

Compound Curve

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A compound curve consist of 2 arcs of different radii bending in the same direction and lying on the same side of their common tangent. Then the center being on the same side of the curve.

R_1 = Smaller radius

R_2 = Larger radius

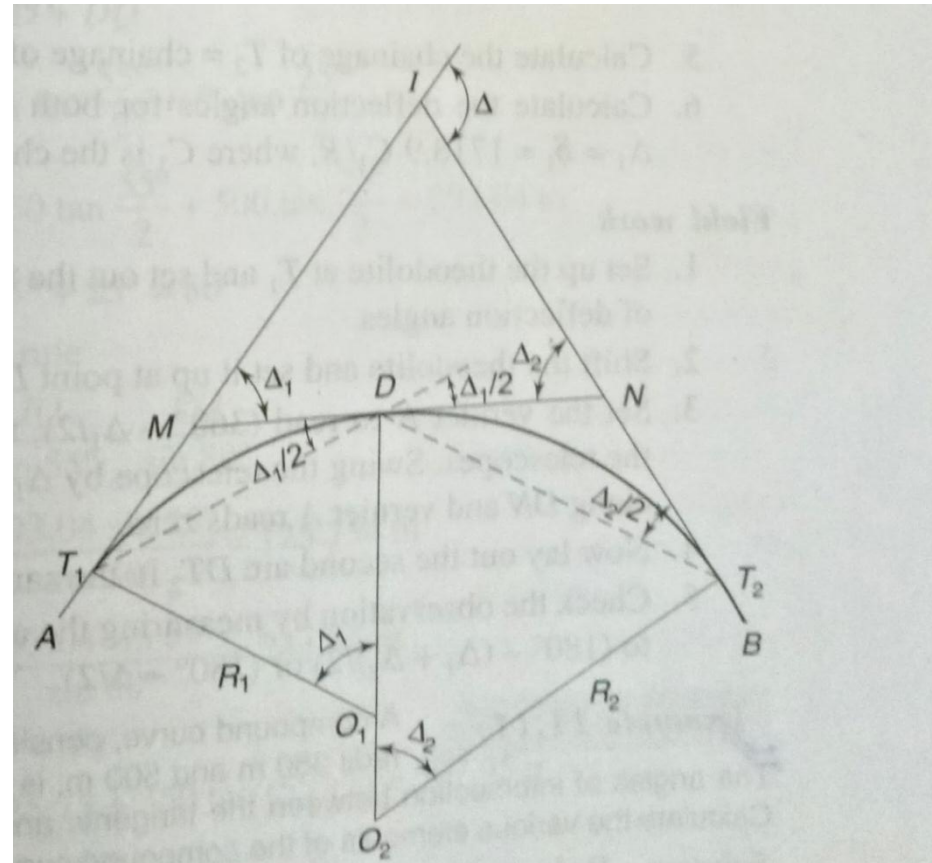
T_s = smaller tangent length = IT1

T_l = larger tangent length = IT2

Δ_1 = deflection angle b/w common tangent and rear tangent

Δ_2 = angle of deflection b/w common tangent and forward tangent

D = point of compound curvature
 MN = common tangent



AI and BI are two straight lines intersecting at I (P.I.). T_1DT_2 is the compound curve consisting of two arcs of radii R_1 and R_2 (Fig. 1), and D is the point of compound curvature. MN is the common tangent making deflection angles Δ_1 and Δ_2 at M and N.

so that $\Delta = \Delta_1 + \Delta_2$
 from the triangle IMN,

$$\frac{IM}{\sin \Delta_2} = \frac{IN}{\sin \Delta_1} = \frac{MN}{\sin (180^\circ - (\Delta_1 + \Delta_2))}$$

