Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	ADVANCED GEOTECHNIC
COURSE CODE	:	BFG 40203
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS.
		2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**.
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

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THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) Determine the differences between stiffness and strength of the soil.

(5 marks)

(b) Rainfall-induced landslides is one of major disaster in the world including Malaysia. Slope instability is caused by rainwater penetration into unsaturated soil slopes. To assess the stability of the unsaturated slope, important metrics such as the Soil-Water Characteristic Curve (SWCC) are necessary. Discuss about the SWCC in the;

i. design of unsaturated soil slopes.

(4 marks)

ii. relationship with other unsaturated properties.

(4 marks)

(c) The dimensions of laboratory cylindrical sample of soil 75mm in diameter and 150mm long are subjected to an axial effective stress of 500kN/m^2 and radial effective stress of 150kN/m^2. The axial and radial displacements are 0.75mm and –0.09mm respectively. Assuming the soil is anisotropic and elastic material, evaluate the following:

i. The mean stress (p') and deviatoric stress (q)

(3 marks)

ii. The volumetric strain (ε_v) and shear strain (ε_s)

(3 marks)

iii. The bulk modulus (K') and shear modulus (G)

(3 marks)

iv. The Poisson's ratio and Young's modulus (E)

(3 marks)

Q2 (a) Soil suction can be determined in the laboratory test such as filter paper, Tempe cell and pressure plate test.

i. Please do suggest and explain briefly the best method in determination of soil suction for unsaturated soil sample in the lab.

(6 marks)

ii. Discuss the advantages and disadvantages of the pressure plate extractor and Tempe cell in the determination of SWCC.

(4 marks)

(b) **Table 1** shows the data which obtained from triaxial test for unsaturated residual soil specimen size of 38mm in diameter and 76mm height.

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(i) Plot the graph shear stress versus matric suction and shear stress versus net stress.

(6 marks)

(ii) Determine the shear strength of the soil if the applied matric suction and the net stress are 300 kN/m^2 and 550 kN/m^2 respectively.

(4 marks)

(iii) If the soil becomes saturated, what is the strength of the soil when the effective normal stress is 500 kN/m^2. Comment your answer.

(5 marks)

Q3 (a) Single stage loading and multi stage loading could be applied in the construction of the embankment on soft soil. Explain the advantages and disadvantages between these methods.

(4 marks)

(b) You are given a task to propose the typical instrumentation of preloading on soft soil. Therefore, illustrate the arrangement of the proposed instrument for field monitoring on the performance of fill preloading method.

(5 marks)

(c) An embankment will be constructed on soft soil as shown in **Figure Q3(c)**. The Groundwater table (GWT) is located 1 m below the ground surface.

i. Estimate the stress increase at point A, B and C by using Osterberg influence value as shown in **Figure Q3(c)(i)**.

(6 marks)

ii. Discuss the results obtained in **Q3(c)(i)** in term of stress increment.

(2 marks)

iii. Predict the primary settlement (S_p) due to embankment load.

(8 marks)

Q4 (a) The selection of a constitutive model in numerical modelling is crucial to obtain accurate results. Deliberate the advantages and disadvantages of the Mohr-Coulomb model and the soft soil model in geotechnical modeling.

(5 marks)

(b) Discuss the advantages and limitations of the geosynthetic usage for road improvement.

(5 marks)

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(c) **Figure Q4(c)** shows the highway embankment which would be constructed on normally consolidated soft soil. The PVDs with the spacing of 1.15m will be placed in a triangular pattern to the top of the dense sand to accelerate the consolidation. The selected PVDs have the cross-sectional dimensions of 110mm and 4.2mm. The allowable discharge capacity of the PVD is $2.5 \times 10^{-4} m^3/s$. The smear zone is assumed 2.3 times the equivalent diameter of PVD. The permeability of the smear zone is 45% of the vertical permeability of the natural soil.

i. Determine the maximum height of embankment to fulfil the factor of safety against bearing failure of 1.3 during the construction.

(5 marks)

ii. Predict the overall degree of consolidation by the end of the 6 months preloading.

(10 marks)

)

-END OF QUESTIONS-

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Table 1: Triaxial test results

(u_a-u_w) (kN/m^2)	$(\sigma- u_a)$ (kN/m^2)	Shear stress, τ (kN/m^2)
0	0	10
93	50	44
159	100	68
225	150	92
288	200	115
354	250	139
420	300	163

