CE 103: Surveying

Lecture 13: Curve setting (Contd.)

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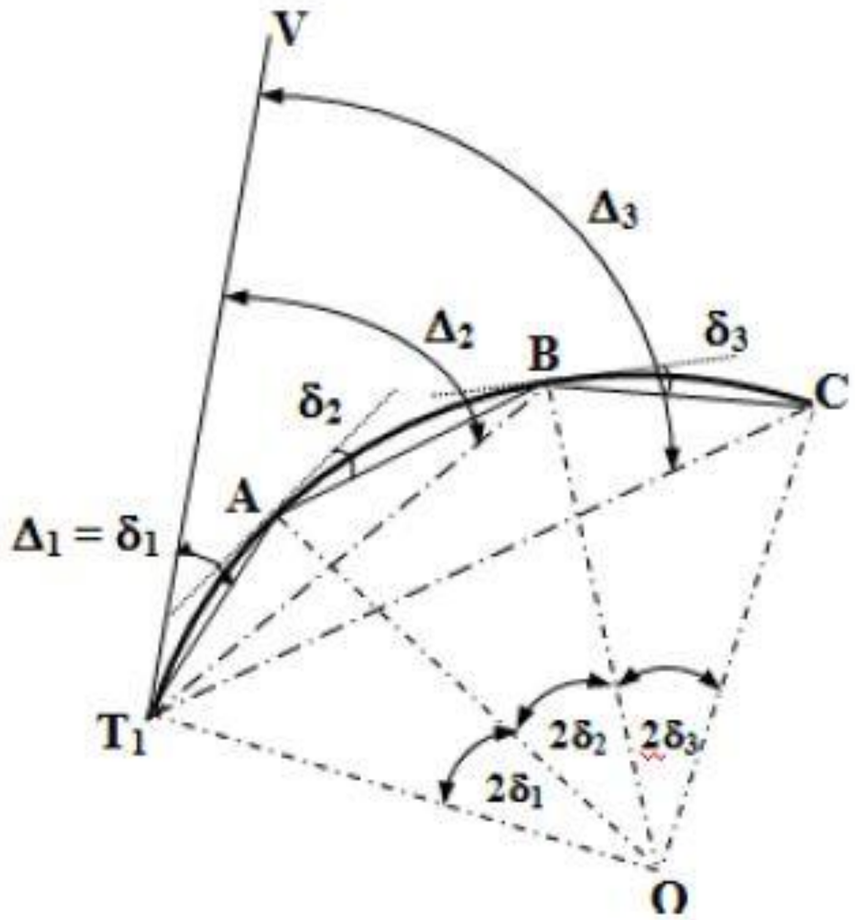
Outline

- Ranking’s method
- Super elevation
- Transition curve
- Compound curve, shift

- Rankin's Method



- δ_1, δ_2, δ_3 …..= The Deflection angles or the angles which each of the successive cords T_1A, AB, BC ….. make with the respective tangents to curve at T_1, A, B, C ……
- $\Delta_1, \Delta_2, \Delta_3$ ….. = Total tangential angles or the deflection angles to points A, B, C ……
- C_1, C_2, C_3 …..= Lengths of the cord T_1A, AB, BC ……….
- $\delta_1 = 1718.9\ C_1/R$ min, $\delta_2 = 1718.9\ C_2/R$ min, $\delta_3 = 1718.9\ C_3/R$ min
- $\Delta_1 = \delta_1$, $\Delta_2 = \Delta_1 + \delta_2$, $\Delta_3 = \Delta_2 + \delta_3$
  $\Delta_n = \Delta_{n-1} + \delta_n$

Question: Calculate the necessary data to set out a $5°$ curve by Rankin's method between two straight roads intersecting at an angle of $160°$. The chainage at the point of intersection is 3540.00 ft.

Solution:

$R = 5730/D = 5730/5 = 1146$ ft.

