AUSTRALIAN RAIL TRACK CORPORATION LTD

Discipline: Engineering (Track & Civil) **Category: Standard**

Alignment Surveys

ETD-00-03

Applicability

New South Wales	✓	CRIA (NSW CRN)	

Primary Source

ARTC NSW Standard TEP 25

Document Status

Version	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
1.1	18 Jun 10	Standards	Manager Standards	Exec Manager SS&P 21/06/2010	CEO

Amendment Record

Version	Date Reviewed	Clause	Description of Amendment
1.0	01 Dec 09		Implementation draft. Supersedes NSW Standard TEP 25 v1.2
1.1	18 Jun 10		Banner added regarding mandatory requirements in other documents and alternative interpretations.

Contents

1 Scope

This specification defines the components of both horizontal and vertical alignment and the relationship between components and their associated parameters.

The horizontal alignment defines the centreline of '4 foot' of each track. The vertical alignment defines the position of the low rail of each track.

The kilometrage defines the distance from Sydney along the centreline '4 foot', of each track.

2 Horizontal Alignment Components

Horizontal alignment is defined as a series of four individual components, namely:

1) Straights
2) Circular curves
3) Transitions
4) Compound transitions. These components are connected by inter-related coordinated points.

Note: See Diagram 1 for clarification of component names, point names and various combinations of components.

2.1 Straights

Each straight is generally defined by a pair of coordinated points, each called a tangent point (TP).

A straight may also be defined by two or more straights separated by a bend or bends.

A bend is defined as the point of intersection of two separate straights. The design requirements for a bend are given in the ARTC CoP.

Where a bend or bends exist in a straight, then each part of the straight will be defined by the TP and the bend or by successive bends depending on the location of the particular straight.

Each TP or bend has a unique coordinate set (Easting-E, Northing-N) where the value of each component is absolute to 0.001m.

The bearing and distance of each straight are derived numbers and are shown to 1" of arc and 0.001m respectively.

When the alignment definition must stop along a straight, one location on the straight then becomes a bend and is to be held for any continuation of the alignment, unless modification to the previous alignment is carried out.

When calculating track geometry that projects from a specific point on the straight at a predetermined angle, say for a turnout, then the bearing to be adopted for the initial straight should be determined using sound procedures to ensure a "correct" result. The bearing obtained automatically using the two end TP coordinates is not necessarily the "correct" result due to rounding off of co-ordinates to 0.001m.

Note: See Diagram 2 for the mathematical relationships for straights.

2.2 Circular Curves

The circular curve is defined by three coordinated points, two being the end points of the circular curve on the centreline and the third being the centre of circle (CC).

Each of the three points has a unique coordinate set (E,N) where the value of each component is absolute to 0.001m.

The radius of the circular curve is a derived number and is to be the arithmetic mean of the distances calculated from each end point coordinate set to the CC coordinate set.

The extent of the circular curve is nominated by the arc distance, shown in metres to 0.001m.

Note: See Diagram 3 for the mathematical relationships for circular curves.

2.3 Transitions

The transition is the component that joins the straight to the circular curve and is based on a cubic parabola.

The transition is defined by three co-ordinate points, being the tangent point (TP), transition point (TRS) and the centre of circle (CC).

Each of the three points has a unique coordinate set (E,N) where the value of each component is absolute to 0.001m.

The associated radius and transition data (Xc, X', h, θ, Ø, m, L) are derived values using the three coordinate sets.

The length of the transition (L) is a derived distance and is to be rounded to 0.001m.

Note: See Diagrams 4 & 5 for the mathematical relationships for transition curves.

2.4 Compound Transition

The compound transition is the component that joins two circular curves of different radii.

The compound transition is defined by four coordinated points, two being the common points joining the compound transition to the two radii (CTRS) and the other two being the respective centre of circles of each circular curve.

Each of the four points has a unique coordinate set (E,N) where the value of each component is absolute to 0.001m.

The compound transition is a specific segment of a transition.

Note: See Diagram 6 for the mathematical relationships for compound transitions.

3 Location of Kilometrage

3.1 Frame Points

Each frame point (ie, TP, TRS, CTP, CTRS or BEND) is to be given a label called a survey kilometrage.

The survey kilometrage is a distance measured from Sydney along the centreline '4 foot' of each track.

The survey kilometrage of any frame point is the cumulative total from Sydney of the individual component lengths. Each component length being derived and rounded to 0.001m before summation.

3.2 Kilometrage Adjustments

Kilometrage adjustments are incorporated to align the survey kilometrage of one track to another, or to ensure that marked track kilometrages such as on bridges, km posts etc are not out of step to the design alignment kilometrage.

A kilometrage adjustment is to be placed at all locations where the difference between the through kilometrage and the hard conversions of the imperial mileage of a monument or plaque exceeds 10.0m.

