Nilachal Polytechnic

Bhubaneswar

[redacted]

NOTE

Sem.: 4th Subject- Highway Engg.

Branch : Civil Engineering

Name of the Faculty : Sweta Sarangi

Text Book to be followed by Student / Faculty

Book-1 : (Khana & Justo, Ch No- 02)

Chapter- 2 : Road Geometric Design

1.Learning Objective

Students will learn -

i)Factors affecting the geometric design,Highway alignment, road classification,

ii)Pavement surface characteristics,

iii)Cross-section elements including cross slope, various widths of roads and features in the road margins.

iv)Sight distance elements including cross slope, various widths and features in the road margins.

v)Horizontal alignment which includes features like super elevation, transition curve, extra widening and set back distance.

vi)Vertical alignment and its components like gradient, sight distance and design of length of curves.

2.Essential Questions

i) What do you mean by design speed?
ii) What is SSD & OSD?
iii) what is super elevation or cant and what are the methods of providing it?
iv)Explain P.I.E.V theory?
v) What are the cross-sectional elements?
vi) What is gradient and also expalin its various types?
vii) What is curve and what are the types of it?
viii) What is kerb and cross-slope?

3. Hours Required

Theory	3 hours
Problems	2 hours
Question & Answer Theory	2hours
Total	**7 hours**

4. Question for Teaching / Assignment / Self Practice

	02 Marks	**05 Marks**	**10Marks**
Teaching	10	5	6
Assignment	4	3	3
Self Practice	4	3	3
Total	18	11	12

Lesson Description

The geometric design of highways deals with the dimensions and layout of visible features of the highway.

The emphasis of the geometric design is to address the requirement of the driver and the vehicle such as safety, comfort, efficiency, etc.

The features normally considered are the cross section elements, sight distance consideration, horizontal curvature, gradients, and intersection.

The design of these features is to a great extend influenced by driver behavior and psychology, vehicle characteristics, traffic characteristics such as speed and volume. Proper geometric design will help in the reduction of accidents and their severity.

Therefore, the objective of geometric design is to provide optimum efficiency in traffic operation and maximum safety at reasonable cost

Enclosed :

Course Material.

CHAPTER - 02

Road Geometric Design

It deals with the dimensions and layout of visible features of the highway.

It provides optimum efficiency in the traffic operation which is more safety and reasonable cost.

It mainly deals with following elements:-

Cross section elements like pavement width, formation width, surface characteristics, camber etc.

Sight distance

Horizontal and vertical alignment detail

Intersection elements

There are 3 important factors affecting the geometrical design of a highway. They are:-

Classification of roads

Topography of the area

Traffic characteristics

Cross section elements:-

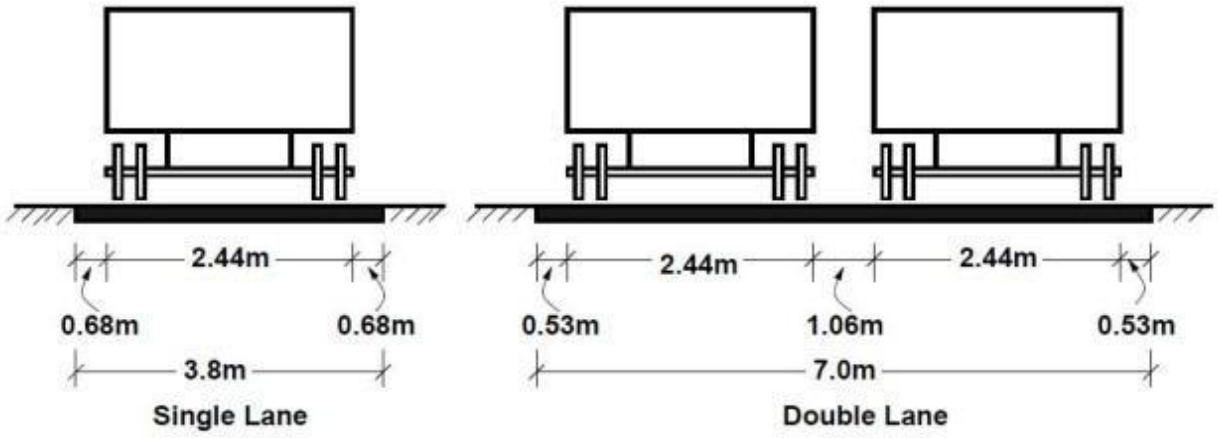
Generally cross section elements consisting of several elements or aspects they are pavement width, formation width, camber etc.

Carriage way width or pavement width:-

The carriage way width depends upon the traffic lane and the no. of lanes.

The lane width is determined on the basics of vehicle width and the minimum side clearance provided for safety purpose.

As per the IRC specification the maximum width of vehicle is 2.44m. and with side margins of 680mm, the total width of single lane will be 3.80m. as shown below.



