

Spiral Curves

Design Manual
Chapter 2
Alignments

Originally Issued: 09-22-00
Revised: 01-29-10

Spiral curves are generally used to provide a gradual change in curvature from a straight section of road to a curved section. They assist the driver by providing a natural path to follow. Spiral curves also improve the appearance of circular curves by reducing the break in alignment perceived by drivers. Figure 1 shows the placement of spiral curves in relation to circular curves. Figure 2 shows the components of a spiral curve. Use spiral curves with circular curves requiring a superelevation of 3% or greater.

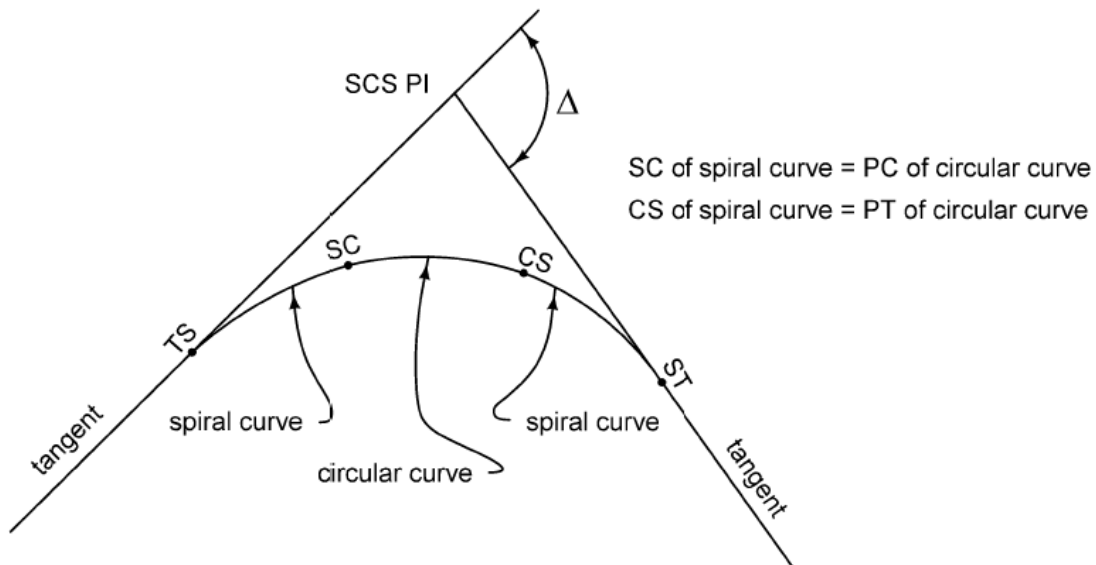


Figure 1: Placement of spiral curve.

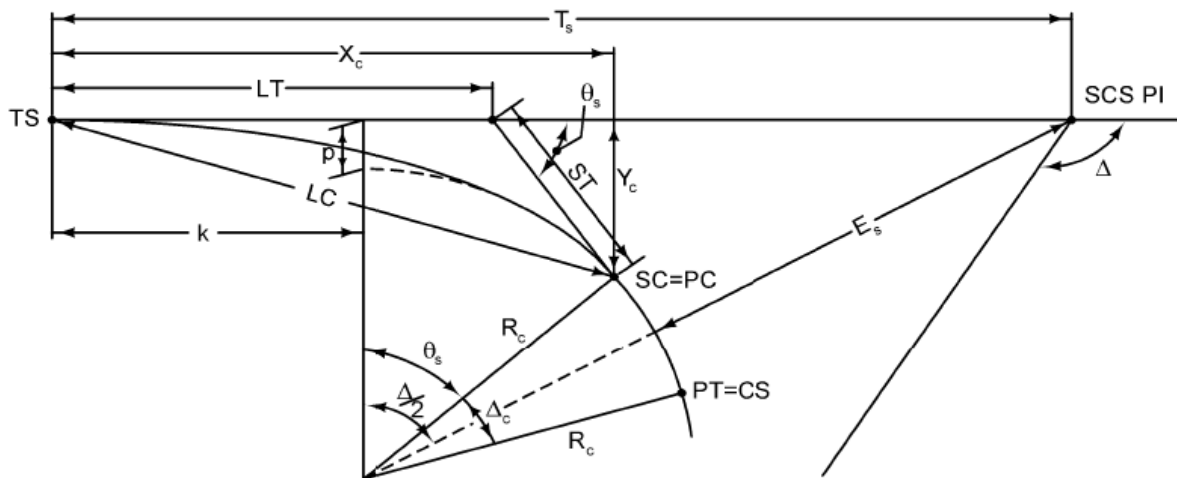


Figure 2: Components of a spiral curve.

Definitions

SCS PI = Point of intersection of main tangents.

TS = Point of change from tangent to spiral curve.

SC = Point of change from spiral curve to circular curve.

CS = Point of change from circular curve to spiral curve.

ST = Point of change from spiral curve to tangent.

LC = Long chord.

LT = Long tangent.

ST = Short tangent.

PC = Point of curvature for the adjoining circular curve.

