

**Drafting and Design Presentation Standards Manual (DDPSM)**

**Volume 3: Structural Drafting Standards**  
**Chapter 3 - Bridge Geometry**

**January 2026**

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## 1 General

This section is intended to provide guidance on setting out bridges to suit the geometry of the road corridor and how the bridge superstructure types are selected to efficiently fit into those constraints.

For bridges drafted in 2D environments, it is recommended that a set out plan with the deck units / girders and other features be drafted to investigate the fitment of the complete structure, including the fitment of transverse stressing bars, where they are proposed.

This document shall be read in conjunction with Department of Transport and Main Roads Technical Specifications, *Design Criteria Bridges and other Structures (DCBoS)*, *Road Planning and Design Manual 2<sup>nd</sup> Edition (RPDM)*, and *Austrroads Guide to Road Design – Part 3: Geometric Design*.

## 2 Planar bridge set out within the Map Grid of Australia survey grid of the road design

Bridges are typically designed and set out using a planar coordinate system based on ground distances where the scale factor is 1:1. In contrast, the adjoining roadworks at either approach to the bridge are set out using a scaled survey coordinate system called Map Grid of Australia (MGA) that accounts for the Earth's curvature and geodetic factors.

For shorter bridges, the difference between the 2 set-out methods may be negligible. For longer bridges, the discrepancy between MGA and ground distances (planar) may become significant. If not addressed, this can lead to misalignment between the bridge abutments and the approach roadworks or embankments, causing construction issues.

Designers are responsible to assess the bridge layout and ensure the approach embankments are designed appropriately to ensure the coordinates of the embankments match the locations of the bridge abutments.

### 2.1 Summary of alignment design and bridge layout aims

As stated in DCBoS, the bridge geometry of all departmental bridges shall be compatible with the geometric road design. The combined effects of horizontal curve (HC) / vertical curve (VC) / skew / grade / superelevation can complicate the geometric layout of a bridge significantly especially bearing and deck unit / girder geometry and placement.

Where practical, designers should seek to reduce complex geometry by minimising these alignment features.

The desired outcomes of an optimised alignment and bridge layout are:

- A straight bridge for a curved horizontal alignment, where no part of the bridge kerbs and wing walls are to deviate from the alignment by more than 75 mm.
- Simplified design alignment where possible to reduce complexity – minimising skew angles, horizontal and vertical curvature, superelevation, and longitudinal grade.
- Layouts of 30° or less skews to comply with departmental standards, where possible, so as to minimise design and construction complexity and fabrication costs.
- Use of transverse stressing bars in a deck unit bridge, where the geometry permits (larger radius curves), thereby eliminating the need for cast-insitu decks – unless span lengths or durability requirements necessitate one.
- Use of a cast-insitu deck where tighter radius curves do not permit the fitment of transverse stressing bars (the fitment of transverse stressing bars may be checked via a layout diagram).
- The optimisation of span lengths and skew where practical to reduce production costs and complexity:
  - On multi-span curved bridges, consider using an average skew across adjacent spans to minimise variation in girders or deck unit geometry. For example, a 6 span bridge may use 3 distinct skews averaged across Spans 1 and 2, 3 and 4, 5 and 6.
  - Where possible, adopt standard length girders and deck units to align with published Standard Drawings, and
  - For curved alignments, consider fanning deck units to maintain uniform unit lengths, allowing transverse gaps to vary as needed to accommodate the curvature.
- The management of the overhang of cast-insitu deck on curved decks within design limitations (fitment of drainage systems also needs to be considered).
- For deck unit and girder bridges with longitudinal gradient greater than 2.5%, the designed end kick of precast elements should be as close to vertical as possible when placed. This facilitates efficient installation and ensures the required nominal end clearance of 50 mm is maintained between girders or deck units, the ballast walls at abutments, and piers. A drafting check to confirm these clearances can be performed using a scaled elevation or 3D model of the superstructure and substructure, and

- The top and bottom faces of deck units should be assessed in relation to the grade / crossfall / superelevation to ensure correct placement of formed holes and adequate clearances to end walls and ballast walls at abutments. A drafting check to validate formed hole locations and clearances, unit lengths, stressing bar fitment and so on can be done in a layout drawing or 3D model, the latter is especially useful for complex geometry.

## **2.2 Bridge geometry terms**

The following terms are used throughout this chapter:

- Horizontal alignment:
  - refers to the layout of the bridge as viewed in plan, as straights and/or circular curves, and shows the road corridor elements within the bridge width
- Bridge control:
  - refers to the principal line of reference for use throughout the bridge drawings
- Parallelogram shapes:
  - refers here to the shapes formed by the outer girders or the inside edges of kerbs, and
- Vertical alignment:
  - refers to the crossfall or superelevation and gradient of the bridge as viewed in section and elevation.

## **3 Horizontal alignment**

A bridge on a straight road and with little or no skew has no horizontal geometric constraints and is the simplest layout for a bridge.

A bridge on a large horizontal radius and skew 30° or less can be orientated as a straight bridge with the parallelogram shapes of the bridge superstructure parallel to that straight line of the bridge control (refer to Figure 3.1.1(a) and Figure 3.1.1(b)).

Where the road curve is tighter and does not permit a straight line, the simple solution is a straight line from each headstock to the next with a slight change in angle, to locate the bridge around the curve with each span set out as a parallelogram along each span chord (refer to Figure 3.3).

### **3.1 Orientation of bridge control to road control**

The following are departmental guidelines for fitting a bridge to a HC.

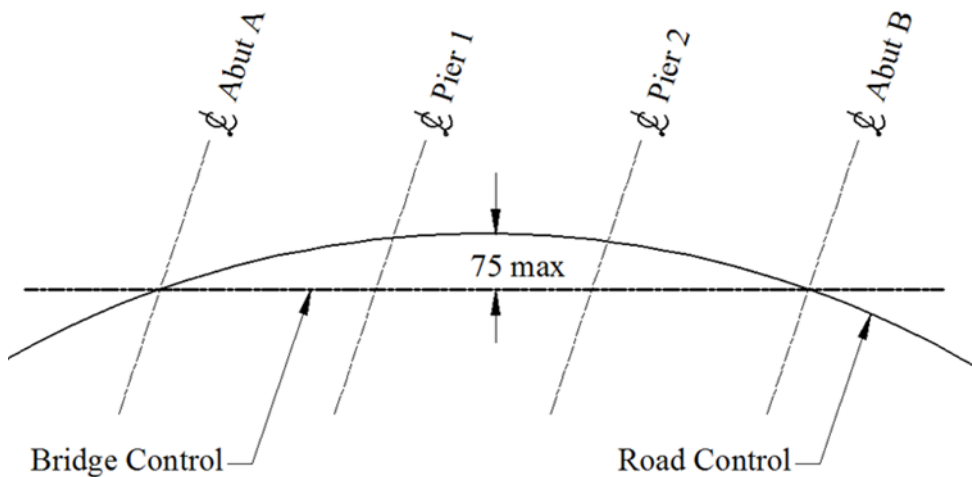
### 3.1.1 Method 1 - the straight line

A straight bridge alignment may be adopted even when the road control follows a HC, provided that the maximum allowable bridge offset of 75 mm between the straight bridge control and the curved road control can be achieved.