Lane width for single and two lane roads

For road pavements having 2 or more lane the width of 3.50m. per lane is considered as sufficient.

Thus for a 2 lane pavement, the width of pavement will be 7.0m. with side margins of 530mm. and central clearance distance of 1060mm.

The width of pavement or carriage way various classes of roads have been standardized by the IRC are:-

No.	Class of Road	Width of Pavement
1	Single Lane	3.5m. for all roads may be described to 3m. for village road
2	Two lanes without raised kerb	7m.
3	Two lanes with raised kerb	7.50m.
4	Intermediate carriage way	5.50m.
5	Multilane pavements	3.50m. per lane

Road way width or formation width:-

As we know the highway may either be in embankment or in cutting so the top width of embankment or the bottom width of cutting is known as roadway width or formation width .

It mainly consist of following 2 component i.e.

(Formation width = width of pavement + width of shoulder)

Camber or Cross slope:-

Camber is the slope provided in the transverse direction of the road to drain off the rain water from the road surface.

It is also referred to as cross-fall or cross slope or transverse slope.

The camber is usually designated by expression 1 in n which means that the transverse slope is in the ratio of 1 vertical to ‘n’ horizontal.

The camber is also sometimes expressed as a percentage of road width . Thus a camber with 2.50% will mean that for 100m. width of road, the height at crown will be 2.50m.

Necessity:-

The camber is mainly provided for drainage and quick disposal of rain water from the road surface.

Rate of camber:-

The minimum camber needed to drain off the surface water may be adopted keeping in view the amount of rainfall in the locality and the type of surface.

The too steep camber causes the following undesirable effects on the traffic.

The excessive camber causes uncomfortable side thrust and drag on the steering of the automobile.

During overtaking operation excessive camber causes discomfort to the occupants.

Excessive camber causes problems of over topping to the highly laden bullock carts.

The vehicle running at high speeds are likely to slip towards the edges.

So the steep rate is to be adopted for heavy rainfall areas and for light rainfall areas the falter rate is to be adopted.

Types of Camber:-

In general there are 3 types of cambers are provided depending upon the types of pavement surfaces.

Parabolic camber or Barel camber

Slopped camber or straight line camber

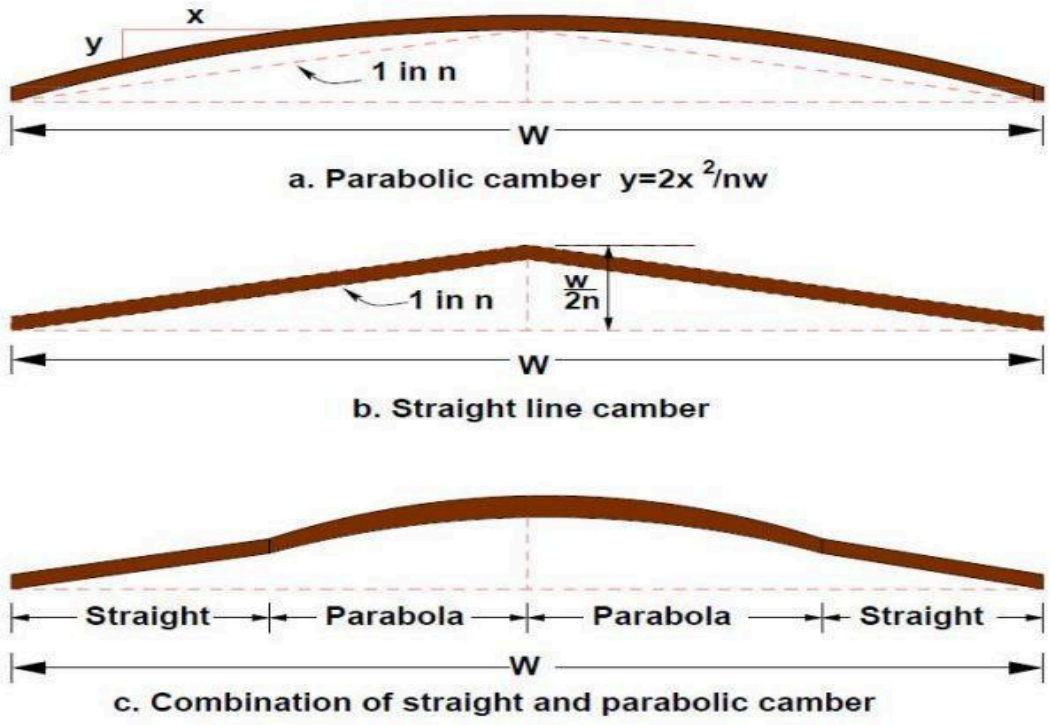
Composite camber or combined camber

A . Parabolic Camber or Barel Camber

It consists of continuous curve either parabolic or elliptical.

In this type of camber the shape of the surface is flat at the middle & steeper towards the edge.

This type of camber is preferred for fast moving vehicles as they have to cross the central or crown line frequently quring overtaking operation.



