UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	FOUNDATION ENGINEERING
COURSE CODE	:	BFC 43103/ BFC 4043
PROGRAMME	:	BACHELOR IN CIVIL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	JUNE 2015 / JULY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY.

THIS QUESTION PAPER CONSISTS OF **FOURTEEN (14)** PAGES

Q1 (a) Ground improvement is defined as the controlled alteration of the state, nature or mass behaviour of ground materials in order to achieve an intended satisfactory response to existing or projected environmental and engineering actions. Discuss:

(i) **TWO (2)** type of ground improvement for cohesive soil.

(6 marks)

(ii) **TWO (2)** type of ground improvement for cohesionless soil.

(6 marks)

(b) An earth fill has to be carried out for a housing project at Parit Raja. After completion, it will occupy a net volume of 200,000 m^3. The borrow material is stiff clay imported from Air Hitam. In its "bank" condition, the borrow material has a bulk unit weight, γ_b of 17 kN/m^3, water content (w) of 15%, and an in-place void ratio (e) of 0.60. The fill will be constructed in layers of 200 mm in depth, loose measure, and compacted to a dry unit weight (γ_d) of 19 kN/m^3 at a water content of 17.5%.

(i) Determine the required volume of borrow pit excavation in m^3 from Air Hitam.

(7 marks)

(ii) What is the shrinkage factor due to compacting the fill?

(6 marks)

Q2 (a) In conventional site investigation using the wash boring technique, the sample that can be retrieved at various depths can be classified as disturbed and undisturbed.

Describe the **TWO (2)** tests that can be carried out on the disturbed samples, **TWO (2)** tests on undisturbed samples and the examples of the usage of the results from each test in the design of geotechnical structures.

(8 marks)

(b) The Standard Penetration Test (SPT) is routine field or in situ test that is carried out in a borehole at various depths.

Explain the SPT test stating the instruments, the process, the kind of information that can be obtained and examples of usage of the result in designing the geotechnical structures.

(7 marks)

(c) A thin walled-tube (Shelby tube) sampler was pushed into soft clay at the bottom of a borehole for a distance of 600 mm. When the tube was recovered, a measurement down inside the tube indicated a recovered sample length of 400 mm.

(i) What is the recovery ratio of the sample?

(2 marks)

(ii) Give your comment about sample quality based on **Q2(c)(i)**.

(3 marks)

(iii) If a Shelby tube sampler was not available during a site investigation work, name any other **TWO (2)** samplers that can be used to obtain soil sample that has almost the same quality as the sample retrieve from a Shelby tube sampler.

(5 marks)

Q3 (a) Briefly explain with a neat sketch the nature of bearing capacity failure in soil which implemented by Vesic in 1973 where this general concept is essential in the design of shallow foundations.

(5 marks)

(b) A rectangular column foundation (L = $2B$) situated on a ground surface has to carry a gross allowable total load of 150 kN. The load is inclined at angle of 20° to the vertical (**Figure Q3(b)**).

(i) Determine the width of the foundation, B, by using Meyerhof's (general bearing capacity equation). Apply the factor of safety of 3.00.

If the ground water table has rised and allocated at the base of the foundation, does the shallow foundation is still in safe conditions?

(11 marks)

(ii) With the same width value obtained from **Q3(b)(i)** and the ground water table is located at the base of the foundation, estimate the consolidation settlement of the foundation. Thickness of the clay layer is 5 m.

Use **Table 1** for I_c determination on this problem.

(7 marks)

(iii) The building codes requirement for shallow foundations has to satisfy the minimum factor of safety of 3.5 and minimum settlement of 50 mm. Does the dimension would fulfill the criteria especially where the ground water table allocated at the base of the foundation?

(2 marks)

Q4 (a) Piles can be divided into three major categories depending on their lengths and the mechanisms of load transfer to the soil, namely (a) point bearing piles, (b) friction piles.

Explain with a neat sketch the principle of point bearing piles and friction piles.

(7 marks)

(b) The section of a 3 x 4 group pile in a layered saturated clay is shown in **Figure Q4(b)**. The piles are circle in cross section (406 mm in diameter). The length and width of the group pile section are $L_g = 2.246$ m and $B_g = 1.726$ m. Note that the groundwater table is 3.3 m from the ground surface. All clays are normally consolidated.

