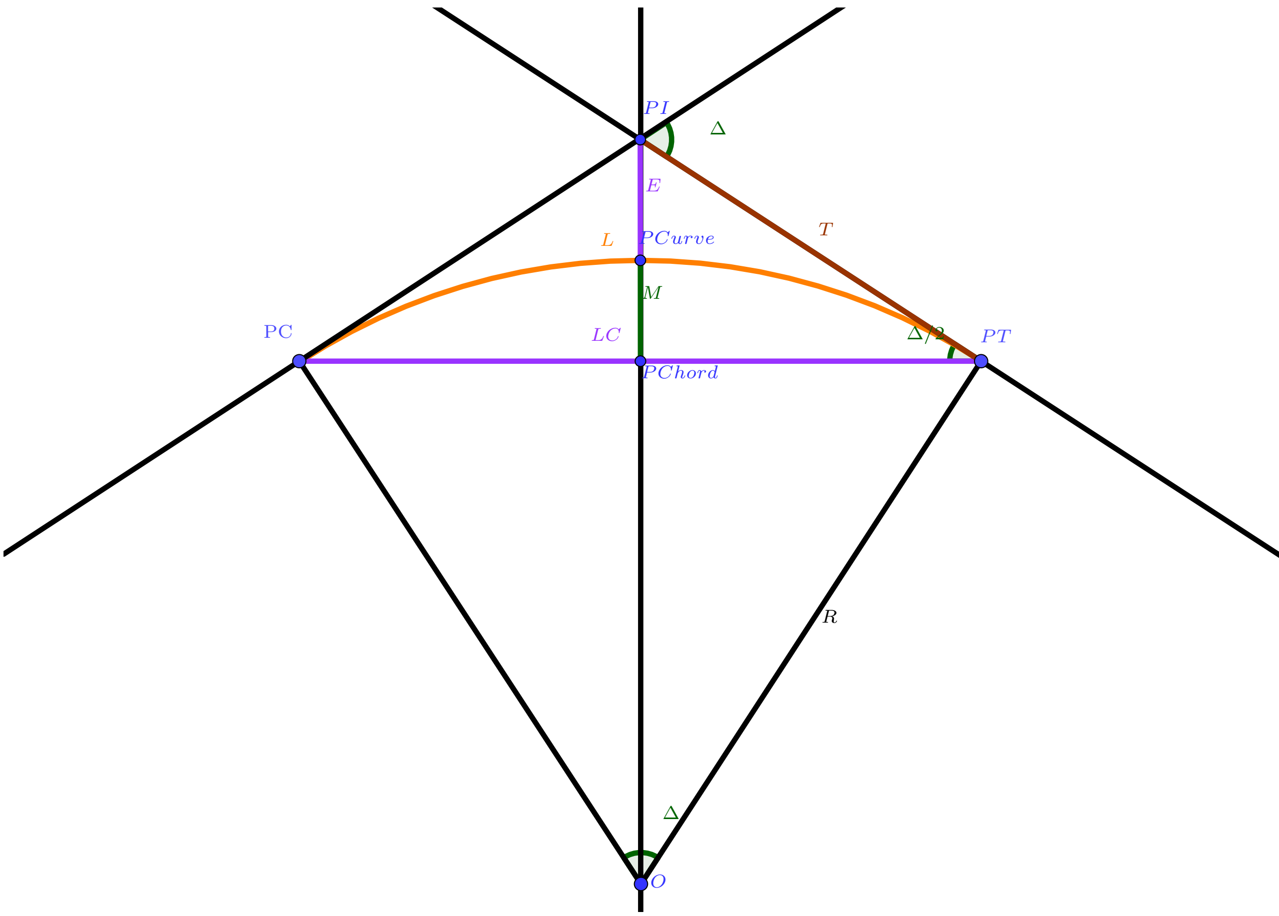
Contents

4 Chapter 04 horizontal Alignment

4.1 Objectives

1. Horizontal Curve Elements
2. Superelevation
3. Design Horizontal Curve

4.2 Horizontal Curve Diagram



4.3 Horizontal Curve diagram

Terms:

1. PI: point of intersection, intersection of tangent and curve

2. PC: point of curve(where curve starts), intersection of tangent and curve
3. PT: point of tangency(where curve ends), intersection of 2 tangents
4. PCurve: intersection of line PI-O and curve PC-PT
5. PChord: intersection of chord PC-PT and line PI-O
6.
7. R: the radius of the curve
8. D: in degree, degree of curve, the degree matches 100ft arc
   (a) highways:(small) D $->$ arc length of 100ft
   (b) railroads(big) D $->$ cord length of 100ft
9. Δ - the degree of the curve, **the same as the bearings of 2 tangents**
10. L: in feet, curve length
11. T: line segment from PI to PT/PC
12. E: external distance, line segment of PI-PCurve
13. M: middle ordinate, line segment of PCurve-PChord
14. LC: chord PC-PT
15. curvature - how big is a curve, $curvature = 1/R$

