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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	GEOTECHNICAL ENGINEERING
COURSE CODE	:	DAC 22103
PROGRAMME CODE	:	DAA
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS FROM SECTION A AND **THREE (3)** QUESTIONS FROM SECTION B. 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 **TEN (10)** PAGES

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SECTION A (40 MARKS)

Q1 (a) Define the terms below

(i) Consolidation

(1 mark)

(ii) Normally consolidated clay

(1 mark)

(iii) Over-consolidated clay

(1 mark)

(iv) Settlement of soil

(1 mark)

(b) The following readings in **Table Q1.1** were collected from the oedometer test for an increment of vertical stress of 20 kPa. A clay sample with a diameter of 75 mm and 20 mm thick was used and the drainage was permitted from the bottom and the top.

Table Q1.1 Results from oedometer test.

Time (min)	0	0.25	1	2.25	4	9	16	25	36	24 hours
ΔH (mm)	0	0.12	0.23	0.33	0.43	0.59	0.68	0.74	0.76	0.89

Using the Taylor's method,

(i) Plot the graph for the settlement of clay for the first 36 minutes.

(7 marks)

(ii) Evaluate the value of t_{90} for the clay sample by showing all the necessary construction line.

(5 marks)

(iii) Calculate the value of coefficient of consolidation, C_v

(4 marks)

Q2 (a) List down four (4) testing that can be perform for determining the shear strength of soil.

(2 marks)

(b) Triaxial compression tests on three specimens of a soil sample were performed. Each test was carried out until the specimen experienced shear failure. The test data are tabulated in **Table Q2.1**.

Table Q2.1 Result from triaxial test.

Specimen number	**Minor Principal Stress, σ_3 (Confining Pressure) (kN/m^2)**	**Deviator Stress at Failure (kN/m^2)**
1	69	276
2	136	328
3	207	359

(i) Determine σ_1 = axial pressure / major principal stress for each specimen

(3 marks)

(ii) Draw Mohr's circle with suitable axes (x and y) in a graph paper and determine the soil's cohesion.

(9 marks)

(c) Direct shear tests were performed on dry, sandy soil. The size of specimen was 50 mm (W) x 50 mm (B) x 20 mm (H). Test results were as given as in **Table Q2.2**:

Table Q2.2 Results from direct shear test.

Test No	Normal Force (N)	Shear force at Failure (N)
1	90	54
2	135	82.35
3	315	189.5

(i) Calculate normal stress for every test

(3 marks)

(ii) Determine the shear stress at failure for every test

(3 marks)

SECTION B (60 MARKS)

Q3 (a) Explain the concept of a soil phase diagram, highlighting the transition from a three-phase diagram to a two-phase diagram as soil saturation occurs.

(4 marks)

(b) From the following masses in **Table Q3.1**, determine the particle density or specific gravity of a sample of sand.

Table Q3.1 Results from specific gravity test.

Description	Mass (grams)
Mass of bottle (with stopper)	27.464 g
Mass of bottle and sand	33.660 g
Mass of bottle, sand and water	84.000 g
Mass of bottle and water	80.135 g

(5 marks)

(c) The moist mass of a soil specimen is 20.7 kg. The specimen's volume measured before drying is 0.011 m^3. The specimen's dried mass is 16.3 kg. The specific gravity of solids is 2.68. Determine the following:

(i) Void ratio

(5 marks)

(ii) Degree of saturation

(2 marks)

(iii) Wet unit mass (ρ)

(2 marks)

(iv) Dry unit mass (ρ_d)

(2 marks)

Q4 (a) Explain the properties and behaviour of cohesive soil and non-cohesive soil

(4 marks)

(b) A group of students from Geotechnical Engineering class were gathered a soil sample from the nearest site and sieve analysis was conducted. The mass of soil retained on each sieve are given in a **Table Q4.1**. The total amount of soil used without considering the quantity of soil retained on pan is 593 g.

Table Q4.1 Results from sieve analysis test.

Sieve No.	Opening (mm)	Mass of soil retained on each sieve (g)
4	4.75	28
10	2	42
20	0.84	48
40	0.425	128
60	0.25	221
140	0.106	86
200	0.075	40
Pan		24

(i) Determine the percent retained and percent passing for this soil.