$Ø = 180-160 = 20°$

Tangent length, $VT_1 = VT_2 = R \tan(Ø/2) = 202$ ft

Length of Curve, $T_1CT_2 = \frac{\pi R}{180°}\phi = \frac{\pi \times 1146 \times 20}{180} = 400\,ft$

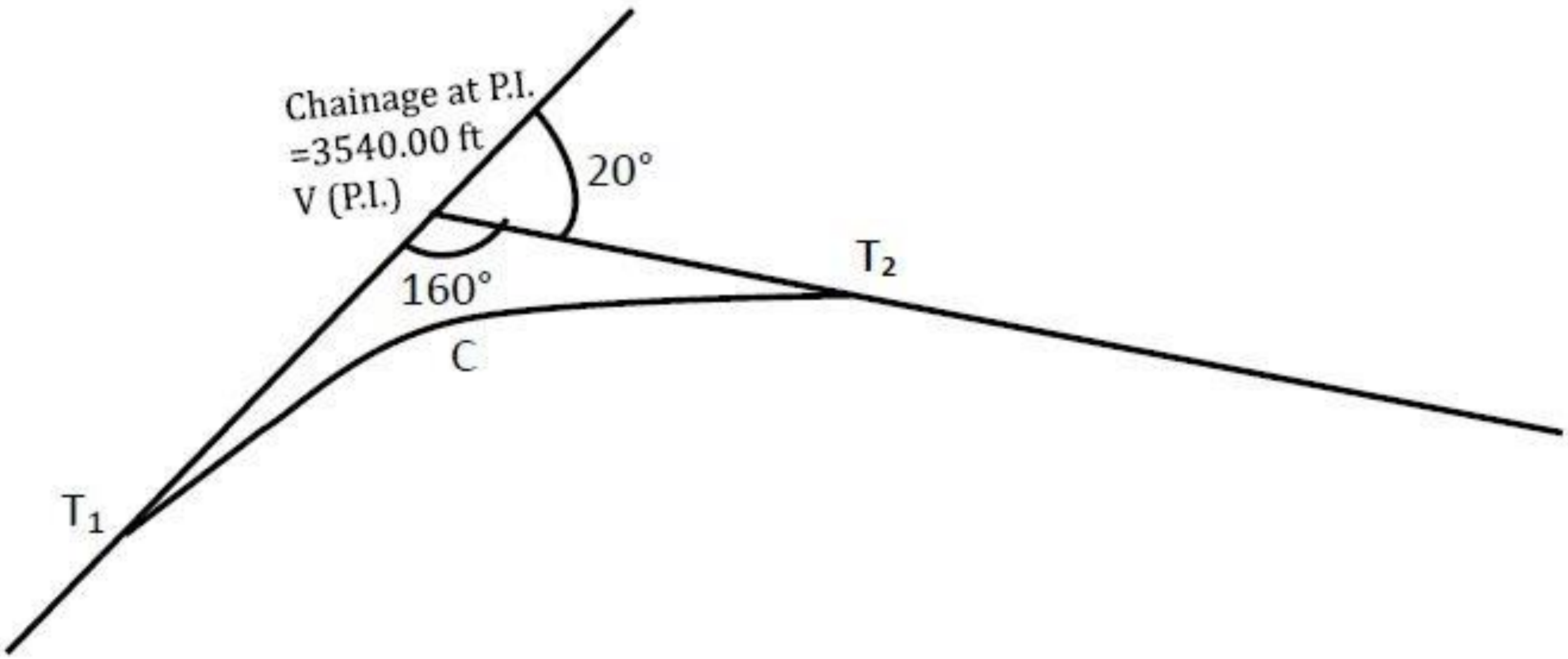
Chainage at $T_1 = 3540 - 202 = 3338$ ft

Chainage at $T_2 = 3338 + 400 = 3738$ ft

Assuming major chords of 50 ft.

Length of first sub chord = 3350-3338 = 12 ft.

Length of last sub chord = 3738-3700 = 38 ft.


