UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2013/2014

COURSE NAME	:	ADVANCED FOUNDATION ENGINEERING
COURSE CODE	:	BFG 40103/BFG 4013
PROGRAMME	:	4 BFF
EXAMINATION DATE	:	JUNE 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **THIRTEEN (13)** PAGES

Q1 (a) On some occasions, mat foundations may have to be built on rocks. We may use Terzaghi's bearing capacity equations with the bearing capacity factors given by Stagg and Zienkiewicz (1968). The cohesion (c') of rock can be estimated from the unconfined compression strength (q_{uc}). Bowles (1996) suggested that the calculated ultimate bearing capacity (q_u) should be modified as $q_{u(modified)} = q_u\,(RQD)^2$

Clearly explain the reasons why that q_u for design purposes has to be modified according to Bowles.

(5 marks)

(b) Two continuous shallow foundations are constructed alongside each other in a granular soil. For the foundation: $B = 1.2$ m, $D_f = 1$ m, and center-to-center spacing = 2 m. For the soil: friction angle, Ø' is 35° and unit weight, γ is 16.8 kN/m^3.

Use a factor of safety, FS = 4 , estimate the net allowable load capacity per unit length of the foundation.

(10 marks)

(c) A mat foundation with dimensions of 3 m x 3 m was constructed in a sand deposit (γ = 17 kN/m^3) at a depth of 1.5 m (foundation level) but resting on a bed of siltstone. The properties of siltstone are as follows: γ = 25 kN/m^3 , Ø' = 31°, c' = 32 MN/m^2 and RQD = 50%. By using the factor of safety (FS) = 4 and allowable compression stress in concrete (f_c') = 30 MN/m^2, predict the allowable load capacity of the foundation.

(10 marks)

Q2 (a) With the help of neat sketches, clearly explain the load transfer mechanism from drilled shaft to soil.

(8 marks)

(b) Figure **Q2(b)** shows a drilled shaft with a bell placed in a layer of dense sand and gravel. Given: $D_s = 1$ m , $D_b = 1.75$ m. For the dense sand layer, Ø' = 36°. The medium dense sand layer above the dense sand has a unit weight of 16.5 kN/m^3 and Ø' = 20°.

By using Berezantzev et. al. (1961) design approach:

Determine:

(i) The net ultimate point load capacity

(ii) The ultimate skin resistance

(iii) The working load the drilled shaft could carry(Q_w) for FS = 3.

(12 marks)

(c) The most common procedure used in the construction of drilled-shaft involves rotary drilling. There are three major types of construction methods: the *dry method*, the *casing method*, and the *wet method.*

Produce and explain the procedure for *casing method* with the aids of appropriate sketches.

(5 marks)

Q3 (a) Foundation supporting engines or machines are subjected to vibration caused by unbalanced machine forces as well as the static weight. Discuss **FOUR (4)** main design considerations for a safe and well performance of machine foundation.

(10 marks)

(b) A reinforced concrete foundation of 2.5 m in diameter is designed to support a machine which has a total weight (machine and foundation) of 280 kN. The machine imparts a vertical vibrating force $Q = Q_o \sin \omega t$ with $Q_o = 28$ kN (not frequency dependent). The operating frequency is 150 cpm. For the soil supporting the foundation of unit weight = 19 kN/m^3, Shear modulus = 45000 kPa, and Poisson' ratio = 0.3, determine:

(i) Resonant frequency
(ii) The ratio of resonant frequency to the operating frequency
(iii) The amplitude of vertical vibration at the resonant frequency.

(15 marks)

Q4 (a) In some parts of the world, certain soils make the construction of foundations extremely difficult. For example , *expansive* and *collapsible* soils may cause high differential movements in structure through excessive settlement.
Clearly explain the differences between *expansive soil* and *collapsible soil.*

(7 marks)

(b) If a soil possesses a high swell potential (expansive soil) , a commonly used techniques for dealing with this type of soil is changing the nature or properties of the soil.
Briefly explain **TWO (2)** techniques or methods that can be practically applied to change the nature or properties of expansive soil.

(8 marks)

(c) In the design of braced excavation, theoretically the sheet piles are required to be driven only up to the bottom of the excavation. However in normal construction practice the sheet piles are driven to a certain depth below the bottom of the excavation.

Discuss the reasons for this practice.

(10 marks)

Q5 (a) Define the following members and neatly sketch their locations in a braced excavation system used in construction work:

(i) sheet pile
(ii) soldier beam
(iii) lagging
(iv) wale
(v) strut
(vi) wedge

(9 marks)

(b) A 7 m deep braced excavation in clay is shown in Figure **Q5(b)**. The unit weight (γ) and cohesion (c) of the soil is 17.5 kN/m^3 and 60 kN/m^2 respectively. The center-to-center spacing of struts in the plan is 5 m.

