Problem 1:

Design horizontal alignment of a rural highway using following data. Calculate necessary parameters for setting out transition curve and half of circular curve.

- Deflection angle = 45°
- Chainage at PI = 5000 m
- Design speed of vehicle = 70 km/hr

Solution:

Given,
Deflection angle, $\Delta = 45^\circ$
Chainage at PI = 5000m
Design speed of vehicle = 70 km/hr
$= 19.44\ ms^{-1}$
$f_{max} = 0.14$
$e_{max} = 0.08$

$$e_{max} + f_{max} = \frac{V^2}{gR_{min}}$$

or, $$R_{min} = \frac{V^2}{(e_{max}+f_{max}) \times g}$$

$$= \frac{19.44^2}{(0.08+0.14)\times 9.8}$$

$$= 175 m$$

If $f = 0$

$$R = \frac{(19.44)^2}{9.8 \times (.08+0)} = 482\ m$$

Length of transition curve

Rate of change of radial acceleration (c) is considered $0.3\ m/s^3$ for high standard road,

$$\therefore L = \frac{V^3}{RC} = \frac{19.44}{482 \times .3}\ m = 50.8\ m$$

Spiral angle, $$\Delta_s = \frac{L}{2R} = \frac{50.8}{2\times 482} = 0.05269\ rad$$

$$= 0.05269 \times \frac{180^\circ}{\pi}$$

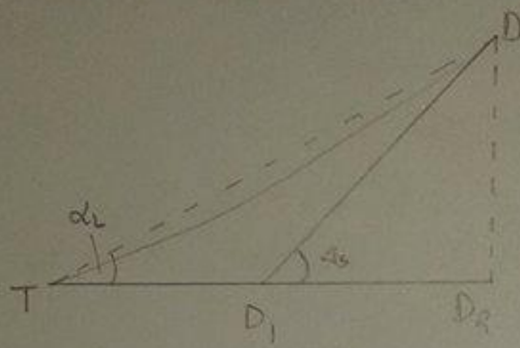
$$= 3.01^\circ$$

$$= 3^\circ 1' 10''$$

maximum polar-deflection angle, $\alpha_L = \frac{3.01}{3} = 1.006°$
$= 1°0'23.39''$

Shift, $s = \frac{L^2}{24R} = \frac{(50.8)^2}{24 \times 482} = 0.2231$

Maximum offset $= 4s = 4 \times 0.2231 = 0.8924\,m$



$TD_1 = \frac{2 \times 50.8}{3} m = 33.86m$

$D_1D_2 = \frac{1}{3}L = \frac{1}{3} \times 50.8 = 16.93m$

Total tangent length $= \frac{L}{2} + (R+s)\tan \Delta/2$

$= \frac{50.8}{2} + (482 + 0.223)\tan 45/2$

$= 225.14m$

Apex distance, $E = \frac{R+s}{\cos \Delta/2} - R$

$= \frac{482 + 0.223}{\cos 45/2} - 482$

$= 39.95\ m$

Length of circular curve $= R(\Delta - 2\Delta_s)$

$= 482(0.785 - 2 \times 0.05269)$

$= 327.567\ m$

Length of combined curve,

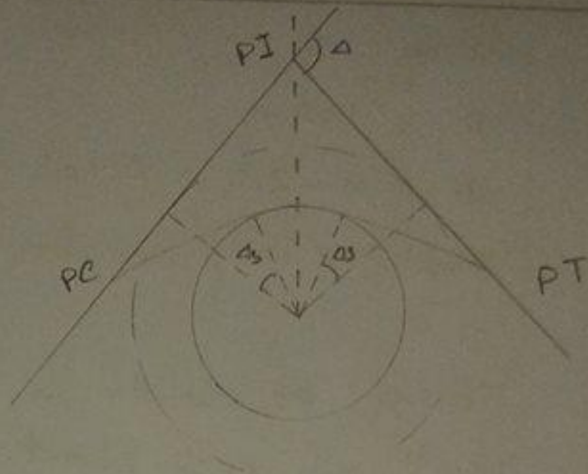
$= (50.8 + 327.567 + 50.8)\,m$

$= 429.167\ m$

Chainage of T_1 (PC)

