Roll No.											

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem: Odd Sem 2019-20 | Date: 30.09.2019

Course Code: CIV 301 | Time: 11.00AM to 12:00PM

Course Name: PAVEMENT DESIGN | Max Marks: 40

Program & Sem: B.Tech (CIV) & V DE | Weightage: 20%

Instructions:

(i) Assume values accordingly if not provided

(ii) Tables for Layered Theory will be provided

(iii) Draw Figures wherever necessary

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries four marks **(3Qx4M=12M)**

1. Explain the failure mechanism of Rigid pavement and Flexible

(C.O.NO.1)[Knowledge]

2. Explain the concept of rigidity factor. What is the standard value of tyre pressure stated in IRC?

(C.O.NO.1)[Knowledge]

3. List the assumptions used in Single layer theory of flexible pavement analysis

(C.O.NO.1)[Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries six marks. **(3Qx6M=18M)**

4. In a dual wheel assembly of an axle, the load on each tyre is 4000kg. If centre to centre distance between the tyres is 50cm and clear distance between the tyres is 25cm. Determine the ESWL at depth of 10, 20 and 70cm.

(C.O.NO.2)[Comprehension]

5. The following data pertains to the number of commercial vehicles per day for the design of a flexible pavement for a National Highway as per IRC 37-1984

Type of commercial vehicle observed	Frequency	Vehicle Damage Factor
Two axle trucks	2000	5
Tandem Axle Trucks	200	6

Assuming traffic growth factor of 7.5% per annum for both the type of vehicle. Calculate design traffic for design period of 10 years. Take Lane Distribution factor as 0.75.
(C.O.NO.2)[Comprehension]

6. A homogeneous half space is subjected to two circular loads, each 10 inches in diameter and spaced at 20 inches on centers. The pressure on the circular area is 50 psi. The half space is has elastic modulus of 10,000 psi and poisons ratio 0.5. Determine the vertical stress, strain and deflection at point A. Which is located 10 inches below the centre of one circle. (C.O.NO.2)[Comprehension]

Part C [Problem Solving Questions]

Answer the Question. The Question carries Ten marks. **(1Qx10M=10M)**

7. It was decided to construct a four lane undivided carriage way for a design period of 20 years. Traffic volume studies carried out for preliminary investigation revealed that the road carries a total traffic of 1860 vehicles/day under mixed traffic conditions with a growth rate of 7.5%. Details of distribution of wheel load of commercial vehicles is given below. What will be the design traffic for the road for various wheel loads equivalent to 2268Kg? (C.O.NO.2)[Application]

Wheel Load (Kg)	% in Total Volume
2268	25
2722	12
3175	9
3629	6
4082	4
4536	2
4990	1

SCHOOL OF ENGINEERING

Semester: Five

Course Code: CIV 301

Course Name: Pavement Design

Date: 30-09-2019

Time: 11:00 am to 12:00 pm

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	1	Module-1	4									4
2	1	Module-1	4									4
3	1	Module-1	4									4
1	2	Module-2				6						6
2	2	Module-2				6						6
3	2	Module-2				6						6
1	2	Module-2							10			10
	Total Marks		12			18			10			40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I here certify that All the questions are set as per the above lines Gayatri]

Annexure- II: Format of Answer Scheme

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

SOLUTION

Semester: Five

Course Code: CIV 301

Course Name: Pavement Design

Date: 30-09-2019

Time: 11:00 am to 12:00 pm

Max Marks: 40 Marks

Weightage: 20%

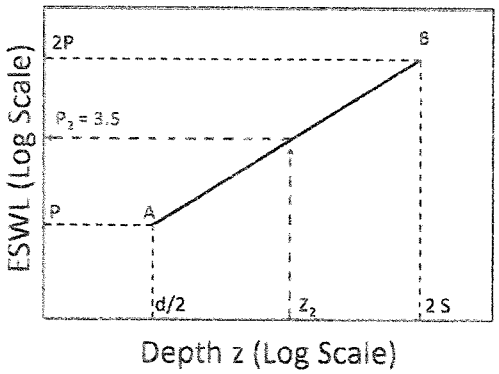
Part A (3Q x4 M =12 Marks)

