Compound Horizontal Curve Design

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Simple horizontal curves, such as those discussed in Section 2A-1, are preferred for their ease of computation and staking. However, situations often arise when a compound horizontal curve better suits a given design situation. Ramps and loops are two examples. Turning movements for many design vehicles are also best represented by compound horizontal curves.

Essentially, a compound curve consists of two curves that are joined at a point of tangency and are located on the same side of a common tangent. Though their radii are in the same direction, they are of different values.

The most commonly used compound horizontal curve designs are two-centered and three-centered. Figure 1 illustrates a two- and a three-centered compound curve. It is possible for a curve to have four or more centers; however, these are complicated to compute and stake. Three curves should be considered a practical limit for compound curves.

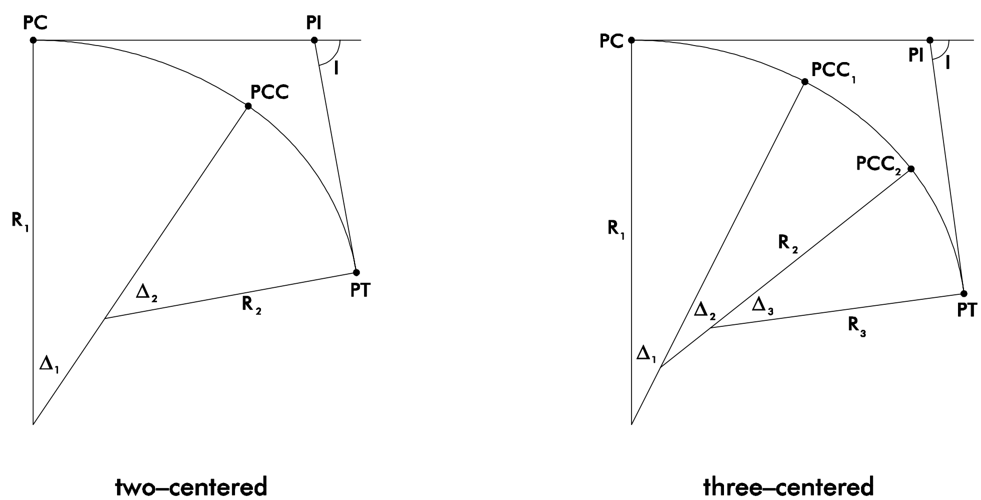

Figure 1: Two- and three-centered compound curves.

Definitions

PI = Point of Intersection of back tangent and forward tangent.

PC = Point of Curvature—point of change from back tangent to circular curve.

PT = Point of Tangency—point of change from circular curve to forward tangent.

PCC = Point of Compound Curvature.

T_L = Long Tangent of the compound curve.

T_S = Short Tangent of the compound curve.

I = Total intersection angle of the compound curve.

X = Distance from PC to PT in the direction of the backward tangent.

Y = Perpendicular distance from the backward tangent to the PT.

Formulas

Relationships between intersection angles and radii can be found using information in Section 2A-1 of this Manual.

Two-centered Compound Curves

Figure 2 provides a more detailed illustration of a two-centered curve.

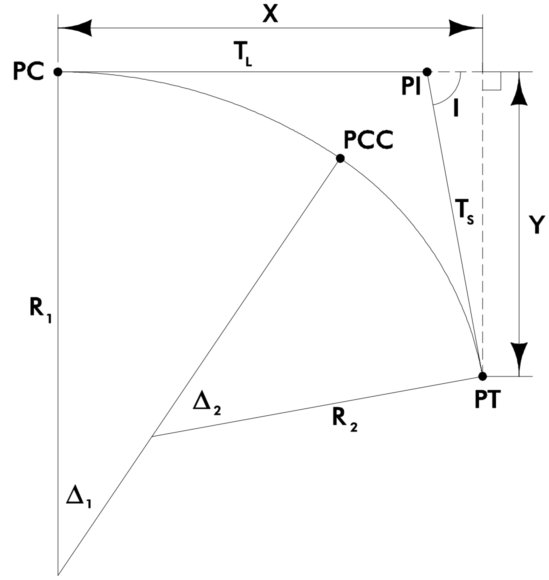

Figure 2: Components of a two-centered compound curve.

