Cairo University
Faculty of Engineering
Public Works Department

Highway and Traffic Engineering
PBW 401
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4. Horizontal Alignment : Superelevation

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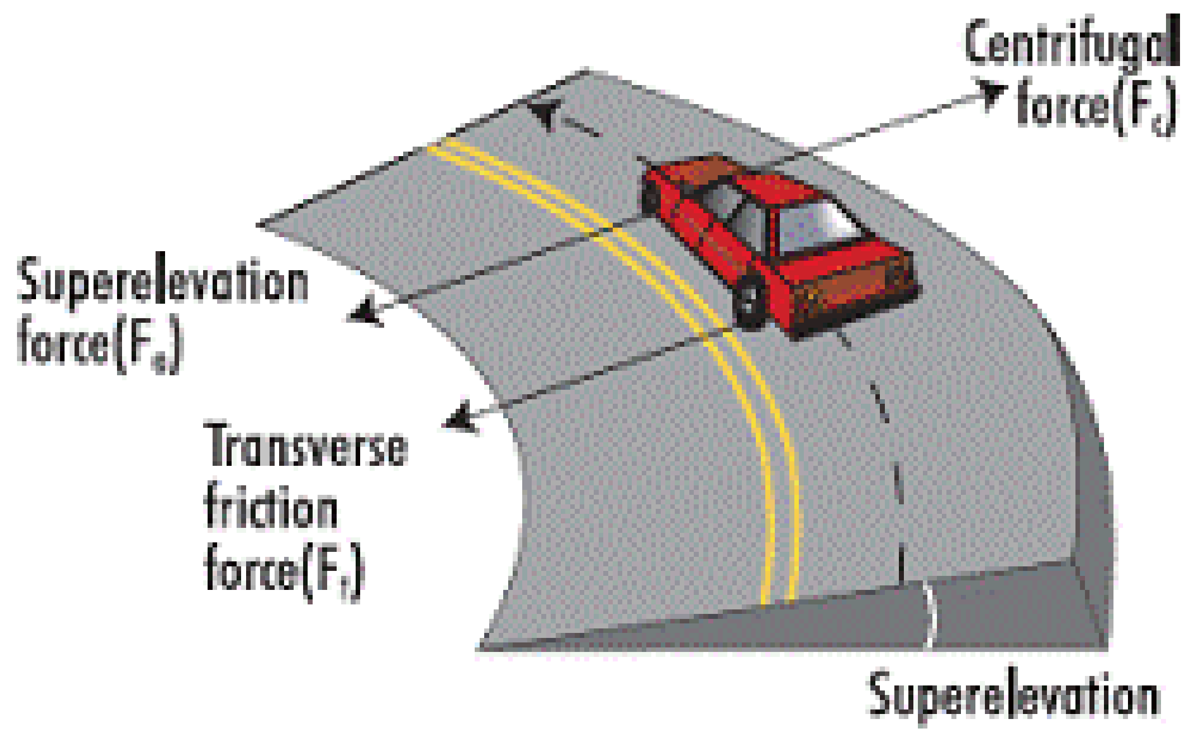
Horizontal Alignment

– Minimum radius of a circular horizontal curve is governed by:

1.



PIARC 2003

Table 4.5: Maximum safe side friction factors (f_s)

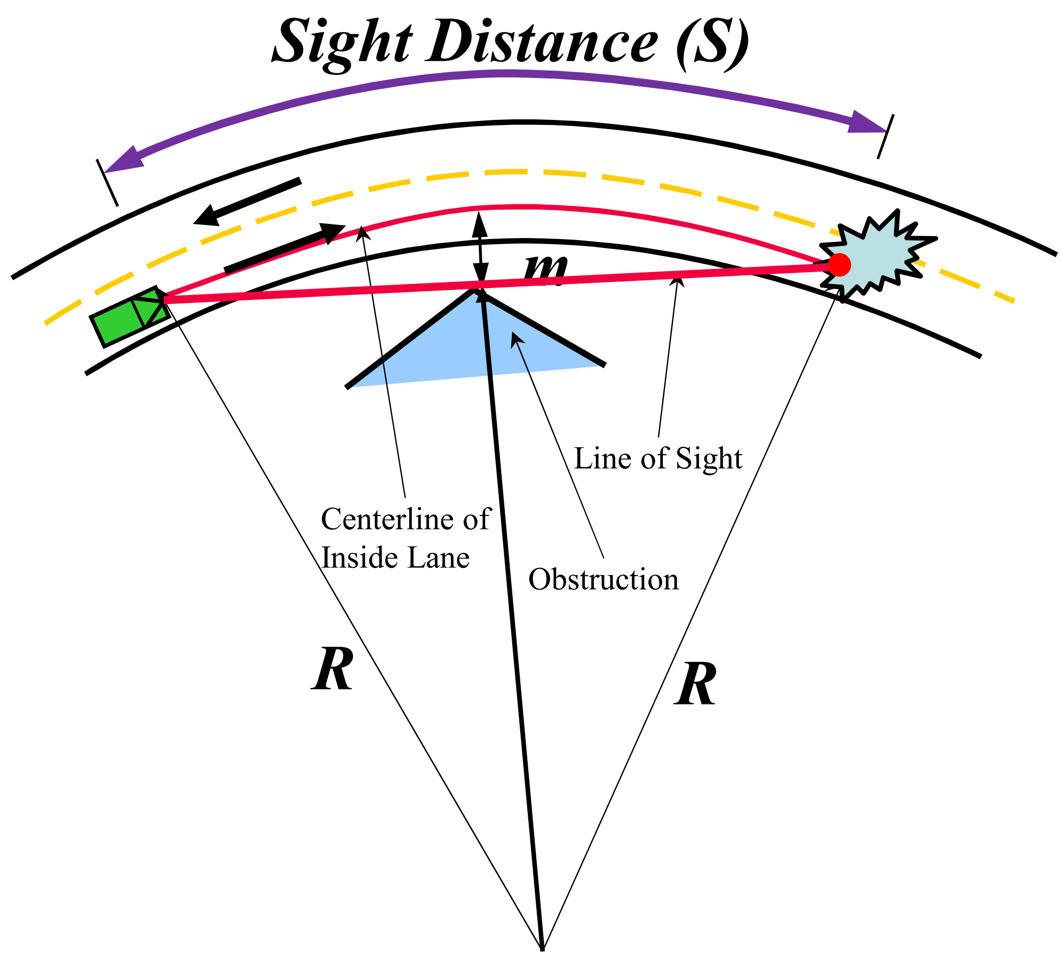
Design Speed, kph	40	50	60	70	80	90	100	110	120
Side Friction Factor	0.17	0.16	0.15	0.15	0.14	0.13	0.13	0.12	0.12

Max Superelevation (e)

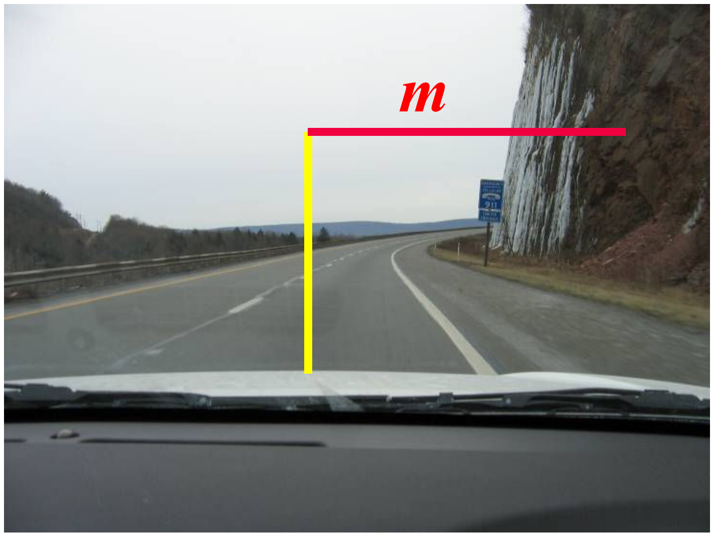
- Controlled by 4 factors:
  1. Weather conditions in area (amount of ice and snow)
  2. Type of terrain (flat, rolling, mountainous)
  3. Highway Location (rural or urban)
  4. Frequency of slow moving vehicles (may be affected by higher superelevation rates
  - Highest in common use = 10%, 12% with no ice and snow
  - 8% is logical maximum to minimize slipping by stopped vehicles, considering snow and ice
  - For consistency a single rate within a project or on a highway is used

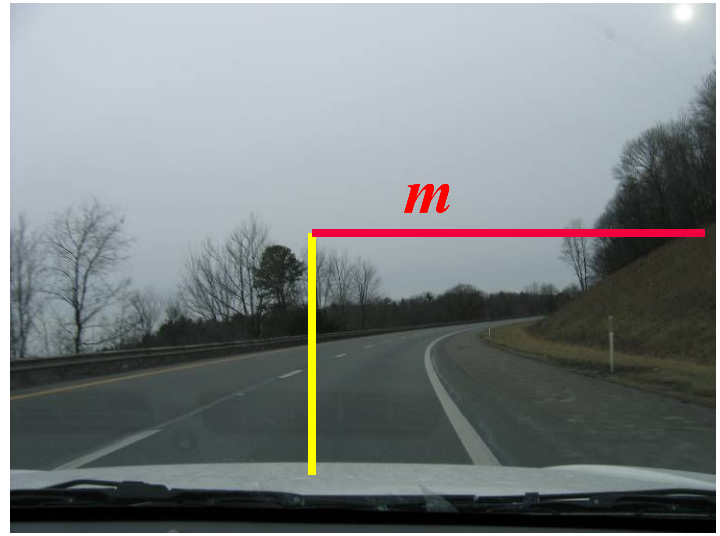
Horizontal Alignment

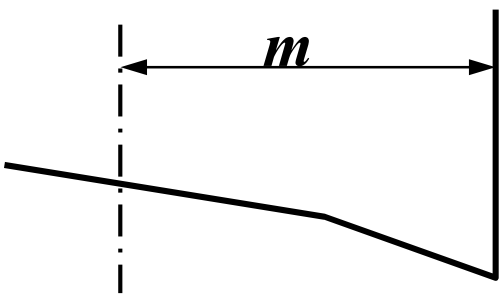
– Minimum radius of a circular horizontal curve is governed by:



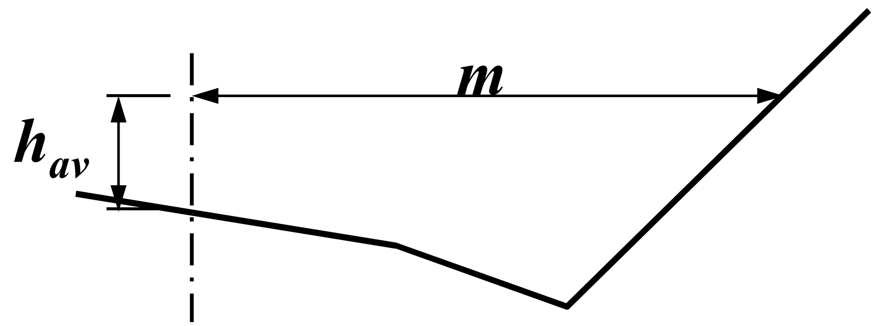
– Note: Object can have a constant height (m = constant) or a variable height







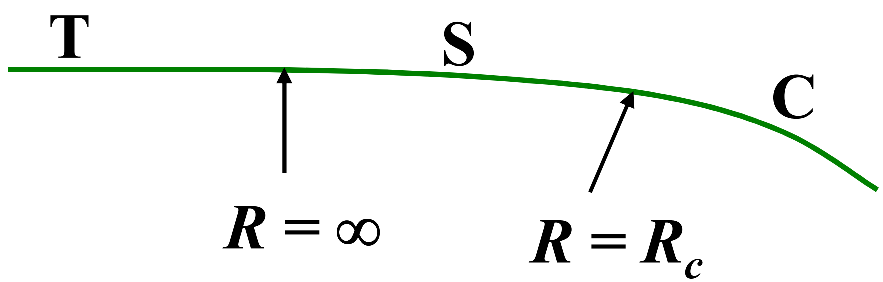
CL of inside lane

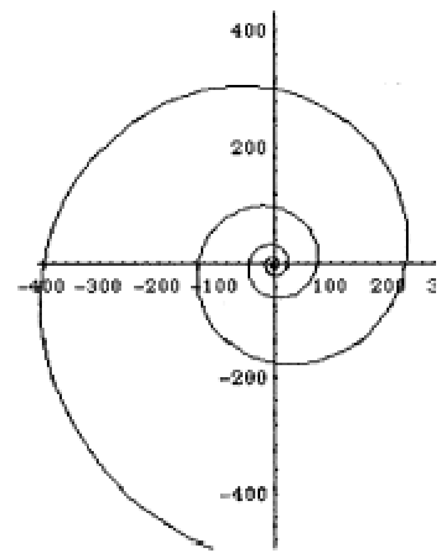


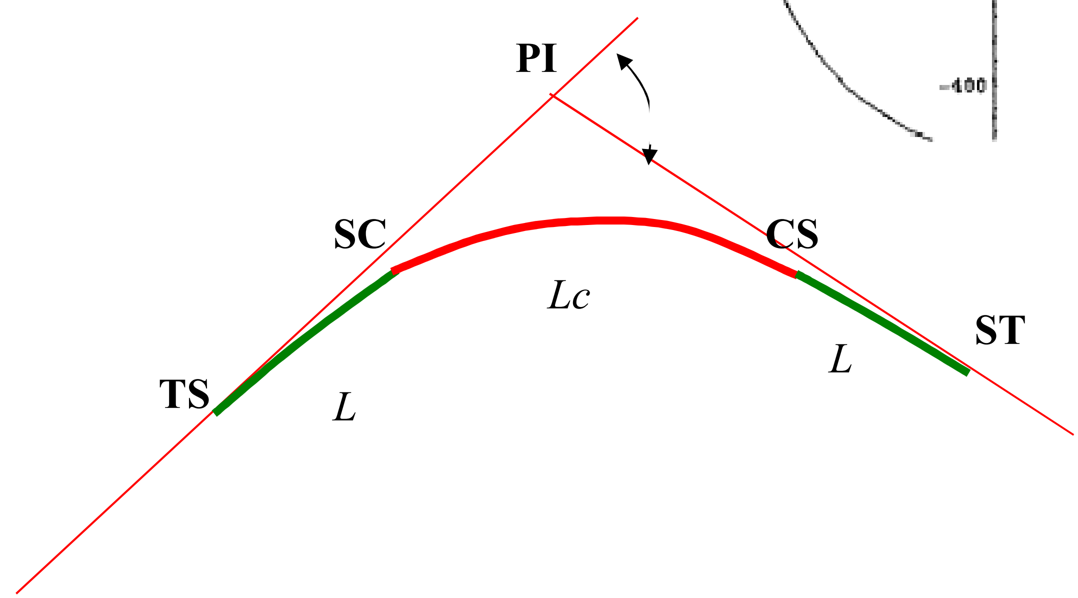
CL of inside lane

Spiral (transition) curves

– Spiral (transition) curves are curves with changing radii, and are placed between tangents and circular curves or between two successive circular curves







Spiral Curve

Advantages

1. Provides a vehicle path that gradually increases or decreases the radial force as the vehicle enters or leaves a curve. (lateral force increases and decreases gradually)
2. Provides location for superelevation runoff (not part on tangent/curve)
3. Aesthetic

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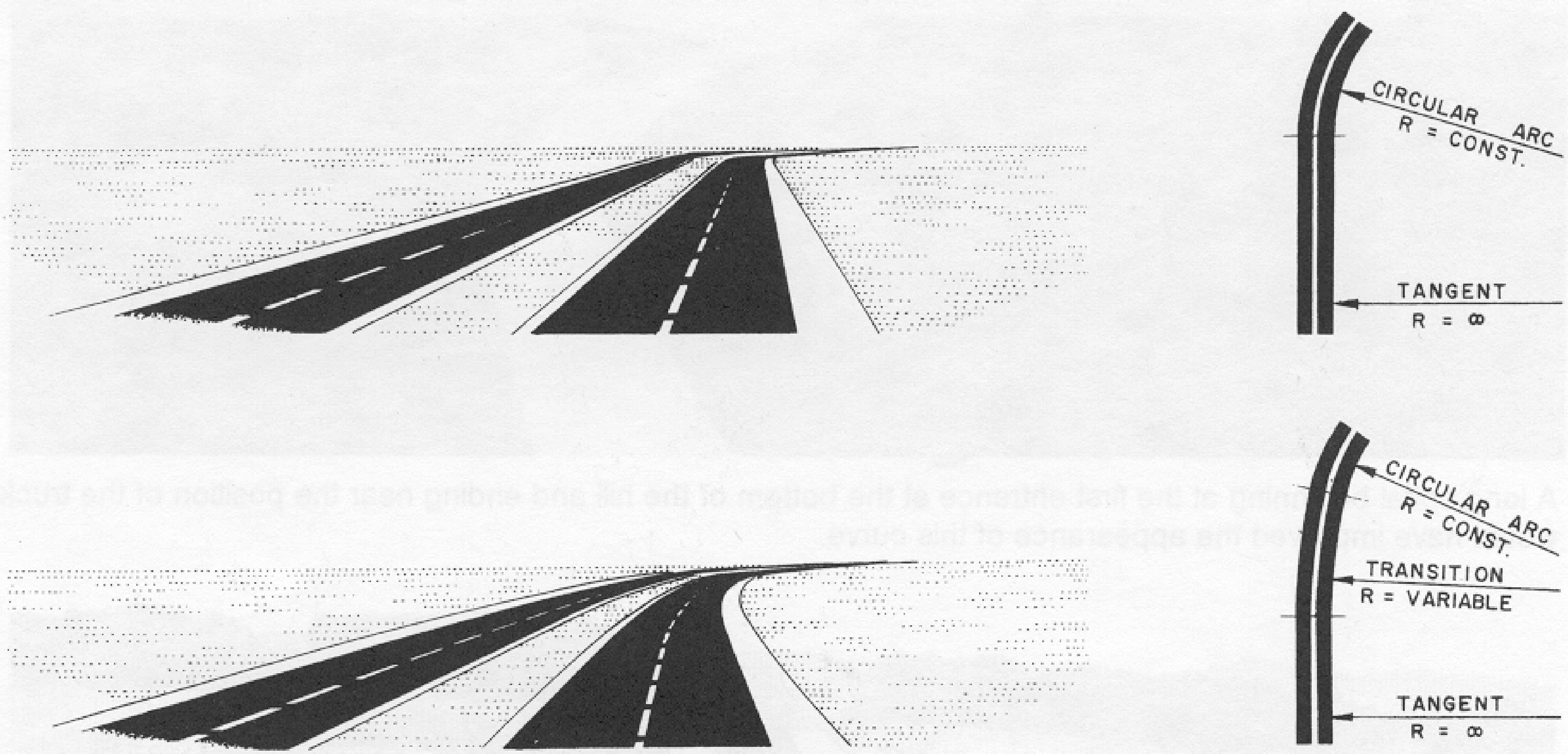
Spiral (transition) curves

– Common form for spiral curves:

$R \propto \frac{1}{ls}$, or

$R\,l_s = A^2$ (A = spiral parameter)

Figure 2.1.4.6 Examples of Good and Poor Alignment Coordination and Aesthetics[1]



One effect of perspective viewing is that distant objects seem nearer than they really are. The circular curve consequently appears to diverge from the tangent rather rapidly and the curve no longer seems continuous. This gives the impression the designer was unable to make the curve meet the tangent properly. To remedy this situation, the use of long spirals is suggested and is illustrated in the upper picture.

