Spiralling Highway Curves

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An innovation in highway practice, that of spiralling curves, has recently been put into effect in certain districts in Illinois. The writer last summer served as resident engineer in the district immediately north of Springfield, in which the form of spiral shown in the accompanying sketch is used.

The state of Illinois has appropriated millions of dollars for a network of monolithic concrete roads, which are being constructed in accordance with the most up-to-date highway practice. Vertical parabolic curves are provided for all points of change in the grade, and also, simple circular curves are required at every place where a ch in direction is to occur. Ordinarily, for a small turn in the direction of the road, just a simple circular curve is run in between the two tangents, but in all cases where the turn approximates a right angle, a spiral easement curve is put in, extra, between each tangent and the curve connecting them.

A spiral easement curve is one, the radius of which gradually changes from infinity at the point of spiral on the tangent to a length equal to that of the simple curve at the point of connection with the latter. Since a 28 degree curve is relatively speaking a very sharp one, it is a necessity to provide spirals to reduce the suddenness of the turning, especially on roads designed par-

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ILLINOIS HIGHWAY SPIRAL

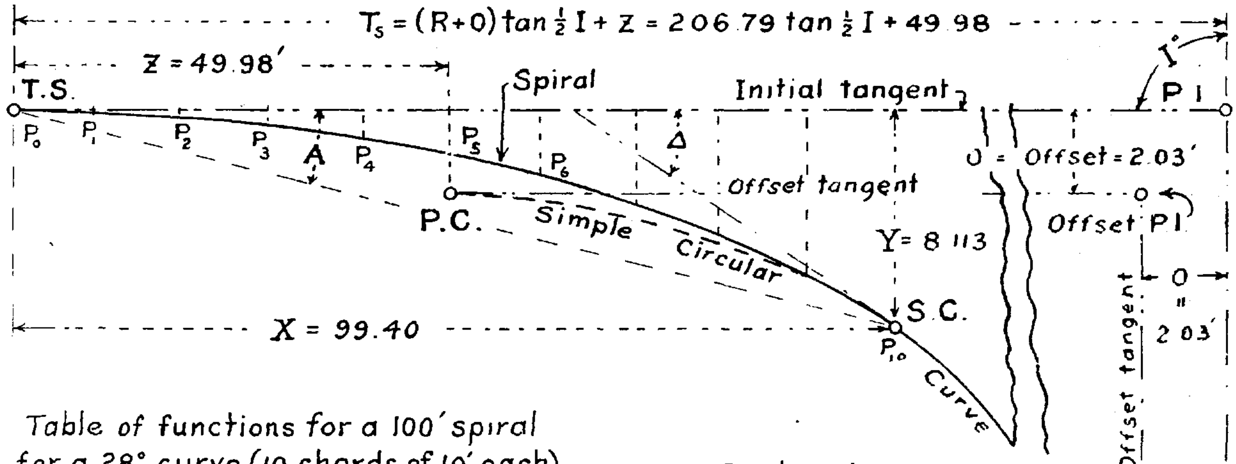

Table of functions for a 100′ spiral for a 28° curve (10 chords of 10′ each)

Point	X-Co-or	Y-Co-or	Def(P_0-P)	X-Corec.	Super-El (16′)
P_0	0.0 ft.	0.0 ft	0° 00′	0.00 ft	0.0 feet
P_1	10.00	0.008	0° 02.8	0.00	0.133
P_2	20.00	0.066	0° 11.2	0.00	0.266
P_3	30.00	0.224	0° 25.2	0.00	0.399
P_4	39.99	0.532	0° 44.8	0.01	0.532
P_5	49.98	1.008	1° 10′	0.02	0.665
P_6	59.95	1.764	1° 40.8	0.05	0.798
P_7	69.90	2.800	2° 17.2	0.10	0.931
P_8	79.80	4.172	2° 59.1	0.20	1.064
P_9	89.65	5.936	3° 46.8	0.35	1.197
P_{10}	99.40	8.113	4° 40′	0.60	1.333