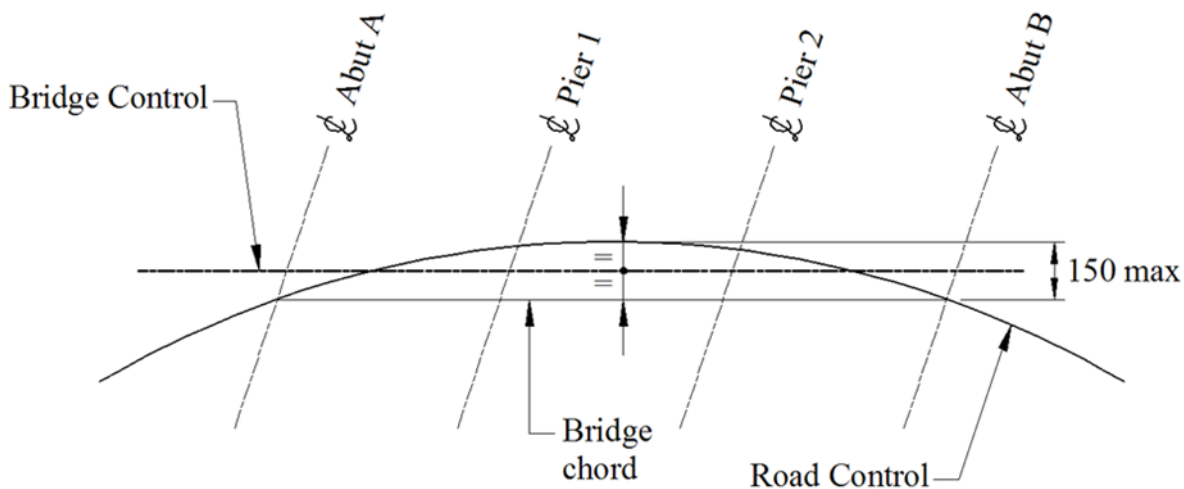
Two configurations are permissible under this method:

1. Configuration A: The bridge offset does not exceed 75 mm at the midpoint of the HC and intersects with road control at the abutment centrelines (refer to Figure 3.1.1(a)), and
2. Configuration B: The bridge exceeds 75 mm but remains within a 150 mm limit, with equal offsets at both the midpoint of the HC and the abutment centrelines (refer to Figure 3.1.1(b)).

**Figure 3.1.1(a) - Bridge offset 75 mm maximum**



**Figure 3.1.1(b) - Bridge offset 150 mm maximum**



### 3.1.2 Method 2 - the chord for each span along the curve

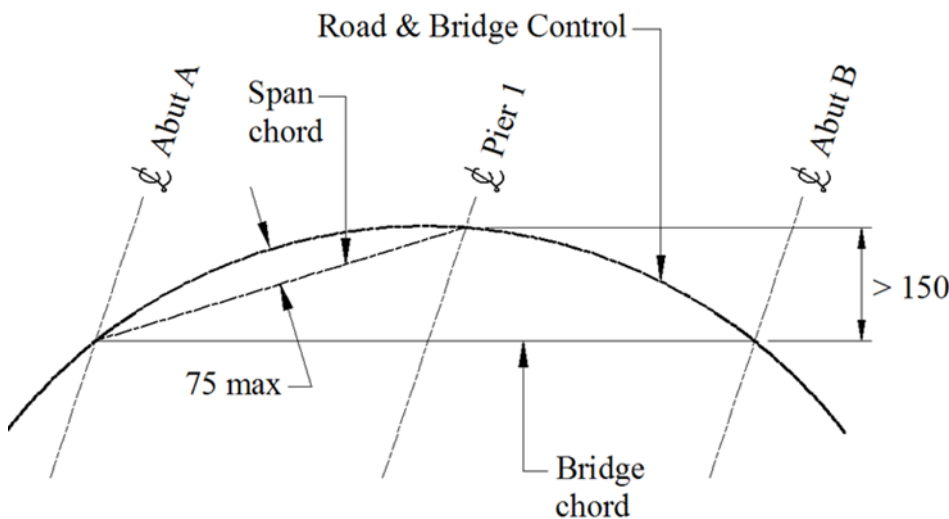
Where the combination of a small radius curve and overall bridge length precludes the use of a straight line for the bridge control, the bridge may be aligned to follow the curve with each span set out as a parallelogram.

This method is governed by the ability to maintain a maximum allowable span offset of 75 mm between the span chord and the curved road control.

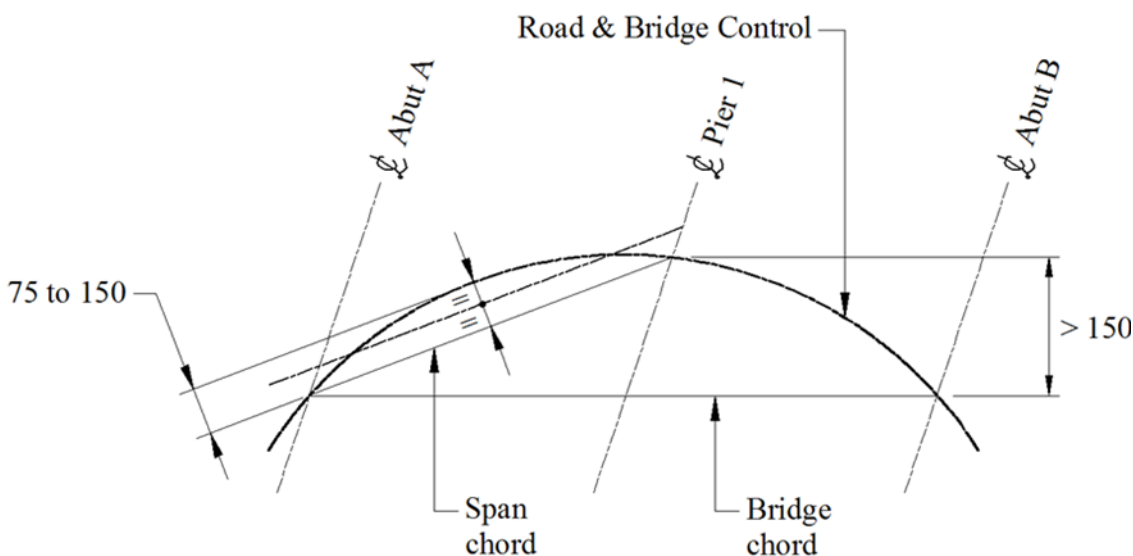
Two offset conditions are considered acceptable:

1. Condition A: The overall bridge offset exceeds 150 mm, while the span offset remains within the 75 mm limit (refer to Figure 3.1.2(a)), and
2. Condition B: The span offset from the span chord to road control exceeds 75 mm but does not exceed 150 mm (refer to Figure 3.1.2(b)).

**Figure 3.1.2(a) - Span offset 75 mm maximum**



**Figure 3.1.2(b) - Span offset 150 mm maximum**



### **3.2 Prestressed concrete deck units on small radius curves**

A deck unit bridge can be set out in a series of parallelograms from the span chords until the gaps between the units exceed 30 mm in width.

The use of this system of simple parallelograms may not work for a combination of factors such as the amount of skew, tightness of curve, or length of bridge. In the event of that system not working, then the following system should be used.

If parallelograms are used with a curved bridge, the bridge will increase in width in a particular direction, depending on the orientation of the curve and direction of the skew. Therefore, the geometric calculations are to commence from the narrowest end.

After setting the span lengths along the road control, the commencing span is set up as a parallelogram. For the next span, 2 parallel lines are set either side of the chord for that span, representing the inside face of the cast-insitu kerb or the outer edge of the outer deck unit. These lines are then intersected by an arc (with a radius equal to the span length) centred at the intersection of the pier centreline and the edge line for the preceding spans. The connection of these points creates the centreline of the next pier.

Refer to the procedure below and accompanying figure for further explanation.

It will be noted that this pier centreline is no longer parallel to the previous pier or abutment centreline as the skew is slightly increased. Due to this effect, the commencing skew angle shall allow the designed bridge skew to be correct ( $\pm 1^\circ$ ) at the heaviest flow section of the waterway. The same procedure is then repeated for each successive span.