In multiple track locations, kilometrage adjustments are to be placed at the beginning of parallel straights so as to align the kilometrage of each centreline. This is to be done at all practicable locations and ideally in straights greater than 100 metres in length.

The Down track is to be adopted as the through survey kilometrage. The kilometrage adjustment is to be in the form of a point adjustment.

The nominated survey kilometrage at this point is to be the adjusted kilometrage, ie, the kilometrage to be carried forward.

3.3 Long and Short Intervals

A long or short interval is to be nominated as well as the actual length.

This interval is to be located on a straight immediately before the point adjustment.

The length of the interval is to be limited to the distance between the last increment point and the point adjustment.

The length of the interval is to be such that there is only one location for any nominated kilometrage.

A long interval is to be known as a negative adjustment. A short interval is to be known as a positive adjustment.

The interval must be contained within the track to which it relates and be contained wholly within a straight which ideally is >100m in length.

The kilometrage of a point within a long interval is to be nominated as 'the start of interval kilometrage' plus a distance eg, in **Diagram 7** the end of platform kilometrage would be 43km200+24.308.

4 Vertical Alignment Components

Vertical alignment is defined as a series of straight grades connected by vertical curves (VC). The parameters which define the components are:

a) Intersection Point, reduced level (IPRL), value absolute to 0.001m.

b) Vertical curve, length (L_v), value absolute to 0.001m.

4.1 Straight Grade

Each straight grade is defined by a pair of terminal points called intersection points (IP), which are located at whole 20m kilometrage points.

Each IP has a defined reduced level (RL) absolute to 0.001m.

The 'grade' of each straight grade is to be expressed as a percentage. This is to be given to sufficient significant figures such that the difference in level between consecutive IP's is accurate to 0.001m.

The percentage grade is to be an exact increment of 0.005% except where kilometrage adjustment or other similar constraints occur.

