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Internal Assessment Test 3 – January 2022

Sub:	Highway Engineering					SubCode:	18CV56	Branch:	CIVIL
Date:	25/01/2022	Duration:	90 mins	Maxmarks	50	Sem/Sec:	V	OBE	

Answer any five questions.
Provide neat sketches wherever necessary

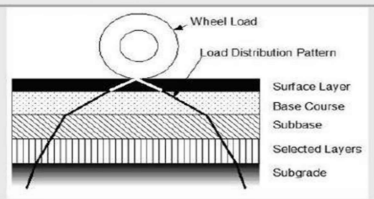
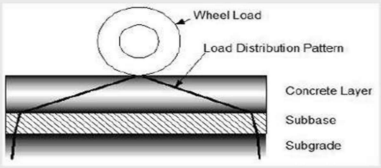
		MARKS	CO	RBT
1 a)	Differentiate between flexible and rigid pavement .	[04]	CO3	L2
b)	What is the equivalent single wheel load of a dual wheel assembly carrying 20440 N each for pavement thickness of 20 cm? Center to center spacing of tyres 27 cm and distance between the walls of the tyres is 11 cm.	[06]	CO3	L3
2	Describe the Rothfuch method with help of neat figure.	[10]	CO3	L2
3	Explain the steps involved in construction of highway sub grade?	[10]	CO4	L2
4 a)	What are the requirements of highway drainage system?	[04]	CO4	L2
b)	The maximum quantity of water expected in one of the open longitudinal drains on the clayey soil is 0.188 m^3/sec. Design is the cross section and longitudinal slope of trapezoidal drain assuming the bottom width of trapezoidal section to be 0.5 m & cross slope to be 1V:1.5H. The allowable velocity of flow in the drain is 0.8 m/sec & n= 0.025.	[06]	CO4	L4
5	Describe Methods of sub surface drainage with suitable figures.	[10]	CO4	L2
6 a)	List the factors affecting vehicular operating cost ?	[04]	CO5	L1
b)	Calculate the annual cost of a stretch of highway from the following particulars	[06]	CO5	L3

Item	Total cost, Rs. In lakhs	Estimated life, years	Rate of interest, %
Land	35.0	100	6
Earthwork	40.0	40	8
Bridges, culverts and drainage	50.0	60	8
Pavement	100.0	15	10
Traffic signs and road appurtenances	15.0	5	10

The average cost of maintenance of the road is Rs. 1.5 lakhs per year.

Internal Assessment Test 3 – January 2022 SOLUTION

1 a)	Differentiate between flexible and rigid pavement .	[04]	CO3	L2
b)	What is the equivalent single wheel load of a dual wheel assembly carrying 20440 N each for pavement thickness of 20 cm? Center to center spacing of tyres 27 cm and distance between the walls of the tyres is 11 cm.	[06]	CO3	L3
2	Describe the Rothfuch method with help of neat figure.	[10]	CO3	L2

	Flexible Pavement	Rigid Pavement
1.	It consists of 4 component layers with the highest quality materials at or near the surface of pavement.	It consists of 3 component layers
2.	It reflects the deformations of subgrade and subsequent layers on the surface.	It is able to bridge over localized failures and area of inadequate support.
3.	Possess low flexural strength	Possess high flexural strength
4.	Pavement design is greatly influenced by the subgrade strength.	Minimum imperfections or weak spots below the slab is taken care by the slab itself.
5.	Design is based on CBR value	Design is based on modulus of subgrade reaction.
6.	Design life is around 10-20 yrs.	Design life is around 30-40 yrs.
7.	Causes more hazardous environment due to heating of bitumen	No negative environmental effects
8.	Black in colour and hence need more lighting	Grey in colour; causes glare effect.
9.		

