

Setting out of Curve

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Method of setting out simple circular curves :

Setting out means locating various points at equal and convenient distances along the length of the curve.

Distance between two successive points called as peg interval.

There are two type of methods for setting out simple circular curves based on the instrument used in method :

1. Linear method.
2. Angular method.

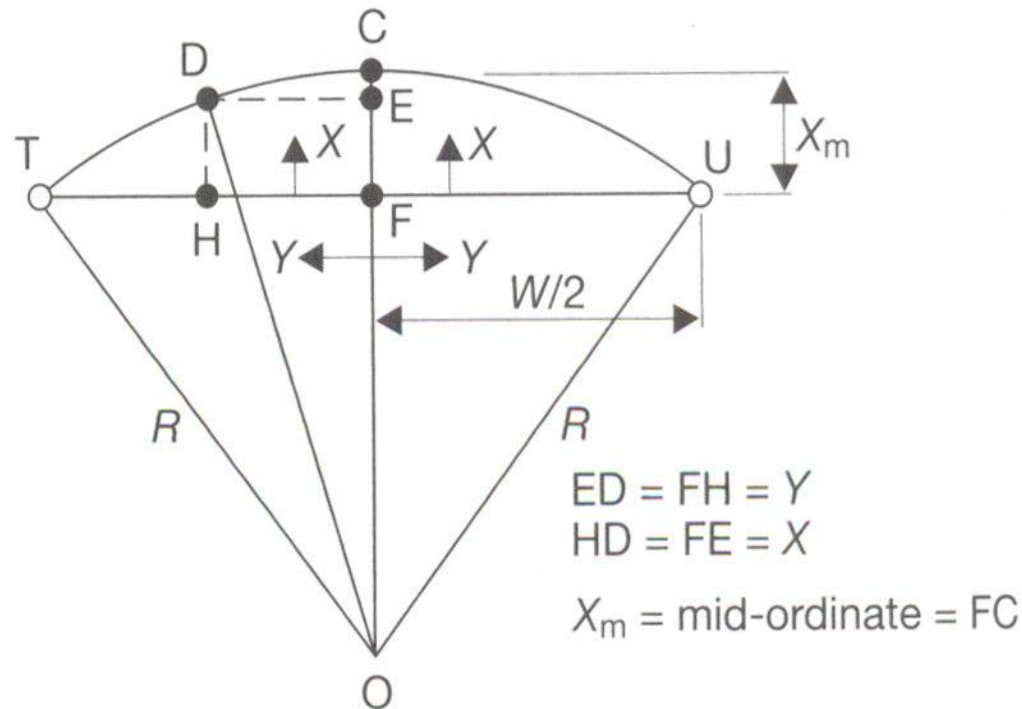
Setting out Circular Curves by linear Methods :

There are 4 methods by which pegs on the centreline of circular curves can be set out:

1. Offsets from the long chord.
2. Offsets from chords produced.
3. Offsets from the tangent lengths
4. Method of successive bisection of arcs or chords.

1. Setting out using Offsets from the Long Chord :

This traditional method also requires two tapes and is also suitable for curves of small radius such as kerbs or boundary walls.



5. Offset from long chord Let it be required to lay a curve T_1CT_2 between two intersecting straight lines T_1I and T_2I (Fig. 11.9). R is the radius of the curve, O the mid-ordinate, and O_x the offset at a point P at a distance x from the mid-point M of the long chord.

