SECTION 5

SETTING OUT
5 SETTING OUT

5.1 GENERAL

The geometry of the road defines the shape of the bridge (more particularly the deck). The geometry of the deck therefore must be defined before that of the substructure and footings and/or piles. Road design information and bridge site survey information provide relevant coordinates, alignment data etc. Generally setting out is carried out by one of two methods;

a) alignment method (chainage and offset)
b) a coordinate system

For structures which are on a straight alignment, setting out should be carried out using the control line. The use of chainages and offsets is the preferred method, however, coordinates may be used.

Chainages and offsets or, alternatively, coordinates may be used to locate the centre of elements ie spread footings etc as shown in Figure 5.6 whilst the dimensions for each particular element shall be related to the defined location and shall be normal to the element centreline (defined by a grid bearing).

The preparation of a CAD Base Plan as a design aid for the purposes of checking the setting out of structures is strongly recommended as it may be used to verify dimensions.

5.2 CHAINAGES

Chainages, give along the Control Line, shall be adopted from the road design and/or site survey information provided.

Where possible and practical, chainages for the centrelines of piers, bearings etc shall be given in metres to the nearest 0.005 metre, eg. 320.605. Chainages being used for calculating purposes shall not be rounded off.

Chainages with values in excess of 1 km shall be given in metres, eg. 320.605 NOT 2 km 320.605 except at the beginning of the alignment or when the km values change along the alignment. In such cases the full chainage shall be shown in the following manner: eg 2km 320.605.
5.3 COMPASS BEARING

The bearing of a line is the angle measured clockwise from grid north to the subject line and is given in degrees, minutes and seconds.

The bearing of the Control Line shall always be given in the direction of increasing chainage along the line.

The bearing of a line is relative to where one is stationed, See Figure 5.3.

5.4 COORDINATES

The coordinate system adopted for a project may be an arbitrary local one, ISG (Integrated Survey Grid) or GDA (Geocentric Datum of Australia).

The coordinates are normally quoted in metres to the nearest 0.001 metre. In recording both GDA and ISG coordinates, the Easting is always placed before the Northing.

The following procedure is recommended for the listing of coordinates.
At the head of any listing of coordinates the figures common to all coordinates are noted as constants. These constants, one for the Eastings and one for the Northings are subtracted from all coordinates in the coordinate list and in the computations, in order to avoid carrying redundant digits. A gap shall be placed between the third and fourth figures, and also between the sixth and seventh figures from the decimal point to assist in the alignment of figures, as indicated in the example below.

<table>
<thead>
<tr>
<th>Location</th>
<th>E</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200 000.000</td>
<td>1 100 000.000</td>
</tr>
<tr>
<td>A5</td>
<td>155.161</td>
<td>115.153</td>
</tr>
<tr>
<td>B27</td>
<td>311.002</td>
<td>351.854</td>
</tr>
<tr>
<td>B39</td>
<td>101.113</td>
<td>295.695</td>
</tr>
<tr>
<td>C11</td>
<td>115.354</td>
<td>015.706</td>
</tr>
</tbody>
</table>

The coordinates shall be obtained from the road design and/or the site survey information. The method of calculating the length and bearing of a line between two coordinated points is given in Figure 5.4. Alternatively, where electronic survey or design information is available, required information may be measured directly from the electronic file.

Generally, lists of coordinates can be obtained by electronic means and this information can be transferred to drawing files on the CAD System.

5.5 PILES

The setting out of the piles shall be shown on a “Pile Layout”. This drawing is not necessarily to scale but should have reasonable proportions. On curved bridges it is sometimes advantageous to exaggerate the curvature to show dimensions more clearly. Horizontal alignment data for the Control Line shall be provided on the pile layout drawing.

The pile layout should be shown on Pile Detail Sheet where possible and include all information necessary for the positioning of the piles. Generally piles are in a straight line or groups.
Piles in one line: The centreline of the pile group shall be defined by chainage and bearing to the Control Line with the location of each individual pile being dimensioned from the intersection of the control line and the centreline of piles, parallel / normal to the centreline of the piles.

Piles in a group: The centre of the pile group shall be defined by a chainage and bearing to the Control Line together with a dimension from the Control Line or alternatively by a set of coordinates with the location of each individual pile being dimensioned from centre of the pile group parallel / normal to the centreline of the piles.

Raked piles - Where raked piles are used, a note shall be added to the drawing to indicate that the location shown is at a nominated RL (usually the top of pile). Raked piles shall also have the degree of rake shown together with an arrow to indicate the direction of the rake in relation to the centreline of piles.

