BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
CE -F244 HIGHWAY ENGINEERING
SEMESTER II, 2022-23
MID SEMESTER EXAMINATION

Date : 13-03-2023 **Time : 90 minutes**
Max. Marks: 60

INSTRUCTIONS:

- *Assume any missing data suitably, if required, and justify your assumption(s). Use reference appendix for information.*
- *Provide neatly labelled diagrams wherever necessary*

****

1. "*For a given numerical value of traffic volume, two values of speed can occur for a vehicle.*" Represent this statement through a neatly labelled figure and provide the reason for this observation. **[6 Marks]**

2. Graphically represent the following : (Detailed labelling is required)

(i) Design hourly volume **[3 Marks]**

(ii) Safe speed limit, design speed and lower speed limit **[4 Marks]**

3. While designing a vertical curve for a Major District Road on a rolling terrain, a highway geometric designer found the point of vertical intersect to be located below the road level. The vertical curve consists of an entering gradient of 1 in 200 joining a level stretch. If the designer aims to provide a vertical curve such that a Type 2-3 vehicle and Type 3-S1 vehicle can travel safely, then

(i) Name the type of vertical curve in this design. **[1 Mark]**

(ii) What is the length of the vertical curve? **[6 Marks]**

(iii) Draw the axle load configurations of Type 2 -3 vehicle and Type 3 – S1. The configuration must include data pertaining to axle weights, axle type, wheel type. (*No Partial Marking for each type of vehicle).* **[2x3Marks]**

4. Table 1 shows the observations of a speed and delay study in the test route between CEERI Gate (C) till Alumni House (A), BITS Pilani of distance 1.9 km. *Detailed steps are required.*

(i) Name the method used in the speed and delay study as per Table 1 and what is the reason behind that term? **[2 Marks]**

(ii) Determine the average traffic flow in both directions of travel. **[13 Marks]**

(iii) What is the average journey time for all vehicles in the traffic stream travelling in each direction? **[4 Marks]**

(iv) What is the difference in average running speeds while travelling in each direction? **[4 Marks]**

Table 1 : Observations of a speed and delay study

Trip No.	Direction of trip	Trip start time (HH:MM:SS)	Trip end time (HH:MM:SS)	Delay (MM:SS)	No.of vehicles overtaking test vehicle	No.of vehicles overtaken by test vehicle	No. of vehicle from opposite direction
1.	C – A	10: 02: 30	10: 07: 22	01:04	4	2	202
2.	A – C	10: 10: 11	10: 16: 37	01:41	6	2	161
3.	C – A	10: 21: 00	10: 25: 09	00:58	9	4	149
4.	A – C	10: 27: 37	10: 31: 04	00:43	7	4	267
5.	C – A	10: 34: 23	10: 40: 15	01:21	8	6	99
6.	A – C	10: 43: 29	10: 51: 04	02:02	2	3	181

HH: Hour; MM: Minute; SS: Seconds

5. A circular curve of radius 1245 m is proposed to be designed for Rajgarh - Nohar Road under the ODR category having a carriageway width of 3.75m and earthen shoulders of 0.75m on either side. Considering a higher service life of rigid pavements, this road is to be constructed as a cement concrete pavement over the plain terrain area that receives minimal rainfall. Then,

(i) Determine the superelevation to be provided and corresponding coefficient of friction developed. Justify your answer. **[6 Marks]**

(ii) Draw a detailed sectional view of the right of way at any point of the curve. Assume an extrawidening of 0.21 m provided entirely on the inner side of the curve. **[5 Marks]**

REFERENCE APPENDIX

Table 2: Ruling and Minimum design speed (km/h)

Road Classification	Plain terrain		Rolling terrain		Mountainous terrain		Steep terrain	
	R	M	R	M	R	M	R	M
NH & SH	100	80	80	65	50	40	40	30
MDR	80	65	65	50	40	30	30	20
ODR	65	50	50	40	30	25	25	20
VR	50	40	40	35	25	20	25	20

Table 3

Speed km/h	20 to 30	40	50	60	65	80	100
Longitudinal coefficient of friction, f	0.40	0.38	0.37	0.36	0.36	0.35	0.35

Table 4

Design speed (km/h)	35	40	50	65	80	100
Minimum length of vertical curve,m	15	20	30	40	50	60

Table 5

Types of Road Surface	Range of camber in areas of rainfall range	
	Heavy	Light
Cement concrete and high type bituminous surface	1 in 50 (2.0%)	1 in 60 (1.7%)
Thin bituminous surface	1 in 40 (2.5%)	1 in 50 (2.0%)
Water bound macadam, and gravel pavement	1 in 33 (3.0%)	1 in 40 (2.5%)
Earth	1 in 25 (4.0%)	1 in 33 (3.0%)

FORMULA SHEET

$NH + SH + MDR = \left[\frac{A}{8} + \frac{B}{32} + 1.6N + 8T\right] + D - R$		
$ODR + VR = [0.32V + 0.8Q + 1.6P + 3.2S] + D$		
$NH = \left[\frac{A}{64} + \frac{B}{80} + \frac{C}{96}\right] + [32K + 8M] + D$		
$NH + SH = \left[\frac{A}{20} + \frac{B}{24} + \frac{C}{32}\right] + [48K + 24M + 11.2N + 1.6P] + D$		
$NH + SH + MDR = \left[\frac{A}{8} + \frac{B}{16} + \frac{C}{24}\right] + [48K + 24M + 11.2N + 9.6P + 6.4Q + 2.4R] + D$		
$NH + SH + MDR + ODR = \left[\frac{3A}{16} + \frac{3B}{32} + \frac{C}{16}\right] + [48K + 24M + 11.2N + 9.6P + 12.8Q + 4R + 0.8S + 0.32T] + D$		
$NH + SH + MDR + ODR + VR = \left[\frac{A}{4} + \frac{B}{8} + \frac{C}{12}\right] + [48K + 24M + 11.2N + 9.6P + 12.8Q + 5.9R + 1.6S + 0.64T + 0.2V] + D$		
$\text{SSD} = vt + \frac{v^2}{2g\left(f \pm \frac{n}{100}\right)}$	$\text{OSD} = v_b t + v_b T + 2s + v_c T$ $e + f = \frac{v^2}{gR}$	$W_e = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$
$m = R - (R - d)cos\frac{\propto}{2} + \left(\frac{S - L_c}{2}\right)\sin\left(\frac{\propto}{2}\right);$		$L_s = \frac{Ne(W + W_e)}{2}$
$L_s = \frac{2.7V^2}{R}; L = 2\sqrt{\frac{Nv^3}{C}}$	$L_s = Ne(W + W_e)$	$\bar{t} = t_w - \frac{n_y}{q}$
$m = R - Rcos\left(\frac{\propto}{2}\right)$	$m = R - Rcos\frac{\propto}{2} + \left(\frac{S - L_c}{2}\right)\sin\left(\frac{\propto}{2}\right)$	$m = R - (R - d)\,cos\left(\frac{\propto}{2}\right)$
$L_s = \frac{v^3}{CR} \qquad S = \frac{L_s^2}{24R}$	$L_s = \frac{V^2}{R}; \quad L = 2S - \frac{2\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}{N}$	$q = \frac{n_a + n_y}{t_w + t_a}$
$L = \frac{NS^2}{2(h_1 + S\,tan\alpha)}$	$L = 2S - \frac{2(h_1 + S\,tan\alpha)}{N}$	$L = \frac{NS^2}{2\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}$

****