$= (5000 - 225.14)$ m

$= 4774.86$ m



Chainage of T_2 (PT)

$= (4774.86 + 429.167)$ m

$= 5204.027$ m

maximum offset, $Y = 4s$

$= 4 \times 0.223$ m $= 0.892$ m

setting out transition curve,

$\theta = \frac{l^2}{2RL}$, $\alpha = \theta/3$, $y = \frac{l^3}{6RL}$

Peg stn	l = x(m)	alpha (Grad)	alpha (degree)	alpha			y (m)	super elevation
				Deg	min	sec		
01	5	0.00017	0.0097	0	0	35.67	0.00085	0.1260
02	10	0.00068	0.03896	0	2	20.26	0.00068	0.252
03	15	0.00153	0.0877	0	5	15.59	0.02297	0.378
04	20	0.00272	0.156	0	9	21.04	0.0545	0.504
05	25	0.00425	0.2435	0	14	36.63	0.1064	0.630
06	30	0.00613	0.3512	0	21	4.4	0.1837	0.756
07	35	0.00834	0.4778	0	28	40.25	0.2918	0.882
08	40	0.01089	0.6239	0	37	26.22	0.4356	1.001
09	45	0.01378	0.7895	0	47	22.33	0.6203	1.134
10	50	0.01702	0.9752	0	58	30.63	0.8508	1.250
11	50.8	0.01756	1.006	0	0	23.39	0.892	1.28

setting out half circle.

$R = 482\ m$

$\beta = \Delta - 2\Delta_s = 0.785 - 2 \times 0.0527 = 0.679\ rad$

Length of half circular curve $= \frac{327.567}{2} m$

$= 163.784 m$

Taking 20 chords in half-circle,

Length of each chord $= \frac{163.784}{20} = 8.18 m$

Subtended angle by each chord $= \frac{0.679/2}{20} rad$

$= 0.017\ rad$

$= 0.973°$

$= 58' 21.35''$

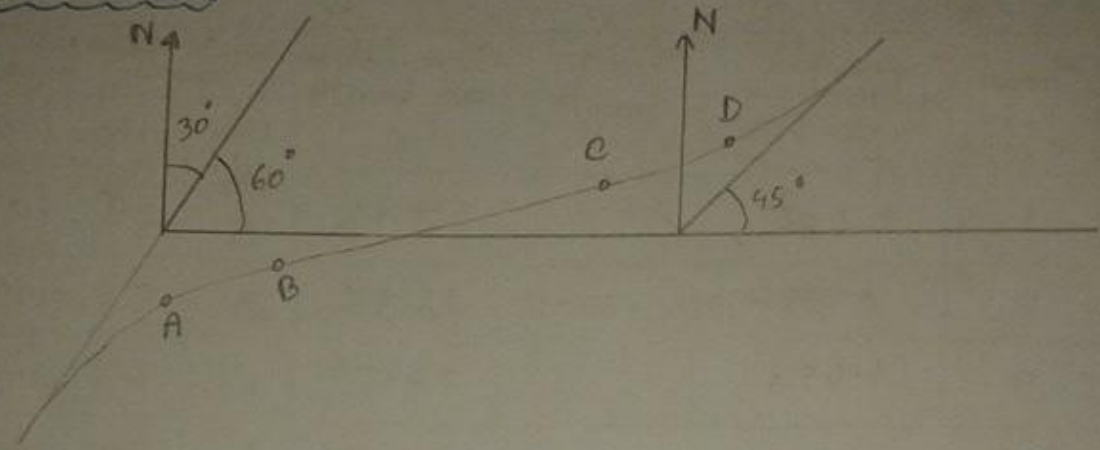
Tangential deflection angle by each chord

$= \frac{58' 21.35''}{2}$

$= 0.486°$

$= 0° 29' 10.67''$

Problem 2 solve:



Given,

1st deflection angle, $\Delta_1 = 60°$

2nd deflection angle, $\Delta_2 = 45°$

$e_{max} = 0.08$

$f_{max} = 0.12$

design speed, $v = 80\ km/h = 22.22\ ms^{-1}$

setting out Circular curve : Using Rankine's method :