PT = Point of tangency for the adjoining circular curve.

T_s = Tangent distance from TS to SCS PI or ST to SCS PI.

E_s = External distance from the SCS PI to the center of the circular curve.

R_c = Radius of the adjoining circular curve.

D_c = Degree of curve of the adjoining circular curve, based on a 100 foot arc (English units only).

D = Degree of curve of the spiral at any point, based on a 100 foot arc (English units only).

l = Spiral arc from the TS to any point on the spiral ($l = l_s$ at the SC).

l_s = Total length of spiral curve from TS to SC (typically the superelevation runoff length, see [Section 2A-2](#) and [Section 2A-3](#)).

L = Length of the adjoining circular curve.

θ_s = Central (or spiral) angle of arc l_s .

Δ = Total central angle of the circular curve from TS to ST.

Δ_c = Central angle of circular curve of length L extending from SC to CS.

p = Offset from the initial tangent.

k = Abscissa of the distance between the shifted PC and TS.

Y_c = Tangent offset at the SC.

X_c = Tangent distance at the SC.

x and y = coordinates of any point on the spiral from the TS.

Formulas

$$D_c = \frac{18000}{\pi R_c} \quad R_c \text{ given in feet, } D_c \text{ in decimal degrees (English units only)}$$

$$D_c = 200 \times \frac{\theta_s}{l_s} \quad \theta_s \text{ and } D_c \text{ in decimal degrees, } l_s \text{ in feet (English units only)}$$

$$l_s = 200 \times \frac{\theta_s}{D_c} \quad \theta_s \text{ and } D_c \text{ in decimal degrees, } l_s \text{ in feet (English units only)}$$

$$\theta_s = \frac{l_s \times D_c}{200} \quad \theta_s \text{ and } D_c \text{ in decimal degrees, } l_s \text{ in feet (English units only)}$$

$$\Delta = \frac{180 \times L}{\pi \times R_c} \quad L \text{ and } R_c \text{ in feet (meters)}$$

$$\theta_s = \frac{l_s}{2 \times R_c} \quad \theta_s \text{ in radians, } l_s \text{ and } R_c \text{ in feet (meters)}$$

$$\theta_s \text{ (decimal degrees)} = \frac{180}{\pi} \times \theta_s \text{ (radians)}$$

$$X_c = \left(\frac{l_s}{100} \right) \times (100 - 0.0030462(\theta_s)^2) \quad \theta_s \text{ in decimal degrees, } l_s \text{ in feet (meters)}$$

$$Y_c = \left(\frac{l_s}{100} \right) \times (0.58178\theta_s - 0.000012659(\theta_s)^3) \quad \theta_s \text{ in decimal degrees, } l_s \text{ in feet (meters)}$$

$$p = Y_c - R_c \times (1.0 - \cos\theta_s) \quad Y_c, R_c, \text{ and } p \text{ in feet (meters) and } \theta_s \text{ in decimal degrees}$$

$$A = \frac{20000 \times \theta_s}{l_s^2} \quad A \text{ and } l_s \text{ in feet (meters), } \theta_s \text{ in decimal degrees}$$

$$k = \frac{1}{2} l_s - 0.000127A^2 \times \left(\frac{l_s}{100} \right)^5 \quad A \text{ and } l_s \text{ in feet (meters)}$$

$$T_s = (R_c + p) \times \tan \frac{\Delta}{2} + k \quad T_s, R_c, p, \text{ and } k \text{ in feet (meters), } \Delta \text{ in decimal degrees}$$

$$E_s = (R_c + p) \times \operatorname{exsec} \frac{\Delta}{2} + p \quad E_s, R_c, p, \text{ and } k \text{ in feet (meters), } \Delta \text{ in decimal degrees, and}$$

$\operatorname{exsec}\alpha \text{ is defined as } (\tan\alpha)\left(\tan\frac{1}{2}\alpha\right)$

$$LT = X_c - (Y_c \times \cot\theta_s) \quad LT, X_c, \text{ and } Y_c \text{ in feet (meters), } \theta_s \text{ in decimal degrees}$$

$$ST = \frac{Y_c}{\sin\theta_s} \quad ST \text{ and } Y_c \text{ in feet (meters), } \theta_s \text{ in decimal degrees}$$

$$LC = l_s - 0.00034A^2 \times \left(\frac{l_s}{100} \right)^5 \quad LC, A \text{ and } l_s \text{ in feet (meters)}$$

$$\Delta_c = \Delta - 2 \times \theta_s \quad \Delta_c, \Delta, \text{ and } \theta_s \text{ measured in decimal degrees}$$

Plan Curve Data

Provide the following Spiral Curve Data on the plan and profile sheets for each spiral curve: Δ , E_s , T_s , l_s , θ_s , p , k , X_c , Y_c , LT , ST , LC , and SCS PI stationing.

Curve data, superlevation data, and coordinates of each control point should be shown within the G sheets on tabulations [101-16](#) and [101-17](#).

See Design Manual [Section 21B-58](#) for details on filling tabulations [101-16](#) and [101-17](#).