USN :

CMR Institute of Technology, Bangalore
DEPARTMENT OF CIVIL ENGINEERING
II - INTERNAL ASSESSMENT

Semester: 6-CBCS 2017
Subject: HIGHWAY ENGINEERING (17CV63)
Faculty: Ms Divya Viswanath

Date: 23 Jun 2021
Time: 09:00 AM - 10:30 AM
Max Marks: 50

Instructions to Students :

Answer all Questions.

Answer All Questions

Q.No			Marks	CO	BT/CL
1	a	Discuss the different types of gradients.	6	CO2	L2
	b	Calculate the values of ruling minimum and absolute minimum radius of horizontal curve of a NH in plain terrain. Assume ruling design speed and minimum design speed values as 100 and 80 kmph respectively.	4	CO2	L3
2	a	Explain PIEV theory with a neat sketch.	5	CO2	L2
	b	Calculate the extra widening required for a pavement of width 7m on a horizontal curve of radius 250 m if the longest wheel base of vehicle expected on the road is 7 m. Design speed is 70 kmph.	5	CO2	L3
3	a	Define camber. Discuss the functions of camber and factors on which amount of camber to be provided depends.	4	CO2	L2
	b	Calculate the safe overtaking sight distance on one-way traffic road for a design speed of 96 kmph. Take A=2.5 kmph/sec and assume all other data suitably.	6	CO2	L4
4	a	The design speed of a highway is 80 kmph. There is a horizontal curve of radius 200 m on a certain locality. Design the superelevation needed. Safe limit of transverse coefficient of lateral friction is 0.15.	6	CO2	L3
	b	What are the desirable properties of aggregates? List the tests involved in determining these properties.	4	CO3	L2
5		Define modulus of subgrade reaction. With a neat sketch explain plate load test for determining the k value. Also explain the corrections applied in plate load test.	10	CO3	L2

IAT-2-SOLUTIONS

HIGHWAY ENGINEERING (17CV63)

1.a.

Ruling gradient :-The ruling gradient or the design gradient is the maximum gradient with which the designer attempts to design the vertical profile of the road. This depends on the terrain, length of the grade, speed, pulling power of the vehicle and the presence of the horizontal curve. In flatter terrain, it may be possible to provide at gradients, but in hilly terrain it is not economical and sometimes not possible also. The ruling gradient is adopted by the designer by considering a particular speed as the design speed and for a design vehicle with standard dimensions. But our country has a heterogeneous traffic and hence it is not possible to lay down precise standards for the country as a whole. Hence IRC has recommended some values for ruling gradient for different types of terrain.

Limiting gradient :-This gradient is adopted when the ruling gradient results in enormous increase in cost of construction. On rolling terrain and hilly terrain it may be frequently necessary to adopt limiting gradient. But the length of the limiting gradient stretches should be limited and must be sandwiched by either straight roads or easier grades.

Minimum gradient :-This is important only at locations where surface drainage is important. Camber will take care of the lateral drainage. But the longitudinal drainage along the side drains requires some slope for smooth flow of water. Therefore minimum gradient is provided for drainage purpose and it depends on the rain fall, type of soil and other site conditions. A minimum of 1 in 500 may be sufficient for concrete drain and 1 in 200 for open soil drains are found to give satisfactory performance.

1.b.

$$R_{ruling} = \frac{V^2}{127(e+f)} = \frac{100^2}{127(0.07+0.15)} = 357.9 \text{ m say } 360$$

The absolute minimum radius is calculated from the minimum design of V'' = 80 kmph, using Eq. 4.14.

$$R_{min} = \frac{V'^2}{127(e+f)} = \frac{80^2}{127(0.07+0.15)} = 229.1 \text{ m say } 230 \text{ m}$$

2.a.

PIEV Theory : According to this theory the total reaction time of the driver is split into four parts, viz., time taken by the driver for :

(i) Perception

(ii) Intellection

(iii) Emotion, and

(iv) Volition

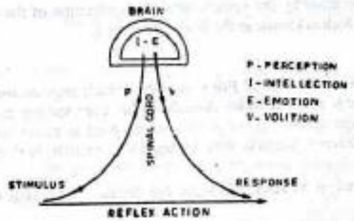
Perception time is the time required for the sensations received by the eyes or ears to be transmitted to the brain through the nervous system and spinal chord. In other words, it is the time required to perceive an object or situation.

