Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	FOUNDATION ENGINEERING
COURSE CODE	:	BFC 43103
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 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 **EIGHT (8)** PAGES

Q1 Pile foundation is a foundation system that transfer loads to a deeper and competent soil layer.

(a) List and explain conditions that require pile foundation.

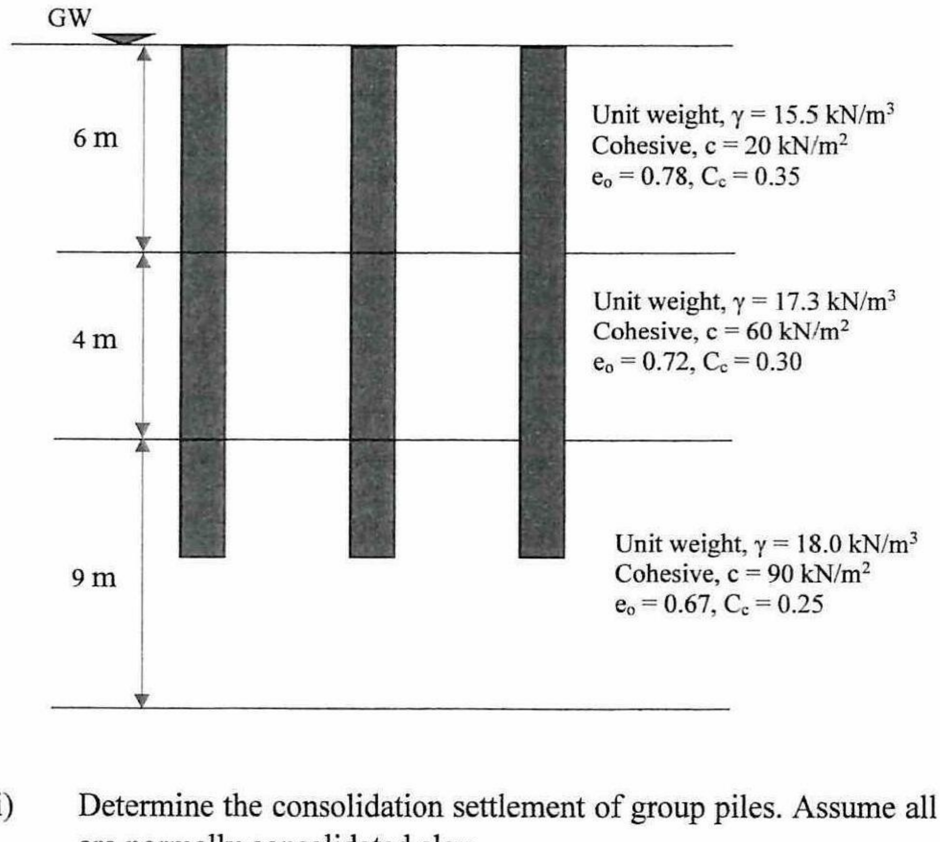
(5 marks)

(b) A 3 x 3 group pile with closed-ended 300 mm diameter steel pile is driven into sand. The water table is at ground surface and the friction angle (ϕ) of the sand is ϕ 36° and the unit weight (γ) is 19.8 kN/m³. The pipe pile's skin friction is 250 kN. The effective earth pressure coefficient (K) is 1.3 and soil pile friction angle (δ') of $0.8\phi'$, where the critical depth for the unit skin friction (f) is at a magnitude of 15 to the pile diameter. Estimate the required length of the pile embedded in the sand.

(10 marks)

(c) The group piles of 2 x 3 was embedded in saturated clay layer as shown in Figure Q1.1 The piles size are 200 mm diameter, pile length 12 m long and pile spacing 600 mm spacing. The loads applied to this column were 2500 kN.

Figure Q1.1 Group pile in saturated clay



(i) Determine the consolidation settlement of group piles. Assume all clay are normally consolidated clay.

(10 marks)

Q2 Retaining wall is a relatively rigid or flexible wall used for supporting soil laterally to avoid slope failure or land slide to occurs.

(a) Discuss **THREE (3)** type of sheet pile and function for each type of sheet piles.

(6 marks)

(b) As a design engineer, you are in charge in designing a 8 m high reinforce earth retaining structure with the following specification.