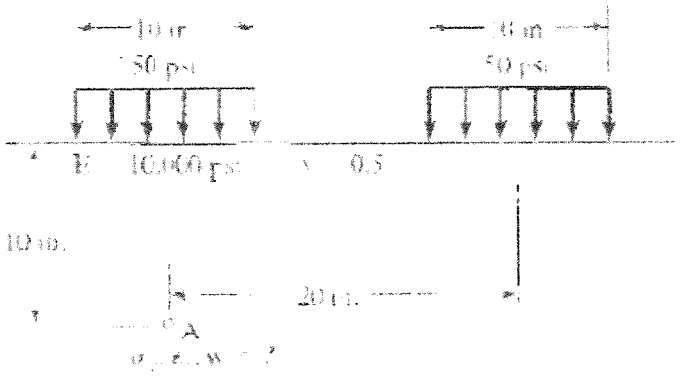
Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	Flexible pavements will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the points of contact in the granular structure. The wheel load acting on the pavement will be distributed to a wider area, and the stress decreases with the depth. Rigid pavements have sufficient flexural strength to transmit the wheel load stresses to a wider area below. In rigid pavement, load is distributed by the slab action, and the pavement behaves like an elastic plate resting on a viscous medium.	**2+2**	**5 minutes**
2	Rigidity Factor is the ratio of contact pressure to Tyre pressure. The Rigidity Factor under ideal condition is taken as 1, i.e., when the Tyre Pressure and Contact Pressure are same (7 kg/cm^2). When Tyre Pressure is	**3+1**	**5 minutes**

	greater than 7kg/cm^2, Rigidity Factor is less than 1 and when the Tyre Pressure is less than 7kg/cm^2, Rigidity Factor is greater than 1. Standard Tyre pressure as specified in IRC is 8kg/cm^2		
3	(i) The material is assumed to be Homogeneous and Isotropic. (ii) Full Friction is developed between layers (iii)Each layer has finite thickness, except subgrade which is assumed to extend vertically infinite and also in lateral direction (iv)The Stress solutions are characterized by two material properties i.e. Modulus of Elasticity and Poissons Ratio	4	**5 minutes**

Part B

(Q x M = Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	For desired depth z1 = 5 cm, which is half the distance between the walls of tyre, **ESWL = P = 4000kg** For z3 = 40 cm, which is twice the tyre spacing, ESWL = **2P = 8000kg.**  From Graph and From Interpolation, log ESWL corresponding to 70cm depth is 3.851. In normal scale Antilog (3.851) = **7103.23 Kg**	2 4	10 minutes
2	Design Traffic $N = \frac{365 \times [(1+r)^n - 1]}{r} \times A \times D \times F$ Where, r = Growth Rate n= design period A = Anticipated Design Traffic after completion of project D = Lane Distribution Factor F = Vehicle Damage Factor Given D = 0.75,	1 2	10 minutes

	r = 7.5% n = 10 years **Case 1: A = 2000 and F = 5** **N1 = 38.7277X10^6 SA** **Case 2: A = 200 and F = 6** **N2 = 4.647X10^6 SA** **Total Traffic = N1+N2 = 43.375X10^6 SA**	2 1	
3	 Given , E = 10,000 psi μ = 0.5 z = 10 inches a = 10 inches p = 50 psi From Design Table , Vertical Stress = p [A+B] At A , For Coordinates (2,0) A = 0.10557, B = 0.17889. **Vertical Stress = 14.223 psi** **Strain = 1.5p B/E1 = 1.34*10^{-8}** **Vertical Deflection =** $\frac{1.5pa}{E1}\left(\frac{z}{a}.A+\frac{H}{2}\right)$ **H = 0.47214 (From Chart) = 0.0167 inches**	2 2 2	10 minutes

Part C (Q x M = Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question

1				15 minutes

S.No	Wheel Load	% Total Traffic	Equivalency Factor
1	2268	25	$(2268/2268)^4 = 1$
2	2722	12	2.07
3	3175	9	3.84
4	3629	6	6.55
5	4082	4	10.5
6	4536	2	16
7	4990	1	23.43

5

Equivalency Factor =
(Actual Load/ Standard Load)^4

VDF = $\frac{\Sigma Nifi}{\Sigma Ni}$

= 3.74

5

Based on given condition, for a Four lane undivided Highway, LDF = 0.4

Hence Design Traffic,

$$N = \frac{365 \times [(1+r)^n - 1]}{r} \times A \times D \times F$$

Given Total Vehicle count for Mixed Traffic condition as 1860 vehicles per day.