(i) Draw the earth pressure diagram
(ii) Determine the loads in the struts A, B and C
(iii) If the length of the excavation is 12.5 m , determine the factor of safety against bottom heave for the braced excavation.

(16 marks)

- **END OF QUESTION** -

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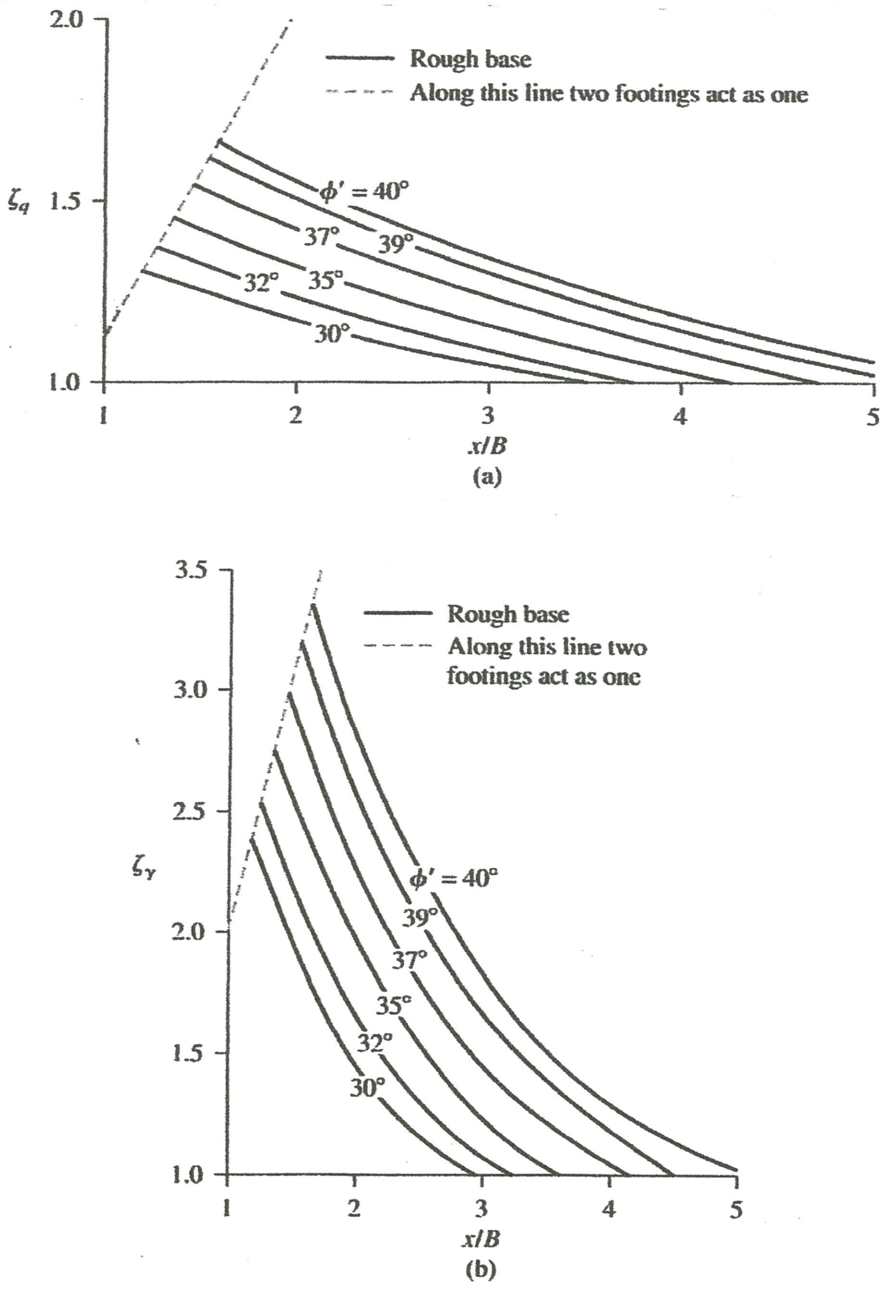

(a)

(b)

Variation of efficiency ratios with x/B and ϕ'

FIGURE Q1(b)(i)

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TABLE 1

Terzaghi's Bearing Capacity Factors–
Kumbhojkar (1993)

ϕ'	N_c	N_q	$N_\gamma{}^a$	ϕ'	N_c	N_q	$N_\gamma{}^a$
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				