From triangle OMT_1

$$OM = \sqrt{OT_1^2 - MT_1^2} \quad \text{Fig. 11.9}$$

$$= \sqrt{R^2 - (L/2)^2}$$

Now, $CM = OC - OM$

or $O_0 = R - OM$

or $O_0 = R - \sqrt{R^2 - (L/2)^2}$

In triangle $OP'G$

$$OG = \sqrt{R^2 - x^2} \quad \text{and} \quad OM = R - O_0$$

The required offset

$$PP' = OG - OM$$

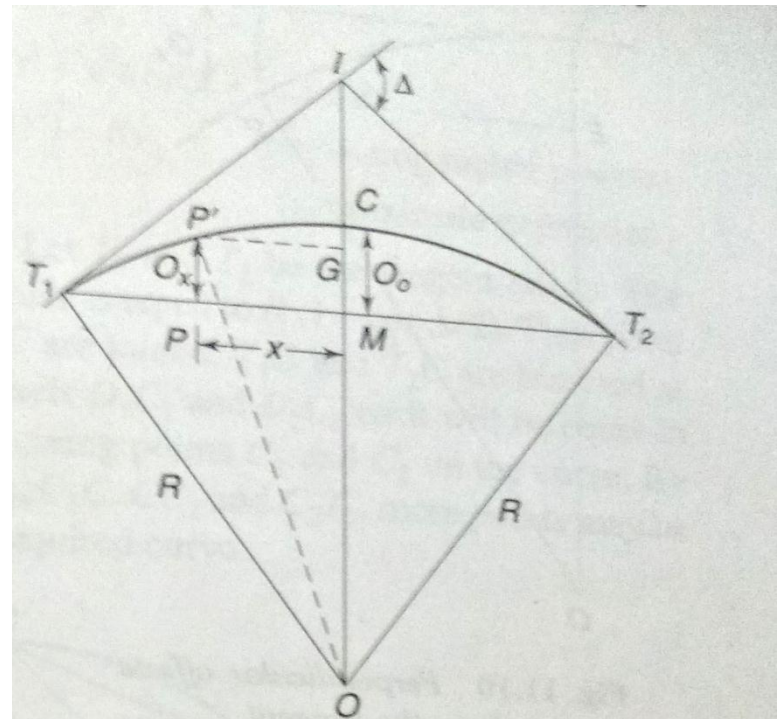
Hence, $PP' = \sqrt{R^2 - x^2} - (R - O_0)$

or $O_x = \sqrt{R^2 - x^2} - (R - O_0)$

$$= R(1 - x^2/R^2)^{1/2} - R + O_0$$

$$= R(1 - x^2/(2R^2) + \dots) - R + O_0$$

$$= O_0 - \frac{x^2}{2R}$$



(i) By offsets or ordinate from the long chord.

$$O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$O_x = \sqrt{R^2 - x^2} - (R - O_0)$$