(2 marks)

(ii) Plot the grain-size distribution curve.

(5 marks)

(iii) Determine D_{10}, D_{30} and D_{60} from the grain-size distribution curve.

(3 marks)

(iv) Calculate the uniformity coefficient, C_u and coefficient of gradation, C_c.

(4 marks)

(v) Classify the soil condition.

(2 marks)

Q5 (a) (i) Sketch a general distribution of stress for vertical pressure under a concentrated load.

(2 marks)

(ii) Explain the concept of stress distribution in soil.

(2 marks)

(b) Point load with the magnitude of 100 kN, 200 kN and 300 kN act at point B, C and D respectively are shown in **Figure Q5.1**. By using Westergaard's equation, find the increase of vertical stress at a depth of 6 m below the point A. Refer to Figure APPENDIX A.1 for the value of influence factor.

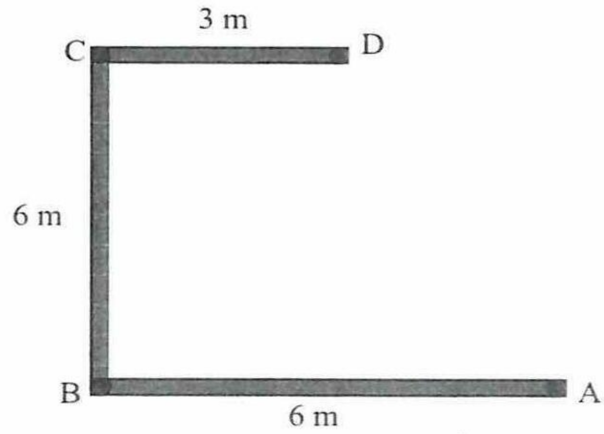

Figure Q5.1 Illustration of distance between point A, B, C and D

(10 marks)

(c) An 8 m by 6 m rectangular foundation carrying a uniform load of 250 kN/m^2 is applied to the ground surface. Calculate the vertical stress increment due to this uniform load at a point 4 m below the corner of the rectangular loaded area. Refer Table APPENDIX B.1 to find the value of Influence Coefficient, I.

(6 marks)

Q6 (a) List down four (4) factors that influence the rate of water flow in soil

(4 marks)

(b) For a constant head permeability test, the following values are given:
L = 300 mm
A = specimen area = 32 cm^2
k = 0.0244 cm/sec

The head difference (h) was slowly changed in steps 800, 700, 600, 500 and 400 mm.

(i) Calculate rate of flow *(q)* in cm^3/sec for each *h*

(3 marks)

(ii) Plot the rate of flow (*q*) against the head difference (*h*)

(3 marks)

(c) For a falling head permeability test, the following values are given:
Length of specimen = 38 cm
Area of specimen = 19 cm^2
Permeability, *k* = 0.175 cm/min.

Calculate the area of standpipe for the head to drop from 64 cm to 30 cm in 9 min.

(3 marks)

(d) For the flow net depicted in **Figure Q6.1**, the coefficient of permeability of the permeable soil stratum is 4.80 x 10^{-3} cm/s. Calculate the total rate of seepage per unit width of sheet pile through the permeable stratum.