(i) Determine the allowable load-bearing capacity of the pile group. Use FS = 4. **Figures Q4(b)(i)** and **Q4(b)(ii)** can be applied on this question.

(9 marks)

(ii) Determine the consolidation settlement of the pile group.

(9 marks)

Q5 (a) Explain clearly the difference between a cantilever sheet pile wall and an anchored sheet pile wall. Sketch the pressure distributions showing forces, for which each should be designed.

(5 marks)

(b) Discuss in details the major differences between Rankine's and Coulumb's theories of lateral earth pressures.

(5 marks)

(c) A 17 m deep braced excavation in clay is shown in **Figure Q5(c)**. The unit weight (γ) and cohesion (c) of the soil are 18 kN/m^3 and 0 kN/m^2 respectively. The center-to-center spacing of struts in the plan is 8 m.

(i) Illustrate the earth pressure envelope.

(6 marks)

(ii) Analyze the loads in the struts A, B and C.

(9 marks)

- END OF QUESTIONS -

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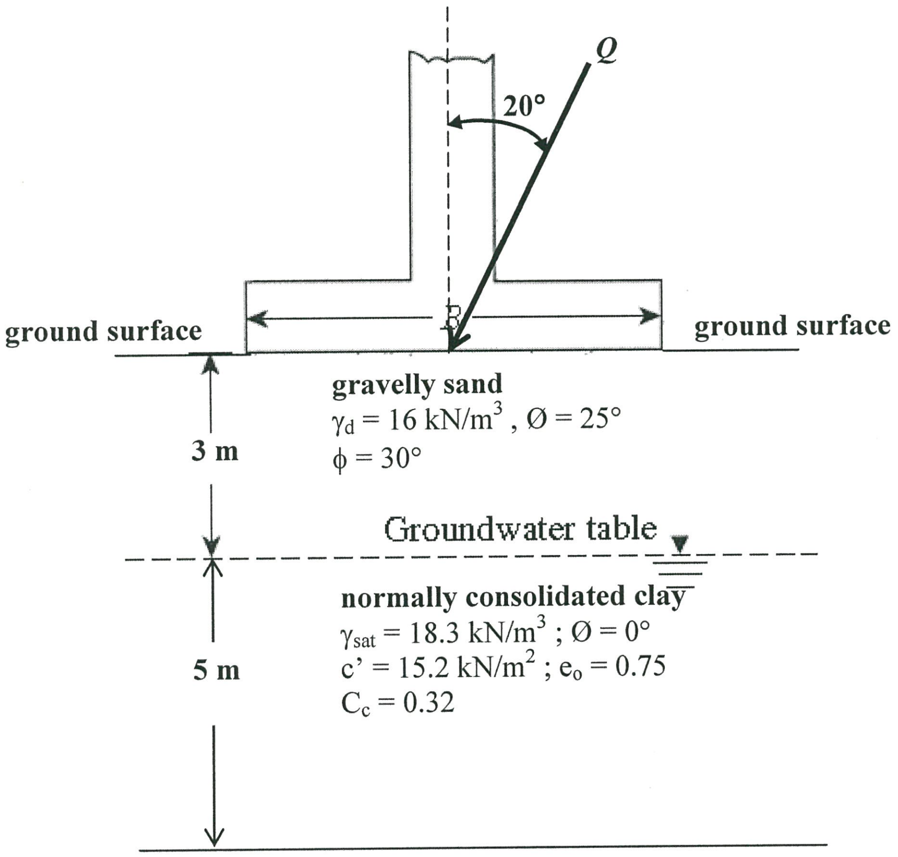