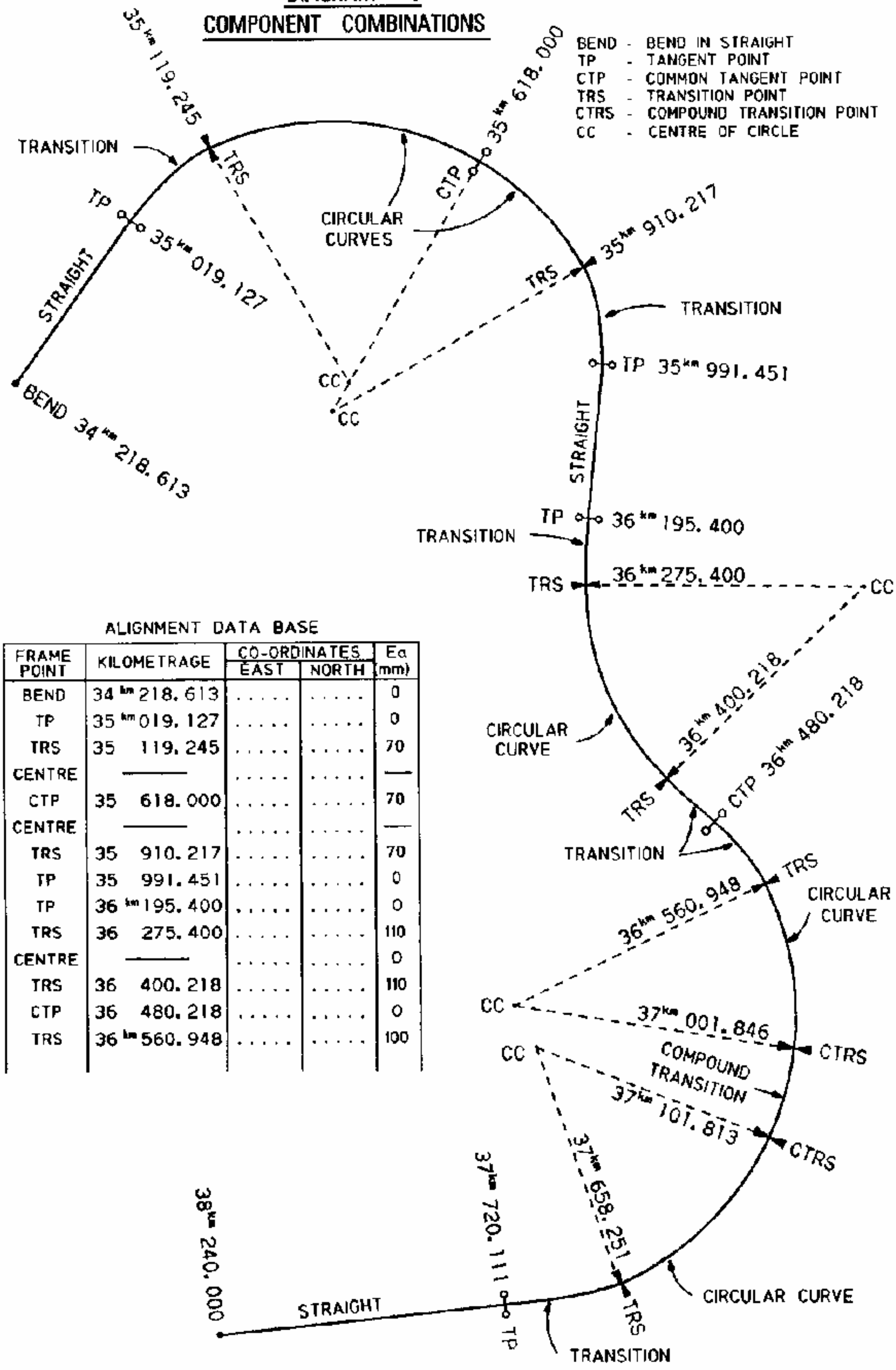
4.2 Vertical Curves

The vertical curve is defined by the length (L_v) and is to be a multiple of 40m i.e. 40m, 80m, 120m unless approved otherwise by ARTC.

The vertical curve is based on the quadratic parabola. However in the determination of its length it is equated to a circular curve for convenience and practical purposes.

Note: The parameters of the vertical curve are defined by the formulae in Diagram 8.

