-Versa

Full S.E.

(Lecture 3
18/04/19)

- **Extra widening** → Extra width provided to road at horizontal curve is called extra widening.

Object to provide extra widening.

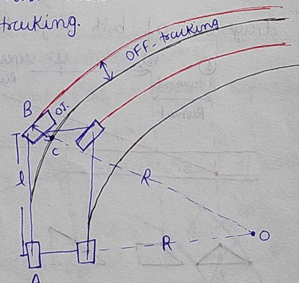
✓ (a) To account off-tracking due to rigidity wheel base
✓ (b) To encounter Psychological tendency of driver

$$W_E = W_{mechanical} + W_{psychological}$$

✓ (c) To increase visibility at curve
✓ (d) To account lateral skidding

(2) Mechanical widening :-

- Off-tracking → Path travelled by rear axle is not same as path travelled by front axle on Horizontal curve this Phenomena is called off tracking.



from ΔOAB

$OB^2 = OA^2 + AB^2$

$= (R+O_T)^2 = R^2 + l^2$

$R^2 + O_T^2 + 2RO_T = R^2 + l^2$

$O_T(2R + O_T) = l^2$

$O_T <<< 2R$

$2R + O_T \simeq 2R$

$O_T \times 2R = l^2$

$$O_T = \frac{l^2}{2R}$$

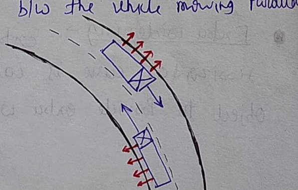
Mechanical widening is Provided to account off tracking

for n lane $$O_T = W_m = \frac{nl^2}{2R}$$

- Psychological widening → On curved Path there is tendency of driver to drive the vehicle close to the edge of Pavement and to maintain max side gap b/w the vehicle moving Parallely

$$W_p = \frac{V}{9.5\sqrt{R}}$$

(W_p → m, V → Kmph, R → m)



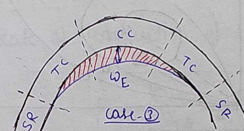
$$W_E = W_P + W_M$$

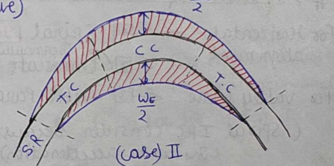
$$W_E = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

As per IRC

(1) $R \geq 300m$ (extra widening is not required)

(2) $50m < R < 300m$ (extra widening is Provided on both side of curve) $\frac{W_E}{2}$





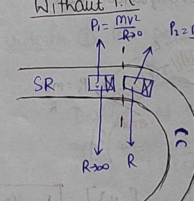
(3) when $R \leq 50m$ (extra widening will be Provided only to the inner side)

- For single lane road Psychological widening is not required ($W_P = 0$) (n=1)

[Transition curve :] Provided to change the Horizontal alignment from straight circular gradually.

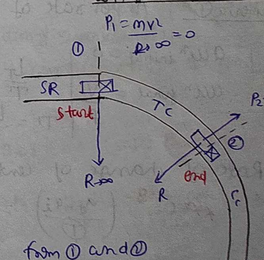
- transition curve have the radius = infinite at starting point which gradually changes desinated radius at end Point toward circular curve.

Without T.C



Impact (Sudden jerk) (Sudden centrifugal force)

With Transition curve



from (1) and (2)

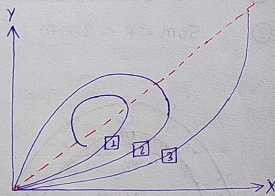
$$\uparrow P = \frac{mv^2}{R \uparrow}$$ (centrifugal force increase gradually)

Objective to Provide transition curve:

1. To introduce centrifugal force gradually.
2. To Provide superelevation gradually.
3. To Provide extra widening
4. To ~~Provi~~ avoid sudden jerk

Nature of transition curve :-

For Horizontal alignment ← [1] Spiral [Ideal T.S]
[2] Bernoullis Lemniscate
For valley curve ← [3] Cubic Parabola
(spiral IRC consider because of Constant acceleration) ***



- For spiral nature T.S

1. length of T.S is inversely proportional to Radius $\left(L_T \propto \frac{1}{R}\right)$
2. Rate of change of centrifugal acceleration is constant.

AS per IRC ***

$$C = \left(\frac{80}{75+V}\right) m/s^3 \quad [0.5 \le C \le 0.8 \ m/s^3]$$

(V → Kmph)

- Length of transition curve it is design on the basis of max. of following 2 criteria and then it should be checked with min length of T.S as per IRC.