B. Slopped Camber or Straight line Camber:-

This type of camber consists of 2 straight slopes joining at the centre.

This type of camber is provided in relatively impervious pavement surfaces such as cement concrete pavements.

C . Composite Camber or Combined Camber:-

This type of camber consists of 2 straight slopes with parabolic portion at the centre.

This type of camber is preferred for slow moving vehicles such as bullock drawn in iron tyred carts.

Road Margins:-

Various elements included in the road margins are:-

Cycle track

Drive ways

Embankment slopes

Footpaths

Frontage roads

Guard rails

Parking lanes

Shoulder

Cycle Track:-

Cycle tracks are provided in urban areas when the volume of cycle traffic is high Minimum width of 2 meter is required, which may be increased by 1 meter for every additional track.

Drive ways:-

Drive way connects the main highway with the service station or fuel station.

They should be located away from intersection.

Safe crossing, the width of drive way should be kept minimum & its radius maximum.

Embankment slopes:-

For the purpose of safe traffic movements and also for aesthetic reason, the embankments slopes provided.

The slope should be kept as flat as possible.

Footpaths:-

Footpaths are exclusive right of way to pedestrians, especially in urban areas.

They are provided for the safety of the pedestrians when both the pedestrian traffic and vehicular traffic is high.

Minimum width is 1.5 meter and may be increased based on the traffic.

The footpath should be either as smooth as the pavement or more smoother than that to induce the pedestrian to use the footpath.

Guard rails:-

They are provided at the edge of the shoulder usually when the road is on an embankment.

They serve to prevent the vehicles from running off the embankment, especially when the height of the fill exceeds 3 m. Various designs of guard rails are there.

Guard stones painted in alternate black and white are usually used.

They also give better visibility of curves at night under headlights of vehicles.

Parking Lanes:-

Parking lanes are provided in urban lanes for side parking.

Parallel parking is preferred because it is safe for the vehicles moving on the road.

The parking lane should have a minimum of 3.0 m width in the case of parallel parking.

Shoulder:-

Shoulders are provided along the road edge and is intended for accommodation of stopped vehicles, serve as an emergency lane for vehicles and provide lateral support for base and surface courses.

The shoulder should be strong enough to bear the weight of a fully loaded truck even in wet conditions.

The shoulder width should be adequate for giving working space around a stopped vehicle. It is desirable to have a width of 4.6 m for the shoulders.

A minimum width of 2.5 m is recommended for 2-lane rural highways in India.

Frontage roads:-

These roads are provided to give areas to the properties along on important highway.

These roads may run parallel to the highway and attached to the highway at selected points.

Kerb:-

Kerbs indicate the boundary between the carriage way and the shoulder or islands or footpaths. Different types of kerbs are

Low or mountable kerb

Semi – Barrier type kerb

Barrier type

Low or mountable kerbs :

This type of kerbs are provided such that they encourage the traffic to remain in the through traffic lanes and also allow the driver to enter the shoulder area with little difficulty.

The height of this kerb is about 10 cm above the pavement edge with a slope which allows the vehicle to climb easily.

This is usually provided at medians and channelization schemes and also helps in longitudinal drainage.

Semi-barrier type kerbs :

When the pedestrian traffic is high, these kerbs are provided. Their height is 15 cm above the pavement edge.

This type of kerb prevents encroachment of parking vehicles, but at acute emergency it is possible to drive over this kerb with some difficulty.

Barrier type kerbs :

They are designed to discourage vehicles from leaving the pavement.

They are provided when there is considerable amount of pedestrian traffic.

They are placed at a height of 20 cm above the pavement edge with a steep batter.

Design and average running speed, stopping and passing sight distance
Design speed:

The design speed, as noted earlier, is the single most important f actor in the design of horizontal alignment.

The design speed also depends on the type of the road.

For e.g, the design speed expected from a National highway will be much higher than a village road, and hence the curve geometry will vary significantly.

The design speed also depends on the type of terrain.

A plain terrain can afford to have any geometry, but for the same standard in a hilly terrain requires substantial cutting and filling implying exorbitant costs as well as safety concern due to unstable slopes.

Therefore, the design speed is normally reduced for terrains with steep slopes.

For instance, Indian Road Congress (IRC) has classified the terrains into four categories, namely plain, rolling, mountainous, and steep based on the cross slope as given in table.

Based on the type of road and type of terrain the design speed varies.

Sight Distances:-

The safe and efficient operation of vehicles on the road depends very much on the visibility of the road ahead of the driver.

Thus the geometric design of the road should be done such that any obstruction on the road length could be visible to the driver from some distance ahead .

This distance is said to be the sight distance.

