BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
CE -G549 RURAL ROAD TECHNOLOGY
SEMESTER I, 2022-23
MID - SEMESTER EXAMINATION (CLOSE BOOK)

Date : 03-11-2022 **Time : 90 minutes**
Max. Marks: 50

INSTRUCTIONS:

*(i) Support your answers with **neatly labelled** sketches/ nomographs wherever necessary.*

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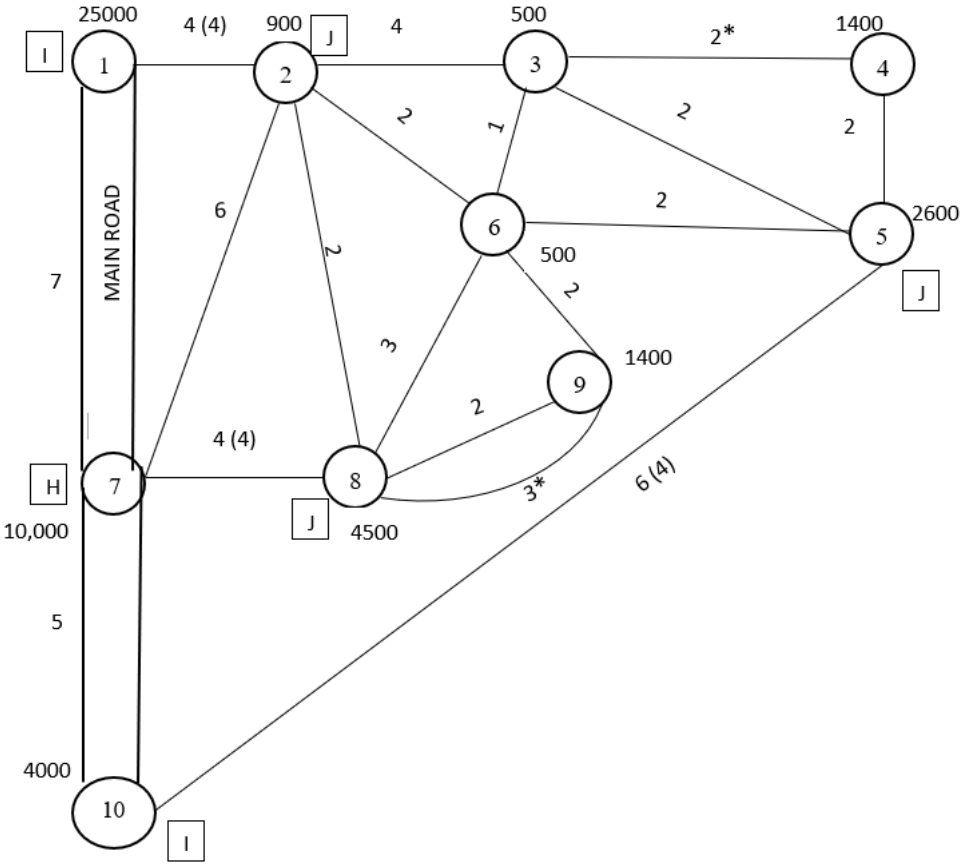
Q1. Find the optimum network using FBRNP method for the area shown, if JMAX = 4 km, HMAX = 10 km and IMAX = 10 km. Links consisting of * symbol indicate that the links are being converted from Water Bound Macadam surface to Black Top surface. ***(18 Marks)***



Q2. During the alignment of an Other District Road in a mountainous terrain with a design gradient of 4.95%, a horizontal curve of radius 140 m was encountered. If a Type 3 vehicle travels along the curve turning the steering wheel at an angle of 35^0 in counter clockwise direction with a tractive force of 125 kN in the rear axles, then

(i) Determine the curve resistance. ***(2 Marks)***

(ii) Is compensation in gradient required for the curve? If yes, determine the compensation in gradient and compensated gradient. If not, justify your answer. ***(5 Marks)***

Q3. **(i)** Define lime fixation point. ***(2 Marks)***

(ii) List the different states of aggregate mix and how frost action differs among these states. ***(3 Marks)***

Q4. The construction of an intermediate lane of length 5.7 km connecting Bandigani and Chimmad habitations in Karnataka is planned to start on 03 November 2022. The route comes under Other District Road category with existing bituminous construction. The classified traffic volume survey, axle load survey, soil investigations and hydrological survey (Tables 1 to 4) were conducted on May 03, 2022 (lean season). The construction period is of 12 months. The axle load survey revealed different types of vehicles (Table 3 and Figure 2). Considering the design life to be of 10 years with a traffic growth rate of 6 %,

(i) Determine the critical or equilibrium subgrade moisture content in percentage. ***(4 Marks)***

(ii) Determine the average vehicle damage factors for each category of vehicles (loaded and overloaded for each class – HCV, MCV). Assume the following: ***(8 Marks)***

- Axle weights were measured from the front of each vehicle.
- The standard axle should be considered according to axle configuration (i.e, standard single axle load = 80 kN & standard tandem axle load = 148 kN)
- In tandem axle configurations, consider the sum of each axle of a tandem axle while calculating VDF.
- To categorize vehicles in HCV: Gross laden weight ≥ 16.2 tonnes and,
- To categorize vehicles in MCV: Gross laden weight = 10 to 15 tonnes.

