSM Chapter 8 [Ref 4.N] normally recommends that a mandatory speed limit is undesirable where the length of the speed limit is less than 800m. However, at a crossover the length of any locally lower mandatory speed limit will normally be less than 800m. In the case of an additional reduction of 10 mph this is normally acceptable as the advance signing of the crossover and the need to change steering input tends to make the lower limit self-enforcing. Any reduced speed limit for a crossover at the start of a contraflow will apply to all lanes on the approach to the crossover until the point the contraflow starts. If needed for a return crossover the start of any limit would be at the end of the contra-flow and start of the crossover. This ensures that the same speed limit applies in both directions over the length of the contraflow and the reduced limit applies to traffic in the primary direction only. The design and choice of any speed enforcement technology will need to accommodate any change in mandatory speed limit through a crossover. The requirements of TSM Chapter 8 [Ref 4.N] means it is not acceptable to omit the reduced mandatory speed limit for the sole reason of adopting a single section of an average speed camera system to cover the scheme before and after the crossover.

Where the design of the works provides the full stopping sight distance on the approach to the crossover, the approach signing meets the recommended sizes and visibility distance in TSM Chapter 8 [Ref 4.N] and the capacity of the crossover is sufficient to avoid queuing traffic on the approach, then the extra reduction in mandatory speed limit may be dispensed where there is up to a one-step reduction in design speed. If the same limitations apply then a 10 mph extra reduction in mandatory speed limit may be implemented where there is a two-step reduction design speed. The adoption of either option may depend on the wider design of the schemes and will need to be justified in the scheme specific risk assessment required by TSM Chapter 8 [Ref 4.N].

B2 Design philosophy

The design philosophy adopted for crossovers is based on providing acceptable horizontal radii for an "ideal" crossover and where various adverse factors exist, reducing the risk by increasing the radii in steps to continue to provide an acceptable layout. Appendix D gives design tables to determine the curve radii to be used for a particular situation. The tables do not identify a specific requirement; they can be used to identify if TSM Chapter 8 [Ref 4.N] requires a lower provision to be justified in the schemes specific risk assessment.

B3 Horizontal alignment

Horizontal curvature on the existing carriageway, i.e. a bend at the proposed crossover location, may cause difficulties in the design. It is preferable that the radius of curvature of the entry curve into the crossover is the same as that of the exit curve. The effect of any existing bends on the ability to provide this has to be assessed, see Table D.3.

The provision of equal entry and exit curve radii poses no difficulty if the carriageway is straight.

Any existing horizontal bend has an adverse effect on the curves forming the crossover. An existing right hand bend results in a tighter entry radius than would be the case with a straight road. Similarly an existing left hand bend causes tightening on the exit curve.

An existing bend may also effectively form a third curve either before entry to the crossover or on the exit. Although this occurs entirely on the existing carriageway, it will cause a 'triple' bend to be created. Introducing a third change of direction for drivers to negotiate is undesirable.

Where a bend on the approach to a crossover has superelevation in any direction, the radius of the crossover entry curve should be increased in accordance with Table D.3 to allow a greater margin of safety when drivers are already experiencing different sideways forces before entering the crossover.

Where the entry and/or exit curves are located partly on the existing carriageway and partly on the central reserve there may be a change of vehicle sideways acceleration. Crossover radii should be increased in accordance with Tables D.3 and D.4 when acceleration changes occur on any curve. The extreme case is a change from assisting superelevation to adverse camber.

An extreme case is where the existing bend is of the same hand and its radius is approaching the design limit for the radius of the entry curve. In this case the entry curve approximates so closely to the radius of the existing bend that, effectively, no 'lateral shift' can take place. In these circumstances the crossover should be sited elsewhere.

The use of unequal curve radii through the crossover is undesirable and it should be avoided, but with one exception: where a right-hand bend exists, the radius of the exit curve can be greater than that of the entry curve, provided that the crossover will only be used in this direction. If the crossover is to be used later in the other direction then undesirable "tightening" through the crossover would occur. In this situation the crossover would need to be designed and constructed with equal radii curves. Alternatively the crossover would need to be reconstructed if used in the reverse direction.

