Cairo University
Faculty of Engineering
Public Works Department

Highway and Traffic Engineering
PBW 401
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3. Horizontal Alignment

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Highway Location

– Highway Location involves the acquisition of data concerning the terrain upon which the road will traverse and the economical siting of an alignment

1. Reconnaissance Study of Existing Information
2. Preliminary Design
3. Detailed Design
4. Tender Documents and Specifications

1. Reconnaissance Study

- To identify several feasible routes, each within a band of a limited width of a few hundred feet
- Aerial photography (e.g. Google Earth) is widely used if information is scarce
- Factors considered in identifying feasible routes:
  - Terrain and soil conditions (level, rolling, mountainous)
  - Serviceability of route to industrial and population areas
  - Crossing with other transportation facilities (rivers, railroads, other highways)
  - Directness of route
- Establish control points if any

Flat Terrain

Rolling Terrain

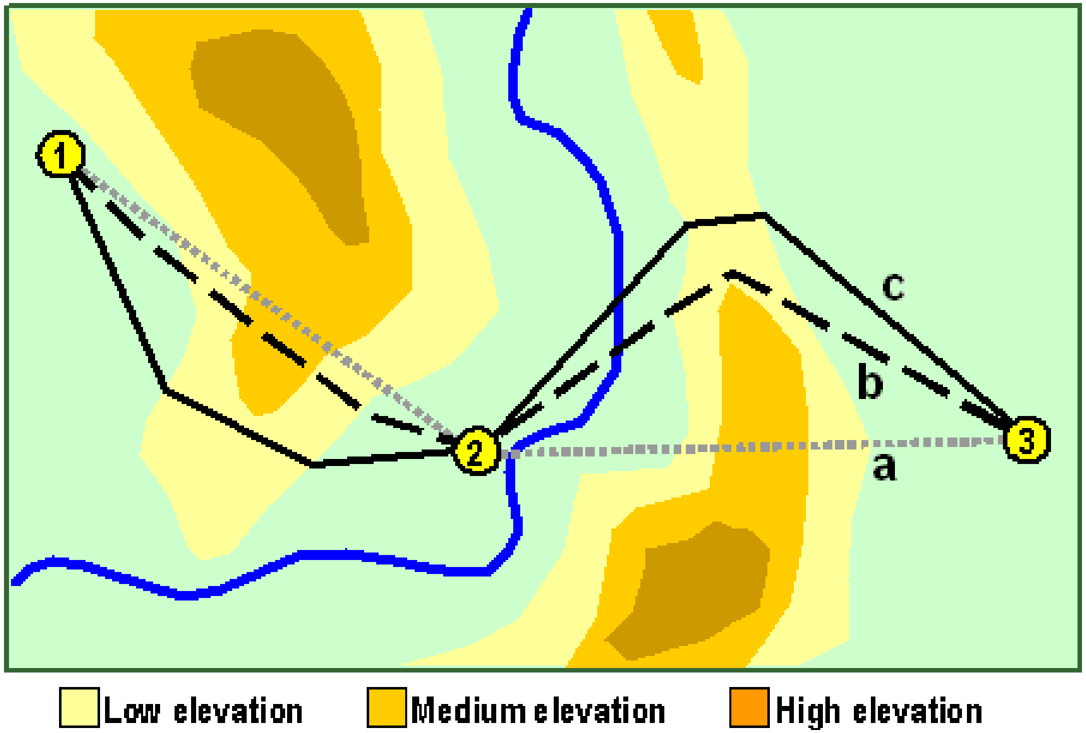
3. Mountainous Terrain

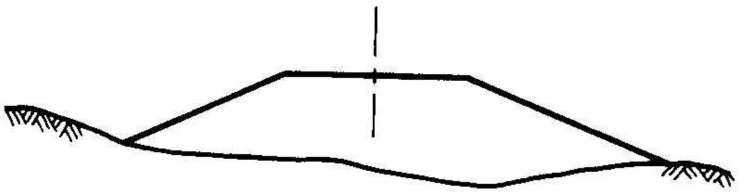
2. Preliminary Design:

- Positions of feasible routes are set as closely as possible
- Control points and preliminary horizontal and vertical alignments are established
- The feasibility of alternative routes is evaluated based on:
  –
  –
- The best alternative is selected as the preliminary alignment

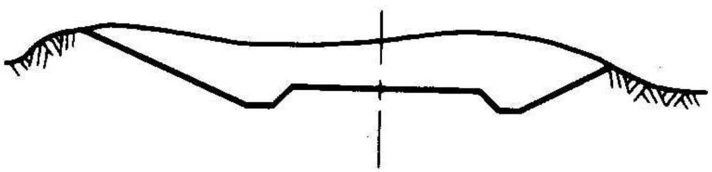
  – Check out this report:

http://www.infratrans.gov.ab.ca/INFTRA_Content/docType182/Production/RteEvalua.pdf

