BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
CE -G534 PAVEMENT MATERIAL CHARACTERIZATION
SEMESTER I, 2022-23
COMPREHENSIVE EXAMINATION (OPEN BOOK*)

Date: 24-12-2022 **Time: 180 minutes**
Max. Marks: 70

INSTRUCTIONS:

- *Open Book: Print of IRC:44 – 2017 (Page 1 to 27) is ONLY allowed.*

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Q1. You are working as a design consultant in company **X**. Your client **C** approaches you to verify the design mix that **C**'s contractor prepared for the construction of a low - volume rigid pavement, with surface course of 200 mm thickness. The rigid pavement is also abutting a bridge. The data provided by the client are given in **Table 1**. With the percentage of superplasticizer recommended by the contractor, the desired slump of 30 ± 10 mm was not achieved. Hence you increased the percentage of superplasticizer to 1.2% of cementitious materials. It was requested by the client that the mix should be sustainable for which 32% of Ground Granulated Blast Furnace Slag (GGBFS) was used as a partial replacement of cement, by mass. At the same time, Client C wants to utilize a non-sag type silicone sealant in the transverse and longitudinal joints. Prepare the detailed design report addressing the following:

(i) What is the grading zone of fine aggregates used for the mix design as per IRC: 44 - 2017? Provide detailed steps and reasons (in tabular form) for identification. ***2 Marks***

(ii) What is the Nominal Maximum Aggregate Size (NMAS) of the aggregate mixture? ***1 Marks***

(iii) Provide the amount of each ingredient required to prepare $1m^3$ of M30 grade concrete mixture as per IRC:44 – 2017 with OPC Grade 43 cement, such that the target flexural strength is achieved by the mix. Consider the site conditions during the construction period. ***30 Marks***

(iv) To increase the sustainability of the concrete mix designed above (Q.1(iii)), if 25% volume of coarse aggregates are replaced by Recycled Concrete Aggregates (RCA) having a specific gravity of 2.4, water absorption of 1.7% and free (surface) moisture of 0.2%, what is the amount of each ingredient in the mix in dry condition? ***8 Marks***

(v) Which type of backer rod must be used in the transverse joints considering the rod material to be of lower cost and does not absorb moisture? Justify your answer. ***2 Marks***

(vi) Determine the minimum thickness of the early entry saw for cutting the transverse contraction joints? ***5 Marks***

(vii) Draw a detailed sketch of the anchor beam and terminal slab for the designed concrete mixture. ***6 Marks***

Q2. 3 bituminous mixture samples are provided. ***6 Marks***

- Sample A is obtained from an existing 2-year bituminous pavement of composition, 125 mm base/binder course and 40 mm surface course.
- Sample B is prepared in laboratory aimed to be used as bituminous macadam of 50 mm and Premix carpet of 20 mm.
- Sample C is obtained from an existing 15-year bituminous pavement.

Fatigue tests are proposed to be conducted on these samples. Provide the loading condition for each sample with reason (*Marks are allotted for answers only with reason*).

Q3. Provide short answer for the following:

(i) Which test is used to determine the suitability of emulsions at low temperature? (*Do not write options for the faculty to select*) ***1 Mark***

(ii) Which test is used to determine the suitability of bitumen at low temperature? (*Do not write options for the faculty to select*) ***1 Mark***

(iii) After the particle charge test of an emulsion sample, the anode was relatively clean as compared to cathode. Which type of emulsion is the sample? Justify your answer (*No partial marking)* ***1 Mark***

(iv) Bitumen A and Bitumen B have softening points of 55^0C and 60^0C respectively, while the stripping inflection points were observed to be 12500 passes and 13000 passes. **Justify your answers**. (*No partial marking)* ***1 Mark***

(a) Which bitumen sample is more susceptible to temperature?
(b) Which bitumen sample is more susceptible to moisture?

(v) Draw the graphs (in detail) that are required to obtain the optimum binder content as per Marshall Mix Design. ***2 Mark***

(vi) List the distresses that are considered for Superpave Mix Design (*No Partial Marking)* ***2 Marks***

2 Marks

(vii) Describe resilient modulus of soil.

Table 1: Material & Site details

I. Aggregates		
Sieve Size (mm)	Cumulative percentage passing	
	Coarse Aggregate	Natural sand
37.5	100	100
31.5	100	100
19	91	100
9.5	11	100
4.75	3	93.5
2.36	0	82.5
1.18	0	80
0.6	0	63
0.3	0	10
0.15	0	9
0.075	0	2
water absorption (%)	0.98	1.02
free (surface) moisture(%)	0.25	0.30
Specific gravity	2.62	2.48
Shape	Angular & Non-flaky	
Condition at site & quarry	Dry	Dry
Source of aggregates	Local	
II. Superplasticizer		
Type	High range superplasticizer	
Base	Lignosulphonates	
Water reduction capacity	25%	
Specific gravity	1.07	
III. Binders		
Cement	3.15 (specific gravity)	
GGBFS	2.90 (specific gravity)	
IV. Joint Sealant		
Type	Silicone sealant (Non sag, low modulus, self levelling)	
MAF	100% to - 50%	
Shape Factor	0.75	
V. Site and rigid pavement Details		
State	Rajasthan	
Rainfall during construction	Nil	
Maximum temperature differential	13.1 ^{0}C	
Coefficient of thermal expansion	10 x $10^{-6}/^{0}$C	
Panel size	3.75 m x 4.5 m (W X L)	

FORMULA SHEET

Terms have the standard definition

GI=0.2a+0.005ac+0.01bd	$\Delta = 1.18\frac{pa}{E}$	
$T_{pav} = 1.56 + 0.72T_{air} - 0.004Lat^2 + 6.26\log_{10}(H + 25) - Z\sqrt{(4.4 + 0.52\sigma_{air}^2)}$		
$T_{20mm} = (T_{air} - 0.00618Lat^2 + 0.2289Lat + 42.2)(0.9545) - 17.78$		
VTM or (% air voids) = $\frac{G_t - G_m}{G_t}$ x 100	VMA = [VTM + ($\frac{W_B}{G_B} \times \frac{G_m}{W}$)] x 100	VFB = $\frac{(VMA - VTM)}{VMA}$ x 100
$G_{se} = [\frac{1 - P_b}{(\frac{1}{G_{mm}} - \frac{P_b}{G_b})}]$	$P_{ba} = G_b\left(\frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}}\right) \times 100$	

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