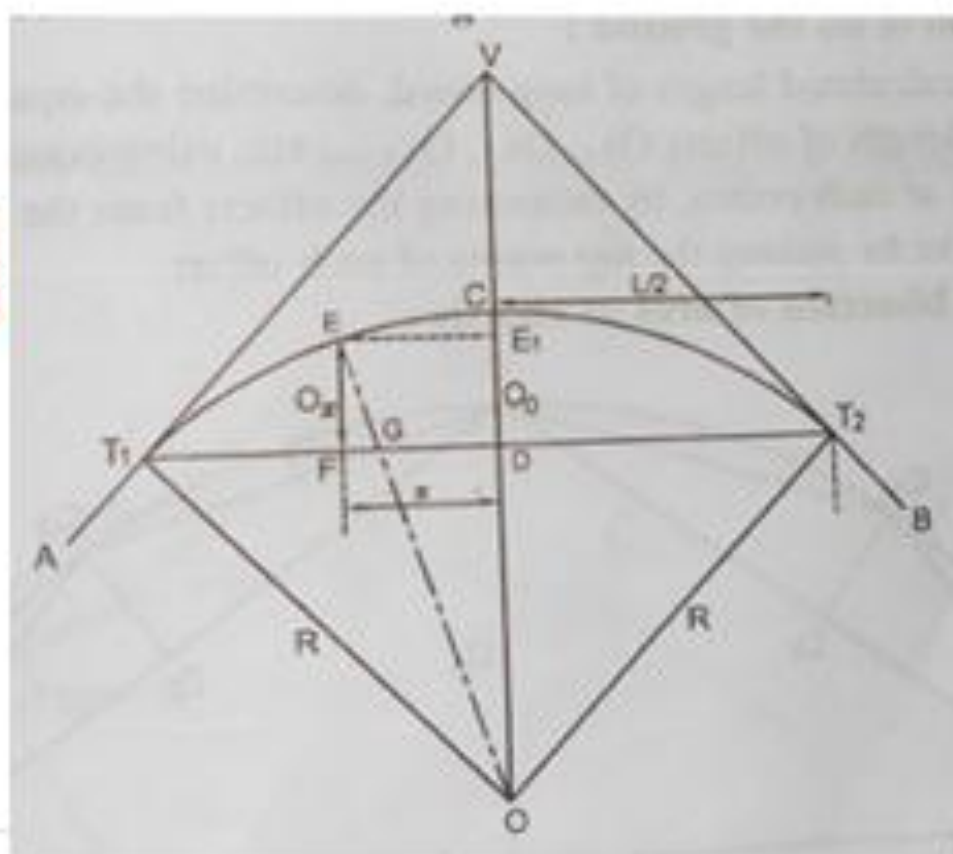
R = Radius of curve

O₀ = Mid ordinate

O_x = Ordinate at distance x

T₁, T₂ = tangents point

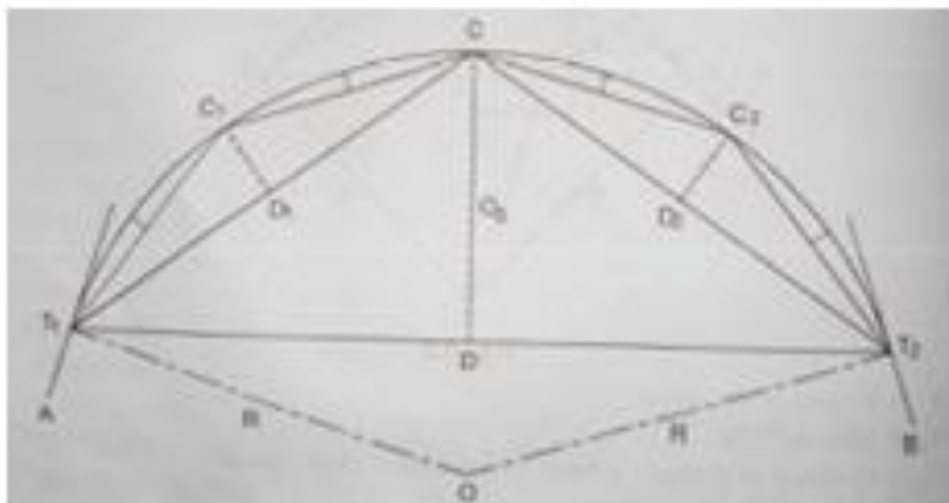
L = Length of long chord.



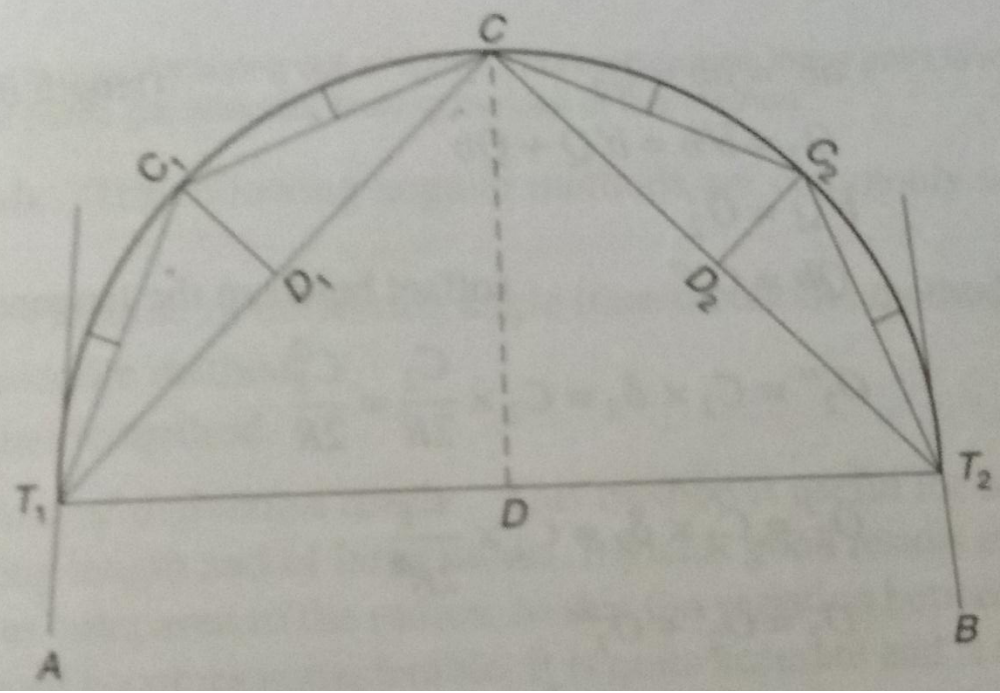
(ii) By successive bisection of arcs or chords.

$$O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

- T1-T2= L
- T1-C = L
- T2-C = L
- C-C1, C-C2=L
- C1-T1, C2-T2=L



Successive bisection of arcs or chords Let T_1 and T_2 be the tangent points. The long chord $T_1 T_2$ is bisected at D . Mid-ordinate is equal to $R(1 - \cos \Delta/2)$. Thus point C is established (Fig. 11.12). $T_1 C$ and $T_2 C$ are joined. $T_1 C$ and $T_2 C$ are bisected at D_1 and D_2 , respectively. Perpendicular offsets $D_1 C_1$ and $D_2 C_2$ each will be equal to $R(1 - \cos \Delta/4)$. These offsets are set out giving points C_1 and C_2 on the curve. By the successive bisection of the chords $T_1 C_1$, $C_1 C$, $C C_2$ and $C_2 T_2$, more points may be obtained which when joined produce the required curve.



By offsets from the chords produced This is the best method for setting out a long curve by linear method and is usually employed for highway curves when a theodolite is not available.

