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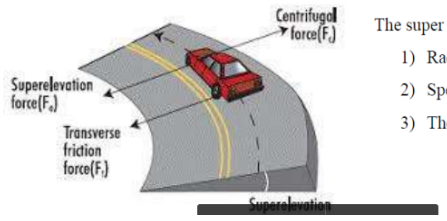
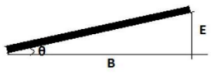
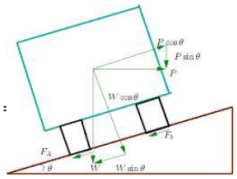
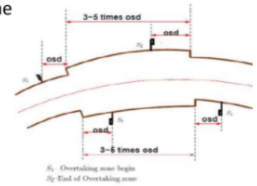
Internal Assessment Test 2 – December 2021

Sub:	Highway Engineering					SubCode:	18CV56	Branch:	All Branches
Date:	17.12.2021	Duration:	90 mins	Max Marks:	50	Sem/Sec:	V	OBE	

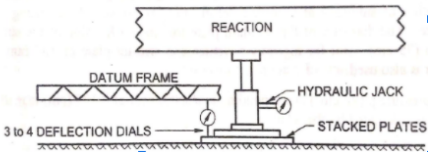
Answer any five full questions.
Provide neat sketches wherever necessary

		MARKS	CO	RBT
1 a)	What are the desirable properties of sub grade? Desirable properties of sub grade soil as highway material. 1. Stability 2. Incompressibility 3. Permanency of strength 4. Minimum changes in volume and stability under adverse condition of weather and ground water. 5. Good drainage 6. Ease of compaction	[04]	CO3	L2
b)	Calculate the safe stopping sight distance for design speed of 50kmph. For (i) Two way traffic on two lane road (ii) Two way traffic on a single lane road. Assume f = 0.37 and reaction time , t = 2.5 sec. Stopping Distance, SD = Lag Distance + Braking Distance $SD = v\,t + \frac{v^2}{2gf}$ in meters SSD = 61.23 m ii) For single lane road two way traffic Minimum SSD = 2 x SSD calculated iii) For two lane two way traffic Minimum SSD = SSD calculated i-> 61.23m ii -> 122.46m	[06]	CO2	L3
2	Why super elevation is provided? Derive the expression for super elevation and list the factors affecting super elevation? **Definition: Raising of the outer edge** of pavement **with respect to** the **inner** on a horizontal curve**. It is a transverse slope.** In order to counteract the effect of centrifugal force and to reduce the tendency of the vehicle to overturn or skid, the outer edge of the pavement is raised with respect to the inner edge, thus providing a transverse slope throughout the length of the horizontal curve. This transverse inclination to the pavement surface is known as **SUPER ELEVATION or CANT or BANKING.**  The super elevation depends upon 1) Radius of the curve R, 2) Speed of the vehicle V 3) The coefficient of lateral friction f	[10]	CO2	L2

	a) Super elevation is given by $e = \tan\theta = \text{Sin}\,\theta = \frac{E}{B}$ e is the rate of super elevation E: Total super elevation height  **b) General equation** $\boxed{e+f = v^2/gR}$ e = rate of super elevation f = design value of lateral friction coefficient = v = speed of the vehicle, m/sec R = radius of the horizontal curve, m g = acceleration due to gravity = 9.8 m/sec^2  **C) Equilibrium super elevation (NO FRICTION)** $e+\cancel{f}^{0} = v^2/gR$ Both tyres of vehicle will have same pressure Dr. Smaranika Panda d) **If there is no super-elevation** provided due to some practical reasons, then e = 0 and becomes f = v ^{2}/gR . This results in a very high coefficient of friction. e) **If e = 0 and f = 0.15** then for safe travelling speed is given by v = $\sqrt{\text{fgR}}$ where v is the restricted speed. f) Maximum super elevation as per IRC e max= 7% for plain, rolling and in snow hilly terrain e max = 10% for hilly terrain not bound by snow			
3	The speed of overtaking and overtaken vehicles are 70 and 40 kmph, respectively on a two way traffic road. If the acceleration of overtaking vehicle is 0.99m/sec^2 Calculate safe overtaking sight distance, Mention the minimum length of overtaking zone. (a) OSD for two way traffic = d1+d2+d3 v= (70/3.6)m/s = 19.4m/s vb= (40/3.6)m/s = 11.1m/s $s = (0.7v_b + 6) = (0.7\times11.1+6) = 13.8m$ $T = \sqrt{\frac{4s}{a}} = \sqrt{\frac{4\times13.8}{0.99}} = 7.47\,\text{sec}$ $d_1 = v_b t = 11.1\times2 = 22.2m$ $d_2 = v_b T + 2s = 11.1\times7.47+2\times13.8 = 110.5m$ $d_3 = vT = 19.4\times7.47 = 144.9m$ $OSD = d_1 + d_2 + d_3 = (22.2+110.5+144.9)m = 277.6m \approx 278m$ (b) Minimum length of overtaking zone = 3 (OSD) = 3 (d1+d2+d3) = 834m Desirable length of overtaking zone =5 (OSD) = 1390m (c) Draw overtaking zone  	[10]	CO2	L3

