

Plan Preparation Guide

Chapter 6

Horizontal Alignment (Center Line)

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1. Horizontal Curves (Circular)

The changes in direction along a highway are basically accounted for by curves consisting of portions of a circle. Its principal characteristic is measured by the RADIUS or by a related quality referred to as the DEGREE of curve.

When it is necessary to relocate the roadway centerline of a project, new points for the relocated PC, PI, PT, and POT's should be determined and shown on the plan's Reference Sheet. These new points should be identified as relocated points. Each point will be identified by xyz coordinates on the Reference Sheet and shown on the plan sheet as "Relocated PC", etc. with stationing. This procedure is in lieu of providing station-offsets for the relocated points. Use the new coordinate description on all future work. A note should be placed on the plan sheet to bring attention to the relocation and should read as follows:

**Relocate centerline between
Sta. _____ and Sta. _____.**

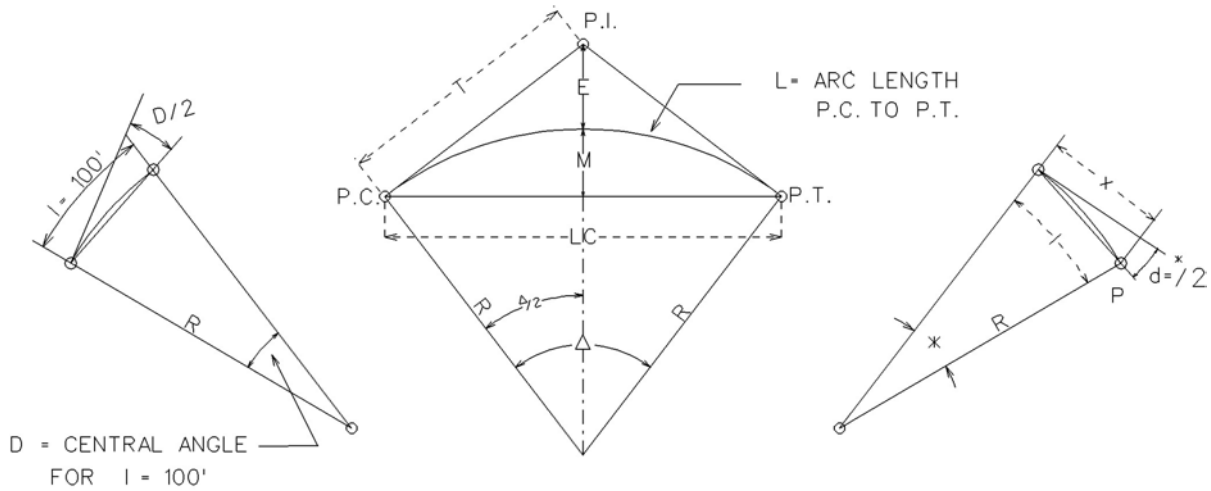
A set of plans with only one or two plan sheets typically will not have a Reference Sheet due to the simple nature of the plan sheets themselves. It will be necessary to show the relocation notes and references on the plan sheets themselves.

The fundamental properties of the circle, as utilized in highway engineering consist of interrelated elements (standard nomenclature) as shown on the following sheet.

1. HORIZONTAL CURVES (CIRCULAR)

The changes in direction along a highway are basically accounted for by curves consisting of portions of a circle. Its principal characteristic is measured by the RADIUS or by a related quality referred to as the DEGREE of curve.

