2.1 ELEMENTS OF A COMPOUND CURVE

In Fig. 2.1, T_1DT_2 is a *two centred compound curve* having two circular arcs T_1D and DT_2 meeting at a common point D known as the point of compound curvature (P.C.C.). T_1 is the *point of curve* (P.C.) and T_2 is the *point of tangency (P.T.)*. O_1 and O_2 are the centres of the two arcs.

R_S = the smaller radius (T_1O_1)

R_L = the longer radius (T_2O_2)

D_1D_2 = common tangent

Δ_1 = deflection angle between the rear and the common tangent

Δ_2 = deflection angle between the common and the forward tangent

Δ = total deflection angle

t_S = the length of the tangent to the arc (T_1D) having a smaller radius

t_L = the length of the tangent to the arc $D\,T_2$ having a longer radius

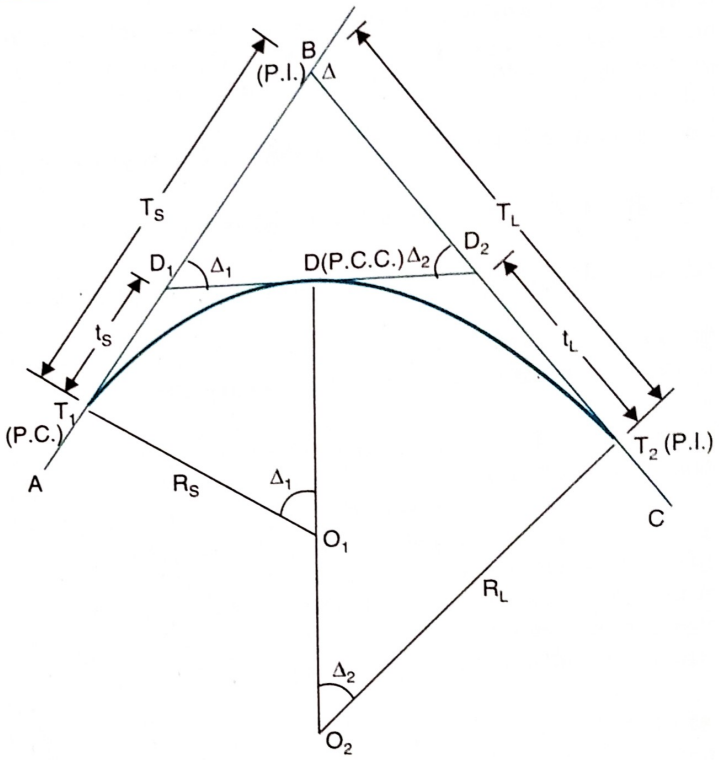


Fig. 2.1 Two Centred Compound Curve.

T_S = tangent distance $T_1\,B$ corresponding to the shorter radius

T_L = tangent distance BT_2 corresponding to the longer radius

From Fig. 2.1, we have

$$t_S = T_1D_1 = D_1D = R_S \tan \tfrac{1}{2}\Delta_1 \qquad \ldots[2.1\,(a)]$$

$$t_L = T_2D_2 = D_2D = R_L \tan \tfrac{1}{2}\Delta_2 \qquad \ldots[2.1\,(b)]$$

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$$\Delta = \Delta_1 + \Delta_2 \qquad ...(2.2)$$

From triangle BD_1D_2, we have

$$D_1B = D_1D_2 \cdot \frac{\sin \Delta_2}{\sin \Delta} = (t_S + t_L)\frac{\sin \Delta_2}{\sin \Delta}$$

and

$$D_2B = D_1D_2 \cdot \frac{\sin \Delta_1}{\sin \Delta} = (t_S + t_L)\frac{\sin \Delta_1}{\sin \Delta}$$

$\therefore$

$$T_S = T_1D_1 + D_1B = t_S + (t_S + t_L)\frac{\sin \Delta_2}{\sin \Delta} \qquad ...[2.3\ (a)]$$

and

$$T_L = T_2D_2 + D_2B = t_L + (t_S + t_L)\frac{\sin \Delta_1}{\sin \Delta} \qquad ...[2.3\ (b)]$$

2.2 RELATIONSHIP BETWEEN THE PARTS OF A COMPOUND CURVE

There are seven quantities of two centred compound curve, *i.e.* Δ, R_S, T_S, Δ_1, R_L, T_L and Δ_2. When four of these, including an angle, are given or assumed, the other three may be determined. Usually, the lengths of the two radii, R_S and R_L are established from the plan and the angle Δ is measured in the field. The fourth quantity out of Δ_1, Δ_2, T_S and T_L is usually selected from the plan. The calculation of the rest of the three quantities may be made as explained below:

Case (1): *Given:* Δ, R_S, R_L, Δ_1 (or Δ_2)

Required: Δ_2 (or Δ_1), T_S and T_L. This is the most common case.