Types of sight distance Sight distance available from a point is the actual distance along the road surface, over which a driver from a specified height above the carriage way has visibility of stationary or moving objects. Three sight distance situations are considered for design:

1. Stopping sight distance (SSD) or the absolute minimum sight distance

2. Intermediate sight distance (ISD) is defined as twice SSD

3. Overtaking sight distance (OSD) for safe overtaking operation

4. Safe sight distance to enter into an intersection.

The most important consideration in all these is that at all times the driver travelling at the design speed of the highway must have sufficient carriageway distance within

his line of vision to allow him to stop his vehicle before colliding with a slowly moving or stationary object appearing suddenly in his own traffic lane.

The computation of sight distance depends on:

1. Reaction time of the driver Reaction time of a driver is the time taken from the instant the object is visible to the driver to the instant when the brakes are applied. The total reaction time may be split up into four components based on PIEV theory. In practice, all these times are usually combined into a total perception-reaction time suitable for design purposes as well as for easy measurement. Many of the studies shows that drivers require about 1.5 to 2 secs under normal conditions. However, taking into consideration the variability of driver characteristics, a higher value is normally used in design. For example, IRC suggests a reaction time of 2.5 secs.

2. Speed of the vehicle The speed of the vehicle very much affects the sight distance. Higher the speed, more time will be required to stop the vehicle. Hence it is evident that, as the speed increases, sight distance also increases.

3. Efficiency of brakes The efficiency of the brakes depends upon the age of the vehicle, vehicle characteristics etc. If the brake efficiency is 100%, the vehicle will stop the moment the brakes are applied. But practically, it is not possible to achieve 100% brake efficiency. Therefore the sight distance required will be more when the efficiency of brakes are less. Also for safe geometric design, we assume that the vehicles have only 50% brake efficiency.

4. Frictional resistance between the tyre and the road The frictional resistance between the tyre and road plays an important role to bring the vehicle to stop. When the frictional resistance is more, the vehicles stop immediately. Thus sight required will be less. No separate provision for brake efficiency is provided while computing the sight distance. This is taken into account along with the factor of longitudinal friction. IRC has specified the value of longitudinal friction in between 0.35 to 0.4.

5. Gradient of the road. Gradient of the road also affects the sight distance. While climbing up a gradient, the vehicle can stop immediately. Therefore sight distance required is less. While descending a gradient, gravity also comes into action and more time will be required to stop the vehicle. Sight distance required will be more in this case. **Stopping sight distance (SSD)**

Stopping sight distance (SSD) is the minimum sight distance available on a highway at any spot having sufficient length to enable the driver to stop a vehicle travelling at design speed, safely without collision with any other obstruction.

There is a term called safe stopping distance and is one of the important measures in traffic engineering.

It is the distance a vehicle travels from the point at which a situation is first perceived to the time the deceleration is complete.

Drivers must have adequate time if they are to suddenly respond to a situation.

Thus in highway design, sight distance at least equal to the safe stopping distance should be provided.

The stopping sight distance is the sum of lag distance and the braking distance.

Lag distance is the distance the vehicle travelled during the reaction time t and is given by vt, where v is the velocity in m⁄sec2 .

Braking distance is the distance travelled by the vehicle during braking operation.

For a level road this is obtained by equating the work done in stopping the vehicle and the kinetic energy of the vehicle.

If F is the maximum frictional force developed and the braking distance is l, then work done against friction in stopping the vehicle is Fl = fWl where W is the total weight of the vehicle.

The kinetic energy at the design speed is

$$\begin{aligned} \frac{1}{2}mv^2 &= \frac{1}{2}\frac{Wv^2}{g} \\ fWl &= \frac{Wv^2}{2g} \\ l &= \frac{v^2}{2gf} \end{aligned}$$

Therefore, the SSD = lag distance + braking distance and given by:

$$SSD = vt + \frac{v^2}{2gf}$$

When there is an ascending gradient of say +n%, the component of gravity adds to braking action and hence braking distance is decreased.

The component of gravity acting parallel to the surface which adds to the the braking force is equal to W sin α ≈ W tan α = Wn⁄100.

Equating kinetic energy and work done:

$$\begin{aligned} \left(fW + \frac{Wn}{100}\right) l &= \frac{Wv^2}{2g} \\ l &= \frac{v^2}{2g\left(f + \frac{n}{100}\right)} \end{aligned}$$

Overtaking sight distance:-

The overtaking sight distance is the minimum distance open to the vision of the driver of a vehicle intending to overtake the slow vehicle ahead safely against the traffic in the opposite direction.

The overtaking sight distance or passing sight distance is measured along the centre line of the road over which a driver with his eye level 1.2 m above the road surface can see the top of an object 1.2 m above the road surface.

The factors that affect the OSD are:

1. Velocities of the overtaking vehicle, overtaken vehicle and of the vehicle coming in the opposite direction.
2. Spacing between vehicles, which in-turn depends on the speed
3. Skill and reaction time of the driver
4. Rate of acceleration of overtaking vehicle
5. Gradient of the road

The dynamics of the overtaking operation is given in the figure which is a time-space diagram.