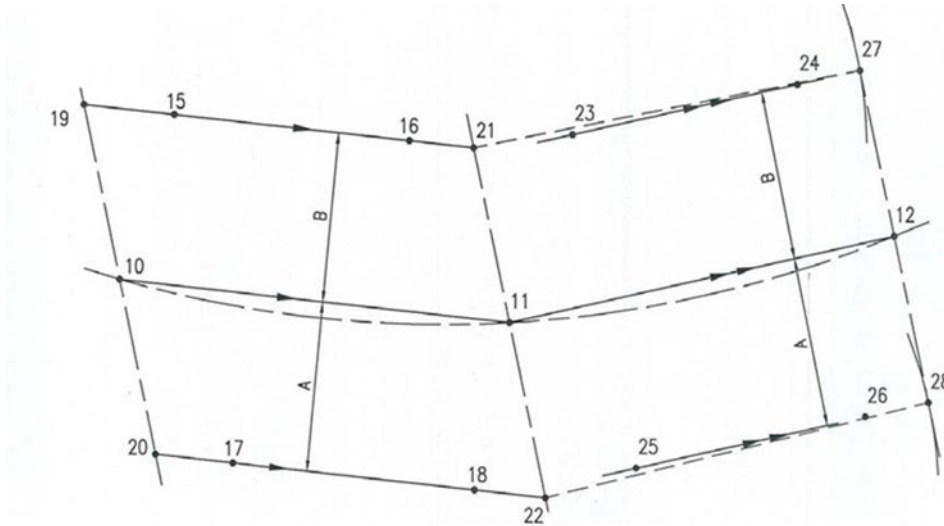
### **3.3 Procedure for setting out deck units on small radius curves**

With reference to Figure 3.3, the procedure for setting out deck units on small curves is:

- a) set up both the horizontal alignment and vertical alignment
- b) locate the abutment and pier positions along the alignment (points 10 to 12)
- c) at the commencement end, set up parallel lines, either side of the chord, representing the bridge edge (inside face of the cast-insitu kerb or the outer edge of the outer deck unit) (points 15 to 18)
- d) find the intersection of these lines with the centrelines of the abutments and piers (points 19 to 22)
- e) set up parallel lines in the next span to the same width as before (points 23 to 26)
- f) intersect these lines with arcs (with a radius equal to the span length) centred at points on the pier (points 21 and 22)

- g) join these points (27 and 28) thus determining the bearing of the next pier, and
- h) repeat the previous 3 steps for the remainder of the bridge.

**Figure 3.3 – Prestressed concrete deck unit bridges on small radius curves**



### 3.4 Layout of reinforced concrete deck bridges

#### 3.4.1 Prestressed concrete deck unit bridges with large amount of skew

The bridge designer shall refer to Section 4.9.2.3 of DCBoS for skew angle considerations, and to SD2042 *Precast Units – Design Assumptions for Transversely Stressed Standard Deck Units (Drawing 1 of 2 to Drawing 2 of 2)*. As skew angles increase due to the curve, at a certain point it becomes impractical to use transverse stressing bars for bridges on a HC due to the “saw tothing” of the deck units.

Use of a reinforced cast-in-situ deck eliminates the need for transverse stressing bars and so enables the fitment of a bridge around tighter radius curves where fitment of transverse stressing bars would not work. Of course, the limit of where transverse stress bars will fit and where a cast-in-situ deck is required is related to the combined effect of both span length and curve radius.

Bridge overhang from the outside of the outer deck unit to the outside face of the kerb is discussed in Section 6.4 of DDPSM Volume 3, Chapter 4.

**Figure 3.4.1 – Formwork for overhang – prestressed concrete deck unit bridge on small radius curve**



### 3.4.2 Prestressed concrete girder bridges

When detailing a prestressed concrete girder bridge on a HC, first preference should be given to locating girders parallel in each span. This will simplify detailing and subsequent construction of the cross girders and the Prestressed Concrete (PSC) girders.

Care should be exercised in locating the intersection of girder centre lines and abutment and pier centre lines in order that:

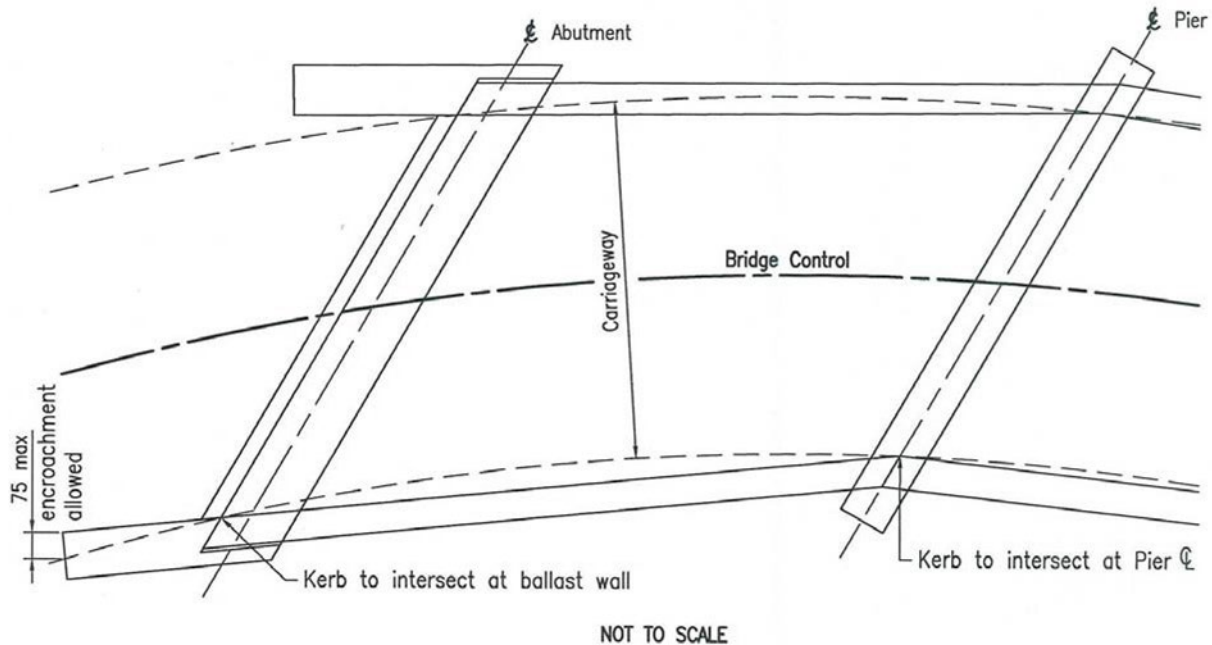
- a maximum cantilever of 1.25 m from centre line of girder to outside face of the girder flange is maintained
- if deck drainage is required, enough width shall be provided in the outermost girder flange to fit scuppers and a drainage pipe for the full length of each span including the narrow portions of the girder flanges on curved structures
- when factors of skew, span length, and tightness of HC make the above parameters unattainable, then girders should be splayed, i.e. spacing of girders would vary from one end of span to the other end, and
- length and skew of girders are rationalised, where possible, to minimise costs.

### 3.5 Encroachment of wing wall into traffic lane

On small radius curves and when spans are located around the curve, a check should be made to ensure that the end of the wing walls that follow the same line as the kerb on the adjacent span do not project more than 75 mm into the traffic lane.

If this is the case, the wing walls may be set parallel to a chord line running from the start of the abutment at the ballast wall to the end of the wing wall. Where this occurs, the bridge traffic rails will need to be kinked at the abutments to accommodate this change (refer to Figure 3.5).

**Figure 3.5 - Example of wing encroachment on a curved alignment**



### 3.6 Bridge width

For minimum bridge carriageway, traffic lane and shoulder widths, refer to DCBoS.

## 4 Vertical alignment

In accordance with DCBoS, crossfall and longitudinal gradient on all new bridges shall be compatible with the geometric road design. For widened bridges, these parameters should closely match those of the existing bridge.

The positioning of a new bridge in the longitudinal vertical plane will follow the vertical alignment of the road control, which may consist of a straight or curved grade, or a combination of both.