TAC (1999)

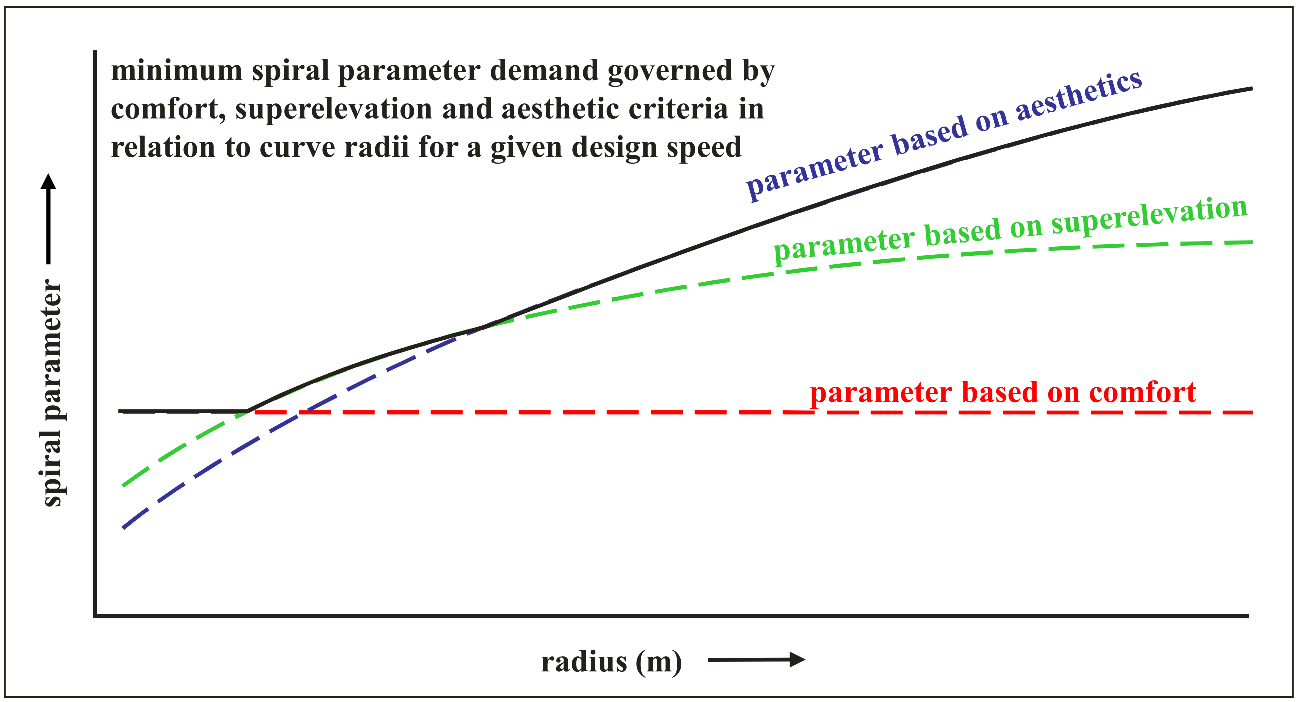
Spiral Length

1. Limit rate of change of centripetal acceleration (maximum = 1 to 3 ft/sec^2/sec)

   – (V = km/h, R = m, C = 0.6)

2. Provide enough length of superelevation runoff

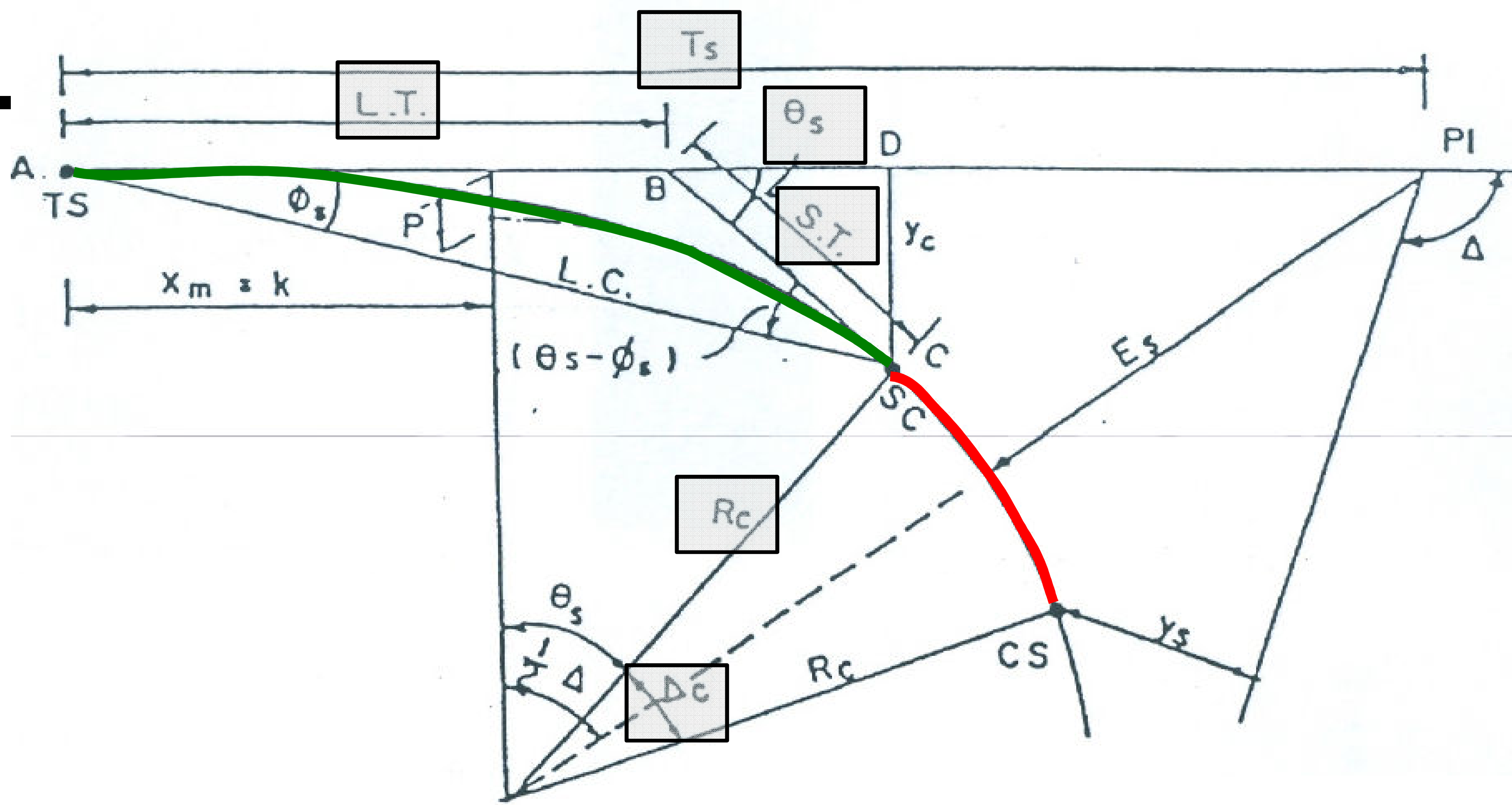
3. Add to the highway aesthetics



- For all these criteria: get A from the design tables
- Then: $ls = A^2/R$

Table 4.6: Minimum spiral parameters

Design Speed, kph	40	60	80	100	120	140
Min. Parameter (A_{min}), m	50	100	150	200	350	500



$$\theta_s = \frac{L_s}{2R_c} \qquad p = \frac{L_s^2}{24R_c}$$

$$\Delta = \Delta_c + \theta_{s1} + \theta_{s2} = \Delta_c + 2\theta_s \quad \text{for equal spirals}$$

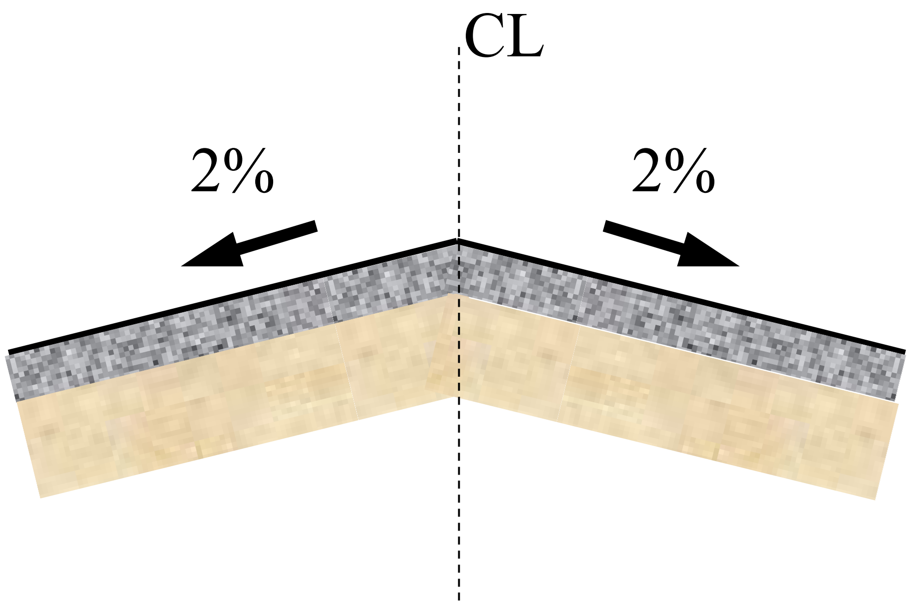
Development of Superelevation

- Highway cross section on straight segments is “normal crown”
- On curved segments, it is “superelevated”
- To change a normal crown section into a superelevated section, a superelevation runoff length is required
- Superelevation runoff length equals the length of the spiral curve
- If no spiral curve is used, superelevation runoff length is distributed as 67% on tangent and 33% on curve
- Superelevation can be attained by revolving section about:
  -
  -
  -