T_1 is the P.C. along the tangent T_1P (Fig. 11.13). T_1a is the first sub-chord, C_1 . From the P.C., a length equal to first sub-chord C_1 (T_1a) is taken. The perpendicular offset (O_1) aa' is set out, thereby getting point a . T_1a is joined and produced by distance C_2 (full chord length). The second offset O_2 (bb') is set out to get point b . a and b are joined and produced further by distance C_3 (full chord

This is the best method for setting out a

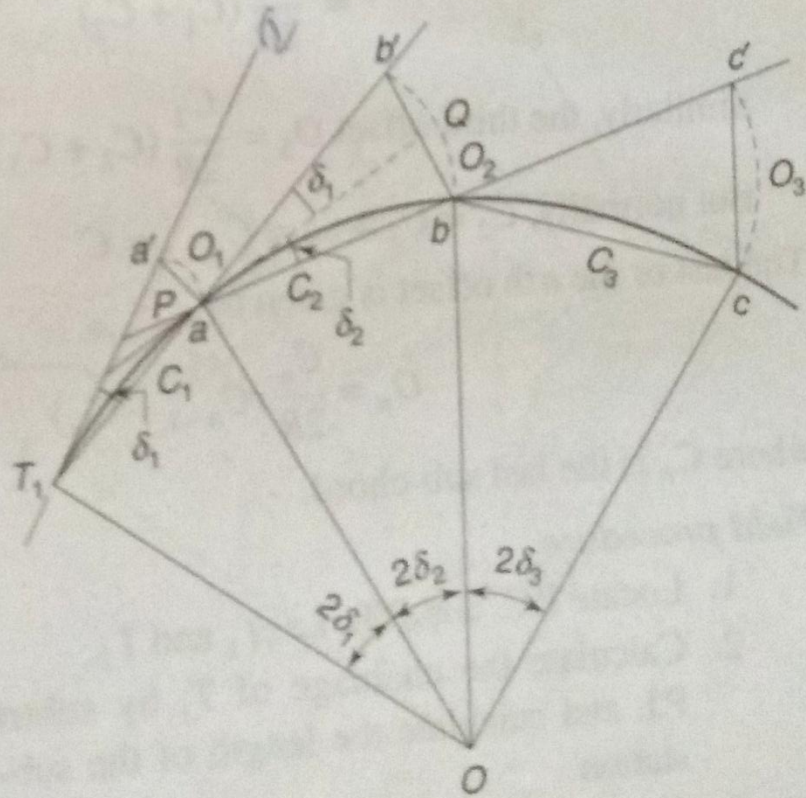


Fig. 11.13 Offsets from chords produced

length). The third offset O_3 (cc') is set out to get point c . The procedure is repeated till the curve is completed.

so that

$$\angle a'T_1a = \delta_1 = \text{deflection angle of the first chord} \quad (1)$$

$$O_1 = a'a = T_1a\delta_1 = C_1\delta_1$$

$$\angle T_1Oa = 2\angle aT_1a' = 2\delta_1$$

$$T_1a = R \times 2\delta_1$$

$$\delta_1 = \frac{T_1a}{2R} = \frac{C_1}{2R}$$

or

Putting this value of δ_1 in Eq. (1) we get

$$O_1 = C_1 \times \frac{C_1}{2R} = \frac{C_1^2}{2R}$$

For computing O_2 , a tangent PQ is drawn to the curve at a , and is produced both ways.

$$ab' = ab = C_2$$

(length of second chord)

$$O_2 = b'b = b'Q + Qb$$

$$b'Q = O_2'$$

$$Qb = O_2''$$

(offset between the tangent and the chord)

$$O_2'' = C_2 \times \delta_2 = C_2 \times \frac{C_2}{2R} = \frac{C_2^2}{2R}$$

$$O_2' = C_2 \times \delta_1 = C_2 \times \frac{C_1}{2R}$$

so that

$$O_2 = O_2' + O_2''$$

$$= \frac{C_1C_2}{2R} + \frac{C_2^2}{2R}$$

$$= \frac{C_2}{2R} (C_1 + C_2)$$

Similarly, the third offset $O_3 = \frac{C_3}{2R} (C_2 + C_3) = cc'$

But normally, $C_2 = C_3 = \dots = C$

3. By offsets from the tangents :

There are two types for sitting out simple circular curves by method of offsets from the tangents :