<u>FIGURE Q3(b)</u>

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TABLE 1: Values of I_c with Varies of m_1 and n_1

	m_1									
n_1	1	2	3	4	5	6	7	8	9	10
0.2	0.994	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.997
0.4	0.960	0.976	0.977	0.977	0.977	0.977	0.977	0.977	0.977	0.977
0.6	0.892	0.932	0.936	0.936	0.937	0.937	0.937	0.937	0.937	0.937
0.8	0.800	0.870	0.878	0.880	0.881	0.881	0.881	0.881	0.881	0.881
1.0	0.701	0.800	0.814	0.817	0.818	0.818	0.818	0.818	0.818	0.818
1.2	0.606	0.727	0.748	0.753	0.754	0.755	0.755	0.755	0.755	0.755
1.4	0.522	0.658	0.685	0.692	0.694	0.695	0.695	0.696	0.696	0.696
1.6	0.449	0.593	0.627	0.636	0.639	0.64	0.641	0.641	0.641	0.642
1.8	0.388	0.534	0.573	0.585	0.590	0.591	0.592	0.592	0.593	0.593
2.0	0.336	0.481	0.525	0.540	0.545	0.547	0.548	0.549	0.549	0.549
3.0	0.179	0.293	0.348	0.373	0.384	0.389	0.392	0.393	0.394	0.395
4.0	0.108	0.190	0.241	0.269	0.285	0.293	0.298	0.301	0.302	0.303
5.0	0.072	0.131	0.174	0.202	0.219	0.229	0.236	0.24	0.242	0.244
6.0	0.051	0.095	0.130	0.155	0.172	0.184	0.192	0.197	0.2	0.202
7.0	0.038	0.072	0.100	0.122	0.139	0.15	0.158	0.164	0.168	0.171
8.0	0.029	0.056	0.079	0.098	0.113	0.125	0.133	0.139	0.144	0.147
9.0	0.023	0.045	0.064	0.081	0.094	0.105	0.113	0.119	0.124	0.128
10.0	0.019	0.037	0.053	0.067	0.079	0.089	0.097	0.103	0.108	0.112

$m_1 = L/B$, $n_1 = z/(B/2)$

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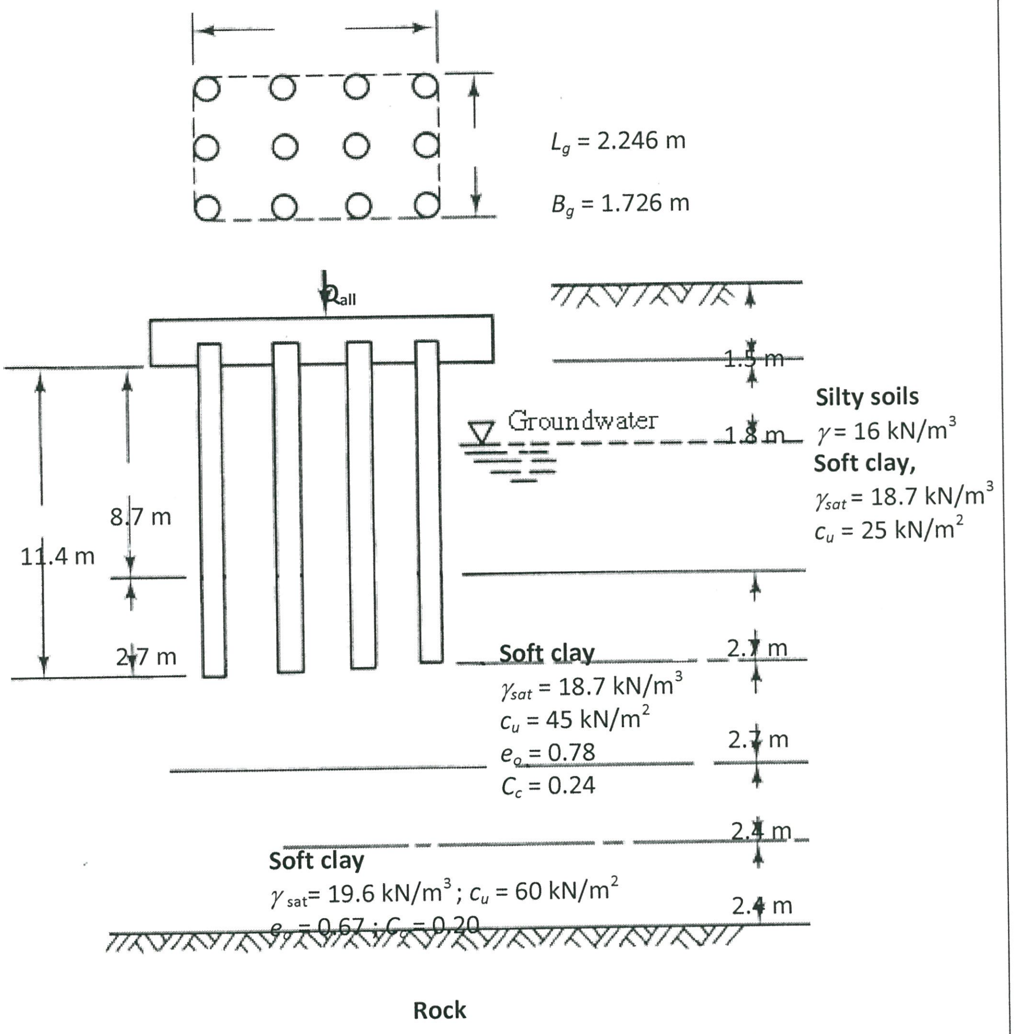