Hence, $IM = \frac{MN \sin \Delta_2}{\sin (\Delta_1 + \Delta_2)}$

or $IM = \frac{MN \sin \Delta_2}{\sin \Delta}$

Also, $IN = \frac{MN \sin \Delta_1}{\sin (\Delta_1 + \Delta_2)}$

$IN = \frac{MN \sin \Delta_1}{\sin \Delta}$

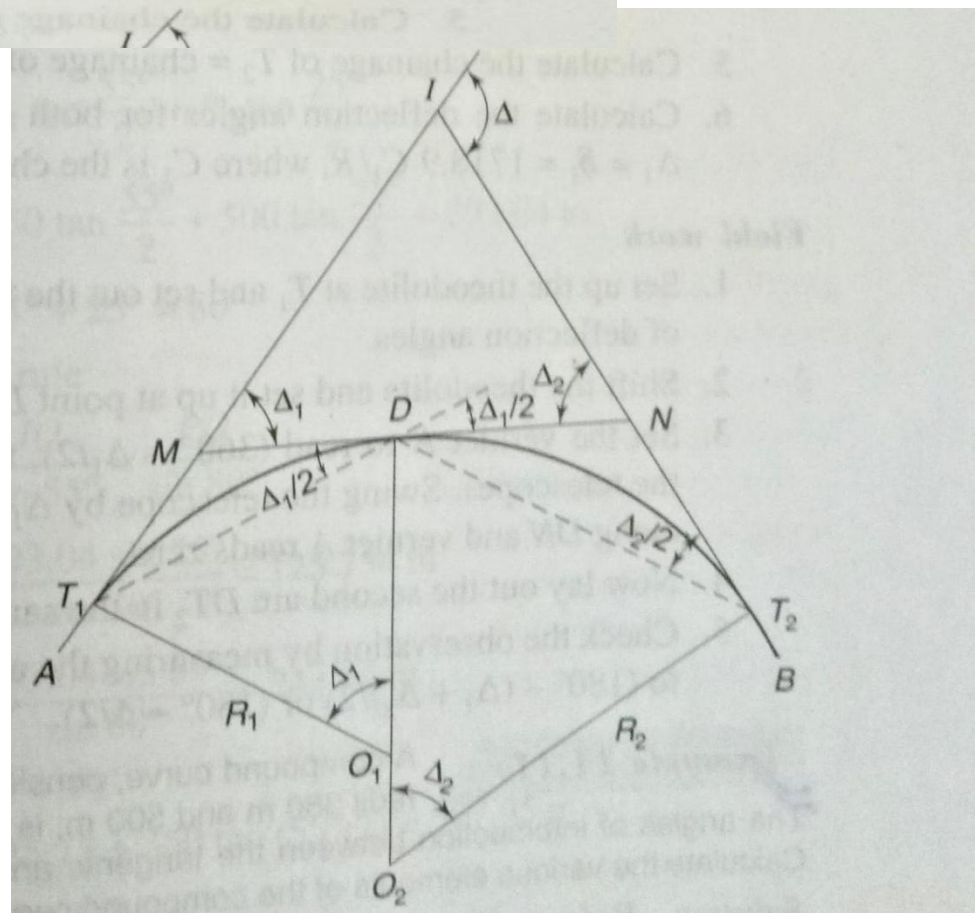
Common tangent MN

$$MD = R_1 \tan \frac{\Delta_1}{2}$$

$$DN = R_2 \tan \frac{\Delta_2}{2}$$

Now, $MN = MD + DN$

or, $MN = R_1 \tan \frac{\Delta_1}{2} + R_2 \tan \frac{\Delta_2}{2}$



A compound curve is normally set out by the method of deflection angles, using a theodolite (Fig 3). The procedure for setting out a compound curve may be split into office work and field work for the purpose of explanation.

Office work

1. Calculate all the seven elements of the curve.
2. Locate P.I. (I), P.C. (T_1) and P.T. (T_2).
3. Calculate the chainage of T_1 (chainage of I – tangent length T_2I)
4. Calculate the chainage of the point of compound curvature D .