1. RADIAL OFFSET.

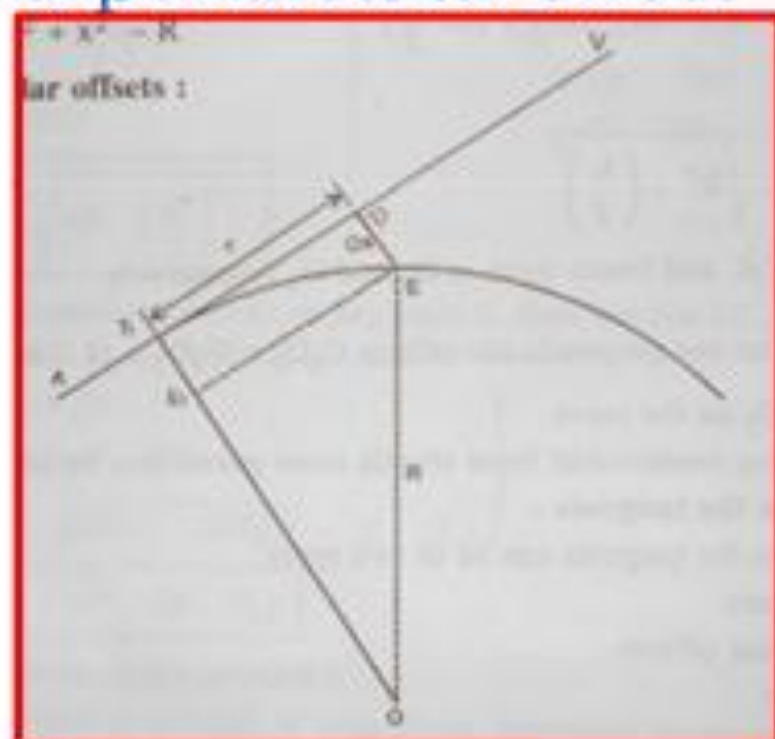
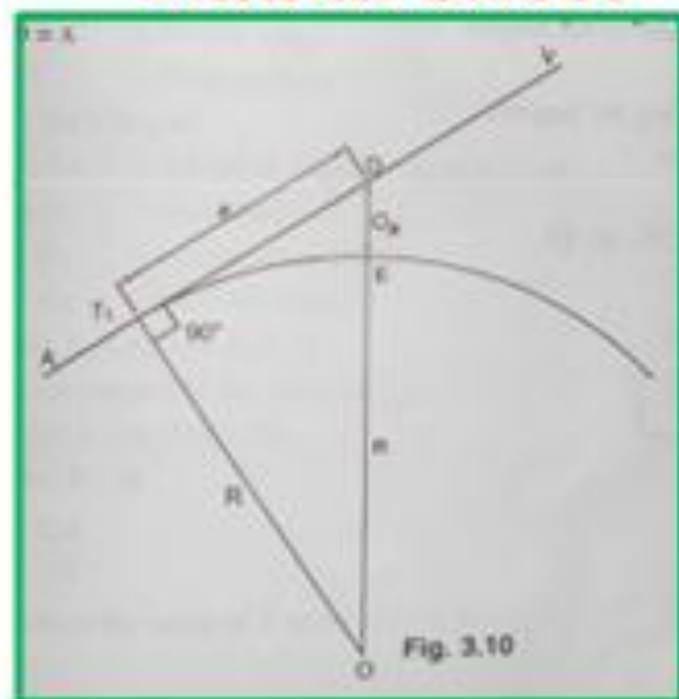
2. PERPENDICULAR OFFSET.

(iii) By offsets from the tangents.

• Two types

• Radial offset

Perpendicular offset



$$O_x = \sqrt{R^2 + x^2} - R$$

$$O_x = R - \sqrt{R^2 - x^2}$$

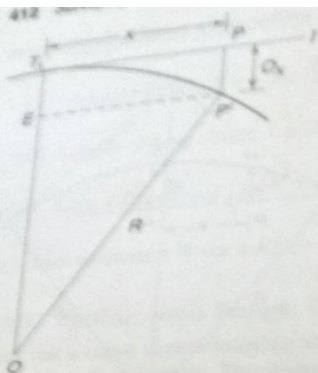


Fig. 11.10 Perpendicular offsets from the tangent

In the triangle OEP

$$PO^2 = OE^2 + PE^2$$

or $R^2 = (R - O_x)^2 + x^2$

or $(R - O_x)^2 = R^2 - x^2$

or $(R - O_x) = \sqrt{R^2 - x^2}$

or $O_x = R - \sqrt{R^2 - x^2}$ (exact expression)

$$= R - (R^2 - x^2)^{1/2}$$

$$= R - R(1 - x^2/R^2)^{1/2}$$

$$= R - R(1 - x^2/(2R^2) + x^4/(8R^4) + \dots)$$

$$= R - R(1 - x^2/(2R^2)) \quad (\text{neglecting higher powers})$$

$$= R - R + Rx^2/(2R^2)$$

or $O_x = x^2/2R$ (approximate expression)

Assigning different values to x , the corresponding values of offsets O_x can be calculated. These calculated offsets can be laid from the tangent at known distances x and the points can be established in the field which when joined produce the required curve.