From equation 2.2, $\Delta_2 = \Delta - \Delta_1$

(or $\Delta_1 = \Delta - \Delta_2$)

From equations 2.3 and 2.1, we have

$$T_S = R_S \tan \tfrac{1}{2}\Delta_1 + (R_S \tan \tfrac{1}{2}\Delta_1 + R_L \tan \tfrac{1}{2}\Delta_2)\frac{\sin \Delta_2}{\sin \Delta}$$

and

$$T_L = R_L \tan \tfrac{1}{2}\Delta_2 + (R_S \tan \tfrac{1}{2}\Delta_1 + R_L \tan \tfrac{1}{2}\Delta_2)\frac{\sin \Delta_1}{\sin \Delta}$$

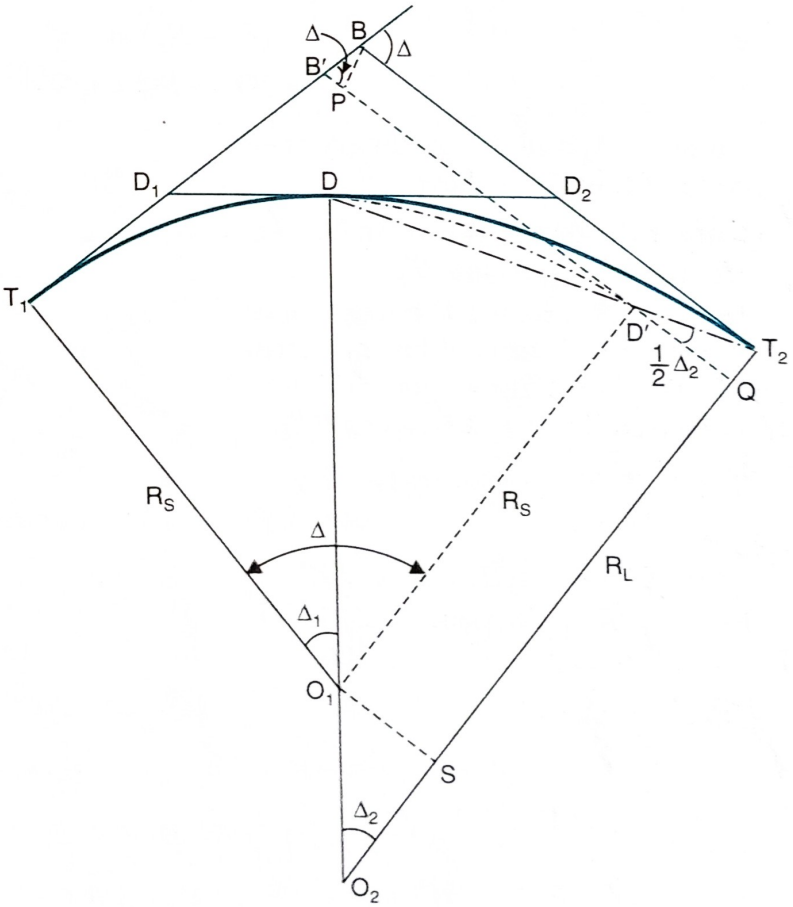


Fig. 2.2 Calculation of Δ_1, Δ_2 and T_L.

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Case (2): *Given:* Δ, R_S , R_L and T_S.

Required: Δ_1, Δ_2 and T_L.

In Fig. 2.2, prolong the short curve T_1D to a point D' until it has the central angle Δ. Its tangent $B'D'$ will then be parallel to the tangent BT_2.

Then $$T_1B' = B'D' = R_S \tan \tfrac{1}{2}\Delta \quad ...(1)$$

Draw BP perpendicular to $B'D'$.

Prolong $B'D'$ to meet O_2T_2 in Q. Draw O_1S perpendicular to O_2T_2.

Then $$T_2Q = BP = BB' \sin \Delta = (T_1B - T_1B') \sin \Delta = (T_S - R_S \tan \tfrac{1}{2}\Delta) \sin \Delta \quad ...(2)$$

Also, $$B'P = BB' \cos \Delta = (T_S - R_S \tan \tfrac{1}{2}\Delta) \cos \Delta \quad ...(3)$$

Now, $$O_2S = O_2T_2 - T_2Q - QS = R_L - BP - R_S \quad ...(4)$$

From triangle O_1O_2S, $$\cos \Delta_2 = \frac{O_2S}{R_L - R_S} \quad ...(5)$$

$$\Delta_1 = \Delta - \Delta_2 \quad ...(6)$$

and $$O_1S = (R_L - R_S) \sin \Delta_2 \quad ...(7)$$

$$T_L = BT_2 = PQ = QD' + B'D' - B'P = O_1S + B'D' - B'P \quad ...(8)$$

Thus Δ_1, Δ_2 and T_L are determined from (5), (6) and (8) above.