Chainage at P.I.
=3540.00 ft
V (P.I.)
20°
160°
T2
C
T1

Number of chords (except first and last one) $= \frac{3700-3350}{50} = 7$

$\delta_1 = 1718.9 \text{ X } (12/1146) = 18'$

$\delta_2 = 1718.9 \text{ X } (50/1146) = 75'$

$\delta_9 = 1718.9 \text{ X } (38/1146) = 57'$

$\Delta_1 = \delta_1 = 18'$

$\Delta_2 = \Delta_1 + \delta_2 = 18'+75' = 93' = 1°33'$

$\Delta_3 = \Delta_2 + \delta_3 = 93'+75' = 168' = 2°48'$

$\Delta_4 = \Delta_3 + \delta_4 = 168'+75' = 243' = 4°3'$

$\Delta_5 = \Delta_4 + \delta_5 = 243'+75' = 318' = 5°18'$

$\Delta_6 = \Delta_5 + \delta_6 = 318'+75' = 393' = 6°33'$

$\Delta_7 = \Delta_6 + \delta_7 = 393'+75' = 468' = 7°48'$

$\Delta_8 = \Delta_7 + \delta_8 = 468'+75' = 543' = 9°3'$

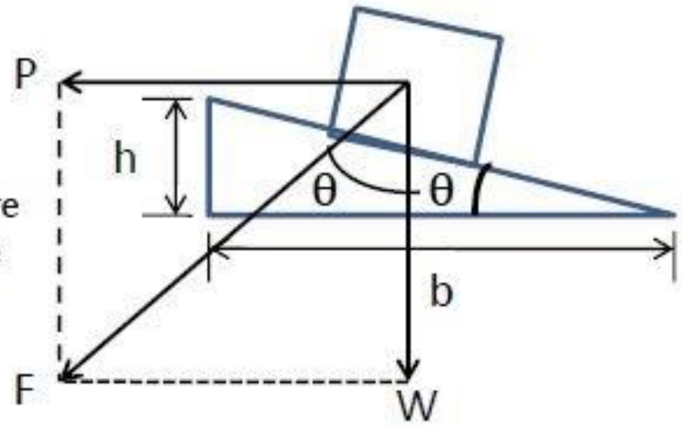
$\Delta_9 = \Delta_8 + \delta_9 = 543'+57' = 600' = 10°$

Check: $\Delta_9 = Ø/2 = 20°/2 = 10°$

Super Elevation

- Super-elevation or cant is the distance by which the outer end of the road or outer rail is raised above the inner one.
- When vehicle moves on a curve, there are two forces acting on it- (i) weight of the vehicles (W) and (ii) the centrifugal force (P).

R = radius of the curve
v = velocity of vehicle



$$P = mass \times accelerration$$

$$\Rightarrow P = m \times a$$

$$\Rightarrow P = \frac{W}{g} \times \frac{v^2}{R}$$

$$\Rightarrow \frac{P}{W} = \frac{V^2}{gR}$$

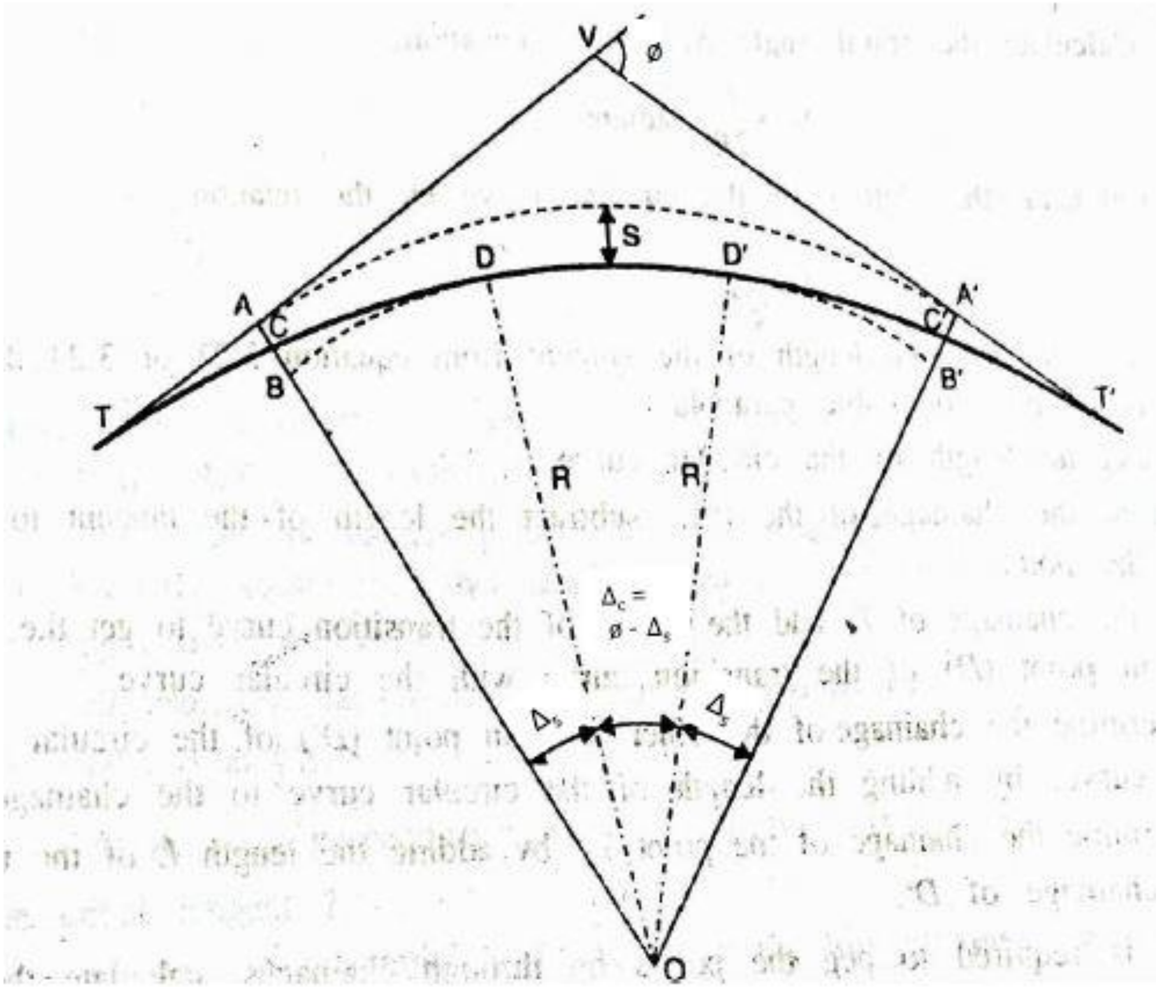
$$\tan\theta = \frac{P}{W} = \frac{v^2}{gR}$$