DIAGRAM 1
COMPONENT COMBINATIONS

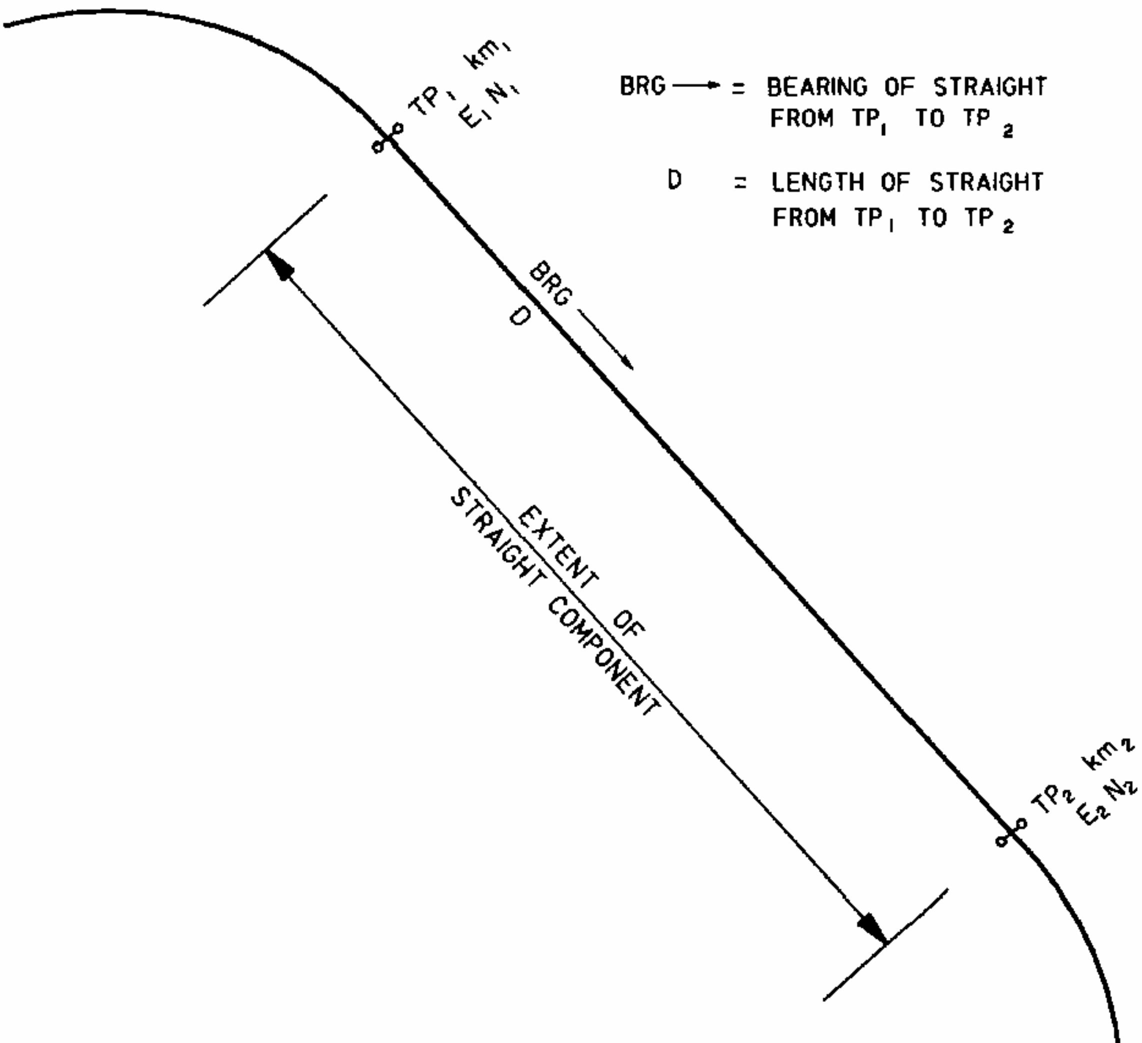


ALIGNMENT DATA BASE

FRAME POINT	KILOMETRAGE	CO-ORDINATES EAST	NORTH	Ea (mm)
BEND	34 km 218.613	.....	.....	0
TP	35 km 019.127	.....	.....	0
TRS	35 119.245	.....	.....	70
CENTRE	———	.....	.....	—
CTP	35 618.000	.....	.....	70
CENTRE	———	.....	.....	—
TRS	35 910.217	.....	.....	70
TP	35 991.451	.....	.....	0
TP	36 km 195.400	.....	.....	0
TRS	36 275.400	.....	.....	110
CENTRE	———	.....	.....	0
TRS	36 400.218	.....	.....	110
CTP	36 480.218	.....	.....	0
TRS	36 km 560.948	.....	.....	100

DIAGRAM 2

STRAIGHT COMPONENT



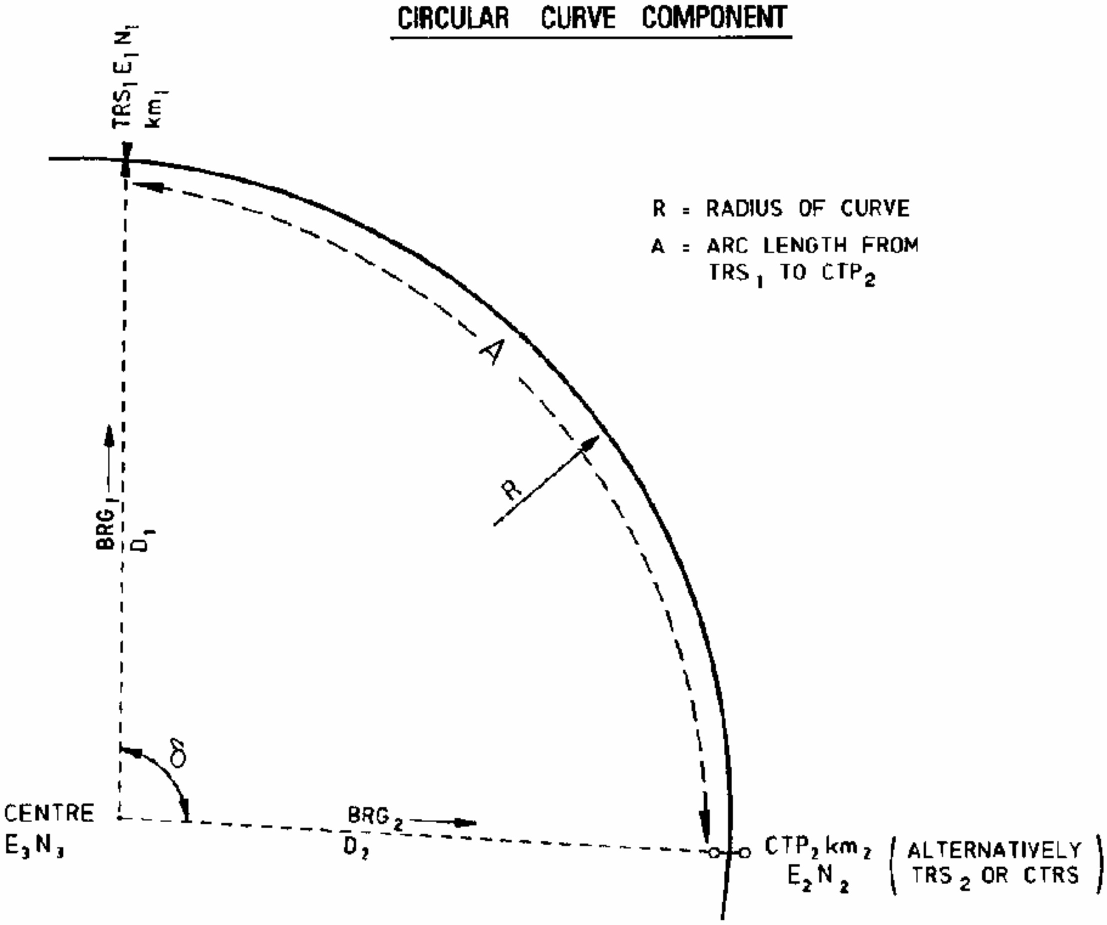
$$BRG \longrightarrow = \tan^{-1}\left(\frac{E_2 - E_1}{N_2 - N_1}\right) + \left(180^\circ \text{ IF } N_2 - N_1 < 0\right) + \left(\begin{array}{l} 360^\circ \text{ IF } N_2 - N_1 \geqslant 0 \\ \text{AND } E_2 - E_1 < 0 \end{array}\right)$$