Instructions for laying out spiralled curve

1. Offset initial tangent by amount "O"
2. Lay off tangent distance ($R \tan \frac{1}{2} I$) on offset tangents locating P.C. & P.T. of simple curve
3. Run in simple curve from new P.C. to P.T.
4. Locate T_s on initial tangent by measuring $T_s = (R+O) \tan \frac{1}{2} I + Z$ from initial P.I.
5. Locate points (P_1 – P_{10}) on the spiral by measuring from P_0 the corresp'g X co-ord's on the initial tangent and offsetting the corresp'g Y co-ord's.
6. Super-elev. for each chord point can be taken from the last column of the table (for 16′ pav't)

For 28° curve, R (run with 25′ chords) = 204.76; Δ = 14° 00′; A = 4° 40′; O = 2.03′; Length of simple curve P.C. to P.T. = I° × 3.572′ — To adapt tables to a simple curve of any other degree D multiply the tabular deflections and values of Y above by D ÷ 28, and for X co-ordinates multiply X-corrections by $D^2 \div 28^2$ and subtract the result from total length of spiral from P_0 to point corresponding to the X, correction used.

SPIRALLING HIGHWAY CURVES

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ticularly for high speed automobile traffic. The simple curve could be made any convenient degree of curvature. The spiral shown is designed for a simple 28 degree curve. Since a different degree of curve would, of course, necessitate a somewhat different spiral whose chord deflections and tangent offsets are rather laborius to calculate, it was the custom on our division to run in nothing but 28 degree curves where spiralling was to be done.

All spirals were made 100 feet long (actual length of curve), and were so placed that the middle of the spiral came at that point which would have been the beginning of the simple curve, had no spiral been used. It can be seen from the drawing that a small offset is necessary for the insertion of the spiral between the simple curve and the tangent, ammounting to 2.03 feet for a 28 degree curve.

The following example will illustrate the general method followed in running in a spiral.

Given: Two tangents whose angle of intersection I=90°.

Simple curve 28 degrees R=204.76′ (for 25′ chords).

Station of P. I.=541+92.9.

Offset O=2.03′ Z=49.98′.

Required: The station of the P. S.

The distance from the point of intersection (P. I.) to the point of spiral (P. S.)=(R+O) tan ½ (I+Z)=256.77.

(541+92.9)—(2+56.8)=539+36.1=Sta. of P. S.

Stakes for the placing of steel forms are required by the contractor at every 25 foot interval, so it can be seen that it is necessary to locate three other points on the spiral, and although the tables are made out for 10 foot distances, stakes were never set at other than the beginning and end, and 25′, 50′, and 75′ points along the spiral. These intermediate points can be located either by deflections from the tangent or by right angle offsets from the tangent. Of these two methods the latter is by far the more simple. It is also much quicker and was therefore used exclusively. For our work it was considered accurate enough to dispense with the transit in turning the right angle for the offset, this being done with the steel tape or sometimes by eye. All measurements were made to the nearest one-tenth of a foot, although in the tables they are calculated to thousandths of a foot in some cases.

To locate the point on the spiral 25 feet from the P. S., the transit was first used to spot a point on the tangent 25 feet ahead of the P. S. An offset of 0.14′ from this determined the required point. At 50′ along the tangent the offset was 1.01′, at 74.9′ it was 3.37′, and at 99.4′ it was 8.11′.

After setting the 5 required points on the spiral, set the P. C. at an offset of 2.03′ from a point 49.98′ along the initial tangent from the beginning. Then sight along the offset tangent and deflect 7° 00′ (half the total spiral angle) from a foresight along this tangent to see if it checks the end stake of the spiral. If checked, run in the simple curve as usual to the P. T. with the transit at the point P. C. Then run the forward spiral by the offsets already calculated for the first one, checking on the similar end point.

All curves whether spiralled or not were superelevated on the outside, i. e. the center line of the road was run at the profile grade, but the outside was made higher and the inside lower than the center. The amount of super-elevation (difference in height between outside and inside of curve) varies along the spiral from zero at the P. S. to 1.333′ at S. C. after which it is constantly 1.333′ all along the simple curve, and then gradually decreases along the forward spiral to zero at the tangent again. When we consider the fact that the paved roadway is only 18 feet wide, a superelevation of 1.333′ corresponds to a transverse slope of 7.4%. This is greater than the maximum permissible longitudinal grade in some parts of the country. With such banking of the roadway on sharp curves, it is evident that these roads are built for speed and that spirals are a necessity.