Where raked piles are in two or more rows beneath a pilecap, a dimension between the design location of pile centrelines at the top of the finished pile shall be provided. For examples of pile setting out, refer to Section 6 of this Manual.

5.6 FOOTINGS

The setting out of footings on structures with complicated geometry shall generally be shown on a “Footing Layout”, however on straight, square bridges, the location of footings can be clearly indicated on the plan of piers or abutments.

The “Footing Layout” shall indicate plan dimensions of individual footings and relative position in relation to a known point, see Figure 5.6. Where a layout is a combination of piles and footings it shall be known as a “Foundation Plan”.

The “Footing Layout” does not necessarily need to be to scale, however it should be reasonably proportioned. On curved bridges it is advantageous to exaggerate the curvature in order that dimensions may be shown more clearly.

Horizontal alignment data for the Control Line shall be provided on the Footing Layout drawing.

5.7 PIERS AND ABUTMENTS

Each part of a pier or an abutment shall be defined from a known point (such as the intersection of the pier centreline or the end of deck and the Control Line. NEVER dimension from footings or piles when setting out columns, ALWAYS dimension from a known point. By always dimensioning from a known point, the chance of compounding any differences in location due to allowable construction tolerances can be greatly reduced.

Curved Bridges

Bridges on geometric and/or transition spirals and more particularly those on skews, could have supports of varying lengths. Ends of spans may not be parallel and this should be particularly noted when setting out the superstructure and wingwalls.

5.8 BEARINGS

Bearings shall be set out from either the pier centreline or abutment curtain wall and a known point eg. the intersection of the Control Line and the centreline of pier.

Where bearings are not parallel to the pier centreline, the orientation shall be indicated on an enlarged detail. The setting out details shall be shown on the pier or abutment by means of formed holes for bearing anchor bolts or dowels as appropriate. A Northpoint shall be included on all Plan views where setting out information is shown.
5.9 GIRDERS

Girders are placed at bearing locations. Bearing locations shall be indicated on pier and abutment drawings.

Curved Bridges
Care shall be exercised when locating girders due to the variations caused by the curvature. It should be noted that variations become greater on skewed bridges.

Steps for calculating spacing and length of girders - (using Figure 5.9 as an example).

i. Given number of girders (n) and approximate spacing(s), locate outside girders at abutment and pier. Initially spacing should be worked out on pier centreline and front face of curtain wall. Spacing will be converted to skew.

ii. The width of the deck may vary between the abutment and pier and between the piers. In such cases the spacing of girders/planks must be adjusted so that x’s are approximately equal and y’s are approximately equal. Generally several locations need to be trialled to determine which is the best fit.

iii. When satisfied with the fit of the girders/planks in Span 1, repeat the procedure for Span 2 or, if required, other spans.

   Attempt to maintain the spacing at the pier and adjust the spacing at the abutment so that the 'x's' are approximately equal and so are the 'y's'.

iv. When satisfied with spacing fit, the length of the girders needs to be determined. Determine the length of each individual girder from the centreline of the pier to the front face of the curtain wall and compare the differences.

v. If the girders are to be the same length then the distance from the end of the girder to centreline of the pier or the front face of the abutment needs to vary across the span and from span to span.

vi. Abutments and piers shall be checked to ensure that bearings will fit on headstocks. If the variation is too great, the skew of the supports may need to be adjusted to suit (ie supports may not be parallel).

Radial Supports

Radial supports are not normally considered when using girders but they may be an option provided that the length of the span on the outer curve is not significantly greater than that on inner curve. If the variation is not great, then constant length girders can be used. This can be achieved by varying the distance from centreline of pier to centreline of bearings.

The use of girders of many different lengths is neither practical or economical and should be avoided.

5.10 DECK

5.10.1 General
As stated in Clause 5.1, setting out must start with the deck and then moved down through girders, bearing, piers and abutments, and finally footings and/or pile caps and piles.

In general, all bridge structures shall be set out in accordance with the principles shown in Figure 5.1

5.10.2 Determination of parameters

For a bridge of length 30 m or less with a mid-ordinate of D = 50 mm or less, the horizontal alignment of the bridge shall be straight, ie. the chord of the arc between the ends of the deck.

For a bridge over 30 m long with a horizontal mid-ordinate of D = 75mm or less, the horizontal alignment of the bridge shall also be straight, eg. a bridge 40m long with a Control Line on radius 2700m gives D = 74mm, so the bridge shall be straight.

No increase in road width is necessary in such cases (other than that required by the RTA Road Design Guide).

The mid-ordinate can be found with the formula: 
\[ D = R - 0.5 \sqrt{4R^2 - C^2} \]

See Figure 5.10(a)

For any other bridge the horizontal alignment of the deck is to be set out on the curve or in chords of such length that the mid-ordinate between the chord and the curve does not exceed D = 5 mm. The maximum length of this chord can be found with the formula C = \sqrt{40R}. See Figure 5.10(a).