$$D = \sqrt{(E_2 - E_1)^2 + (N_2 - N_1)^2} \quad \text{(ROUNDED TO NEAREST 0.001m)}$$

$$km_2 = km_1 + D$$

DIAGRAM 3

CIRCULAR CURVE COMPONENT



FROM CO-ORDINATES OF TRS_1, CTP_2 AND CENTRE CALCULATE BEARING AND DISTANCE AS INDICATED

$R = \frac{D_1 + D_2}{2}$ (ROUNDED TO NEAREST 0.001m FOR DISPLAY ONLY) (ROUNDED TO NEAREST 0.01mm FOR CALCULATION PURPOSES)

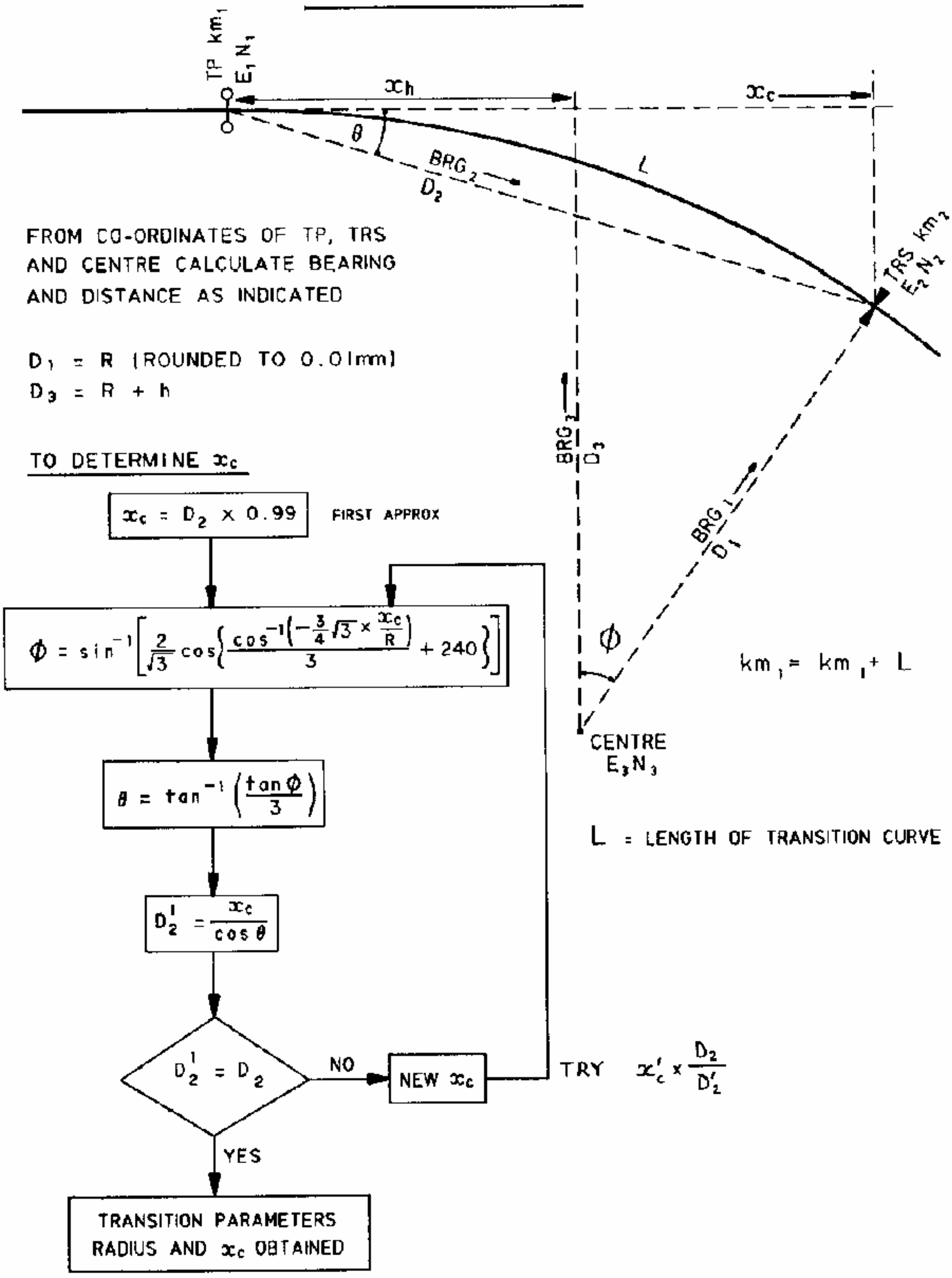
$\delta = BRG_2 - BRG_1$ (ROUNDED TO NEAREST 0.01")