Case (3): *Given:* Δ, R_S, R_L and T_L

Required: Δ_1, Δ_2 and T_S

In Fig. 2.3, prolong the long curve T_2D to a point D' until it has a central angle $D'O_2T_2 = \Delta$. Its tangent $B'D'$ will then be parallel to the tangent BT_1.

Then $$T_2B' = B'D' = R_L \tan \tfrac{1}{2}\Delta \quad ...(1)$$

Draw BP perpendicular to $D'B'$.

Prolong BT_1 to meet $D'O_2$ in Q. Draw O_1S perpendicular to $D'O_2$.

Then, $$D'Q = BP = BB' \sin \Delta$$
$$= (T_2B' - T_2B) \sin \Delta$$
$$= (R_L \tan \tfrac{1}{2}\Delta - T_L) \sin \Delta \quad ...(2)$$

Also, $$B'P = BB' \cos \Delta$$
$$= (R_L \tan \tfrac{1}{2}\Delta - T_L) \cos \Delta \quad ...(3)$$

Now, $$O_2S = O_2D' - D'Q - QS$$
$$= R_L - BP - R_S \quad ...(4)$$

From triangle O_1O_2S, $$\cos \Delta_1 = \frac{O_2S}{R_L - R_S} \quad ...(5)$$

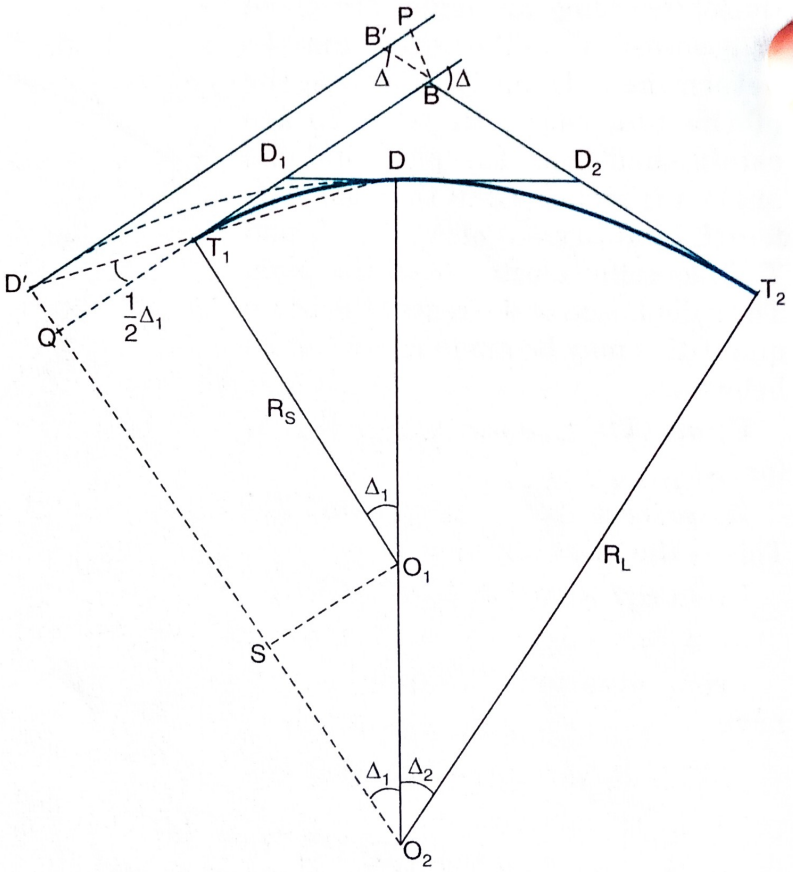


Fig. 2.3 Calculation of Δ_1, Δ_2 and T_S.

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$$\Delta_2 = \Delta - \Delta_1 \quad ...(6)$$

$$O_1S = (R_L - R_S) \sin \Delta_1 \quad ...(7)$$

and

$$T_S = T_1B = QB - QT_1 = D'P - O_1S$$
$$= D'B' + B'P - O_1S \quad ...(8)$$

Thus, Δ_1, Δ_2 and T_S are determined from (5), (6) and (8) above.

Case (4): *Given:* Δ, T_S, T_L and R_S.

Required: Δ_1, Δ_2 and R_L.

