Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME	:	FOUNDATION ENGINEERING
COURSE CODE	:	BFC 43103
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 **EIGHT (8)** PAGES

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

(a) Discuss the importance of group efficiency in design group piles

(3 marks)

(b) The group piles of 2 x 3 was embedded in saturated clay layer as shown in The piles size are 200 mm diameter and pile spacing 600 mm spacing. The loads applied to this column were 2000 kN.

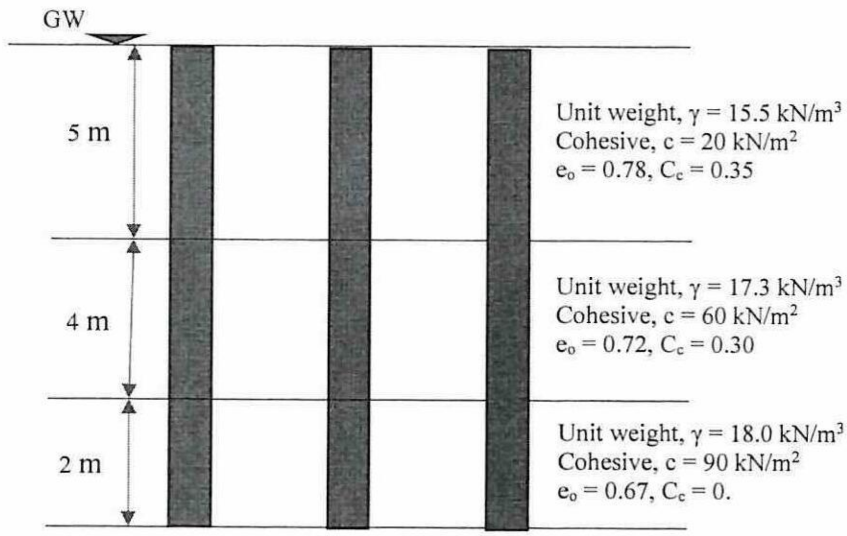

Figure Q1.1 Group pile in saturated clay

(i) If factor safety is 3, analyse whether the group piles able carry the load.

(12 marks)

(ii) 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 prevent slope failure or land slide to occur.

(a) Discuss advantage and disadvantage for **THREE (3)** type of retaining wall

(3 marks)

(b) As a design engineer, you are in charge in designing a 10 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 36°

Galvanised steel reinforcement
Width of strip, w = 60 mm
S_v = 1 m center-to-center
S_H = 1 m center-to-center
F_y = 250,000 kN/m^2
$\phi'_\mu = 24°$

$FS_{(B)} = 3$
$FS_{(P)} = 3$

(i) Calculate the appropriate tie thickness for the steel-strip reinforcement. Assume the corrosion rate of the galvanised steel to be 0.02 mm/year and the life span of the structure to be 50 years.

(7 marks)

(ii) Calculate the tie length at 2 m, 4 m, 6 m, 8 m and 10 m below the top of the retaining structure.

(10 marks)

(iii) Assess the overturning stability for the retaining structure.

(5 marks)

Q3 Shallow foundation must be have 2 characteristics; safe against shear failure and cannot undergo excessive settlement. The construction of shallow foundation is cheaper compare to 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 of deep foundation. Compared the difference between shallow foundation and deep foundation. Use sketches to support your answer.

(6 marks)

(b) A shallow foundation has eccentricity in x-direction with value 0.15m. The size of footing is 3 m x 3 m. The soil properties of the soil given as unit weight, γ is 17.5 kN/m^3, cohesive, c is 0 kN/m^2 and friction angle, φ = 35°. Design the allowable load that the foundation can carry with factor of safety of 3.

(19 marks)

Q4 Hydraulic modification for fine material is very important to control the settlement of the structure. Hydraulic modification is the process lowering down the ground water level before the construction begin.

(a) Discuss the differences between preloading and vertical drain and give the major beneficial effects for both techniques in civil engineering work.

(10 marks)

(b) As an engineer in a consultancy firm, you are requiring to propose a soil improvement method of 30 km long highway project from Batu Pahat to Pontian. It is a new highway with two lanes in each direction constructed largely in areas that are underlain by soft clay deposits. The proposal should include reasons that associate with cost, time and the efficiency of the method.

(15 marks)

- END OF QUESTIONS -

APPENDIX A Design Table and Chart

Table APPENDIX A (1) : 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 APPENDIX A (1) : α for frictional resistance in clay

$\frac{c_u}{p_o}$	α
≤ 0.1	1.00
0.2	0.92
0.3	0.82
0.4	0.74
0.6	0.62
0.8	0.54
1.0	0.48
1.2	0.42
1.4	0.40
1.6	0.38
1.8	0.36
2.0	0.35
2.4	0.34
2.8	0.34

