UNIVERSITY OF JOHANNESBURG

PROGRAM	:	Baccalaureus Ingeneriae (BIng) *CIVIL ENGINEERING SCIENCE*
SUBJECT	:	**GEOTECHNICAL ENGINEERING**
CODE	:	**GTG 4A11**
DATE	:	JUNE MAIN 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 MAY / JUNE EXAMINATION 2018

DEPARTMENT OF CIVIL ENGINEERING SCIENCE

UNIVERSITY OF JOHANNESBURG

QUESTION NUMBER 1 (20 Marks)

[A] What are the major application and advantages of Drilled piles?

[B] Consider a 20 m long concrete pile with a cross section of 0.55m X 0.55m fully embedded in a dense sandy soil formation. For the sand, the unit weight, y = 18.50kN/m^3; and soil friction angle $\varphi' = 30$. Estimate the ultimate point bearing capacity of the pile [Qp] with each of the following method

Meyerhof method

Vesic Method

Based on the different result adopt a value for the Qp.

QUESTION NUMBER 2 (20 Marks)

[A] A Laboratory test result of reddish drown sand revealed a specific gravity of 2.65. The specific gravity test was conducted with 10 grams of soil and mass was measured with a balance of 0.1g precision. The Lecturer believed that the specific gravity of the sand should be greater than 2.65. Explain

[B] Cubrinovski and Ishihara (2002) presented a correlation of minimum and maximum void ratio for residual sands or tropical sands with fines as

$e_{max} = 0.25 + 1.37\ e_{min}$

$$e_{max} - e_{min} = 0.23 + \frac{0.06}{D_{50}}$$

The median grain size (D_{50}) of a residual sand is 0.65 mm. The sand is compacted in the field to a dry unit weight of 18.9 kN/m^3. Estimate the relative density of compaction. Given Gs for sand is 2.66.

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

To prevent failure of the proposed foundation in the sand formation, the Geotechnical Engineer recommended that the Relative density be increased by 50%. Illustrate by calculation, How to achieve the 50% increase in RD.

QUESTION NUMBER 3 (20 Marks)

[A] Discuss the limitations of the Classical Terzaghi Bearing capacity equations.

[B] One of the major columns of the APK Civil Engineering Workshop was supported by a square footing in Transported Sandy Clays Soil formation. The column transits a structural load of 500 kN. The major geotechnical properties of the fairly homogenous formation are Undrained shear strength of the clay of 100 kPa and Y = 15 KN/m^3

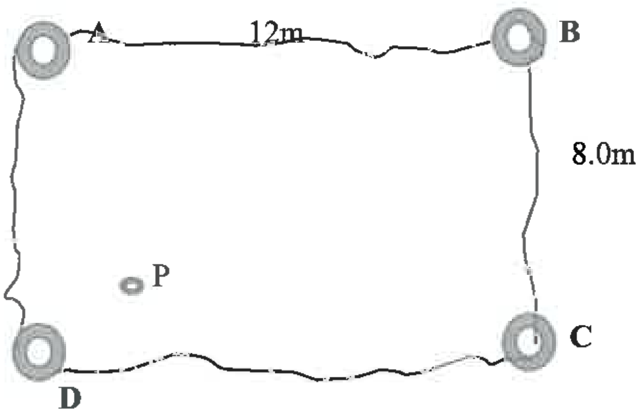
The footing was founded at a depth of 1.0 m from the ground surface.

Determine the required footing width to a Factor of safety of 2.5. Ignore the ground water table.

QUESTION NUMBER 4 (20 Marks)

[A] Discuss the function of bentonite in pile installation.

[B] A grid of 4 piles were installed in a sandy clay soil with Cohesion of 35kPa. For the column load eccentric to both x and y axis of the pile grid, the column load is given as 10 Tons. The (X, Y) Coordinate of [P] from the centre of the pile grid is (-3, -2) from the Centre of Pile Grid.



(i) Determine the maximum load transferred from the cap to the piles.

(ii) The End bearing capacity of the piles of each of the piles is 12 Tonnes. Specific for the maximum load transferred to the piles, Determine the Factor of safety against pile capacity failure, assuming that piles are 600mm diameter piles and were installed to a depth of 20m. The adhesion factor is 0.85.