$$Again, \tan\theta = \frac{h}{b}$$

$$\Rightarrow \frac{h}{b} = \frac{v^2}{gR}$$

$$\Rightarrow h = b\frac{v^2}{gR}$$

Transition Curve



- TD and T′D′ is transition curve.
- DD′ is circular curve.

$$Shift, s = \frac{L^2}{24R}$$

- Length of transition curve, $L = \frac{v^3}{\alpha R}$

α = rate of change of radial acceleration.

- Total Tangent Length , TV = (R+S) tan (ø/2) + (L/2)

- Length of circular curve = $\frac{\pi R}{180°}\Delta c = \frac{\pi R}{180°}(\phi - 2\Delta s) = \frac{\pi R}{180°}\phi - \frac{\pi R}{180°}2\Delta s = \frac{\pi R}{180°}\phi - L$

A transition curve is required for a circular curve of 200 metre radius, the gauge being 1.5 m and maximum super-elevation restricted to 15 cm. The transition is to be designed for a velocity such that no lateral pressure is imposed on the rails and the rate of gain of radial acceleration is 30 cm / sec^3 . Calculate the required Length of the transition curve and the design speed.

Solution.

On the basis of radial acceleration, the length of the transition curve is given by

$$L = \frac{v^3}{\alpha R}$$

where

$\alpha = 0.30 \ m/sec^3$; $R = 200 \ m$; v = velocity in m/sec

$$\therefore \quad L = \frac{v^3}{0.3 \times 200} = \frac{v^3}{60} \qquad \ldots(i)$$

The velocity v is determined from the requirement of no lateral pressure on a super-elevation of 15 cm for $G = 15$ m.

$$\therefore \quad \tan\theta = \frac{15}{150} = \frac{v^2}{gR}$$

$$\therefore \quad v = \left(\frac{15}{150} \times gR\right)^{1/2} = \left(\frac{1}{10} \times 9.81 \times 200\right)^{1/2}$$

$= 14$ m/sec or **50.4 km/hour.**

Substituting the value of v in (i), we get

$$L = \frac{v^3}{60} = \frac{(14)^3}{60} \approx 46 \text{ m.}$$

- Two broadguage line meet at an angle of 112°30′.

Given,

Radius of the circular curve = 800 ft.

Rate of gain of radial acceleration = 0.98 ft/sec^3

Maximum design speed = 49 ft/sec

Chainage of intersection point = 1230 ft.

Calculate-

(a) Length of transition curve

(b) Length of circular curve

(c) Length of composite curve

(d) Chainages at beginning and end of transition curve and the junctions of transition curves with circular arc.

Solution (See figure in next slide):

R = 800 ft

α = 0.98 ft/sec^3

v = 49 ft/sec

Deflection angle, ø = 180°- 112°30' =67°30'