Chord	Tangential deflection angle (deg)	chord length (m)	Cumulative arc length (m)	Total deflection angle from common tangent			Super elevation
				Deg	min	sec	
1	0.486		8.18	0	29	9.6	
2	0.972		16.36	0	58	19.2	
3	1.458		24.54	1	27	28.8	
4	1.944		32.72	1	56	38.4	
5	2.430		40.90	2	25	48	
6	2.916		49.08	2	54	57.6	
7	3.402		57.26	3	24	7.2	
8	3.888		65.44	3	53	16.8	
9	4.374		73.62	4	22	26.4	
10	4.860	8.18	81.80	4	51	36	1.28
11	5.346		89.98	5	20	45.6	
12	5.832		98.16	5	49	55.2	
13	6.0318		106.34	6	19	4.8	
14	6.804		114.52	6	48	14.84	
15	7.290		122.7	7	17	24	
16	7.776		130.88	7	46	33.6	
17	8.262		139.06	8	15	43.2	
18	8.748		147.24	8	44	52.8	
19	9.234		156.42	9	14	2.4	
20	9.72		163.784	9	43	12	

$$R_{min} = \frac{v^2}{(e_{max} + f_{max})g} = \frac{(22.22)^2}{9.8 \times (0.08+0.12)} = 251.902 m$$

for $f=0$, $$R = \frac{v^2}{g(e+0)} = \frac{(22.22)^2}{9.8 \times 0.08} = 629.756 m$$

Let, length of transition curve between AB and BC is L_1

$$\therefore L_1 = \frac{v^3}{RC}$$

$$= \frac{(22.22)^3}{629 \times 0.3}$$

$$= 58.138 m$$

Length of transition curve between BC and CD is L_2. It is same as L_1 as all elements v, R, C are same for both case.

$$\text{Shift}(S_1) = \frac{L_1^2}{24R} = 0.224 m$$

Tangent distance for curve 1.

$$T_1 = \frac{L_1}{2} + (R+S)\tan \Delta_1/2$$

$$= \frac{58.138}{2} + (629.756 + 0.224)\tan 60/2$$

$$= 392.79 m$$

Tangent distance for curve-2

$$T_2 = \frac{L_2}{2} + (R+S)\tan \frac{\Delta_2}{2}$$

$$= \frac{58.138}{2} + (629.756 + 0.224)\tan \frac{45}{2}$$

$$= 290.02 m$$

Total tangent distance, $T_1 + T_2 = (392.79 + 290.02) m$

$$= 682.805 m$$

Calculation of elements of circular and transition curve:-

Spiral angle, $\Delta_s = \frac{L}{2R} = \frac{58.138}{2 \times 629.756}$

$= 0.046$ rad

$= 2.63° = 2°38'8.18''$

Maximum polar deflection angle,

$\alpha_L = \frac{\Delta_s}{3} = 0.0153$ rad

$= 0.876°$

$= 0°52'42.73''$

Apex distance for curve-1,

$E_1 = \frac{R+S}{\cos \Delta_1/2} - R$

$= \frac{629.756 + 0.224}{\cos(60/2)} - 629.756$

$= 97.213$ m

Apex distance for curve-2,

$E_2 = \frac{R+S}{\cos \Delta_2/2} - R$

$= \frac{629.756 + 0.224}{\cos(45/2)} - 629.756$

$= 52.129$ m

Length of circular curve-1 $= R(\Delta_1 - 2\Delta_s)$

$= 629.756(1.0472 - 2 \times 0.046)$

$= 601.54$ m

Length of circular curve-2 $= R(\Delta_2 - 2\Delta_s)$

$= 629.756 \times (0.7854 - 2 \times 0.046)$

$= 436.67$ m

Length of combined curve - 1 $= (2 \times 58.138 + 601.54)\,m$

$= 717.816\,m$

Length of combined curve - 2 $= (2 \times 58.138 + 436.67)\,m$

$= 552.946\,m$

maximum offset, $Y = 4s$

$= 4 \times 0.224$

$= 0.896\,m$

setting out transition curve $\theta = \frac{L^2}{2RL}$, $\alpha \cong \theta/3$, $y = \frac{l^3}{6RL}$

