Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME	:	ADVANCED GEOTECHNICS
COURSE CODE	:	BFG 40203
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JANUARY/FEBRUARY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Microstructure and mineralogy are essential aspects of soil science, providing insights into the composition and arrangement of particles within a soil mass. Recommend with clear explanations on the suitable test to analyse the microstructure and mineralogy of the soil respectively.

(4 marks)

(b) Triaxial tests offer several benefits for practical engineering purposes in the field of geotechnical and civil engineering. These tests provide valuable data and insights that are crucial for various engineering applications. Explain in detail the key benefits of conducting triaxial tests in practical engineering.

(6 marks)

(c) A soil sample was obtained from a site at a depth of 8m of thick saturated marine clay. Further investigation found that the sample have a saturated unit weight (γ_{sat}) of 13 kN/m^3. The shear strength of the soil was required to be determined using the consolidated undrained triaxial test where the results are shown in **Table Q1.1.**

Table Q1.1: Triaxial Test results

Test No.	Cell pressure, σ_3 (kN/m^2)	Deviator stress, q (kN/m^2)	Pore pressure at failure, $(\Delta u)_f$ (kN/m^2)
1	120	250	-20
2	240	420	-40
3	370	600	-50

(i) With reference to the results obtained, construct the Mohr Circles for the total and effective stress in a suitable graph.

(5 marks)

(ii) From the constructed Mohr Circle, estimate the values of the Mohr-Coulomb effective shear strength parameters of c' and ϕ'.

(6 marks)

(iii) Based on the strength parameters of c' and ϕ', predict the effective shear strength of the clay sample that was obtained from the site at the stated depth.

(4 marks)

Q2 (a) Unsaturated soils are a complicated matter in soil mechanics that plays an important role in soil behaviour. Explain in detail the processes and factors involved in the formation of unsaturated soils.

(6 marks)

(b) Measuring the matric suction is essential in identifying the soil suction or pore-water pressure that describes the potential energy state of water within the unsaturated zone of a soil. Choose and explain the suitable methods for measuring matric suction in soil, differentiating between laboratory and field-based techniques.

(6 marks)

(c) An unsaturated soil sample was collected to conduct a matric suction measurement using a Tempe Cell in a laboratory setting. The data is provided in **Table Q2.1** where it shows the increase in air pressure resulted in a mass change in the soil specimen as pore water pressure is expelled at each air pressure increment. At the end of the test, the soil sample was removed, and the weight of the wet sample was recorded to be 35.71g. After it was oven dried, the sample then weights 32.1g.

Table Q2.1: Tempe Cell testing results

Air Pressure (kPa)	Mass Change (g)
0	0
23	0
36	0
12	0
18	0
22.5	2.07
30	1.725
45	1.215
51	0.525
75	0.525
112.5	0.69
147	0.315

(i) Construct the matric suction characteristics curve for the soil.

(8 marks)

(ii) Discuss the significance of matric suction measurements during the test.

(5 marks)

Q3 (a) Critical state soil is a concept in geotechnical engineering that represents a specific mechanical and stress-strain state that certain soils achieve under certain conditions of stress and deformation. Explain in detail the key characteristics of critical state soil behavior.

(8 marks)

(b) Imagine you are a geotechnical engineer tasked with evaluating soil behavior for the construction of a high-rise building in an urban area. The site consists of predominantly silty clay soil. You are required to recommend the key engineering applications involving critical state soil mechanics.

(10 marks)

(c) **Table Q3.1** shows the consolidation test results on a clay soil. Based on the results given.

Table Q3.1: Result for consolidation test

P' (kN/m^2)	25	50	200	400	800	1600	800	400	200
e	1.65	1.64	1.62	1.57	1.51	1.44	1.45	1.46	1.47

(i) plot the lnp' vs e graph.

(3 marks)

(ii) determine the values of λ, κ, and eΓ.

(4 marks)

Q4 (a) Geosynthetics are synthetic materials used in civil engineering and construction projects to improve the performance of soil, rock, and other geotechnical materials. Explain with clear definitions on the types of geosynthetics available for construction engineering.

(10 marks)

(b) A prefabricated vertical drain (PVD), also known as wick drains or band drains are prefabricated geotextile filter-wrapped plastic strips with moulded channels. It is essential that PVD is carefully designed to maximise its performance. For a certain construction, the spacing (d) of the square pattern PVD are set to be 1.8m with a size of a = 100 mm and b = 5 mm. For no smear case, S = 1, $k_h = k_s$. The time needed for full consolidation is 9 months with a permanent load ($\Delta\sigma_{(p)}$) on the clay layer of 115 kN/m^2. The average effective overburden pressure ($\Delta\sigma_o$) also at the middle of the clay layer is 210 kN/m^2. The properties of the clay layer are as follows, Hc = 6 m, Cc = 0.28, e_o = 0.9, and $c_v = c_{vr}$ = 0.36 m2/mo.

(i) Design a suitable surcharge/preconsolidation pressure that is suitable to fulfil the time needed for full consolidation with the existence of PVD.

(8 marks)

(ii) Estimate the time needed for full consolidation if the surcharge or preconsolidation is increased to 400 kN/m^2.