Commercial Vehicle percentage = 0.59 (Total of CV survey data)

Hence A = 0.59x1860

= 1094.4 cv/day

Hence N = 25.87 MSA

Wheel Load (Kg)	% in Total Volume
2268	25
2722	12
3175	9
3629	6
4082	4
4536	2
4990	1

Roll No.													

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20
Course Code: CIV 301
Course Name: PAVEMENT DESIGN
Program & Sem: B.Tech (CIV) & V

Date: 18.11.2019
Time: 11:00 AM to 12:00 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) ***Read the questions carefully and answer accordingly.***
(ii) ***All questions are compulsory***
(iii) ***Draw appropriate diagrams if it is required.***
(iv) ***IRC 37-2018 is permitted for the Test***

Part A [Memory Recall Questions]

Answer All the Questions. Each Question carries four marks. (3Qx4M=12M)

Q.1 Write the expression to find GROUP INDEX of Soil and describe the terms [4M]

(C.O.3) [Bloom's level: Knowledge]

Q.2. Define Marshall Stability and Marshall flow [4M]

(C.O.3) [Bloom's level: Knowledge]

Q.3. Define : (a) Voids filled by Bitumen (VFB) (b) Voids in Mineral Aggregates (VMA), (c) Theoretical Specific Gravity and Apparent Specific Gravity. [4M]

(C.O.3) [Bloom's level: Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries eight marks. (2Qx8M=16M)

Q.4. Derive the expression to find the thickness of flexible pavement by Triaxial Method.

[8M] (C.O.3) [Bloom's level : Comprehension]

Q.5. The Specific gravities and weight proportions for aggregate and Bitumen are as under for preparation of Marshall Mix Design. The volume and weight of one Marshall specimen was found to be 475cc and 1100gm. Assuming absorption of bitumen in aggregate is zero. Find Vv,Vb,VMA,VFB.

Item	A1	A2	A3	A4	B
Weight (gm)	825	1200	325	150	100
G	2.63	2.51	2.46	2.43	1.05

[8M] (C.O.3) [Bloom's level: Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries twelve marks. (1Qx12M=12M)

Q.6. Design a new flexible pavement for a 2-lane undivided carriageway using following data.

- Design CBR of Subgrade = 5%
- Initial Traffic on completion of construction = 1500 cv/day
- Average Growth Rate = 6%
- Design Life = 10 yrs
- VDF = 2.5

[12M] (C.O.3) [Bloom's level: Application]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: V

Course Code: CIV 301

Course Name: Pavement Design

Date: 18-11-2019

Time: 10.00 to 11.00am

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
Q1	1	Module 3	4									4
Q2	3	Module 3	4									4
Q3	1	Module 3	4									4
Q4	2	Module 3				8						8
Q5	3	Module 3				8						8
Q6	3	Module 3							12			12
	Total Marks		12			16			12			40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

SOLUTION

Semester: V

Course Code: CIV 301

Course Name: Pavement Design

Date: 18-11-2019

Time: 10:00 to 11:00 am

Max Marks: 40

Weightage: 20%

Part A (3Qx 4M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
Q1	**GI = 0.2a + 0.005 ac + 0.01bd** Where, a= percentage of soil passing 0.074 mm sieve in excess of 35 per cent, not exceeding 75. b= percentage of soil passing 0.074 mm sieve in excess of 15 per cent, not exceeding 55. c= Liquid limit in per cent in excess of 40. d= Plasticity index in excess of 10.	**4 marks**	**5min**

Q2	**Marshall Stability** – Maximum load carried in kg at a standard temperature of 60°c Marshall stability indicates the resistance to deformation. **Marshall Flow** – Total deformation under maximum load in mm. It indicates resistance to deformation due to flexibility,	**(2+2=4) marks**	**5min**
Q3	**Voids Filled With Bitumen (VFB)** – Voids in mineral aggaregate framework filled by Bitumen $VFB = \frac{V_b \times 100}{VMA}$ **Voids in Mineral Aggregate** is the voids present in aggregates and is the sum of air voisds and volume of Bitumen $VMA = V_v + V_b$ **Theoretical Specific Gravity** is the specific gravity of the mix without considering air voids. $G_t = \frac{W_{total}}{V_{solid}\,\gamma_w}$ **Apparent Specific Gravity** is the specific gravity with air voids $G_m = \frac{W_m}{W_m - W_w}$	**4 marks**	**5min**