Chainage of D = chainage of T_1 + length of arc T_1D

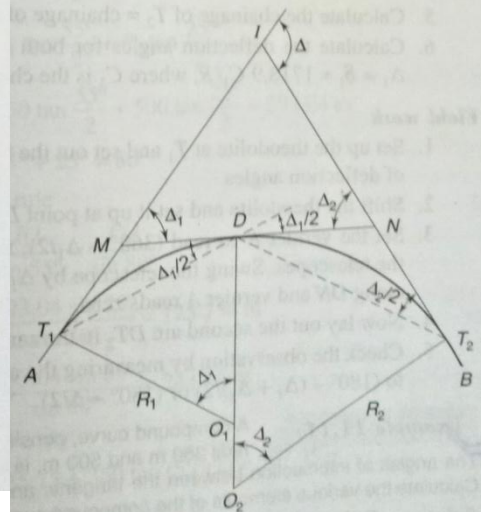
$$= \text{chainage of } T_1 + \frac{\pi R_1 \Delta_1}{180^\circ}$$

5. Calculate the chainage of T_2 = chainage of D + $\pi R_2 \Delta_2 / 180^\circ$
6. Calculate the deflection angles for both the arcs from their tangents, e.g. $\Delta_1 = \delta_1 = 1718.9 C_1 / R$, where C_1 is the chord length and R is the radius.

Field work

1. Set up the theodolite at T_1 and set out the first arc T_1D by Rankine's method of deflection angles.
2. Shift the theodolite and set it up at point D .
3. Set the vernier A to read $(360^\circ - \Delta_1/2)$, take a backsight on T_1 and transit the telescopes. Swing the telescope by $\Delta_1/2$ so that the telescope is directed along DN and vernier A reads zero.
4. Now lay out the second arc DT_2 in the same manner till T_2 is reached.
5. Check the observation by measuring the angle T_1DT_2 which should be equal to $(180^\circ - (\Delta_1 + \Delta_2)/2)$ or $(180^\circ - \Delta/2)$.

Fig 3



Question:1

A compound curve ,consisting of two simple circular curves of radii 350m and 500m ,is to be laid out between two straights .The angles of intersection between the tangents and the two straights are 25° and 55° .Calculate the various elements of the d compound curve

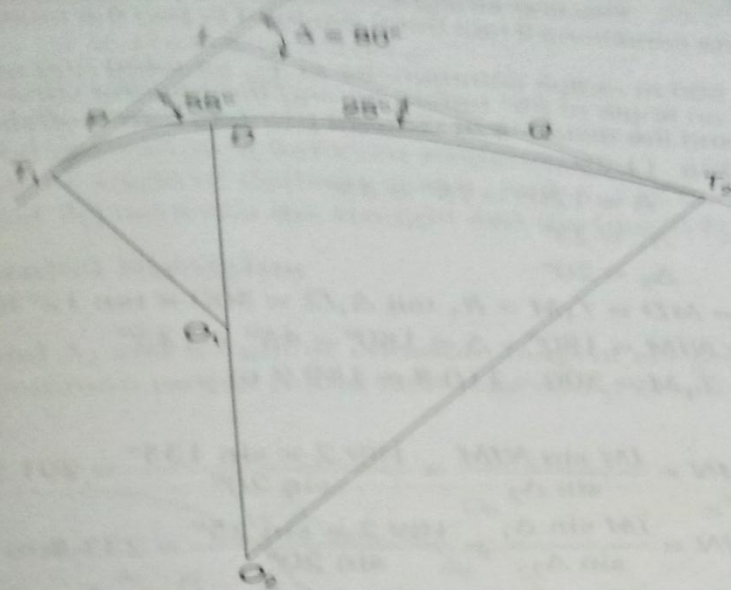


Fig-4

length of the common tangent

$$\begin{aligned}
 PQ &= PD + DQ \\
 &= R_1 \tan \frac{55^\circ}{2} + R_2 \tan \frac{25^\circ}{2} \\
 &= 350 \tan \frac{55^\circ}{2} + 500 \tan \frac{25^\circ}{2} = 293.04 \text{ m}
 \end{aligned}$$

$$\Delta = 55^\circ + 25^\circ = 80^\circ$$

From triangle IPQ, by the sine rule

$$\frac{IP}{\sin 25^\circ} = \frac{IQ}{\sin 55^\circ} = \frac{PQ}{\sin 80^\circ}$$

$$IP = \frac{293.04 \sin 25^\circ}{\sin 80^\circ} = 125.754 \text{ m}$$

$$IQ = \frac{293.04 \sin 55^\circ}{\sin 80^\circ} = 243.74 \text{ m}$$

and

$$\begin{aligned}
 \text{Length of tangent } IT_1 &= IP + PT_1 \\
 &= 125.75 + 350 \tan (55^\circ/2) = 307.95 \text{ m}
 \end{aligned}$$

$$\begin{aligned}
 \text{Length of tangent } IT_2 &= IQ + QT_2 \\
 &= 243.74 + 500 \tan (25^\circ/2) = 354.59 \text{ m}
 \end{aligned}$$

Question-2

The centre line of a new railway line is to be set out along a valley.