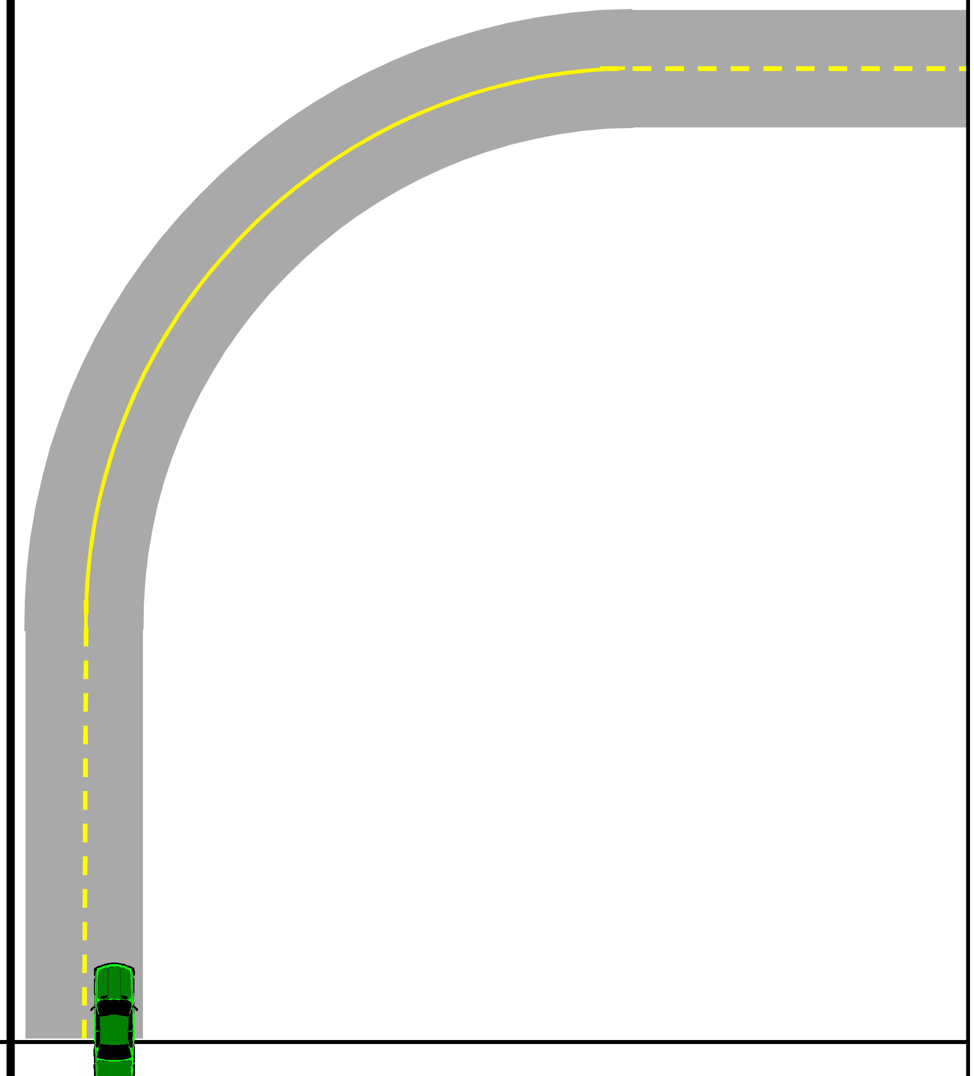
Superelevation

Superelevation

Road Section View

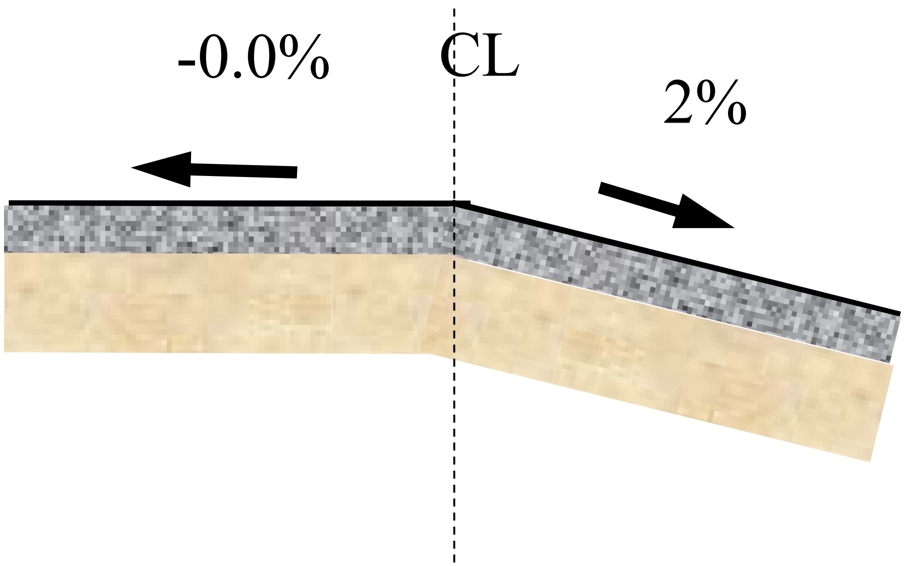


Road Plan View

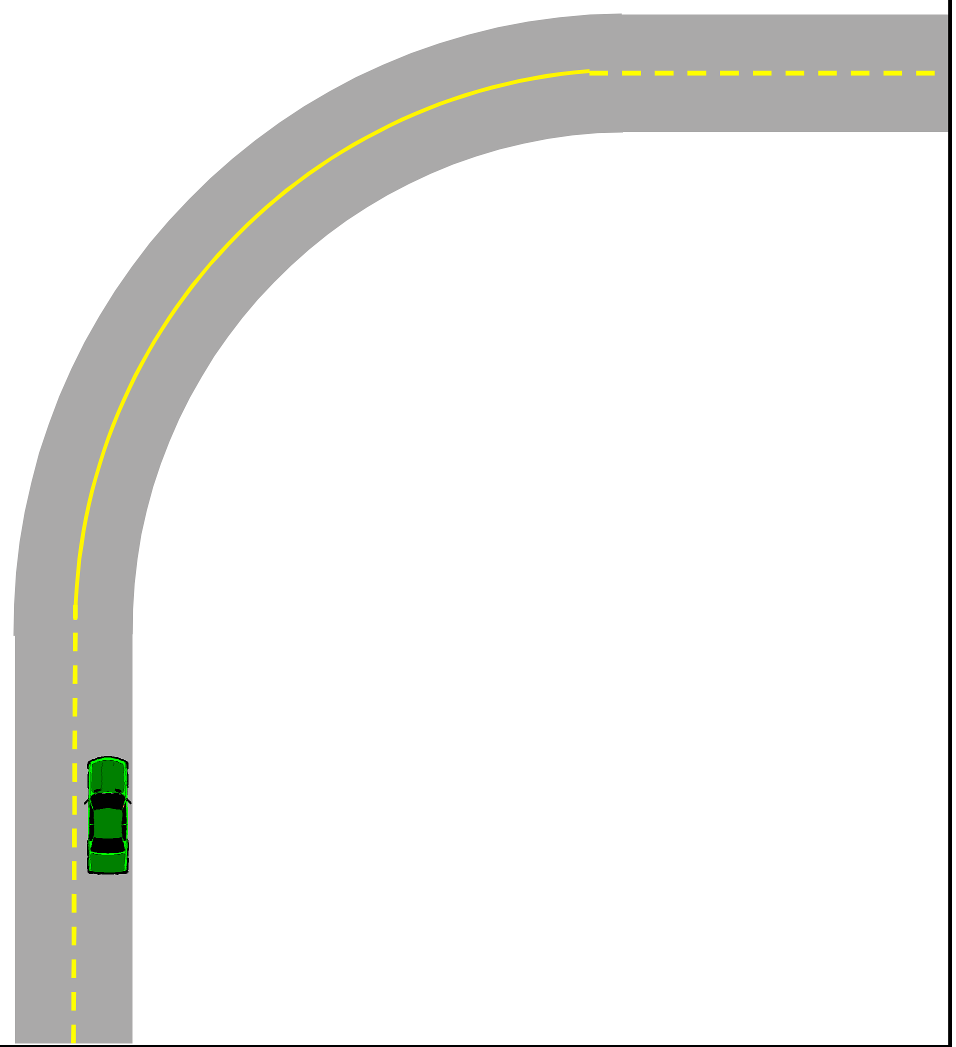


Superelevation

Road Section View

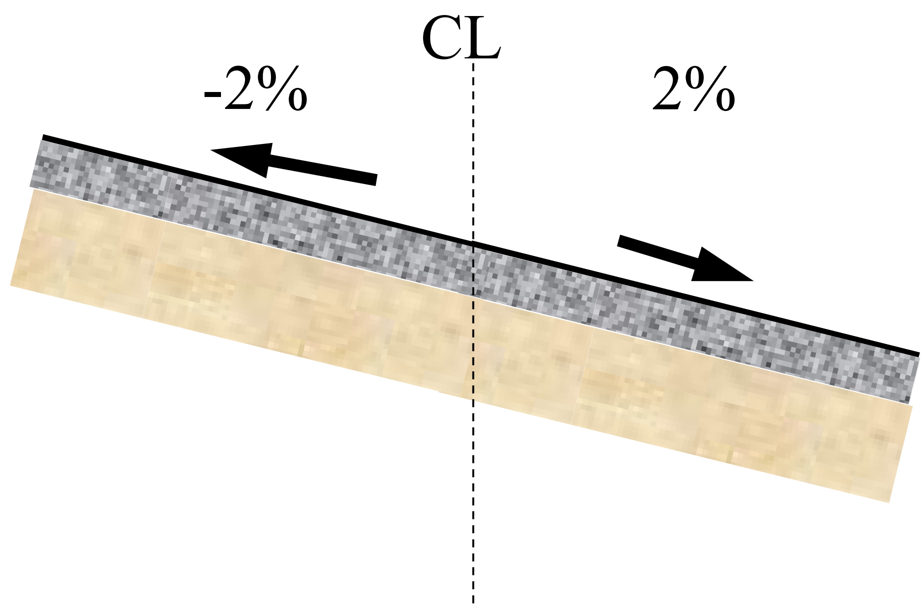


Road Plan View

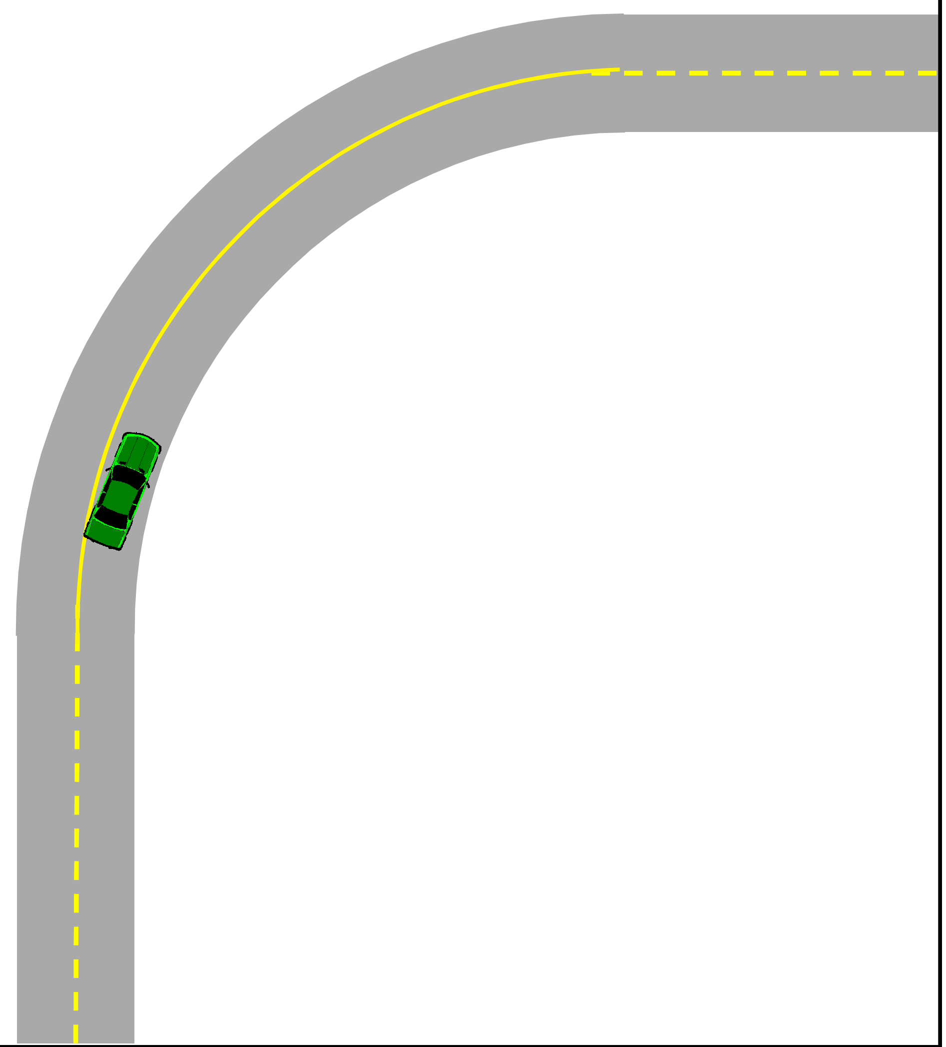


Superelevation

Road Section View

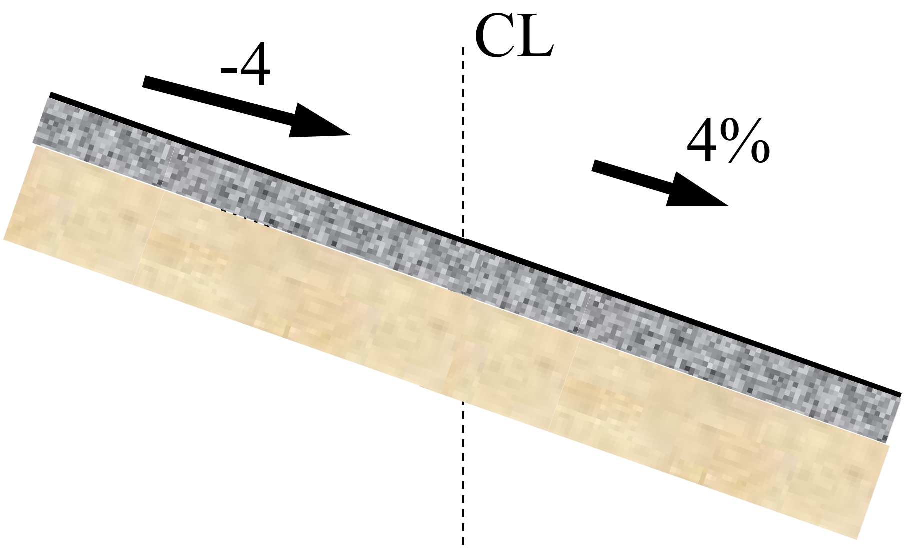


Road Plan View