FIGURE Q4(b)

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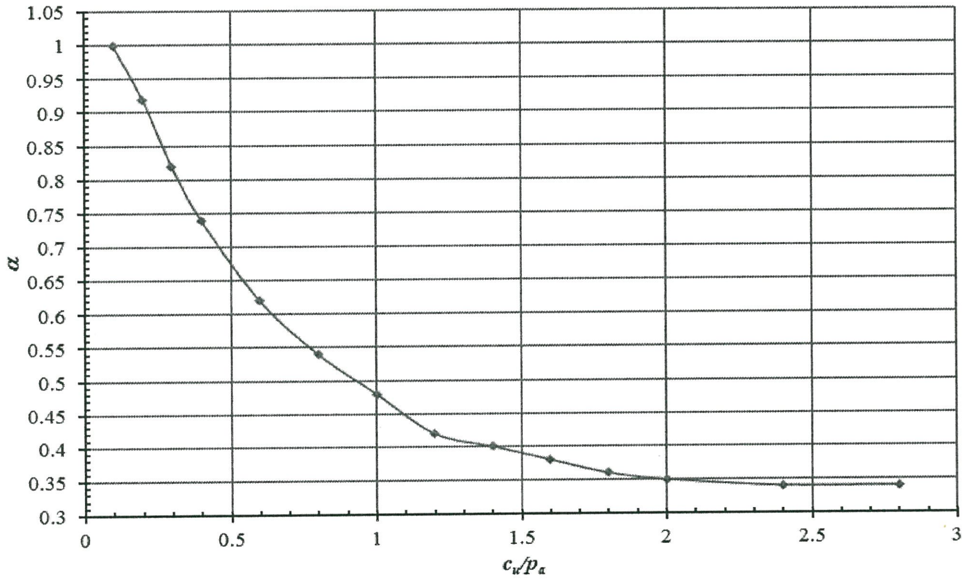

FIGURE Q4(b)(i)

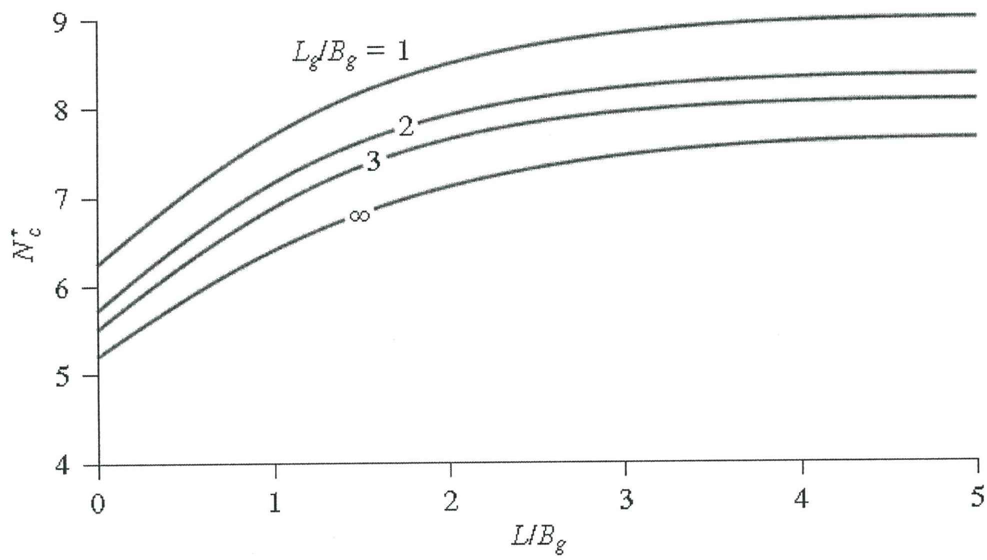

FIGURE Q4(b)(ii)

