Traffic Control Devices for Horizontal Curves

Operational Instruction 2.1

March 2025

Government of South Australia
Department for Infrastructure and Transport

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We acknowledge the Traditional Custodians of the Country throughout South Australia and recognise their continuing connection to land and waters. We pay our respects to the diversity of cultures, significance of contributions and to Elders past, present and emerging.

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1 Scope

This document shall be read in conjunction with the requirements of Australian Standard *AS 1742.2 Manual of Uniform Traffic Control Devices Part 2: Traffic Control Devices for General Use (2022)* Clause 4.3 in relation to the treatment of substandard horizontal curves. It provides specific guidance on determining advisory speeds and locating Curve Alignment Markers (CAMs).

On some local roads drivers' response to the road environment, terrain, geometry, traffic volume and composition will normally reduce their expectation that all curve delineation traffic control devices will be in place. Devices for the treatment of horizontal curves may not therefore be required on such roads, including residential streets in urban areas and very low volume rural roads and severely geometrically constrained rural roads where there is an expectation of the restricted environment by the road user.

When used in accordance with this Operational Instruction, these traffic control devices may be installed under the Minister's *Instrument of General Approval and Delegation to Council*, or the *Instrument of Authorisation and Delegation* to the Department's Network Management Services. Traffic control devices which vary from this Operational Instruction require the separate approval of the Manager, Traffic Services for each location prior to installation.

2 Advisory speeds

The advisory speed for a curve is obtained by measuring the centripetal force exerted on a vehicle when travelling around a curve at a particular speed, and from that information, the travel speed can be determined when the centripetal force is at the predetermined acceptable maximum.

A horizontal curve is considered to be substandard if the advisory speed of the curve is at least 15 km/h less than the 85th percentile speed on the immediately preceding section of road.

W1-3(R) with W8-2

The advisory speed sign (W8-2) is used to recommend the speed for comfortable and safe travel through a curve. The geometry of the curve shall be indicated by the accompanying warning sign.

This speed is a maximum based on good weather, traffic and road conditions. If the measured advisory is less than 15 km/h below the posted speed limit speed, no advisory speed sign is used. However, the appropriate curve or warning sign should be displayed.

When speed limits are altered, a survey should be made of all advisory speed signs within the zone to ensure they are correct and they do not indicate an advisory speed either above the new speed limit, or within 15 km/h below the new speed limit. Speed limit signs and advisory speed signs should not be placed where drivers can read both at the one time.

3 Methods for determining an advisory speed

This instruction outlines the two methods by which advisory speeds on substandard horizontal curves are determined.

3.1 The desktop method (road geometry data acquisition system method)

This method requires known road geometry to determine an advisory speed. It is based on the findings of the Transfund New Zealand *Research Report 226 Curve Advisory Speeds in New Zealand (2002).*

Where available, design plans should be sought to establish the correct curve radius. If plans are not available, then the procedure in Appendix A may be adopted to determine the radius on site. The radius can also be scaled from aerial images following the geometric principles in Appendix A.

The following formula can be used to determine the Advisory Speed AS (km/h), comparable to VA using the ball bank indicator method.

$$AS = -\left(\frac{107.95}{H}\right) + \sqrt{\left(\frac{107.95}{H}\right)^2 + \left[\frac{127{,}000}{H}\right]\left[0.3 + \frac{X}{100}\right]}$$

where:

H = Absolute horizontal curvature = 1000 / (Radius in metres)
X = % gradient crossfall

3.2 The ball bank indicator method

The method described in Appendix F of *AS 1742.2 (2022)* is included in this document for ease of reference.

Only experienced engineering or technical personnel should perform the ball bank procedure. The details outlined within this instruction should be considered supplementary to engineering and technical judgement and not a replacement for it.

Alternative instruments such as digital devices or mobile phone apps capable of measuring the ball bank angle may be used in lieu of the ball bank indicator described in *AS 1742.2 (2022*) Appendix F, provided that they are capable of being mounted in the correct plane, levelled, and read to the nearest ±0.5 degree.

3.2.1 Procedure

a) Calibrate the vehicle speedometer:

Driving the vehicle at a constant speed over an accurately measured distance and noting the variation between indicated and true speed will allow the calibration of the vehicle speedometer. This step is to be

repeated three or four times at approximately equal increments of speed so as to provide coverage of the range of speeds likely to be used in surveys.