Intellection time is the time required for understanding the situation. It is also the time required for comparing the different thoughts, regrouping and registering new sensations.

Emotion time is the time elapsed during emotional sensations and disturbance such as fear, anger or any other emotional feelings such as superstition etc. with reference to the situation. Therefore the emotion time of a driver is likely to vary considerably depending upon the problems involved.

Volition time is the time taken for the final action.

It is also possible that the driver may apply brakes or take any avoiding action by the reflex action, even without thinking. The PIEV process has been illustrated in Fig. 4.12.



2.b.

Extra widening required $W_e = W_m + W_{ps}$

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

Hence, n = 2 (two lanes for pavement width of 7.0 m)

$$l = 7.0$$

$$R = 250 \text{ m}$$

$$V = 70 \text{ kmph}$$

$$W_e = \frac{2 \times 7^2}{2 \times 250} + \frac{70}{9.5\sqrt{250}}$$

$$= 0.196 + 0.466 = 0.662 \text{ m}$$

3.a.

Cross Slope or Camber

Cross slope or *chamber* is the slope provided to the road surface in the transverse direction to drain off the rain water from the road surface. Drainage and quick disposal of water from the pavement surface by providing cross slope is considered important because of two reasons :

(i) To prevent the entry of surface water into the subgrade soil through pavement; the stability, surface condition and the life of the pavement get adversely affected if the water enters in the subgrade and the soil gets soaked.

(ii) To prevent the entry of water into the bituminous pavement layers, as continued contact with water causes stripping of bitumen from the aggregates and results in deterioration of the pavement layer.

(iii) To remove the rain water from the pavement surface as quickly as possible and to allow the pavement to get dry soon after the rain; the skid resistance of the pavement gets considerably decreased under wet condition, rendering it slippery and unsafe for vehicle operation at high speeds.

The required camber of a pavement depends on :

(i) the type of pavement surface, and

(ii) the amount of rainfall

A flat camber of 1.7 to 2.0% is sufficient on relatively impervious pavement surface like cement concrete or bituminous concrete. In pervious surface like water bound macadam or earth road which may allow surface water to get into the subgrade soil, steeper cross slope is required. Steeper camber are also provided in areas of heavy rainfall.

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

3.b.

$$O.S.D = (d_1 + d_2) \text{ for one-way traffic}$$

$$= (d_1 + d_2 + d_3) \text{ for two-way traffic}$$

$$V = 96 \text{ kmph}$$

Assume $V_b = V - 16 = 80$ kmph and

A 2.5 kmph/sec. (from Table 4.7); t = 2 secs.

$$d_1 = 0.28\, V_b\, t = 0.28 \times 80 \times 2 = 44.8 \text{ m}$$

$$d_2 = 0.28\, V_b\, T + 2s$$

$$s = (0.2\, V_b + 6) = 0.2 \times 80 + 6 = 22 \text{ m}$$

$$T = \sqrt{\frac{14.4 s}{A}} = \sqrt{\frac{14.4 \times 22}{2.5}} = 11.3 \text{ secs.}$$

$$d_2 = 0.28 \times 80 \times 11.3 + 2 \times 22 = 297 \text{ m}$$

$$d_3 = 0.28\, V\, T = 0.28 \times 96 \times 11.3 = 303.7 \text{ m}$$

O.S.D. on one-way traffic road $= d_1 + d_2 = 341.8$ m; say 342 m

O.S.D. on two-way traffic road $= d_1 + d_2 + d_3 = 645.5$ m; say 646 m

4.a.

$$e = \frac{V^2}{225\, R}$$

i.e.,

$$e = \frac{80^2}{225 \times 200} = 0.142$$

Maximum allowable value of e is to be limited to 0.07.

Check for the value of friction developed,

$$f = \frac{V^2}{127\, R} - 0.07$$

$$= \frac{80^2}{127 \times 200} - 0.07 = 0.18$$

As this value is greater than the maximum allowable safe friction coefficient of 0.15 and also as the radius can not be increased, the speed has to be restricted.

Hence the maximum allowable speed (V_a kmph) on this curve is obtained by assuming the full value of design friction coefficient on 0.15. This is given by the Eq. 4.11.

$$V_a = \sqrt{27.94\, R} = 74.75 \text{ kmph}$$

Hence the speed may be restricted to less than 74 or say 70 kmph at this curve.

