Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	FOUNDATION ENGINEERING
COURSE CODE	:	BFC 43103
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS IN PART A AND CHOOSE ANY **THREE (3)** QUESTIONS IN PART B

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

PART A

Q1 (a) Briefly illustrate the 'Wash Boring' methods for drilling boreholes, and the use of an open drive sampler for collecting soils samples from the borehole.

(5 marks)

(b) Field exploration and soil test were carried out in order to gather important information and soil parameters that are required for foundation design. As a geotechnical engineer, you will be involved in designing and analyzing. ELABORATE in details the procedures that would be practically implement in order to obtain information on surface and subsurface construction at a proposed large area projects.

(8 marks)

(c) The observed standard penetration test value (N) in a deposit of fully submerged sand was 45 at a depth of 6.5m. The average effective unit weight of the soil is 9.69 kN/m^3. The additional data given are ;

Hammer efficiency = 0.8
Drill rod length correction factor = 0.9
Borehole correction factor = 1.05

ANALYZE the corrected SPT value for standard energy;
(i) R_{es} = 60 %
(ii) R_{es} = 70%

(12 marks)

PART B

Q2 (a) As an engineer that will in charge for construction on site where need to propose shallow foundation in design. **COMPARE TWO (2)** methods to determine the design of bearing capacity for shallow foundations. Differentiate the advantages and disadvantages perceived for both method.

(5 marks)

(b) A square foundation 4.5 m x 4.5 m is founded at 2.4 m in a soil with the following properties:

$\gamma = 17.6\ kN/m^3$
$\gamma_{sat} = 20.4\ kN/m^3$
$c = 32.0\ kN/m^2$
$\varphi = 28°$

(i) **COMPUTE** the ultimate bearing capacity in kN/m^2 by using Terzaghi's and Meyerhof's methods when the water table is level with the foundation base (FS=3).

(15 marks)

(ii) Using Terzaghi's method, **CALCULATE** the percentage reduction in bearing capacity when the water table rises to 0.5 m below ground level.

(5 marks)

Q3 (a) There are different methods for determining load carrying capacity between piles on clayey soils and sand soil. As an experienced engineer, you are required to **POINT OUT** the main differences for both methods.

(5 marks)

(b) A 40 cm square pre-cast pile is driven by 9 m into a sandy bed. The standard penetration test results, performed on this ground are given in Table 1.

CALCULATE the factor of safety available if 1100 kN of compressive load is applied on this pile.

(8 marks)

(c) A concrete pile of 45 cm diameter is driven through a system of layered cohesive soils. The length of the pile is 16m. The water table is close to the ground surface. Below is the following data ;

Top layer 1 : Soft clay, thickness = 8m, unit cohesion c = 30 kN/m^2 and adhesion factor $\alpha = 0.90$
Layer 2 : Medium stiff, thickness = 6m, unit cohesion c_u = 50 kN/m^2 and α = 0.75
Layer 3: Stiff stratum extends to a great depth, unit cohesion c_u = 105 kN/m^2 and $\alpha = 0.50$

CALCULATE the Q_u and Q_a with $F_s = 2.5$

(12 marks)

Q4 (a) Sometimes construction work requires ground excavations with vertical or near-vertical faces— for example, basements of buildings in developed areas or underground transportation facilities at shallow depths below the ground surface (a cut-and-cover type of construction). The vertical faces of the cuts need to be protected by temporary bracing systems to avoid failure that may be accompanied by considerable settlement or by bearing capacity failure of nearby foundations. Two types of braced cut commonly used in construction work. DISCUSS in details the function of both types.

(10 marks)

(b) The gravity wall shown in **Figure Q4(c),** is to support backfill with unit weight 19.5 kN/m^3 and shear strength parameters $c' = 0$ and $Ø' = 36^0$. The unit weight of the wall materials is 24 kN/m^3 and the angle of friction δ between the wall and the backfill is 27^0 and at the base of the wall is 25^0. Evaluate;

(i) The factors of safety against overturning and sliding
(ii) The maximum and minimum bearing pressures.