QUESTION NUMBER 5 (20 Marks)

[A] Explain the concept of critical embedment ratio in sand formations.

[B] The Central Library building in DFC campus was supported by columns on square footings in recently compacted sandy clay formation overlying soft dolerite rock and very stiff dolerite formations. The footing is 1m square and founded at a depth below ground surface of 1.5m , the silty clay is 0.5 m thick , the soft rock is 4m thick, and the stiff dolerite extends very deep into the ground. The entre profile is dry. The columns transmit a load of 400KN to the underling soil.

Soil sample taken from a depth of 1.80m below the footing revealed the following

$\Upsilon = 15.0$ KN/m^3 $e_o = 0.93$ Cc = 0.17, Cr = 0.076,

The Compression Modulus (G) MPa of the soft dolerite is 1600MPa

Calculate the total settlement of the formation. The allowable total settlement is 25mm and the concrete rigidity factor of 0.85.

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	149.5

Case I

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

Case II

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

Case III

$$\gamma' = \gamma$$

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

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

For circular footings: $q_{ult} = 1.3c'N_c + \sigma'_D N_q + 0.3\gamma' B N_\gamma$

For circular loaded areas

$$I_\sigma = 1 - \left(\frac{1}{1+(B/2z_f)^2}\right)^{1.5}$$

For square loaded areas,

$$I_\sigma = 1 - \left(\frac{1}{1+(B/2z_f)^2}\right)^{1.76}$$

For continuous loaded areas (also known as strip loads) of width B and infinite length,

$$I_\sigma = 1 - \left(\frac{1}{1+(B/2z_f)^{1.38}}\right)^{2.60}$$

For rectangular loaded areas of width B and length L,

$$I_\sigma = 1 - \left(\frac{1}{1+(B/2z_f)^{1.38+0.62B/L}}\right)^{2.60-0.84B/L}$$

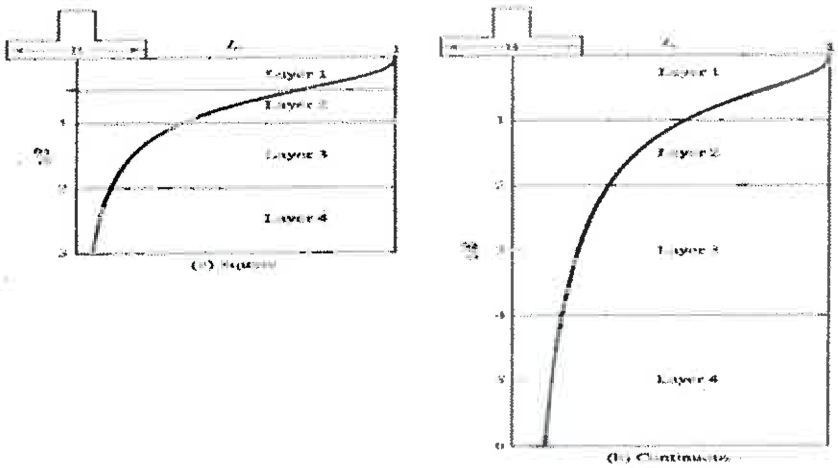


Figure: Guidelines for selecting layer thicknesses in hand settlement computations for uniform soils

For Normally consolidated soils

$$\delta_{C,ult} = \sum \frac{C_c}{1+e_0} H \log\left(\frac{\sigma'_{zf}}{\sigma'_{z0}}\right)$$

For overconsolidated soils case I $(\sigma'_{z0} < \sigma'_{zf} \leq \sigma'_c)$

$$\delta_{C,ult} = \sum \frac{C_r}{1+e_0} H \log\left(\frac{\sigma'_{zf}}{\sigma'_{z0}}\right)$$

For overconsolidated case soils II $(\sigma'_{z0} < \sigma'_c \leq \sigma'_{zf})$

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

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

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

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

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

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

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

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)