In cases where the bridge is subject to potential inundation, a zero longitudinal gradient is permissible. This configuration helps to minimise undesirable turbulence effects during progressive submersion.

For deck unit and girder bridges with longitudinal gradient exceeding 2.5%, the precast elements (for example, girders or deck units) should be designed with an end kick that is as close as possible to true vertical when in their final designed position. This ensures the required nominal end clearance of 50 mm between girders or units and ballast walls is a vertical gap and so provides sufficient tolerance when vertically lowering girders into place.

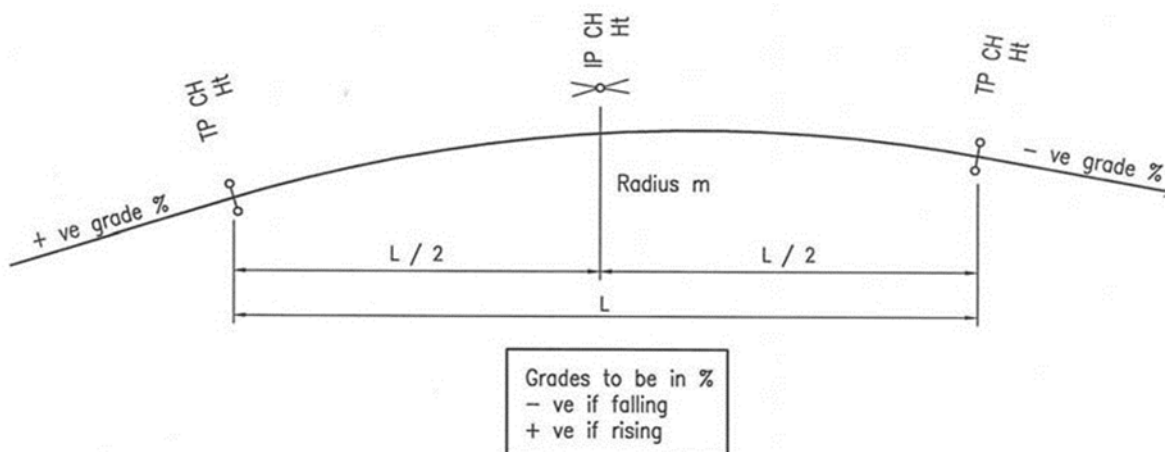
### 4.1 Vertical curves

Vertical curves (VC) for Transport and Main Roads vertical geometry are parabolic curves and not pure circular curves and are expressed as a K value. The VC denoted on working drawings will have a particular radius calculated for a VC which is only a nominal radius that applies at that part of the parabola that very closely resembles a pure circular curve.

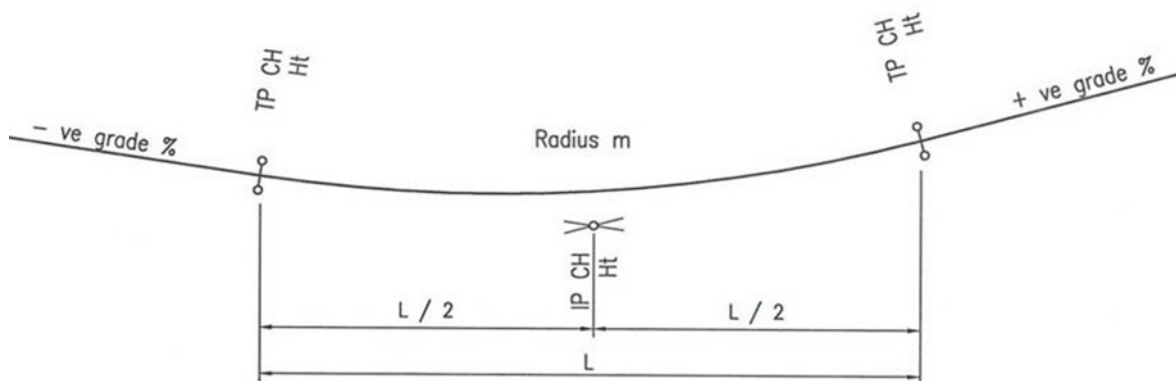
Vertical curves (VC) come in 2 forms:

- Crest VC – the centre chainage of the curve is high (refer to Figure 4.1(a)), and
- Sag VC – the centre chainage of the curve is low (refer to Figure 4.1(b)).

**Figure 4.1(a) – Crest vertical curve details**



**Figure 4.1(b) – Sag vertical curve details**

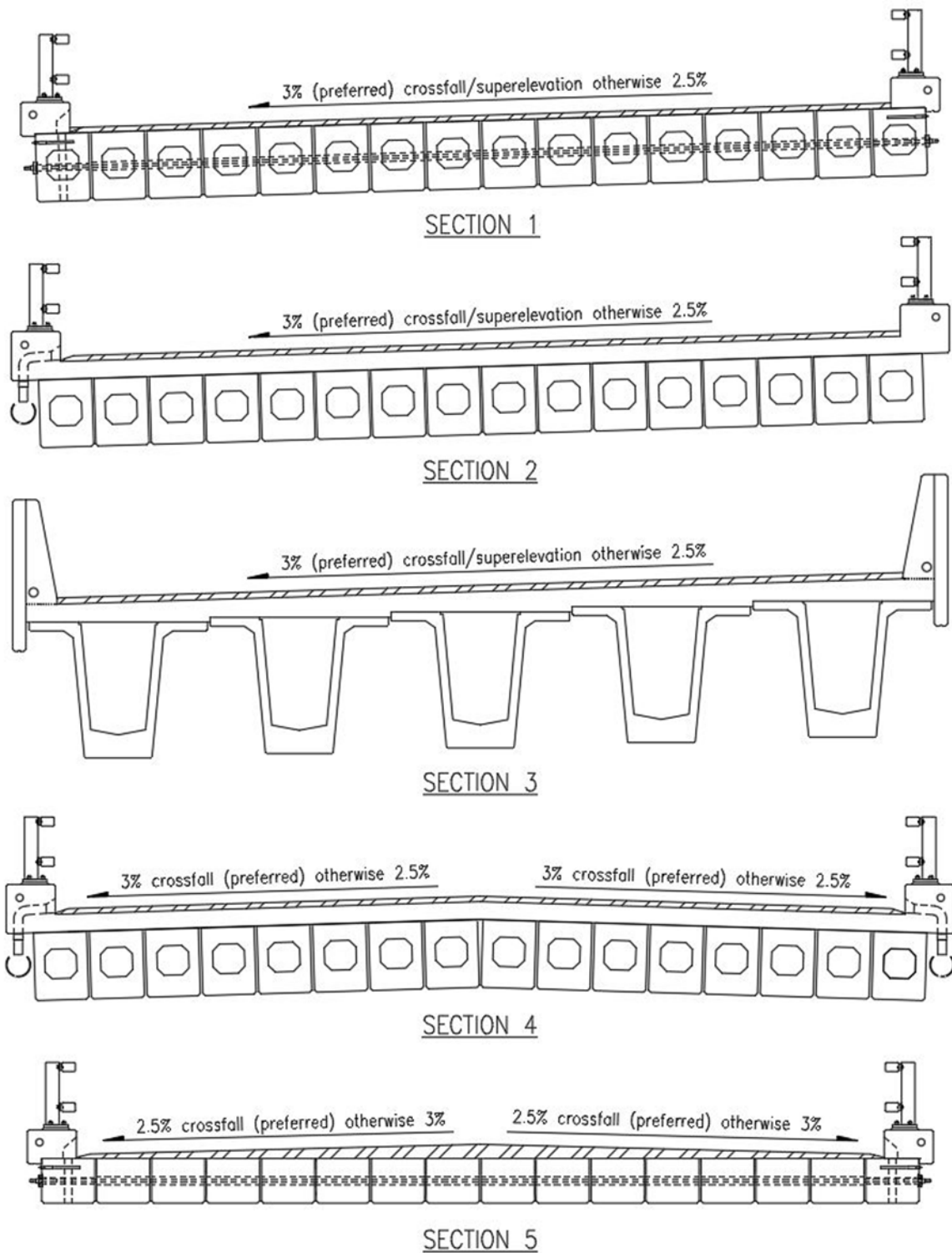


## **4.2 Bridge crossfall and superelevation**

As stated in DCBoS, the crossfall shall be compatible with the geometric road design:

- the minimum crossfall on new bridges is 2.5%
- for widened bridges, this may be similar to the existing bridge
- the maximum crossfall for a footpath is 2.5%, though 2.0% is preferred
- 3.0% is the preferred crossfall for water to run off the road surface as quickly as possible, and suits bridges with a deck or bridges that are superelevated where the deck wearing surface (DWS) is a constant thickness (refer to Sections 1 to 4 in Figure 4.2), and
- 2.5% crossfall is preferred on transversely stressed deck unit bridges without a deck to reduce the DWS thickness (refer to Section 5 in Figure 4.2).

