BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

AEH 302

Department Of Engineering and Physics
Bachelor of Science (Honours) in Agricultural Engineering
Soil Mechanics and Cultivation

OCT 2024

3 HOURS (100 MARKS)

INSTRUCTIONS

Answer any ***FOUR*** questions. Each question carries 25 marks.

Question 1

a. If a dry soil with Gs = 2.71 is mixed with 16% by weight of water and compacted to produce a cylindrical sample of 38 mm diameter and 76 mm long with 6% air content, calculate:
   i. the mass of the soil that will be required, **[10 marks]**
   ii. void ratio of the sample. **[4 marks]**

b. In a fill section of a construction site, 1500 m^3 of moist compacted soils is required. The design water content of the fill is 15%, and the design unit weight of the compacted soil is 18.5 kN/m^3. If the necessary soil is brought from a borrow site, with the soil having 12% natural water content, 17.5 kN/m^3 wet unit weight, and Gs = 2.65, determine the quantity of the borrow material required to fill the construction fill section (m^3). **[11 marks]**

Question 2

a. Describe, with the aid of a diagram, the following soil failure pressure patterns:
   i. active pressure, **[4 marks]**
   ii. passive pressure, and **[4 marks]**
   iii. at-rest pressure. **[4 marks]**

b. A sieve analysis was performed on a sample of soil and the results are shown in Table 1.

Table 1

US Sieve No.	Opening (mm)	Weight retained (g)
4	4.75	15.6
10	2.0	35.4
20	0.85	121.8
40	0.425	102.3
60	0.25	82.8
100	0.15	50.4
140	0.106	37.8
200	0.075	30.6
Pan		56.7

i. Plot the particle-size distribution curve, [9 marks]
ii. determine the coefficient of uniformity (C_u), and [2 marks]
iii. determine the coefficient of gradation (C_c). [2 marks]

Question 3

a. Briefly describe three soil mechanical properties of importance to an Agricultural Engineer. [6 marks]

b. In a laboratory constant head permeability test, a cylindrical sample 100 mm in diameter and 150 mm high is subjected to an upward flow of 540 cm^3/min. If the head loss over the length of sample is measured to be 360 mm, calculate the coefficient of permeability (m/s). [8 marks]

c. In an undrained triaxial test on three specimens of sandy clay soil taken from a depth of 2.5 m below ground level, the results in Table 2 were obtained.

Table 2

Cell pressure (kN/m^2)	Deviator stress (kN/m^2)
150	185
300	270
450	435

i. Draw the Mohr diagram, [8 marks]
ii. Determine the apparent cohesion, and [2 marks]
iii. angle of shearing resistance of the soil. [1 mark]

Question 4

a. State four assumptions of Terzaghi's consolidation theory. [4 marks]

b. A 2 m thick clay layer in the field under a given surcharge will undergo 5 cm of total primary consolidation. If the first 2.5 cm of settlement takes 60 days, calculate the time required for the first 1.5 cm of settlement. [10 marks]

c. For a field pumping test, a well was sunk through a horizontal stratum of sand 13.0 m thick and underlain by a clay stratum. Two observation wells were sunk at horizontal distances of 15 m and 30 m respectively from the pumping well. The initial position of the water table was 2.0 m below ground level. At a steady-state pumping rate of 1800 litres/min, the drawdowns in the observation wells were found to be 1.85 m and 0.95 m, respectively. Calculate the coefficient of permeability of the sand. [11 marks]

Question 5

a. Explain the most influencing factor that affect soil permeability. [5 marks]

b. Briefly describe four types of heavy duty compaction rollers used in construction industry. [8 marks]

c. A footing 2.0 m x 3.0 m is located at a depth of 2.0 m below the ground surface, in an over- consolidated clay layer. The groundwater level is 2 m below the ground surface. The unconfined compressive strength of that clay is 150 kPa, γ_{bulk} = 18 kN/m^3, and γ_{sat} = 20 kN/m^3. Determine the net allowable bearing capacity, assuming a factor of safety of 3. [12 marks]

Question 6

a. Figure 1. shows water flow though the soil specimen in a cylinder. If the specimen's k value is 3.4×10^{-4} cm/s, calculate:

i. pressure heads h_p at Points A, B, C, and D. **[7 marks]**

ii. the amount of water flow q through the specimen. **[3 marks]**

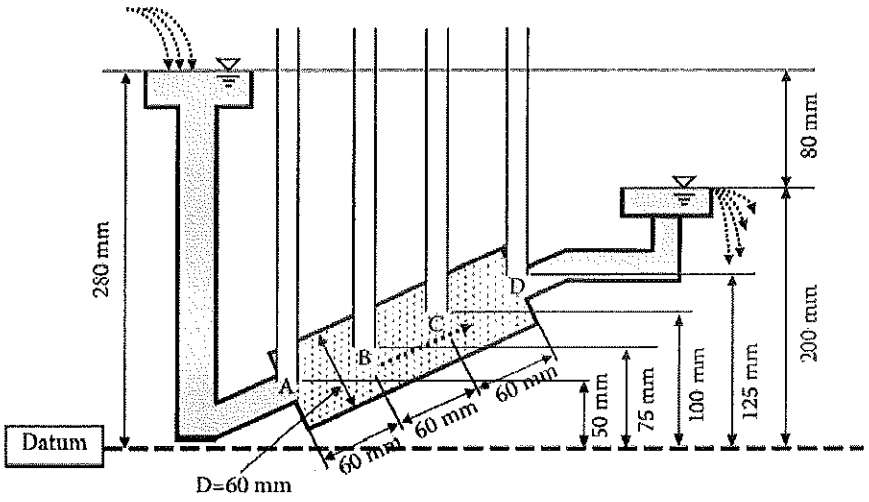

Figure 1

b. Describe the three types of soil laboratory triaxial tests. **[15 marks]**

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