However, for a simply-supported bridge when the length of the span is less than this chord, the horizontal alignment is to be set out from pier to pier.

For spans up to and including 12 metres, where the mid-ordinate of individual spans is 10mm or less and the angular deviation from one span to the next is less than one degree (1°), consideration shall be given to making individual spans straight. See Figure 5.10(b).

If individual spans are set out as being straight on structures which will carry barrier railings, careful examination of railing joints shall be made to ensure that the angular difference can be accommodated.

5.10.3 Procedure

Set up a “Base Plan” on CAD. The base plan initially includes Control Line outline of parapets, kerb lines, median, coordinates of main points, chainages, bearings, radii, etc. Location of piers, abutments may then be superimposed on the base plan. If drawn accurately many dimensions for elements may be measured directly off the plan. Information such as length of abutments, piers, angles of wing walls, lengths of railings etc may be measured. Although values will be correct if basic input is correct, they should be checked independently.

Final details of deck setting out shall include a Plan, Cross Section and Table(s). See Figure 5.1, Sheets 1 and 2.

On curved structures, where the piers, abutments and ends of superstructure are skewed to the Control Line, the setting out information at supports shall be given along the skew.

The setting out data for all other chainage increments shall be given radially. See Figure 5.1, Sheets 1 and 2.
Skew angles for curved structures shall be defined in a Skew Diagram as shown on Sheet 2 of Figure 5.1.

Reduced levels for selected points on the cross section shall be given to the top of the finished concrete surface, not the top of the asphalt wearing surface.

The Plan view shall show the outline of the deck, the Control Line, the ends of deck and the pier centrelines. Locations of the deck accessories may be shown, however it is preferable that they be shown on a separate deck layout plan. The Plan view is generally not to scale and the curvature shall, in most cases be exaggerated for clarity.

Setting Out Tables shall show the values of offsets and levels at chosen locations along bridge.

Increments for cross sections taken along the bridge should not exceed the following:

<table>
<thead>
<tr>
<th>Radius (m)</th>
<th>Increment (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1.5</td>
</tr>
<tr>
<td>100</td>
<td>2.0</td>
</tr>
<tr>
<td>150</td>
<td>2.5</td>
</tr>
<tr>
<td>200</td>
<td>3.0</td>
</tr>
<tr>
<td>300</td>
<td>3.5</td>
</tr>
<tr>
<td>400</td>
<td>4.0</td>
</tr>
<tr>
<td>500</td>
<td>4.5</td>
</tr>
<tr>
<td>1000</td>
<td>5.0</td>
</tr>
<tr>
<td>2000 and straight bridges</td>
<td>10.0</td>
</tr>
</tbody>
</table>

The increments shown are guidelines only and values should be adjusted to suit span lengths etc.

### 5.10.4 Bridge on a Curved Vertical Alignment

For a bridge of length 30 m or less on a sag vertical curve only with a mid-ordinate over the length of the bridge of \( D = 50 \) mm or less, the vertical alignment of the bridge shall be straight.

Levels can be calculated using the Vertical Curve Geometry program or the Bridge Deck Geometry program, each of which is loaded on Bridge Section PC’s. The maximum increment used in the program and to be shown on Table of Levels shall be the value \( C \).

An example of setting out points that should be included are shown in Figure 5.1.

Increments for cross sections taken along the bridge shall not exceed the following:

(i) Increments determined for straight bridges or for bridges on a curved horizontal alignment above and

(ii) The difference between the vertical curve and the chord between the two sections must not exceed 20mm.

### 5.10.5 Information required on drawings where it is not required for construction

Where it is positively known that the provision of deck setting out information, as defined in Clauses 5.10.1 to 5.10.4 of this Manual, will not be required for construction purposes, such as on large Design/Construct/Maintain or Public Private Partnership type contracts where an interactive Design Model File, used in conjunction with survey equipment
method of setting out may be used, the information for deck offsets and Reduced Levels shall be provided on the drawings for records and maintenance purposes, however, the spacing of cross sections as defined in Clause 5.10.3 of this Manual may be increased to double the increments shown in Clause 5.10.03, up to $R = 10\,000\text{m}$. The maximum increment will remain the same at 10.0m.

### 5.11 BARRIER RAILINGS

All types of barrier railings shall be divided into panels of a length which are not difficult to handle and erect.