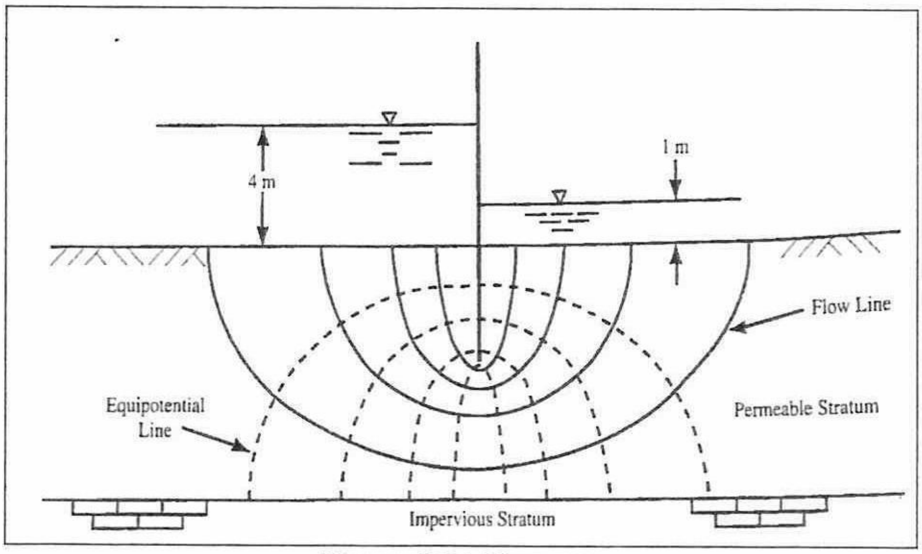

Figure Q6.1 Flow net.

(7 marks)