Chainage at V = 1230'

a) Length of transition curve, $L = \dfrac{v^3}{\alpha R}$ = 150 ft

b) length of circular curve = $\dfrac{\pi R}{180°}\phi - L = \dfrac{\pi \times 800 \times 67°30'}{180} - 150 = 792.5\,ft$

c) Total length of composite curve = 792.5+2x150 = 1092.5 ft

d) $Shift, s = \frac{L^2}{24R}$ = 1.17 ft

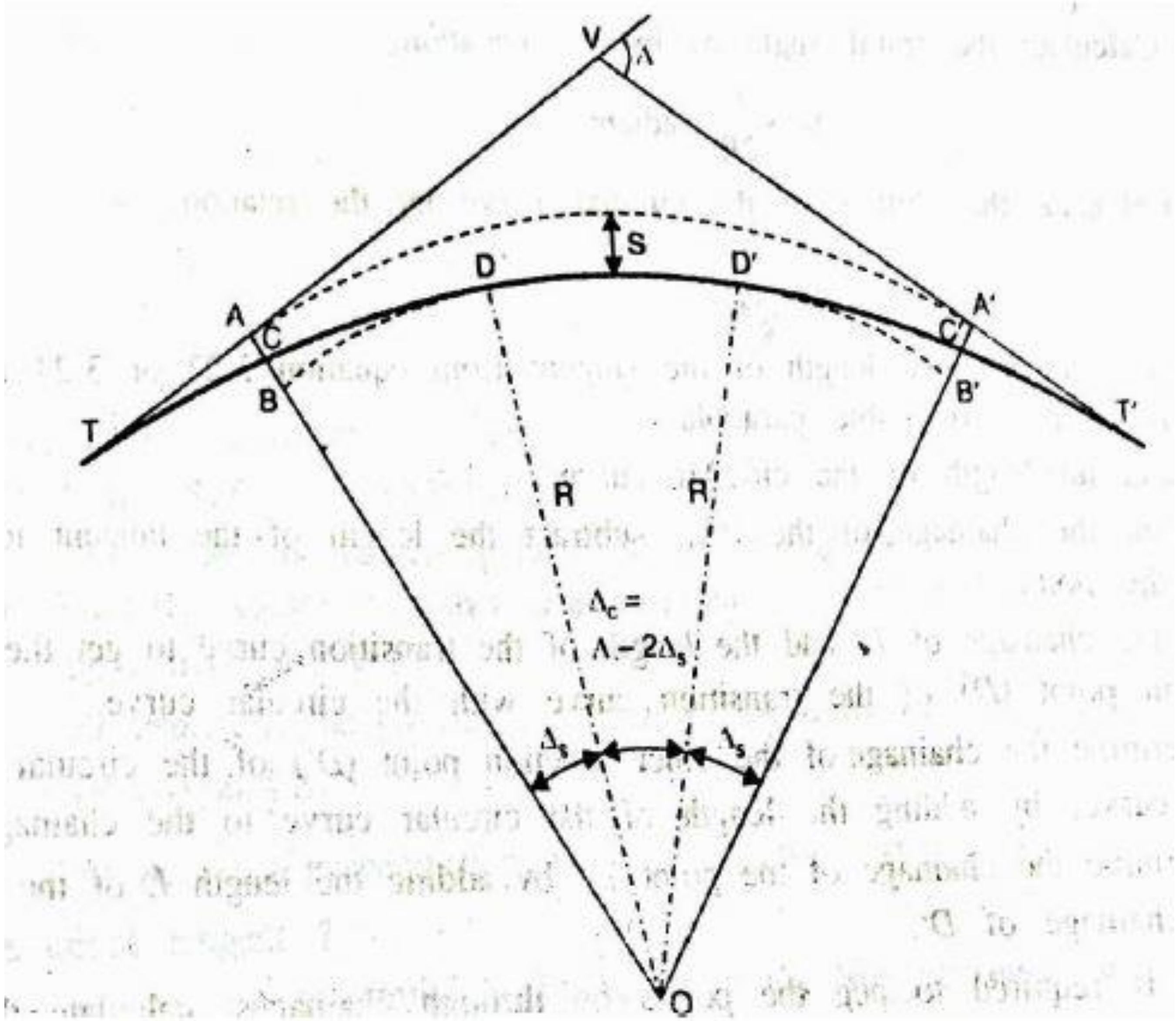
Tangent Length, TV = (R+S) tan (Ø/2) + (L/2) = (800+1.18) tan (67°30′/2) + (150/2) = 610.3 ft

Chainage at T = 1230′-610.3′ = 619.7 ft

Chainage at D = 619.7 + 150 = 769.7 ft

Chainage at D′ = 769.7 + 792.5 = 1562.2 ft

Chainage at T′ = 1562.2 + 150 = 1712.2 ft


V
Λ
S
D
D'
A
A'
C
C'
B
B'
T
T'
R
R
$\Delta_c =$
$\Lambda - 2\Delta_s$
Δ_s
Δ_s
O