Approximate maximum panel lengths are:
- 6000 mm for traffic barrier railings and
- 3000 mm for pedestrian railings

Panel lengths and post spacing should be calculated along a concrete edge (usually the inside top edge of the concrete safety barrier for traffic barrier railings and the outside edge of the footway for pedestrian railings). Spacing of posts and hence bolt groups, shall be given horizontally in accordance with Figure 5.11.

Where traffic barrier railings are used, each panel shall have a maximum of two posts, as a general rule, to facilitate ease of erection. On rare occasions, it may be necessary to detail panels containing three posts to ensure that panels can be placed to clear expansion joints and other obstructions.

**The detailing of railing panels containing three posts shall be kept to an absolute minimum, especially on curved bridges.**

When structures are constructed on grades of less than 4%, anchor bolts for all types of railings shall be cast-in normal to the concrete surface. See Figure 5.11.

When the grade on any structure is 4% or greater at any one point, anchor bolts for traffic barrier railings shall shall be cast-in so that they are truly vertical over the full length of the structure. See Figure 5.11.

Where aluminium pedestrian barrier railings are used on any structure, the anchor bolts for the railing shall be cast-in so that they are truly vertical in all cases. See Figure 5.11.

In all cases, the spacing of anchor bolt groups shall be given horizontally in accordance with Figure 5.11.
TABLE 1 - HORIZONTAL ALIGNMENT DATA FOR CONTROL MC01

<table>
<thead>
<tr>
<th>POINT</th>
<th>LOCATION</th>
<th>EASTING</th>
<th>NORTHING</th>
<th>BEARING IN</th>
<th>BEARING OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCN</td>
<td>CENTRE OF CIRCLE</td>
<td>4369.378</td>
<td>3838.305</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>HTP1</td>
<td>CH 34 345.996</td>
<td>4883.368</td>
<td>4022.478</td>
<td>233° 58' 8.7&quot;</td>
<td>—</td>
</tr>
<tr>
<td>HTP2</td>
<td>CH 34 329.515</td>
<td>4993.377</td>
<td>3808.153</td>
<td>—</td>
<td>235° 34' 1.0&quot;</td>
</tr>
</tbody>
</table>

FIGURE 5.1

VERTICAL ALIGNMENT DIAGRAM

NOT TO SCALE

LENGTH OF VERTICAL CURVE = 233 000

TABLE 1 - HORIZONTAL ALIGNMENT DATA FOR CONTROL MC01
The coordinates of a point \((X_1Y_1)\) given its distance \((L)\) and bearing \((\theta)\) from a co-ordinated point \((X,Y)\) can be calculated by the following formulae:

\[
\begin{align*}
X_1 &= X + L \sin \theta \\
Y_1 &= Y + L \cos \theta
\end{align*}
\]

The length of the lines OA, OB, OC and OD is given by

\[
\sqrt{(\Delta X_1)^2 + (\Delta Y_1)^2}
\]

\[
\theta = \tan^{-1} \left( \frac{\Delta X_1}{\Delta Y_1} \right) = \tan^{-1} \left( \frac{\text{DIFERENCE IN EASTINGS}}{\text{DIFERENCE IN NORTINGS}} \right)
\]

Bearing of line OA in first quadrant = \(\theta\)
- OB in second quadrant = 180 - \(\theta\)
- OC in second quadrant = 180 + \(\theta\)
- OD in second quadrant = 360 - \(\theta\)

**Figure 5.4**
SHEETS No 14 AND 15 FOR PIER FOOTING DETAILS.

PLAN

- Indicates dimension normal to E of footing and piers and front face of curtainwall at abutments
- Indicates dimension parallel to L of footing and piers and front face of curtainwall at abutments

Dimensions shown for footings on southbound bridge are typical for similar locations on northbound bridge.

NOT TO SCALE

GENERAL NOTES

Scales as shown. See sheets No. 4 and 5 for abutment footing details and sheets No. 16 and 17 for pier footing details.

FIGURE 6.8
**MID-ORDINATE RULE**

The mid-ordinate, $D$, can be found using the formula:

$$D = R - \frac{1}{2} \sqrt{4R^2 - C^2}$$

**FIGURE 5.10(a)**

**DETERMINATION OF CURVATURE**

$D = 10$ mm or less

Typical

**FIGURE 5.10(b)**
ANCHOR BOLT GROUP ELEVATION
FOR TRAFFIC BARRIER RAILINGS

For grades greater than 4%, anchor bolts for all traffic barrier railings shall be truly vertical.

ANCHOR BOLT GROUP ELEVATION FOR STEEL PEDESTRIAN BARRIER RAILINGS
Not to scale

ANCHOR BOLT GROUP ELEVATION FOR ALUMINIUM PEDESTRIAN BARRIER RAILINGS
Not to scale

FIGURE 5.11