Data given d= 11 cm

S= 20 cm

Step 1:

When z = d/2 = 5 cm Load = p = 2044 kg

Step 2

When z= 2xS = 40 cm

Load = 2 x p = 2 x 2044 = 4088 kg

Step 3

When z = 20 cm

$$\log_{10} ESWL = \log_{10} P + \frac{0.301 \log_{10}(\frac{z}{d/2})}{\log_{10}(\frac{2S}{d/2})}$$

ØAfter selecting the aggregates and their gradation, proportioning of aggregates has to be done

ØVarious methods such as trial and error, graphical method (triangular and Rothfuch method), analytical method are there one of such methods

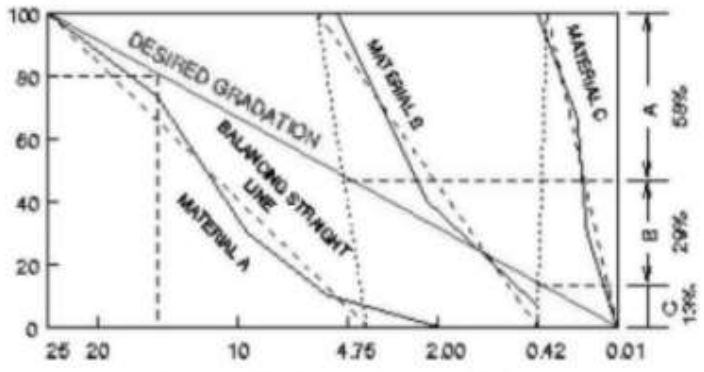
Rothfuch's Method of proportioning:

This method is used when a number of materials have to be mixed together

Step 1: On a graph paper when **Y-axis represents percent passing** and **X-axis** representing **particle size** a diagonal line is drawn from point corresponding to 100 percent particles passing i.e maximum particle size passing to a point corresponding to zero percentage passing i.e smallest particle size.

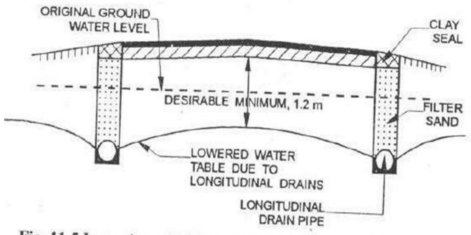
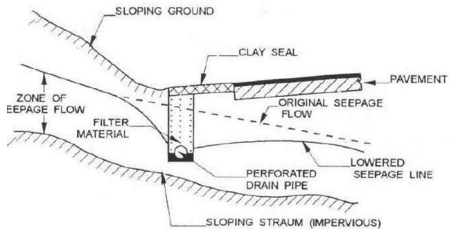
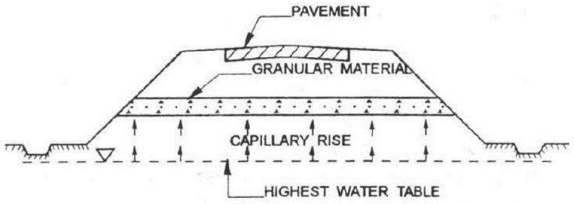
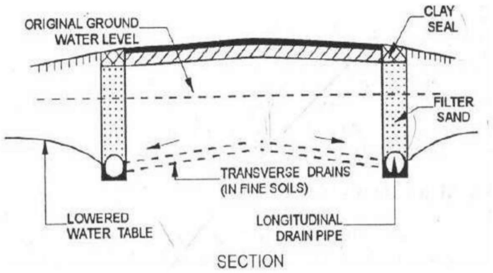
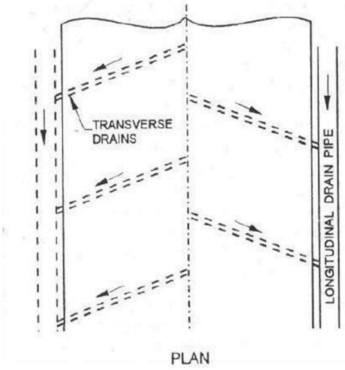
Step 2: For different material say **A, B and C sieve analysis** has to be done and **percentage finer** has to be calculated at each range of particle size for all the materials.

