Lec. NO.8

Principles of Transportation

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Basics of horizontal and vertical alignment

The center line layout or position on the ground surface is called Alignment. There are two types of Alignments horizontal Alignment and Vertical Alignment.
Horizontal Alignment includes the straight path, curves or deviation in horizontal direction.
Vertical Alignment includes vertical curves and gradient on the ground.
But it is difficult to change the alignment once the road is constructed, so care has to be taken in finalizing the alignment.

Basic Requirement of an Ideal Alignment

1. It should have a shortest path.
2. The alignment must be easy to construct and maintain and also it should be easy for vehicle operation.
3. It should be safe in case of designing the horizontal and vertical curves.
4. The alignment should be selected in such a way that it is economical during construction.

Vertical Alignment

•Specifies the elevations of points along a roadway.

•Elevations are determined by need to provide proper drainage and driver safety.

•A primary concern of vertical alignment is to establish a transition between two roadway grades by means of a vertical curve.

Types of Vertical Alignment
•Two types of Vertical Curves:

1. Crest Vertical Curves.

2. Sag Vertical Curves.

Vertical Curve Properties

•The initial road grade is called G1 the final road grade is called G2and is typically given in percent.

•PVC is the point of the vertical curve.

•The point of intersection of the initial tangent grade and the final tangent grade is the point of vertical intersection (PVI).

•The point of intersection of the vertical curve with the final tangent grade is called the PVT .

•The length (L) of the vertical curve is the horizontal distance between PVC and PVT.

•Equal Tangent, if PVC to PVI is L/2.

Vertical Curve Design

•Vertical Curves maximum grades depend on:

–Design Speed

–Type of Terrain

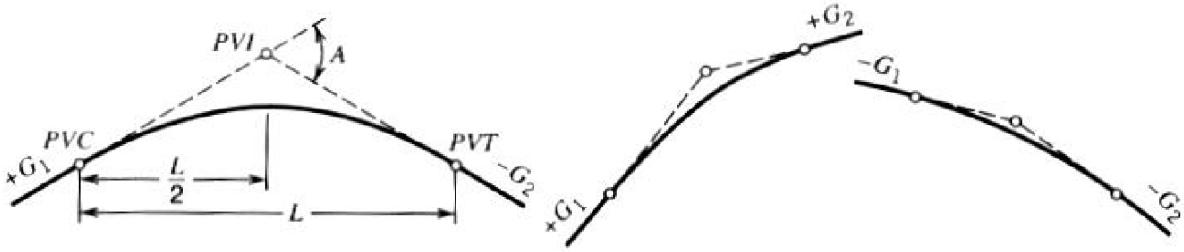
–Length of Grade

•Grades also affect:

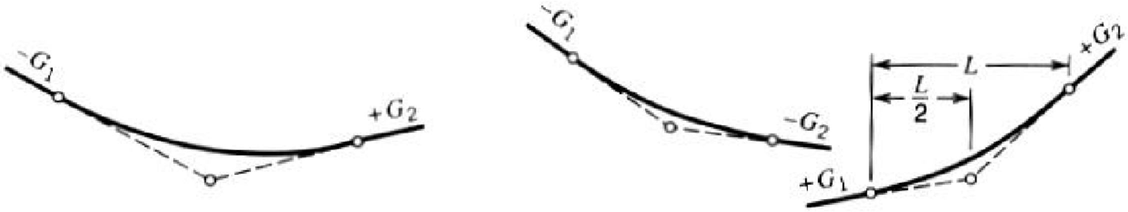
–fuel consumption

–speed

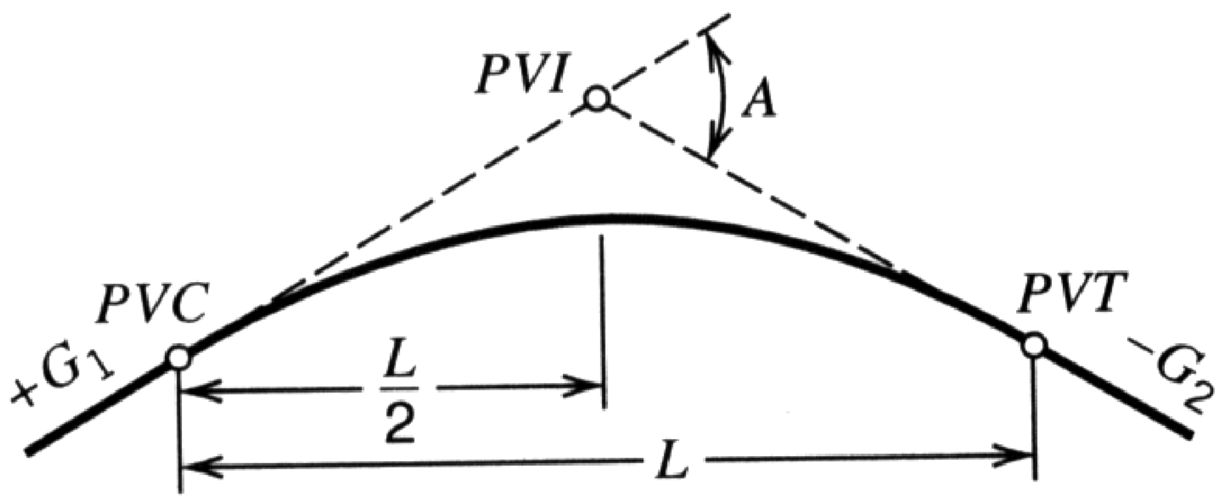
–accidents (speed differential)