$A = \frac{\delta \times \pi \times R}{180}$ (ROUNDED TO NEAREST 0.001m)

$km_2 = km_1 + A$

DIAGRAM 4

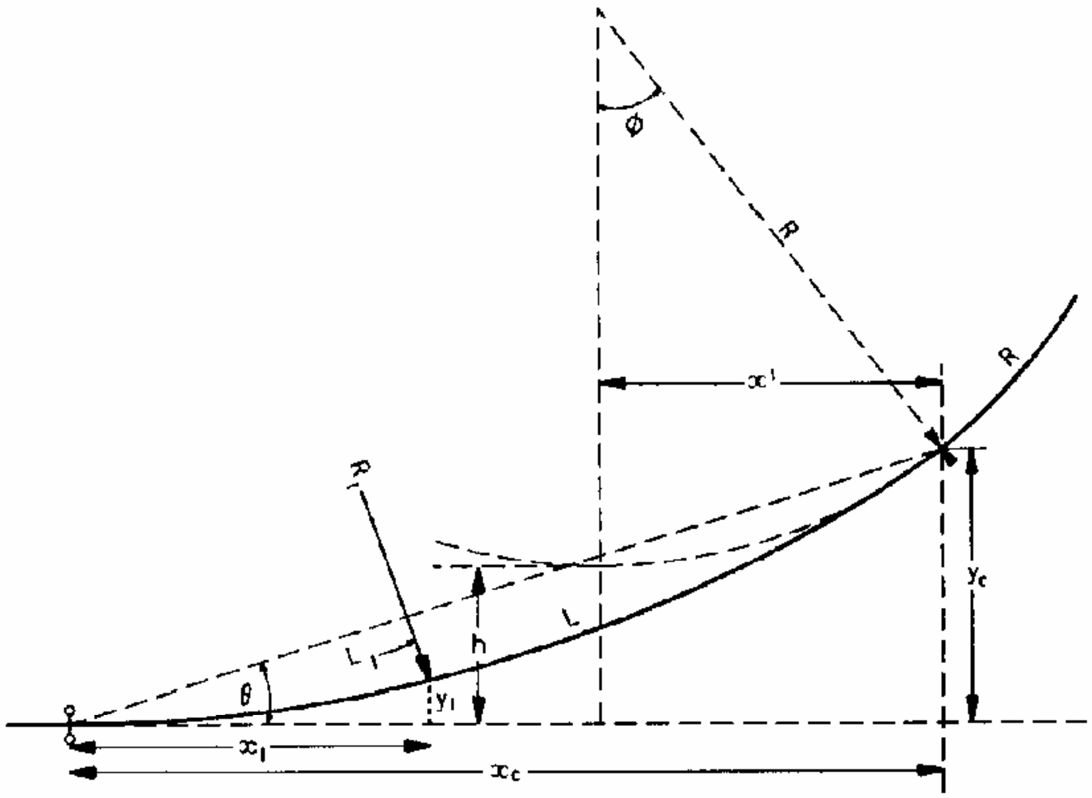
TRANSITION COMPONENT



SEE DIAGRAM 5 FOR ALL TRANSITION FORMULAE

DIAGRAM 5

TRANSITION FORMULAE



PARAMETERS: Radius - R ; Transition Identifier - x_c

$$\phi = \sin^{-1}\left[\frac{2}{\sqrt{3}}\cos\left\{\frac{\cos^{-1}\left(-\frac{3}{4}\sqrt{3}\times\frac{x_c}{R}\right)}{3} + 240\right\}\right]$$

$$m = \frac{\tan\phi}{3x_c^{\,2}}$$

$$y_c = m\,x_c^{\,3}$$

$$x' = R.\sin\phi$$

$$h = y_c + R(\cos\phi - 1)$$

$$\theta = \tan^{-1}\left(\frac{\tan\phi}{3}\right)$$

$$L = x_c + \frac{9}{10}m^2 x_c^5 - \frac{9}{8}m^4 x_c^9 + \frac{729}{208}m^6 x_c^{13} - \frac{32805}{2176}m^8 x_c^{17} + \ .....$$