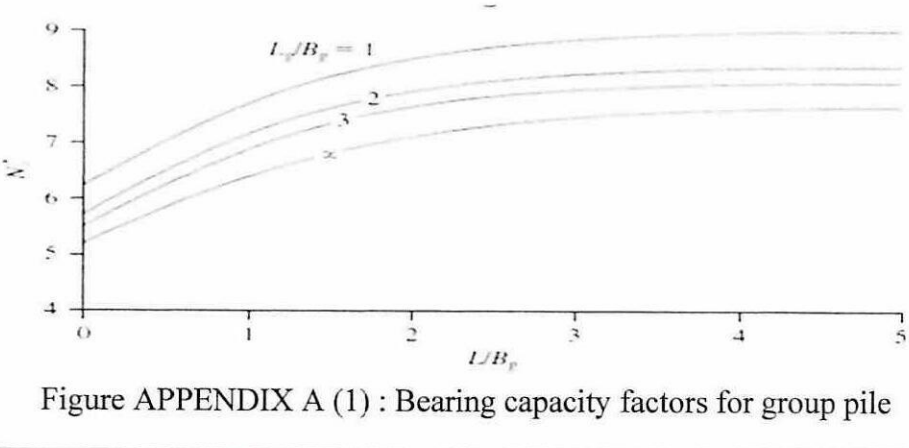

Figure APPENDIX A (1) : Bearing capacity factors for group pile

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.
$q_u = cN_c + qN_q + 0.5\gamma BN_\gamma ....(strip.foundation)$ $q_u = 1.3cN_c + qN_q + 0.4\gamma BN_\gamma ....(square.foundation)$ $q_u = 1.3cN_c + qN_q + 0.3\gamma BN_\gamma ....(circular.foundation)$		
$q_u = c'N_cF_{cs}F_{cd}F_{ci} + qN_qF_{qs}F_{qd}F_{qi} + \frac{1}{2}\gamma BN_\gamma F_{\gamma s}F_{\gamma d}F_{\gamma i}$		
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		
$D_f/B \le 1, for\ \phi = 0$		
$F_{cd} = 1 + 0.4(^{D_f}/_B)$	$F_{qd} = 1$	$F_{\gamma d} = 1$
$^{D_f}/_B \le 1, for\ \phi > 0$		
$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c tan\phi'}$	$F_{qd} = 1 + 2tan\phi'(1 - sin\phi')^2\frac{D_f}{B}$	$F_{\gamma d} = 1$
$D_f/B > 1, for\ \phi = 0$		
$F_{cd} = 1 + 0.4\ \underbrace{tan^{-1}\left(^{D_f}/_B\right)}_{radians}$	$F_{qd} = 1$	$F_{\gamma d} = 1$
$D_f/B > 1, for\ \phi > 0$		
$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c tan\phi'}$	$F_{qd} = 1 + 2\tan\phi'(1 - sin\phi')^2\underbrace{tan^{-1}(\frac{D_f}{B})}_{radians}$	$F_{\gamma d} = 1$
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	
$q_{max} = \frac{Q}{BL} \pm \frac{6M}{B^2L}$	$e = \frac{M}{Q}$
$q_{max} = \frac{4Q}{3L(B-2e)}$	$FS = \frac{Q_{ult}}{Q}$

Ultimate Capacity of Piles and Group Piles in Saturated Clay

$Q_s = \sum f p \Delta L$

$f = \beta \sigma_o'$

$\beta = K \tan \phi_R'$

$K = 1 - \sin \phi_R'$

$K = 1 - \sin \phi_R' \sqrt{OCR}$

$OCR = \frac{P_c}{P_o}$

$Q_p = A_p q_p$

$Q_p = A_p q' N_q^*$

$Q_p \approx N_c^* c_u A_p$

$Q_p = 9 c_u A_p$

$f_{av} = \lambda(\bar{\sigma}_o' + 2c_u)$

$$Q_p = 0.4\, A_p\, (q_p) = A_p \left[0.4\, P_a\, N_{60} \frac{L}{D}\right] \leq A_p\, (4\, P_a N_{60})$$

Rankine's Theory	
$P_a = \frac{1}{2} K_a \gamma_1 H^2$	$FS_{overturning} = \frac{\sum M_R}{\sum M_O}$
$P_a = \frac{1}{2} K_a \gamma_1 H^2 + q K_a H$	$\sum M_O = P_h \left(\frac{H'}{3}\right)$
$P_v = P_a \sin \alpha^\circ$	$P_h = P_a \cos \alpha$
$P_h = P_a \cos \alpha^\circ$	$P_v = P_a \sin \alpha$
$P_p = \frac{1}{2} K_p \gamma_2 D^2 + 2c_2' \sqrt{K_p} D$	

$K_a = \tan^2\left(45° - \frac{1}{2}\phi_1'\right)$ $K_p = \tan^2\left(45° + \frac{1}{2}\phi_2'\right)$	
$FS_{sliding} = \frac{\sum F_{R'}}{\sum F_d} = \frac{\left(\sum V\right)\tan\left(k_1\phi_2'\right) + Bk_2c_2' + P_p}{P_a \cos\alpha}$	

$$t = \frac{(\sigma_a\, S_v\, S_H)[FS_B]}{w\, f_y}$$

$$L = \frac{H - z}{\tan\left(45 + \frac{\Phi}{2}\right)} + \frac{FS_P \sigma_a\, S_v\, S_H}{2\, w\, \sigma_a\, \tan \Phi_\mu}$$