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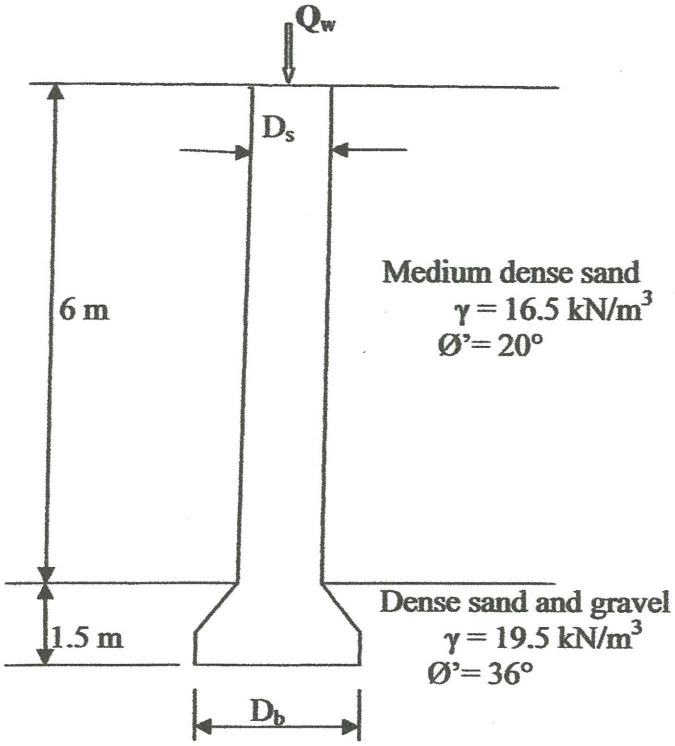

FIGURE Q2(b)

TABLE 2

Variation of N_q^* with ϕ'

ϕ' (deg)	N_q^*
25	14.72
26	17.45
27	20.68
28	24.52
29	29.06
30	34.44
31	40.83
32	48.39
33	57.36
34	67.99
35	80.59
36	95.52
37	113.22
38	134.20
39	159.07
40	188.55
41	223.49
42	264.90
43	313.99
44	372.17
45	441.14

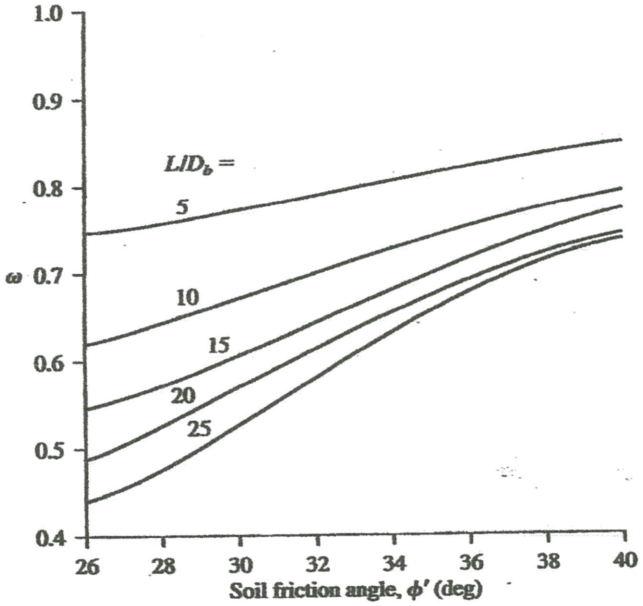

FIGURE Q2(b)(i)

