UNIVERSITY OF JOHANNESBURG

PROGRAM	:	Baccalaureus Ingeneriae (BIng) *CIVIL ENGINEERING SCIENCE*
SUBJECT	:	**GEOTECHNICAL ENGINEERING**
CODE	:	**GTG 4A11**
DATE	:	JUNE SUPPLEMENTARY EXAMINATION 2018
DURATION	:	3 HOURS
WEIGHT	:	50:50
TOTAL MARKS	:	100

EXAMINER	:	PROFESSOR F N OKONTA
MODERATOR	:	MR MED KWESIGA

INSTRUCTIONS	:	QUESTION PAPERS MUST BE HANDED IN.
ECSA REQUIREMENTS	:	QUESTIONS ADDRESSED ECSA ELO 4

INSTRUCTIONS TO CANDIDATES:

PLEASE ANSWER ALL THE QUESTIONS.

GEOTECHNICAL ENGINEERING 4A

FIRST SEMESTER SUPPLEMENTARY EXAMINATION 2018

DEPARTMENT OF CIVIL ENGINEEIRNG SCIENCE

UNIVERSITY OF JOHANNESBURG

QUESTION NUMBER 1 (20 Marks)

[A] Explain a laboratory method of determining e_{max} of (a) sand and (b) clay

[B] For a normally consolidated soil, the void ratio and hydraulic conductivity relations for a clay soil is given in table 1

Table 1.

Void ratio	K (cm/sec)
1.23	0.599×10^{-7}
1.56	1.53×10^{-7}

Estimate the hydraulic conductivity of the clay at a void ratio of 1.399 using the conventional model of Mesri and Olson (1971) Log k = A' log e + B'.

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QUESTION NUMBER 2 (25 marks)

(i) Explain in detail, the different displacement drilled pile method

(ii) Consider a pipe pile (flat driving point) having outside diameter of 406mm. The embedded length of the pile in layered saturated clay is 30m. The following are the details of the subsoil.

Depth from Ground Surface (m)	Saturated Unit weight Y (KN/m^3)	Cu (KN/m^2)
0 - 5	18	30
5 - 10	18	30
10 – 30	19.6	100

The ground water table is located at a depth of 5m from the ground surface. Estimate Qp using the

Meyerhof method

Vesic Method

QUESTION NUMBER 3 (20 marks)

[A] Drilled piles can be installed by direct shaft method. Explain by illustration the major stages of the installation.

[B] Design a square piled foundation in the heavily weathered Parktown clay shale formation to support a Four Storey building. The square pile group will carry a super structural load of 500KN. The piles are 500mm diameter and 10 m long. Unconfined compressive strength of the clay soil decreased linearly from 100 KN/m^2 near the ground surface to $75KN/m^2$ at the depth of 15m. The adhesion factor is assumed to be 0.6. and with good knowledge of the formation, the design engineer worked with a Factor of safety against single pile and block failure of 2.7.

Evaluate the performance of an assumed pile group. A grid of 3 rows of 3 piles.

QUESTION NUMBER 4 (15 marks)

[A] A rectangular footing of 1.8m X 1.2 m , is founded at a depth of 1.5m above the ground surface in a residual fine sand formation. The properties of the sand are given unit weight, y = 15 kN/m^3 ; and soil friction angle $\varphi' = 31$ and Cohesion = 0.

Determine the magnitude of the gross ultimate load applied eccentrically to bearing capacity failure in the soil. The load is applied on the X axis, 0.4 m from the centre of the footing.

QUESTION NUMBER 5 (20 marks)

[A] Explain the process of drilled pile installation in soft soils with very shallow water table.

[B] The columns of Civil Engineering Lecture theatre were supported by a square footing in cohesive Soil formation. The column transits a structural load of 330 kN. The major geotechnical properties of the fairly homogenous formation are Undrained shear strength of the clay of 75 kPa and Y = 16.5 KN/m^3

The footing was founded at a depth of 1.5 m from the ground surface.

Determine the required footing width to a Factor of safety of 3.0.

What is the benefit of increasing the width by 30%?