Peg stn	$l = x$ (m)	alpha (rad)	alpha			y (m)
			Deg	Min	Sec	
01	5	0.0001	0	0	20.63	0.0005
02	10	0.0004	0	1	22.51	0.00455
03	15	0.0010	0	3	26.26	0.0154
04	20	0.0018	0	6	11.28	0.0364
05	25	0.0028	0	9	37.54	0.0711
06	30	0.0041	0	14	5.69	0.1229
07	35	0.0056	0	19	15.08	0.1951
08	40	0.0073	0	25	5.73	0.2913
09	45	0.0092	0	31	37.64	0.4148
10	50	0.0114	0	39	11.42	0.569
11	55	0.0138	0	47	26.45	0.757
12	58.138	0.0153	0	52	42.73	0.896

$R = 629.756m$

$\beta_1 = \Delta_1 - 2\Delta_s = 1.047 - 2\times 0.046 = 0.955$ rad

$\beta_2 = \Delta_2 - 2\Delta_s = 0.785 - 2\times 0.046 = 0.693$ rad

Length of circular curve-1 $= 601.54m$

$\therefore$ Half Length of circular curve-1 $= \dfrac{601.54}{2}m$

$= 300.77m$

length of each chord for 15 chords in curves-I.

$\dfrac{300.77}{15} = 20.05m$

Angle subtended by each chord for curve-I $= \dfrac{\beta_1/2}{15}$

$= \dfrac{0.955/2}{0.032}$

$\therefore$ Tangential deflection angle for 1^{st} curve by each chord $= \dfrac{1.82}{2} = 0.91$

length of circular curve-2 $= 436.67m$

Half length of circular curve-2 $= \dfrac{436.67}{2} = 218.335m$

Length of each chord $= \dfrac{218.335}{15} = 14.56m$

Angle subtended by each chord for curve-2

$= \dfrac{\beta_2/2}{15} = 0.0231$

$= 1.32°$

$\therefore$ Tangential deflection angle for 2nd curve

$= \dfrac{1.32°}{2} = 0.655°$

For 1st circular curve:

Chord	tangential Deflection (deg)	Chord length	Cumulative chord length	Tangential deflection angle		
				Deg	min	sec
C_1	0.91		20.05	0	54	36
C_2	1.82		40.1	1	49	12
C_3	2.73		60.15	2	43	48
C_4	3.64		80.2	3	38	24
C_5	4.55		100.25	4	33	0
C_6	5.46		120.3	5	27	36
C_7	6.37	20.05	140.35	6	22	12
C_8	7.28		160.4	7	16	48
C_9	8.19		180.45	8	11	24
C_{10}	9.1		200.5	9	6	0
C_{11}	10.01		220.55	10	0	36
C_{12}	10.92		240.6	10	55	12
C_{13}	11.83		260.65	11	49	48
C_{14}	12.74		280.7	12	44	24
C_{15}	13.65		300.75	13	39	0

For 2nd circular curve:

Chord	Tangential deflection angle	Chord length	Cumulative chord length	Tangential deflection angle deg	min	sec
C_1	0.655		14.56	0	39	18
C_2	1.31		29.12	1	18	36
C_3	1.965		43.68	1	54	54
C_4	2.62		58.24	2	37	12
C_5	3.272		72.86	3	16	19.2
C_6	3.930		87.36	3	55	48
C_7	4.585	14.56	101.92	4	35	06
C_8	5.240		116.48	5	14	24
C_9	5.895		131.04	5	53	42
C_{10}	6.55		145.6	6	33	0
C_{11}	7.205		160.16	7	12	18
C_{12}	7.806		174.72	7	51	36
C_{13}	8.515		189.28	8	30	54
C_{14}	9.17		203.84	9	10	12
C_{15}	9.825		218.335	9	49	30

Problem 3 solve:

Given,

Deflection angle, $\Delta = 18°36' = 18.60°$

Radius of circular curve, $R = 450m$

Design speed, $v = 70 \, km/h = 19.44 \, ms^{-1}$

chainage at PI = 2524.20m

Road width = 16m

$f_{max} = 0.10$

$e_{max} = 0.06$

Length of transition curve

$$L = \frac{V^3}{RC} = \frac{(19.44)^3}{450 \times 0.3} = 54.42m = 55m$$

Calculation of elements of circular curve and transition curve.