A calibration to plus or minus 1 km/h will be adequate for this survey. Ideally the survey vehicle should be fitted with 'Cruise Control' to assist with accuracy.

b) Calibrate the ball bank indicator:

Level the instrument by parking the vehicle on a flat surface with driver and observer aboard and adjust the device to the zero mark.

c) Survey the curve:

Calibrate the vehicle in accordance with the procedures in the previous section. Assess the curve noting the nature and change of direction and estimate the approximate 85th percentile approach speed.

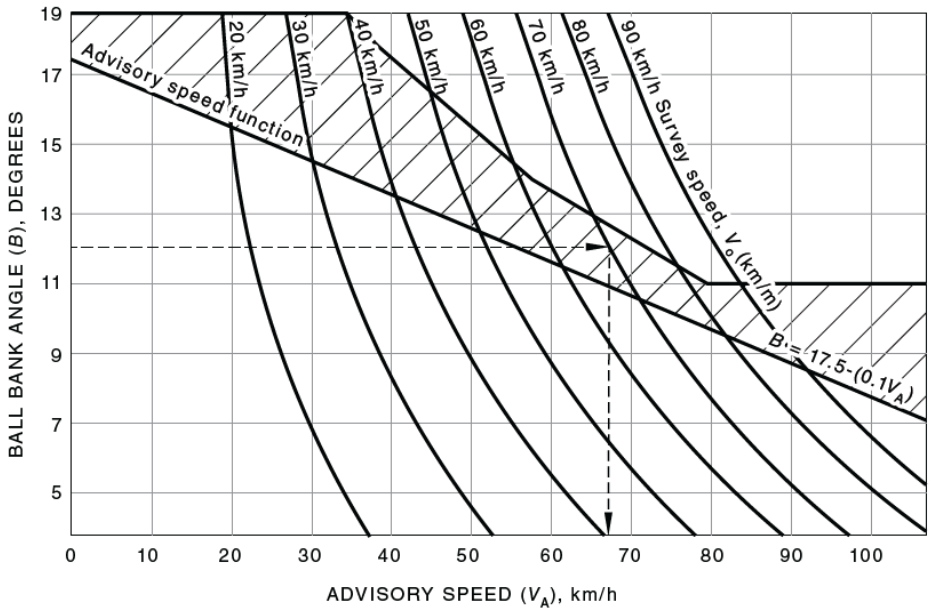
Conduct the initial survey from each approach to the curve by driving the survey vehicle at a constant speed around the curve as nearly parallel to the road centreline as possible. Drive on the correct side of the road and avoid sudden corrections while in the curve. If fitted, the use of a cruise control is considered suitable for simplifying this task.

To simplify the selection of the most appropriate speed the vehicle should be driven as near as possible to a multiple of 10 km/h.

Record the ball bank reading, B (degrees) and the speedometer reading V (km/h) in the central non-transitional portion of the curve. An example of the record sheet template is included in Appendix D. Both the speedometer and the ball bank should be steady at this instant with the ball at or near its maximum point of deflection for the curve.

d) Adjust for speedometer variation.

Adjust the indicated speed according to the variation found in Step a) to determine the true survey speed, VO and plot the ball-bank angle against the speed on Figure 3.1 (*AS 1742.2 (2022)* Figure F.2 and Table F.1).



NOTE 1 The example shows an observed reading of 12 degrees at a survey speed of 70 km/h The advisory speed is 66 km/h

NOTE 2 The graph is based on the matching of ball bank angle to advisory speed as shown in Table F.1.

Source: AS 1742.2 (2022) Figure F.2

Ball bank angle degrees	Advisory speed km/h
8.0	95
8.5	90
9.0	85
9.5	80
10.0	75
10.5	70
11.0	65
11.5	60
12.0	55
12.5	50
13.0	45
13.5	40
14.0	35
14.5	30
15.0	25

Source: AS 1742.2 (2022) Table F.1

Figure 3.1 Determination of Advisory Speed on a Horizontal Curve from Ball Bank Indicator Reading

e) Check if plotted point is in shaded band.

If the plotted point does not lie within the shaded band in Figure 3.1 *(AS 1742.2 (2022)* Figure F.2), repeat Steps c) and d) at 10 km/h increments or decrements until the plotted point lies within that band. Read off the advisory speed VA at that point.

f) Repeat for multiple lanes.

Where the road has two or more lanes in one direction survey the advisory speed for each lane separately and record the lowest value.

g) Surveying a section of road:

Where multiple curves on a section of road need to be surveyed, start the survey from a recognised Permanent Reference Point (PRP) such as a road junction. For Common Road Reference System roads commence the survey at the 0.00 point in accordance with the Road Inventory Management System (RIMS). This information may be obtained from the Department for Infrastructure and Transport, Road Features Report:

http://itims.dit.sa.gov.au/rff/index.html

The chainage for all existing curve warning signs, approximate tangent points at the beginning and end of the curve, including the change of direction for the curve (left or right) and any side road information for both sides of the road should be recorded (Refer to example template shown at Appendix E). A 'TerraTrip' Rally Computer or similar distance-measuring device calibrated to measure in increments of 0.01 kms (10 m) is suitable for this task.

