



MACHAKOS UNIVERSITY

UNIVERSITY EXAMINATIONS 2024/2025

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

**FIFTH YEAR FIRST SEMESTER EXAMINATION FOR BACHELOR
OF SCIENCE IN CIVIL ENGINEERING**

ECV 503: HIGHWAY MATERIALS

Date:

Time :

INSTRUCTIONS

- *This paper comprises of **FIVE** questions. Answer **THREE** questions*
- *Question one is **Compulsory** and carries 30 marks*
- *Answer any other **TWO** questions*

QUESTION ONE

1. (a) Define SC 70, MC-3000, MC 30, RC 250, SC 800, symbols used for asphalt mixes (5 marks)
- (b) Discuss the two main sources of asphalt. (4 marks)
- (c) Differential between bitumen, asphalt, and coal tar. (9 marks)
- (d) Two samples of bitumen A and B have penetration values of 102 and 205 respectively at 25°C and 230 and 438 respectively at 35°C. Find an expression between the penetration and temperature for the two grades of bitumen. Determine the bitumen penetration grades, penetration index (PI), and temperature susceptibility of the two grades of bitumen. Which bitumen is likely to be blown asphalt why? (10 marks)

Note $PI = (20 - 500A)/(1 + 50A)$.

(e) Explain temperature susceptibility as a property of asphalt. (2 marks)

QUESTION TWO

2. (i) Briefly describe the procedure for hydrometer test. (5 marks)

(ii) With the aid of a sketch, prove the following phase relationship formulas in soils for use in highways. Reasonable assumptions may be made. e is the voids ratio, n is porosity, ρ_d is dry density, ρ_b is bulk density and w is the water content.

$$e = \frac{n}{1 - n}, \quad \rho_d = \rho_b / (1 + w)$$

(10 marks)

(iii) a) What is a Superpave system? (1 mark)

b) Specify the characteristics of a mix design of Superpave as per *the Superpave Mix Design Manual for New Construction Overlays*. (4 marks)

QUESTION THREE

3. (i) The moist weight of 5130 cc of soil is 9.612 kg. If the moisture content is 18 percent and the specific gravity of soil solids is 2.55, find the following: (a) bulk density, (b) dry density, (c) void ratio, (d) porosity, (e) degree of saturation, and (f) volume occupied by water (cc).. (10 marks)

(ii) A California Bearing Ratio, CBR test on a sample yielded the results shown in Table Q3i. Table Q3ii is a material of 100% CBR. Find the CBR. Is this material suitable for subgrade? Why? (10 marks)

Table Q3i(CBR Test Results)

Penetration test Data			
S.N.	Pen	Dial Gauge Reading	Load(Kg)
1	0	0	0
2	1	7	47.6
3	1.5	10	68
4	2	13	88.4
5	2.5	16	108.8
6	3	19	129.2
7	4	23	156.4
8	5	27	183.6
9	7.5	35	238
10	10	37	251.6
11	12.5	38	258.4

Table Q3ii (100% CBR)

Penetration (mm)	Load (kN)
2	11.5
4	17.6
6	22.2
8	26.3
10	30.3
12	33.5

QUESTION FOUR

4. The aggregate mix used for the design of an asphalt paving concrete consists of 42 percent coarse aggregates, 51 percent fine aggregates, and 7 percent mineral fillers. If the respective bulk-specific gravities of these materials are 2.60, 2.71, and 2.69, and the effective specific gravity of the aggregates is 2.82, determine the optimum asphalt content as a percentage of the total mix, using results obtained using the Marshall method as shown **Table Q4**. Also, enumerate the properties of the chosen mix design (20 marks)

NB: Reasonable assumptions can be made

Table Q4

Percent Asphalt	Weight of Specimen (g)		Stability (kg)	Flow (0.025 mm)
	in Air	in Water		
5.5	1325.3	785.6	815	13
6.0	1330.1	793.3	833	14
6.5	1336.2	800.8	845	16
7.0	1342.0	804.5	825	20
7.5	1347.5	805.1	770	25

QUESTION FIVE

5. (i) What are organic cements? Elucidate the use of cement, lime, and bitumen as soil stabilizing agents and state whether they are chemical or physical stabilizing agents.

(9 marks)

- (ii). Make notes on the soil strength and Atterberg limits requirements for soil for use as a base layer in Highways/Airports.

(6 marks)

- (iii). The result of an asphalt cement tested as follows (Table Q5). Find the PI & temperature susceptibility of the sample.

(5 marks)

NB: Ask for more graph paper if required.

Table Q5

Test	penetration		Temp. °C	
	Standard	46 °C @50 gm ; 5 sec	R&B	Field
Result	42	32	52	46