The soils parameter for the wall backfill
Unit weight of soil, γ, is 18.5 kN/m^3
Soil internal friction angle, ϕ', is 32°
Friction angle at geotextile-soil interface, $\frac{2}{3}\phi'$.
Factor of safety against breaking and pullout, 1.5

Geotextiles reinforcement

Ultimate tensile strength	= 85 kN/m
RF_{id}	= *1.5*
RF_{cr}	= *3*
RF_{cbd}	= *1.2*

(i) Calculate the internal stability of the reinforced earth retaining structure. Consider the design of the reinforced earth retaining structure for every 2 m depth interval.

(14 marks)

(ii) After checking for internal stability, the Sv was 0.5m and the L was 3.5m, determine the overturning stability for the retaining structure.

(5 marks)

Q3 For shallow foundation,it must have 2 characteristics which are safe against shear failure and cannot undergo excessive settlement. The construction of shallow foundation is cheaper compare with deep foundation.

(a) A new building will be constructed at Taman Seri Indah area. For foundation, the consultant engineer has suggested to use a shallow foundation instead deep foundation. The soil properties of the soil given as bulk unit weight, γ is 17.5 kN/m^3, cohesive, c is 40 kN/m^2 and friction angle, $\Phi = 27^o$. The load varies from 100 kN to 200 kN. Determine the size of the square foundation can carry the load with factor of safety of 2.5 and depth of foundation is 1.0 m.

(8 marks)

(b) A shallow foundation has eccentricity in x-direction with value 0.1m. The size of footing is 3 m x 3 m x 1.5m depth. The ground water level was monitored and the worst condition was 0.5m from the ground surface.The soil properties of the soil given as saturated unit weight, γ_{sat} is 19.3 kN/m^3, bulk unit weight, γ is 17.5 kN/m^3, cohesive, c is 40 kN/m^2 and friction angle, $\Phi = 27°$. Design the allowable load that the foundation can carry with factor of safety of 3.

(17 marks)

Q4 Mechanical ground modification refers to soil densification by external forces. Mechanical modification is synonymous with compaction.

(a) Discuss the importance of compaction works especially in road or highway construction and how to monitor the quality of compaction works in site.

(13 marks)

(b) As an engineer in consultancy firm, you need to design a compaction works of 30 km long highway project from Batu Pahat to Pontian. It is a new highway with two lanes in each direction. An earth fill, when completed, will occupy a net volume of 142 950 m^3. In its "bank" condition, the borrow material has a wet unit weight, γ 20.28 kN/m^3, a water content, m of 16.5%, and an in-place void ratio (e) of 0.620. The fill will be constructed in layers of 20.32 cm depth compacted to a dry unit weight γ_{dry} 17.92 kN/m^3 at a water content of 18.3%.

(i) Determine the shrinkage factors and swell factors if the wet unit weight of loose soil is 30 kN/m^3

(8 marks)

(ii) Design the net volume of bank condition.

(4 marks)

- END OF QUESTIONS -

APPENDIX A Design Table and Chart

Table 1 : General bearing capacity factors

ϕ'	N_c	N_q	N_γ	ϕ'	N_c	N_q	N_γ
0	5.14	1.00	0.00	26	22.25	11.85	12.54
1	5.38	1.09	0.07	27	23.94	13.20	14.47
2	5.63	1.20	0.15	28	25.80	14.72	16.72
3	5.90	1.31	0.24	29	27.86	16.44	19.34
4	6.19	1.43	0.34	30	30.14	18.40	22.40
5	6.49	1.57	0.45	31	32.67	20.63	25.99
6	6.81	1.72	0.57	32	35.49	23.18	30.22
7	7.16	1.88	0.71	33	38.64	26.09	35.19
8	7.53	2.06	0.86	34	42.16	29.44	41.06
9	7.92	2.25	1.03	35	46.12	33.30	48.03
10	8.35	2.47	1.22	36	50.59	37.75	56.31
11	8.80	2.71	1.44	37	55.63	42.92	66.19
12	9.28	2.97	1.69	38	61.35	48.93	78.03
13	9.81	3.26	1.97	39	67.87	55.96	92.25
14	10.37	3.59	2.29	40	75.31	64.20	109.41
15	10.98	3.94	2.65	41	83.86	73.90	130.22
16	11.63	4.34	3.06	42	93.71	85.38	155.55
17	12.34	4.77	3.53	43	105.11	99.02	186.54
18	13.10	5.26	4.07	44	118.37	115.31	224.64
19	13.93	5.80	4.68	45	133.88	134.88	271.76
20	14.83	6.40	5.39	46	152.10	158.51	330.35
21	15.82	7.07	6.20	47	173.64	187.21	403.67
22	16.88	7.82	7.13	48	199.26	222.31	496.01
23	18.05	8.66	8.20	49	229.93	265.51	613.16
24	19.32	9.60	9.44	50	266.89	319.07	762.89
25	20.72	10.66	10.88				