spiral Angle, $\Delta_s = \frac{L}{2R} = \frac{55}{2 \times 450} = 0.061 \text{ rad}$

$$= 3.50°$$

Maximum polar deflection angle,

$$\alpha_L = \frac{\Delta_s}{3} = \frac{0.061}{3} \text{ rad}$$

$$= 0.0203 \text{ rad}$$

$$= 1.167°$$

Shift, $s = \frac{L^2}{24R} = \frac{55^2}{24 \times 450} = 0.28m$

total tangent length,

$$T = \frac{L}{2} + (R+s) \tan\frac{\Delta}{2}$$

$$= \frac{55}{2} + (450 + 0.28) \tan\left(\frac{18.60}{2}\right)$$

$$= 101.236 \text{ m}$$

Apex distance, $E = \frac{R+S}{\cos \Delta/2} - R$

$$= \frac{450 + 0.28}{\cos\left(\frac{18.60}{2}\right)} - 450$$

$$= 6.277 m$$

Length of circular curve $= R(\Delta - 2\Delta_s)$

$$= 450(0.325 - 2 \times 0.061)$$

$$= 91.35 m$$

Length of combined curve $= (2 \times 55 + 91.35)$

$$= 201.35 \ m$$

Chainage at T_1 (PC) $= (2524.20 - 101.236) m$

$$= 2422.964 \ m$$

Chainage at T_2 (PT) $= (2422.964 + 201.35) m$

$$= 2624.2 m$$

Setting out transition curve:

$\theta = \frac{l^2}{2RL}$, $\alpha = \theta/3$, $y = \frac{l^3}{6RL}$

$e_{max} = 0.06$

$h_{max} = 0.96 m$

Peg stn	l=x	alpha (rad)	alpha (deg)	alpha			y(m)	super elevation
				(deg)	min	sec		
1	5	0.00017	0.0096	0	0	35	0.00084	0.0872
2	10	0.00067	0.0386	0	2	19	0.00673	0.1745
3	15	0.00152	0.0868	0	5	13	0.02273	0.2618
4	20	0.00269	0.1543	0	9	16	0.05387	0.3491
5	25	0.00421	0.2411	0	14	28	0.10521	0.4363
6	30	0.00606	0.3472	0	20	50	0.18181	0.5236
7	35	0.00824	0.4726	0	28	22	0.28872	0.6109
8	40	0.01077	0.6173	0	37	02	0.43027	0.6911
9	45	0.01363	0.7813	0	46	33	0.61363	0.7854
10	50	0.01683	0.9645	0	57	52	0.84175	0.8727
11	55	0.02037	1.1671	1	16	02	1.12037	0.9600

setting out half circle using Rankine's method by tangential deflection angle:

$R = 450 m$

$\beta = \Delta - 2\Delta_s = (0.325 - 2 \times 0.0611)$

$= 0.2028 \text{ rad}$

$= 11.6195^\circ$

length of circular curve $= 91.35 m$

length of each chord taking 15 chords in a half circle.

length of each chord $= \frac{91.35}{2 \times 15} = 3.045 m$

subtended angle by each chord $= \frac{\beta/2}{15} = \frac{11.6195/2}{15}$

$= 0.387^\circ$

Tangential deflection angle by each chord

$= \frac{0.387}{2} = 0.194$

Problem 4 solve:

Given,

road width, (b) = 10m

Maximum rate of super elevation = 0.06

Maximum side friction co-efficient = 0.12

The rate of change of radial acceleration = $0.3\ m/s^3$

Chainage at PI = 2000 m

Deflection angle, $\Delta = 15°$

Design speed, $v = 80\ km/h = \frac{80 \times 1000}{3600}\ ms^{-1}$

$= \frac{200}{9}\ ms^{-1}$

Radius of the end of transition curve, R = 500m

We know,

$$e+f = \frac{v^2}{gR}$$

$$\therefore R_{min} = \frac{v^2}{g(e+f)} = \frac{(200/9)^2}{9.8 \times (0.06+0.12)}$$

$$= 279.66\ m$$

For $f_{max} = 0$, $R = \frac{(200/9)^2}{9.81 \times 0.06} = 838.98m$

Since the curve is wholy transitional, so there is no angle subtended by circular curve.

$$\therefore \Delta - 2\Delta_s = 0$$

or, $\Delta_s = \frac{\Delta}{2} = \frac{15}{2} = 7.5° = \frac{7.5\pi}{180}$ rad.