The use of crossovers with equal entry and exit curve radii will result in long crossover lengths if they are situated on a significant bend in the road and such crossovers will be asymmetric. However, this is preferred as this will not be particularly noticeable to a driver whereas any change of radii would.

B4 Transition curves

Generally transition curves are not required in the design of a crossover and the 'tightening radius' effect created is undesirable. However, the lack of a transition curve will increase the impact of narrow lanes on road user's ability to stay in lane through the crossover. If transitions are not provided for the reasons identified below, to mitigate this risk delineation via road markings, studs, cones and/or cylinders would need to be enhanced as identified in TSM Chapter 8 [Ref 4.N].

The use of a transition curve will cause the overall length of the crossover to increase. This will normally increase the length of the central reserve gap in most designs with a resulting increase in construction costs.

Where the crossover cannot be better located or designed in accordance with the recommendations of this document, the use of a transition curve may be required to reduce sideways acceleration or overturning problems.

B5 Vertical alignment

The vertical alignment to be considered in the design of the crossover is that lying on the vehicle path for the temporary layout, rather than that of the centreline of the normal carriageway.

The longitudinal vertical curve to be considered is the approximate curve that can be fitted between the two existing vertical curves, one for each carriageway, allowing for any temporary construction. Figure B.2 gives an example of fitted curve diagrams for a particular case where the secondary carriageway is higher than the primary carriageway.

Adverse factors through the crossover has to be assessed due to the effects of the crest curve on the limits of adhesion or the overturning of large vehicles. See Tables D.3 and D.5.

Any sag curve has to be assessed to avoid an unacceptable reduction in comfort level or distances illuminated by headlights. See Tables D.3 and D.5.

Taking the fitted curve as shown in Figure C.2, the vertical alignment through the crossover should be designed to comply with Table D.5.

The affects of a two-way crossovers will need to be included when assessing gradient.

Crossovers should not be located where the downhill gradient exceeds the desirable maximum reproduced below:

3% Motorways

4% AP Dual Carriageways

Where downhill gradients steeper than these are unavoidable, measures to reduce speed e.g. speed enforcement cameras, may be required. Downhill gradients may cause undesirable adverse camber effects (Table D.2) and horizontal radii may need to be increased (Table D.3).

The effect of an uphill gradient on approach to the crossover is generally beneficial. However, if the uphill gradient or height risen is near to the advice limits for the start of provision of climbing lanes in CD 109 [Ref 2.N] then traffic throughput may be reduced to unacceptable levels.

B6 Crossfall and height differences between carriageways

The longitudinal alignment should be checked along the centreline of the temporary lanes through the crossover, including entry and exit curves. The effective alignment along this path will involve both the existing fitted vertical curve (Figure C.2) and the effects of carriageway crossfall and level differences between the carriageways. Situations may arise where the gradient of the fitted curve and the crossfall combine to give an unacceptable resultant value of adverse camber. The resultant value of adverse camber and downhill fitted gradient is calculated using Table D.2. Along the full S-curve there may be various different values of resultant adverse camber. The worst value should be determined and inserted into Table E.3. As gradient will usually vary along the fitted curve, the worst case instantaneous downhill gradient that occurs along the length of route at which adverse camber is being considered should be used. Relieving effects of uphill gradients are not taken into account.

The section of road being assessed should have minimum crossfalls to both carriageways wherever possible. In circumstances where the road falls to the nearside verge of each carriageway, the crossfalls will form an adverse camber on the curves through the crossover. It will only be in the circumstances where the road falls towards the central reserve that it will assist with one or both curves through the crossover.

Whenever possible, the crossover location should have no significant difference in the levels between the edges of each carriageway across the central reserve.

Where the level of the secondary carriageway is lower than that of the primary carriageway, assuming a superelevation not greater than 7% is formed, this will normally assist with the entry into the contraflow section, but will normally create an adverse camber at the exit curve, and the latter case should be used to determine the horizontal design.