(15 marks)

Q5 (a) Preloading is one of the traditional method for ground improvement but still commonly used in practice. **DISCUSS** the principle of preloading and the advantage of using this method.

(4 marks)

(b) The use of geosynthetics has proven to be effective and practical for improving soil conditions for some categories of construction project especially for soft soil. **ILUSTRATE** the concept behind the basic propose for typical uses and ground improvement especially for soft ground. **RECOMMEND ONE (1)** case that related to construction on soft ground that use geosynthetics.

(8 marks)

(c) The challenges faced by geotechnical engineers in road construction over soft soil include limited accessibility, difficult traffic ability, expectations of very large settlements over an extended time period, and possibility of stability problems. The high compressibility, low shear strength and high ground water level cause specific problems for designing and constructing structures on such types of soil. You as geotechnical engineer responsible to construct road construction on this area. **DIFFERENTIATE** TWO **(2)** methods (with diagram) that will be use to overcome these problems. **JUSTIFY** why you use these methods.

(13 marks)

– END OF QUESTIONS –

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TABLE 1 : SPT Values

Depth (m)	1.5	3	4.5	6	7.5	9	10.5	12
SPT N Values	4	6	12	12	20	24	35	39

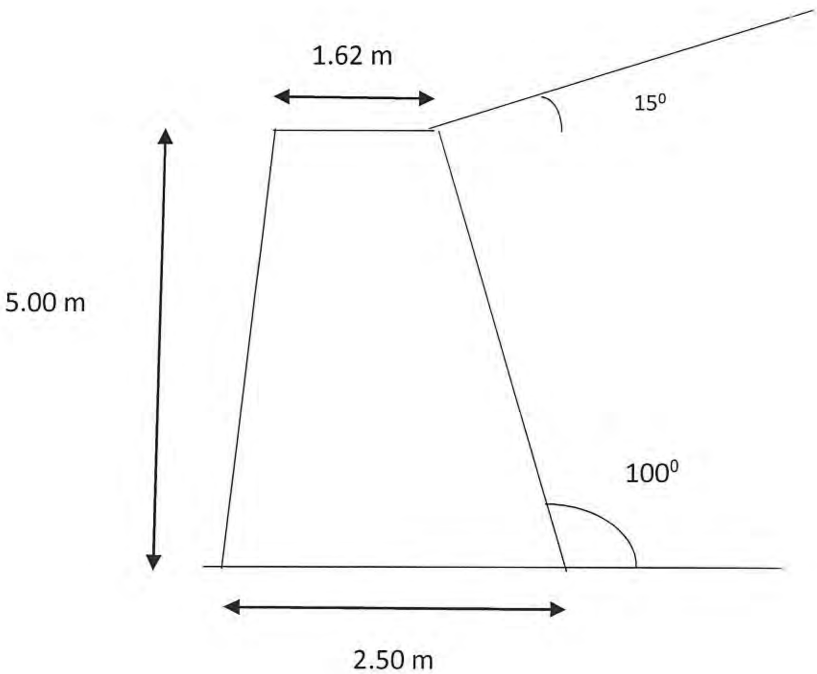

Figure Q4(c) : Retaining Wall

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TABLE 2 : Terzaghi Bearing Capacity Factor

ϕ'	N_c	N_q	N_γ^*	ϕ'	N_c	N_q	N_γ^*
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				

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TABLE 3 : Meyerhof's bearing capacity factor

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				

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Shape, depth and inclination factor

