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Internal Assessment Test 3 – November 2018

Sub:	Highway Geometric design				Sub Code:	10CV755	Branch :	CIVIL
Date:	22/11/2018	Duration:	90 mins	Max Marks: 50	Sem / Sec:	Exit Scheme		OBE

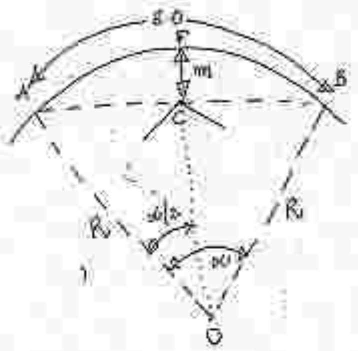
Answer **ALL** QUESTIONS

		MARKS	CO	RBT
1	Derive setback distance on Horizontal Curves.	[10]	CO2	L3

Case I: $L_c > S$

The length of circular curve > Sight distance(S)

C: obstruction ACB - Line of sight AFB = S



Setback distance, $m = CF = OF - OC$

$OF = R$

$\cos\frac{\alpha}{2} = \frac{OC}{R}$

$OC = R\cos\frac{\alpha}{2}$

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

Note: $\frac{\alpha}{2} = \frac{S}{2R}$ radians $= \frac{S}{2R} \times \frac{180}{\pi}^{\circ}$

In case of ~~lane~~ roads with two or more lanes :-

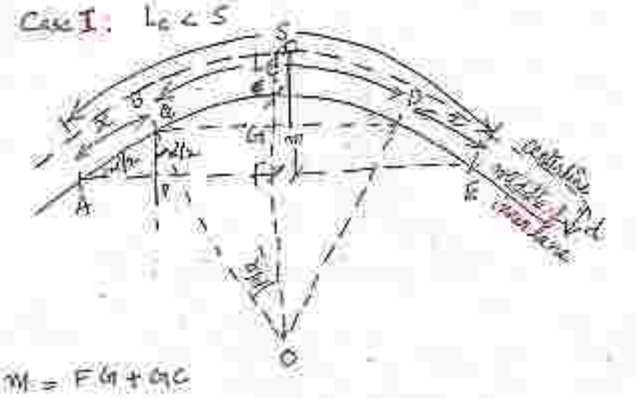
$m = R - (R-d)\cos\frac{\alpha'}{2}$ (m is measured from centerline of road.)

$\frac{\alpha'}{2} = \frac{S'}{2(R-d)}$ radians.

where 'd' is the distance in metres b/w the centerline and the middle of the inner lane.

S': sight distance measured along the middle of inner lane.

Case I : $L_c < S$



$m = EG + GC$

Calculating EG

* Find α' (angle subtended from O to the middle of inner lane)

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

2 A state highway passing through a rolling terrain has a horizontal curve of radius equal to the ruling minimum radius. Design all the geometric features of this horizontal curve, assuming suitable data. Specify the minimum set-back distance from the center line of the two lane highway on the inner side of the curve up to which the buildings should not be constructed so that ISD is available throughout the circular curve. Assume the length of the circular curve is greater than the sight distance. [15] CO2 L3

1.

(a) Ruling minimum radius, R_{ruling}

Ruling design speed, V = 80 kmph.

$$R_{ruling} = \frac{V^2}{g[e+f]}$$

$$= \frac{(80\times 5/18)^2}{9.81[0.07+0.15]}$$

$$= 229 m \approx 230$$

(b) Superelevation, e

$$e = \frac{(0.75V)^2}{gR}$$

$$= \frac{(0.75\times 80\times 5/18)^2}{9.81\times 230}$$

$$= 0.124 > 0.07$$

Limit $e = 0.07$

$$e + f = \frac{V^2}{gR}$$

$$0.07 + f = \frac{(80\times 5/18)^2}{9.81\times 230}$$

$$f = 0.14 < 0.15$$

$e = 0.07$ for V = 80 kmph is safe

(c) Extra widening

Assume $l = 6.0\,m$

$$W_e = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$$= \frac{2\times 6^2}{2\times 230} + \frac{80}{9.5\sqrt{230}}$$

$$= \underline{\underline{0.712\ m}}$$

Provide a total width of $7 + 0.712 = 7.712\,m$

(d) Length of transition curve

(i) Based on rate of intro of centrifugal acceleration

$$C = \frac{80}{75+V} = \frac{80}{75+80} = 0.52$$

C is b/w 0.5 & 0.8 → its safe.

$$L_s = \frac{v^3}{CR} = \frac{(80\times 5/18)^3}{0.52\times 230} = \underline{\underline{92\,m}}$$

(ii) Based on rate of intro of superelevation

$$L_s = \frac{E}{2}\times N$$

3	Explain the different types of gradients.	[05]	CO2	L2

Types of gradient

1. Ruling gradient
2. Limiting gradient
3. Exceptional gradient
4. Minimum gradient

Ruling gradient

It is the maximum gradient within which the vertical gradient can be fixed. It is also known as the "design gradient". The selection of a ruling gradient depends on the following factors —

a) Terrain

b) Length of the grade

c) Speed

d) Pulling power of vehicles

e) Presence of horizontal curves

Flatter the terrain lower will be the ruling gradient. Length of grade is more a lower gradient should be adopted. If the speed is more higher speed can adopt higher gradients considering loss of speed on gradients. If pulling power of vehicle is less then lower gradient is suitable. So selecting the ruling gradient for a mixed traffic conditions is difficult.

Limiting gradient

When topography of a place requires adopting for a steeper gradient than the ruling gradient 'limiting gradient' is used. It should be noted that the length of roads having limiting gradient should be limited. On rolling & hilly terrain it may be frequently necessary to exceed ruling gradient & adopt limiting gradient.