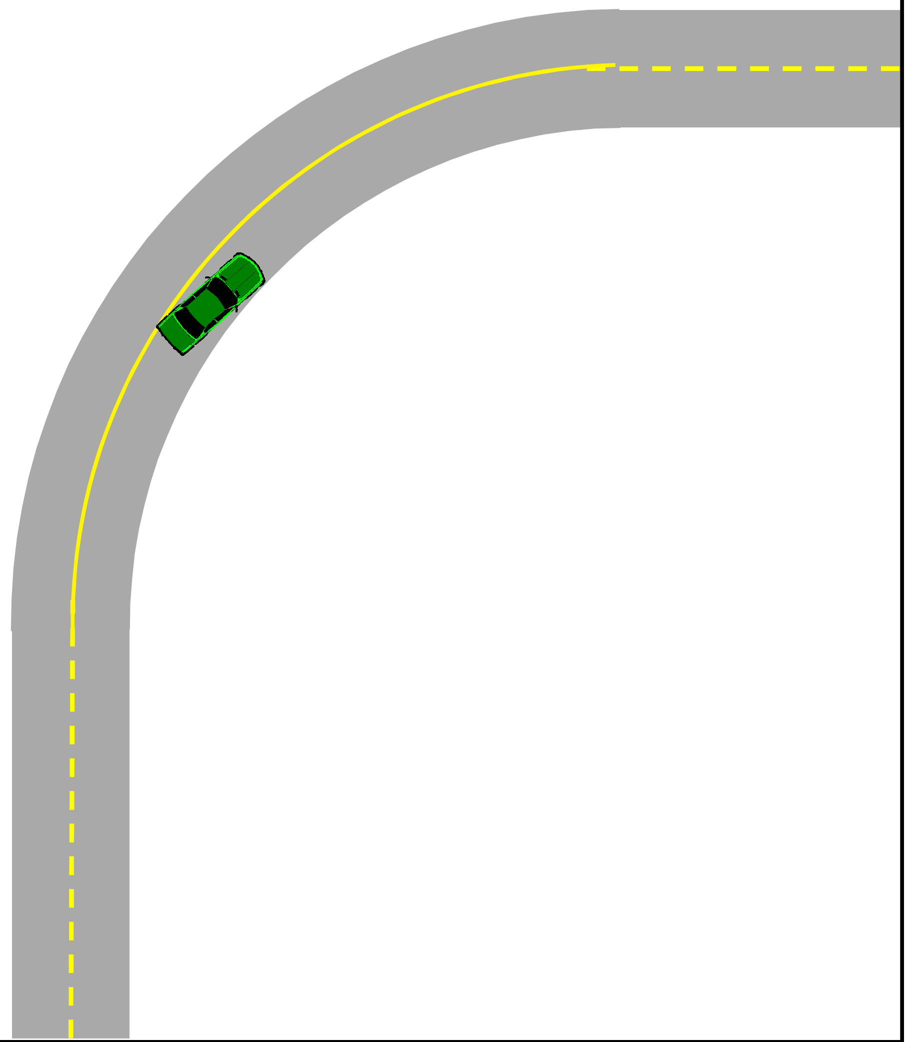


Super elevation

Road Section View

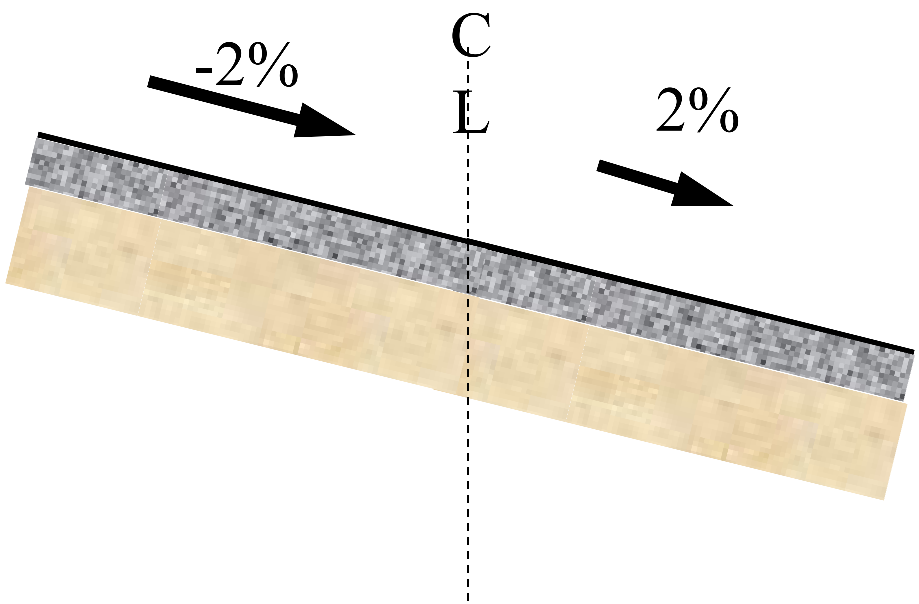


Road Plan View

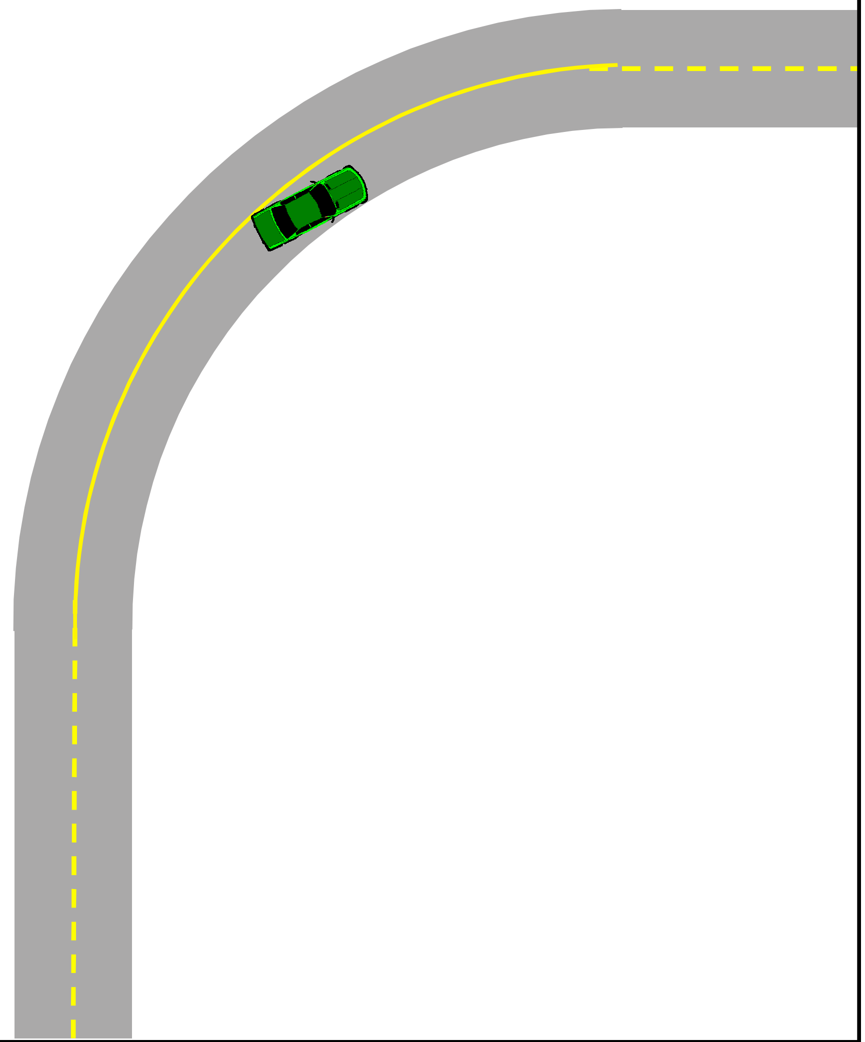


Superelevation

Road Section View

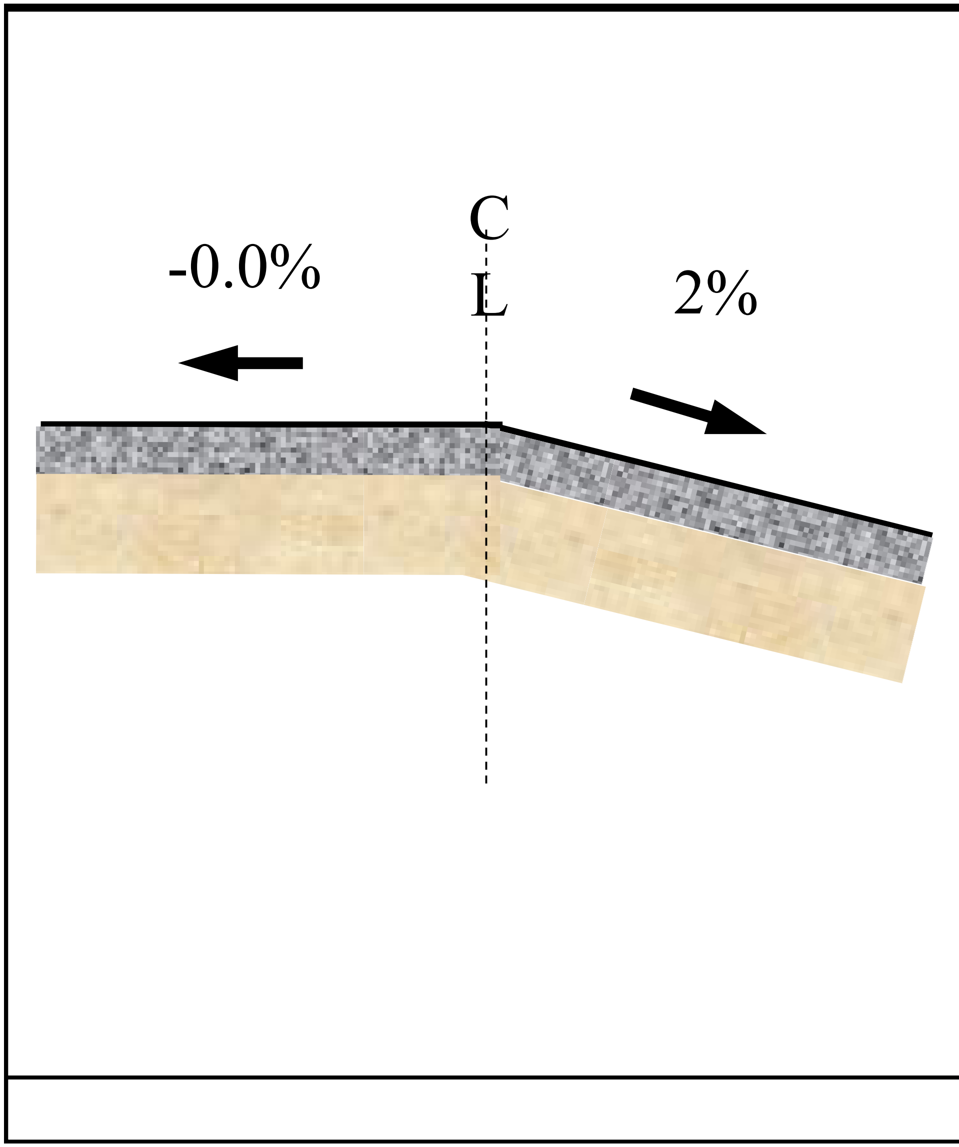


Road Plan View

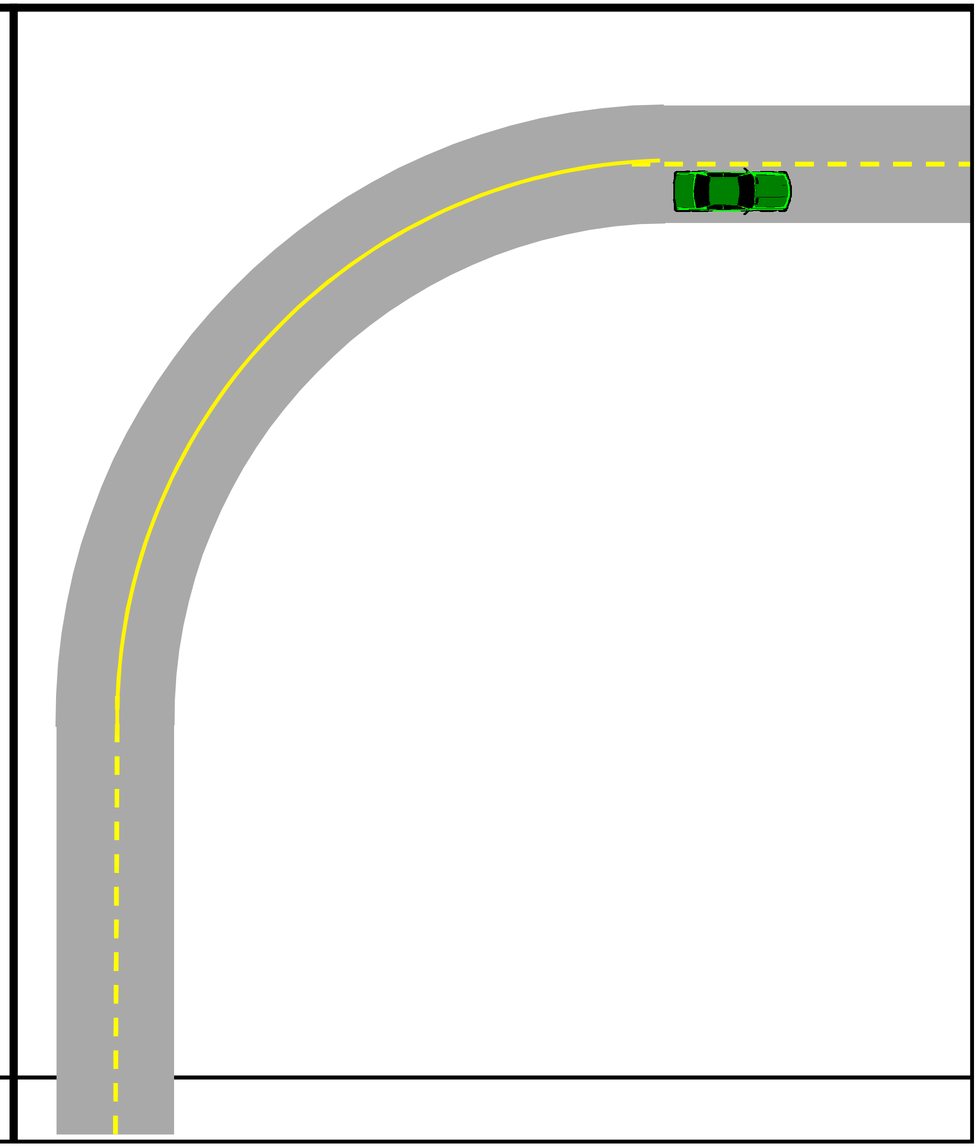


Superelevation

Road Section View

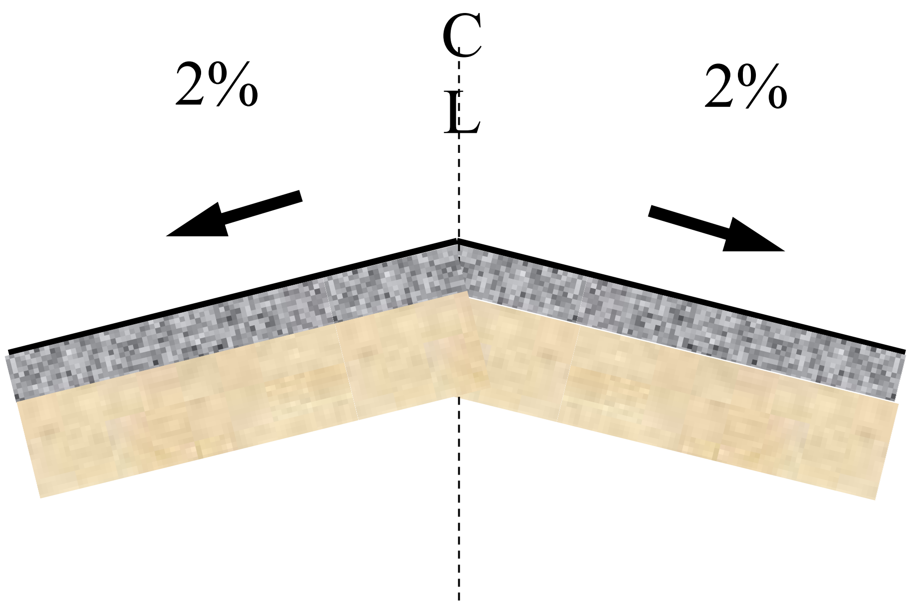


Road Plan View