Radial offsets from tangent O_x is the radial offset PP' at any distance x along the tangent from T_1 (Fig. 11.11).

From the triangle OT_1P

$$OP^2 = OT_1^2 + T_1P^2$$

$$(R + O_x)^2 = R^2 + x^2$$

$$R + O_x = \sqrt{R^2 + x^2}$$

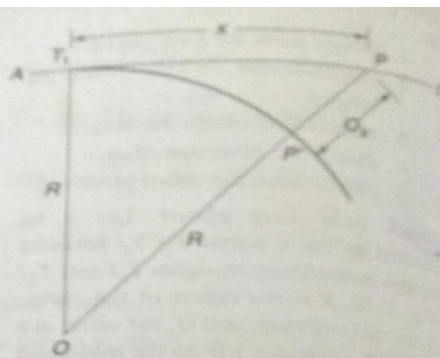


Fig. 11.11 Radial offsets from the tangent

$$O_x = \sqrt{R^2 + x^2} - R \quad (\text{exact expression})$$

$$= R(1 + x^2/R^2)^{1/2} - R$$

$$= R(1 + x^2/(2R^2) + x^4/(8R^4) + \dots) - R$$

$$= R(1 + x^2/(2R^2)) - R \quad (\text{neglecting higher powers})$$

$$O_x = x^2/2R \quad (\text{approximate expression})$$

Angular method :

- Used when length of curve is large
- More accurate than the linear methods.
- Theodolite is used

The angular methods are:

1) Rankine method of tangential angles.

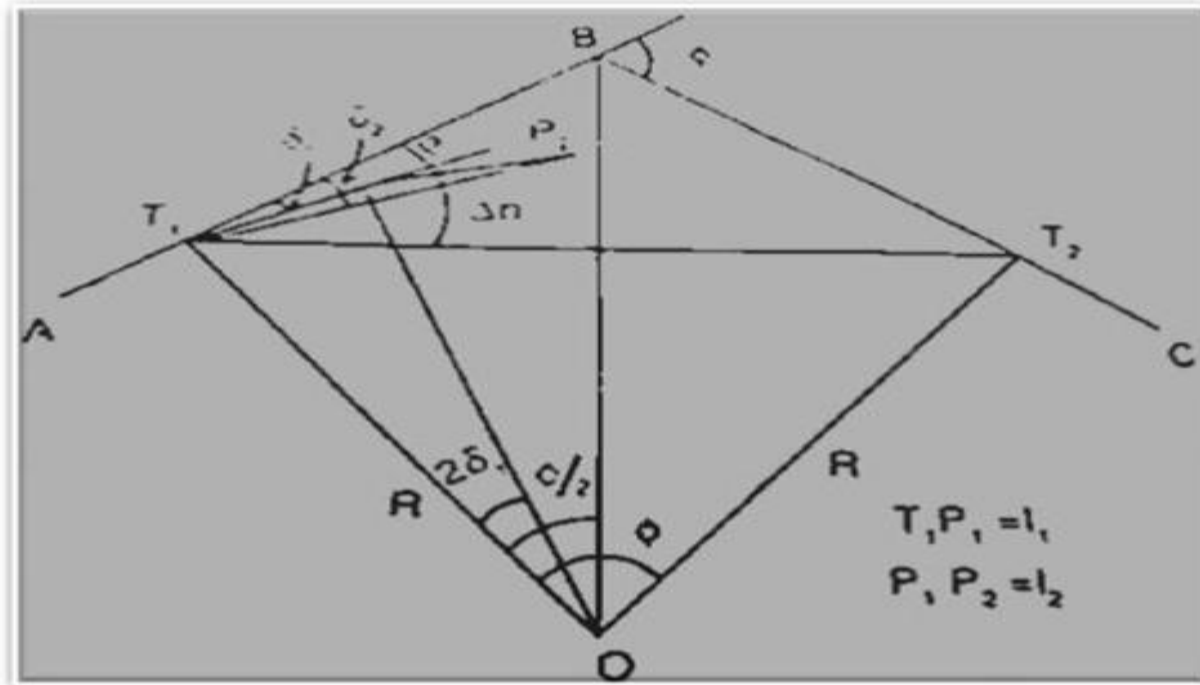
OR

One theodolite method

2) Two theodolite method.