Refer Fig. 2.2,

As in case (2), we have

$$T_1B' = B'D' = R_S \tan \tfrac{1}{2} \Delta \quad ...(1)$$

$$T_2Q = (T_S - R_S \tan \tfrac{1}{2}\Delta) \sin \Delta \quad ...(2)$$

and

$$B'P = B'B \cos \Delta = (T_S - R_S \tan \tfrac{1}{2}\Delta) \cos \Delta \quad ...(3)$$

Now,

$$O_1S = QD' = QP + PB' - B'D' = T_L + B'P - B'D' \quad ...(4)$$

Join DD' and prolong it to pass through T_2.

Evidently, $\angle T_2D'Q = \tfrac{1}{2}\Delta_2$

$\therefore$

$$\tan \tfrac{1}{2}\Delta_2 = \frac{T_2Q}{QD'} = \frac{BP}{QD'} \quad ...(5)$$

$$\Delta_1 = \Delta - \Delta_2 \quad ...(6)$$

$$R_L - R_S = O_1O_2 = \frac{O_1S}{\sin \Delta_2}$$

$\therefore$

$$R_L = R_S + \frac{O_1S}{\sin \Delta_2} \quad ...(7)$$

Thus, Δ_1, Δ_2 and R_L can be computed from (5), (6) and (7) above.

Case (5): *Given:* T_S, T_L and R_L

Required: Δ_1, Δ_2 and R_S

Refer Fig. 2.3. As in case (3), we have

$$T_2B' = B'D' = R_L \tan \tfrac{1}{2}\Delta \quad ...(1)$$

$$D'Q = BP = (R_L \tan \tfrac{1}{2}\Delta - T_L) \sin \Delta \quad ...(2)$$

and

$$B'P = BB' \cos \Delta = (R_L \tan \tfrac{1}{2}\Delta - T_L) \cos \Delta \quad ...(3)$$

Now,

$$O_1S = QT_1 = QB - T_1B = D'P - T_1B = D'B' + B'P - T_S \quad ...(4)$$

Join DT_1 and prolong it to pass through D'.

Evidently, $\angle D'T_1Q = \tfrac{1}{2}\Delta_1$

$\therefore$

$$\tan \tfrac{1}{2}\Delta_1 = \frac{D'Q}{QT_1} = \frac{BP}{O_1S} \quad ...(5)$$

$$\Delta_2 = \Delta - \Delta_1 \quad ...(6)$$

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$$R_L - R_S = O_1O_2 = \frac{O_1S}{\sin \Delta_1} \quad \ldots(7)$$

$$R_S = R_L - \frac{O_1S}{\sin \Delta_1}$$

Thus, Δ_1, Δ_2 and R_S can be computed from (5), (6) and (7).

2.3 SETTING OUT COMPOUND CURVE

The compound curve can be set by method of deflection angles. The first branch is set out by setting the theodolite at T_1 (P.C.) and the second branch is set out by setting the theodolite at the point D (P.C.C.). The procedure is as follows:

1. After having known any four parts, calculate the rest of the three parts by the formulae developed in § 2.2.
2. Knowing T_S and T_L, locate points T_1 and T_2 by linear measurements from the point of intersection.
3. Calculate the length of curves l_S and l_L. Calculate the chainage of T_1, D and T_2 as usual.
4. For the first curve, calculate the tangential angles etc., for setting out the curve by Rankine's method.
5. Set the theodolite at T_1 and set out the first branch of the curve as already explained.
6. After having located the last point D (P.C.C) shift the theodolite to D and set it there. With the vernier set to $\left(360° - \frac{\Delta_1}{2}\right)$ reading, take a backsight on T_1 and plunge the telescope. The line of sight is thus oriented along T_1D produced and if the theodolite is now swung through $\frac{\Delta_1}{2}$, the line of sight will be directed along the common tangent DD_2. Thus the theodolite is correctly oriented at D.
7. Calculate the tangential angles for the second branch and set out the curve by observations from D, till T_2 is reached.
8. Check the observations by measuring the angle T_1DT_2, which should be equal to $\left(180° - \frac{\Delta_1 + \Delta_2}{2}\right)$ or $\left(180° - \frac{\Delta}{2}\right)$.