Table 2 : Terzaghi bearing capacity factors

Table 4.1 Terzaghi's Bearing Capacity Factors—Eqs. (4.15), (4.13), and (4.11).[a]

ϕ'	N_c	N_q	N_γ^a	ϕ'	N_c	N_q	N_γ^a
0	5.70	1.00	0.00	26	27.09	14.21	9.84
1	6.00	1.10	0.01	27	29.24	15.90	11.60
2	6.30	1.22	0.04	28	31.61	17.81	13.70
3	6.62	1.35	0.06	29	34.24	19.98	16.18
4	6.97	1.49	0.10	30	37.16	22.46	19.13
5	7.34	1.64	0.14	31	40.41	25.28	22.65
6	7.73	1.81	0.20	32	44.04	28.52	26.87
7	8.15	2.00	0.27	33	48.09	32.23	31.94
8	8.60	2.21	0.35	34	52.64	36.50	38.04
9	9.09	2.44	0.44	35	57.75	41.44	45.41
10	9.61	2.69	0.56	36	63.53	47.16	54.36
11	10.16	2.98	0.69	37	70.01	53.80	65.27
12	10.76	3.29	0.85	38	77.50	61.55	78.61
13	11.41	3.63	1.04	39	85.97	70.61	95.03
14	12.11	4.02	1.26	40	95.66	81.27	115.31
15	12.86	4.45	1.52	41	106.81	93.85	140.51
16	13.68	4.92	1.82	42	119.67	108.75	171.99
17	14.60	5.45	2.18	43	134.58	126.50	211.56
18	15.12	6.04	2.59	44	151.95	147.74	261.60
19	16.56	6.70	3.07	45	172.28	173.28	325.34
20	17.69	7.44	3.64	46	196.22	204.19	407.11
21	18.92	8.26	4.31	47	224.55	241.80	512.84
22	20.27	9.19	5.09	48	258.28	287.85	650.67
23	21.75	10.23	6.00	49	298.71	344.63	831.99
24	23.36	11.40	7.08	50	347.50	415.14	1072.80
25	25.13	12.72	8.34				

APPENDIX B

Equations

Modification of Bearing Capacity Equations for Water Table		
Case I for water within $0 \le D_1 \le D_f$; $q = D_1\gamma_{dry} + D_2(\gamma_{sat} - \gamma_w)$ $\gamma' = \gamma_{sat} - \gamma_w$	Case II for water within $0 \le d \le B$; $q = D_1\gamma_{dry}$ $\bar{\gamma} = \gamma' + \frac{d}{B}(\gamma_{dry} - \gamma')$	Case III when the water table is located so that $d \ge B$, the water will have no effect on the ultimate bearing capacity.

$$q_u = cN_c + qN_q + 0.5\gamma BN_\gamma \text{.......(} strip.foundation \text{)}$$
$$q_u = 1.3cN_c + qN_q + 0.4\gamma BN_\gamma \text{........(} square.foundation \text{)}$$
$$q_u = 1.3cN_c + qN_q + 0.3\gamma BN_\gamma \text{.........(} circular.foundation \text{)}$$

$$q_u = c'N_cF_{cs}F_{cd}F_{ci} + qN_qF_{qs}F_{qd}F_{qi} + \tfrac{1}{2}\gamma BN_\gamma F_{\gamma s}F_{\gamma d}F_{\gamma i}$$

Shape Factor		
$F_{cs} = 1 + \frac{B}{L}.\frac{N_q}{N_c}$	$F_{qs} = 1 + \frac{B}{L}\tan\phi$	$F_{\gamma s} = 1 - 0.4\frac{B}{L}$