1) Rankine method of tangential angles :

➤ This method is based on the following geometry:



Rankine's method of deflection angle This method is useful for setting out a circular curve of long length and of large radius. It yields good results except when the chords are long as compared to the radius, so that the variation between the length of an arc and its chord becomes considerable. It is quite accurate and is frequently used on highways and railways.

A deflection angle to any point on the curve is the angle at P.C. between the tangent and the chord from P.C. to that point. According to Rankine's method, this deflection angle is equal to half the angle subtended by the arc at the centre.

In Fig. 11.14, T_1 is the P.C.; a, b, c , etc. are the points on the curve; $\delta_1, \delta_2, \delta_3$, etc. are the respective deflection angles between the chords and the respective tangents at T_1, a, b , etc.; $\Delta_1, \Delta_2, \Delta_3$, etc. are the total deflection angles to the points a, b, c , etc.

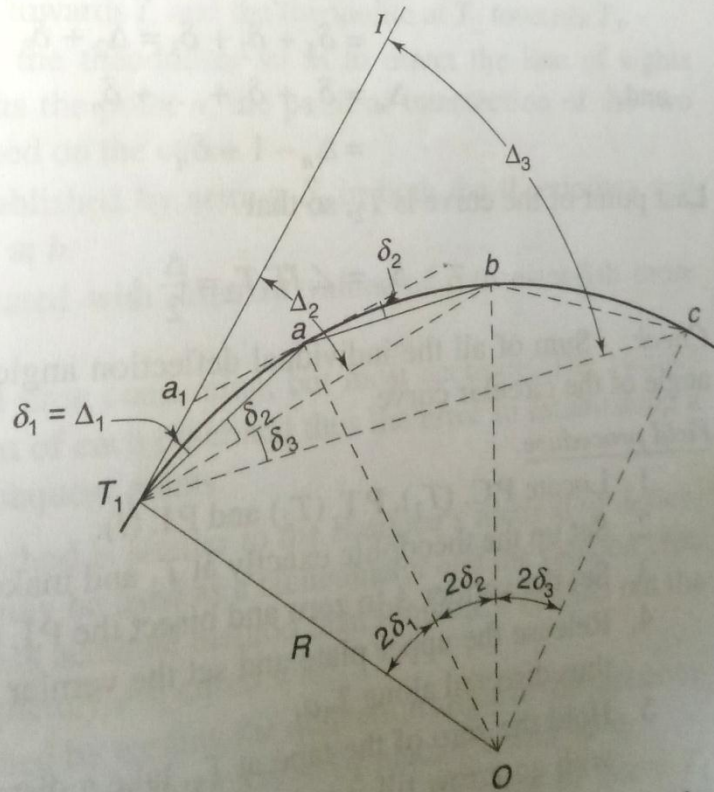


Fig. 11.14 Rankine's method of deflection angle

From the property of a circle that the angle subtended by a chord at the centre is twice the angle between the tangent and the chord. Then,

$$\angle T_1 O a = 2 \times \angle I T_1 a = 2 \delta_1$$

Now

$$R \times 2\delta_1 = T_1 a = C_1$$

or

$$\delta_1 = \frac{C_1}{2R} \text{ radians}$$

or

$$\delta_1 = \frac{C_1}{2R} \times \frac{180^\circ}{\pi} \text{ degrees}$$

$$= \frac{C_1}{2R} \times \frac{180^\circ}{\pi} \times 60 \text{ minutes}$$

i.e.

$$\delta_1 = 1718.9 \frac{C_1}{R} \text{ minutes}$$

Similarly,

$$\delta_2 = 1718.9 \frac{C_2}{R} \text{ minutes}, \delta_3 = 1718.9 \frac{C_3}{R} \text{ minutes}$$

For the first chord $T_1 a$, the deflection angle Δ_1 is its tangential angle δ_1 . For the second point b on the curve, the deflection angle $\Delta_2 = \angle I T_1 b$.

Let the tangential angle for chord $ab = \delta_2$, i.e. the angle between the tangent at a and chord ab .

The angle subtended by the chord ab at T_1 is $\angle a T_1 b = \delta_2$, so that

$$\begin{aligned} \Delta_2 &= \angle I T_1 b = \angle I T_1 a + \angle a T_1 b \\ &= \delta_1 + \delta_2 = \Delta_1 + \delta_2 \end{aligned}$$

Similarly,

$\angle b T_1 c = \delta_2$, so that

$$\begin{aligned} \Delta_3 &= \angle I T_1 c = \angle I T_1 b + \angle b T_1 c \\ &= \delta_1 + \delta_2 + \delta_3 = \Delta_2 + \delta_3 \end{aligned}$$

and

$$\begin{aligned} \Delta_n &= \delta_1 + \delta_2 + \dots + \delta_n \\ &= \Delta_{n-1} + \delta_n \end{aligned}$$

Last point of the curve is T_2 , so that

$$\Delta_n = \angle I T_1 T_2 = \frac{\Delta}{2}$$

Check: Sum of all the individual deflection angles is equal to half the deflection angle of the circular curve.