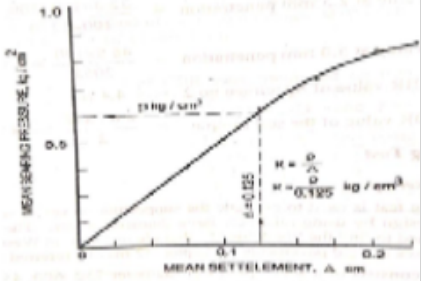
4	Enumerate the identification and classification tests of soils.
	• A-1 to A-7
	• Sieve analysis , liquid limit test, plastic limit test – these test was conducted to come down to this classification.
	• A-1 to A-3 – granular soils or coarse grained soils
	  • % of passing 0.075mm sieve is less than 35
	• A-4 to A-7 – fine grained soils or silty clay soils
	  • % of passing 0.075mm sieve is more than 35
		[10]	CO3	L2

	A -1 group
	• Well graded mixture of stone particles , gravel, sand and some fine particles.
	  • A-1-a – predominately having stone particles.
	  • A-1-b - predominately having coarse sand.
	
	A -2 group
	• Consists of granular soil particles from group A-1 to A-3 and 35% of fine particles from the group of A-4 to A-7
	  • A-2-4
	  • A-2-5
	  • A-2-6
	  • A-2-7
	
	A -3 group
	• Medium graded sand and fine particles, it also consists of stone particles and gravels.
	
	A -4 group
	• Non plastic or slightly plastic silty soils
	  • Silty soils – Liquid limit < 40% and PI < 10%
	
	A -5 group
	• Consists of plastic clay soil i.e they have very high volume change characteristics with change in moisture content
	• LL > 40% and PI < 10%
	
	A -6 group
	• Consists of plastic clay soil i.e they have very high volume change characteristics with change in moisture content
	• LL < 40% and PI > 10%
	
	A -7 group
	• Consists of soil finer than A-6 group
	• LL > 40% and PI > 10%			

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.
	Modulus of subgrade reaction 'K'
	It is defined as the pressure sustained per unit deformation of subgrade at specified deformation or pressure level using specified plate size.
	• To evaluate the supporting strength of the subgrade or pavement as a whole.
	• Originally – to find Modulus of subgrade reaction 'K' – Westergaard's wheel load analysis
	• Apparatus:-
	  • Plates of 75, 60, 45 and 30 cm diameter.
	  • Loading frame with a hydraulic jack
	  • Reaction frame
	  • Datum Frame
	 
	
	Plate load test
	Test procedure:-
	1. Test site is levelled
	2. Plates in decreasing diameters are placed on the prepared surface.
	3. Hydraulic jack is then placed over it and reaction frame will be attached.
	4. From the lower plate, series of dial gauges will be attached to measure the settlement values.
	5. A seating load (320kg for 75 cm diameter plate) of 0.07 kg/cm^2 is applied to properly seat the plates on the surface. It is then released after few seconds
	6. Dial gauges are set to zero.
	7. Load causing approximately 0.25 mm average settlement is applied
	8. When rate of settlement <0.025mm per minute, reading of the dial gauges are noted and corresponding load value.
		[10]	CO3	L3

Test procedure:-

9. Load is increased to cause further 0.25 mm average settlement
10. Again when rate of settlement <0.025mm per minute, reading of the dial gauges are noted and corresponding load value.
11. This is repeated till settlement reaches 1.75 mm
12. A graph is plotted



Bearing pressure – settlement curve

Modulus of subgrade reaction 'K'

It is defined as the pressure sustained per unit deformation of subgrade at specified deformation or pressure level using specified plate size.

The pressure p corresponding to a settlement of 0.125(cm) is read and the K-value is calculated by the relation,

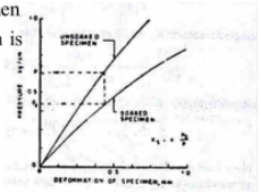
$$K = \frac{p}{0.125}\ kg/cm2/cm\ or\ kg/cm3$$

where p is the pressure = $\frac{Load}{Area\ of\ plate}$

Allowance for worst subgrade moisture:-

- To represent the worst moisture condition likely to occur at the test site.
- The modulus of subgrade reaction K for current moisture content may be modified for soaked condition
- Consolidation test on unsoaked and soaked specimen
- Modulus of subgrade reaction for soaked condition is