**Figure 4.2 – Bridge crossfall / superelevation**



### **4.3 Deck wearing surface**

Deck wearing surface (DWS) profiles generally fall into 2 categories: decks with 2-way crossfall (crowned) and decks with one-way or constant crossfall (superelevation). The minimum thickness of DWS for PSC deck unit bridges is described in Section 4.11 of DCBoS.

On deck unit bridges, the thickness of DWS is varied to achieve the design profile of the road and to account for the hog of the deck units.

On bridges with a reinforced concrete (RC) deck, the DWS is a constant thickness because the deck accounts for the hog of the deck units and any changes in crossfall / superelevation.

The DWS on bridges typically consists of a tack coat, bituminous waterproof membrane, and a surfacing layer. In some cases, a corrector course is laid between the bituminous waterproof membrane and the surfacing layer. This intermediate layer is used to correct irregularities caused by the hogging of the girders and units or construction tolerances, thereby providing a more uniform base for the final surfacing layer.

DWS can also be used on an RC deck. In such cases, most surface irregularities are addressed during deck construction, and typically only a final surfacing layer is required to achieve a smooth and even running surface.

The overall thickness of DWS should be minimised to reduce the dead load on the bridge, while still being sufficient to:

- accommodate deck hog and construction tolerances
- maintain appropriate crossfall from the bridge centreline, and
- address minor alignment variations over the length of the bridge.

Refer to Section 5 in Figure 4.2 for further guidance.

#### **4.3.1 Thickness of DWS on PSC deck unit bridge with one-way crossfall**

As per Section 4.11 of DCBoS, for one-way crossfall carriageways on PSC deck unit bridges without a cast-in-situ deck slab, the minimum thickness shall be 85 mm on trafficked lanes, 70 mm at kerb.

The 10 mm thick bituminous waterproof membrane is not included when calculating DWS quantities, as it is itemised separately in the schedule.

The thickness of DWS varies along the length of the span due to the hog of the deck units, with the minimum thickness occurring at midspan (refer to Figure 4.3.6(b)).

At abutments and piers, the formula for nominal DWS thickness at the centreline of roadway is:

Half width between kerbs (mm) x crossfall (%) + design hog (mm) at 100 days (or as otherwise advised by the designer) + 85 mm

For example, with:

width between kerbs = 9220 mm,

crossfall = 2.5%,

design hog at 100 days = 35 mm.

then the thickness of DWS at the centreline of abutments and piers will be:

$$\frac{9220}{2} \times 0.025 + 35 + 85 = 235.25 \approx 235 \text{ mm}$$

#### 4.3.2 Thickness of DWS on PSC deck unit bridge with one-way crossfall

As per Section 4.11 of DCBoS, for 2-way crossfall carriageways on PSC deck unit bridges without a cast-in-situ deck slab, the minimum thickness shall be 85 mm constant across the width of the deck.

The 10 mm thick bituminous waterproof membrane is not included when calculating DWS quantities as it is itemised separately in the schedule.

The thickness of DWS varies along the length of the span due to the hog of the deck units, with the minimum thickness occurring at midspan.

At abutments and piers for this instance, the formula for nominal DWS thickness is:

Design hog (mm) at 100 days (or as otherwise advised by the designer) + 85 mm.

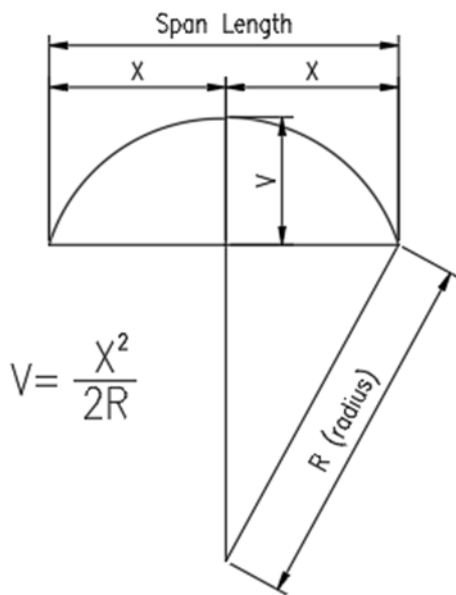
For example, design hog (mm) at 100 days (or as otherwise advised by the designer) = 35 mm, then the thickness of DWS at the centreline of abutments and piers will be:

$$35 + 85 = 115 \text{ mm.}$$

#### 4.3.3 Thickness of DWS on PSC deck unit bridge with 2-way crossfall and vertical curve

Vertical Curves (VC) are not true circles, rather they are parabolic curves. The following formula may be used to calculate the vertical offset (V) on a VC. Note that because the curve is parabolic, the formula is not completely accurate, however, it is usually accurate enough for the purpose of calculating vertical offsets.

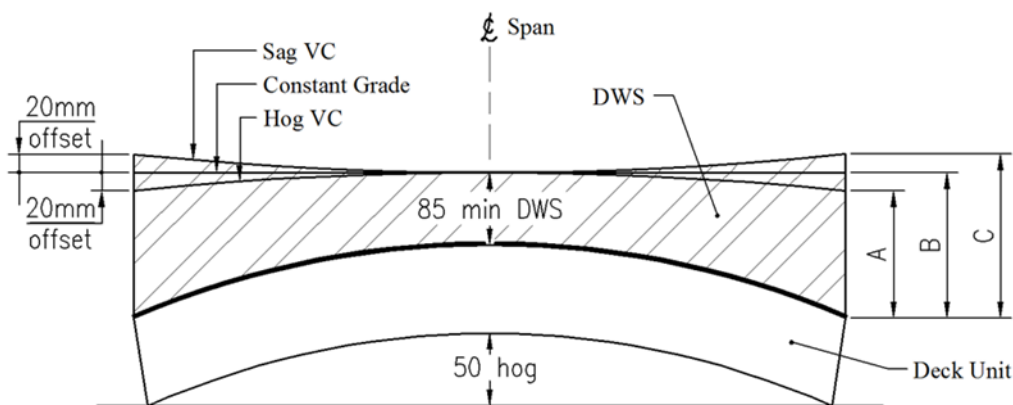
**Figure 4.3.3(a) - Diagram to explain vertical offset (V)**



Consider the following example:

A bridge with a crowned deck is on a crest VC producing a vertical offset of 20 mm per span, which gives an extra 20 mm of DWS thickness from the deck unit at the centre of the span to the running surface. The thickness of DWS required at the abutments and piers should be reduced by 20 mm to maintain the minimum 85 mm thickness at the centre of the span (refer to Figure 4.3.3(b) and the accompanying calculations).

**Figure 4.3.3(b) - DWS profiles for PSC deck unit bridge with 2-way crossfall**



Note: Dimensions shown in the diagram are examples only.