Once the task of collecting this data has been completed the curve data is transcribed onto a Ball Bank log sheet (refer example in Appendix D) from the start point (0.00) recording the number of the curve along with the change of direction (left or right) for each curve in each direction.

Initial speed runs are conducted from each direction for all curves according to the procedures previously outlined for single curves. If the road surveyed is particularly lengthy, sections of road containing closely spaced series of curves may be treated in isolation and treated with the recommended advisory speed sign option prior to moving on.

3.3 Advisory speed adjustment

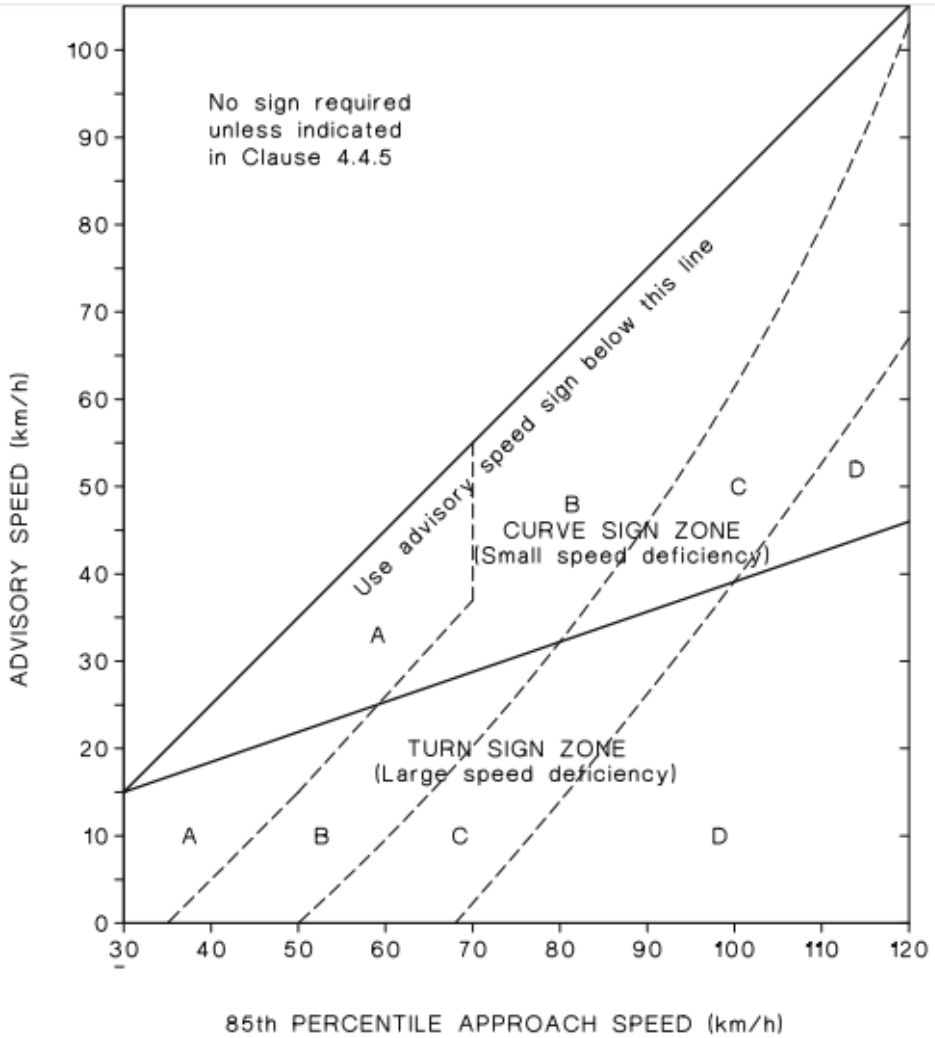
To determine the speed to be displayed on the advisory speed sign (W8-2), the speed obtained from the above methods shall be adjusted as necessary, to a multiple of 5 km/h by rounding one unit up or three units down e.g., if the advisory speed reading obtained was 39 km/h then the corrected speed is 40 km/h. Conversely if the advisory speed reading obtained was 38 km/h then the corrected speed is 35 km/h.