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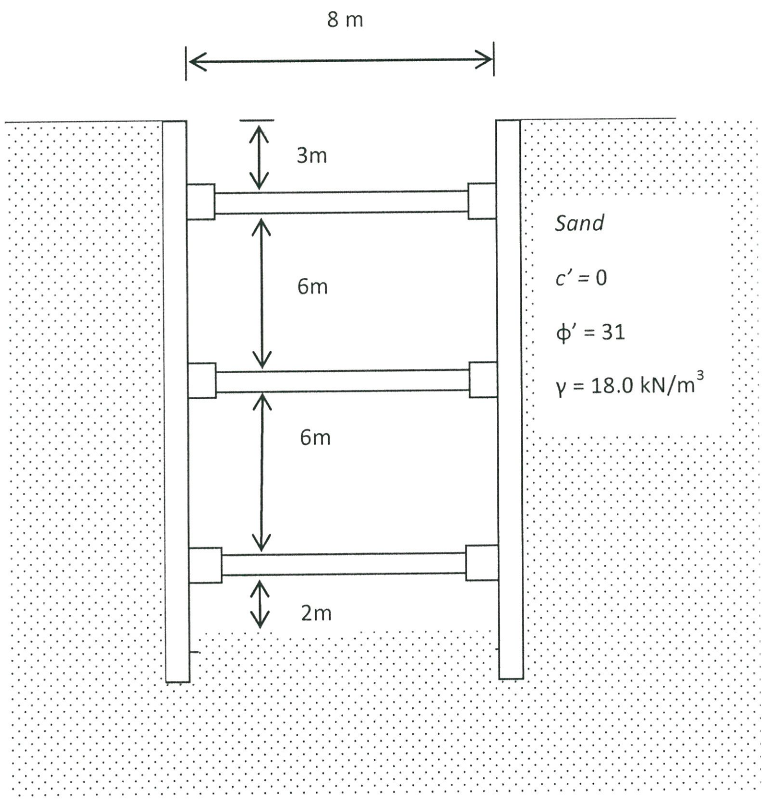

FIGURE Q5(c): Braced Cut

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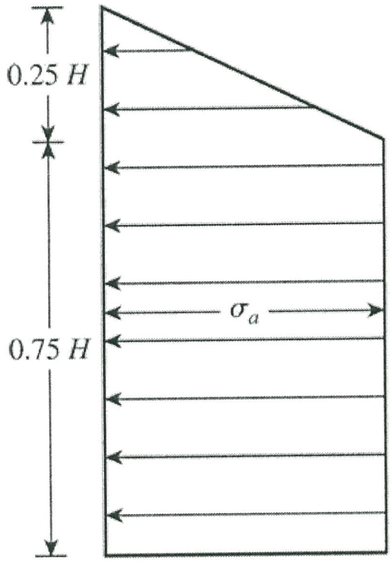
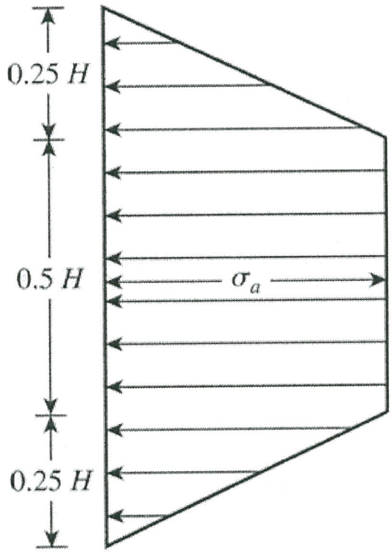
Useful formulas for Q5:



Peck's (1969) apparent-pressure envelope cuts in soft to medium clay



Peck's (1969) apparent-pressure for envelope for cuts in stiff clay

$\sigma_a = 0.65\gamma H K_a$

$\sigma_a = 0.2\gamma H \text{ to } 0.4\gamma H$

and

$\sigma_a = 0.3\ \gamma\ H$

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Ground improvement

retaining walls with geotextile and geogrid reinforcement

$$\sigma'_o = \sigma'_{o_1} + \sigma'_{o_2} \qquad \sigma'_{o_1} = \gamma_1 z$$

$$\sigma'_{o_2} = \frac{qa'}{a'+z} \text{ for } z \le 2b' \qquad \sigma'_{o_2} = \frac{qa'}{a'+\frac{1}{2}z+b'} \text{ for } z > 2b'$$

$$FS_B = \frac{wf_y}{\sigma'_a S_V S_H} \qquad F_R = 2L_e w\sigma'_o \tan\phi'_\mu$$

$$\sigma'_a = \sigma'_{a_1} + \sigma'_{a_2} \qquad \sigma'_{a_1} = \gamma_1 z K_a$$

$$\sigma'_{a_2} = M\left[\frac{2q}{\pi}(\beta - \sin\beta\cos 2\alpha)\right] \qquad M = 1.4 - \frac{0.4b'}{0.14H} \ge 1$$

$$FS_P = \frac{2L_e w\sigma'_o \tan\phi'_\mu}{\sigma'_a S_V S_H} \qquad L = \frac{H-z}{\tan(45^\circ + \frac{1}{2}\phi'_1)} + \frac{FS_P \sigma'_a S_V S_H}{2w\sigma'_o \tan\phi'_\mu}$$

overturning factor of safety

$$FS = \frac{M_R}{M_O} = \frac{(W_1x_1 + W_2x_2 + \ldots + qa')\left(b' + \frac{1}{2}a'\right)}{P_a z_a}$$

sliding factor of safety

$$FS = \frac{F_R}{F_d} = \frac{(W_1x_1 + W_2x_2 + \ldots + qa')[\tan(\phi'_1)]}{P_a}$$

bearing capacity factor of safety

$$FS = \frac{q_{ult}}{\sigma'_{o_H}} = \frac{c'_2 N_c + \frac{1}{2}\gamma_2 L_2 N_\gamma}{\gamma_1 H + \sigma'_{o_2}}$$

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Terzhaghi's bearing capacity

general shear failure

$$q_u = c'N_c + \overline{q}N_q + \tfrac{1}{2}\overline{\gamma}BN_\gamma \qquad q_u = 1.3c'N_c + \overline{q}N_q + 0.4\overline{\gamma}BN_\gamma$$

$$q_u = 1.3c'N_c + \overline{q}N_q + 0.3\overline{\gamma}BN_\gamma$$

local shear failure

$$q_u = \tfrac{2}{3}c'N_c' + \overline{q}N_q' + \tfrac{1}{2}\overline{\gamma}BN_\gamma' \qquad q_u = 0.867c'N_c' + \overline{q}N_q' + 0.4\overline{\gamma}BN_\gamma'$$

$$q_u = 0.867c'N_c' + \overline{q}N_q' + 0.3\overline{\gamma}BN_\gamma'$$

Factor of safety

$$q_{all} = \frac{q_u}{FS} \qquad q_{all(\text{net})} = \frac{q_u - \gamma D_f}{FS}$$

$$\overline{q} = D_1\gamma + D_2(\gamma_2 - \gamma_w) \qquad \overline{q} = \gamma D_f$$

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

Meyerhof's general bearing capacity

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

$$F_{cs} = 1 + \frac{B}{L}\cdot\frac{N_q}{N_c} \qquad F_{qs} = 1 + \frac{B}{L}\tan\phi' \qquad F_{\gamma s} = 1 - 0.4\left(\frac{B}{L}\right)$$

$$F_{ci} = F_{qi} = \left(1 - \frac{\beta°}{90°}\right)^2 \qquad F_{\gamma i} = \left(1 - \frac{\beta}{\phi'}\right)^2$$

$$\frac{D_f}{B} \le 1 : \phi' = 0°$$

$$F_{cd} = 1 + 0.4\left(\frac{D_f}{B}\right) \qquad F_{qd} = 1 \qquad F_{\gamma d} = 1$$

$$\frac{D_f}{B} \le 1 : \phi' > 0°$$

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi'} \qquad F_{qd} = 1 + 2\tan\phi'(1 - \sin\phi')^2\frac{D_f}{B} \qquad F_{\gamma d} = 1$$

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cont.