◉ Here,

$$\angle T_1OP_1 = 2 \times \angle BT_1P_1 = 2\delta_1$$

◉ Again,

$$\text{Chord } T_1P_1 \approx \text{arc } T_1P_1$$

◉ Now,

$$\frac{\angle T_1OP_1}{l_1} = \frac{360^\circ}{2\pi R}$$

$$\therefore 2\delta_1 = \frac{360^\circ \times l_1}{2\pi R}$$

◉ OR,

$$\therefore \delta_1 = \frac{360^\circ \times l_1}{2 \times 2\pi R} \text{ Degrees}$$

$$\therefore \delta_1 = \frac{360 \times 60 \times l_1}{2 \times 2\pi R} \text{ min s}$$

$$\therefore \delta_1 = \frac{1718.9 \times l_1}{R} \text{ min s}$$

◉ similarly,

$$\therefore \delta_2 = \frac{1718.9 \times l_2}{R} \text{ min s}$$

$$\therefore \delta_3 = \frac{1718.9 \times l_3}{R} \text{ min s}$$

➤ then,

$$\delta_n = \frac{1718.9 \times l_n}{R} \text{ min}$$

➤ when the degree of curve D is given,

$$\therefore \delta_1 = \frac{D \times l_1}{60} \text{ Degrees}$$

$$\therefore \delta_2 = \frac{D \times l_2}{60} \text{ Degrees}$$

⊙ finally,

$$\delta_n = \frac{D \times l_n}{60} \text{ deg}$$

⊙ Arithmetical check:

$$\delta_1 + \delta_2 + \delta_3 + \dots + \delta_n = \Delta_n = \frac{\phi}{2}$$

8. The same... point T_2 is reached.
Two-theodolite method This method is most convenient when the ground is undulating, rough and not suitable for linear measurements. In this method, two theodolites are used and linear measurements are completely eliminated. Hence, this is the most accurate method. It is based on the principle that the angle between the tangent and the chord is equal to the angle subtended by the chord in the opposite segment.

Thus, in Fig. 11.15,

$$\angle IT_1a = \delta_1 = \angle aT_2T_1 \text{ and } \angle IT_1b = \delta_2 = \angle bT_2T_1$$

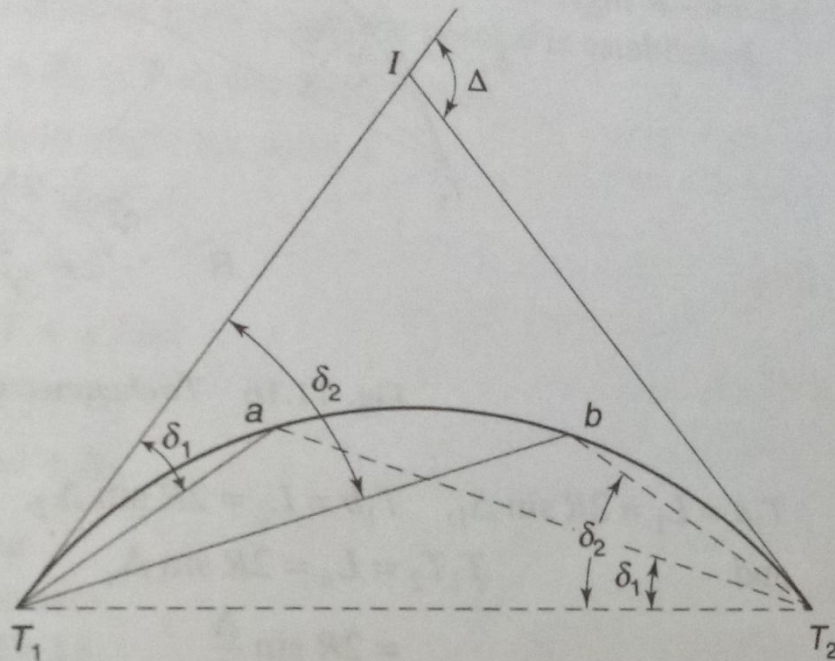


Fig. 11.15 Two-theodolite method

Obstacles in setting out simple curves :

- **Case –I -When P.I. is inaccessible**
- **Case –II -When P.C. is inaccessible**
- **Case –III -When P.T. is inaccessible**
- **Case –IV - When both P.C. and P.T. Is inaccessible.**
- **Case –V - When obstacles to chaining.**

THANK
YOU