The first straight AI bears 75° , whilst the connecting straight IB bears 120° . Due to site condition it has been decided to join the straights compound curve.

The first curve of radius r_1 commences at T₁, Situated 300m from I on straight AI, and deflects through an angle of 25° before joining 2nd curve. Calculate the radius of the 2nd curve and distance of tangent point T₂ from I on the straight IB.

$$\Delta = 120^\circ - 75^\circ = 45^\circ$$

$$\Delta_1 = 25^\circ$$

$$\Delta_2 = 20^\circ$$

Hence,

$$\text{Tangent length} = MD = T_1M = R_1 \tan \Delta_1/2 = 500 \times \tan 12^\circ 30' = 110.8 \text{ m.}$$

$$\text{In triangle } MIN \quad \angle NIM = 180^\circ - \Delta = 180^\circ - 45^\circ = 135^\circ$$

$$\text{Length } T_1I - T_1M = 300 - 110.8 = 189.2 \text{ m}$$

Now,

$$MN = \frac{IM \sin NIM}{\sin \Delta_2} = \frac{189.2 \times \sin 135^\circ}{\sin 20^\circ} = 391.2 \text{ m}$$

$$IN = \frac{IM \sin \Delta_1}{\sin \Delta_2} = \frac{189.2 \times \sin 25^\circ}{\sin 20^\circ} = 233.8 \text{ m}$$

$$T_2N = ND = MN - MD = MN - T_1M = 391.2 - 110.8 = 280.4 \text{ m}$$

$$T_2N = R_2 \tan \Delta_2/2$$

$$\text{or } 280.4 = R_2 \tan 10^\circ$$

$$\Rightarrow R_2 = 1590 \text{ m}$$

$$IT_2 = IN + NT_2 = 233.8 + 280.4 = 514.2 \text{ m}$$

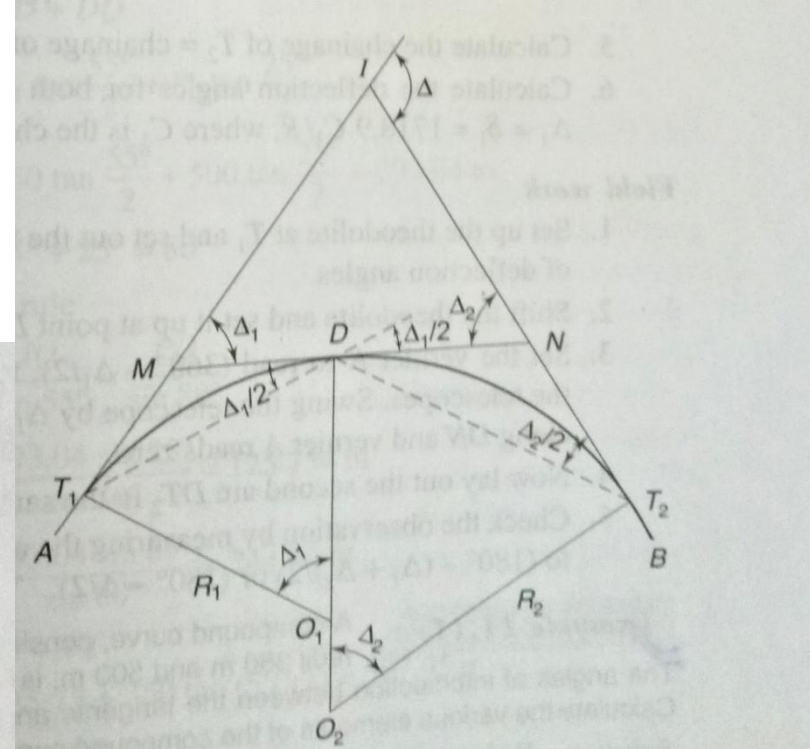
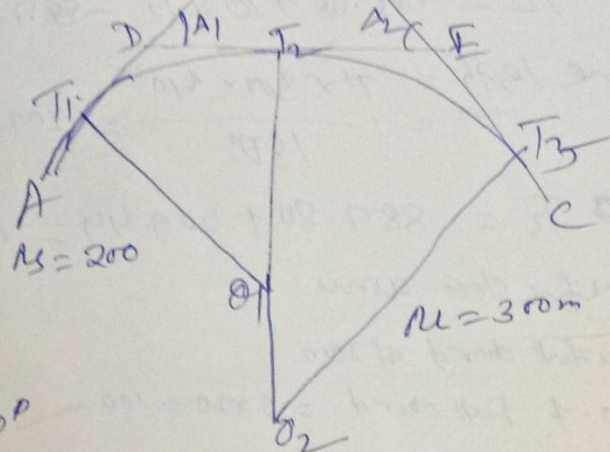