Factor	Relationship	Reference
Shape	$F_{cs} = 1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$ $F_{qs} = 1 + \left(\frac{B}{L}\right)\tan\phi'$ $F_{\gamma s} = 1 - 0.4\left(\frac{B}{L}\right)$	DeBeer (1970)
Depth	$\frac{D_f}{B} \le 1$ For $\phi = 0$: $F_{cd} = 1 + 0.4\left(\frac{D_f}{B}\right)$ $F_{qd} = 1$ $F_{\gamma d} = 1$ For $\phi' > 0$: $F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi'}$ $F_{qd} = 1 + 2\tan\phi'(1 - \sin\phi')^2\left(\frac{D_f}{B}\right)$ $F_{\gamma d} = 1$ $\frac{D_f}{B} > 1$ For $\phi = 0$: $F_{cd} = 1 + 0.4\underbrace{\tan^{-1}\left(\frac{D_f}{B}\right)}_{\text{radians}}$ $F_{qd} = 1$ $F_{\gamma d} = 1$ For $\phi' > 0$: $F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi'}$ $F_{qd} = 1 + 2\tan\phi'(1 - \sin\phi')^2\underbrace{\tan^{-1}\left(\frac{D_f}{B}\right)}_{\text{radians}}$ $F_{\gamma d} = 1$	Hansen (1970)
Inclination	$F_{ci} = F_{qi} = \left(1 - \frac{\beta^\circ}{90^\circ}\right)^2$ $F_{\gamma i} = \left(1 - \frac{\beta}{\phi'}\right)$ β = inclination of the load on the foundation with respect to the vertical	Meyerhof (1963); Hanna and Meyerhof (1981)

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$$q_u = cN_c + qN_q + 0.5\gamma BN_\gamma ....(strip.foundation)$$

$$q_u = 1.3cN_c + qN_q + 0.4\gamma BN_\gamma ....(square.foundation)$$

$$q_u = 1.3cN_c + qN_q + 0.3\gamma BN_\gamma ....(circular.foundation)$$

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

$$\overline{\gamma} = \gamma' + \frac{d}{B}(\gamma - \gamma')$$

$$A_R(\%) = \frac{D_O^2 - D_i^2}{D_i^2}(100)$$

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List of formula

Ultimate Capacity of Piles	
Point Bearing ***Meyerhof*** **Sand** $Q_p = A_p q' N_q^* \leq A_p q_l$ $q_l = 0.5 p_a N_q^* tan\phi'$ **Clay** $Q_p = 9 c_u A_p$ ***Vesic*** **Sand** $Q_p = A_p q_p = A_p \bar{\sigma}_o' N_\sigma^*$ **Clay** $Q_p = A_p q_p = A_p c_u N_c^*$ **Frictional Resistance** **Sand** $Q_s = \Sigma p \Delta L f$ $f = K \sigma_o' tan\delta'$ $\delta = 0.8\phi$ **Clay** **α method,** $Q_s = \Sigma \alpha c_u p \Delta L$ **λ method,** $Q_s = pL f_{av}$ $f_{av} = \lambda(\bar{\sigma}_o' + 2c_u)$ **β method** $Q_s = \Sigma f p \Delta L$ $f = \beta \sigma_o'$	**Correlation with Cone penetration** $Q_p = A_p q_c$ $q_p = q_c$ $Q_s = \Sigma p \Delta L f$ $f = \alpha' f_c$ $f_c = Frictional\ resistance$ **Pile Load Test (Davisson's method)** $s_u(mm) = 0.012 D_r + 0.1\left(\frac{D}{D_r}\right) + \frac{Q_u L}{A_p E_p}$ $D_r = reference\ pile\ diameter\ (= 300mm)$ $D\ is\ in\ mm$

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Retaining Wall

$T_{max} = \sigma_{a(max)} S_V S_H$ $\sigma_{a(max)} = \gamma_1 H K_a$ $K_a = tan^2\left(45 - \frac{\emptyset'_1}{2}\right)$ $t = \frac{(T_{max})[FS_{(B)}]}{w f_y}$ $L = \frac{(H-z)}{tan^2\left(45 + \frac{\emptyset'_1}{2}\right)} + \frac{FS_{(P)} \gamma_1 z K_a S_V S_H}{2 w \gamma_1 z \, tan\emptyset'_\mu}$	$FS_{(overturning)} = \frac{W_1 x_1}{P_a z'}$ $FS_{(sliding)} = \frac{W_1 tan(k\emptyset'_1) + Bkc}{P_a}$