3.4 Advisory speed signs

The speed to be shown on the advisory speed sign (W8-2) shall be recorded for each curve measured, in each direction of travel, and where more than one advisory speed was measured in a particular direction for closely spaced reverse curves e.g., separated by a 120 m tangent length, the adjusted speed corresponding to the lowest measured value is used.

4 Determining the curve speed deficiency

The speed deficiency is indicated by the difference between the approach speed (85th percentile) to the curve and the recommended advisory speed through the curve. The speed deficiency determines the recommended sign size and spacings.



NOTE: A, B, C and D indicate the size of the sign. B size is the minimum size recommended for arterial roads. Increase one size where either the sign is cantilevered over the roadway, there are two or more lanes in one direction or the sign is more than 6 m from edge of running lane.

Source: AS 1742.2 (2022) Figure 4.1

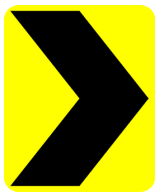
Figure 4.1 Guide to the Signposting of Substandard Horizontal Curves

5 Signing

Refer to Figure 4.1 (*AS 1742.2 (2022)* Figure 4.1) to determine whether the curve has a large or small speed deficiency and determine the appropriate sign size. Signs shall be located in accordance with Appendix C for a large speed deficiency, or Appendix D for a small speed deficiency.

6 Curve delineation

6.1 Curve alignment markers (CAMs)



D4-6

Curve Alignment Markers (D4-6) shall only be used to enhance the following delineation measures for substandard curves:

- Closer spacing of the guide posts with delineators,
- Dividing lines and edge lines supplemented with retro-reflective raised pavement markers (RRPMs),
- Curve or turn warning signs with associated advisory speed signs.

CAMs shall be used in accordance with *AS 1742.2 (2022)* clause 4.3.6.1. However, CAMs shall not be used as referenced in *AS 1742.2 (2022)* clause 4.3.2.

CAMs shall not be used unless the other delineation devices listed above are in place and an engineering assessment indicates that additional delineation measures are required to guide traffic safely through the curve.

Curve alignment markers shall be reserved exclusively for curve delineation of substandard curves and shall not be used for the delineation of islands or other obstructions, or for any other purpose.

6.2 Unidirectional hazard markers

CAMs are reserved to delineate the pathway through a curve and are only necessary in rural high speed locations. Curves in urban areas do not generally require advisory speeds or CAMs as sight distance and speeds are such that drivers have opportunities to react to the curve.

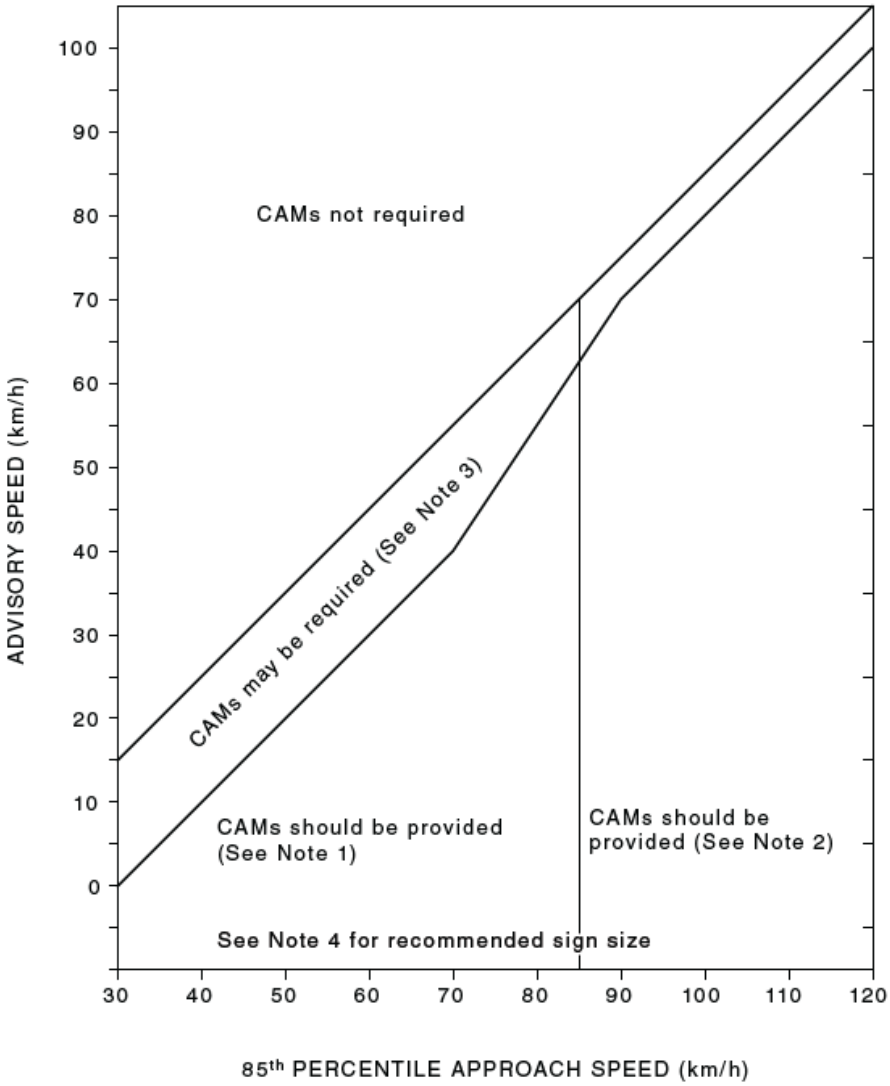
However, in some situations in rural and urban environments where a curve is not considered substandard but may present a hazard, a single white on black uni-directional hazard marker (D4-SA1-1) may be placed in the verge in the driver's line of approach, to indicate the hazard and not to delineate the curve. For example, where a long straight section of road precedes the curve in such a way that it is unexpected to the road user, a hazard marker D4-SA1-1 or D4-1-2 may be appropriate in alignment with the start of the curve.