Part B

(2Q x8M = 16 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question

Q4	$$\Delta = \frac{3pa^2}{2E(a^2+z^2)^{1/2}} \quad (7.10)$$ Here $p = P/\pi a^2$ $$\therefore \Delta = \frac{3P}{2\pi E(a^2+z^2)^{1/2}}$$ $$(a^2+z^2)^{1/2} = \frac{3P}{2\pi E\Delta}$$ $$(a^2+z^2) = \left(\frac{3P}{2\pi E\Delta}\right)^2$$ $$z = \sqrt{\left(\frac{3P}{2\pi E\Delta}\right)^2 - a^2}$$ Assuming that the pavement is incompressible, z becomes T, the thickness of pavement. $$T = \sqrt{\left(\frac{3P}{2\pi E_s\Delta}\right)^2 - a^2} \quad (7.11)$$ Here T = pavement thickness, cm P = wheel load, kg E_s = modulus of elasticity of subgrade from triaxial test results, kg/cm^2. Considering, Rainfall Coefficient and Traffic Coefficient, a = Radius of contact area Δ = Design Deflection = 0.25cm $$T_s = \sqrt{\left(\frac{3P\,XY}{2\pi E_s\Delta}\right)^2 - a^2}$$	8 Marks	7Min
Q5		8Marks Each Values 2 Marks Each	7min

Given Data ; $W_1 = 825$; $W_2 = 1200$; $W_3 = 325$; $W_4 = 150$; $W_b = 100$

$G_1 = 2.63$; $G_2 = 2.51$; $G_3 = 2.46$; $G_4 = 2.43$; $G_b = 1.05$

$$G_t = \frac{(W_1 + W_2 + W_3 + W_4 + W_b)}{\left(\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_4}{G_4} + \frac{W_b}{G_b}\right)} = \frac{(825+1200+325+150+100)}{\left(\frac{825}{2.63} + \frac{1200}{2.51} + \frac{325}{2.46} + \frac{150}{2.43} + \frac{100}{1.05}\right)} = \frac{2600}{1080.86} = 2.406$$

$$G_m = \frac{1100g}{475cc \times 1g/cc} = 2.316$$

Percent of Air Void, $V_v = \left(\frac{G_t - G_m}{G_t}\right) \times 100 = \left(\frac{2.406 - 2.316}{2.406}\right) \times 100 = 3.74\%$

Percent volume of bitumen, $V_b = \frac{\left(\frac{W_b}{G_b}\right) \times 100}{\left(\frac{W_1 + W_2 + W_3 + W_4 + W_b}{G_m}\right)} = \frac{\frac{100}{1.05}}{\frac{(825+1200+325+150+100)}{2.316}} \times 100 = 8.48\%$

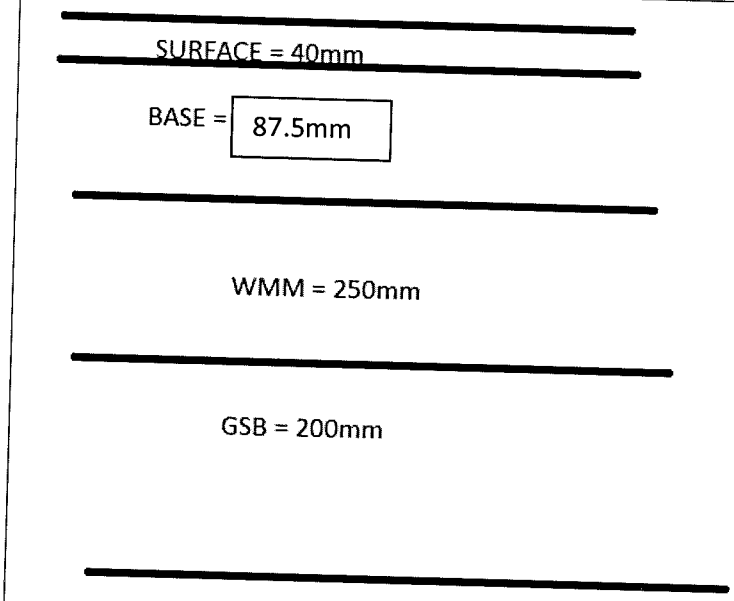
$\therefore$ $VMA = (V_v + V_b) = (3.74 + 8.48) = 12.22\%$

