Horizontal Curve

Problem 1:

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

Deflection Angle , $\triangle$ = **45°**

Chainage at PI = 5000 m

Design Speed of vehicle = 70 km/hr

Road width = 4m x 4 = 16.0 m

Solution:

Step 1:

Radius of circular curve, R=?

a) Decision making for e_{max},

$$e_{max} = 0.08$$

b) f_{max}= ?

Design Speed, V $= 70\ \text{km/hr}$

$$= \frac{70 \times 1000 \times 3.28}{3 \times 1760} mph$$

$$= 43.5\ \text{mph}$$

$$= \frac{70 \times 1000}{60 \times 60} m/s$$

$$= 19.44 m/s$$

From AASHTO guideline, Table -III-6,

V=40 mph ⇒ f_{max} = 0.15
V=50 mph ⇒ f_{max} = 0.14 (safe side)

∴ f_{max} = 0.14

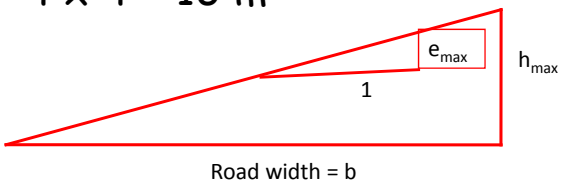
∴e_{max} + f_{max} = 0.08 + 0.14

=0.22

c) Maximum superelevation, h_{max} =?

Road width , b = 4 x 4 = 16 m

e_{max} = 0.08



$h_{max} = b \times e_{max} = 16 \times 0.08$

$= 1.28$ m

$= 1.28 \times 3.28$ ft

= 4.20 ft

d) R = ?

$$R_{min} = \frac{V^2}{g(e+f)} = \frac{(19.44)^2}{9.8 \times (0.22)} = 175\ m$$

$$= 575\ ft$$

Decision making for R,

For f=0, $R = \frac{(19.44)^2}{9.8 \times (0.08+0)}$

$= 482m \ = 1528ft$

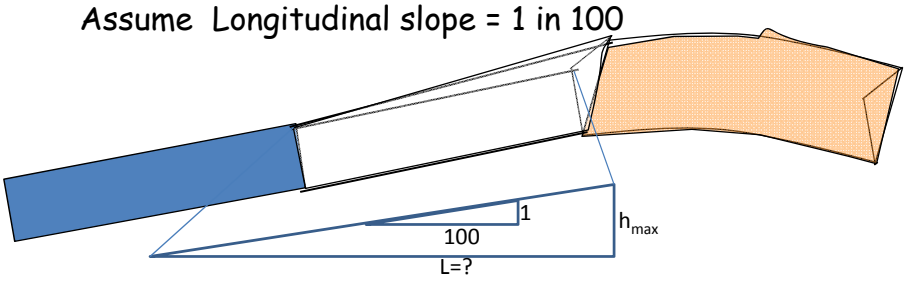
R = 400m = 1312 ft

Step 2 :

Length of transition curve

Method A :
Arbitrary gradient method (1 in 50, 100, 200 etc)

Assume Longitudinal slope = 1 in 100



$$\frac{1}{100} = \frac{h_{max}}{L} \Rightarrow L = h_{max} \times 100 = 128m$$

Method C :

rate of change of radial acceleration

C = 1 ft/s^3 for railroad = 0.3 m/s^3
= 1~3 ft/s^3 for highways = 0.3~0.9 m/s^3
For high standard road , c = 1 ft/s^3 = 0.3 m/s^3

$$\therefore \quad L = \frac{V^3}{RC} = \frac{(19.44)^3}{400 \times 0.3} = 60.3m$$

Decision Making for L

Use, L=100 m

Step 3 :

Calculate elements of circular and transition curve

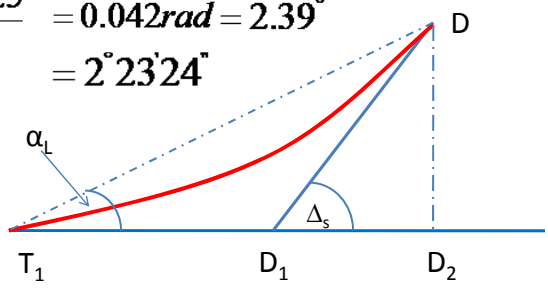
Spiral Angel, $\Delta_s = \frac{L}{2R} = \frac{100}{2\times400} = 0.125rad$