Example 2.1: *Two straights AB and BC are intersected by a line D_1D_2 (Fig. 2.1). The angles BD_1D_2 and BD_2D_1 are 40° 30′ and 36° 24′ respectively. The radius of the first arc is 600 metres and that of the second arc is 800 metres. If the chainage of intersection point B is 8248.1 metres, find the chainages of the tangent points and the point of compound curvature.*

Solution:

$$\angle BD_1D_2 = \Delta_1 = 40° 30'$$

$$\angle BD_2D_1 = \Delta_2 = 36° 24'$$

$$\therefore \quad \Delta = \Delta_1 + \Delta_2 = 40° 30' + 36° 24' = 76° 54'$$

For the first branch, the central angle = $\Delta_1 = 40° 30'$

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$$t_S = T_1 D_1 = D_1 D = R_S \tan \frac{\Delta_1}{2} = 600 \tan 20° 15' = 221.4 \text{ m}$$

For the second branch, the central angle = $\Delta_2 = 36° 24'$

$$\therefore \quad t_L = T_2 D_2 = D_2 D = R_L \tan \frac{\Delta_2}{2} = 800 \tan 18° 12' = 263 \text{ m}$$

$$\therefore \quad D_1 D_2 = D_1 D + D D_2 = 221.4 + 263 = 484.4 \text{ m}$$

From triangle BD_1D_2, we have

$$\frac{BD_1}{\sin \Delta_2} = \frac{D_1 D_2}{\sin \Delta}$$

$$BD_1 = D_1 D_2 \frac{\sin \Delta_2}{\sin \Delta} = 484.4 \times \frac{\sin 36° 24'}{\sin 76° 54'} = 295.1 \text{ m}$$

$$\text{Length of the first arc} = l_1 = \frac{\pi R_S \Delta_1}{180°} = \frac{\pi \times 600 \times 40° 30'}{180°} = 424.1 \text{ m}$$

$$\text{Length of the second arc} = l_2 = \frac{\pi R_L \Delta_2}{180°} = \frac{\pi \times 800 \times 36° 24'}{180°} = 508.2 \text{ m}$$

$$T_S = BD_1 + T_1 D_1 = 295.1 + 221.4 = 516.5 \text{ m}$$

Chainage of P.I. = 8248.1 m
Subtract T_S = 516.5
Chainage of T_1 = **7731.6**
Add length l_1 = 424.1
Chainage of P.C.C. = **8155.7**
Add length l_2 = 508.2
Chainage of T_2 = **8663.9**

Example 2.2: *The following data refer to a compound circular curve which bears to the right:*
Total deflection angle 93°
Degree of first curve 4°
Degree of second curve 5°
Point of intersection at 45 + 61 (20 m units)
Determine in 20 metre units the running distance of the tangent points and the point of compound curvature, given that the latter point is 6 + 24 from the point of intersection at back angle of 290° 36' from the first tangent.

Solution: (Fig. 2.1)

Let R_1 = Radius corresponding to 4° curve
and R_2 = Radius corresponding to 5° curve

From Eq. 1.3, $R = \frac{1146}{D}$ metres

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$$\therefore \quad R_1 = \frac{1146}{4} = 286.5 \text{ m}$$

and $$R_2 = \frac{1146}{5} = 229.2 \text{ m}$$

$$BD = 6 + 24 \text{ in } 20 \text{ m units} = 6.24 \times 20 = 124.8 \text{ m}$$

$$\angle T_1BD \text{ (external)} = 290° 36'$$

$$\therefore \quad \angle T_1BD \text{ (internal)} = 360° - 290° 36' = 69° 24'$$

From triangle T_1BD,

$$\frac{\sin BT_1D}{BD} = \frac{\sin T_1BD}{T_1D}$$

But $$\angle BT_1D = \frac{\Delta_1}{2}$$

and $$T_1D = 2R_1 \sin \frac{\Delta_1}{2} = 573 \sin \frac{\Delta_1}{2}$$

Hence, $$\frac{\sin \frac{\Delta_1}{2}}{124.8} = \frac{\sin 69° 24'}{573 \sin \frac{\Delta_1}{2}}$$

or $$\left(\sin \frac{\Delta_1}{2}\right)^2 = \frac{124.8}{573} \times \sin 69° 24'$$

or $$\sin \frac{\Delta_1}{2} = \left(\frac{124.8}{573} \times \sin 69° 24'\right)^{1/2}$$

From which, $$\frac{\Delta_1}{2} = 26° 50', \text{ or } \Delta_1 = 53° 40'$$

$$\Delta_2 = \Delta - \Delta_1 = 93° - 53° 40' = 39° 20'$$

$$t_1 = T_1D_1 = R_1 \tan \frac{\Delta_1}{2} = 286.5 \tan 26° 50' = 144.9 \text{ m}$$

$$t_2 = T_2D_2 = R_2 \tan \frac{\Delta_2}{2} = 229.2 \tan 19° 40' = 81.9 \text{ m}$$

$$T_1 = T_1B = t_1 + (t_1 + t_2) = \frac{\sin \Delta_2}{\sin \Delta}$$

$$= 144.9 + (144.9 + 81.9) \frac{\sin 39° 20'}{\sin 93°} = 288.9 \text{ m}$$

Length of the first arc $= l_1$

$$= \frac{\Delta_1}{D_1} \times 20 = \frac{53° 40'}{4°} \times 20 = 268.3 \text{ m}$$