$\therefore$ $VFB = \frac{V_b \times 100}{VMA} = \frac{8.48 \times 100}{12.22} = 69.39\%$

Part C

(1Q x 12M =12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
Q6	$CSA = \frac{365*A*((1+r)^n-1)*LDF*VDF}{r}$ CSA = 14 MSA For CBR =8% , CSA = 14MSA Thickness of GSB = 200mm Thickness of WMM = 250mm Thickness of Base Course = 87.5mm Thickness of Surface = 40mm	12 Marks Calculating CSA = 2Marks Finding thickness of each layer = 2 Marks Figure = 2Marks	15M



Total = 12 Marks

Roll No											

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20 | **Date**: 24 December 2019

Course Code: CIV 301 | **Time**: 9.30 AM to 12.30 PM

Course Name: PAVEMENT DESIGN | **Max Marks**: 80

Program & SEM: B.Tech (CIV) & V (DE-II) | **Weightage**: 40%

Instructions:

(i) Read the all questions carefully and answer accordingly.
(ii) Use of IRC 37-2012 is permitted for the test
(iii) Draw figures wherever necessary
(iv) Logically assume values, if not provided
(v) Bradbury's chart to find out warping stress coefficient is attached with the question paper

---

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 5 marks. (4Qx5M=20M)

1. Write the difference between rigid pavement and Flexible pavement (C.O.No.1) [Knowledge]

2. Give the expression to find the design traffic in a pavement and expand each term (C.O.No.2) [Knowledge]

3. Give the expression to find the thickness of a pavement using Triaxial method and expand the terms (C.O.No.3) [Knowledge]

4. What are the possible critical stress combinations that can be experienced in a rigid pavement? (C.O.No.4) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries 10 marks. (3Qx10M=30M)

5. Compute the radius of relative stiffness of 20cm thick cement concrete slab from the following data:

   (i) Modulus of elasticity of cement concrete = 2.1x10^5 kg/cm^2

   (ii) Poisson's ratio for concrete = 0.15

   (iii) Load Sustained by rigid plate = 2000kg

   A circular plate of diameter 75 cm is used to find modulus of subgrade reaction using plate load test for a deflection of 1.25mm (C.O.No.4) [Comprehension]

6. What is the equivalent single wheel load of a dual wheel assembly carrying 20,440N each for pavement thickness of 20cm and 60cm? Centre to centre spacing of tyre is 27cm and the distance between the walls of the tyre is 11cm. (C.O.No.2) [Comprehension]

7. A soil subgrade has the following data:

   (i) Soil passing through 75 micron sieve = 60%

   (ii) Liquid limit = 45%

   (iii) Plastic limit = 20%

Find out the thickness of pavement. (Use table to find the thickness of pavement)

Group Index	Thickness (cm)
0	30
05	45
10	62
15	78
20	90

(C.O.No.3) [Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries 15 marks (2Qx15M=30M)

8. Show that the design thickness of a concrete pavement slab is safe for combined load and temperature stresses for longitudinal end conditions, given the following data:

   a. Design thickness = 20cm

   b. Maximum wheel Load = 4080kg

   c. Modulus of Elasticity of concrete = 3x10^5 kg/cm^2

   d. Modulus of subgrade reaction = 6kg/cm^3

   e. Poisson's ratio of concrete = 0.2

   f. Tyre Pressure = 7kg/cm^2

   g. Slab dimension = 4.5m x 3.8m

   h. Thermal Coefficient of concrete = 8x10^{-6}

   i. Temperature difference during the day = 0.5°C/cm

   j. Allowable flexural strength of concrete = 35kg/cm^2

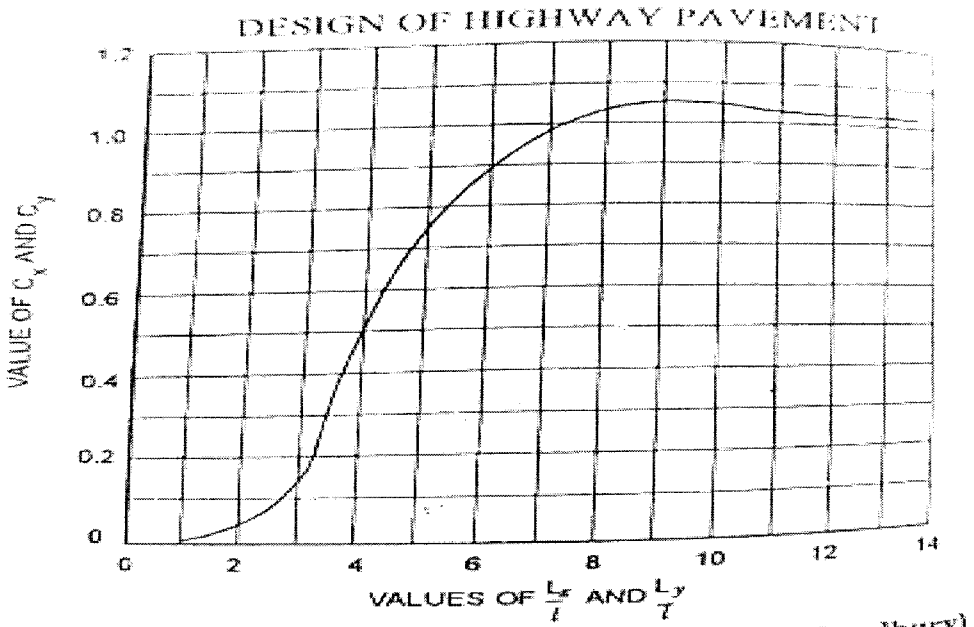


Fig. 7.20 Warping stress coefficient chart (by Bradbury)

(C.O.No.4)[Application]

9. Design a flexible pavement for a two lane undivided carriageway for the following data
    - Initial Traffic on completion of construction = 1500 cv/day
    - Average growth rate = 6%
    - Design life = 10 years
    - VDF = 2.5

The CBR values obtained at various points in the construction site is given below.

Location Points	CBR Values
1	5.58
2	5.65
3	5.19
4	5.35
5	5.21
6	6.65
7	7.83
8	6.12
9	5.45
10	5.91
11	6.34
12	7.98
13	8.91
14	5.34
15	6.35
16	6.14
17	4.45
18	4.36
19	5
20	6.45

(C.O.No.3)[Application]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

END TERM FINAL EXAMINATION

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	A	
1	1	Module-1	5			5
2	2	Module-2	5			5
3	3	Module-3	5			5
4	4	Module-4	5			5
5	4	Module-4		10		10
6	2	Module-2		10		10
7	3	Module-3		10		10
8	4	Module-4			15	15
9	3	Module-3			15	15
	Total Marks		20	30	30	80

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60% of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I hereby certify that all the questions are set as per the above guidelines.

Faculty Signature:

Reviewer Commend:

Format of Answer Scheme

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SOLUTION

Semester: Odd Sem. 2019-20
Course Code: CIV 301
Course Name: PAVEMENT DESIGN
Program & Sem: B.TECH (Civil) & Fifth

Date: 24.12.2019
Time: 3 HRS
Max Marks: 80
Weightage: 40%

Part A (4Q x 5M = 20Marks)