4.4 Horizontal Curve formulas

$$\frac{D}{100} = \frac{360}{2\pi R}$$
$$D = \frac{360 \cdot 100}{2\pi R}$$
$$L = 100 \cdot \Delta/D$$
$$L_{in\_meter} = 30.48 \cdot \Delta/D$$
$$T = R \cdot tan\frac{1}{2}\Delta$$
$$M = R(1 - cos\frac{1}{2}\Delta)$$
$$E = R(\frac{1}{cos\frac{1}{2}\Delta} - 1)$$
$$LC = 2R \cdot sin\frac{1}{2}\Delta$$

4.5 stationing calculations - for PI, PC and PT

Stationing is the concept of assigning distances along a line, such as a survey baseline (initial field survey) or center line (design)

52+48.63 means 52 hundreds 48 ft and .63 ft

Given PI, calculate the locations:

1. why???
2. PC = PI - T
3. PT = PC + L

4.6 bearings calculations

A bearing refers to the direction and orientation of a line

N 73°30'38"E
52+48.63 means 52 hundreds 48 ft and .63 ft

4.7 types of horizontal curves

1. simple
2. compound (R1 and R2)
3. reverse
4. spiral (change radius btw 2 Rs)

VDOT: The use of spiral transitions for compound and reverse curves on urban roadways should be avoided, ...

4.8 sight distance on curves

terms:

1. highway centerline $->$ highway radius
2. centerline inside a lane $->$ R_v
3. line of sight
4. sight obstruction
5. sight distance

sight distance fomula:

$$M_s = R_v \cdot (1 - cos_{degrees} \frac{90SSD}{\pi R_v})$$
$$M_s = R_v \cdot (1 - cos_{radians} \frac{SSD}{R_v})$$

M_s : **the middle ordinate, distance from centerline to obstruction**
R_v : **the radius of the curve, inside lance — for the centerline of the *1st* lane**
SSD : **the stopping sight distance**

4.9 superelevation - centrifugal force

suggestion value:
$1mph = 1.47ft/sec$

superelevation formula:
$$\frac{e+f}{1-ef} = \frac{v^2}{gR} = \frac{V^2}{15R}$$

minimam radius:
$$R_{min} = \frac{V^2}{15(f_s + e_{max})} = \frac{v^2}{g(f_s + e_{max})}$$

e: superelevation rate, e.g. 0.04
f: coefficient of friction
f_s: side friction, e.g. 0.10
g: 9.8, the acceleration of gravity
v: in ft/sec, the speed in ft/sec
V: in mph, the speed in mph
R: in ft, the radius of the curve in feet

4.10 superelevation - selection of e

1. too high or too low?
2. What factors should be considered?
3.

4. e $\leq$ 0.10 on any paved road
5. e $\leq$ 0.12 on unpaved roads
6. e $\leq$ 0.08 where there is ice and snow
7. e $\leq$ 0.06 in Illinois where ever practical
8. e $\leq$ 0.04 in Illinois for urban freeways

4.11 superelevation - transition design control

1. Tangent runout (TR): the distance needed to change from a normal crown section to a point where the outside lane(s) is level
2. Superelevation Runoff (L): the distance needed to change the cross slope from the end of TR to the design full superelevation rate.
3. IDOT practice: TR and 1/3 runoff on the tengent; 2/3 of runoff on the curve;
4. ASSHTO: placing the PC at between 60% and 80% of the transition length
5. ALDOT: 80/20 split (of the entire STL)
6. VDOT: this split is of the superelevation runoff portion only, not the entire STL
7. Many states, including Virginia, use 2:1 split

4.12 axis of rotation

Axis of Rotation is the point about which the pavement edges are revolved to superelevate the roadway.

1. typically, on undivided highways the centerline of roadway is the axis of rotation.
2. typicallly, divided highways rotate around the median edge
3. also, some roadway revolved about inside edge!

4.13 superelevation runoff fomula

superelevation runoff for *TWO-Lane* roads:
$L_{sro} \cong 30e(V + 32)$, for 12 ft lans
$L_{sro} \cong 25e(V + 32)$, for 10 ft lans
L_{sro} : superelevation runoff length
e: superelevation rate

full superelevation curve length:
$L_{full} = L_{curve} - 2L_{sro}$
L_{full} : full superelevation curve length
L_{curve} : horizontal curve length (arc length)

for multilane roads: (AASHTO Green Book)
times 1.5 for 4 lanes (2 in each direction)
times 2.0 for 6 lanes

4.14 tangent runout formula

tangent runout formula, given runoff:

$$TR = L_{sro}\frac{NC}{e}$$

TR: tengent runout
L_{sro}: superelevation runoff length
NC: normal crown rate

4.15 Terms

gradient: slope rate

4.16 Rules

4.17 Formulas

4.18 Reference