D4-1-2

D4-SA1-1

7 Application of CAMs (D4-6)

Using the advisory speed determined in Section 3, refer to Figure 7.1 to determine whether CAMs are required.



NOTE 1 CAMs should be provided at curves in this region in accordance with *Clause 4.3.6.1** and the spacing given for V_{85} – Less than 85km/h in *Table 4.3**.

NOTE 2 CAMs should be provided at curves in this region in accordance with *Clause 4.3.6.1** and the spacing given for V_{85} – 85km/h and greater in *Table 4.3**.

NOTE 3 Curves in this region will not normally require CAMs but may be required where the existence or direction of the curve may not be clear to approaching drivers, e.g. where the curve is just beyond a crest, or the locality is subject to frequent fogs or other adverse weather conditions.

NOTE 4 Generally B size CAMs should be used for all installations, including on multi-lane roads. However, in urban situations where the speed limit is less than 70km/h, use of A size CAMs may be appropriate. It is recommended that C size CAMs are used on expressways.

**Clauses and Table referred to in the notes above are from AS 1742.2:2022*

Source: AS 1742.2 (2022) Figure 4.2

Figure 7.1 Guide for the use of Curve Alignment Markers (CAMs)

7.1 Determining the curve radius

Spacing of CAMs is based on the radius of the curve and the 85th percentile approach speed (refer to Table 7.1).

Where available, design plans should be sought to establish the correct curve radius and enable the application of the spacings indicated in Table 7.1 (*AS 1742.2 (2022)* Table 4.3). If plans are not available, then the procedure in Appendix A should be adopted to determine the radius on site. The radius can also be scaled from aerial images following the geometric principles in Appendix A.

7.2 Determining layout of CAMs

Recommended spacing for markers is given in the following table with their location at the beginning, end and through the curve determined in accordance with this section and Appendices B and C.

Curve radius (m)	**CAM spacing (m)***	
	85th percentile approach speed	
	Less than 85 km/h	**85 km/h and greater**
< 50	10	6
50-99	12	8
100-149	18	12
150-199	24	16
200-249	30	20
250-300	36	24
>300	40	26

** the spacings in this table are subject to a tolerance of ±10%*

Source: AS 1742.2 (2022), Table 4.3.

Table 7.1 Spacing of Curve Alignment Markers (CAMs)

As a general rule the most effective way of determining the layout of CAMs and the positioning of the first marker for large and small speed deficiencies follows the principles outlined in Appendix B and C, where for a two-way two-lane road with a left hand curve the separation line is prolongated and for a right hand curves, the left hand edge line is used. Large and small speed deficiencies are determined in Section 4.

If the road does not have an edge line, then estimation will need to be made using the edge of bitumen.

On all multi-lane roads with single direction curves the right hand edge line is prolongated for left hand curves and the left hand edge line for right hand curves.

7.3 Minimum number of CAMs

A minimum of three (3) markers shall be used on short curves and a minimum of two markers are to be visible from a point from each approach to a curve. To achieve the distance equivalent to 3 seconds of travel time in advance of the start of the curve, the recommended spacing for markers may need to be decreased to meet this requirement. Refer to Table 7.2.