(iii) Determine the design traffic and provide your technical comments. Table 4 shows the Average Daily Traffic as on May 03, 2022 (lean season) of both directions. (Duration of harvesting season = 75 days, n = 1) ***(8 Marks)***

Table 1

Chainage (km / m)	**Depth of water table from ground level (m)**	**Field dry density (g/cc)**	**Maximum Dry Density (Lab – based) (g/cc)**	**Liquid Limit**	**Plastic Limit**
0/700	2.20	1.80	1.85	45	27
1/700	1.75	1.75	1.80	44	24
2/700	1.60	1.70	1.60	43	18
3/700	2.00	1.80	1.75	43	27
4/700	1.70	1.60	1.75	43	27
5/700	1.68	1.50	1.60	42	20

Table 2

Month	**Jan**	**Feb**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Rainfall (mm)	900	1200	2400	1500	1800	2300	2500	2600	2100	2000	1900	2800

Table 3 (RA : Rear Axles; SW : Single Wheel; DW : Dual Wheel; OL : Overloaded, L : Laden)

Vehicle No.	**No.of axle**	**Vehicle type**	**Load on axle (tonnes)**					**Remark**
			I	**II**	**III**	**IV**	**V**	
V – 1	3	Type – 3	6	11.58	10.52	-	-	RA – DW (OL)
V – 2	3	Type 2 – S1	4.98	9.90	9.17	-	-	RA – DW (L)
V – 3	2	Type 2	4.77	9.75	-	-	-	RA – SW (OL)
V – 4	2	Type 2	4.72	9.46	-	-	-	RA – DW (L)
V – 5	3	Type 2 – S1	5.02	9.58	9.57	-	-	RA – DW (L)
V – 6	5	Type 3 - 2	4.57	9.21	9.24	8.78	8.86	RA – DW (L)

Table 4 : Traffic Survey Details										
	Two Wheeler	Car/Jeep/ Van etc.	Buses		Truck		Agricultural Tractor-		Animal Drawn Veh.	Cycle
			Laden	Overloaded	Laden	Overloaded	Laden	Overloaded		
ADT	215	212	10	7	25	18	43	21	94	133

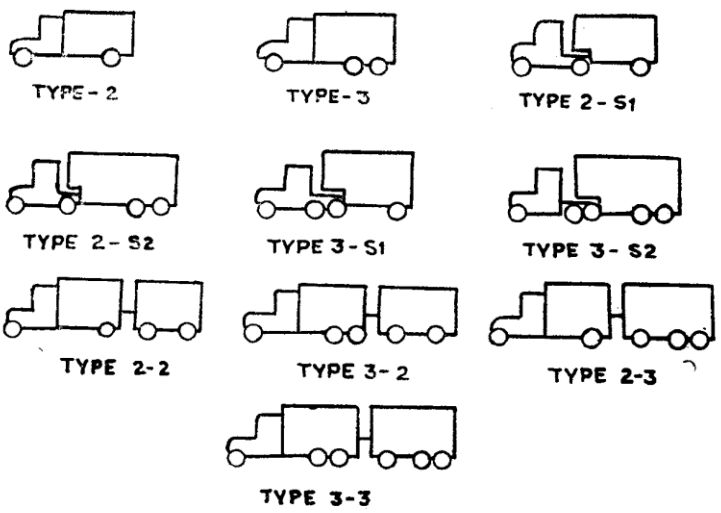


Fig. Vehicle Types

Figure 2

TABLE 2.2. DESIGN SPEED

Road Classification	Design Speed (km/h)							
	Plain Terrain		Rolling Terrain		Mountainous Terrain		Steep Terrain	
	Ruling	Min.	Ruling	Min.	Ruling	Min.	Ruling	Min.
Rural Roads (ODR and VR)	50	40	40	35	25	20	25	20

REFERENCE FORMULA SHEET

$\text{SSD} = vt + \frac{v^2}{2g\left(f \pm \frac{n}{100}\right)}$	$\text{OSD} = v_b t + v_b T + 2s + v_c T$ $e + f = \frac{v^2}{gR}$		$W_e = \frac{nl^2}{2R} + \frac{\boldsymbol{V}}{9.5\sqrt{R}}$
$m = R\ - (R - d)cos\frac{\propto}{2} + \left(\frac{S - L_c}{2}\right)\sin\left(\frac{\propto}{2}\right);$			$L_s = \frac{Ne(W + W_e)}{2}$
$L_s = \frac{2.7V^2}{R};\ L = 2\sqrt{\frac{Nv^3}{C}}$	$L_s = Ne(W + W_e) \quad S_g = vt = 0.278Vt$		$W = \frac{Q}{D}$
$m = R\ - Rcos(\frac{\propto}{2})$	$m = R\ - Rcos\frac{\propto}{2} + \left(\frac{S - L_c}{2}\right)\sin\left(\frac{\propto}{2}\right)$		$m = R\ - (R\ - d\ )\ cos(\frac{\propto}{2})$
$L_s = \frac{v^3}{CR} \qquad S = \frac{L_s^2}{24R}$	$L_s = \frac{V^2}{R};\ \ L = 2S - \frac{2\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}{N}$		$\frac{30 + R}{R}\ ;\ \frac{75}{R}$
$L = \frac{NS^2}{2(h_1 + S\ tan\alpha)}$	$L = 2S - \frac{2(h_1 + S\ tan\alpha)}{N}$		$L = \frac{NS^2}{2\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}$
$LPI = \frac{TN}{L} + 5B$	$VAI_{ij} = \frac{k \times P_i \times Q_j \times TPI(i)}{D_{ij}^n}$		$W_f = \frac{k}{N_f}$
$CS_i = (\sum_f n_f W_f)_i$	$F_{ij} = \frac{P_i P_j \lvert CS_i - CS_j \rvert}{D_{ij}^2}$	$LE_{ij}^1 = \frac{F_{ij}}{L_{ij}}$	$AADT = T + \frac{1.2nTt}{365}$
$N = T_0 \times 365 \times \left[\frac{(1 + 0.01r)^n - 1}{0.01r}\right] \times L$			

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