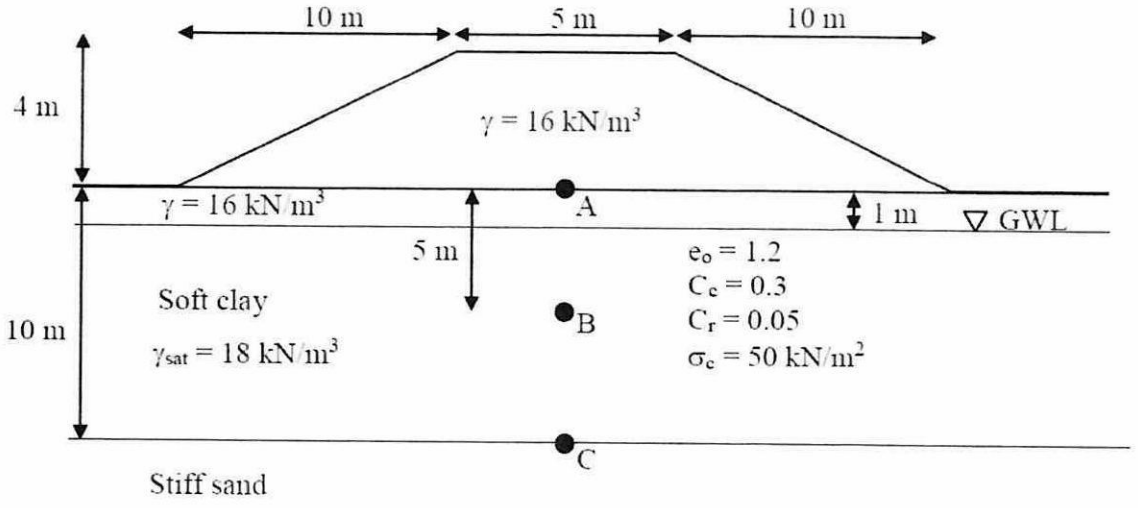

FIGURE Q3(c): An embankment on soft soil

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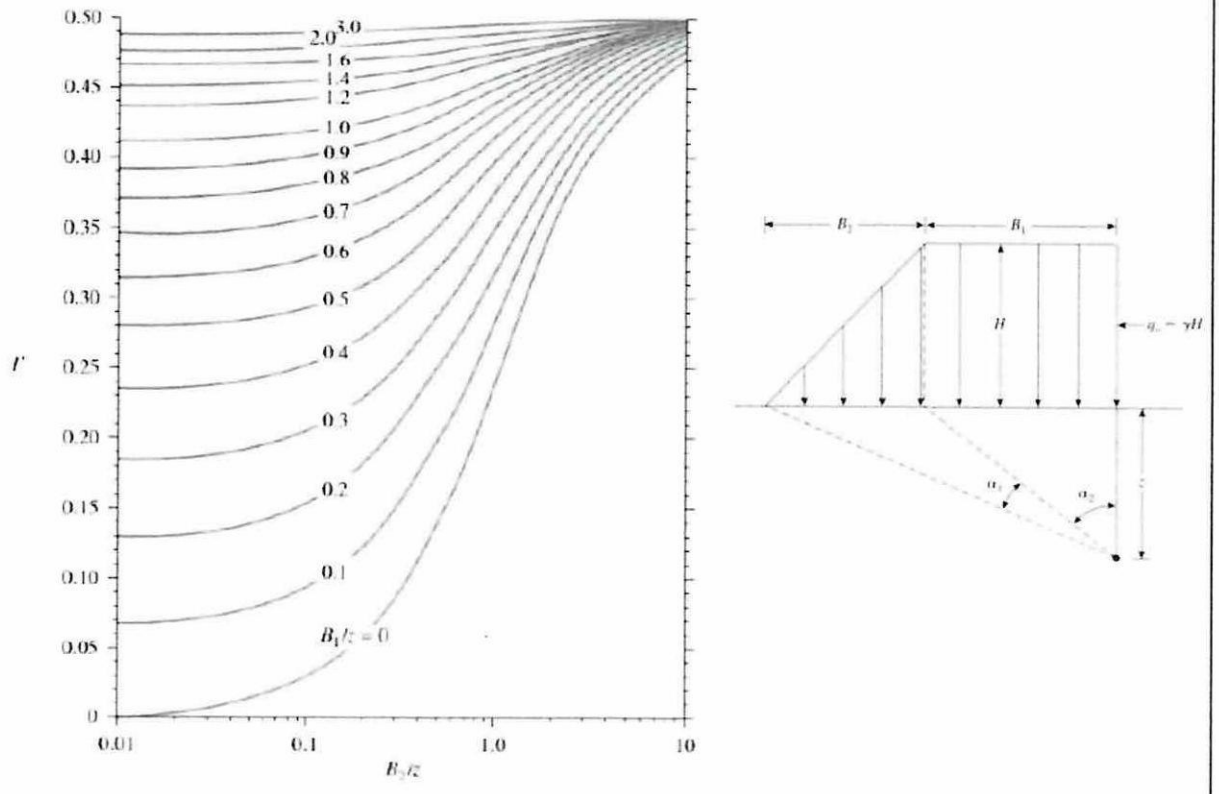