#### 4.3.4 Thickness of DWS at kerb at abutments and piers for 2-way crossfall

Worked examples are as follows:

For Hog VC:                    A        = 50 hog + 85 minimum – 20 offset = 115 mm.

For constant grade:        B        = 50 hog + 85 minimum = 135 mm.

For Sag VC:                    C        = 50 hog + 85 minimum + 20 offset = 155 mm.

Where the offset due to the crest VC is greater than the hog of the deck unit, the minimum 85 mm applies at the abutment and pier kerbs.

The DWS thickness on the kerb line at the centre of the span is 85 mm minimum + offset due to VC.

#### 4.3.5 Thickness of DWS on PSC deck unit bridge with horizontal curve

Superelevation (one-way crossfall) of a horizontally curved bridge deck results in the DWS being shaped in 3D like the edge of a dish. If you cut the edge of a dish in a straight line, the profile of the cut in elevation is a sagging curve. This analogy explains the profile of the DWS on a curved deck over a straight deck unit. The dished effect causes a loss of DWS depth unless it is accommodated by increasing the depth at the abutments and piers.

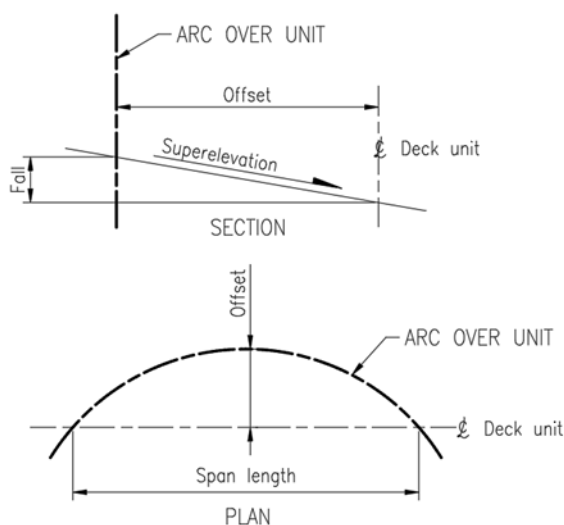
In most cases, the effect is not significant but it should be considered for bridges on tighter curves.

Refer to Table 4.3.5(a) and Table 4.3.5(b) for fall values calculated for 3% and 6%.

Formula to calculate offset allowance for dished effect is:

Fall Value = Offset to curve x superelevation.

**Figure 4.3.5 – Diagram explaining offset allowance for dished effect**



**Table 4.3.5(a) – Dished curve effect sag values (in mm) for 3% superelevation**

Radius (m)	Span Length (m)													
	12	13	14	15	16	17	18	19	20	21	22	23	24	25
<b>Shaded cells indicate where span and radius combinations result in 5 mm or more sag in the deck or DWS</b>														
<b>100</b>	5	6	7	8	10	11	12	14	15	17	18	20	22	23
<b>150</b>	4	4	5	6	6	7	8	9	10	11	12	13	14	16
<b>200</b>	3	3	4	4	5	5	6	7	8	8	9	10	11	12
<b>250</b>	2	3	3	3	4	4	5	5	6	7	7	8	9	9
<b>300</b>	2	2	2	3	3	4	4	5	5	6	6	7	7	8
<b>350</b>	2	2	2	2	3	3	3	4	4	5	5	6	6	7
<b>400</b>	1	2	2	2	2	3	3	3	4	4	5	5	5	6
<b>450</b>	1	1	2	2	2	2	3	3	3	4	4	4	5	5
<b>500</b>	1	1	1	2	2	2	2	3	3	3	4	4	4	5
<b>550</b>	1	1	1	2	2	2	2	2	3	3	3	4	4	4

**Table 4.3.5(b) – Dished curve effect sag values (in mm) for 6% superelevation**

Radius (m)	Span Length (m)													
	12	13	14	15	16	17	18	19	20	21	22	23	24	25
<b>Shaded cells indicate where span and radius combinations result in 5 mm or more sag in the deck or DWS</b>														
<b>100</b>	11	13	15	17	19	22	24	27	30	33	36	40	43	47
<b>150</b>	7	8	10	11	13	14	16	18	20	22	24	26	29	31
<b>200</b>	5	6	7	8	10	11	12	14	15	17	18	20	22	23
<b>250</b>	4	5	6	7	8	9	10	11	12	13	15	16	17	19
<b>300</b>	4	4	5	6	6	7	8	9	10	11	12	13	14	16
<b>350</b>	3	4	4	5	5	6	7	8	9	9	10	11	12	13
<b>400</b>	3	3	4	4	5	5	6	7	8	8	9	10	11	12
<b>450</b>	2	3	3	4	4	5	5	6	7	7	8	9	10	10
<b>500</b>	2	3	3	3	4	4	5	5	6	7	7	8	9	9
<b>550</b>	2	2	3	3	3	4	4	5	5	6	7	7	8	9
<b>600</b>	2	2	2	3	3	4	4	5	5	6	6	7	7	8
<b>650</b>	2	2	2	3	3	3	4	4	5	5	6	6	7	7

Radius (m)	Span Length (m)													
	12	13	14	15	16	17	18	19	20	21	22	23	24	25
<b>Shaded cells indicate where span and radius combinations result in 5 mm or more sag in the deck or DWS</b>														
<b>700</b>	2	2	2	2	3	3	3	4	4	5	5	6	6	7
<b>750</b>	1	2	2	2	3	3	3	4	4	4	5	5	6	6
<b>800</b>	1	2	2	2	2	3	3	3	4	4	5	5	5	6
<b>850</b>	1	1	2	2	2	3	3	3	4	4	4	5	5	6
<b>900</b>	1	1	2	2	2	2	3	3	3	4	4	4	5	5
<b>950</b>	1	1	2	2	2	2	3	3	3	3	4	4	5	5
<b>1000</b>	1	1	1	2	2	2	2	3	3	3	4	4	4	5
<b>1050</b>	1	1	1	2	2	2	2	3	3	3	3	4	4	4

#### 4.3.6 Mass of DWS

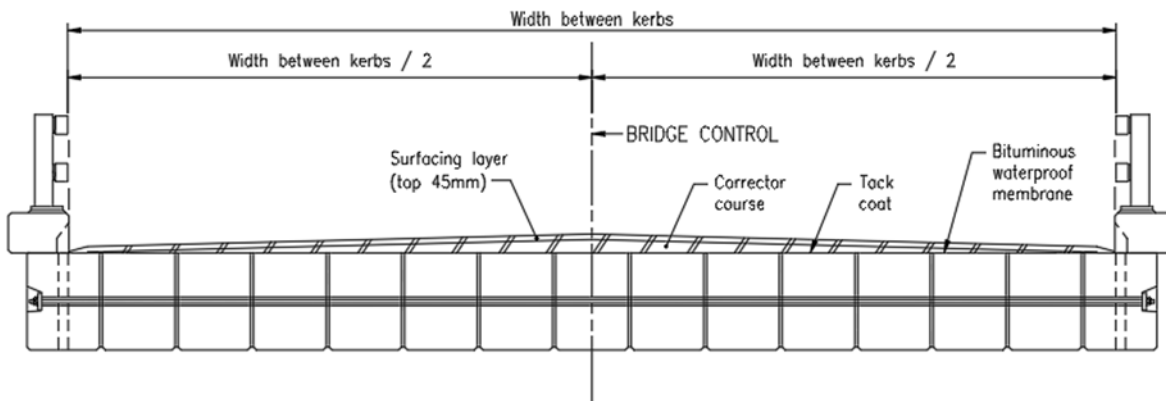
For DWS estimate quantity calculations, the specific density of dense graded asphalt 2.4 tonnes / m<sup>3</sup> shall be used. The total mass shall be shown on the typical bridge cross-section view on the General Arrangement drawings.

Masses are to be adjusted as required for bridges on a VC, and/or with varying superelevation or crossfall.