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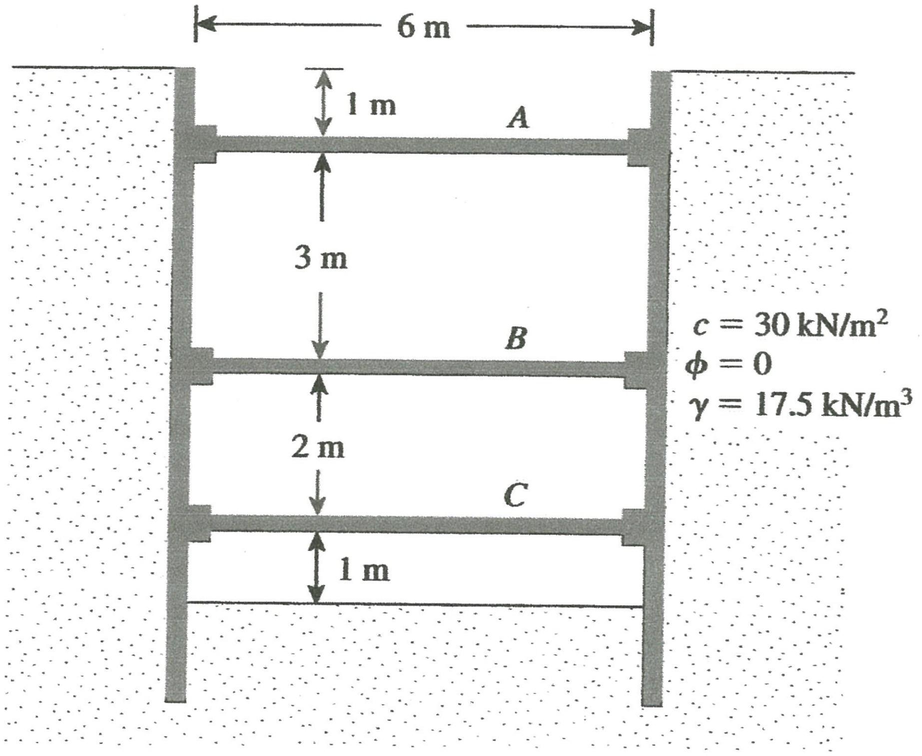
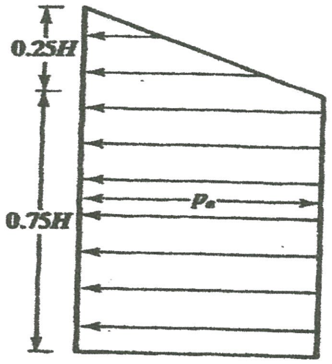
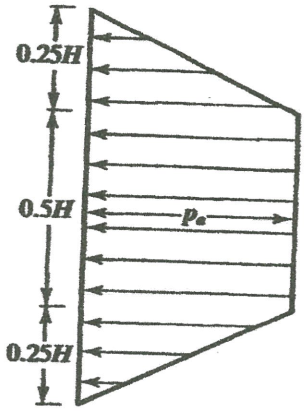


FIGURE Q5(b)



$$\frac{\gamma H}{c} > 4$$

$$p_a = \gamma H\left[1-\left(\frac{4c}{\gamma H}\right)\right] \quad \text{or} \quad p = 0.3\gamma H$$



$$\frac{\gamma H}{c} \leq 4$$

$p_a = 0.2\gamma H..to..0.4\gamma H$ with an average of $0.3\gamma H$

FIGURE Q5(b)(i)

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FORMULAS

SHALLOW FOUNDATION

$$q_u = qN_q\zeta_q + \tfrac{1}{2}\gamma BN_\gamma\zeta_\gamma$$

where ζ_q, ζ_γ = efficiency ratios.

$$q_{net}(\text{kN/m}^2) = \frac{N_{60}}{0.08}\left(\frac{B+0.3}{B}\right)^2 F_d\left(\frac{S_e}{25}\right)$$

where

N_{60} = standard penetration resistance
B = width (m)
$F_d = 1 + 0.33(D_f/B) \leq 1.33$
S_e = settlement, (mm)

$$q_u = c'N_c + qN_q + \tfrac{1}{2}\gamma BN_\gamma$$

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma$$

$$q_u = 1.3c'N_c + qN_q + 0.3\gamma BN_\gamma$$

$$N_c = 5\tan^4\left(45 + \frac{\phi'}{2}\right)$$

$$N_q = \tan^6\left(45 + \frac{\phi'}{2}\right)$$

$$N_\gamma = N_q + 1$$

$$q_{uc} = 2c'\tan\left(45 + \frac{\phi'}{2}\right)$$

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FORMULAS

DEEP FOUNDATION

$$Q_{p(net)} = A_p q'(\omega N_q^* - 1)$$

where

$N_q^* =$ bearing capacity factor $= 0.21e^{0.17\phi'}$
$\omega =$ correction factor $= f(L/D_b)$

$$Q_s = \int_0^{L_1} pf\,dz$$

where

$p =$ shaft perimeter $= \pi D_s$
$f =$ unit frictional (or skin) resistance $= K\sigma'_o \tan\delta'$

$K =$ earth pressure coefficient $\approx K_o = 1 - \sin\phi'$
$\sigma'_o =$ effective vertical stress at any depth z

Thus,

$$Q_s = \int_0^{L_1} pf\,dz = \pi D_s(1 - \sin\phi')\int_0^{L_1} \sigma'_o \tan\delta'\,dz$$

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FORMULAS

MACHINE FOUNDATION

$$B_z = \left(\frac{1-\mu}{4}\right)\left(\frac{m}{\rho r_0^3}\right) = \left(\frac{1-\mu}{4}\right)\left(\frac{W}{\gamma r_0^3}\right)$$

$$f_m = \left(\frac{1}{2\pi}\right)\left(\sqrt{\frac{G}{\rho}}\right)\left(\frac{1}{r_0}\right)\sqrt{\frac{B_z - 0.36}{B_z}}$$

$$A_{z(\text{resonance})} = \frac{Q_0(1-\mu)}{4Gr_0}\,\frac{B_z}{0.85\sqrt{B_z - 0.18}}$$