Length of the second arc $= l_2$

$$= \frac{\Delta_2}{D_2} \times 20 = \frac{39° 20'}{5°} \times 20 = 157.3 \text{ m}$$

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Chainage of P.I. = 912.2 m = 45 + 610 (in 20 m units)
Subtract T_1 = 288.9 = 14 + 445

Chainage of P.C. = 623.3 = **31.165**
Add l_1 = 268.3 = 13.415

Chainage of P.C.C. = 891.6 = **44.580**
Add l_2 = 157.3 = 7.865

Chainage of P.T. = 1048.9 = **52.445.**

Example 2.3: *A compound curve is to consist of an arc of 36 chains followed by one of 48 chains radius and is to connect two straights which yield a deflection angle of 84° 30′. At the intersection point the chainage, if continued along the first tangent, would be 86 + 48 and starting point of the curve is selected at chainage 47 + 50. Calculate the chainage at the point of junction of the two branches and at the end of the curve.*

Solution: (Fig. 2.2).

Here, R_S, R_L, Δ and T_S are given. In order to calculate the chainages of various points, we will have to first determine Δ_1 and Δ_2.

$$T_S = 86.48 - 47.50 = 38.98 \text{ chains.}$$

As in Fig. 2.2, prolong the shorter arc to a point D' so that its central angle is equal to $\Delta = 84° 30'$. The tangent $D'B'$ will then be parallel to initial tangent BT_2. Draw BP perpendicular to $B'D'$.

Then
$$T_2Q = BP = BB' \sin \Delta$$
$$= (T_1B - T_1B') \sin \Delta = (T_S - R_S \tan \tfrac{1}{2}\Delta) \sin \Delta$$
$$= (38.98 - 36 \tan 42° 15') \sin 84° 30' = 6.26 \text{ chains}$$
$$O_2S = O_2T_2 - T_2Q - QS = R_L - T_2Q - R_S$$
$$= 48 - 6.26 - 36 = 5.74 \text{ chains}$$
$$\cos \Delta_2 = \frac{O_2S}{R_L - R_S} = \frac{5.74}{48 - 36}$$
$$\therefore \quad \Delta_2 = 61° 24.$$
$$\therefore \quad \Delta_1 = 84° 30' - 61° 24' = 23° 6'$$

$$\text{Length of the first arc} = l_1 = \frac{\pi R_S \Delta_1}{180°} = \frac{\pi \times 36 \times 23° 6'}{180°} = 14.52 \text{ chains}$$

$$\text{Length of the second arc} = l_2 = \frac{\pi R_L \Delta_2}{180°} = \frac{\pi \times 48 \times 61° 24'}{180°} = 51.44 \text{ chains}$$

Chainage of P.C. = 47.50 chains
Add length of the first arc = 14.52

Chainage of P.C.C. = **62.02**
Add length of the second arc = 51.44

Chainage of end of curve = **113.46**

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Example 2.4: *A compound curve is to connect two straights having a deflection angle of 90°. As determined from the plan, the lengths of the two tangents are 350 metres and 400 metres respectively. Calculate the lengths of the two arcs if the radius of the first curve is be 300 metres.*

Solution: (Fig. 2.2)

Given:

$$T_S = 350 \text{ m}$$
$$T_L = 400 \text{ m}$$
$$\Delta = 90°$$
$$R_S = 300 \text{ m}$$

Required to find Δ_1, Δ_2 and R_L

$$T_1B' = B'D' = R_S \tan \tfrac{1}{2}\Delta = 300 \tan 45° = 300 \text{ m}$$

$$T_2Q = BP = (T_S - R_S \tan \tfrac{1}{2}\Delta) \sin \Delta = (350 - 300 \tan 45°) \sin 90° = 50 \text{ m}$$

$$B'P = BB' \cos 90° = \text{zero}$$

$$O_1S = QD' = QP + PB' - B'D' = T_L + 0 - 300 = 400 - 300 = 100 \text{ m}$$

$$\tan \tfrac{1}{2}\Delta_2 = \frac{T_2Q}{QD'} = \frac{BP}{QD'} = \frac{50}{100} = 0.5$$

$\therefore$ $\tfrac{1}{2}\Delta_2 = 26° 34'$

or $\Delta_2 = 53° 8'$

$$\Delta_1 = \Delta - \Delta_2 = 90° - 53° 8' = 36° 52'.$$

Also, $$R_L - R_S = \frac{O_1S}{\sin \Delta_2}$$

$\therefore$ $$R_L = R_S + \frac{O_1S}{\sin \Delta_2} = 300 + \frac{100}{\sin 53° 8'} = \mathbf{425 \text{ m}}$$