Again, we know spiral angle, $\Delta_s = \frac{L}{2R}$

$$L = 2R\Delta_s$$
$$= 2 \times 500 \times \frac{7.5\pi}{180}$$
$$= 130.90 m$$

$L_{min} = \frac{v^3}{RC}$ ($\because$ considering a maximum)

$$= \frac{(200/9)^3}{0.3 \times 500} = 73.16$$

So, $L_{min} = 73.16 < 130.90 m$

shift, $(s) = \frac{L^2}{24R} = \frac{(130.9)^2}{24 \times 500} = 1.43 m$

Total tangent Length $= \frac{L}{2} + (R+s)\tan \Delta/2$

$$= \frac{130.90}{2} + (500 + 1.43)\tan 7.5°$$
$$= 131.463 m$$

Apex distance, $E = \frac{R+S}{\cos \Delta/2} - R$

$$= \frac{500 + 1.43}{\cos 7.5} - 500$$
$$= 5.757 m$$

total length of curve $= (130.90 + 130.90) m$
$$= 261.8 m$$

Chainage of point of curve $= (3000 - 131.463) m$
$$= 2868.537 m$$

Chainage of point of tangent $= (2868.537 + 261.80) m$
$$= 3130.337 m$$

Problem 5 solve:

Given that,

Road width, (b) = 10 m

Maximum rate of super elevation (e_{max}) = 0.04

Maximum side friction co-efficient (f_{max}) = 0.12

Chainage at PI = 2000 m

Deflection angle, $\Delta = 30^\circ$

Design speed, v = 1000 km/h

$$= \frac{1000 \times 1000}{3600} ms^{-1} = \frac{250}{9} ms^{-1}$$

Radius of circular curve, R = 1000 m

Apex distance, $E = \frac{R+S}{\cos \Delta/2} - R$

As there is no transition curve, So there is no shift.

$$E = \frac{100}{\cos 15^\circ} - 1000 = 35.276 m$$

total length of tangent length, $T = \frac{L}{2} + (R+S) \tan \Delta/2$

$$= R \tan \Delta/2 \quad [\because L, S = 0]$$

$$= 267.95 m$$

total length of curve, $L_c = R \Delta_c$

$$= 1000 \times 30 \frac{\pi}{180}$$

$$= 523.60 m$$

Here, $\Delta_c = 30^\circ$

$= 30 \times \frac{\pi}{180}$ rad

chainage of point of curve (PC) = (2000 − 267.95) m

$$= 1732.05 m$$

chainage of point of tangent $= (1732.05 + 523.60)\,m$

$= 2255.65\,m$

Now, at zero speed. $e + f_1 = \frac{v^2}{gR}$

$\Rightarrow 0.04 + f_1 = 0$

$\therefore f_1 = -0.04$

$f_1 < f_{max}$

So, the curve is safe.

at speed, $v = 150\ km/h = \frac{150 \times 1000}{3600} ms^{-1} = 41.67\, ms^{-1}$

$e + f_2 = \frac{v^2}{gR}$

or, $0.04 + f_2 = \frac{(41.67)^2}{9.8 \times 1000}$

$\therefore f_2 = 0.137$

$\therefore f_2 > f_{max}$, so that the road is not safe.

at $e = 0$, $V = \frac{250}{9} ms^{-1}$ $\quad f_{req} = \frac{(250/9)^2}{9.81 \times 1000}$

$= 0.079$

As, $f_{req} < f_{max}$, so that the road is safe for $e = 0$.