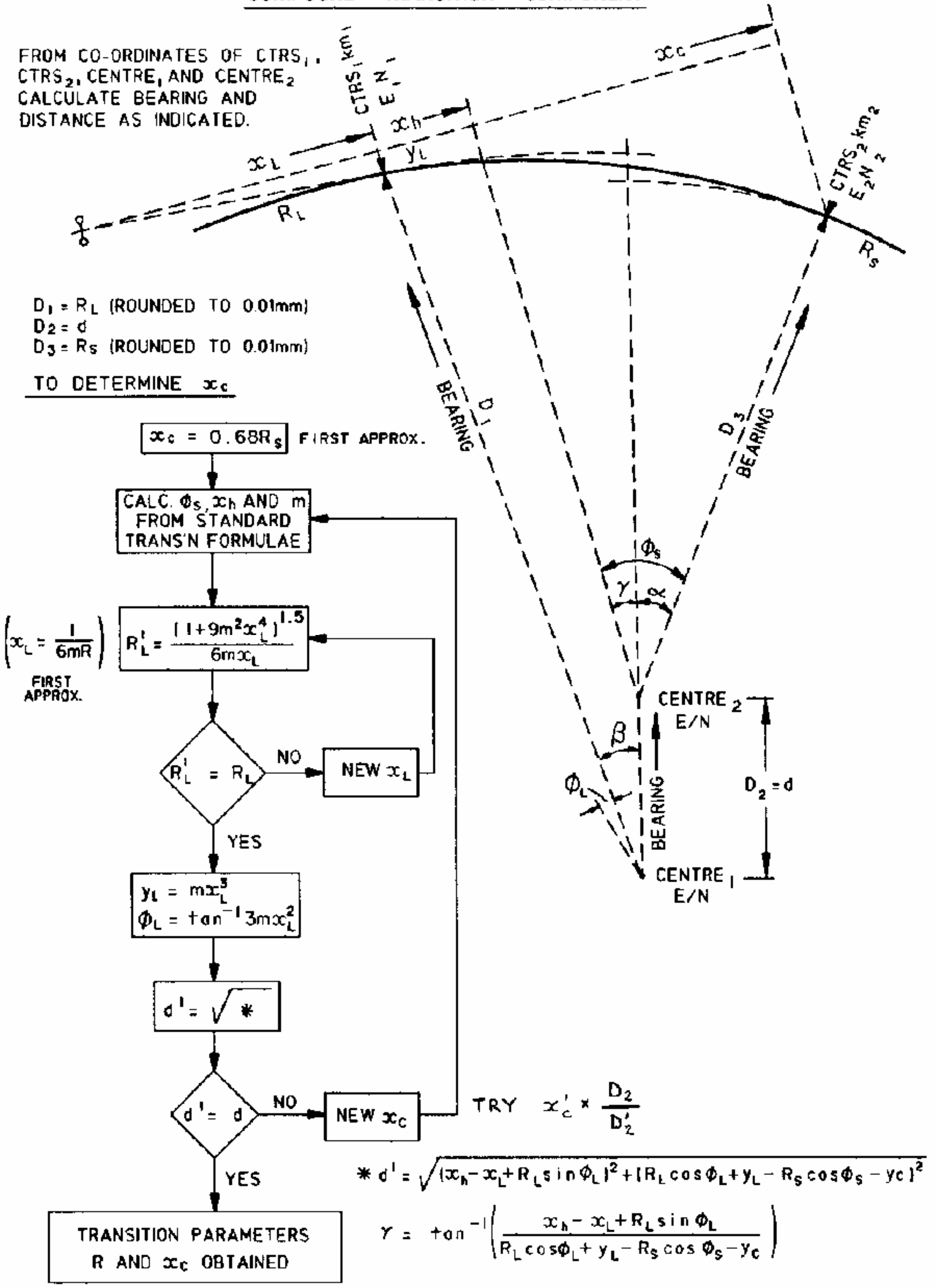
$$R = \frac{(1 + 9m^2 x_c^{\,4})^{3/2}}{6m x_c}$$

$$R_1 = \frac{(1 + 9m^2 x_1^{\,4})^{3/2}}{6m x_1}$$

$$x_1 = L_1 - 0.9m^2 L_1^5 + 5.175m^4 L_1^9 - 43.1948m^6 L_1^{13} + 426.0564m^8 L_1^{17}$$