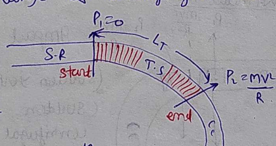
Criteria ① As per rate of change of centrifugal accⁿ

accⁿ initial = 0

accⁿ final = $\frac{V^2}{R}$

$V = \frac{L_T}{T}$

$T = \frac{L_T}{V}$



Rate of change of centrifugal accⁿ

$$*** \ C^{2008} = \left(\frac{a_f - a_i}{T}\right) = \left(\frac{\frac{V^2}{R} - 0}{T}\right) = \frac{\frac{V^2}{R}}{\frac{L_T}{V}} = \left[\frac{V^3}{RL_T}\right]$$

(T → time to pass the transition length)

*** $L_T = \frac{(0.278V)^3}{CR}$

Criteria ② As per rate of introduction of superelevation :-

If rate of introduction of superelevation is 1 in N (1 m outer edge elevation with Respect to level of rotation over N (m) length of transition curve)

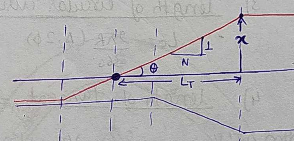
Case ① Rotation about centerline $L_T = \frac{1}{2} eN(W+W_E)$

Case ② Rotation about inner line $L_T = eN(W+W_E)$ 2006

As per IRC ***

Rate of introduction of superelevation

- 1 in 50 For Plains & Rolling terrain
- 1 in 60 for mountaneous & steep
- 1 in 100 for Urban area



$\tan\theta = \frac{x}{L_T}$ ***

$e = \frac{x}{L_T}$ then $x = e \times \left(\frac{1}{2}\right)(W+W_E)$

and $\frac{1}{N} = \frac{x}{L_T}$ ** $L_T = \frac{1}{2} eN(W+W_E)$

- Minimum length of transition curve

$L_T = 2.7\frac{V^2}{R}$ for Plain and Rolling terrain

$= \frac{V^2}{R}$ for mountaneous and steep terrain

(V → Kmph, R → m)

Ques-(51) V = 65 Km/h, R = 220, (W+We) = 7.5m, 1 in 150

Criteria ① As per rate of change of accⁿ $C = \frac{80}{75+V} = \frac{80}{75+65} = 0.571 \ m/s^3$

$$L_T = \left(\frac{(0.278V)^3}{CR}\right) = \frac{(0.278\times65)^3}{0.571\times220} = (46.96) m$$

Criteria ② (As per rate of introduction of superelevation)

$$L_T = \frac{1}{2}eN(W+We) = \frac{1}{2}\times(0.07)(150)(7.5) = 39.37m$$

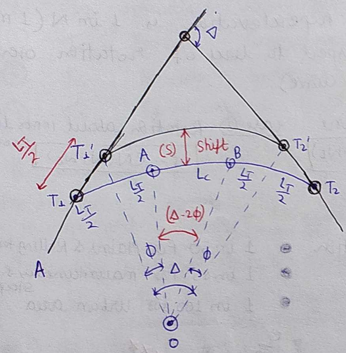
Design of S.E. (e)

① $e = \frac{V^2}{225R} = \frac{(65)^2}{225\times220} = 0.08 \ \cancel{>} \ 0.15$ (safe) Providing e = 7% is safe

② min. length of T.C. $L_T = 2.7\frac{V^2}{R} = \frac{2.7\times(65)^2}{220} = 51.85m$

$L_T = \begin{cases} \text{①} & 46.96 \\ \text{②} & 39.37m \\ 2.7\frac{V^2}{R} & (51.85) \rightarrow L_T \text{ Ans} \end{cases}$

combined curve meet by circular curve and spiral transition curve



1] Shift of curve

$$S = \frac{L_T^2}{24R}$$

2] Spiral angle

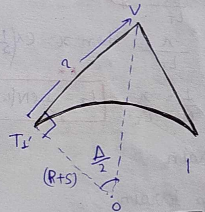
$$\phi = \frac{\frac{L_T}{2}}{R} = \left(\frac{L_T}{2R}\right)_{Rad.}$$

$$\phi = \left(\frac{180 L_T}{2\pi R}\right)_{degree}$$

3] length of circular curve

$$L_c = \frac{2\pi R}{360}(\Delta \cdot 2\phi)$$

4] length of tangent $= VT_1$



from $OT_1'V$ $\quad VT_1 = VT_1' + T_1'T$

$T_1'V = (R+S)\tan\frac{\Delta}{2}$ ***

$$VT_1 = (R+S)\tan\frac{\Delta}{2} + \frac{L_T}{2}$$

- **Shift of curve**

[When T.C. is provided in horizontal alignment then circular curve have to be shifted toward the inner side of curve so that it should meet transition curve tangentially