85th percentile approach speed (km/h)	Distance to first CAM* (m)
120	100
110	92
100	83
90	75
80	67
70	60
60	50
50	42
40	33
30	25

**Distance equivalent to 3 seconds of travel time in advance of the start of the curve. (This is the distance over which a minimum of 2 CAMs should be visible to approaching drivers.)*

Table 7.2 Sight distance to first Curve Alignment Markers (CAMs)

7.4 Mounting height for markers

The mounting height of CAMs should not be more than 1.2 m (to the lower edge of the sign). The mounting height above the road pavement shall always be consistent throughout a curve (refer to *AS 1742.2 (2022)* clause 4.3.6.1).

The height of CAMs may be increased where they are located behind safety barrier. In such instances, the base of the CAM shall be in line with the top of the safety barrier.

7.5 Size of CAMs

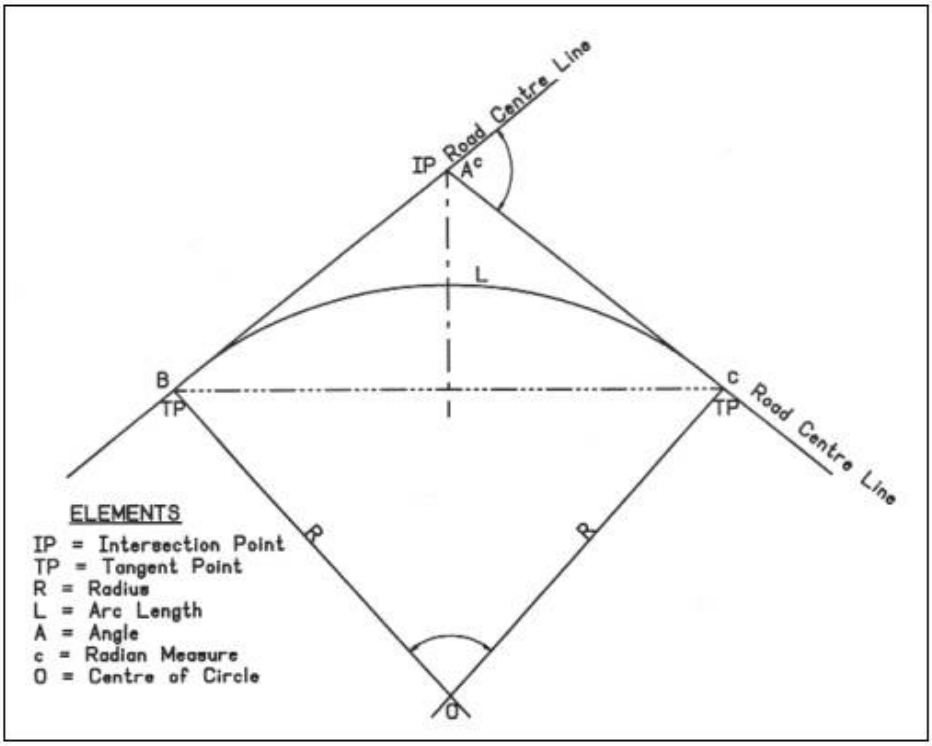
The following sizes should be adopted for use on DIT roads:

Curve Alignment Marker Size		
Size	**Dimension (mm)**	**Applications**
D4-6S	450 x 600	Shall only be used in very low speed restricted environments and is **not** recommended for general use
A	600 x 750	most urban and high-speed rural two lane two-way roads
B	750 x 900	Used for high-speed rural two lane roads with a high number of large speed deficient curves
C	900 x 1125	Used on high-speed multi-lane roads of a Freeway and Expressway standard