Where the level of the secondary carriageway is greater than that of the primary carriageway, an adverse camber is formed which should not exceed the resultant values given in Table D.2. This will generally be the limiting factor when deciding what level difference between the two lanes can be accepted.

Where a significant difference of level between the two carriageways exists and there is no alternative location for the crossover, additional design and construction may be necessary, possibly in the form of an overlay to raise the level of one of the carriageways. The fitted curve can then be adjusted.

The side profiles of drainage channels can cause adverse camber to increase while travelling through the crossover entry or exit curve. Where such drainage items are present then the crossover should be located and designed so that any profile does not adversely affect the design and performance of the crossover. Where this is not possible, the termination of channels and use of alternative drainage methods is advised. The elimination of adverse conditions by filling with wearing course material is not recommended, unless a suitable bond can be guaranteed, because a loss of wearing course filler may create a hazard.

Linear drainage channels systems affect both the lateral and longitudinal alignment levels and need to be assessed under both categories when using Table D.2.

B7 Rollover

The worst case for rollover is when changing from a 7% adverse camber in one direction to a 7% adverse camber in the other. This does not supply enough energy for a large goods vehicle to roll-over although it is close to the limit. Camber changes of greater than 10% (e.g -5 to +5%) are not recommended so as to allow a margin of safety.

These factors would need to be assessed when checking the sufficiency of the design:

a) crossovers from one 7% adverse camber to another would not be within what is acceptable in TSM Chapter 8 [Ref 4.N];

b) crossovers should cross the central reserve at a shallow angle of no more than 20 degrees, where possible, to the existing road. This factor is important whatever the width of the central reserve;

c) changes in level or camber should be gradual and preferably on a straight section.

B8 Stopping sight distance

Stopping sight distances (SSD) should be measured to the low object in accordance with CD 109 [Ref 2.N], for each temporary lane. Sighting outside the line of cones is not permitted when measuring SSD.

Table D.1 gives the absolute minimum requirements for SSD through crossovers for the temporary mandatory speed limit adopted. Cones and barriers should be placed so that Table D.1 values are achieved. For some roads e.g. smart motorways, the SSD requirements for the permanent design of the road may be reduced or subject to extra relaxations. These do not apply during road works as the safety requirements for road users are different and the requirements of Table D.1 apply even if longer than that provided in the permanent road design.

The specification for the temporary traffic management should include details of the required SSD. Sometimes visibility greater than the absolute minimum SSD requirement can be partially achieved if TTM equipment is carefully located to allow some limited enhancement of sightlines across the safety zone or working space.

Where width is limited and narrow lanes and reduced setbacks to cones or barriers are to be adopted, it may be necessary to increase horizontal radii purely for the reason of achieving the required SSD. Where adverse factors exist (Table D.3), the step increases in radii (Table D.4) will also automatically help to improve SSD. Using small radii may compromise SSD in certain circumstances. In all cases SSD should be checked locally, including vertical effects, to ensure that Table D.1 values are achieved. Due to the large number of variables at a crossover, using radii from Table D.4 does not guarantee SSD compliance in the horizontal plane.

Figure B.1 Fitted vertical curve diagrams (Crest curve)