Pb-51 $\quad \frac{L_T^2}{24R} = S$

$\frac{(51.85)^2}{24 \times 220} = S$

$S = 0.509$

Pb-52 $\quad R = 14 \times 20 = 280m$, $L_T = 3 \times 20 = 60m$, $\Delta = 40°$

1] Shift $= \frac{(60)^2}{24 \times 280} = 0.535m$ $\quad$ 2] $\phi = \frac{180 \times 60}{2\pi \times 280} = 6.14°$

3] $L_c = \frac{2\pi \times 280}{360}(40 \cdot 2 \times 6.14°) = 135.46m$ $\quad$ 4] $VT_1 = (280 + 0.535)\tan\frac{40}{2} + \frac{60}{2}$

$= 132.10$

chainage calculation

① chainge at V = 100×20 = 2000m

② chainage at T_1 = chainge at V − VT_1 = 2000 − 132.11 = 1867.89m

② chainage of B = chainage at A + L_c = 1927.89 + 135.46 = 2063.35m

③ chainage of A = chainage at $T_1 + L_T$ = 1867.89 + 60 = 1927.89m

④ chainage at T_2 = chainage at B + L_T = 2063.35 + 60 = 2123.35m

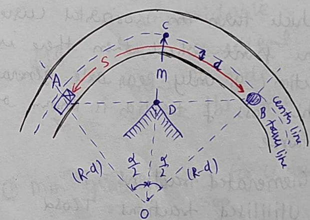
- **SET BACK DISTANCE** : It is the clerance distance required from the center line of horizontal curve to obstruction on the inner side of curve to provide at equate sight distance at a horizontal curve.

Case ① When length of curve > sight distance
(L_c > S.SD)

Set back distance = m = CD = OC − OD

$$m = R - (R-d)\cdot\cos\frac{\alpha}{2}$$

and $$\frac{\alpha}{2} = \frac{180 \cdot S}{2\pi(R-d)}$$

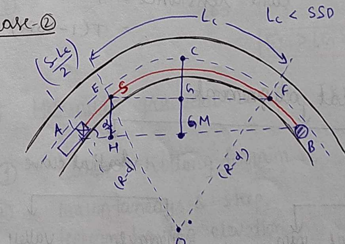


$d = \frac{1}{4}(W + W_e)$

R = Radius of curve

(R−d) = Radius of travel line

Case-② $\quad L_c < SSD$



Set back distance

$m = CD = CG + GD$

$= (OC - OG) + (EH)$

$= R - (R-d)\cos\frac{\alpha}{2} + \left(\frac{S-L_c}{2}\right)\sin\frac{\alpha}{2}$ **

$$m = R - (R-d)\cos\frac{\alpha}{2} + \frac{(S-L_c)}{2}\sin\frac{\alpha}{2}$$

$$\frac{\alpha}{2} = \frac{180 L_c}{2\pi(R-d)}$$ **

Note : ① Set back distance from center line to inner lane (m−d)

② Set back distance from center line to outer lane (m+d)

③ Set back distance from inner edge of pavement (m−2d)

④ Set back distance from outer edge of pavement (m+2d)

Pb- (53) $d = 1.9m$, $R = 400m$, $L_c = 200m$

(a) SSD $= S = 90m$ $(L_c > SD)$

$m = R - (R-d)\cos\frac{\alpha}{2}$

$= 400 - (400 - 1.9)\cos 6.47$

$= 4.43m$

$\frac{\alpha}{2} = \frac{180 \times S}{2\pi(R-d)} = \frac{180 \times 90}{2\pi(400-1.9)}$

$= 6.28$

Set back distance

$= (m-d) = (4.43 - 1.9)$

$= 2.53m$

(b) $L_c = 200m$

SSD $= 300m$

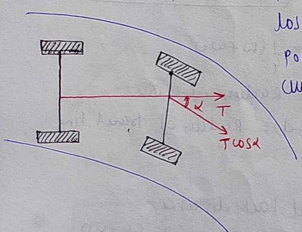
$L_c < SSD$

$m = R - (R-d)\cos\frac{\alpha}{2} + \left(\frac{S-L_c}{2}\right)\sin\frac{\alpha}{2}$

$\frac{\alpha}{2} = \frac{180 L_c}{2\pi(R-d)} = \frac{180 \times 200}{2\pi(400-1.9)} = 14.39$

$m = 26.80m$. set back distance $= (m-d) = 24.30m$

- **Curve resistance**: when a vehicle turn on Horizontal curve by turning the front wheel then there is loss of traction (if only Rear axle generate power) this loss of traction is known as curve resistance.



Generated tractions $= T$

Utilised tractions $= T\cos\alpha$

Curve resistance $= T - T\cos\alpha$

$= T(1-\cos\alpha)$