Step 3: The balancing straight lines of A, B and C are obtained by allowing only

	minimum of the areas on the center sides of the balancing lines. **Step 4:** The opposite ends of the balancing line of A and B are joined (**i.e zero point passing of material A is pointed with 100 percent passing B**). Similarly the opposite ends of the balancing lines of B and C are joined. **Step 5:** The points where **these lines meet the desired gradation** line represent the proportions in which type materials A, B and C are to be mixed. These values may be read from the Y axis by projecting the Points of intersection, as shown in the figure below.  **Proportioning of materials**			
3	Explain the steps involved in construction of highway sub grade? **Setting out –** After the site has been cleared, the work should be set out. The limits of embankment are marked by fixing batter pegs on both sides at regular intervals. The sub grade should be wider than the design dimension so that surplus material may be trimmed **Dewatering –** If the foundation of the embankment is in area with stagnant water, it is feasible to remove it by bailing out or pumping. **Stripping & Storing top soil –** In localities where most of the available embankment materials are not conductive to plant growth, the top soil from all areas of cutting shall be stripped to specified depths not exceeding 150mm & stored in stock piles of height not exceeding 2m for covering embankment slopes. **Compacting ground supporting embankment / sub grade –** ØWhere necessary, the original ground shall be levelled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling so as to achieve minimum dry density as given in table. ØIn case difference in sub grade level and ground level is less than 0.5m & the ground does not have 97% relative compaction, the ground shall be loosened upto a level 0.5m below the sub grade level, watered & compacted in layers to not less than 97% of dry density. **Spreading material in layers & bringing to appropriate moisture content –** The embankment & sub grade material shall be spread in layers of uniform thickness not exceeding 200mm compacted thickness over the entire width of embankment by mechanical means, finished by a motor grader & compacted. Moisture content of the material shall be checked at this site of placement prior to commencement of compaction, water shall be sprinkled from a water tanker filled with sprinkler capable of applying water uniformly. Moisture content of each layer should be checked in accordance with IS – 2720. Clods or hard lumps of earth shall be broken to have max size of 75mm when placed in embankment & max size of 50 mm when placed in sub grade.	[10]	CO4	L2

	Embankments & other areas of unsupported fills shall not be constructed with steeper side slopes, or to greater widths. Whenever fills is to be deposited against the face of a natural slope, steeper than 1vertical on 4 horizontal, such faces shall be benched.			
4 a)	What are the requirements of highway drainage system? 1.Surface **water from the carriageway and shoulder** should be drained off 2.Surface **water from adjoining land** should be drained off 3.Side **drains** should have sufficient **capacity and longitudinal slope** to carry away all the water collected from the road way 4.**Flow of surface water** across road and shoulders and along slopes should not cause **erosion or cross ruts** 5.**Seepage** and other **sources of under ground water** should be effectively intercepted and drained by **sub surface drainage systems** 6.Highest level difference of **Ground water and sub grade** should be preferably kept **at least 1.2** **m**. If its less than 1.2 m it is desirable to lower the ground water and provide sub surface drainage system 7. In water logging areas special precautions should be taken. More care if detrimental salts are there or if flooding is prevalent	[04]	CO4	L2
b)	The maximum quantity of water expected in one of the open longitudinal drains on the clayey soil is 0.188 m^3/sec. Design is the cross section and longitudinal slope of trapezoidal drain assuming the bottom width of trapezoidal section to be 0.5 m & cross slope to be 1V:1.5H. The allowable velocity of flow in the drain is 0.8 m/sec & n= 0.025.	[06]	CO4	L4

5	Describe Methods of sub surface drainage with suitable figures. The methods of sub surface drainage are :- •Lowering of water table •Control of Seepage flow •Control of capillary rise –Granular capillary cut off - Impermeable capillary cut-off <u>Lowering of water table</u> •Highest level of WT should be 1.0 to 1.20 m below the sub grade in order to avoid excessive moisture content in the pavement layers. •In places of high WT, **embankment** height should be 1.2 to 1.50m above ground level. •In cases of permeable soil, construct **longitudinal drainage trenches with drain pipe and filter sand.** •Wherever soil is less permeable, in addition to longitudinal trench drains, **transverse drains are provided** **<u>Control of Seepage flow</u>**	[10]	CO4	L2