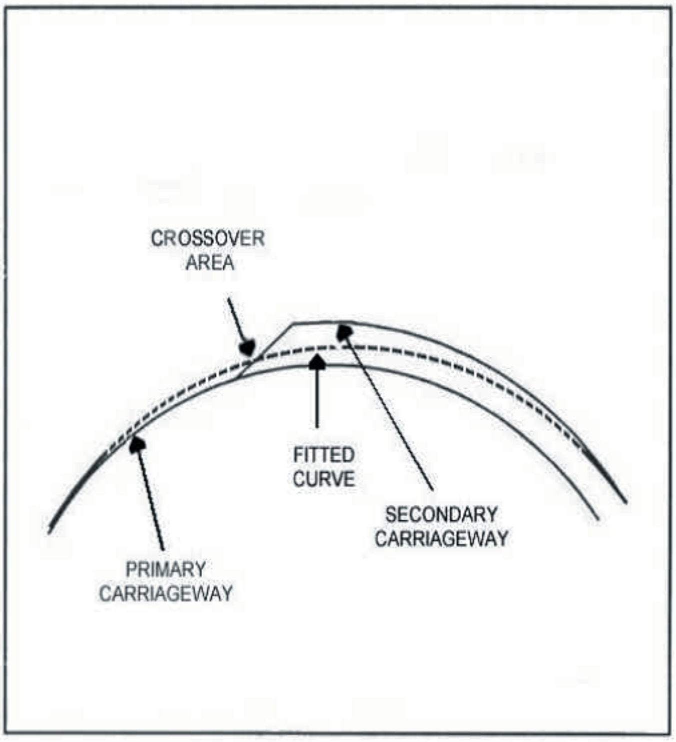
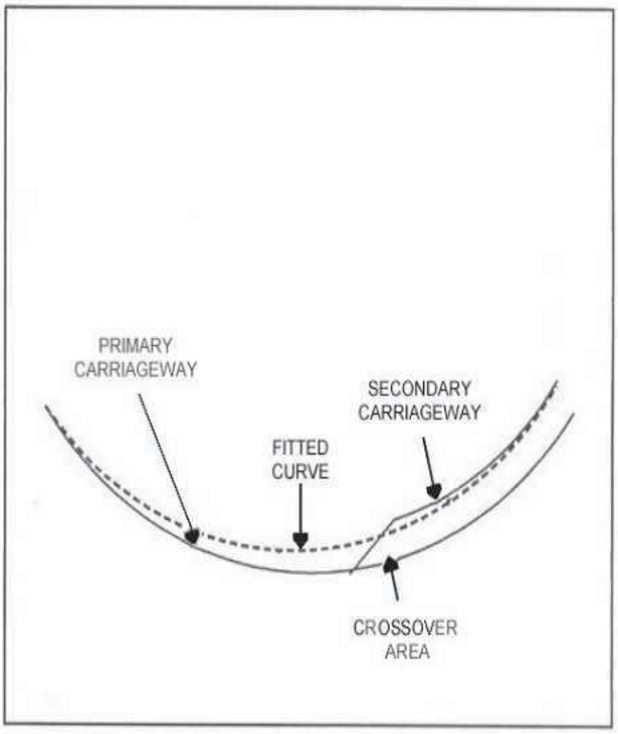


Figure B.2 Fitted vertical curve diagrams (Sag curve)



Appendix C. Changeovers

Changeover geometry should follow the same principles as used with crossovers. Changeovers are more likely to be designed with multiple lanes leading to the need to assess different methods of delineating the layout to road users. In addition changeovers can be used in 'relaxation' schemes where the design speed is always the permanent speed limit.

Changeovers on standard schemes may result in lane widths changing along their length, to fit in with existing lane markings or where all the markings have been removed to enable a narrower lane to be applied. It is recommended that any lane width reduction is implemented in locations where the desirable minimum SSD from CD 109 [Ref 2.N] is achieved to both the high and the low point. This may require lane widths to be maintained where the inner radius of a curve is delineated by cones, cylinders or barriers. Where lane widths do change through a changeover the delineation on both edges of any lane needs to be clear; it would be expected that higher performing products identified in TSM Chapter 8 [Ref 4.N] are used.

To be within the scope of a relaxation scheme identified in TSM Chapter 8 [Ref 4.N] any changeover will need to provide an adequate level of road user safety without the removal or replacement of road markings. If more than one lane is included in the changeover then the edge delineation will need to be enhanced as identified in TSM Chapter 8 [Ref 4.N] i.e. Class R2B cones and warning lamps used as a minimum.

To be within the scope of a relaxation scheme identified in TSM Chapter 8 [Ref 4.N] the SSD at changeovers will need to be at least the desirable minimum for the design speed from CD 109 [Ref 2.N]. Transient reduction in SSD to the low point caused by the TTM may be acceptable but SSD to the high point will need to be be maintained throughout the changeover.