FORMULA SHEET.

$e_{field} = \frac{G_s \gamma_w}{\gamma_w} - 1.$

$q = \frac{P/b}{B} + \gamma_c D - u.$

$q = \frac{P + W_f}{A} - u$

$q = \frac{q_{ult}}{F}$

$\Delta\sigma_Z = I_\sigma (q - \sigma'_D)$

$\sigma'_{zf} = \sigma'_{z0} + \Delta\sigma_Z$

Table: Bearing capacity factors for Terzaghi's equations

ϕ' (deg)	N_c	N_q	N_γ	ϕ' (deg)	N_c	N_q	N_γ
0	5.7	1.0	0.0	21	18.9	8.3	5.1
1	6.0	1.1	0.1	22	20.3	9.2	5.9
2	6.3	1.2	0.1	23	21.7	10.2	6.8
3	6.6	1.3	0.2	24	23.4	11.4	7.9
4	7.0	1.5	0.3	25	25.1	12.7	9.2
5	7.3	1.6	0.4	26	27.1	14.2	10.7
6	7.7	1.8	0.5	27	29.2	15.9	12.5
7	8.2	2.0	0.6	28	31.6	17.8	14.6
8	8.6	2.2	0.7	29	34.2	20.0	17.1
9	9.1	2.4	0.9	30	37.2	22.5	20.1
10	9.6	2.7	1.0	31	40.4	25.3	23.7
11	10.2	3.0	1.2	32	44.0	28.5	28.0
12	10.8	3.3	1.4	33	48.1	32.2	33.3
13	11.4	3.6	1.6	34	52.6	36.5	39.6
14	12.1	4.0	1.9	35	57.8	41.4	47.3
15	12.9	4.4	2.2	36	63.5	47.2	56.7
16	13.7	4.9	2.5	37	70.1	53.8	68.1
17	14.6	5.5	2.9	38	77.5	61.5	82.3
18	15.5	6.0	3.3	39	86.0	70.6	99.8
19	16.6	6.7	3.8	40	95.7	81.3	121.5
20	17.7	7.4	4.4	41	106.8	93.8	148.5

Case I

$\gamma' = \gamma_b = \gamma - \gamma_w$

Case II

$\gamma' = \gamma - \gamma_w [1 - (\frac{D_w - D}{B})]$

Case III

$\gamma' = \gamma$

Continuous footings: $q_{ult} = c' N_c + \sigma'_D N_q + 0.5 \gamma' B N_\gamma$

For square footings: $q_{ult} = 1.3 c' N_c + \sigma'_D N_q + 0.4 \gamma' B N_\gamma$

$$\delta_{C,ult} = \sum[\frac{C_r}{1+e_0} H \log(\frac{\sigma_c'}{\sigma_{z0}'}) + \frac{C_c}{1+e_0} H \log(\frac{\sigma_{zf}'}{\sigma_c'})]$$

$$\delta = C_1 C_2 C_3 (q - \sigma_D') \sum \frac{I_\varepsilon H}{E_s}$$

$$C_1 = 1 - 0.5(\frac{\sigma_D'}{q - \sigma_D'})$$

$$C_2 = 1 \; for \; t < 1$$

$$C_2 = 1 + 0.2 \log(\frac{t}{0.1}) \; for \; t \geq 1$$

$$C_3 = 1 \quad for \; square \; footings \; and \; 0.73 \; for \; continuous \; footings$$

$$I_{\varepsilon P} = 0.5 + 0.1 \sqrt{\frac{q - \sigma_D'}{\sigma_{zp}'}}$$

σ_{zp}' = vertical effective stress at depth of the peak strain influence factor (for square footings compute σ_{zp}' at a depth of D+B/2; for continuous footing compute at D+B)

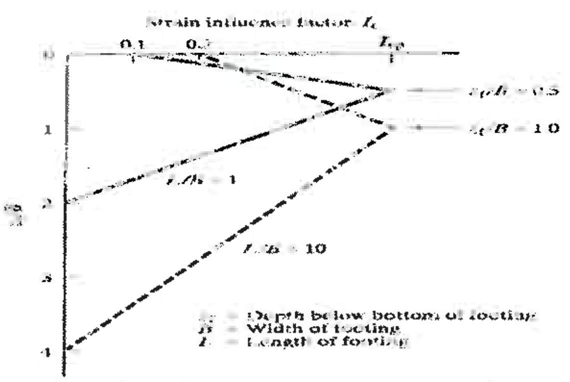

FIGURE 15.15 Distribution of strain influence factor with depth for square and continuous footings. (Adapted from Schmertmann et al., 1978, used with permission of ASCE.)