$= \frac{0.125\times180}{\pi} = 7.16^\circ = 7^\circ 9' 36''$

Maximum deflection angle ,

$\alpha_L = \frac{0.125}{3} = 0.042rad = 2.39^\circ$

$= 2^\circ 23' 24''$



Shift, S= $\frac{L^2}{24R} = \frac{100^2}{24\times400} = 1.042m = 3.42ft$

TD_1 = 2/3 L = 66.7 m = 218.67 ft

D_1D_2= 1/3L = 33.3 m = 109.33 ft

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

$= \frac{100}{2} + (400+1.042)\tan 45/2$

$= 216.117m$

$= 708.86ft$

Apex Distance,

$$E = \frac{R+S}{Cos\,\Delta/2} - R$$

$$= \frac{400+1.042}{Cos\,45/2} - 400$$

$$= 34.084m$$

$$= 111.80\,ft$$

Length of Circular Curve

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

$$= 400\times(0.785 - 2\times 0.125)$$

$$= 214.159m$$

$$\Delta = 45^\circ$$

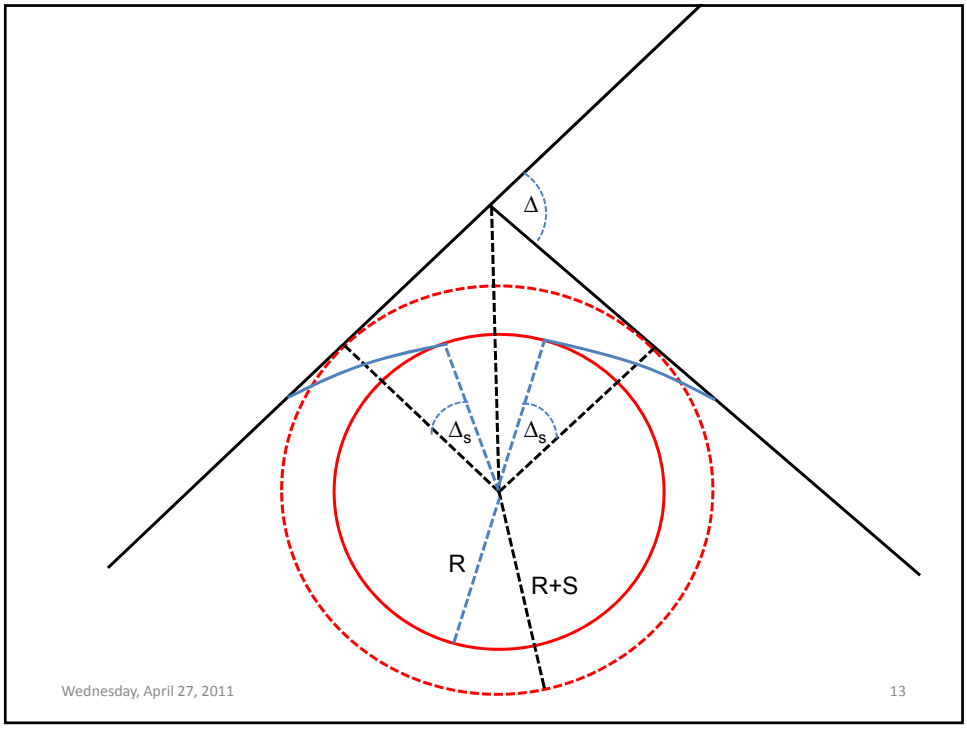
$$= \frac{45\,\pi}{180}\,rad$$

$$= 0.785\,rad$$

Length of Combined Curve

= 100+214.159+100

=414.159m



Chanaige of T_1 (PC) = 5000 - 216.117 m

= 4783.883 m

Chanaige of T_2 (PT) = 4783.883 + 414.159 m

= 5198.042 m

(Along the actual Road)