	•Occurs when ground level as well as the impervious strata below are sloping and **water** seeps by gravity . •**Seepage** depends on permeability of the **soil** and the pressure gradient, • If the seepage zone depth < (0.6 to 0.9 m) from sub grade level, **longitudinal drain in trench filled with filter material** and **clay seal (impervious cap)**may be provided to intercept the seepage flow. <u>Control of capillary rise</u> •The capillary rise may be checked by providing a suitable capillary cut-off by i) granular capillary cut-off and ii) by impermeable capillary cut-off. **Granular Capillary cut-off**:- A layer of granular material is provided during the construction of embankment as shown in fig below. The thickness of this layer should be higher than the anticipated capillary rise within the granular layer **Impermeable capillary cut-off:-** In this case, an impermeable membrane or a bituminous layer is inserted in the place of granular blanket during the construction of embankment.  Fig. 11.5 Lowering of high water table in permeable soils    SECTION  PLAN			
6 a)	List the factors affecting vehicular operating cost ? 1)**Cost dependent on time** expressed as cost per year such as depreciation cost, registration fee, insurance charges, garage rent, driver's license salaries etc as applicable. 2)**Cost depending on distance driven** expressed as cost per vehicle-kilometer. The items which may be included here are fuel, oil, tyres, maintenance and repairs etc 3)**Cost dependent on speed** include cost of fuel, oil and tyre per vehicle-km-time-cost of vehicles, travel time value of passengers, etc. 4)**Cost dependent on type of vehicle and its condition**. Operation costs of larger vehicles are comparatively higher. The operation cost of old vehicles maintained in poor condition is also higher. 5)**Cost dependent on road condition** and geometrics such as types and conditions of pavement surface, magnitude and length of gradients, radius and number of horizontal curves etc. The vehicle operation cost increases with the unevenness index of pavement surface. These factors are also	[04]	CO5	L1

affected by the topography of the region. On hill roads the vehicle operation cost is higher than on plains.

6)**Cost dependent on traffic factor** such as congestion, volume to capacity ratio, flow characteristic, composition of traffic etc.

7)**Accident costs.**

b) Calculate the annual cost of a stretch of highway from the following particulars

Item	Total cost, Rs. In lakhs	Estimated life, years	Rate of interest, %
Land	35.0	100	6
Earthwork	40.0	40	8
Bridges, culverts and drainage	50.0	60	8
Pavement	100.0	15	10
Traffic signs and road appurtenances	15.0	5	10

The average cost of maintenance of the road is Rs. 1.5 lakhs per year.

(i) Annual cost of land $= 35 \times \frac{0.06(1+0.06)^{100}}{(1+0.06)^{100}-1}$

$= 35 \times CRF_{(i=6\% \text{ or } 0.06,\ n=100)} = 35 \times 0.06018$

$=$ Rs. 2.1063 lakhs

(ii) Annual cost of earthwork $= 40 \times CRF_{(i=0.08,\ n=40)} = 40 \times 0.08386$

$=$ Rs. 3.3544 lakhs

(iii) Annual cost of bridges $= 50 \times CRF_{(i=0.08,\ n=60)} = 50 \times 0.08080$

$=$ Rs. 4.04 lakhs

(iv) Annual cost of pavement $= 100 \times CRF_{(i=0.1,\ n=15)} = 100 \times 0.13147$

$=$ Rs. 13.147 lakhs

(iv) Annual cost of Traffic Signs $= 15 \times CRF_{(i=0.1,\ n=5)} = 15 \times 0.26380$

$=$ Rs. 3.9570 lakhs

(v) Average annual maintenance cost = Rs. 1.5 lakhs

(vi) Total annual highway cost = 2.1063 + 3.3544 + 4.0399 + 13.1474 + 3.9570 + 1.50 = Rs. 26.6049 lakhs

[06] CO5 L3