Meyerhof's general bearing capacity

$$\frac{D_f}{B} > 1 : \phi' = 0°$$

$$F_{cd} = 1 + 0.4\tan^{-1}\left(\frac{D_f}{B}\right) \qquad F_{qd} = 1 \qquad F_{\gamma d} = 1$$

$$\frac{D_f}{B} > 1 : \phi' > 0°$$

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi'} \qquad F_{qd} = 1 + 2\tan\emptyset'(1-\sin\emptyset')^2\tan^{-1}\left(\frac{D_f}{B}\right) \qquad F_{\gamma d} = 1$$

One way eccentricity

$$B' = B - 2e \quad \& \quad L' = L \qquad L' = L - 2e \quad \& \quad B' = B$$

Primary consolidation settlement for shallow and pile foundations

normally consolidated clays

$$S_c = \frac{C_c H_c}{1+e_o}\log\frac{\sigma'_o + \Delta\sigma'_{av}}{\sigma'_o}$$

Over consolidated clays

$$\sigma'_o + \Delta\sigma'_{av} < \sigma'_c : S_c = \frac{C_s H_c}{1+e_o}\log\frac{\sigma'_o + \Delta\sigma'_{av}}{\sigma'_o}$$

$$\sigma'_o < \sigma'_c < \sigma'_o + \Delta\sigma'_{av} : S_c = \frac{C_s H_c}{1+e_o}\log\frac{\sigma'_c}{\sigma'_o} + \frac{C_c H_c}{1+e_o}\log\frac{\sigma'_o + \Delta\sigma'_{av}}{\sigma'_c}$$

average increase in pressure

$$\Delta\sigma'_{av} = \tfrac{1}{6}(\Delta\sigma'_{top} + 4\Delta\sigma'_{middle} + \Delta\sigma'_{bottom}) \qquad \Delta\sigma'_o = q_o I_c$$

$$m_1 = L/B \qquad n_1 = z/(B/2)$$

Site investigations

$$A_R = \frac{D_2^2 - D_1^2}{D_1^2} \times 100\% \qquad R_R = RQD = \frac{L_{recovered}}{L_{total}} \times 100\%$$

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Group piles

dimensions

$$L_g = (n_1 - 1)d + 2(D/2) \qquad B_g = (n_2 - 1)d + 2(D/2)$$

increase in effective stress

$$\Delta\sigma_i' = \frac{Q_g}{(B_g + z_i)(L_g + z_i)}$$

consolidation settlement

$$\Delta s_{c_i} = \left[\frac{\Delta e_i}{1 + e_{o_i}}\right] H_i$$

Conventional retaining walls

Rankine active and passive pressure

$$P_a = \tfrac{1}{2} K_a \gamma_1 H^2 \qquad P_a = \tfrac{1}{2} K_a \gamma_1 H^2 + q K_a H$$

$$P_v = P_a \sin\alpha^\circ \qquad P_h = P_a \cos\alpha^\circ$$

$$P_p = \tfrac{1}{2} K_p \gamma_2 D^2 + 2c_2' \sqrt{K_p} D$$

$$K_a = \tan^2\left(45^\circ - \tfrac{1}{2}\phi_1'\right) \qquad K_p = \tan^2\left(45^\circ + \tfrac{1}{2}\phi_2'\right)$$

Factor of safety against overturning

$$FS = \frac{\Sigma W_i X_i}{\Sigma P_{a_i} z_{a_i}} = \frac{\Sigma(A_i \times \gamma_i) X_i}{\Sigma P_{a_i} z_{a_i}}$$

$$FS = \frac{\gamma_{n+i} A_{n+i} x_{n+i} + \ldots + \gamma_n A_n x_n}{P_a \cos\alpha (H'/3)}$$

Factor of safety against sliding

$$FS = \frac{\Sigma V \tan\left(\tfrac{2}{3}\phi_2'\right) + \tfrac{2}{3} B c_2' + P_p}{P_a \cos\alpha}$$