$\therefore$ Length of the first arc $= \dfrac{\pi R_S \Delta_1}{180°} = \dfrac{\pi(300)(39° 52')}{180°} = \mathbf{193.1 \text{ m}}$

Length of the second arc $= \dfrac{\pi R_L \Delta_2}{180°} = \dfrac{\pi(425)(53° 8')}{180°} = \mathbf{394.2 \text{ m}}$

Example 2.5: *A 200 m length of straight connects two circular curves which both deflect to the right. The radius of the first curve is 250 m and that of the second curve is 200 m. The central angle for the second curve is 27° 30'. The combined curve is to be replaced by a single circular curve between the same tangent points. Find the radius of the curve. Assume that the two tangent lengths of the earlier set are equal.*

Also, determine (a) central angle of the new curve, (b) central angle of first curve of radius 250 m.

Solution: Fig. 2.4 shows the two curves T_1A and BT_2 separated by the intervening straight AB of length 200 m. The data of the two curves are such that the tangent lengths T_1D and DT_2 are equal, where D is the point of intersection of the tangents. *This is an essential condition to replace the two curves and the straight by a single circular curve without the change in the direction of original tangents and also without shifting the original tangent points.* Naturally, the central angle (Δ) for the new curve will be the original angle of intersection between the two tangents.

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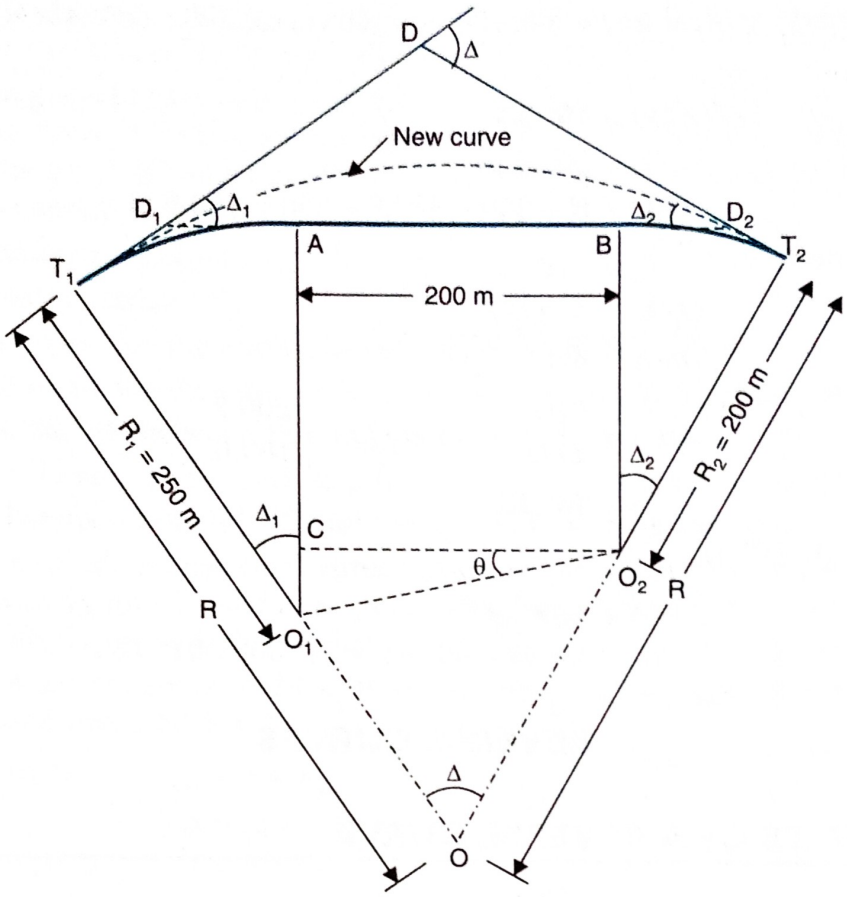


Fig. 2.4

Let O be the centre of the new curve and R be its radius. The centre will coincide with the point of intersection of the external radius vectors T_1O_1 and T_2O_2 (both produced back) of the two original curves.

Join O_1O_2. Draw O_2C perpendicular to O_1A.