Maximum offset Y = 4S

= 4 x 1.042

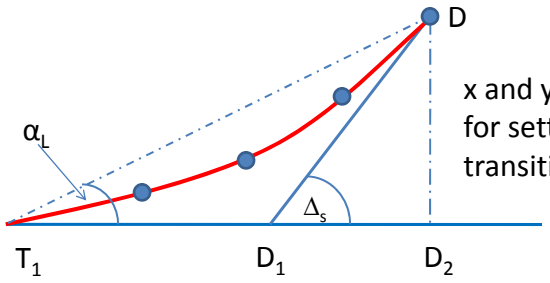
= 4.167 m

= 13.67 ft

Step 4 :
setting out transition curve

$$\theta = \frac{l^2}{2RL} \qquad \alpha \cong \frac{\theta}{3}$$

Unit of angle is radian in this formula



x and y can be used for setting out transition curve

Setting out transition curve

e_{max}= 0.080

h_{max}= 1.280m

Peg stn.	l=x (m)	alpha (rad)	alpha (deg)	alpha (deg)	alpha (min)	alpha (sec)	y (m)	super elev (m)
1	5	0.0001	0.006	0	0	21	0.001	0.064
2	10	0.0004	0.024	0	1	26	0.004	0.128
3	15	0.0009	0.054	0	3	13	0.014	0.192
4	20	0.0017	0.095	0	5	44	0.033	0.256
5	25	0.0026	0.149	0	8	57	0.065	0.320
6	30	0.0038	0.215	0	12	53	0.113	0.384
7	35	0.0051	0.292	0	17	33	0.179	0.448
8	40	0.0067	0.382	0	22	55	0.267	0.512

Peg stn.	l (m)	alpha (rad)	alpha (deg)	alpha (deg)	alpha (min)	alpha (sec)	y (m)	super elev (m)
9	45	0.0084	0.483	0	29	0	0.380	0.576
10	50	0.0104	0.597	0	35	49	0.521	0.640
11	55	0.0126	0.722	0	43	20	0.693	0.704
12	60	0.0150	0.859	0	51	34	0.900	0.768
13	65	0.0176	1.009	1	0	31	1.144	0.832
14	70	0.0204	1.170	1	10	11	1.429	0.896
15	75	0.0234	1.343	1	20	34	1.758	0.960
16	80	0.0267	1.528	1	31	40	2.133	1.024
17	85	0.0301	1.725	1	43	29	2.559	1.088
18	90	0.0338	1.934	1	56	1	3.038	1.152
19	95	0.0376	2.155	2	9	16	3.572	1.216
20	100	0.0417	2.387	2	23	14	4.167	1.280

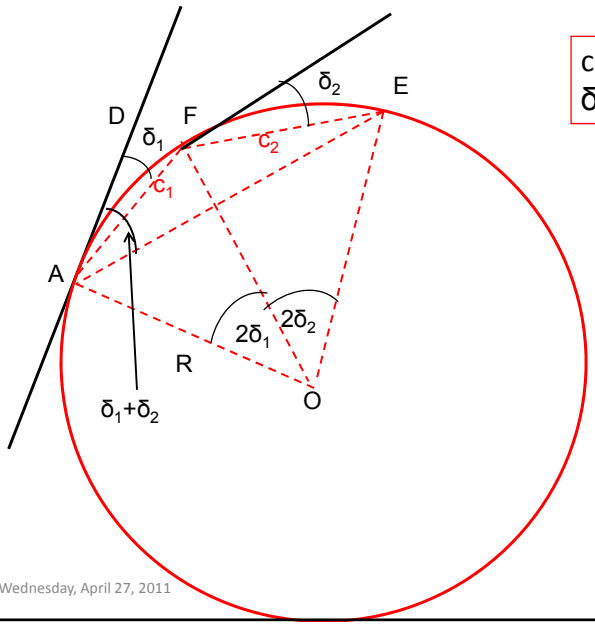
Step 5 :