Fig-5

Question no:3

Two tangents AB and BC intersect at B, another line DE intersect AB and BC at D and E such that angle ADE = 150° and angle DEC = 140° . The radius of curve is 200m and that of 2nd is 300m. Chainage of B is 950m. Calculate all data necessary for setting out the curve.

change of B is 950m. calculate
the curve.



$$A_1 = 180^\circ - 150^\circ = 30^\circ$$

$$A_2 = 180^\circ - 140^\circ = 40^\circ$$

$$A = A_1 + A_2 = 70^\circ$$

$$\textcircled{1} T_1 D = DT_2 = R_1 \tan A_1 = 200 \times \tan 15^\circ = 53.58 \text{ m.}$$

$$\textcircled{1} T_3 E = ET_2 = R_2 \tan A_2 = 300 \times \tan 20^\circ = 109.19$$

$$\textcircled{2} DE = DT_2 + T_2 E = 53.58 + 109.19 = 162.77 \text{ m.}$$

∴ For BDE

$$\frac{DB}{\sin 40^\circ} = \frac{BE}{\sin 30^\circ} = \frac{DE}{\sin 110^\circ}$$

$$DB = DE \times \frac{\sin 40^\circ}{\sin 110^\circ} = 162.77 \times \frac{\sin 40^\circ}{\sin 110^\circ} = 111.34 \text{ m.}$$

$$BE = DE \times \frac{\sin 30^\circ}{\sin 110^\circ} = 162.77 \times \frac{\sin 30^\circ}{\sin 110^\circ} = 86.61 \text{ m.}$$

$$BT_1 = BD + DT_1 = 111.27 + 53.58 = 164.92$$

$$BT_3 = BE + ET_3 = 86.61 + 109.19 = 195.8m$$

$$\textcircled{5} \text{ Chaise } T_1 = 950 - 164.92 = 785.08m$$

$$\textcircled{6} \text{ short arc length} = \frac{\pi \times 200 \times 30^\circ}{180^\circ} = 104.72$$

$$\textcircled{7} \text{ chaise } T_2 = 785.08 + 104.72 = 889.80m$$

$$\textcircled{8} \text{ Long arc length} = \frac{\pi \times 300 \times 40^\circ}{180^\circ} = 209.44m$$

$$\textcircled{9} \text{ chaise } T_3 = 889.80 + 209.44 = 1099.24m$$

Deflection angle for short arc

Taking a full chord of 20m.

$$\text{No. of Full chord} = 5 \times 20 = 100$$

$$\text{length of sub chord} = 104.72 - 10 \times 20 = 4.72$$

$$\delta \text{ for full chord} = \frac{17189 \times 20}{200} = 2^\circ 51' 53''$$

$$\delta \text{ in sub chord} = \frac{17189 \times 4.72}{250} = 0^\circ 40' 34''$$

then

$$\text{Total deflection angle} = A_2 = \frac{30^\circ}{2} = 15^\circ$$

$$\text{calculated angle} = 5 \times 2^\circ 51' 53'' + 0^\circ 40' 30'' = 14^\circ 59' 59''$$

$$= 15^\circ \text{ approx.}$$

deflection angle for long arc

Taking chord length 30m.