- END OF QUESTIONS –

APPENDIX A

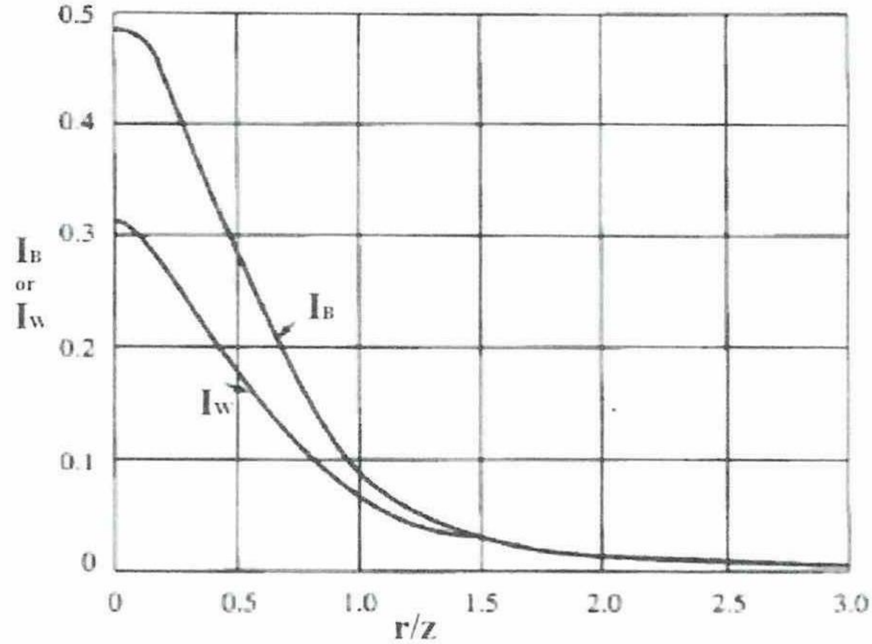

Figure APPENDIX A.1

APPENDIX B

Table APPENDIX B.1

$m=A/z$ or $n=B/z$	$n = B/z$ or $m = A/z$																	
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0	2.5	3.0	5.0	10.0	∞
0.1	0.005	0.009	0.013	0.017	0.020	0.022	0.024	0.026	0.027	0.028	0.029	0.030	0.031	0.031	0.032	0.032	0.032	0.032
0.2	0.009	0.018	0.026	0.033	0.039	0.043	0.047	0.050	0.053	0.055	0.057	0.059	0.061	0.062	0.062	0.062	0.062	0.062
0.3	0.013	0.026	0.037	0.047	0.056	0.063	0.069	0.073	0.077	0.079	0.083	0.086	0.089	0.090	0.090	0.090	0.090	0.090
0.4	0.017	0.033	0.047	0.060	0.071	0.080	0.087	0.093	0.098	0.101	0.106	0.110	0.113	0.115	0.115	0.115	0.115	0.115
0.5	0.020	0.039	0.056	0.071	0.084	0.095	0.103	0.110	0.116	0.120	0.126	0.131	0.135	0.137	0.137	0.137	0.137	0.137
0.6	0.022	0.043	0.063	0.080	0.095	0.107	0.117	0.125	0.131	0.136	0.143	0.149	0.153	0.155	0.156	0.156	0.156	0.156
0.7	0.024	0.047	0.069	0.087	0.103	0.117	0.128	0.137	0.144	0.149	0.157	0.164	0.169	0.170	0.171	0.172	0.172	0.172
0.8	0.026	0.050	0.073	0.093	0.110	0.125	0.137	0.146	0.154	0.160	0.168	0.176	0.181	0.183	0.184	0.185	0.185	0.185
0.9	0.027	0.053	0.077	0.098	0.116	0.131	0.144	0.154	0.162	0.168	0.178	0.186	0.192	0.194	0.195	0.196	0.196	0.196
1.0	0.028	0.055	0.079	0.101	0.120	0.136	0.149	0.160	0.168	0.175	0.185	0.193	0.200	0.202	0.203	0.204	0.205	0.205
1.2	0.029	0.057	0.083	0.106	0.126	0.143	0.157	0.168	0.178	0.185	0.196	0.205	0.212	0.215	0.216	0.217	0.218	0.218
1.5	0.030	0.059	0.086	0.110	0.131	0.149	0.164	0.176	0.186	0.193	0.205	0.215	0.223	0.226	0.228	0.229	0.230	0.230
2.0	0.031	0.061	0.089	0.113	0.135	0.153	0.169	0.181	0.192	0.200	0.212	0.223	0.232	0.236	0.238	0.239	0.240	0.240
2.5	0.031	0.062	0.090	0.115	0.137	0.155	0.170	0.183	0.194	0.202	0.215	0.226	0.236	0.240	0.242	0.244	0.244	0.244
3.0	0.032	0.062	0.090	0.115	0.137	0.156	0.171	0.184	0.195	0.203	0.216	0.228	0.238	0.242	0.244	0.246	0.247	0.247
5.0	0.032	0.062	0.090	0.115	0.137	0.156	0.172	0.185	0.196	0.204	0.217	0.229	0.239	0.244	0.246	0.249	0.249	0.249
10.0	0.032	0.062	0.090	0.115	0.137	0.156	0.172	0.185	0.196	0.205	0.218	0.230	0.240	0.244	0.247	0.249	0.250	0.250
∞	0.032	0.062	0.090	0.115	0.137	0.156	0.172	0.185	0.196	0.205	0.218	0.230	0.240	0.244	0.247	0.249	0.250	0.250

FORMULA

$$c_v = \frac{0.197\,H^2}{4t_{50}}$$

$$c_v = \frac{0.848\,H^2}{4t_{90}}$$

$$c_u = \frac{D_{60}}{D_{10}}$$

a. Uniform if Cu < 5
b. Non uniform if, 5 <Cu<15
c. Uniform if Cu > 15

$$c_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

a. Well graded if 1 ≤Cc ≤ 3
b. Poorly graded if Cc <1 and Cc >3

$$p = \frac{P}{Z^2} I_w$$

$$p = \frac{P}{Z^2} I_B$$

m = A/z, n = B/z

q= Iw

$$\gamma_d = \frac{G_s \gamma_w}{1+e}$$

$$V_s = \frac{M_s}{G_s\,\rho_w}$$

$$k = \frac{2.3\,aL}{At} \log \frac{h_1}{h_2}$$

$$\gamma = \frac{G_s(1+w)}{1+e}\gamma_w$$

$$e = \frac{V_v}{V_s}$$

σ = F/A

$$S_r = \frac{wG_s}{e}$$

$$S = \frac{V_w}{V_v}$$

$\sigma_3 + (\Delta\sigma_d) = \sigma_1$

ρ = M/V

$\rho_d = M_s/V$

s = R/A

γ = ρg

$\gamma_d = \rho_d g$

$$G_S = \frac{M_2 - M_1}{(M_4 - M_1) - (M_3 - M_2)}$$

q = k i A

I = h/L

$$q = k\frac{h}{L}A$$

$k = \frac{q}{Ai}$ $or\ k = \frac{QL}{Aht}$

k =2.3026 $\frac{aL}{At} log_{10} \frac{h_1}{h_2}$

$$q = \frac{kh N_f}{N_d}$$

$$k = \frac{QL}{Aht}$$