[Proved]

Problem 6 solve:

Given that,

Radius of the larger curve, $R_1 = 1000\ m$

Radius of the smaller curve, $R_2 = 600\ m$

Design speed, $v = 100\ km/h = 27.778\ ms^{-1}$

Rate of charge of radial acceleration, $c = 0.33\ ms^{-3}$

Chainage of the junction point with the curve at large radius $= 1224.00\ m$

Now, $$c = \frac{\frac{v^2}{R_2} - \frac{v^2}{R_1}}{L/v}$$

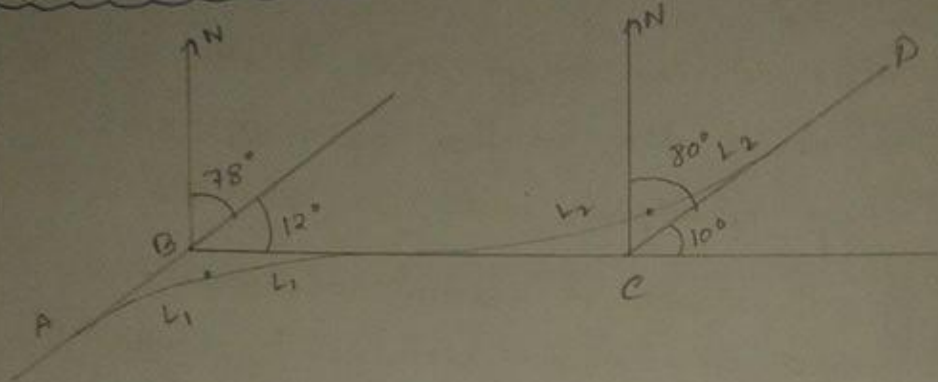
$$\Rightarrow L = \frac{\frac{v^2}{R_2} - \frac{v^2}{R_1}}{c/v} = \frac{\frac{27.778^2}{600} - \frac{27.778^2}{1000}}{\frac{0.33}{27.778}}$$

$$= 43.30m$$

So, Chainage of other junction $= (1224.00 + 43.30)_m$

$$= 1267.30\ m$$

Problem 7 solve:



Given,

1st deflection angle, $\Delta_1 = 12°$

2nd deflection angle, $\Delta_2 = 10°$

Design speed, $v = 70\,kmh^{-1} = 19.44\,ms^{-1}$

rate of change of radial acceleration, $c = 0.3\,ms^{-3}$

change of PC on AB = 1736.31

step 1:

Determination of the radius of curve 1 & 2.

Here the curve is wholly transitional.

So, the length of circular curve = 0

$\therefore R_1(\Delta_1 - 2\Delta_{s_1}) = 0$ (for curve 1)

$\Rightarrow \Delta s_1 = \frac{\Delta_1}{2} = \frac{12°}{2} = 6° = 0.1047$ rad

Now, $\Delta_{s_1} = \frac{L_1}{2R_1}$

$\Rightarrow 0.1047 = \frac{L_1}{2R_1}$

$\therefore L_1 = 0.2094\,R_1$

Again,

$$L_1 = \frac{V^3}{R_1 C}$$

$$\Rightarrow 0.2094 R_1^2 = \frac{V^3}{C}$$

$$\Rightarrow R_1^2 = \frac{(19.44)^3}{0.2094 \times 0.3}$$

$$\therefore R_1 = 342.09m$$

Again, $R_2(\Delta_2 - \Delta_{s_2}) = 0$ (for curve 2)

$$\Rightarrow \Delta_{s_2} = \frac{\Delta_2}{2} = \frac{10^\circ}{2} = 5^\circ = 0.0873 \text{ rad}$$

Now, $\Delta_{s_2} = \frac{L_2}{2R_2}$

$$\Rightarrow 0.0873 = \frac{L_2}{2R_2}$$

$$\therefore L_2 = 0.1745 R_2$$

And $L_2 = \frac{V^3}{R_2 C}$

$$\Rightarrow 0.1745 R_2^2 = \frac{V^3}{C}$$

$$\Rightarrow 0.1745 R_2^2 = \frac{(19.44)^3}{0.3}$$

$$\therefore R_2 = 375m$$

step 2:

Determination of the length of transition curve 1 & 2

$$L_1 = \frac{V^3}{R_1 C} = \frac{(19.44)^3}{342.09 \times 0.3} = 71.635m$$

$$L_2 = \frac{V^3}{R_2 C} = \frac{(19.44)^3}{375 \times .3} = 65.348m$$

Step 3:

Determination of the length of common tangent BC.