$$\text{No. of } \text{full chord} = 30 \times 6 = 180$$

$$\text{length of sub chord} = 209.44 - 180 = 29.44$$

$$\delta \text{ for full chord} = \frac{17189 \times 30}{300} = 2^\circ 51' 53''$$

$$\delta \text{ for final sub chord} = \frac{17189 \times 29.44}{300} = 2^\circ 48' 41''$$

$$\text{Total deflection angle} = A_2 = \frac{40^\circ}{2} = 20^\circ$$

$$\text{calculated angle} = 6 \times 2^\circ 51' 53'' + 2^\circ 48' 41'' = 19^\circ 59' 59''$$

Compound Curves

Problem: Two tangents AB & BC are intersected by a line KM. the angles AKM and KMC are 140° & 145° respectively. The radius of 1st arc is 600m and of 2nd arc is 400m. Find the chainage of tangent points and the point of compound curvature given that the chainage of intersection point is 3415 m.

Solution:

$$\alpha = 180^\circ - 140^\circ = 40^\circ$$

$$\beta = 180^\circ - 145^\circ = 35^\circ$$

$$\phi = \alpha + \beta = 75^\circ$$

$$I = 180^\circ - 75^\circ = 105^\circ$$

$$KT_1 = KN = R_L \tan\left(\frac{\alpha}{2}\right) = 600 \tan(40^\circ/2)$$

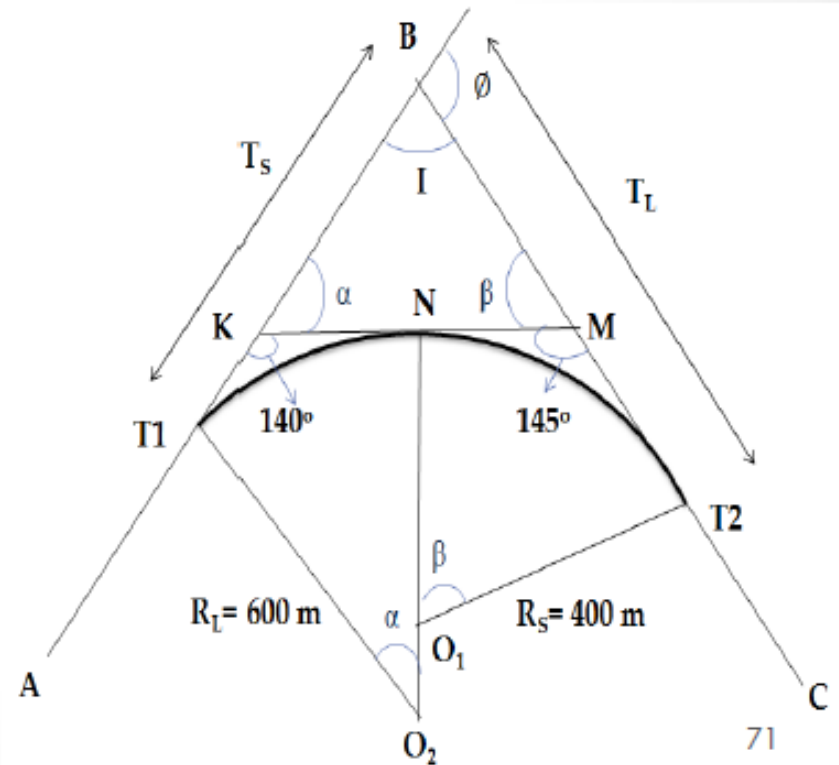
$$KT_1 = KN = 218.38 \text{ m}$$

$$MN = MT_2 = R_S \tan\left(\frac{\beta}{2}\right) = 400 \tan(35^\circ/2)$$

$$MN = MT_2 = 126.12 \text{ m}$$

$$KM = MT_2 + MN = 218.38 + 126.12$$

$$KM = 344.50 \text{ m}$$



Compound Curves

Solution:

Chainage of intersection point	= 3415 m
Minus T_L	= - 422.95 m
Chainage of T_2	= 2992.05 m
Plus L	= + 418.88 m
Chainage of compound curvature (N)	= 3410.93 m
Plus L_s	= + 244.35 m
Chainage of T_2	= 3655.25 m