$$K_s = K\frac{p_s}{p}$$


Correction for Soaking in Plate Bearing Test

Correction for small plate size:-

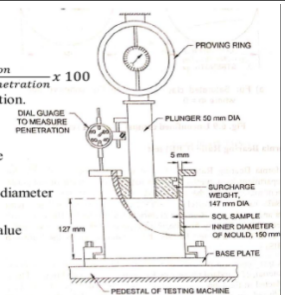
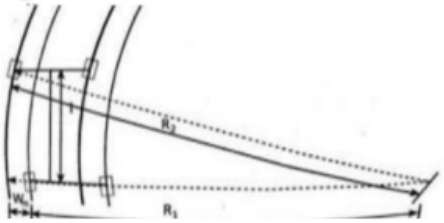
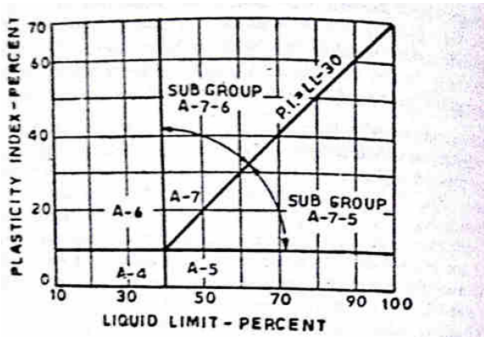
- The load of the reaction load may not be adequate to cause the standard plate diameter of 75cm to settle upto 0.175cm.
- Modulus of subgrade reaction is inversely proportional to diameter of the rigid plate.

$$i.e\ K \propto \frac{1}{d}$$

- Modulus of subgrade reaction K_1 is determined for smaller plate of diameter d_1 is determined by performing plate load test.
- The corrected value of modulus of subgrade reaction K for standard plate is obtained from the relationship:

$$K = K_1\frac{d_1}{d}$$

6 a)	A subgrade soil sample was tested using standard CBR apparatus..Penetration value for the soil specimen corresponding to 2.5 and 5 mm are 60.5 kg and 80.5 kg respectively. Assume the load penetration curve convex throughout. Find the CBR value? Solution:'- CBR at 2.5 mm =60.5/13670 = 4.4% CBR at 5 mm = 80.5/2055 = 3.91% Hence, CBR value of the specimen—> 4.4 %	[04]	CO3	L3
b)	With neat sketch illustrate the CBR test	[06]	CO3	L2

	California bearing ratio (CBR) test $CBR\ \% = \frac{\text{load carried by specimen at standard penetration}}{\text{load carried by standard crushed stone at standard penetration}} \times 100$ CBR value determined for 2.5 mm or 5mm penetration. Apparatus (As per IS:2720 (part 16)) 1. CBR mould – 150 mm diameter with base plate and collar 2. Loading frame – cylindrical plunger of 50 mm diameter (loading rate – 1.25 mm/min) 2. Dial gauge – for measurement of penetration value  Procedure – 1. Preparation of specimen and mould for the test 2. Surcharge weight of 2.5kg or 5 kg is placed on the specimen in the mould 3. The specimen is soaked for 4 days before testing. 4. Place this assembly in the loading frame such that the plunger is in contact with specimen. (seating load – 4 kg) 5. Cylindrical plunger of 50mm is allowed to penetrate into the specimen 6. Record the load values corresponding to the penetration of 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 7.5, 10, 12.5 mm. 7. Draw a graph for penetration in mm (X) vs load value in kg (Y) 8. Then the load values for 2.5mm and 5mm penetration are recorded from the graph and expressed in percentages of standard value to obtain CBR value. 9. The load values on standard crushed stones are 1370 kg and 2055 kg at 2.5 mm and 5.0 mm penetrations respectively.			
7 a)	Derive an expression for the extra widening on horizontal curve. $R_2^2 = R_1^2 + l^2$ $= (R_2 - W_m)^2 + l^2$ $= R_2^2 - 2R_2W_m + W_m^2 + l^2$ $2R_2W_m - W_m^2 = l^2$  Therefore the widening needed for a single lane road is: $W_m = \frac{l^2}{2R_2 - W_m}$ 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, $W_m = \frac{nl^2}{2R_2 - W_m}$ Please note that for large radius, $R_2 \approx R$, which is the mean radius of the curve,then W_m is given by: $W_m = \frac{nl^2}{2R}$ Psychological widening given by Empirical formula by IRC,	[04]	CO2	L2
b)	Classify the given soil into HRB soil classification: Soil % passing 6.3 mm - 100% 2.0 mm - 70% 600**µ** - 65 % 75**µ** - 42% Liquid limit of soil is 45% and plastic limit is 20%  4 Chart for Classifying Fine Grained Soil (H.R.B. system)	[06]	CO3	L3

	$$GI = 0.2a + 0.005\,a\,c + 0.01\,b\,d$$ Here, **a = % Passing 0.074 mm sieve – 35%** → value of a in range (0 to 40) should not be > 40 (if by calculation 'a' is negative then consider a = 0) **b = % Passing 0.074 mm sieve – 15%** → range (0 to 40) should not be > 40 **c = LL – 40** → range (0 to 20) should not be > 20 **d = PI – 10** → range (0 to 20) should not be > 20			