The x-axis denotes the time and y-axis shows the distance travelled by the vehicles.

The trajectory of the slow moving vehicle (B) is shown as a straight line which indicates that it is travelling at a constant speed.

A fast moving vehicle (A) is travelling behind the vehicle B.

The trajectory of the vehicle is shown initially with a steeper slope.

The dotted line indicates the path of the vehicle A if B was absent.

The vehicle A slows down to follow the vehicle B as shown in the figure with same slope from t0 to t1.

Then it overtakes the vehicle B and occupies the left lane at time t3. The time duration T = t3 - t1 is the actual duration of the overtaking operation.

The snapshots of the road at time t0,t1, and t3 are shown on the left side of the figure. From the Figure 1, the overtaking sight distance consists of three parts. 1. d1 the distance travelled by overtaking vehicle A during the reaction time t = t1 - t0 2. d2 the distance travelled by the vehicle during the actual overtaking operation T = t3-t1

3. d3 is the distance travelled by on-coming vehicle C during the overtaking operation (T).

Therefore:

$$OSD = d_1 + d_2 + d_3 \tag{3}$$

It is assumed that the vehicle A is forced to reduce its speed to vb, the speed of the slow moving vehicle B and travels behind it during the reaction time t of the driver. So d1 is given by:

$$d_1 = v_b t \tag{4}$$

Then the vehicle A starts to accelerate, shifts the lane, overtake and shift back to the original lane. The vehicle A maintains the spacing s before and after overtaking. The spacing s in m is given by:

$$s = 0.7v_b + 6 \tag{5}$$

Let T be the duration of actual overtaking. The distance travelled by B during the overtaking operation is 2s + vbT. Also, during this time, vehicle A accelerated from initial velocity vb and overtaking is completed while reaching final velocity v. Hence the distance travelled is given by:

$$\begin{aligned} d_2 &= v_b T + \frac{1}{2} a T^2 \\ 2s + v_b T &= v_b T + \frac{1}{2} a T^2 \\ 2s &= \frac{1}{2} a T^2 \\ T &= \sqrt{\frac{4s}{a}} \\ d_2 &= 2s + v_b \sqrt{\frac{4s}{a}} \end{aligned} \tag{6}$$

The distance travelled by the vehicle C moving at design speed v m⁄sec during overtaking operation is given by:

$$d_3 = vT \tag{7}$$

The overtaking sight distance is

$$OSD = v_b t + 2s + v_b\sqrt{\frac{4s}{a}} + vT \tag{8}$$

where vb is the velocity of the slow moving vehicle in m⁄sec2 , t the reaction time of the driver in sec, s is the spacing between the two vehicle in m given by equation 5 and a is the overtaking vehicles acceleration in m⁄sec2 . In case the speed of the overtaken vehicle is not given, it can be assumed that it moves 16 kmph slower the design speed.

Sight distance at intersections:-

At intersections where two or more roads meet, visibility should be provided for the drivers approaching the intersection from either sides. They should be able to perceive a hazard and stop the vehicle if required. Stopping sight distance for each road can be computed from the design speed. The sight distance should be provided such that the drivers on either side should be able to see each other. This is illustrated in the figure .

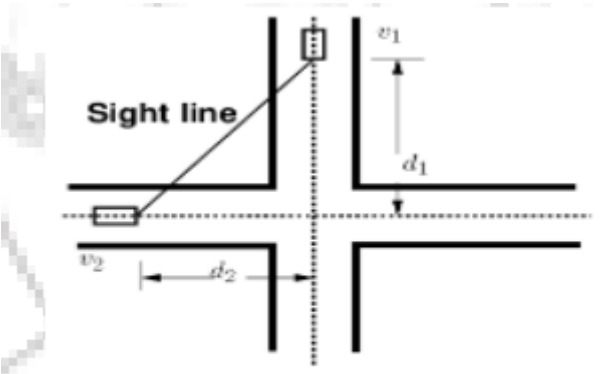


Figure : Sight distance at intersections

Design of sight distance at intersections may be used on three possible conditions:

1. Enabling approaching vehicle to change the speed
2. Enabling approaching vehicle to stop
3. Enabling stopped vehicle to cross a main road

P.I.E.V theory:-

According to P.I.E.V theory developed by some prominent traffic engineers the total reaction time of the driver is composed of the following four elements.

Perception Time:-

It is the required for the sensations received by the eyes or ears to be transmitted to the brain through the nervous system and spinal cord.

In other words it indicates the time required to perceive an object or situation.