Setting out half circle

Using

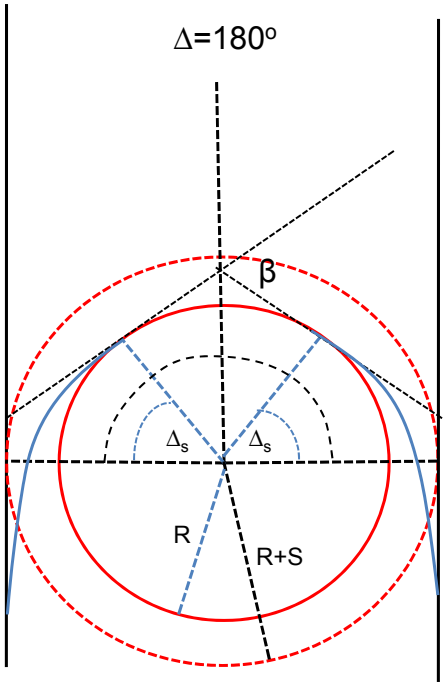
Rankine's method of tangential deflection angle

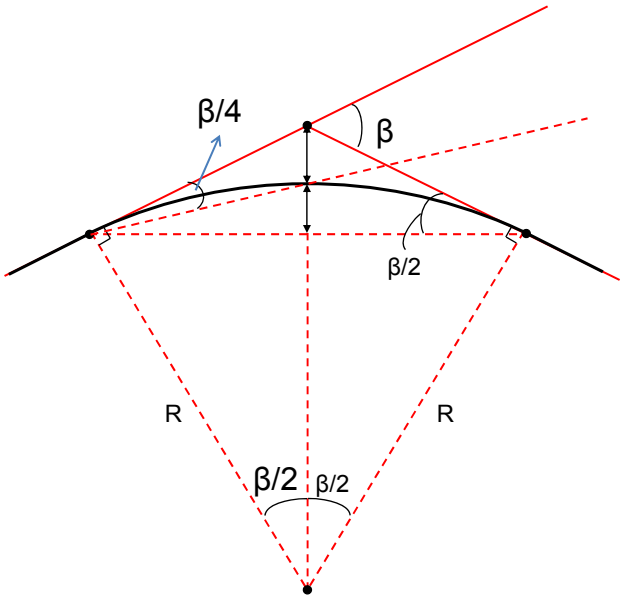
Rankine's method of tangential deflection angle



c_1, c_2, c_3 = known
δ_1, δ_2, δ_3 = ?

$c_1 = R(2\delta_1)$
$\delta_1 = c_1 / 2R$





Setting out half circle

R = 400 m

$\beta = \Delta - 2\Delta_s$

$= 45 - 2 \times 7.16^\circ$

$= 30.676^\circ$

$= \frac{30.676 \times \pi}{180} rad$

= 0.5354 rad

length of circular curve = 214.16 m

half circle = $\frac{214.16}{2} = 107.08m$

If we make 18 chord in half circle,

Length of each chord = $\frac{107.08}{18} = 5.949m$

Subtended Angle by each chord = $\frac{\beta/2}{18}$

$= 0.852^\circ$

Tangential deflection angle by each chord =

$$\frac{0.852}{2} = 0.426^\circ$$

chord	tangential deflection angle	chord length (m)	cumulative arc length	Total deflection angle from common tangent			super elevation
	(deg)	(m)	(m)	(deg)	(min)	(sec)	(m)
c1	0.426	5.949	5.949	0	25	34	1.280
c2	0.852	5.949	11.898	0	51	8	1.280
c3	1.278	5.949	17.846	1	16	41	1.280
c4	1.704	5.949	23.795	1	42	15	1.280
c5	2.130	5.949	29.744	2	7	49	1.280
c6	2.556	5.949	35.693	2	33	23	1.280
c7	2.982	5.949	41.642	2	58	57	1.280
c8	3.408	5.949	47.591	3	24	30	1.280
c9	3.835	5.949	53.539	3	50	4	1.280
c10	4.261	5.949	59.488	4	15	38	1.280
c11	4.687	5.949	65.437	4	41	12	1.280
c12	5.113	5.949	71.386	5	6	46	1.280
c13	5.539	5.949	77.335	5	32	19	1.280
c14	5.965	5.949	83.283	5	57	53	1.280
c15	6.391	5.949	89.232	6	23	27	1.280
c16	6.817	5.949	95.181	6	49	1	1.280
c17	7.243	5.949	101.130	7	14	35	1.280
c18	7.669	5.949	107.079	7	40	8	1.280

Any Question ?