$E_s = 2.5q_c$ for clean sands.

$= 1.5q_c$ for clayey or silty sands.

End bearing: $q = 9\ C_u$

Skin friction in clays: $f_{ult} = \alpha \times S_u$

Table 11.7 Bearing Capacity Factors N_{σ}^{*} Based on the Theory of Expansion of Cavities

ϕ'	I_{rr} = 10	20	40	60	80	100	200	300	400	500
25	12.12	15.95	20.98	24.64	27.61	30.16	39.70	46.61	52.24	57.06
26	13.18	17.47	23.15	27.30	30.69	33.60	44.53	52.51	59.02	64.62
27	14.33	19.12	25.52	30.21	34.06	37.37	49.88	59.05	66.56	73.04
28	15.57	20.91	28.10	33.40	37.75	41.51	55.77	66.29	74.93	82.40
29	16.90	22.85	30.90	36.87	41.79	46.05	62.27	74.30	84.21	92.80
30	18.24	24.95	33.95	40.66	46.21	51.02	69.43	83.14	94.48	104.33
31	19.88	27.22	37.27	44.79	51.03	56.46	77.31	92.90	105.84	117.11
32	21.55	29.68	40.88	49.30	56.30	62.41	85.96	103.66	118.39	131.24
33	23.34	32.34	44.80	54.20	62.05	68.92	95.46	115.51	132.24	146.87
34	25.28	35.21	49.05	59.54	68.33	76.02	105.90	128.55	147.51	164.12
35	27.36	38.32	53.67	65.36	75.17	83.78	117.33	142.89	164.33	183.16
36	29.60	41.68	58.68	71.69	82.62	92.24	129.87	158.65	182.85	204.14
37	32.02	45.31	64.13	78.57	90.75	101.48	143.61	175.95	203.23	227.26
38	34.63	49.24	70.03	86.05	99.60	111.56	158.65	194.94	225.62	252.71
39	37.44	53.50	76.45	94.20	109.24	122.54	175.11	215.78	250.23	280.71
40	40.47	58.10	83.40	103.05	119.74	134.52	193.13	238.62	277.26	311.50
41	43.74	63.07	90.96	112.68	131.18	147.59	212.84	263.67	306.94	345.34
42	47.27	68.46	99.16	123.16	143.64	161.83	234.40	291.13	339.52	382.53
43	51.08	74.30	108.08	134.56	157.21	177.36	257.99	321.22	375.28	423.39
44	55.20	80.62	117.76	146.97	172.00	194.31	283.80	354.20	414.51	468.28
45	59.66	87.48	128.28	160.48	188.12	212.79	312.03	390.35	457.57	517.58

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	I_{rr}									
ϕ'	10	20	40	60	80	100	200	300	400	500
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33	23.34	32.34	44.80	54.20	62.05	68.92	95.46	115.51	132.24	146.87
34	25.28	35.21	49.05	59.54	68.33	76.02	105.90	128.55	147.51	164.12
35	27.36	38.32	53.67	65.36	75.17	83.78	117.33	142.89	164.33	183.16
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38	34.63	49.24	70.03	86.05	99.60	111.56	158.65	194.94	225.62	252.71
39	37.44	53.50	76.45	94.20	109.24	122.54	175.11	215.78	250.23	280.71
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42	47.27	68.46	99.16	123.16	143.64	161.83	234.40	291.13	339.52	382.53
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44	55.20	80.62	117.76	146.97	172.00	194.31	283.80	354.20	414.51	468.28
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