Exceptional gradient

In some extra ordinary situations it is required to provide still steeper gradients than limiting gradient upto 'exceptional gradient' may be provided. However the exceptional gradient should be strictly limited for stretches not exceeding 100m.

Minimum gradient

This is the gradient provided on roads to assist drainage. Drainage is permitted along camber to the side drains, but if only the side drains are allowed with a longitudinal gradient it will result in deep cuts for side drains

Maximum length of an ascending gradient which a loaded truck can operate without undue reduction in speed is called "critical length" of grade for a design. At speed reduction of 25kmph is considered as reasonable. So the critical length of grade depends on —

1. Size of vehicle
2. Load carried by vehicle
3. Power
4. Initial speed at the beginning of grade
5. Desirable limit of speed at the end of grade to prevent interference with movement of other vehicles.

Hence steeper the gradients, lower will be the critical length of the grade.

IRC has recommended ruling gradients values of

a) 1 in 30 on plain & rolling terrain

b) 1 in 20 on mountaineous terrain

c) 1 in 16.7 on steep terrains

4	Explain how the length of summit curve is decided.	[10]	CO2	L4

Length of Summit Curve

Length of summit curve for stopping sight distance (SSD)

Two cases:

(a) When the length of the curve is greater than the sight distance (L > SSD)

(b) When the length of the curve is lesser than the sight distance (L < SSD)

L > SSD

The general equation for length L of the "parabolic" curve is given by —

$$L = \frac{NS^2}{(\sqrt{2H} + \sqrt{2h})^2} \quad \text{(in metres)}$$

where

N: deviation angle
= $n_1 \sim n_2$
= difference in grades

S: SSD, m

H: height of eye of driver above the road, m

h: height of object above the road, m

For SSD

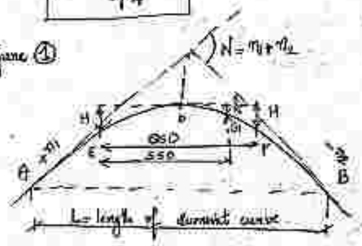
$H = 1.2\,m$

$h = 0.15\,m$

Substituting we get

$$L = \frac{NS^2}{4.4}$$

figure ①



Since the curve is flat $\widehat{AB} = \overline{AB}$

⇒ arc length AB = horizontal projection of AB = L

L < SSD

$$L = 2S - \frac{(\sqrt{2H} + \sqrt{2h})^2}{N}$$

$$L = 2S - \frac{4.4}{N} \quad \text{for } H = 1.2\,m,\ h = 0.15\,m$$

Length of summit curve for OSD or ISD

ⓐ L > OSD or ISD

ⓑ L < OSD or ISD

L > OSD

In equation $L = \frac{NS^2}{(\sqrt{2H} + \sqrt{2h})^2}$ put $H = 1.2\,m$, $h = H = 1.2\,m$

$h = H \Rightarrow L = \frac{NS^2}{8H}$

$h = H = 1.2 \Rightarrow L = \frac{NS^2}{9.6}$

Here S: OSD or ISD in metre

L < OSD

In equation $L = 2S - \frac{(\sqrt{2H} + \sqrt{2h})^2}{N}$

put $h = H \Rightarrow L = 2S - \frac{8H}{N}$

$h = H = 1.2 \Rightarrow L = 2S - \frac{9.6}{N}$

5 (a)	A vertical summit curve is formed at the intersection of two gradients, +3% and -5%. Design the length of summit curve to provide a stopping sight distance for a design speed of 80 kmph. Assume other data	[05]	CO2	L3

$V = 80\,kmph$ $\quad n_1 = 3\%$ $\quad n_2 = -5\%$

Determine SSD

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

$$= \left(80 \times \frac{5}{18} \times 2.5\right) + \frac{(80 \times 5/18)^2}{2 \times 9.81 \times 0.35}$$

$$= 55.56 + 71.91$$

$$= 128\,m$$

Determine length of summit curve.

Deviation angle, $N = n_1 - (-n_2)$

$= 3 - (-5) = 8\%$

$= 0.08$

Assuming L > SSD

$$L = \frac{NS^2}{4.4} = \frac{0.08 \times 128^2}{4.4} = 298\,m$$

As per assumption L > SSD ∴ length of summit curve = 298 m

Check for minimum specified length of summit curve as per Table 1 :

min L = 50m

Hence design length = 298 m

Table 1: Minimum length of vertical curve

Design speed kmph	Max grade change (%) not requiring a vertical curve	Min length of vertical curve, m
35	1.5	15
40	1.2	20
50	1.0	30
65	0.8	40
80	0.6	50
100	0.5	60

(b) An ascending gradient of 1 in 100 meets a descending gradient of 1 in 120. A summit curve is to be designed for a speed of 80 kmph so as to have an overtaking sight distance of 470 m. [05] CO2 L3

Design speed, V = 80kmph

OSD = 470m

$$N = \frac{1}{100} - \left(-\frac{1}{120}\right) = \frac{11}{600}$$

Assume, L > OSD

$$L = \frac{NS^2}{9.6} = \frac{11 \times 470^2}{600 \times 9.6} = 422m$$

as L < OSD the assumption is wrong.

Assume L < OSD

$$L = 2S - \frac{9.6}{N}$$

$$= 2 \times 470 - \frac{9.6 \times 600}{11}$$

$$= 416.4 \text{ m}$$

$$\simeq 417 \text{m}$$

As the value of L = 417 < OSD the assumption is correct.