Intellection Time:-

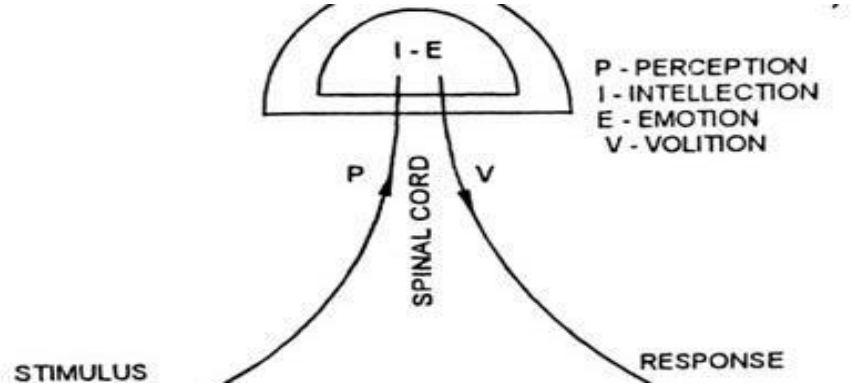
It is required for understanding the problem or situation.

Emotion Time:-

The emotion time is the which is passed during emotional sensations and disturbances such as fear, anger etc.

Volition Time:-

It is the time taken for the final action.



Curves:-

Curves are regular bends provided in the lines of communication like roads, railways etc. and also in canals to bring about the gradual change of direction.

They are also used in the vertical plane at all changes of grade to avoid the abrupt change of grade at the apex.

Curves provided in the horizontal plane to have the gradual change in direction are known as Horizontal curves, whereas those provided in the vertical plane to obtain the gradual change in grade are known as vertical curves.

Curves are laid out on the ground along the centre line of the work. They may be circular or parabolic.

Types of Curves

There are two types of curves provided primarily for the comfort and ease of the motorists in the road namely:

1. Horizontal Curve
2. Vertical Curve

Horizontal Curves

Horizontal curves are provided to change the direction or alignment of a road.

Horizontal Curve are circular curves or circular arcs.

The sharpness of a curve increases as the radius is decrease which makes it risky and dangerous.

The main design criterion of a horizontal curve is the provision of an adequate safe stopping sight distance.

Types of Horizontal Curve:

Simple Curve:

A simple arc provided in the road to impose a curve between the two straight lines.

Compound Curve:

Combination of two simple curves combined together to curve in the same direction.

Reverse Curve:

Combination of two simple curves combined together to curve in the same direction.

Transition or Spiral Curve:

A curve that has a varying radius. It is provided with a simple curve and between the simple curves in a compound curve.

While turning a vehicle is exposed to two forces.

The first force which attracts the vehicle towards the ground is gravity.

The second is centripetal force, which is an external force required to keep the vehicle on a curved path.

At any velocity, the centripetal force would be greater for a tighter turn (smaller radius) than a broader one (larger radius).

Thus, the vehicle would have to make a very wide circle in order to negotiate a turn.

This issue is encountered when providing horizontal curves by designing roads that are tilted at a slight angle thus providing ease and comfort to the driver while turning.

This phenomenon is defined as super elevation, which is the amount of rise seen on a given cross-section of a turning road, it is otherwise known as slope.

Vertical Curves

Vertical curves are provided to change the slope in the road and may or may not be symmetrical.

They are parabolic and not circular like horizontal curves.

Identifying the proper grade and the safe passing sight distance is the main design criterion of the vertical curve, crest vertical curve the length should be enough to provide safe stopping sight distance and in sag vertical curve the length is important as it influences the factors such as headlight sight distance, rider comfort and drainage requirements.

Types of Vertical Curve:

Sag Curve

Sag Curves are those which change the alignment of the road from uphill to downhill,

Crest Curve/Summit Curve

Crest Curves are those which change the alignment of the road from downhill to uphill. In designing crest vertical curves it is important that the grades be not] too high which makes it difficult for the motorists to travel upon it.

Super elevation:

When a vehicle travels in a circular path or curved path, it is subjected to an outward force which makes a vehicle to overturn and skid due to Centrifugal force.

To overcome this force and for safe travel of a vehicle, the outer edge of the road is raised above the inner edge. This is known as super elevation or banking of road.

Super-Elevation / Banking of road reduce the effect of centrifugal force on the running wheels.

If super-elevation is not provided with the entire centripetal force is produced by the friction between the vehicle's tires and the roadway, thus results in reducing the speed of a vehicle.

Advantages of providing Super elevation:-

Super elevation is provided to achieve the higher speed of vehicles. It increases the stability of fast-moving vehicles when they pass through a horizontal curve, and it also decreases the stresses on the foundation.

In the absence of super elevation on the road along curves, potholes are likely to occur at the outer edge of the road.

The Indian road congress (IRC) has prescribed the max value of Super Elevation is 1 in 15.

Derivation of Super Elevation :

When a vehicle passes from a straight to a curved path or in other words when a vehicle negotiates horizontal curve following two forces act on vehicle: 1. Centrifugal Force 2. Weight of the Vehicle

Centrifugal Force - The centrifugal force is a function of the speed of the moving vehicle. It always acts at the centre of gravity of the vehicle.
It's direction always tends to outside, i.e., it always tends to push the vehicle out of the track. to counteract this tendency, the outer edge of the road is raised above the inner edge. This rise of the outer edge is called super-elevation or cant or banking.