Depth Factor		
$D_f/B \le 1, for\ \phi = 0$		
$F_{cd} = 1 + 0.4(^{D_f}/_B)$	$F_{qd} = 1$	$F_{\gamma d} = 1$
$^{D_f}/_B \le 1, for\ \phi > 0$		
$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c tan\phi'}$	$F_{qd} = 1 + 2tan\phi'(1 - sin\phi')^2\frac{D_f}{B}$	$F_{\gamma d} = 1$
$D_f/B > 1, for\ \phi = 0$		
$F_{cd} = 1 + 0.4\underbrace{tan^{-1}\left(^{D_f}/_B\right)}_{\text{radians}}$	$F_{qd} = 1$	$F_{\gamma d} = 1$
$D_f/B > 1, for\ \phi > 0$		
$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c tan\phi'}$	$F_{qd} = 1 + 2\tan\phi'(1 - sin\phi')^2\underbrace{tan^{-1}(\frac{D_f}{B})}_{\text{radians}}$	$F_{\gamma d} = 1$

where L is the length of the foundation and L>B.
Inclination Factor
$F_{ci} = F_{qi} = \left(1 - \frac{\beta^\circ}{90^\circ}\right)^2$ $F_{\gamma i} = \left(1 - \frac{\beta}{\phi'}\right)^2$ β is the inclination of the load on the foundation with respect to vertical

Eccentric Loading in Shallow Foundations	
$q_{\max} = \frac{Q}{BL} \pm \frac{6M}{B^2L}$ $q_{\max} = \frac{4Q}{3L(B-2e)}$	$e = \frac{M}{Q}$ $FS = \frac{Q_{ult}}{Q}$

Ultimate Capacity of Piles

$$Q_s = f_{av} pL = (K \overline{\sigma}'_o \tan \delta') pL$$

$$S_{c(p)} = \frac{C_c H_c}{1 + e_o} \log \frac{\sigma'_o + \Delta\sigma'_{av}}{\sigma'_o}$$ (for normally consolidated clays)

$$S_{c(p)} = \frac{C_s H_c}{1 + e_o} \log \frac{\sigma'_o + \Delta\sigma'_{av}}{\sigma'_o}$$ (for overconsolidated clays with $\sigma'_o + \Delta\sigma'_{av} < \sigma'_c$)

$$S_{c(p)} = \frac{C_s H_c}{1 + e_o} \log \frac{\sigma'_c}{\sigma'_o} + \frac{C_c H_c}{1 + e_o} \log \frac{\sigma'_o + \Delta\sigma'_{av}}{\sigma'_c}$$ (for overconsolidated clays with $\sigma'_o < \sigma'_c < \sigma'_o + \Delta\sigma'_{av}$)

Rankine's Theory	
$P_a = \frac{1}{2} K_a \gamma_1 H^2$ $P_a = \frac{1}{2} K_a \gamma_1 H^2 + qK_a H$ $P_v = P_a \sin\alpha°$ $P_h = P_a \cos\alpha°$ $P_p = \frac{1}{2} K_p \gamma_2 D^2 + 2c'_2 \sqrt{K_p} D$ $K_a = \tan^2\left(45° - \frac{1}{2}\phi'_1\right)$ $K_p = \tan^2\left(45° + \frac{1}{2}\phi'_2\right)$	$FS_{overturning} = \frac{\sum M_R}{\sum M_O}$ $\sum M_O = P_h \left(\frac{H'}{3}\right)$ $P_h = P_a \cos\alpha$ $P_v = P_a \sin\alpha$
$FS_{sliding} = \frac{\sum F_{R'}}{\sum F_d} = \frac{(\sum V)\tan(k_1\phi'_2) + Bk_2c'_2 + P_p}{P_a \cos\alpha}$	

$$T_{all} = \frac{T_{ult}}{RF_{id} \times RF_{cr} \times RF_{cbd}}$$

$$S_V = \frac{T_{all}}{\sigma'_a FS_{(B)}} = \frac{T_{all}}{(\gamma_1 z K_a)[FS_{(B)}]}$$

$$l_r = \frac{H - z}{\tan\left(45 + \frac{\phi'_1}{2}\right)} \qquad L = l_r + l_e \qquad l_e = \frac{S_V \sigma'_a [FS_{(P)}]}{2\sigma'_o \tan\phi'_F}$$

$$l_l = \frac{S_V \sigma'_a FS_{(P)}}{4\sigma'_o \tan\phi'_F}$$

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