(7 marks)

- END OF QUESTIONS -

APPENDIX A: Design Charts

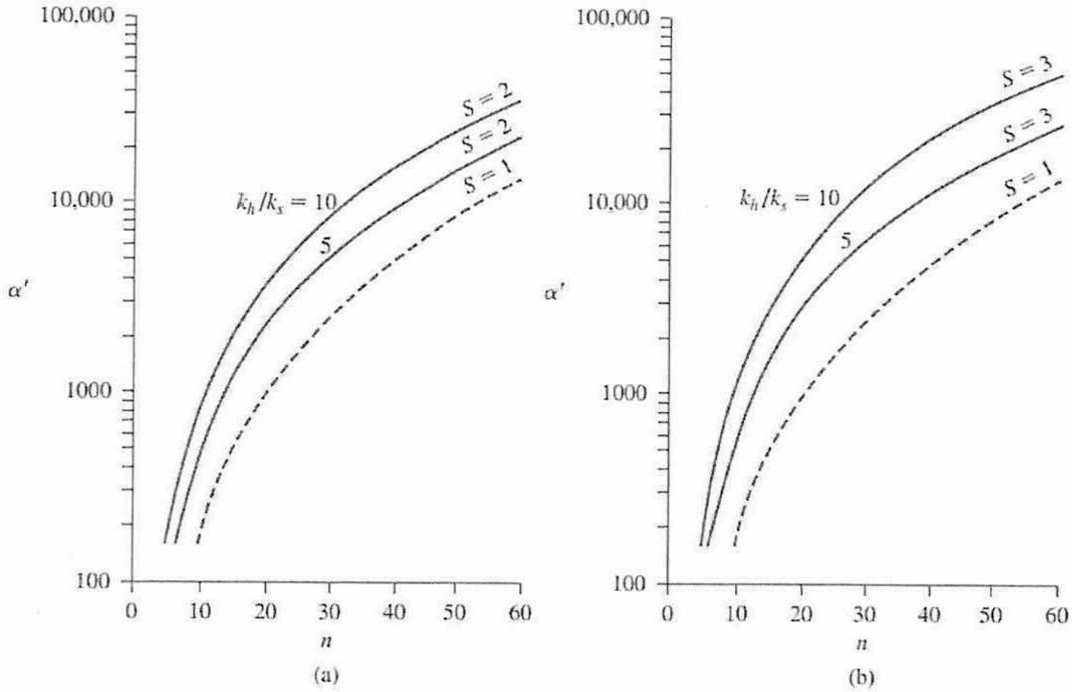

Figure APPENDIX A.1: Plot of α versus n: (a) S= 2; (b) S = 3

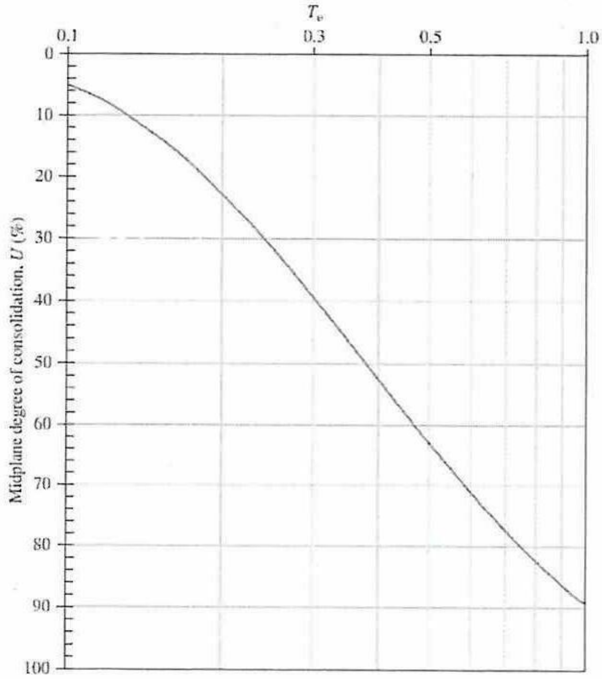

Figure APPENDIX A.2: Plot of U versus T_v

APPENDIX B: Formulas

These formulas may be useful to you. The symbols have their usual meaning.

Crititcal State

$$\lambda = -\frac{\Delta e}{\ln(p'_c) - \ln(p'_1)}$$

$$\kappa = -\frac{\Delta e}{\ln(p'_c) - \ln(p'_o)}$$

$$e_\Gamma = e_o + (\lambda - \kappa)\ln\frac{p'_c}{2} + \kappa \ln p'_o$$

Pre consolidation and Vertical Drain

$$U_{v,r} = \frac{log\left[1 + \frac{\Delta\sigma_{(p)}}{\sigma_o}\right]}{log\left\{1 + \frac{\Delta\sigma_{(p)}}{\sigma_o}\left[1 + \frac{\Delta\sigma_{(f)}}{\Delta\sigma_{(p)}}\right]\right\}}$$

$$U_r = 1 - \frac{1 - U_{v,r}}{1 - U_v}$$

$$U_v = \sqrt{\frac{4T_v}{\pi}} x100$$

$$T_v = \frac{c_v t_2}{H^2} \text{ and } T_r = \frac{c_{vr} t_2}{d_w^2}$$

$$(T_r)_1 = -\frac{\ln(1 - U_r)}{8}$$

$$\alpha = \frac{T_r}{(T_r)_1}$$

$$d_e = nd_w$$

$d = d_e/1.05$ (for triangular pattern)

$d = d_e/1.128$ (for square pattern)

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