Project	PGSuper			Sheet	1
Subject	Spiral curve check calculations			of	1
Route	Made By R. Brice		Supv	Date	12/9/2024

See reference attached at end of these calculations for referenced equations and figures.

Compute Back and Forward Tangent Length

Back and forward tangent lengths are the same because the curve is symmetric.

Spiral Length, $L_s = 145$ (Input from PGSuper)

Circular Curve Radius, $R = 1063$ (Input from PGSuper)

Spiral angle, $\Delta = \frac{L_s}{2R} = \frac{145}{(2)(1063)} = 0.0682\, r$ (Eq. 12.15)

$X = L_s\left[1 - \frac{\Delta^2}{5(2!)} + \frac{\Delta^4}{9(4!)} \ldots\right] = 145\left(1 - \frac{0.0682^2}{10} + \frac{0.0682^4}{216}\right) = 144.93$ (Eq. 12.19)

$Y = L_s\left[\frac{\Delta}{3} - \frac{\Delta^3}{7(3!)} + \frac{\Delta^5}{11(5!)} \ldots\right] = 145\left(\frac{0.0682}{3} - \frac{0.0682^3}{42} + \frac{0.0682^5}{1320}\right) = 3.29$ (Eq. 12.20)

$X_o = X - R\sin\Delta = 144.93 - 1063\sin 0.0682 = 72.48$ (Eq. 12.11)

$o = Y - R(1 - \cos\Delta) = 3.29 - 1063(1 - \cos 0.0682)) = 0.82$ (Eq. 12.12)

Total curve angle, $I = 22° \, 11' \, 49.66" = 22.197° = 0.3874\, r$ (Input from PGSuper)

$T_s = (R + o)\tan\frac{I}{2} + X_o = (1063 + 0.82)\tan\left(\frac{0.3874}{2}\right) + 72.48 = 281.16$, (Eq. 12.13)

PGSuper computes Back and Forward Tangent Length to be 281.175 ft.

Compute TS Station

PI Station = 2356+17.96 (Input from PGSuper)

TS Station = PI Station – Ts = 2356+17.96 – 281.16 = 2353+36.78

PGSuper reports TS Station = 2353+36.78

Compute ST Station

Circular curve angle, $I_c = I - 2\Delta = 0.3874 - 2(0.0682) = 0.2510$ (See Fig 12.10)

Circular curve arc length, $L_c = R\, I_c = 1063(0.2510) = 266.82$

Total curve length, $L = 2L_s + L_c = 2(145) + 266.82 = 556.82$

ST Station = TS Station + Total curve length = 2353+36.78 + 556.82 = 2358+93.60

PGSuper reports ST Station = 2358+93.60

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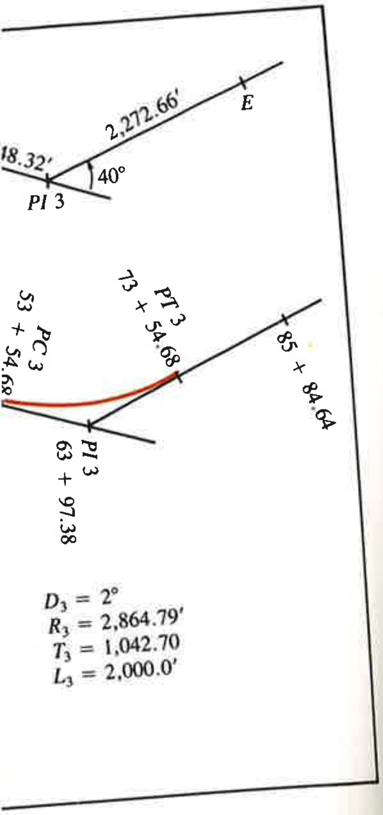

the center line of the route are
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VES

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12.12 EQUAL-TANGENT SPIRALED CIRCULAR CURVE

The geometry of an equal-tangent spiraled circular curve is illustrated in Figure 12.10. It consists of an approach spiral of length L_s, a circular curve, and a leaving spiral also of length L_s. The point where the spiral departs from the tangent is called *TS* (tangent to spiral). At *TS*, the curvature of the spiral is 0°. The curvature gradually increases along the spiral until it reaches the degree of curvature of the circular curve at point *SC* (spiral to curve). The point at which the circular curve runs into the spiral is denoted as *CS* (curve to spiral); and the leaving spiral meets the forward tangent at point *ST* (spiral to tangent).