The fundamental properties of the circle, as utilized in highway engineering consist of interrelated elements (standard nomenclature) as shown here:



SYMBOLS

- Δ = Intersection or Central Angle, Degrees
- R = Radius of Curve
- D = Degree of Curve
- L = Length of Curve
- T = Tangent Distance
- E = External Distance
- M = Middle Ordinate
- LC = Long Chord
- l = Length of ARC between any two points on curve
- * = Central angle subtended by ARC l, degrees
- d = Deflection angle for any ARC length l, degrees
- x = Distance along tangent from P. C. or P. T. to set any point P on curve
- y = Offset from tangent at distance x to set any point P on curve

2. FORMULAS FOR CIRCULAR CURVES

$$D = 5729.57795 \div R$$

$$L = \Delta R \div 57.2958 = 100 \Delta \div D$$

$$T = R \tan \frac{\Delta}{2}$$

$$E = \frac{R}{\cos \frac{\Delta}{2}} - R = R \operatorname{EXSEC} \frac{\Delta}{2}$$

$$M = R (1 - \cos \frac{\Delta}{2}) = R \operatorname{VERS} \frac{\Delta}{2}$$

$$LC = 2 R \sin \frac{\Delta}{2}$$

$$R = (LC^2 + 4M^2) \div 8M$$

$$l = 100 * \div D$$

$$d = \frac{*}{2} = 1718.873 l \div R \text{ (IN MINUTES)}$$

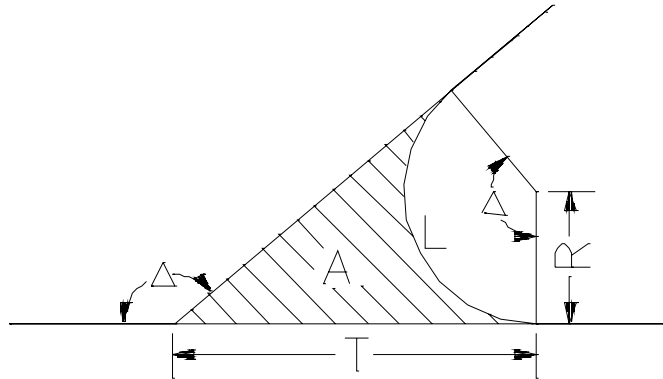
$$= 28.64789 l \div R \text{ (IN DEGREES)}$$

$$\text{FOR ANY LENGTH } x, y = R - \sqrt{R^2 - x^2}$$

$$\text{FOR ANY LENGTH } l, x = R \sin *$$

$$y = R (1 - \cos d) = R \operatorname{VERS} *$$

3. SHORT RADIUS CURVE DATA



Δ = CENTRAL ANGLE
R = RADIUS
T = TANGENT DISTANCE
A = EXTERNAL AREA
L = ARC LENGTH

FORMULAS

$$T = R \tan \frac{\Delta}{2}$$

$$A = R^2 \left(\tan \frac{\Delta}{2} - \frac{\Delta \pi}{360} \right)$$

$$L = \frac{2 \times \pi \times R \times \Delta}{360}$$

4. Short Radius Curve Values

Radius	Arc Length per Degree	Length	90° Values
			External Area
1'	0.017'	1.571'	.21 Sq. Ft.
2	0.035	3.142	.86
3	0.052	4.712	1.93
4	0.070	6.283	3.43
5	0.087	7.854	5.37
6	0.105	9.425	7.73
7	0.122	10.996	10.52
8	0.140	12.566	13.73
9	0.157	14.137	17.38
10	0.175	15.708	21.46
11	0.192	17.279	25.97
12	0.209	18.850	30.90
13	0.227	20.420	36.27
14	0.244	21.991	42.06
15	0.262	23.562	48.29
16	0.279	25.133	54.94
17	0.297	26.704	62.02
18	0.314	28.274	69.53
19	0.332	29.845	77.47
20	0.349	31.416	85.84
21	0.367	32.987	94.64
22	0.384	34.558	103.87
23	0.401	36.128	113.52
24	0.419	37.699	123.61
25	0.436	39.270	134.13
26	0.454	40.841	145.07
27	0.471	42.412	156.44
28	0.489	43.982	168.25
29	0.506	45.553	180.48
30	0.524	47.124	193.14
31	0.541	48.695	206.23
32	0.558	50.266	219.75
33	0.576	51.836	233.70
34	0.593	53.407	248.08
35	0.611	54.978	262.89

Short Radius Curve Values (cont.)