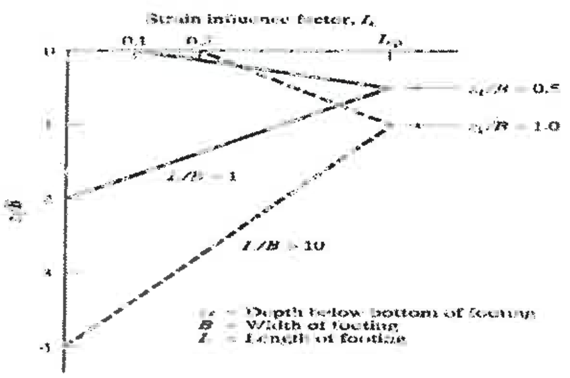


FIGURE 13.15 Distribution of strain influence factor with depth for square and continuous footings. (Adapted from Schmertmann et al., 1978, used with permission of ASCE.)

$E_s = 2.5q_c$ for clean sands.

$= 1.5q_c$ for clayey or silty sands.

End bearing: $q = 9\ C_u$

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

Skin friction in clays (driven piles): $f = \alpha \times C_u$ / f = unit skin friction; C_u = cohesion

$\alpha = 1.0$ for clays with $C_u < 25$ kN/m^2 / $= 0.5$ for clays with $C_u > 70$ kN/m^2

Skin friction in clays (Bored piles): $f = \alpha \times C_u$ / f = unit skin friction; C_u = cohesion / $\alpha = 0.7$ for clays with $C_u < 25$ kN/m^2

$= 0.35$ for clays with $C_u > 70$ kN/m^2

Skin friction in clays: $f_{ult} = \beta \times \sigma$ /

NAVFAC DM 7.2

$f = \alpha \, . \, C_u \, . \, A_p$

S = Skin friction ; C_u = cohesion; A_p = perimeter surface area of the pile

*End bearing of the group = 9 Cu (L*W)*

$$Efficiency\ \eta_g = 1 - \frac{\emptyset}{90^0}\{\frac{m(n-1) + n(m-1)}{mn}\}$$

$$\emptyset = tan^{-1}(d/s)$$

Pile spacing (centre to centre)	Group efficiency	Pile spacing (centre to centre)	Group efficiency
3D	0.67	3D	0.67
4D	0.74	4D	0.78
5D	0.80	5D	0.89
6D	0.87	6D or more	1.00
7D	0.93		
8D	1.00		

$$\sigma_1 = \frac{R_1}{A} = \frac{C}{nA} \pm \frac{C.e_x.a_x}{I_y} \pm \frac{C.e_y.a_y}{I_x}$$

Moment of inertia I = A * r^2 (r = distance to the pile from the axis)

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

Table 11.5 Interpolated Values of N_q^* Based on Meyerhof's Theory

Soil friction angle, ϕ (deg)	N_q^*
20	12.4
21	13.8
22	15.5
23	17.9
24	21.4
25	26.0
26	29.5
27	34.0
28	39.7
29	46.5
30	56.7
31	68.2
32	81.0
33	96.0
34	115.0
35	143.0
36	168.0
37	194.0
38	231.0
39	276.0
40	346.0
41	420.0
42	525.0
43	650.0
44	780.0
45	930.0

$$Q_p = A_p q N_q^*$$

$$Q_p = A_p (0.5 P_a N_q^* \tan\phi')$$

$$Q_p = A_p \sigma_o' N_\sigma^*$$

$$I_{rr} = \frac{I_r}{(1 + I_r \Delta)}$$

$$\sigma_o' = [\frac{1 + 2(1 - \sin\varphi')}{3}] q$$

$$N_\sigma^* = \frac{3N_q}{(1 + 2K_o)}$$

$$I_r = \frac{E_s}{2(1+\mu) q' \tan\varphi}$$

$$m = \frac{E_s}{(P_a)}$$

m = 100 – 200 (loose) / 200 – 500 medium dense / 500 – 1000 dense/

$$\Delta = 0.005(1 - \frac{\varphi' - 25E_s}{20}) \frac{q}{P_a}$$

$$\mu = 0.1 + 0.3(\frac{\varphi' - 25E_s}{20}) \frac{q}{P_a}$$