DIAGRAM 6

COMPOUND TRANSITION COMPONENT

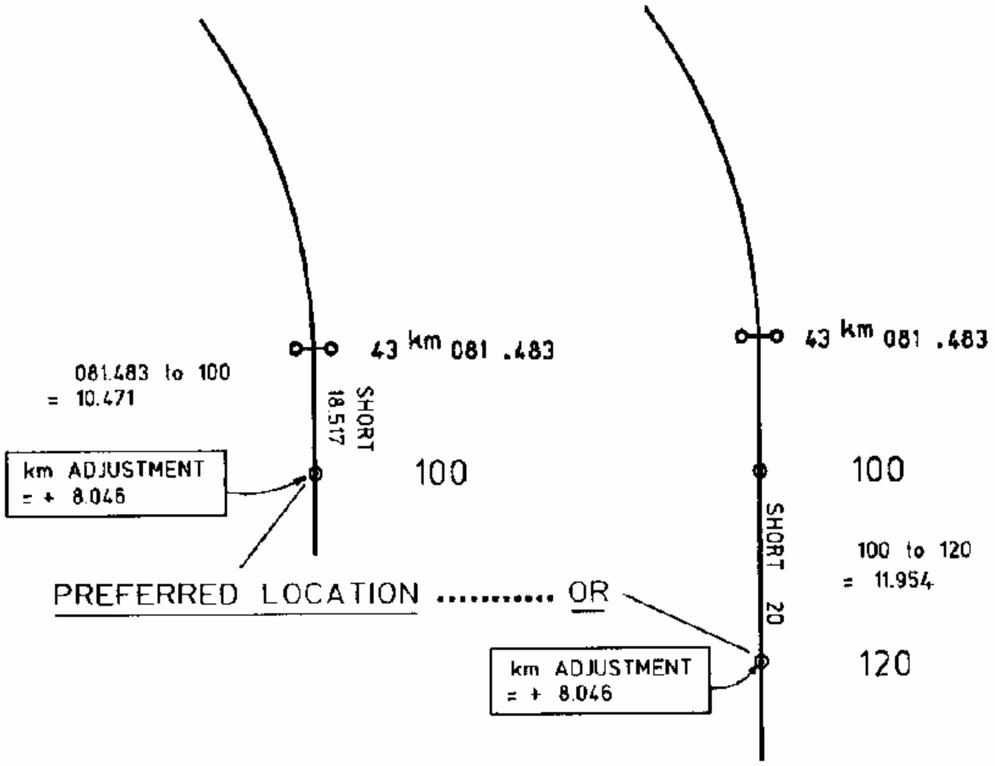


SEE DIAGRAM 5 FOR ALL TRANSITION FORMULAE

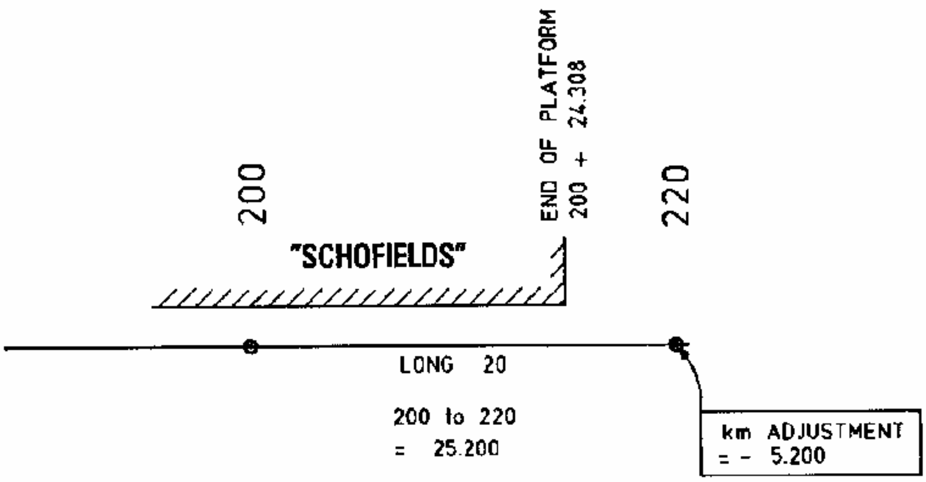
DIAGRAM 7

KILOMETRAGE ADJUSTMENTS

EXAMPLES



SHORT ADJUSTMENTS



LONG ADJUSTMENTS

DIAGRAM 8

VERTICAL CURVES

R_v = average vertical radius in metres

V_m = maximum velocity in km/h

L_v = length in metres

ΔG = difference between the grades %

X = steeper grade % (Note: +VE Grade = UP

X = flatter grade % -VE Grade = DOWN)

1) $R_v = \frac{1}{2}V_m^2$ desirable radius

see ARTC T&C CoP Section 5 for other design constraints relating to vertical curves.

Rv = 400m hump yards, only on hump V.C. in concrete

2) $\Delta G = X + x$ (no V.C. required if $\Delta G < 1\%$ OR IF $\Delta G < 2600/V_m^2$)

3) $L_V = R_V \Delta G/100$

4) round L_V up to even number of 20m intervals (e.g. 40, 80,….). then

$R_V = 100L_V/\Delta G$

5) $Y = L_V\Delta G/200$

6) $y = Y(l/L_V)^2$