Radius	Arc Length per Degree	Length	90° Values
			External Area
36	0.628	56.549	278.12 Sq. Ft.
37	0.646	58.120	293.79
38	0.663	59.690	309.88
39	0.681	61.261	326.41
40	0.698	62.832	343.36
41	0.716	64.403	360.74
42	0.733	65.974	378.55
43	0.750	67.544	396.80
44	0.768	69.115	415.47
45	0.785	70.686	434.57
46	0.803	72.257	454.09
47	0.820	73.828	474.05
48	0.838	75.398	494.44
49	0.855	76.969	515.25
50	0.873	78.540	536.50
60	1.047	94.41	
70	1.221	109.89	
75	1.309	117.81	
90	1.571	141.39	
100	1.745	157.05	
125	2.182	196.38	
150	2.618	235.62	
175	3.054	274.86	
200	3.491	314.19	

5. Maximum Degree of Curve for Design Speed

Design Speed MPH	Max Table 0.04 D	Max Table 0.06 D	Max Table 0.08 D
10	188° 27'	205° 35'	222° 43'
11	155° 44'	169° 54'	184° 03'
12	130° 52'	142° 46'	154° 40'
13	111° 30'	121° 39'	131° 47'
14	93° 57'	102° 42'	107° 04'
15	81° 51'	89° 28'	93° 16'
16	71° 56'	78° 38'	81° 58'
17	62° 14'	68° 10'	74° 06'
18	55° 31'	60° 48'	66° 06'
19	49° 50'	54° 35'	59° 19'
20	44° 58'	49° 15'	53° 32'
21	40° 47'	44° 41'	48° 34'
22	37° 10'	40° 42'	44° 15'
23	34° 00'	37° 15'	40° 29'
24	30° 29'	33° 28'	36° 26'
25	28° 06'	30° 50'	33° 35'
26	25° 59'	28° 31'	31° 03'
27	23° 30'	25° 51'	28° 12'
28	21° 51'	24° 02'	26° 13'
29	20° 22'	22° 24'	24° 27'
30	19° 02'	20° 56'	22° 51'
31	17° 50'	19° 37'	21° 24'
32	16° 44'	18° 24'	20° 04'
33	15° 44'	17° 18'	18° 53'
34	14° 27'	15° 56'	17° 25'
35	13° 38'	15° 02'	16° 26'
36	12° 53'	14° 12'	15° 32'
37	11° 53'	13° 08'	14° 23'
38	11° 16'	12° 27'	13° 39'
39	40° 42'	11° 50'	12° 57'
40	10° 10'	11° 15'	12° 19'
41	9° 41'	10° 42'	11° 43'
42	9° 14'	10° 12'	10° 10'
43	8° 48'	9° 44'	10° 39'
44	8° 11'	9° 04'	9° 54'
45	7° 50'	8° 40'	9° 31'
46	7° 29'	8° 18'	9° 07'
47	6° 59'	7° 45'	8° 32'
48	6° 41'	7° 26'	8° 11'
49	6° 25'	7° 08'	7° 51'
50	6°10'	6° 51'	7° 32'

Maximum Degree of Curve for Design Speed (cont.)

Design Speed MPH	Max Table 0.04 D	Max Table 0.06 D	Max Table 0.08 D
51	5° 56'	6° 25'	7° 15'
52	5° 33'	6° 11'	6° 49'
53	5° 20'	5° 57'	6° 33'
54	5° 00'	5° 35'	6° 10'
55	4° 49'	5° 23'	5° 57'
56	4° 38'	5° 11'	5° 44'
57	4° 21'	4° 53'	5° 24'
58	4° 12'	4° 42'	5° 13'
59	3° 56'	4° 26'	4° 55'
60	3° 48'	4° 17'	4° 45'
61	3° 41'	4° 09'	4° 36'
62	3° 27'	3° 54'	4° 21'
63	3° 20'	3° 46'	4° 12'
64	3° 08'	3° 33'	3° 58'
65	3° 02'	3° 27'	3° 51'
70	2° 27'	2° 48'	3° 00'