To be within the scope of a relaxation scheme identified in TSM Chapter 8 [Ref 4.N] a single lane changeover will need to be wider than the desirable minimum for the class(es) of vehicle using the changeover e.g. non-notifiable abnormal loads. The lane width downstream of the changeover will need to be at least 3.3m. If a scheme is designed outside this boundaries then it would not meet the criteria for a relaxation scheme.

Appendix D. Geometric design tables

Table D.1 Design and stopping sight distances for crossovers

Reduced mandatory speed limit	Design speed for crossover	Absolute minimum SSD required
30 mph	60 kph	50 m
40 mph	70 kph	70 m
50 mph	85 kph	90 m
60 mph	100 kph	120m

Table D.2 Resultant value of adverse camber for gradient-crossfall combinations for downhill fitted curves

Downhill gradient of fitted vertical curve [F]	Adverse crossfall [C]			
	2.5%	3.5%	5%	7%
1%	2.7%	3.6%	5.1%	X
2%	3.2%	4.0%	5.4%	X
2.5%	3.5%	4.3%	5.6%	X
3%	3.9%	4.6%	5.8%	X
3.5% (*)	4.3%	4.9%	6.1%	X
4% (*)	4.7%	5.3%	6.4%	X
5% (**)	5.6%	6.1%	X	X
6% (**)	6.5%	6.9%	X	X

NOTE 1 Formula used is Resultant = √[C2 + F2].

NOTE 2 X = not recommended for design.

NOTE 3 * = not recommended for new motorways, but may be present where crossover is envisaged.

NOTE 4 ** = not recommended for new dual carriageways or motorways, but may be present where crossover is envisaged.

NOTE 5 C is adverse when the existing crossfall falls from central reserve to nearside verge on either carriageway. Take worst case of entry and exit curve.

NOTE 6 For uphill situations insert value of C directly into Table E.3.

NOTE 7 Table E.2 also to be used to check acceptable level difference between carriageways.

Table D.3 Number Of step increases In radii (See Table E.4) required if adverse conditions exist through crossover

Adverse conditions	Num. of steps increase required
No adverse factor	0
Worst case resultant adverse camber ≥2.5% and ≤5%	1
Worst case resultant adverse camber >5% and ≤7%	2
Worst case resultant adverse camber >7%	X
Any change of value of superelevation / adverse camber through entry or exit curve	1
Change from assisting superelevation to adverse camber through entry or exit Curve	2
Desirable minimum crest K value	0
One step below minimum crest K value	1
Absolute minimum sag K value	1
Approach bend with superelevation of 2.5%	1
Approach bend with superelevation >2.5% and ≤7%	2
Rollover: Change in camber ≥5% and ≤7%	1
Rollover: Change in camber >7% and ≤10%	2
Rollover: Change in camber > 10%	X

NOTE 1 The number of step increases is cumulative for all tests and is the same for all design speeds

NOTE 2 'Bend' and 'curve' have specific meanings: see definitions.

NOTE 3 X denotes "Not recommended".

Table D.4 Horizontal curve radii For design dpeeds

Steps from table 3	Design speed			
	100kph	85 kph	70 kph	60 kph
0	720 m	510 m	360 m *	255 m *
1	1020 m	720 m	510 m	360 m *
2	1440 m	1020 m	720 m	510 m
3	2040 m	1440 m	1020 m	720 m
4 or more	2880 m	2040 m	1440 m	1020 m

NOTE 1 * denotes curve widening may be required in accordance with CD 109 [Ref 2.N] if a lane used by large goods vehicles is less than 3.65m wide and radius is less than 400m. If lane widening is not practical then radius may need to be increased.

NOTE 2 Refer to SSD requirements in Appendix B which can affect use of Table D.4.

Table D.5 Limiting 'K' values Of vertical curvature for crest and sag curves

Design speed	100kph	85 kph	70 kph	60 kph
Desirable minimum crest K value	100	55	30	17
One step below desirable minimum crest K value	55	30	17	10
Absolute minimum sag K value	26	20	20	13

NOTE 1 The K values given in Table D.5 should be checked against the fitted curves shown in Figure C2.