Iowa Department of Transportation
Office of Design

2C-1

Spiral Curves

Design Manual
Chapter 2
Alignments
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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.

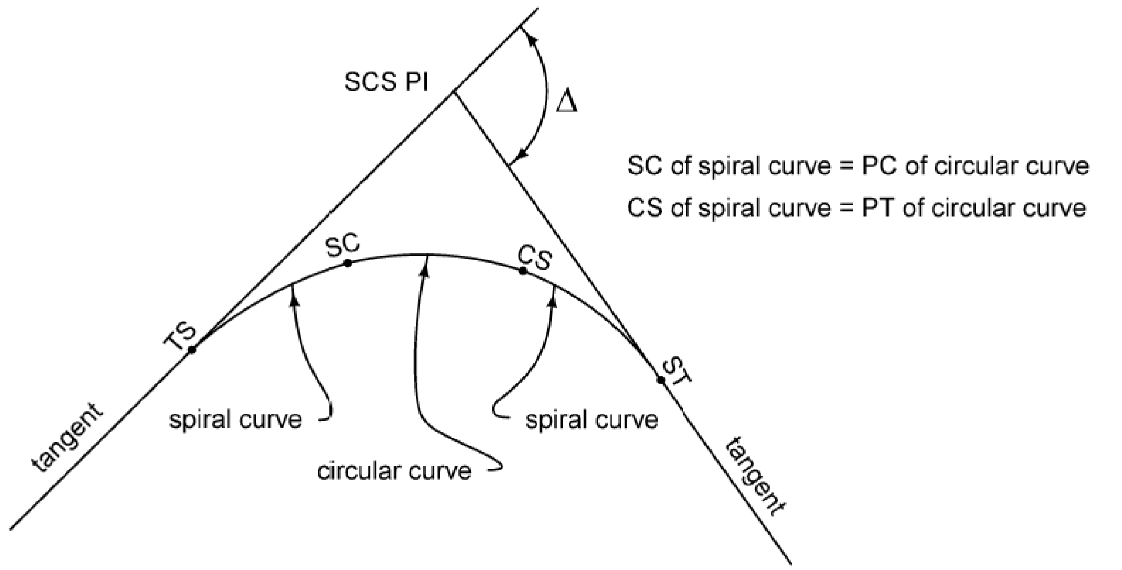

Figure 1: Placement of spiral curve.

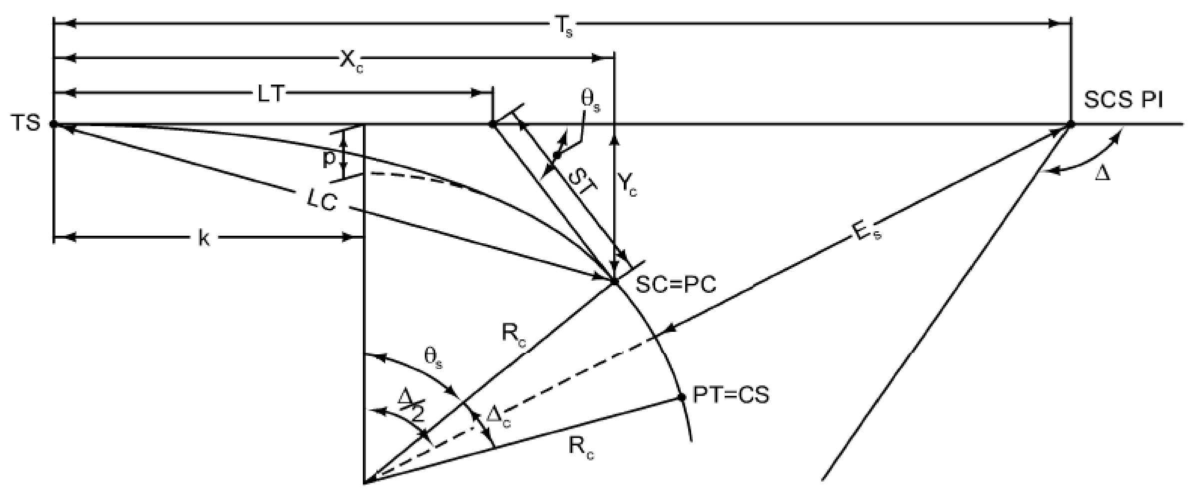

Figure 2: Components of a spiral curve.