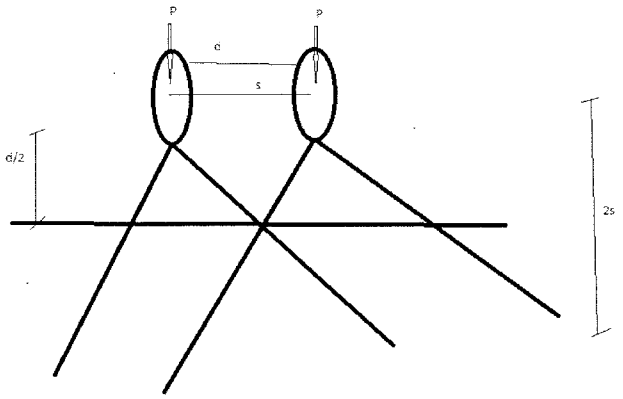
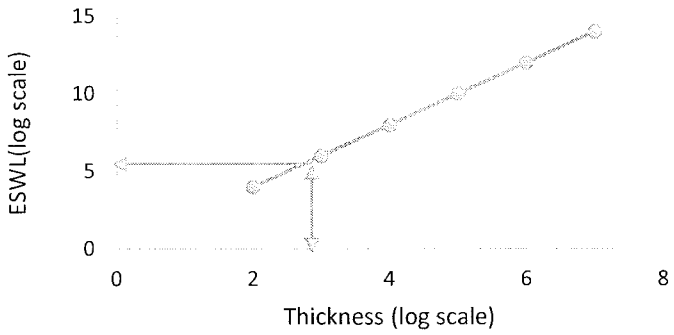
<table>
<tr><th>Q No</th><th>Solution</th><th>Scheme of Marking</th><th>Max. Time required for each Question</th></tr>
<tr><td>1</td><td>
<table>
<tr><th>Flexible Pavement</th><th>Rigid Pavement</th></tr>
<tr><td>Made of Asphalt Bitumen</td><td>Made of Pavement Quality Concrete</td></tr>
<tr><td>Grain to Grain transfer of loads from contact point</td><td>Directly transfers the load to a wider area in the subgrade</td></tr>
<tr><td>Pavement has multiple layer and layered theory is used for pavement analysis</td><td>Pavement act as a rigid plate on an elastic subgrade – Plate theory is used for pavement analysis</td></tr>
<tr><td>Any deformation happening in the subgrade will lead to the total failure of pavement. Hence cannot be used where the subgrade strength is poor.</td><td>The stresses are resisted by the flexural strength of concrete. Hence can be used even if the subgrade strength is poor.</td></tr>
</table>
</td><td>Minimum three points under Rigid and flexible – 5 Marks

Apart from these points any valid points can also be considered at the discretion of the evaluator</td><td>15 Minutes</td></tr>
<tr><td>2</td><td>Design Traffic, N = $\frac{365*A*((1+r)^n-1)*VDF*LDF}{r}$
Where A is the anticipated traffic at the end of construction in cv/day
n is the design life of the pavement
r is the growth rate
VDF is the vehicle damage factor
LDF is the Lane distribution factor</td><td>Equation for N – 3 Marks. Expanding the terms – 2 Marks</td><td>15 Minutes</td></tr>
<tr><td>3</td><td>(Tp)= $\sqrt{\left(\frac{3PXY}{2\pi Es\Lambda}\right)^2 - a\text{^}2(\frac{Es}{Eb})\text{^}(1/3)}$
Where, P – Wheel load
X – Traffic Coefficient
Y – Rainfall Coefficient
Es- Modulus of Elasticity of subgrade
Λ- Design Deflection</td><td>Equation – 3 Marks Expanding terms – 2 Marks</td><td>15 Minutes</td></tr>
</table>

	Eb – Modulus of elasticity of base course layer a- Radius of contact area		
4	Critical Combination of stresses: Summer Mid-day - Se+St(e)- σf Summer Mid Night - Sc+St(c) Winter mid-day - Se+St(e)+ σf Where Se is the Wheel load stress at the edge Sc is the wheel load stress at the corner St(e) is the warping stress at the edge St(c) is the warping stress at the corner σf Frictional stress due to seasonal variation of temperature	Critical stress equations – 3 Marks Terms – 2 Marks	15 Minutes

Part B (3Q x 10M = 30 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	Radius of relative stiffness, l = $(\frac{Eh^3}{(12k*(1-\mu^2)})^{\wedge}(1/4)$ Given, h = 20cm E = 2.1*10^5 μ = 0.15 P = 2000 kg To find Modulus of subgrade reaction, K k = p/Λ Diameter of plate =75cm A = $\frac{\pi}{4} * 75^2$ = 4417.86cm^2 Pressure sustained by 75cm dia plate = Load/contact area = 2000/4417.86 = 20.453kg/cm^2 Hence K = 3.62 kg/cm^3 l = 79.31cm	Equation for k = 2Marks K – 3 Marks Equation for l = 2 Marks l – 3 Marks	
6	Consider a dual wheel assembly carrying wheel load P. The centre to centre distance between the tyres is's' and the distance between walls of the tyres is'd'. At a depths less than d/2, ESWL is P And at depths more than 2s, ESWL is 2P. ESWL, in depths between d/2 and 2s has a linear variation and can be obtained graphically.	Concept of ESWL – 2 Marks ESWL at 20cm – 4 Marks ESWL at 60 cm – 4 Marks The solution for ESWL can be obtained graphically also. Variation in answer +/- upto 5 KN is permitted if done Graphically.	