Source: Adapted from AS 1742.2 (2022) Figure 4.2

Table 7.3 Curve Alignment Markers (CAMs) sizes

Appendix A - Determing the curve radius

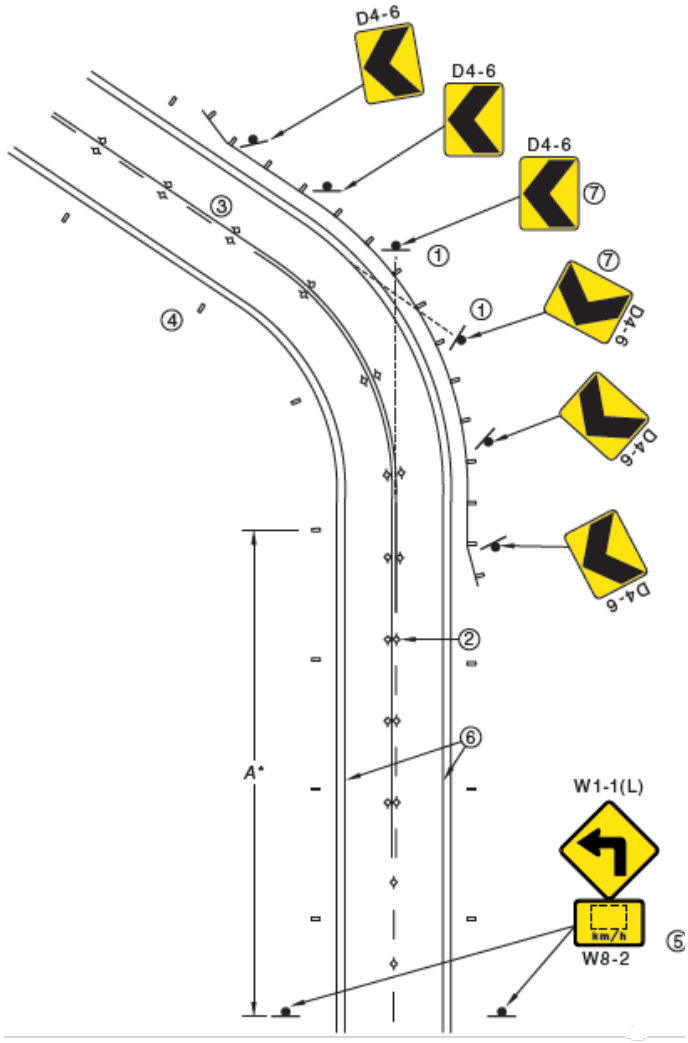


Using a prismatic compass or similar instrument the angle shown at A should be determined approximately by recording the change of direction for the section of road along the separation line. The arc length (L) of the curve should also be measured between the tangent points (an estimate of the curves starting and finishing points) as indicated at B and C in the figure above. On site, depending on the length of the curve, a pedometer is considered sufficient to achieve this task. Once this has been done the curve radius, R is given by:

$$\boldsymbol{R = \frac{L}{A^c}}$$ where A is measured in radians (c)

$$R = \frac{180 \times L}{\pi \times A^0}$$ **OR** $$R = 57.3 \times \frac{L}{A^0}$$ where A is measured in degrees (°)

Appendix B - Sign positions on curves (large speed deficiencies)



** For Dimension A, see Table D.1 of AS1742.2:2022*

Source: AS 1742.2 (2022) Figure 4.3

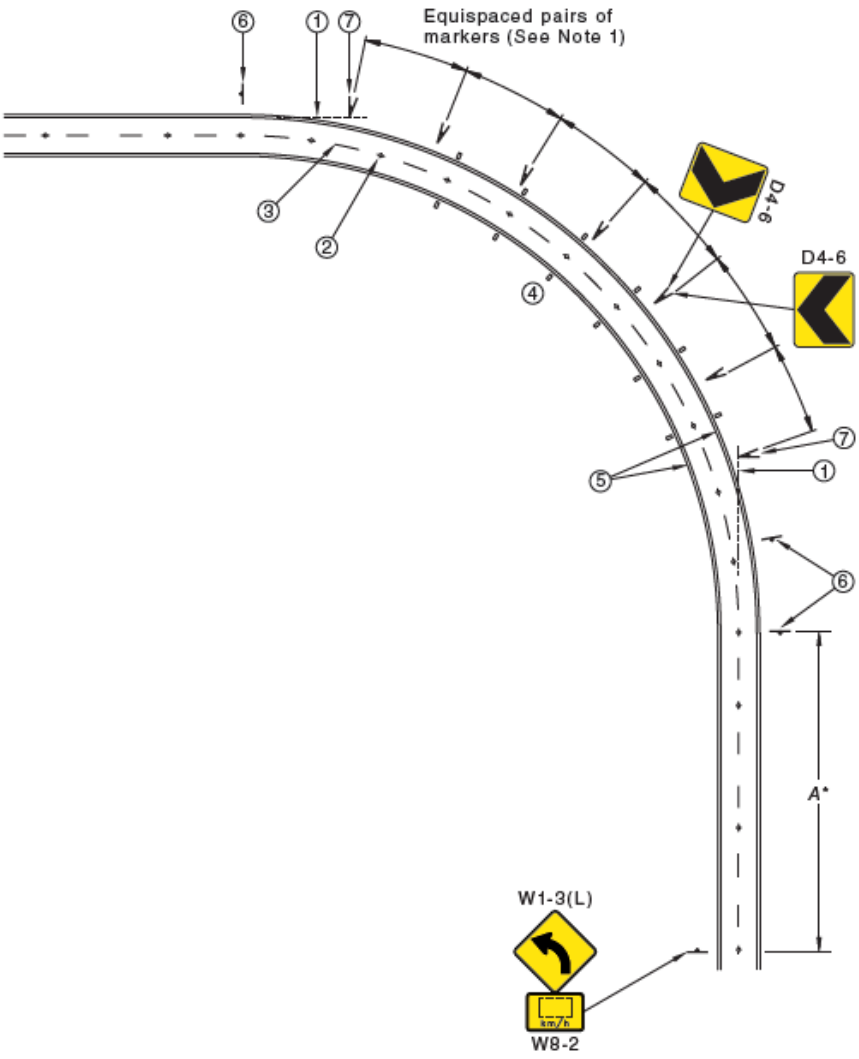
NOTES:

1. The first Curve alignment Marker (D4-6) sign in each direction of travel is located as follows:
   a. Two-way road way as follows:
      i. Left-hand curve – on prolongation of the dividing line.
      ii. Right-hand curve – on prolongation of the left-hand edge line.
   b. One-way roadway as follows:
      i. Left-hand curve – on prolongation of the right-hand edge line.
      ii. Right-hand curve – on prolongation of the left-hand edge line.

   The last sign is placed at the end of the circular curve, and intermediate signs equally spaced at the spacing shown in Table 4.3 of AS 1742.2 (2022). A minimum of three signs are displayed to each approach direction. A minimum of two signs are to be visible on each approach to the curve, see Clause 4.3.6.1 of AS 1742.2 (2022).
2. Raised retroreflective pavement markers should be used to supplement the dividing lines on pavement 6.8m or wider.
3. No overtaking zones are marked if necessary.
4. Guide posts with delineators, or delineators on safety barrier, are provided on both sides of the curve at the spacing given in Clauses 4.2.4.4 and 4.2.5.4 of *AS 1742.2 (2022)*.
5. Advance signs may be duplicated on the right-hand side of the road.
6. Edge line should be provided on pavements 6.8m or wider and may be supplemented with RRPMs.
7. Where a Curve Alignment Maker x km/h (D4-7) sign is appropriate as indicated by clause 4.3.6.2(b) of *AS 1742.2 (2022),* it replaces the first Curve Alignment Marker (D4-6) sign at the location specified in Note 1.

Source: AS 1742.2 (2022) Clause 4.3.6.3(a)

Appendix C - Sign position on curves (small speed deficiencies)



** For Dimension A, see Table D.1 of AS 1742.2 (2022)*

Source: AS 1742.2 (2022) Figure 4.4

NOTES:

1. Location of first and last sign for each direction of travel is as given in Note 1 for Figure 4.3 of *AS 1742.2 (2022)* clause 4.3.6.3(a).
2. Raised retroreflective pavement markers should be used to supplement the dividing lines on pavement 6.8m or wider.
3. No overtaking zones are marked if necessary.
4. Guide posts with delineators, or delineators on safety barriers, are provided on both sides of the curve at the spacing given in Clauses 4.2.4.4 and 4.2.5.4 of *AS 1742.2 (2022).*
5. Edge lines should be provided on pavements 6.8m or wider and may be supplemented with RRPMs.
6. Additional signs at the spacing determined for the pairs of signs are placed to each end of the circular curve. These are not required on reverse curves with negligible connections straights.
7. Where a Curve Alignment Maker x km/h (D4-7) sign is appropriate as indicated by clause 4.3.6.2(b) of *AS 1742.2 (2022),* it replaces the first Curve Alignment Marker (D4-6) sign at the location specified in Note 1.

Appendix D - Example of advisory speed ball bank log

ADVISORY SPEED BALL BANK INDICATOR LOG

Tested By:		**Date:**	
RN/DR:	**Name:**		
Council / Region:		**Page:**	

Direction of Travel: To/From _____

RRD	Speed Limit or Zone	Direction of Travel	Curve Type & No.	Test Speed (km/h)					Calculated Safe Speed	Comments

SKETCH ON THE REVERSE SIDE

Appendix E - Example of advisory speed sign record

ADVISORY SPEED SIGN RECORD

DATE _____

RN/DR _____ DIRECTION _____

COUNCIL _____ COMMENCEMENT POINT _____

CURVE NUMBER	LOCATION		DEG	EXISTING CONTROLS		NEW CONTROLS		REMARKS
				LEFT	RIGHT	LEFT	RIGHT	