The mass of bituminous waterproof membrane is excluded in the mass of DWS for all calculations.

The corrector course is calculated as the volume of DWS above the bituminous waterproof membrane and below the surfacing layer (refer to Figure 4.3.6(a)).

The surfacing layer is calculated using the area of deck, including the relieving slabs, x 45 mm thickness for deck unit bridges, or 50 mm for RC deck bridges (refer to Figure 4.3.6(b)).

**Figure 4.3.6(a) – Example deck section showing corrector course and surfacing layer****Sample calculation for DWS mass for a single span:**

Formula to calculate mass of DWS for a deck unit span:

$$\text{Mass} = \text{Density tonnes} / \text{m}^3 \times \text{Volume m}^3$$

Volume = (nominal span length x cross-sectional area of DWS at abutments and piers) – (two-thirds deck unit length x width between kerbs x hog) and noting that all dimensional values are expressed in metres.

Worked example:

Span length (nominal) = 14 m

Minimum depth of DWS at kerbs = 0.045 m

Design hog at 100 days = 0.035 m

Depth of DWS at kerbs at abutments and piers = 0.045 + 0.035 = 0.08 m

Width between kerbs = 9.22 m

Crossfall = 2.5%

Depth of DWS at centreline at abutments and piers (rounded up to nearest 5 mm)  
 $= 9.22 / 2 \times 2.5\% + 0.08 = 0.195 \text{ m}$

Depth of DWS at abutments and piers used for the cross-sectional area = Depth of DWS at centreline – depth of DWS at kerbs = 0.195 – 0.08 = 0.115 m

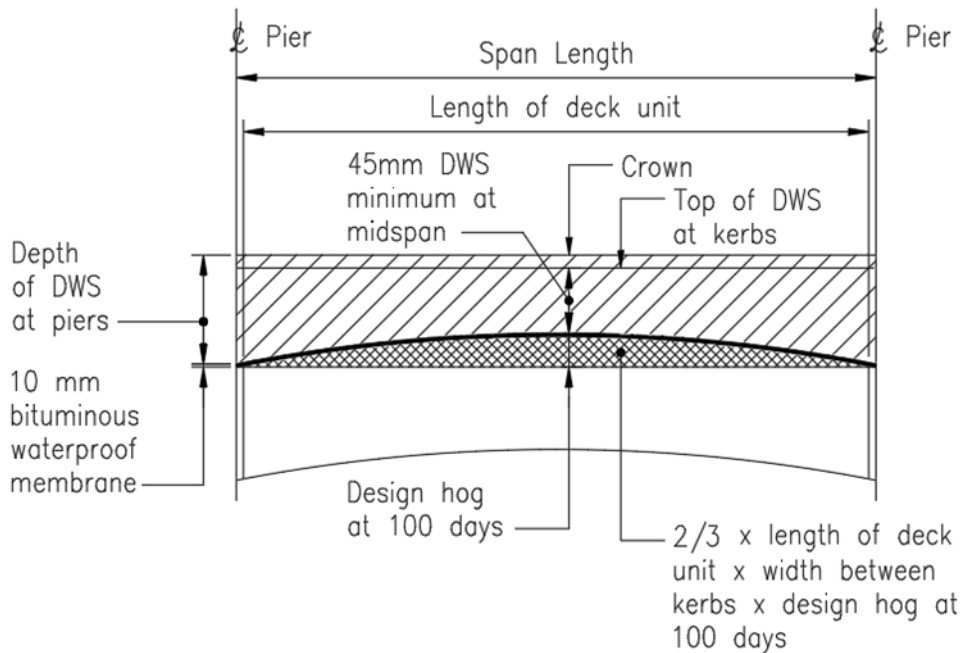
Cross-sectional area of DWS at abutments and piers =  $9.22 \times 0.08 + 9.22 / 2 \times 0.115$   
 $= 1.268 \text{ m}^2$

Mass of DWS for one span =  $2.4 \times (14 \times 1.268 - 2/3 \times 13.95 \times 9.22 \times 0.035)$   
 $= 35.402 \text{ tonnes}$

Mass of surfacing layer =  $2.4 \times (14 \times 9.22 \times 0.045) = 13.941$  tonnes, rounded up = 14.0 tonnes

Mass of corrector course =  $39.266 - 14 = 25.266$  tonnes, rounded up = 25.3 tonnes.

**Figure 4.3.6(b) - Diagram for mass of DWS for deck units**



**Sample calculation for DWS mass for a relieving slab**

Formula for mass of DWS for one relieving slab:

Mass = Density x length of relieving slab/cos (skew) x cross-sectional area of DWS at abutments and piers.

Using the previous worked example with a 15° skew, the mass of dense graded asphalt DWS on a 3 m long relieving slab =  $2.4 \times 3 / \cos (15) \times 1.383 = 10.31$  tonnes.

**Mass of DWS for reinforced concrete decks**

Formula for mass of DWS for one span"

Mass = Density x nominal span length x cross-sectional area of DWS at abutments and piers.

## 5 Drafting a pier headstock – geometric considerations

Once the horizontal alignment and grade of the bridge control have been established, the next step is to determine the locations of abutments and piers along the bridge control. At each intersection of bridge control and centreline of abutment or piers, the design height of the DWS is used as a reference to calculate the structural heights down to the bearing shelf of each headstock.

The following procedure outlines the method for accurately drafting the headstock geometry for an abutment or pier in all 3 planes, eastings, northings, and heights, considering the effects of skew, crossfall and superelevation.

### 5.1 Procedure for drafting a headstock in all 3 planes

The initial step in setting out a headstock is to determine its height relative to the set out point (SOP). From this reference, the elevations at the extremities of the headstock can be calculated, accounting for skew, crossfall, and any vertical curvature.

To accurately define the headstock geometry in all 3 spatial planes, the following geometric information is required:

- bearing or radius of the bridge control
- grade of the bridge control
- span lengths between headstock centres
- instantaneous skew at each pier (may change for a horizontally curved control)
- an understanding of the deck section at the pier(s) including the bridge control, crossfall, or superelevation of the deck, and all the superstructure present, namely, the DWS thickness, cast-insitu deck thickness if present, the type, number, and spacing of girders or deck units used, and associated bearings or mortar
- layout diagram in plan showing both the upper and lower faces of any deck units (these will be different due to crossfall / superelevation which produces an offset to formed hole locations)
- hog values of the girders or units, and
- pre-camber values of cast-insitu deck if present.

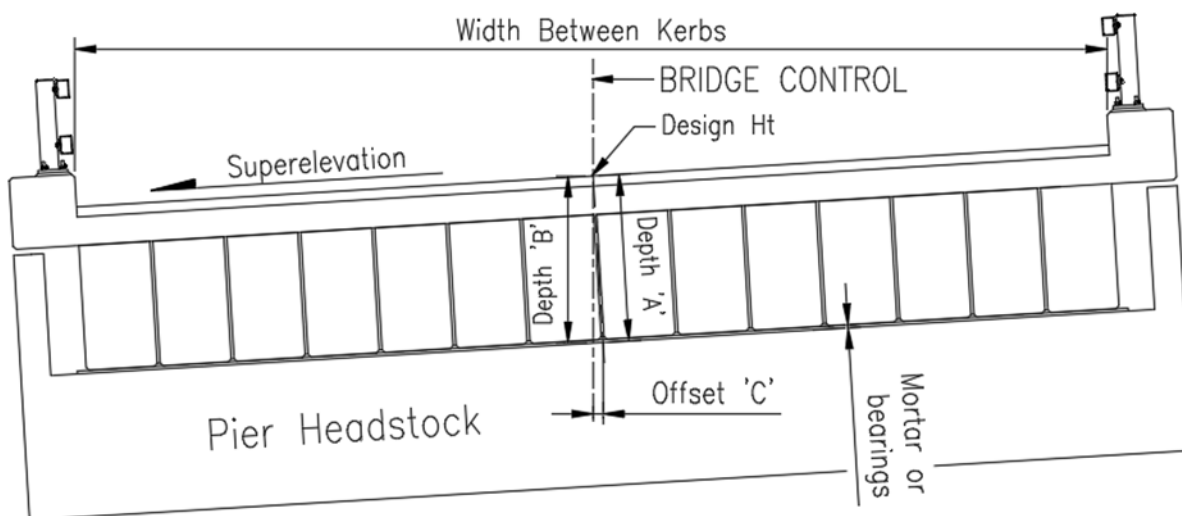
NOTE: Each value shall be verified to match project specific design.