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 = Ls at the SC).

Ls =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 (or Theta)= Central (or spiral) angle of arc Ls.

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

$D_c = \dfrac{18000/\pi}{R_c}$ — R_c given in feet, D_c in decimal degrees

$D_c = 200 \times \dfrac{\theta_s}{Ls}$ — θ_s and D_c in decimal degrees, Ls in feet

$Ls = 200 \times \dfrac{\theta_s}{D_c}$ — θ_s and D_c in decimal degrees, Ls in feet

$\theta_s = \dfrac{Ls \times D_c}{200}$ — θ_s and D_c in decimal degrees, Ls in feet

$\Delta = \dfrac{180 \times L}{\pi \times R_c}$ — L and R_c in feet

$\theta_s = \dfrac{Ls}{2 \times R_c}$ — θ_s in radians, Ls and R_c in feet

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

$X_c = \left(\dfrac{Ls}{100}\right) \times (100 - 0.0030462(\theta_s)^2)$ — θ_s in decimal degrees, Ls in feet

$Y_c = \left(\dfrac{Ls}{100}\right) \times (0.58178\theta_s - 0.000012659(\theta_s)^3)$ — θ_s in decimal degrees, Ls in feet

$p = Y_c - R_c \times (1.0 - \cos\theta_s)$ — Y_c, R_c, and p in feet and θ_s in decimal degrees

$A = \dfrac{20000 \times \theta_s}{Ls^2}$ — A and Ls in feet, θ_s in decimal degrees

$k = \dfrac{1}{2} Ls - 0.000127A^2 \times \left(\dfrac{Ls}{100}\right)^5$ — A and Ls in feet

$T_s = (R_c + p) \times \tan\dfrac{\Delta}{2} + k$ — T_s, R_c, p, and k in feet, Δ in decimal degrees

$E_s = (R_c + p) \times \text{exsec}\dfrac{\Delta}{2} + p$ — Es, R_c, p, and k in feet, Δ in decimal degrees, and exsecα is defined as $(\tan\alpha)(\tan\frac{1}{2}\alpha)$

$LT = X_c - (Y_c \times \cot\theta_s)$ — LT, X_c, and Y_c in feet, θ_s in decimal degrees

$ST = \dfrac{Y_c}{\sin\theta_s}$ — ST and Y_c in feet, θ_s in decimal degrees

$LC = Ls - 0.00034A^2 \times \left(\dfrac{Ls}{100}\right)^5$ — LC, A and Ls in feet

$\Delta_c = \Delta - 2 \times \theta_s$ — Δ_c, Δ and θ_s measured in decimal degrees

Spiral Curves on Bridges

Spiral curves should be avoided on bridges. The designer should select a curve radius which doesn't require a spiral curve. The designer should contact the Methods Section for additional assistance on removing spiral curves from bridges.

Plan Curve Data

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

Curve data, superelvation data, and coordinates of each control point should be shown within the G sheets on tabulations 101-16 and 101-17.

Spiral curve data should be displayed in following order on plan sheets:

SCS PI Sta.
Δ =
Theta =
Ls =
Ts =
Es =
P =
K =
Xc =
Yc =
LT =
ST =
LC =

Chronology of Changes to Design Manual Section:

002C-001 Spiral Curves

5/28/2010 Revised

Add language about removing sprial curves from bridges. Removed metric formulas. Added language on displaying curve data in plans. Deleted requirement for spirials with superelevation of 3% or greater (new requirments are covered in 2A-2).

1/29/2010 Revised

Update to current standards