	 Given, P = 20,440N s = 27 cm d = 11 cm at d/2; 5.5---------- 20440 at 2s; 54----------2*20440 = 40880 Hence at 20cm depth $$\frac{\log(20)-\log(5.5)}{l0g(54)-\log(5.5)}=\frac{\log(x)-\log(20440)}{\log(40880)-\log(20440)}$$ X – ESWL at 20 cm depth = 30242.26 KN OR ESWL GRAPH  At 60 cm: 60>2s i.e., 54cm Hence ESWL = 2P = 40880KN		
7	Group Index = 0.2a+0.005ac+0.01bd a- Percent fines passing through 75 micron sieve in excess of 35% b- Percent fines passing through 75 micron sieve in excess of 15% c- Liquid limit in excess of 40% d- Plasticity Index in excess of 10% GI = 12.375	Group Index formula – 2Marks Finding Group Index – 3 Marks Finding Thickness from Table by interpolation – 4 Marks	15 Minutes

	From Table thickness can be found out by linear interpolation. Total thickness of pavement after interpolation = 68.4cm	Unit- 1 Mark	

Part C (2Q x 15M = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
8	h = 20cm Tyre Pressure, p = 7kg/cm^2 Maximum Wheel load, P = 4080kg Radius of tyre imprint, a = $\sqrt{\frac{P}{\pi * p}}$ a = 13.621 cm Radius of relative stiffness, l = ($\frac{Eh^3}{(12k*(1-\mu^2)}$)^(1/4) l = 76.763 cm b = $\sqrt{1.6a^2+h^2}$-0.675h ; if $\frac{a}{h} < 1.724$ a=b ; if a/h > 1.724 a/h < 1.724 Hence, b = 12.897cm. Wheel Load Stress at the Edge, Se = $\frac{0.572P}{h^2} * \left[4\log\left(\frac{l}{b}\right) + 0.359\right]$ 20.1733 kg/cm^2 Temperature stress at edge $\frac{CxEet}{2}$ Cx depends on Lx/l Cx = 0.88 St(e) = 10.56kg/cm^2 Total Stress = Se+St(e) = 30.733kg/cm^2 The allowable flexural strength of concrete = 35kg/cm^2 This is less than the critical stress acting on the pavement Hence the pavement is safe	Finding 'a' – 1 Marks Finding 'l' – 1Marks Finding 'b' – 1Marks Finding Se – 3 Marks Finding St(e) – 3 Marks Critical Combination – 3 Mark Checking if thickness is safe – 3 Marks. If units are not written reduce up to 2 Marks Values may vary depending on the value of Cx taken. Hence variation of +/- 2 kg/cm^2 can be considered	50 Minutes

9

Use of IRC-37:2018

To design pavement CBR and Design Traffic is required

Design Traffic N = $\frac{365*A*((1+r)^n-1)*VDF*LDF}{r}$

A = 1500 cv/day
r = 6%
n = 10 years
VDF = 2.5
LDF = 0.75 (2lane undivided highway)

N = 13.53 – 14 MSA

To find CBR from given CBR values]

CBR-Arranged acsending order	% of CBR greater than or equal to
4.36	100
4.45	95
5	**90**
5.19	85
5.21	80
5.34	75
5.35	70
5.45	65
5.58	60
5.65	55
5.91	50
6.12	45
6.14	40
6.34	35
6.35	30
6.45	25
6.65	20
7.83	15
7.98	10
8.91	5

Effective CBR – CBR greater than or equal to 90% of CBR values
As per table , Effective CBR is 5%

From IRC 37-2018
After Interpolation (between N = 10 and 20 for CBR 5%)
Thickness :- GSB = 200mm
WMM = 250mm
Binder = 87.5mm
Surface = 40mm

Surface = 40mm

Finding Design Traffic – 3 Marks

Finding Effective CBR – 5 Marks (Either graphically or directly)

Finding correct thicknesses – 5 Marks

Figure – 2 Marks

Variation of thickness at Binder course is permitted upto +/- 3mm

If units are not written, then 2 Marks can be deducted.

	Binder = 87.5mm WMM = 250mm GSB = 200mm		