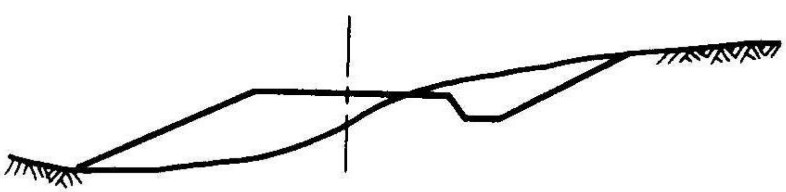

1
2
3
c
b
a
Low elevation
Medium elevation
High elevation



(a) Fill



(b) Cut



(c) Fill and cut

4. Detailed Design:

- Involves detailed layout of the selected route
- Final horizontal and vertical alignments
- Establishes final positions of structures and drainage channels
- Usually, a trial-and-error process

4. Tender Documents:

- Tender drawings
- Bill of quantities (BOQ)
- Specifications (Specs)
  - General Specs
  - Special Specs

Location of Highways in Urban Areas

- More complex situation than rural areas
- Additional factors to consider:
  - Connection to local streets
  - Right-of-way acquisition
  - Coordination of the highway system with other transportation systems
  - Adequate provision for pedestrians and other road users

Horizontal Alignment

- Horizontal alignment consists of straight section (tangents) connected by horizontal curves

Horizontal Alignment

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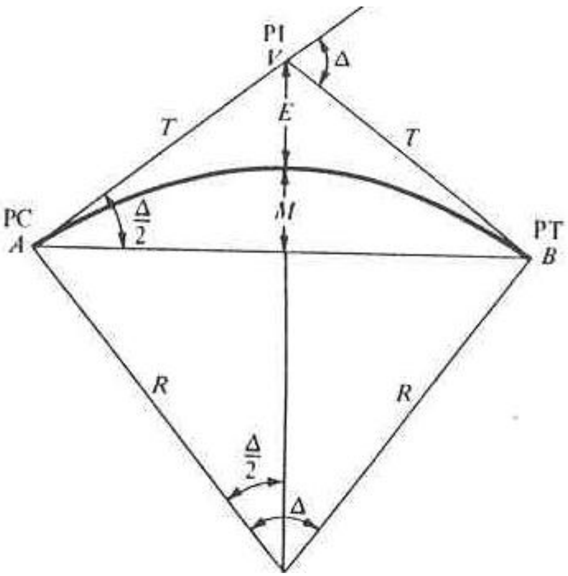
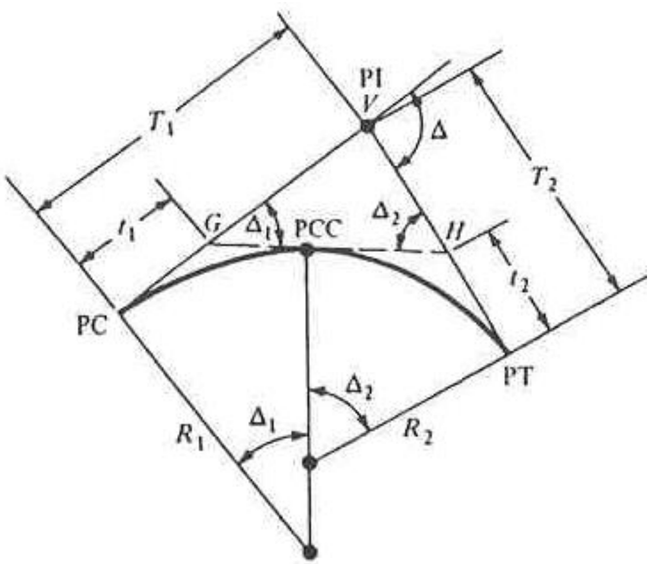
– Types of Curves:

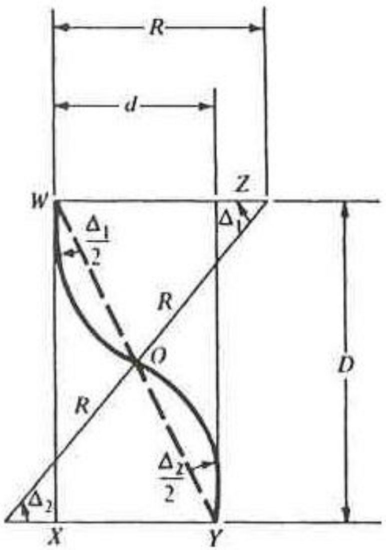
(1) Simple horizontal curve



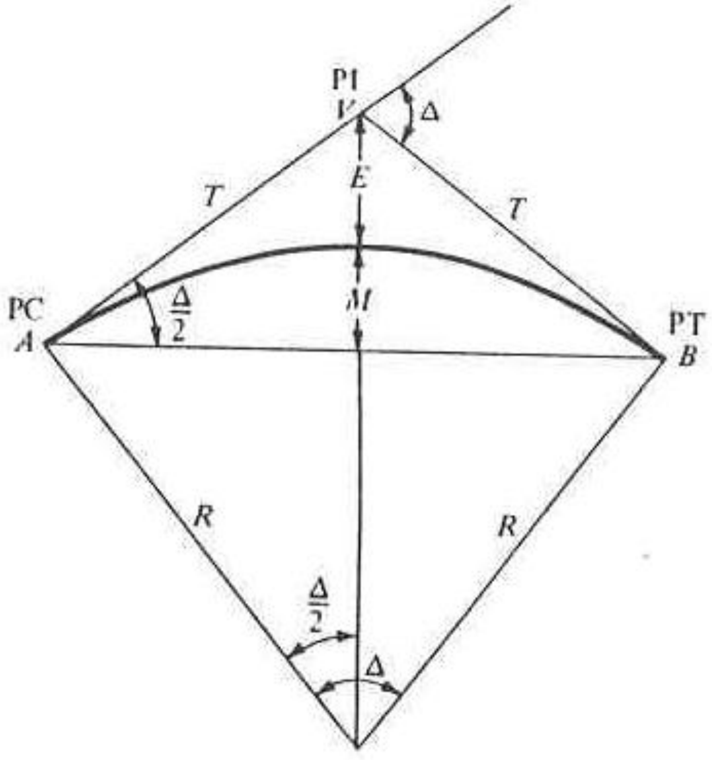
(2) Compound curve



(3) Reverse curve



Horizontal Curve Elements



R = radius of circular curve
T = tangent length
Δ = deflection angle
M = middle ordinate

PC = point of curve
PT = point of tangent
PI = point of intersection
E = external distance

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

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

$$C = 2R\,sin\,\frac{\Delta}{2}$$

$$E = R\,sec\,\frac{\Delta}{2} - R = R\left[\frac{1}{cos\,\frac{\Delta}{2}} - 1\right]$$

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

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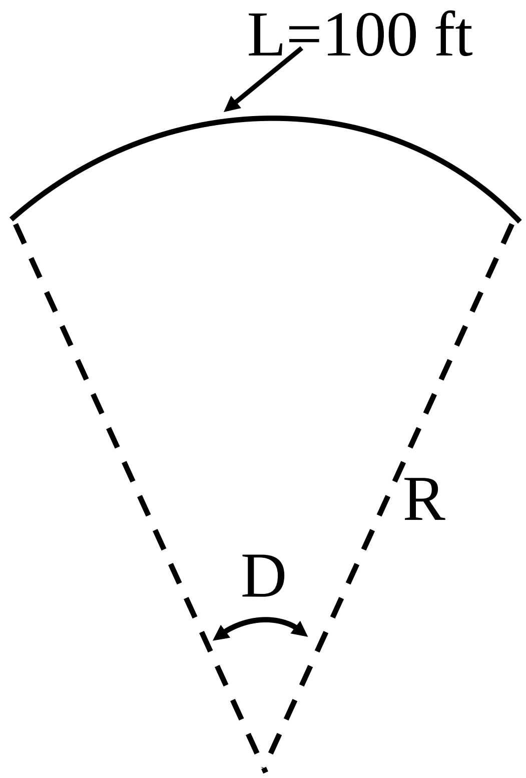


D (degree of curvature) = Central angle subtended by 100ft arc length (30.5 m)