FIGURE Q3(c)(i): Influence value, I for embankment loading

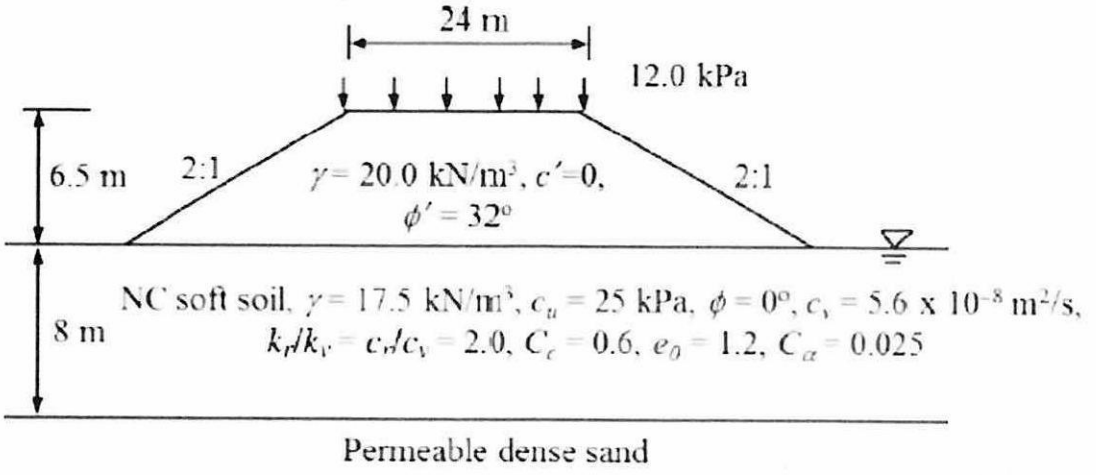

FIGURE Q4(c): Soil profile of soft soil improved PVD

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LIST OF FORMULA

STRESS STRAIN PARAMETERS

$$q' = \sigma'_1 - \sigma'_3$$

$$p' = \frac{1}{3}(\sigma'_1 - \sigma'_3)$$

$$\varepsilon_s = \frac{2}{3}(\varepsilon_1 - \varepsilon_3)$$

$$\varepsilon_v = \varepsilon_1 + 2\varepsilon_3$$

$$K' = \frac{\delta p'}{\delta \varepsilon_v}$$

$$3G' = \frac{\delta q'}{\delta \varepsilon_s}$$

$$E' = \frac{\delta' \sigma'_1}{\delta \varepsilon_1}$$

$$\upsilon' = -\frac{\delta' \varepsilon_3}{\delta \varepsilon_1}$$

$$\upsilon' = \frac{3K' - 2G}{2G + 6K'}$$

$$G' = \frac{E'}{2(1+\upsilon')}$$

$$K' = \frac{E'}{3(1-2\upsilon')}$$

CONSOLIDATION

$$OCR = \frac{\sigma'_c}{\sigma'_o}$$

$$S_p = H\frac{\Delta e}{1+e_o}$$

$$S_p = \frac{C_c H}{1+e_o}\log\left(\frac{\sigma'_o + \Delta\sigma'}{\sigma'_o}\right)$$

$$S_p = \frac{C_r H}{1+e_o}\log\left(\frac{\sigma'_o + \Delta\sigma'}{\sigma'_o}\right)$$

$$S_p = \frac{C_r H}{1+e_o}\log\left(\frac{\sigma'_c}{\sigma'_o}\right) + \frac{C_c H}{1+e_o}\log\left(\frac{\sigma'_o + \Delta\sigma'}{\sigma'_c}\right)$$

$$T_v = \frac{c_v t}{H_{dr}^2}$$

$$m_v = \frac{a_v}{1+e_o}$$

$$a_v = \frac{C_c\,(\log\sigma_2 - \log\sigma_1)}{\sigma_2 - \sigma_1}$$

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PRELOADING AND PVD

$$F_s = \frac{N_c c_u}{\Delta\sigma}, \text{where } N_c = 5.14$$

$$T_v = \frac{C_v t}{h_{dr}^2}$$

$$U_v = \sqrt{\frac{4T_v}{\pi}}$$

$$U_{vr} = 1-(1-U_v)(1-U_r)$$

$$U_r = 1-\frac{(1-U_v)}{(1-U_{vr})}$$

$$d_c = \frac{b+t_g}{2}$$

$d_e = 1.13S$, for square pattern
$d_e = 1.06S$, for triangular pattern

$$N_D = \frac{d_e}{d_c}$$

$$T_r = \frac{C_r t}{d_e^2}$$

$$F_m(N_D) = \ln\frac{N_D}{N_s} + \frac{k_r}{k_s}\ln(N_s) - \frac{3}{4} + \pi z(2h_{dr} - z)\frac{k_r}{Q_c}$$

$$U_r = 1-\exp\left(\frac{-8T_r}{F_m(N_D)}\right)$$

$$m_v = \frac{a_v}{1+e_o}$$

$$a_v = \frac{C_c\,(\log\sigma_2 - \log\sigma_1)}{\sigma_2 - \sigma_1}$$

$$k_v = c_v m_v \gamma_w$$

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