4.b.

Aggregates:- The desirable properties of sub grade soil as a highway material are:

Strength

- ✓ The aggregates should be strong to withstand the stresses due to traffic wheel load.
- ✓ Aggregates used in top layers of pavements I.e. wearing course have to be capable of withstanding high stresses in addition to wear and tear hence should posses resistance to crushing.

Hardness

- ✓ The aggregate used in surface course are subjected to constant rubbing or abrasion due to moving traffic.
- ✓ They should be hard enough the wear due to abrasive action of traffic.

Toughness

- ✓ Aggregates in pavements are subjected to impact due to moving wheel loads.
- ✓ Severe impact like hammering is seen when heavily loaded steel tyred vehicles move on WBM roads.

Durability

- ✓ They should be durable and should resist disintegration due to action of weather.
- ✓ The property of the stones to withstand adverse action of weather is called soundness.

- ✓ The aggregates are subjected to physical and chemical action of rain and ground weather and hence road stones should be sound enough to withstand weathering action.

Shape of aggregates

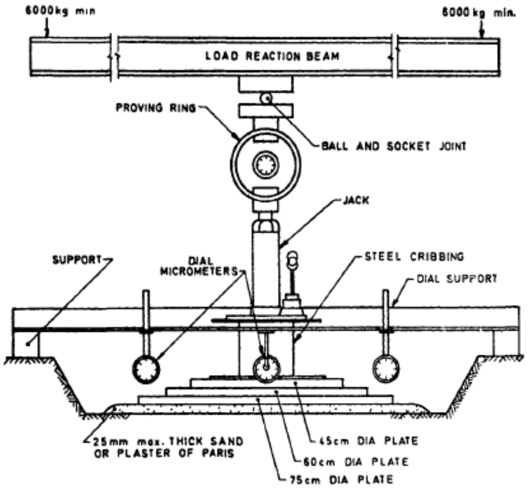
- ✓ Flaky and elongated aggregates will have less strength compared with cubical, angular or rounded particles.

Adhesion with Bitumen The aggregates used in bituminous pavements should have less affinity with water or else bituminous coating on the aggregate will be stripped off in presence of water.

Test for Road Aggregates:-

1. Crushing test
2. Abrasion test
3. Impact test
4. Soundness test
5. Shape test
6. Specific gravity and water absorption test
7. Bitumen adhesion test

5. Modulus of sub grade reaction (K) is the reaction pressure sustained by the soil sample under a rigid plate of standard diameter per unit settlement measured at a specified pressure or settlement. IRC specifies that the K value be measured at 1.25 mm settlement. A compressive stress is applied to the pavement layer through plates of large size and deflections are measured for various stress values. Prepare the test site and remove the loose material so that 75 cm diameter plate rests horizontally in full contact with the soil sub-grade. Place the plate accurately and then apply a seating load equivalent to a pressure of 0.07 kg/cm^2 and release it after few seconds. The settlement dial readings are adjusted to zero for zero load. A load is applied by means of the jack, sufficient to cause an average settlement of about 0.25 mm.



When there is no perceptible increase in settlement or when the rate of settlement is less than 0.025 mm per minute, the load dial reading and the settlement dial readings are noted. The average of the three or four settlement dial readings is taken as the average settlement of the plate corresponding to the applied load. The load is increased till the average settlement increased to a further amount of about 0.25 mm and the load and the average settlement readings are noted as before. The procedure is repeated until the settlement is about 1.75 mm. A graph is plotted with the mean settlement (mm) on x axis and load (kN/m ^{2}) on y-axis. The pressure p corresponding to a settlement of 1.25 mm is obtained from the graph. The modulus of sub-grade reaction K is calculated from the relation K = P/0.00125 kN/m ^{2} /m or kN/m ^{3}

Correction for plate size:- If the reaction load is to be reduced a plate of smaller diameter has to be used. If K_1 is the modulus of sub grade of smaller size plate and a_1 is the diameter of the smaller plate, then the K value corresponding to the standard plate (diameter a) is K = $(K_1a_1)/a$.

Allowance for worst subgrade moisture:- Two samples are collected from the site where the plate load test was conducted. One sample is subjected to laboratory compression test under unsoaked condition and the other in soaked condition. Pressure sustained by the soil samples at different settlements is plotted.