Horizontal Transition Curves

Transition curve is provided to change the horizontal alignment from straight to circularcurve gradually and has a radius which decreases from infinity at the straight end (tangent point) to the desired radius of the circular curve at the other end (curve point)

Thus, the functions of transition curve in the horizontal alignment are given below:

- To introduce gradually the centrifugal force between the tangent point and the beginningof the circular curve, avoiding sudden jerk on the vehicle. This increases the comfort ofpassengers.
- To enable the driver, turn the steering gradually for his own comfort and safety
- To enable gradual introduction of the designed super elevation and extra widening of pavement at the start of the circular curve.
- To improve the aesthetic appearance of the road

Type of transition curve

Different types of transition curves are

a) Spiral or Clothoid
b) Cubic Parabola
c) Lemniscates

IRC recommends spiral as the transition curve because:

1) It full fills the requirement of an ideal transition, as the rate of change of centrifugal acceleration is uniform throughout the length.
2) The geometric property of spiral is such that the calculation and setting out the curve inthe field is simple and easy.

Length of transition curve

The length of the transition curve should be determined as the maximum of thefollowing three criteria

1) Rate of Change of Centrifugal Acceleration
2) Rate of Change of Super Elevation
3) An Empirical Formula Given by IRC

Rate of Change of Centrifugal Acceleration

At the tangent point, radius is infinity and hence centrifugal acceleration (v^2 /R) is zero,as the radius is infinity. At the end of the transition, the radius R has minimum value Rm. Hencethe rate of change of centrifugal acceleration is distributed over a length Ls

Let the length of transition curve be Ls m. If ‘t’ is the time taken in seconds to traverse this transition length at uniform design speed of v m/sec, t = Ls/v. The maximum centrifugal acceleration of v^2/R is introduced in time t through the transition length Ls and hence the rate of centrifugal acceleration C is given by

$$C = \frac{v^2}{Rt} = \frac{\frac{v^2}{RL_s}}{v} = \frac{v^3}{L_s R}$$

The IRC has recommended the following equation

$$C = \frac{80}{(75 + V)}$$

The minimum and maximum value of C are limited to 0.5 and 0.8

The length of the transition curve Ls is given by |

$$L_s = \frac{v^3}{CR}$$

If the design speed is given in kmph

$$L_s = \frac{V^3}{46.5\ CR}$$

C - rate of change of centrifugal acceleration, m/sec^3

Ls – length of transition curve

R – radius of the circular curve, m

Rate of introduction of super-elevation

Raise (E) of the outer edge with respect to inner edge is given by

E = eB = e(W +We)

If it is assumed that the pavement is rotated about the centre line after neutralizing the camber,then the max amount by which the outer edge is to be raised at the circular curve with respect to the centre = E/2. Hence the rate of change of this raise from 0 to E is achieved gradually with a gradient of 1 in N over the length of the transition curve (typical range of N is 60-150).Therefore, the length of the transition curve Ls is given by

$$L_s = \frac{EN}{2} = \frac{eN}{2}(W + W_e)$$

However, if the pavement is rotated about the inner edge, the length of transition curve is given by

$$L_s = EN = eN(W + W_e)$$

By Empirical Formula

According to IRC standards the length of horizontal transition curve Ls should not be less than the value given by the following formulas for two terrain classification

a) For plain and rolling terrain

$$L_s = \frac{2.7\,V^2}{2}$$

b) For mountainous and steep terrain

$$L_s = \frac{V^2}{2}$$

Setting out Transition Curve

Transition curves are introduced between the tangent points of the straight stretches andthe end of the circular curve on both sides. If the length of transition curve is Ls and the radiusof the circular curve is R, the shift S of the transition curve is given by the formula

$$S = \frac{L_s^{\,2}}{24\,R}$$

Setback Distance on Horizontal Curves

Setback distance m or the clearance distance is the distance required from the centrelineof a horizontal curve to an obstruction on the inner side of the curve to provide adequate sightdistance at a horizontal curve. The setback distance depends on:

a) Required Sight Distance, S
b) Radius of Horizontal Curve, R
c) Length of the curve, Lc which may be greater or lesser than S

a) When Lc > S

When the length of curve Lc is greater than the sight distance S, let the angle subtendedby the arc length S at the curve be α. On narrow roads such as single lane roads, the sight distance is measured along the centre line of the road and the angle subtended at the centre, α is equal to S/R radians. Therefore, half central angle id given by

$$\frac{\alpha}{2} = \frac{S}{2R}\ radians = \frac{180\,S}{2\,\pi R}\ degrees$$

The setback distance m, required from the centre line on narrow road is given by

$$m = R - R\cos\frac{\alpha}{2}$$

In case of wide roads with 2 or more lanes, if d is the distance between the centre line of the road and the centre line of the inside lane in meters, the sight distance is measured along the middle of the inner side lanes and the setback distance m' is given by

$$m' = R - (R - d)\cos\frac{\alpha'}{2}$$

Where

$$\frac{\alpha'}{2} = \frac{180\,S}{2\,\pi(R - d)}\ degrees$$

a) When Lc < S

If the length of the curve Lc is less than the required sight distance S, then the angle α subtendedat the center is determined with reference to the length of circular curve Lc and the setback distance m' is worked out in 2 parts

$$\frac{\alpha'}{2} = \frac{180\,Lc}{2\,\pi(R - d)}\ degrees$$

The setback distance is given by

$$m' = R - (R - d)\cos\frac{\alpha'}{2} + \frac{(S - Lc)}{2}\sin\frac{\alpha'}{2}$$

Curve Resistance

When the vehicle negotiates a horizontal curve, the direction of rotation of the front andthe rear wheels are different. The front wheels are turned to move the vehicle along the curve,whereas the rear wheels seldom turn. The rear wheels exert a tractive force T in the PQ direction. The tractive force available on the front wheels is T cos θ in the PS direction. This isless than the actual tractive force, T applied. Hence, the loss of tractive force for a vehicle to negotiate a horizontal curve is:

$$\mathbf{CR = T - T\cos\alpha = T\,(1 - \cos\alpha)}$$