Point *O* in Figure 12.10 is the center of the circular curve. The line *OB* is perpendicular to the back tangent and is parallel to the line joining *O′* and *TS*. When the circular curve is extended beyond *SC*, it meets line *BO* at point *G*. The distance *BG* is called the *throw* of the spiral and is usually denoted by the letter *o*. The distance along the back tangent between points *B* and *TS* is denoted as X_o. The position of point *SC* with respect to the point *TS* is defined by the distances *X* along the tangent and the offset distance *Y*. The angle, Δ, subtended by the line *BO* and the radius at *SC* is called the spiral angle.

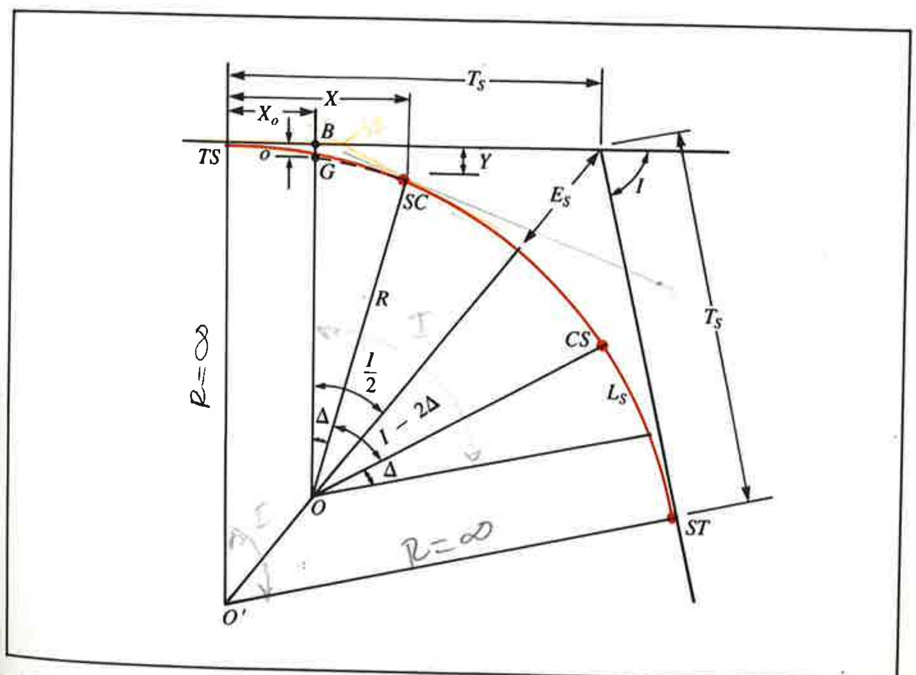

FIGURE 12.10 Equal-tangent spiraled circular curve

Let T_s denote the tangent distance between *PI* and *TS*, E_s denote the external distance, *I* denote the intersection angle, and *R* denote the radius of the circular curve. Then the following relationships can be derived from Figure 12.10:

$$X_o = X - R \sin \Delta \tag{12.11}$$

$$o = Y - R(1 - \cos \Delta) \tag{12.12}$$

$$T_s = (R + o)\tan \frac{I}{2} + X_o \tag{12.13}$$

$$E_s = (R + o)\left(\frac{1}{\cos \frac{I}{2}} - 1\right) + o \tag{12.14}$$

A spiral is usually defined by its length L_s. The spiral angle, Δ, for a spiral of length L_s and connecting to a circular curve of D_a degrees can be computed from the following expression:

$$\Delta \text{ (in degrees)} = \frac{L_s D_a}{200} \tag{12.15}$$

The values of *X* and *Y* in Eqs. (12.11) and (12.12) can be computed using Eqs. (12.17) and (12.18) given in the next section.