Thus super-elevation e is the ratio of the height of the outer edge with respect to the horizontal width.

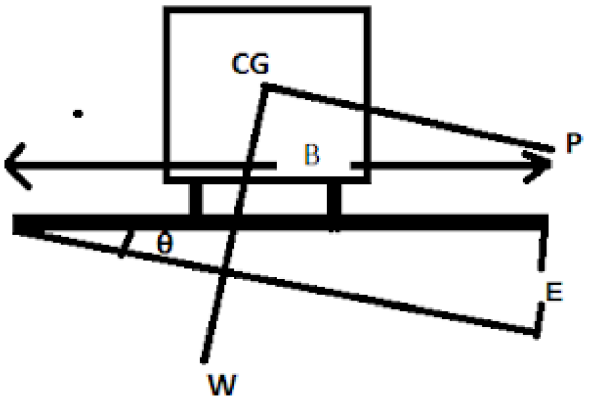
$$e = \tan \theta$$

In practice, the value of θ is kept as 4° or a slope of 1 in 15 with horizontal.

The total height of the outer edge with respect to the inner edge

$E = e \times$ width of road $= e\ B$

The centrifugal force $P = Wv2/gR$



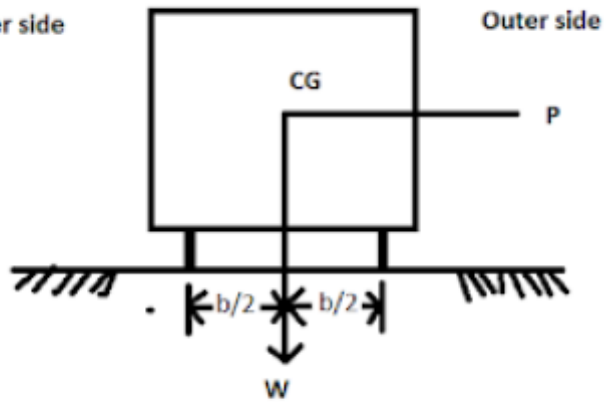
Super Elevation

Where,
W = weight of the vehicle
v = velocity of the vehicle
R = radius of circular curve
P = centrifugal force
g = acceleration due to gravity

1. Effect of Centrifugal Force

1. The tendency to overturn the vehicle.
2. The tendency to skid the vehicle laterally.

Stability Condition Against Overturning



Overturning due to Centifugal force

The figure shows a vehicle moving on horizontal a curve. Forces acting on the vehicle are

a.)Centrifugal force P acting outward at C.G.

b.) Weight W acting downward at C.G.

Let h be the height of C.G. of the vehicle above the road level. The overturning moment due to centrifugal force.

$$= P \times h$$

The restoring moment = $W \times b/2$

where b is the centre to centre distance of wheels of the vehicle. in limiting equilibrium

$$Ph = Wb/2$$

$$P/W = b/2h$$

When the centrifugal ratio, P/W is equal to B/2h there is a danger of overturning.

Thus to avoid overturning, the centrifugal ratio should always be less than b/2h. Also

$$P/W = v2/gR$$

$$v2/gR < b/2h$$

Thus to avoid overturning h should be as small as possible. Only due to this reason modern passenger cars have a low centre of gravity.

Methods of providing super – elevation :

Super-elevation is designed for the particular vehicle called design vehicle which has some standard weight and dimensions.

But in the actual case, the road has mixed traffic conditions. Different vehicles require different values of super-elevation.

For example Heavily loaded trucks require the small value of super-elevation otherwise toppling may occur, fast moving vehicles may be provided with high super-elevation while slow moving ones require small super-elevation.

The design procedure for super-elevation is as follows:

Step 1 Find value of super-elevation taking 75% of design speed neglecting f,

$$\text{Hence, } e = (0.75v)\ 2 / (g*R)$$

Step 2 If value of e is less than 0.07 then it is taken for design otherwise value of e is taken as 0.07.

Step 3 Find value of frictional coefficient (f) with full design speed regarding maximum super-elevation.

$$\text{Hence, } f = v2 / (g*R) – e = v2 / (g*R) – 0.07$$

Step 4 If value for f is less than 0.15 then it is taken for design otherwise value for f is taken as 0.15.

Step 5 The allowable speed for maximum value of e = 0.07 and f = 0.15 is calculated

Hence, Allowable speed (Va) = $\sqrt{}$ (0.22g*R)

If the allowable velocity is greater than or equal to v then the design is adequate otherwise other speed control measures are adopted.

Different guidelines are given in NRS for the design of horizontal curvature.

In terms of velocity in kmph it is calculated as,

$$\text{Or, } V2 / (126.5*R) = e + f$$

$$\text{And, } Va = \sqrt{[126.5*R*(e + f)]}$$

Question Set.