Shift, $s_1 = \frac{L_1^2}{24 R_1}$ (for curve-1)

$$= \frac{(71.635)^2}{24 \times 342.09}$$

$$= 0.6250 \text{ m}$$

Shift, $s_2 = \frac{L_2^2}{24 R_2}$

$$= \frac{(65.348)^2}{24 \times 375} = 0.4744 \text{m}$$

For curve-1, total tangent length,

$$T_1 = \frac{L_1}{2} + (R_1 + s_1) \tan \frac{\Delta_1}{2}$$

$$= \frac{71.635}{2} + (342.09 + 0.625) \tan \frac{12}{2}$$

$$= 71.839 \text{m}$$

For curve-2, total tangent length,

$$T_2 = \frac{L_2}{2} + (R_2 + s_2) \tan \frac{\Delta_2}{2}$$

$$= \frac{65.348}{2} + (375 + 0.4744) \tan \frac{10}{2}$$

$$= 65.524 \text{m}$$

$\therefore$ Length of common tangent, $BC = T_1 + T_2$

$$= (71.839 + 65.524) \text{m}$$

$$= 137.36 \text{m}$$

Step 4:

Determination of the chainage of the tangent point on CD.

Total length of curve-1 $= (71.635 + 71.635) \text{m}$

$$= 143.378 \text{ m}$$

Total length of curve-2 $= (65.348 + 65.348)$ m

$= 130.696$ m

chainage of the tangent point on CD

$= (1736.91 + 143.378 + 130.696)$ m

$= 2010.981$ m

Problem 8 solve:

Given,

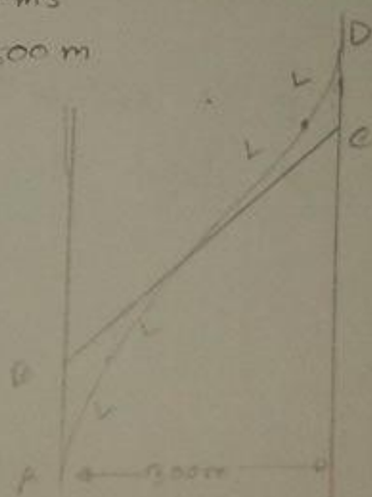
Road width, $b = 12$m

Distance between centre lines of roads $= 30$ m

Design speed, $v = 100 \text{ km/h}^{-1}$

$= 27.78 \text{ ms}^{-1}$

Radius of curvature $R = 500$ m



Rate of change of Radial acceleration, $c = 0.3 \text{ ms}^{-3}$

Length of transition curve, $L = \frac{V^3}{Rc}$

$= \frac{(27.78)^3}{500 \times .3}$

$= 142.889$ m

As there is no circular curve.

So, total length of the curve $= (142.889 \times 4)$ m

$= 571.559$ m

Here, length of circular curve $= 0$

$\therefore R(\Delta - 2\Delta_s) = 0$

or, $\Delta = 2\Delta_s$

Now $\Delta_s = \frac{L}{2R}$

$= \frac{142.889}{2 \times 500} = 0.142889$ rad

$= 8.187^\circ$

$\therefore \Delta = 2 \times 8.187^\circ = 16.3738^\circ = 16^\circ 22' 26''$

Final deflection angle to locate the end of first transition curve $\alpha_L = \frac{\Delta_s}{3} = \frac{0.142889}{3}$

$= 0.0476$ rad

$= 2.7289^\circ$

$= 2^\circ 43' 44''$

Problem 9 solve :

$$R_{min} = \frac{v^2}{g(e+f)}$$

$$= \frac{(16.67)^2}{9.8 \times 0.12}$$

$$= 236.30 m$$

Here,

$$v = 60 kmh^{-1}$$

$$= \frac{60 \times 1000}{3600} ms^{-1}$$

$$= 16.77 ms^{-1}$$

$$f_{max} = 0.12$$

$$e = 0$$