Then $$O_1O_2 = \sqrt{O_1C^2 + O_2C^2},$$

But $$O_1C = O_1A - O_2B = 250 - 200 = 50 \text{ m}$$

and $$O_2C = AB = 200 \text{ m}$$

$\therefore$ $$O_1O_2 = \sqrt{(50)^2 + (200)^2} = 206.2 \text{ m}$$

$$\theta = \tan^{-1}\frac{O_1C}{O_2C} = \tan^{-1}\frac{50}{200} = 14^\circ\ 2'$$

From triangle O_1OO_2,

$$\angle O_1O_2O = 180^\circ - (\theta + 90^\circ + \Delta_2) = 180^\circ - (14^\circ\ 2' + 90^\circ + 27^\circ\ 30') = 48^\circ\ 28'$$

Now, $$O_1O = R - 250 \text{ and } O_2O = R - 200$$

Applying cosine rule,

$$O_1O^2 = (O_1O_2)^2 + (OO_2)^2 - 2O_1O_2 \cdot OO_2 \cos 48^\circ\ 28'$$

or $$(R - 250)^2 = (206.2)^2 + (R - 200)^2 - 2 \times (206.2)(R - 200) \cos 48^\circ\ 28'$$

From which, $$R = \mathbf{430.6} \text{ m}$$

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In order to calculate central angle Δ of the new curve, consider triangle O_1O_2O, in which we have

$$\angle O_1O_2O = 48° 28'$$
$$O_1O_2 = 206.2 \text{ m}$$
$$O_1O = R - 250 = 430.6 - 250 = 180.6 \text{ m}$$

Applying the sine rule,

$$\frac{O_1O_2}{\sin \Delta} = \frac{O_1O}{\sin O_1O_2O}$$

$$\therefore \quad \sin \Delta = \frac{O_1O_2}{O_1O} \times \sin O_1O_2O = \frac{206.2}{180.6} \times \sin 48° 28' = 0.8547$$

$$\therefore \quad \Delta = \mathbf{58° 43'}$$

Now from triangle DD_1D_2,

$$\Delta = \Delta_1 + \Delta_2$$

$$\therefore \quad \Delta_1 = \Delta - \Delta_2 = 58° 43' - 27° 30' = \mathbf{31° 13'}.$$

REVERSE CURVES

2.4 ELEMENTS OF A REVERSE CURVE

A reverse curve consists of two simple curves of opposite direction that join at a common tangent point called the point of reverse curvature (P.R.C.). They are used when the straights are parallel or include a very small angle of intersection and are frequently encountered in mountainous countries, in cities, and in the layout of railway spur tracks and cross-over. The use of reverse curve should be avoided on highways and main railway lines where speeds are high for the following reasons:

1. Sudden change of cant is required from one side of P.R.C. to the other.
2. There is no opportunity to elevate the outer bank at P.R.C.
3. The sudden change of direction is uncomfortable to passengers and is objectionable.
4. Steering is dangerous in the case of highways and the driver has to very cautious.

It is definitely an advantage to separate to curves by either a short length of straight or a reversed spiral. The elements of a reverse curve are not directly determinate unless some condition or dimension is specified as, for example, equal

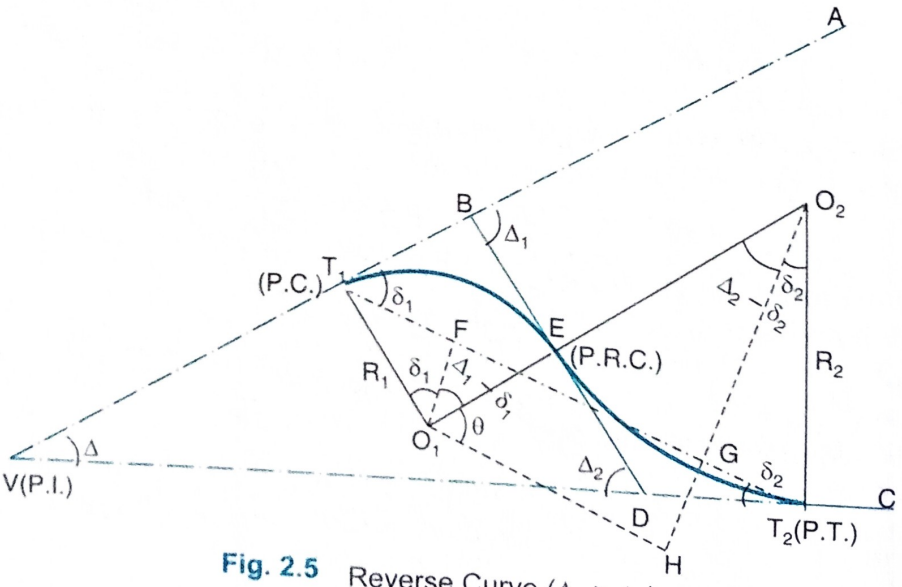


Fig. 2.5 Reverse Curve ($\Delta_1 > \Delta_2$).

Scanned with ACE Scanner