Classroom Teaching

Group- A

Explain right of way. (2015w)[2017W(n)][2018S(n)]
What is kerb ? (2012 s)
What is gradient ?
What is formation width of a road? (2012 s, 2016 s)
Draw general shapes of different types of transition curve? (2015 w)
What do you mean by over taking or safe passing sight distance? [2017W(n)]
What is the building line in a road alignment?
Define cant or super elevation? (2016 s)[2017W(n)]
Why camber is provided in a road? (2012 s)
What do you mean by transition curve? (2016 s)

Group- B

1.Write short notes on

i) Stopping sight distance, ii) Cant and camber iii) Sight distance

2. Calculate the super elevation required for a concrete road 7.5m wide on a curve of 800m radius for a design speed of 50 kmph? [2012S]
3. What do you mean by overtaking sight distance? Derive the expression for overtaking sight distance two lane with two way traffic. [2018S(n)]
4. Calculate the allowable speed on horizontal curve of radius 450m, if the limiting values of lateral co-eff. of friction is 0.15 and the rate of super elevation is 0.07. [2017W(n)]
5. What are the objects of providing transition curve?

Group- C

The speed of overtaking and overtaken vehicles are 70 kmph and 40 kmph respectively on a two way traffic road. If the acceleration of the overtaking vehicle is 0.99 m/sec. [2017W(n)]

Calculate the safe overtaking sight distance if reaction time =2sec.

Determine the minimum length of overtaking zone. [2018S(n)]

iii) Draw a neat sketch of overtaking zone and show the position of sign post.

2. Draw the typical cross-section of a national highway in cutting and filling indicating the width of pavement ,roadway and land also layers of road from the base. [2015(w),2016(w)]
3. Calculate the safe stopping sight distance for design speed of 60 kmph for

(i) two way traffic on a two lane road (ii) two way traffic on a single lane road. Assume co-eff. Of friction 0.37 and reaction time of driver is 2.5 sec. [2017S(n)] [2017W(n)]

4. Calculate the super elevation required for a road of 7.2 m wide on a curve of 240m radius for a permissible speed of 80 kmph. The co-eff. of friction is 0.15

5. The radius of horizontal circular curve is 100m. The design speed is 50 kmph and the design co-efficient of lateral friction is 0.15.

a) Calculate the super elevation required if full lateral friction is assumed to develop.

b) Calculate the co-eff. of friction needed if no super elevation is provided.

6. Design the rate of super elevation for a horizontal highway curve radius 750m and speed 110kmph. [2015 w] [2017W(n)]

2. Assignment Questions

Group-A

Why curves are provided on roads? [2017W(n)]
Define Road Margins.
What is camber or cross slope? (2016 s)
Define shoulder? [2017S(n)

Group- B

1. What is gradient? Explain the types of gradient. [2018S(n)]
2. A vehicle travelling at 60 KMPH was stopped within 2.8 sec after the application of break .Determine the average skid resistance. [2017W(n)]
3. Explain about PIEV theory with neat sketch. [2017S(n)][2018S(n)]

Group- C

Calculate the super elevation required for a concrete road 7.5m wide on a curve of 800m radius for a design speed of 50 kmph. Assume coefficient of lateral friction as 0.15.Also calculate the equilibrium super-elevation for the condition when the pressure on inner and outer wheels will be equal. [2018S(n)]

Design the rate of super elevation for a horizontal highway curve radius 750m and speed 110kmph. [2015 w]

. The design speed of a highway is 80kmph. Horizontal curve of radius is 200m. Transverse coefficient of friction is 0.15.

i. Calculate the superelevation (e) required to maintain this speed.

ii. If the maximum superelevation of 0.07 is not to be exceeded, calculate the maximum allowable speed(V_a) on this horizontal curve. [2017S(n)]

3. Self Practice

Group-A

What is the necessity of highway planning?

State the IRC specifications for width of carriage way for various classes of roads.

What is SSD and HSD ?

Define reverse curve?

Group- B

A vertical summit curve is formed at the intersection of 2 gradients +3.0% and -5.0%.Design the length of summit curve to provide a SSD for design speed of 80 Kmph. Assume other suitable data.

[2017S(n)]

2. Explain total reaction time of the driver.

3. Define camber. What are the objectives of providing camber? Specify the recommended ranges of camber for different types of pavement surfaces.

Group-C

Calculate the stopping sight distance on a highway at a descending gradient of 2.35% for a design speed 65 kmph. Take the reaction time as 2.5 sec and design co-eff. Of friction as 0.35.

2. Write short notes about :

Right of way

Medians

Carriage

iv. Camber

3. calculate the minimum non-passing sight distance on a highway at a descending gradient of 6%. Given the following data :

i. Design speed=80kmph

ii. Reaction time of driver=2.5 sec

iii. Coefficient of friction between tyre and road surface=0.4

Faculty **HOD** **Principal**