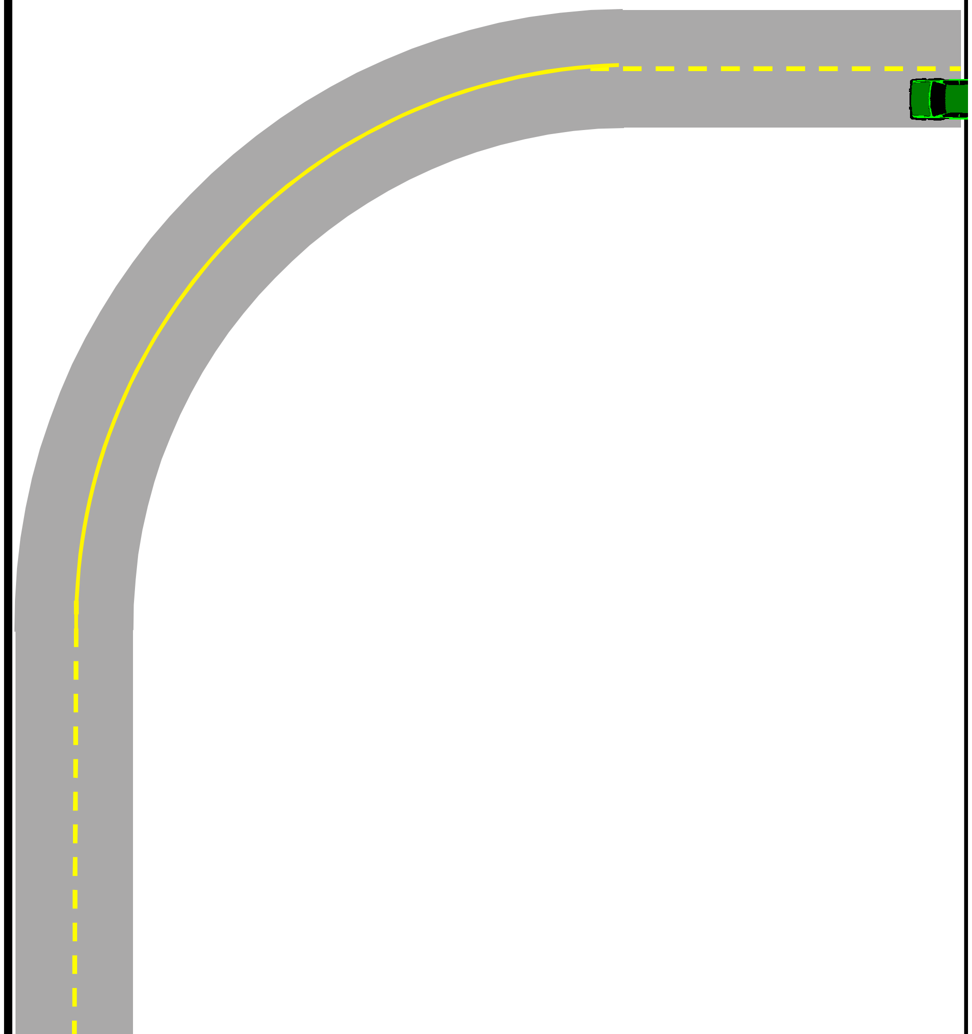


Superelevation

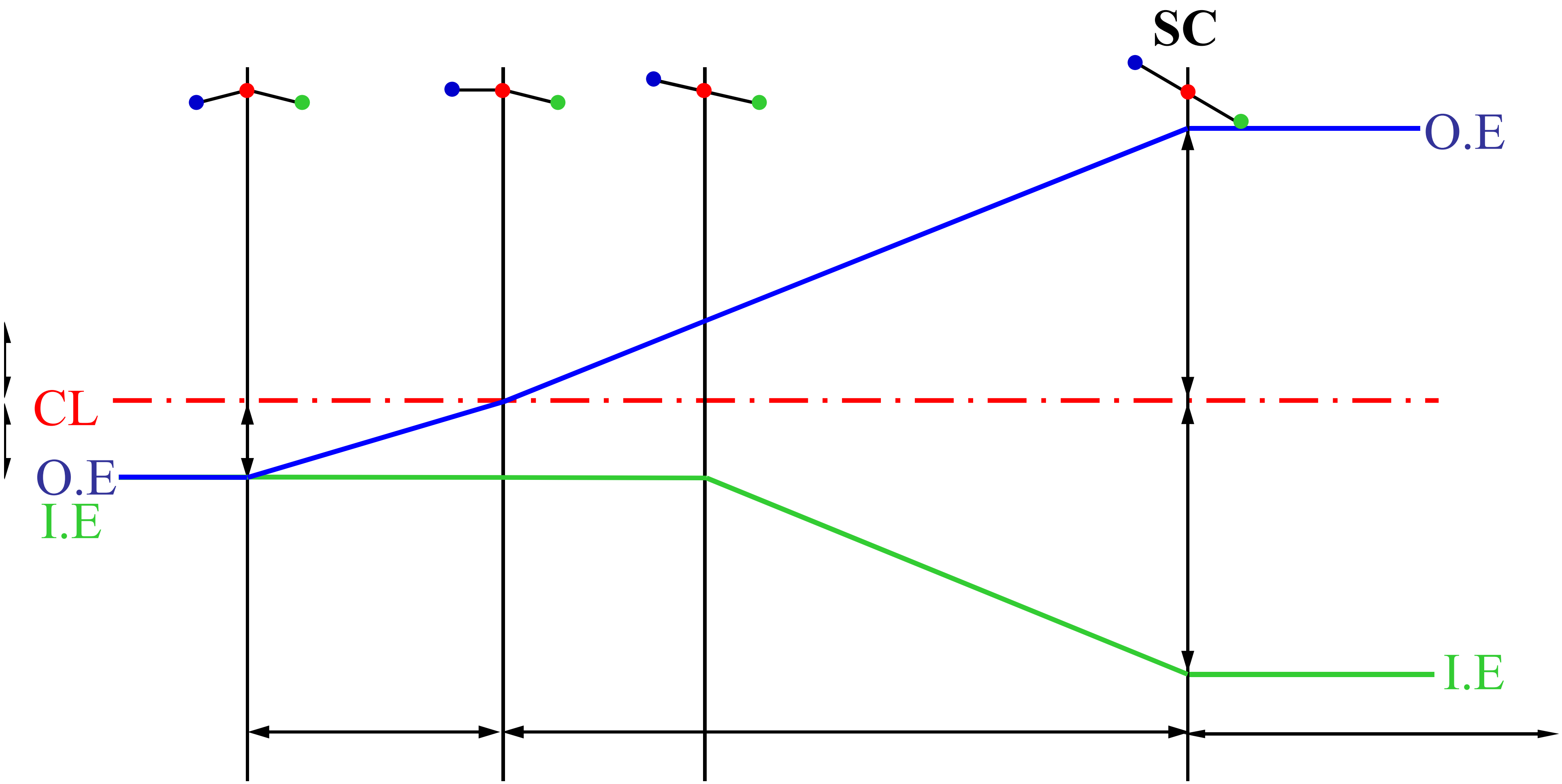
Road Section View



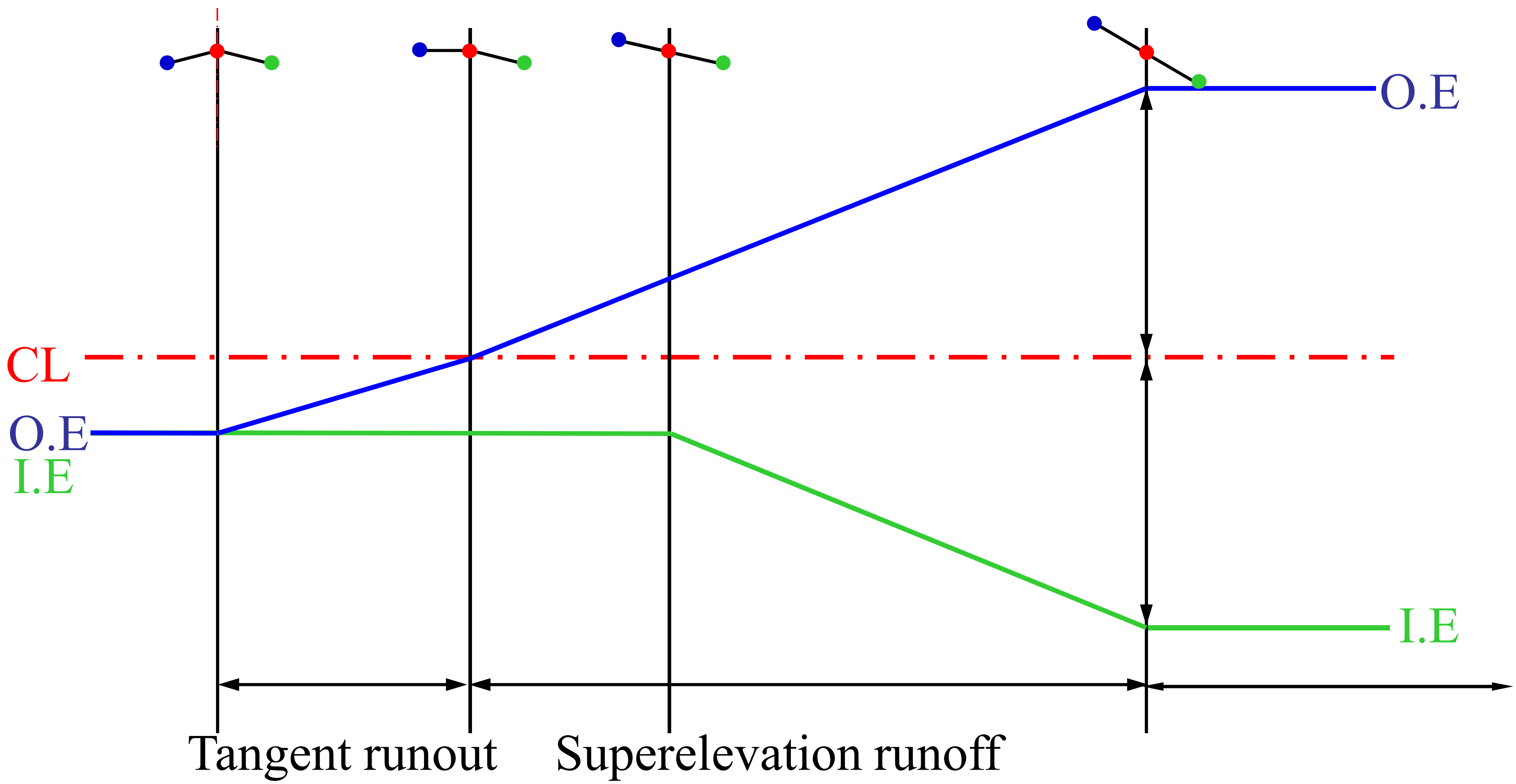
Road Plan View



Rotation about centerline



Rotation about centerline



Maximum Values of Δ_s of relative pavement profile

Table 4.7: Relationship of design speed to maximum relative profile gradients

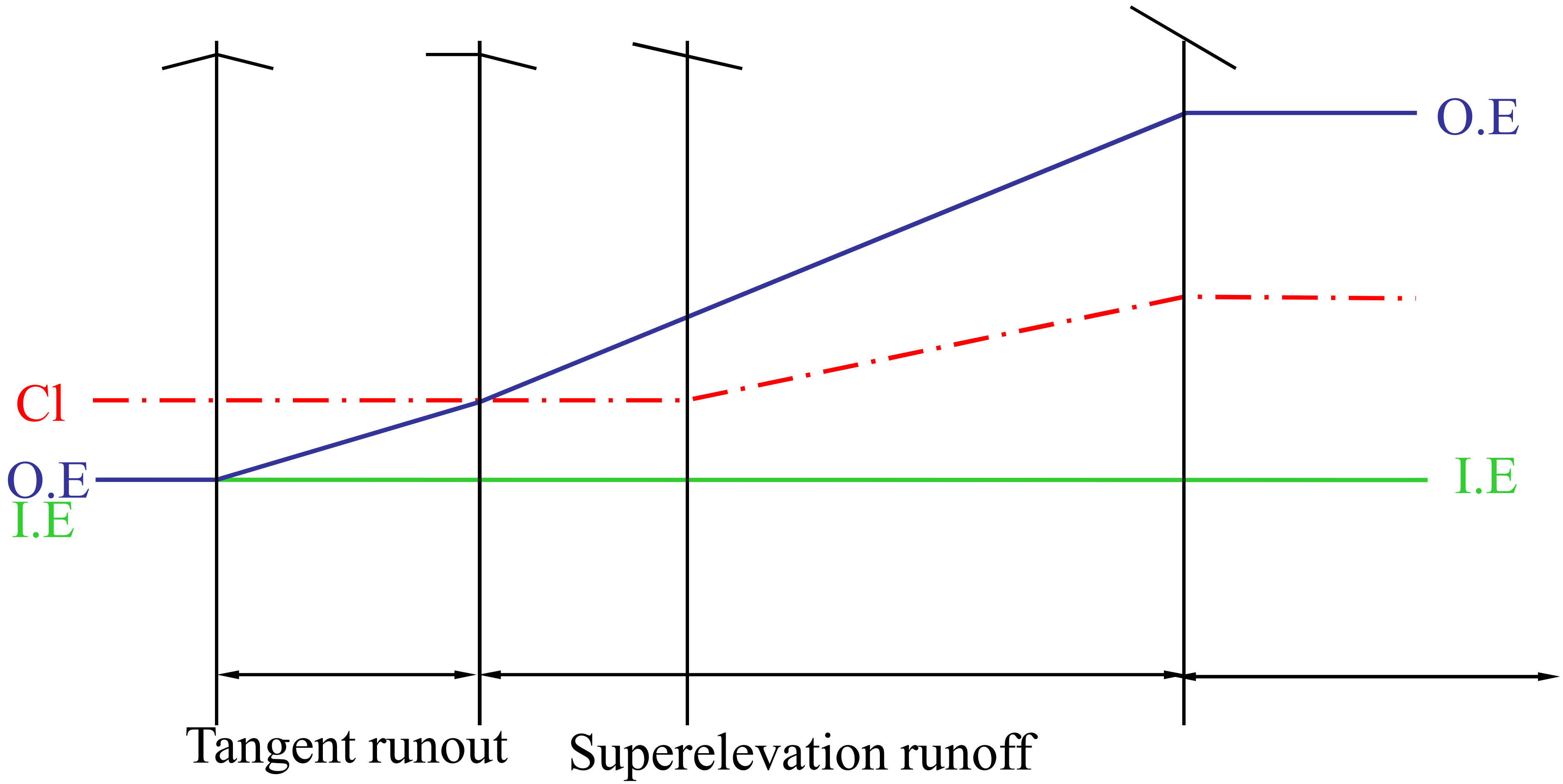