12.13 EQUATIONS OF A HIGHWAY SPIRAL

Let *x* and *y* denote the tangent and offset distances respectively of a point *P* located on the spiral (see Figure 12.11). Suppose that *P* is located at a distance *l*, measured along the spiral, from *TS*. Furthermore, let δ be the angle, measured in radians, subtended by the distance *l*. Then the following relationships exist:

$$x = l\left[1 - \frac{\delta^2}{5(2!)} + \frac{\delta^4}{9(4!)} - \frac{\delta^6}{13(6!)} + \cdots\right] \tag{12.16}$$

and

$$y = l\left[\frac{\delta}{3} - \frac{\delta^3}{7(3!)} + \frac{\delta^5}{11(5!)} - \frac{\delta^7}{15(7!)} + \cdots\right] \tag{12.17}$$

where

$$\delta = \left(\frac{l}{L_s}\right)^2 \Delta \tag{12.18}$$

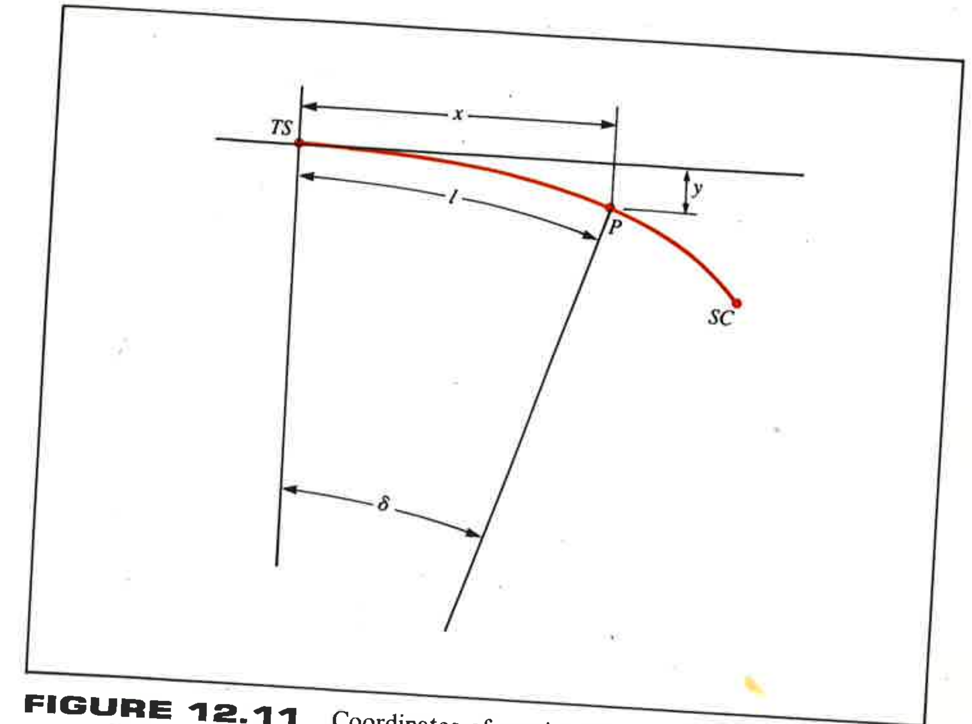

FIGURE 12.11 Coordinates of a point on a spiral

The preceding equations describe a spiral that is used universally in highway applications. A slightly different spiral is used in railroads.

Of particular interest is the tangent and offset distances (*X* and *Y*) of point *SC*. Since $l = L_s$ and $\delta = \Delta$ at *SC*,

$$X = L_s\left[1 - \frac{\Delta^2}{5(2!)} + \frac{\Delta^4}{9(4!)} - \frac{\Delta^6}{13(6!)} + \cdots\right] \tag{12.19}$$

$$Y = L_s\left[\frac{\Delta}{3} - \frac{\Delta^3}{7(3!)} + \frac{\Delta^5}{11(5!)} - \frac{\Delta^7}{15(7!)} + \cdots\right] \tag{12.20}$$

Remember that δ and Δ are expressed in radians in Eqs. (12.16) to (12.20).

For the derivations of Eqs. (12.15) to (12.20), readers are referred to References 12.1 and 12.2.

12.14 LAYOUT OF A SPIRAL

A spiral is usually located in the field using a number of equal sections. Figure 12.12 shows a spiral located in five equal sections. Point 1 on the spiral is located using the deflection angle a_1 and a chord distance equal to $L_s/5$. Point 2 is then located using deflection angle a_2 and a chord distance