

Horizontal alignment

15.2 Guidelines on superelevation: While designing the various elements of the road like superelevation, we design it for a particular vehicle called design vehicle which has some standard weight and dimensions. But in the actual case, the road has to cater for mixed traffic. Different vehicles with different dimensions and varying speeds ply on the road. For example, in the case of a heavily loaded truck with high centre of gravity and low speed superelevation should be less. Otherwise chances of toppling are more. Taking into practical considerations of all such situations, IRC has given some guidelines about the maximum and minimum superelevation etc.

15.2.1 Design of super-elevation: For fast moving vehicles providing higher superelevation without considering coefficient of friction is safe. i.e. centrifugal force is fully counteracted by the weight of the vehicle or superelevation. For slow moving vehicles providing lower superelevation considering coefficient of friction is safe. i.e. centrifugal force is counteracted by superelevation and coefficient of friction. IRC suggests following design procedure:

Step 1 Find e for 75 percent of design speed, neglecting f . i.e. $e = \frac{V^2}{225R}$;

Step 2 If $e \leq 0.07$, then $e_s = e$; else if $e > 0.07$

then Step 3 Find f_1 for the design speed and max e . i.e. $f_1 = 57: - e = 57: - 0.07$.

If $f_1 < 0.15$, then the maximum

$e = 0.07$ is safe for the design speed. else go to step 4.

Step 4 Find the allowable speed on for the maximum $e = 0.07$ and $f = 0.15$. $e = \frac{V^2}{225R}$

If on 2 11 then the

design is adequate. otherwise use speed adopt control measures or look for speed control measures.

15.2.2 Maximum and minimum super-elevation: depends on (a) slow moving vehicle and (b) heavy loaded trucks with high CG. IRC specifies a maximum super-elevation of 7 percent for plain and rolling terrain, while that of hilly terrain is 10 percent and urban road is 4 percent. The minimum super elevation is 2-4 percent for drainage purpose, especially for large radius of the horizontal curve.

15.2.3 Attainment of super-elevation: 1. Elimination of the crown of the cambered section by: a) rotating the outer edge about the crown : The outer half of the cross slope is rotated about the crown at a desired rate such that this surface falls on the same plane as the inner half.

(b) shifting the position of the crown: This method is also known as diagonal crown method. Here the position of the crown is progressively shifted outwards, thus increasing the width of the inner half of cross section progressively.

2. Rotation of the pavement cross section to attain full super elevation by: There are two methods of attaining superelevation by rotating the pavement

(a) rotation about the center line : The pavement is rotated such that the inner edge is depressed and the outer edge is raised both by half the total amount of superelevation. i.e., by $E/2$ with respect to the centre.

(b) rotation about the inner edge: Here the pavement is rotated raising the outer edge as well as the centre such that the outer edge is raised by the full amount of superelevation with respect to the inner edge.

15.3 Radius of Horizontal Curve: The radius of the horizontal curve is an important design aspect of the geometric design. The maximum comfortable speed on a horizontal curve depends on the radius of the curve. Although it is possible to design the curve with maximum superelevation and coefficient of friction, it is not desirable because re-alignment would

be required if the design speed is increased in future. Therefore, a ruling minimum radius R_{min} can be derived by assuming maximum superelevation and coefficient of friction.

Ideally, the radius of the curve should be higher than R_{min} . However very large curves are also not desirable. Setting out large curves in the field becomes difficult. In addition, it also enhances driving strain.

15.4 Extra widening: Extra widening refers to the additional width of carriageway that is required on a curved section of a road over and above that required on a straight alignment. This widening is done due to two reasons: the first and most important is the additional width required for a vehicle taking a horizontal curve and the second is due to the tendency of the drivers to ply away from the edge of the carriageway as they drive on a curve. The first is referred as the mechanical widening and the second is called the psychological widening.

15.4.1 Mechanical widening: The reasons for the mechanical widening are: When a vehicle negotiates a horizontal curve, the rear wheels follow a path of shorter radius than the front wheels. This phenomenon is called off-tracking, and has the effect of increasing the effective width of a road space required by the vehicle. Therefore, to provide the same clearance between vehicles traveling in opposite direction on curved roads as is provided on straight sections, there must be extra width of carriageway available. This is an important factor when high proportion of vehicles are using the road. Trailer trucks also need extra carriageway, depending on the type of joint. In addition speeds higher than the design speed causes transverse skidding which requires additional width for safety purpose. The expression for extra width can be derived from the simple geometry of a vehicle at a horizontal curve as shown in figure 15.5. Let R_1 is the radius of the outer track line of the rear wheel, R_2 is the radius of the outer track line of the front wheel l is the distance between the front and rear wheel, n is the number of lanes, then the mechanical widening W_m (refer figure 15:1) is derived below:

Therefore the widening needed for a single lane road is:

If the road has n lanes, the extra widening should be provided on each lane. Therefore, the extra widening of a road with n lanes is given by,

Please note that for large radius, $R_2 \approx R$, which is the mean radius of the curve, then W_m is given by:

15.4.2 Psychological widening: Widening of pavements has to be done for some psychological reasons also. There is a tendency for the drivers to drive close to the edges of the pavement on curves. Some extra space is to be provided for more clearance for the crossing and overtaking operations on curves. IRC proposed an empirical relation for the psychological widening at horizontal curves

Therefore, the total widening needed at a horizontal curve W_e is

Summary: In our country, the design of super-elevation follows IRC guidelines wherein the initial design is done by considering 75% of design speed and the safety of design is assessed. Pavement is to be given extra width at curves to account for mechanical and psychological aspects.

15.6 Problems