Design Speed, kph	Max. relative gradients* for profiles between the edge of 2-lane pavement and the centerline, %
30	0.75
50	0.67
65	0.58
80	0.50
100	0.45
105	0.41
115	0.40

*The maximum relative gradients between profiles of the edges of 2-lane pavements are double those given in the above table.

Tangent Runout: Length of roadway needed to accomplish a change in outside-lane cross slope from normal cross slope rate to zero

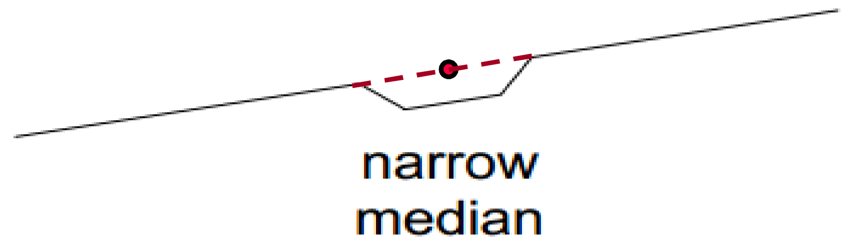
Superelevation runoff: Length of roadway needed to accomplish a change in outside-lane cross slope from 0 to full superelevation or vice versa

Rotation about inside edge

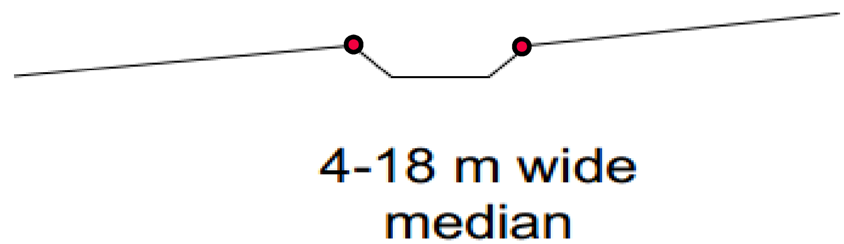


Axis of Rotation for Roads with Median

Case I: whole travelled way is superelevated



Case II: two travelled ways are rotated separately around median edge



Case III: Two travelled ways are treated separately