$$L = RD\frac{\pi}{180}$$

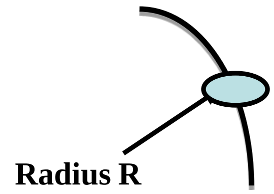
$$100 = RD\frac{\pi}{180}$$

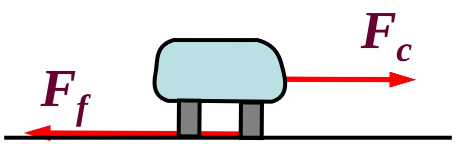
$$D = \frac{30.48}{R}\frac{180}{\pi}$$

$$D = \frac{1750}{R}$$

Minimum Curvature of a Horizontal Curve

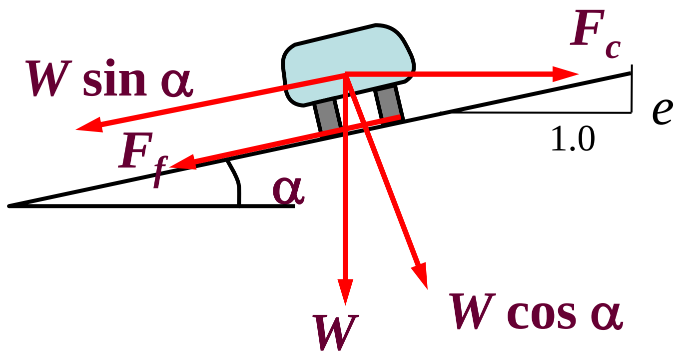
– On horizontal curves, two main forces act on the vehicle:





– Centrifugal forces can cause:

– A third (inward) force can be developed by raising the outside edge of the road (superelevation)



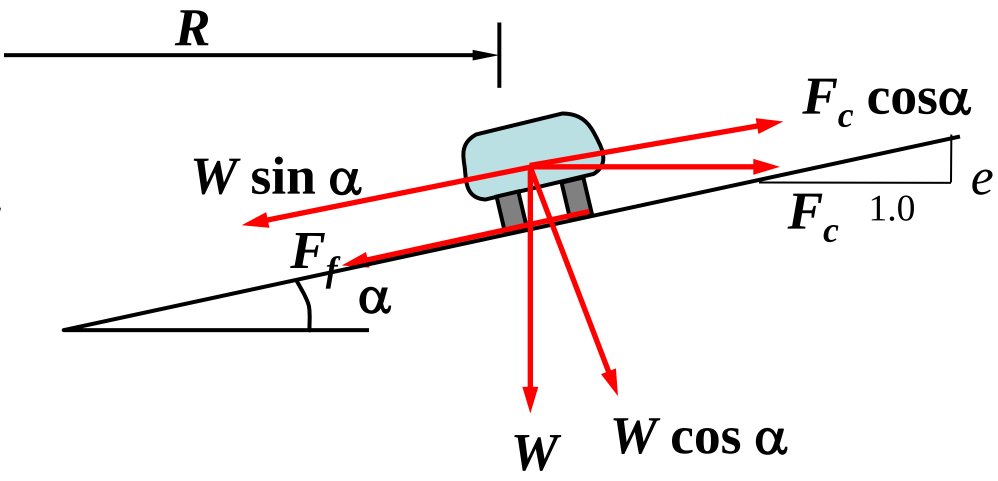
Superelevation rate: $e = \tan \alpha$

Minimum Curvature of a Horizontal Curve

– Minimum horizontal curve radius should provide enough resistance to sliding

$$F_c = \frac{W\,v^2}{g\,R}, \quad F_f = fW\cos\alpha$$

From the balance of forces:



$$\frac{W\,v^2}{g\,R}\cos\alpha = W\sin\alpha + f\,W\cos\alpha$$

$$\frac{v^2}{g\,R} = \tan\alpha + f$$

$\tan\alpha \cong \alpha = e$ (superelevation rate)

$$\therefore R = \frac{v^2}{g\,(f+e)}$$

Or:

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

Where:

V = speed (km/h)

f_s = coefficient of side friction = 0.10 – 0.16

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

Table 4.5: Maximum safe side friction factors (f_s)

Design Speed, kph	40	50	60	70	80	90	100	110	120
Side Friction Factor	0.17	0.16	0.15	0.15	0.14	0.13	0.13	0.12	0.12

Example

- An existing horizontal curve on a highway has a radius of 80 m which restricts the maximum speed on this section to only 60% of the design speed of the highway. If the curve is to be improved so that the maximum speed will be as that of the design speed of the highway, determine the minimum radius of the new curve. Assume the coefficient of side friction is 0.15 and the rate of superelevation is 0.08 for both the existing curve and the new curve to be designed.

Degree of Curve

– The central angle corresponding to a 100-ft (30.48 m) arc

$l = R\,D$

$$30.48 = R \times D^{\circ} \times \frac{\pi}{180}$$

$$\therefore\ D = \frac{1746.4}{R} \qquad (D \rightarrow \text{degrees},\ R \rightarrow \text{m})$$

$$\text{or } D = \frac{5729.7}{R} \qquad (D \rightarrow \text{degrees},\ R \rightarrow \text{ft})$$

l = 100 ft (30.48 m)