#### 5.1.1 Method for calculating the height of bearing shelf for the headstock below the set out point

- Set up the horizontal alignment (bridge control) and vertical alignment.
- Locate the abutment and pier positions along the bridge control.

- Derive the coordinates of the set out point (SOP) for each abutment and pier along the bridge control, being that point where the centreline for the headstock intersects with the bridge control.
- Derive the DWS design height at each SOP.
- On the deck section, if there is significant superelevation, it is more accurate to use the superstructure depth normal to the superelevation from top of DWS to top of bearing shelf of headstock at the SOP. An example is provided and labelled Depth A in Figure 5.1.1.
- For a square bridge, the resultant Offset C is used to adjust Depth A to derive the vertical superstructure depth, Depth B, and then the bearing shelf Height on the headstock below the SOP (refer to worked example for application of these values).
- For a deck unit bridge with cast-insitu deck, the deck thickness is to be adjusted for pre-camber of the deck and hog of the deck units, and
- For a tightly curved structure as seen in the worked example, on a significant superelevation an allowance for the 'dished curve effect' is to be made to the deck thickness. This effect is the result of the deck sagging in section over any straight section. In this example case, this effect occurs over each deck unit.

**Figure 5.1.1 – Diagram of section at pier for worked example**



If a significant crossfall exists, the deductions for DWS, deck, girders, deck units and bearings may be applied normal to the crossfall (refer diagram above), where Depth A is the superstructure depth applied normal to the superelevation, and Depth B is the resultant vertical depth.

For a 6% superelevation, the difference between Depth A and Depth B can be 5 mm or more.

A horizontal Offset C to the centre point of the headstock will result from any superelevation. This offset, when viewed on the section deck, is square to the control, and so shall be adjusted for skew to calculate the actual offset along the pier centreline. This dimension is critical to accurately locating the PSC units in relationship with the deck transversely.

Girders are set vertically and so the offset, if any, will be minor.

### **Worked example and formulae:**

For a bridge on 200 m radius with 6% superelevation, 200 mm minimum thickness cast-insitu deck, 30 mm camber (being 45 mm for hog less 15mm pre-camber), 22 m spans, 900 mm deep deck units, 27 mm thick bearings in 10 mm deep recesses.

Because this is a tightly curved structure, on a significant superelevation, an allowance for the 'dished curve effect' is to be made to the deck thickness.

Formula for 'dished curve effect' allowance to be added to deck thickness =  $[(\text{half span length} \times \text{half span length}) / (2 \times \text{radius})] \times \text{superelevation}$ .

For this example, dished effect allowance =  $[(11 \times 11) / 400] \times 0.06 = 18 \text{ mm}$ .

Formula for adjusted deck thickness = minimum deck thickness + hog – pre-camber + dished curve effect.

For this example, adjusted deck thickness =  $200 + 45 - 15 + 18 = 258$ .

Depth A = DWS + adjusted deck thickness + unit + bearing or mortar

For this example, Depth A =  $85 + 258 + 900 + 27 - 10 = 1260 \text{ mm}$ .

Offset C = Depth A x superelevation.

For this example, Offset C =  $1260 \times 0.06 = 76 \text{ mm}$ .

Depth B = Depth A + Offset C x superelevation

For this example, Depth B =  $1260 + 76 \times 0.06 = 1265 \text{ mm}$ .

And so, when Depth B is applied, height of bearing shelf at SOP = DWS design height – 1265.

### **5.1.2 Method for calculating the heights at the headstock extremities**

Having established the height at the SOP, the heights at the pier extremities can now be calculated.

For a square bridge, step out from the SOP along the headstock centreline slope downwards or upwards for the required offset length, as per the deck section, to each headstock extremity.

Formula for height of bearing shelf at extremity on square bridge = Offset length x superelevation DWS design height – Depth B.

For a curved deck with a superelevation, these slopes are easiest calculated by measuring the chainage and offsets to the pier headstock extremities in plan view. The grade at each chainage can be used to calculate the design DWS height at that point and then the same formula for square bridge can be used to find the height over each headstock extremity.

For headstocks where the fall from front to back is 5 mm or less, the heights may be rationalised by defaulting to the lower of the 2 values.

## **6 Design considerations for low-level frequently flooded bridges**

For the purpose of this document, a bridge is classified as a low-level and frequently flooded when its superstructure may be partially or fully submerged by a flood smaller in magnitude than a 20-year average recurrence interval (ARI).

The following general guidelines are intended to assist road designers and structural engineers, in consultation with hydraulic and geotechnical specialists, in optimising design and reducing construction complexity cost.

### **Crossfall / Superelevation:**

- A 2-way crossfall is generally recommended to facilitate drainage.
- Superelevated decks may be used but require careful consideration:
  - If the fall is toward the upstream side, debris and silt accumulation is more likely after flood water recedes, and
  - If the fall is toward the downstream side, debris may become trapped beneath the deck, uplift forces may increase, though the deck surface is generally cleaner post-flood.
- A constant crossfall / superelevation is preferred for simplicity. Variable crossfall / superelevation may be accommodated but adds to the complexity of the drafting and causes other complexities such as deck drainage issues.

### **Vertical alignment:**

- A level deck is preferred to allow the bridge to function as a weir during overtopping events, promoting uniform flow distribution. Bridges on a grade or VC may concentrate flow at the low end, increasing turbulence and the risk of scour or erosion.
- If a level deck is not possible, a small constant grade is preferred.

- Where stormwater discharge into the stream is restricted, a small crest VC may be introduced, with the crest positioned near mid-space to direct runoff towards the abutments, and
- Combinations of these vertical alignment strategies can be used but are generally discouraged due to increased hydraulics complexity.

#### **Horizontal alignment and skew:**

- Where possible, the alignment should be designed to minimise the length and skew of the bridge. This may be achieved by traversing the watercourse as square as possible to the direction of the floodwater flow. A bridge on a HC, or a bridge that is not square to the flow, may direct water towards the downstream abutment., increasing erosion risk.
- In practice, bridges are often skewed to align abutments and piers parallel to the floodwater flow. Variable skew can be accommodated to suit HC, and
- Skews of 30° or less are preferred, as they conform to the department's published standards to simplify girder and unit design.

## **7 Geometric considerations for bridges and other structures over waterways**

The following principles support cost effective and constructible solutions for structures in waterways:

#### **Crossfall / Superelevation:**

- Constant crossfall / superelevation is preferred, and
- Varying crossfall / superelevation can be accommodated but should be avoided where possible.

#### **Vertical alignment:**

- A minimum longitudinal grade of minimum 0.3% is recommended to facilitate post-flood drainage. This should be adopted where it can be reasonably achieved through approach roadworks.
- Where direct drainage into the stream is restricted, a small crest VC may be introduced to direct runoff towards abutments, and
- A combination of grade and VC is acceptable but should be avoided unless necessary.

### **Horizontal alignment and skew:**

- Ideally, the structure should be straight and aligned as square as possible to the direction of the floodwater flow. This will reduce the skew and the length of the structure.
- A structure crossing a stream is usually skewed so that the abutments and piers are parallel to the floodwater flow. Varying skews may be required to suit HC, and
- Similarly, a culvert structure crossing a stream is skewed so that the culvert cell walls are parallel to the floodwater flow.