Crest Vertical Curves



Sag Vertical Curves



xt=-G1/r   r=G2-G1/L   (lowest point or highest point)

$Ep = Epvc + G1x + r/2(x^2)$ This equation is used to determine the elevation of any point within the vertical curve

Problem:

A 600-feet “equal-tangent” sag vertical curve, with PVC elevation 1250 ft. The initial grade is -3% and the final grade is +5%. Determine the position and elevation of the lowest point on the curve.

Solution:

x_o=-G1/r   r=G2-G1/L   **<u>notice that L=6 stations</u>**

x_o=2.25 station=225 ft

$$Ep = Epvc + G1x + r/2(x^2)$$

$$E(x_o) = 1250 - 3(2.25) + (\frac{1.33}{2})(2.25)^2$$

$E(x_o)$ =1246.625 ft

<u>Horizontal Curves</u>

Elements of curve design

- Curve radius
- Super elevation
- Side friction
- Assumed vehicle speed

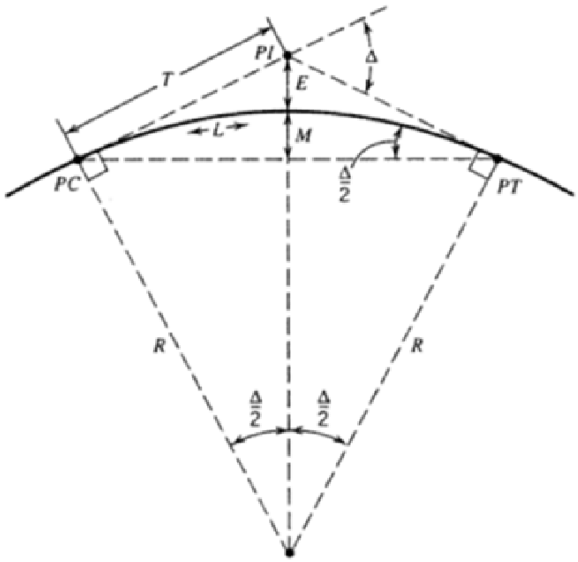


Figure 3.13 Elements of a simple circular horizontal curve.

$$T = R \tan \frac{\Delta}{2} \quad \textbf{(3.36)}$$

$$E = R\left[\frac{1}{\cos(\Delta/2)} - 1\right] \quad \textbf{(3.37)}$$

$$M = R\left(1 - \cos \frac{\Delta}{2}\right) \quad \textbf{(3.38)}$$

$$L = \frac{\pi}{180} R\Delta \quad \textbf{(3.39)}$$

R = radius, usually measured to the centerline of the road, in ft (m),

Δ = central angle of the curve in degrees,

PC = point of curve (the beginning point of the horizontal curve),

PI = point of tangent intersection,

PT = point of tangent (the ending point of the horizontal curve),

T = tangent length in ft (m),

M = middle ordinate in ft (m),

E = external distance in ft (m), and

L = length of curve in ft (m).

Example

A horizontal curve is designed with a 2000-ft radius. The curve has a tangent length of 400 ft and the PI is at station 103 . Determine length of curve and stationing of the PT.

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

$$400 = 2000 \tan \frac{\Delta}{2}$$

$$\Delta = 22.62°$$

So, from Eq. 3.39, the length of the curve is

$$L = \frac{\pi}{180} R\Delta$$

$$L = \frac{3.1416}{180} 2000(22.62) = 789.58 \text{ ft}$$

Given that the tangent length is 400 ft,

stationing PC = 103 + 00 minus 4 + 00 = 99 + 00

Since horizontal curve stationing is measured along the alignment of the road,

stationing PT = stationing $PC + L$

= 99 + 00 plus 7 + 89.58 = $\underline{\underline{106 + 89.58}}$

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The point-mass formula is used to define vehicular operation around a curve. Where the curve is expressed using its radius, the basic equation for a simple curve is:

$$R = \frac{V^2}{15(e + f)}$$

where:

R = radius of curve, ft

e = super elevation rate, decimal
f = side-friction factor, decimal
V = vehicular speed, mph

$$R = \frac{V^2}{127(e+f)}$$

Metric

where:

R = radius of curve, m
V = vehicular speed, km/hr

H.W.

A horizontal alignment with radius 100m, design speed 50 km/hr,coefficient of friction is 0.15

Find:

1)Superelevation.

2)If there is no superelevation find coefficient of friction.