The following formulas correspond to Figure 2.

Δ_1 = Intersection angle of the flatter curve (decimal degrees).

Δ_2 = Intersection angle of the sharper curve (decimal degrees).

R_1 = Radius of the flatter curve.

R_2 = Radius of the sharper curve.

$I = \Delta_1 + \Delta_2$

$$X = R_2 \times \sin I + (R_1 - R_2) \times \sin \Delta_1$$

$$Y = R_1 - R_2 \times \cos I - (R_1 - R_2) \times \cos \Delta_1$$

$$T_L = \frac{R_2 - R_1 \times \cos I + (R_1 - R_2) \times \cos \Delta_2}{\sin I}$$

$$T_S = \frac{R_1 - R_2 \times \cos I - (R_1 - R_2) \times \cos \Delta_1}{\sin I}$$

$$\sin \Delta_1 = \frac{T_L + T_S \times \cos I - R_2 \times \sin I}{R_1 - R_2}$$

$$\sin \Delta_2 = \frac{R_1 \times \sin I - T_L \times \cos I - T_S}{R_1 - R_2}$$

Three-centered Compound Curves

Figure 3 provides a more detailed illustration of a three-centered curve.

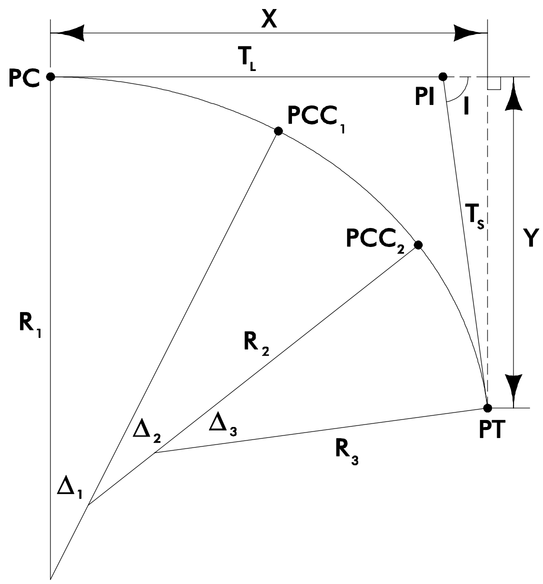

Figure 3: Components of a three-centered compound curve.

The following formulas correspond to Figure 3.

Δ_1 = Intersection angle of the flattest curve (decimal degrees).

Δ_2 = Intersection angle of the middle curve (decimal degrees).

Δ_3 = Intersection angle of the sharpest curve (decimal degrees).

R_1 = Radius of the flattest curve.

R_2 = Radius of the middle curve.

R_3 = Radius of the sharpest curve.

$I = \Delta_1 + \Delta_2 + \Delta_3$

$$X = (R_1 - R_2) \times \sin \Delta_1 + (R_2 - R_3) \times \sin(\Delta_1 + \Delta_2) + R_3 \sin I$$

$$Y = R_1 - R_3 \times \cos I - (R_1 - R_2) \times \cos \Delta_1 - (R_2 - R_3) \times \cos(\Delta_1 + \Delta_2)$$

$$T_L = \frac{R_3 - R_1 \times \cos I + (R_1 - R_2) \times \cos(\Delta_2 + \Delta_3) + (R_2 - R_3) \times \cos \Delta_3}{\sin I}$$

$$T_S = \frac{R_1 - R_3 \times \cos I - (R_1 - R_2) \times \cos \Delta_1 - (R_2 - R_3) \times \cos(\Delta_1 + \Delta_2)}{\sin I}$$

Superelevation

Sections 2A-2 and 2A-3 of this Manual provide more information regarding superelevation.

Plan Curve Data

Each curve of a compound curve should be treated independently as a horizontal curve and the following Plan Curve Data should be provided on the plan sheet for each curve: Δ, D, T, L, E, and R. For superelevated curves the rate of superelevation (e) and runout length (x) should also be shown. The length of transition (m) should be included if a spiral is not used. At intersections, e, x, and m are not required for returns.