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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION (ONLINE) SEMESTER I SESSION 2020/2021

COURSE NAME	:	ADVANCED FOUNDATION ENGINEERING
COURSE CODE	:	MFA 10303
PROGRAMME	:	MFA
EXAMINATION DATE	:	JANUARY / FEBRUARY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATION**

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

Q1 (a) The whole process of the construction design of a structure on soft soils requires detail and careful evaluation. One method to assist the difficult task of engineers is to simulate the conditions of the problematic soil in software analysis. Based on your experience, construct the practicing methods in modeling an embankment construction using the Plaxis finite element software aided with appropriate Figures.

(10 marks)

(b) Properly designed shallow foundations will transfer the loads from the super structure through the sub structure of the foundation. A wrong design can result in shear failure or undesirably excessive structural settlements. Explain in detail the difference on the type of soil and the conditions of the structure whether it is suitable to contruct shallow footing or mat foundation.

(6 marks)

(c) A square footing is used under a three storey building with a size of 1.5 m x 1.5 m. The soil condition has an undrained shear strength (c_u) of 200kN/m^2, with an OCR of 2 and plasticity index (PI) of 45. With the depth of the foundation at 2 meter below the ground level, the load per unit area (q_o) of the foundation is 150 kN/m^2. By estimating the elastic settlement of the foundation, determine if that value is acceptable.

(9 marks)

Q2 **Figure Q2** shows the construction of a newly developed housing project at a hillside that was badly affected by a recent landslide.

(a) Hypothesize **THREE (3)** possible causes in which triggered this geotechnical problem with suitable illustration.

(6 marks)

(b) Propose **TWO (2)** possible methodology for foundation remediation work.

(6 marks)

(c) Estimate a vertical load from superstructure for the foundation.

(6 marks)

(d) Propose your pile bearing capacity design to overcome this problem based on the SPT test results as given.

(7 marks)

Q3 (a) Explain clearly the possible advantages and disadvantages of using ordinary gravity wall as compared to cantilever retaining wall.

(5 marks)

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

(5 marks)

(c) In order to manage for a deep excavation work, a 17 m deep braced excavation in clay was designed as shown in **Figure Q3(c).** The unit weight (γ) and cohesion (c) of the soil are 17.5 kN/m^3 and 35 kN/m^2 respectively. The center-to-center spacing of struts in the plan is 10 m and the allowable flexural stress of the sheet pile material, σ_{all} is 200 X 10^3 kN/m^2.

(i) Illustrate the earth pressure envelope.

(4 marks)

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

(7 marks)

(iii) Determine the section modulus, *S* of the sheet pile section required.

(4 marks)

Q4 (a) Discuss **THREE (3)** purposes of designing appropriate machine foundation.

(3 marks)

(b) Explain the **THREE (3)** types of foundations that is used when dynamic loading exists.

(6 marks)

(c) A single cylinder engine is mounted on a concrete foundation block of the dimension 5.5m x 2.5m x 0.75m (length x width x thickness). The soil below the foundation is a pure clay with a unit weight of 16 kN/m^3, shear modulus of 16,500 kN/m^2, concrete unit weight of 25 kN/m^3 and Poisson's ratio of 0.33. A' is assumed to be 0.20.

The specification of the engine is as follows:

Weight of the machine = 22.00 kN
Primary force , F_p = 9.00 kN
Secondary force , F_s = 3 kN
Operating speed = 2000 rpm

Calculate:

(i) Total force acted on the soil surface due to the mass of foundation block and machine.

(3 marks)

(ii) Radius of loading area, ro for the foundation.

(3 marks)

(iii) Mass ratio, b for the foundation.

(3 marks)

(iv) Resonance frequency, f_{res} for the system.

(3 marks)

(v) Amplitude of vibration for the system.

(4 marks)

-END OF QUESTIONS-

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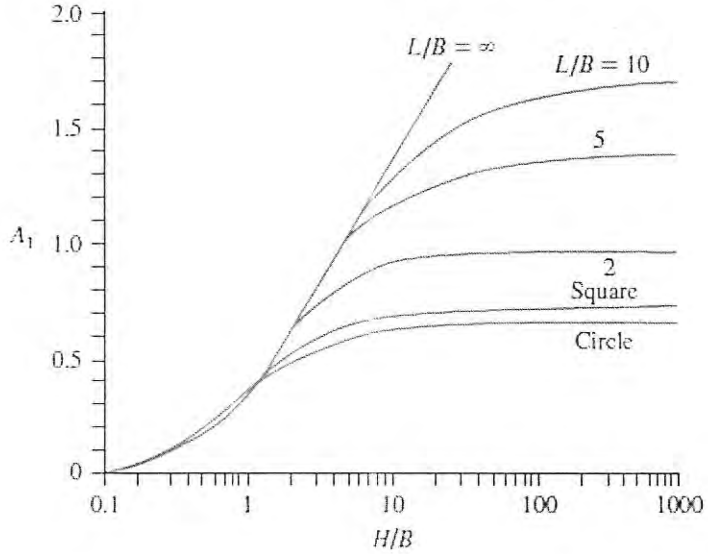

Figure Q1(c)i: Values for A_1 for elastic calculation

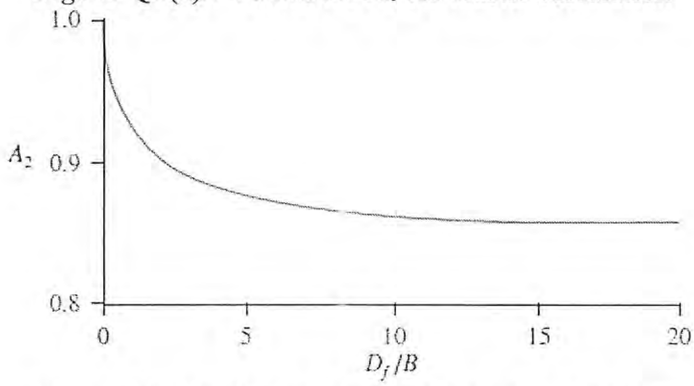

Figure Q1(c)ii: Values for A_2 for elastic calculation

Table Q1(c): Range of β for saturated clay

Plasticity Index	β				
	OCR = 1	OCR = 2	OCR = 3	OCR = 4	OCR = 5
<30	1500–600	1380–500	1200–580	950–380	730–300
30 to 50	600–300	550–270	580–220	380–180	300–150
>50	300–150	270–120	220–100	180–90	150–75

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PULAU PINANG, Nov 5 — High winds and heavy rains have left a massive trail of destruction across Penang even as the Meteorological Department issues a "red" alert warning of continuous heavy rainfall across the northwest island state and Kedah on the mainland.

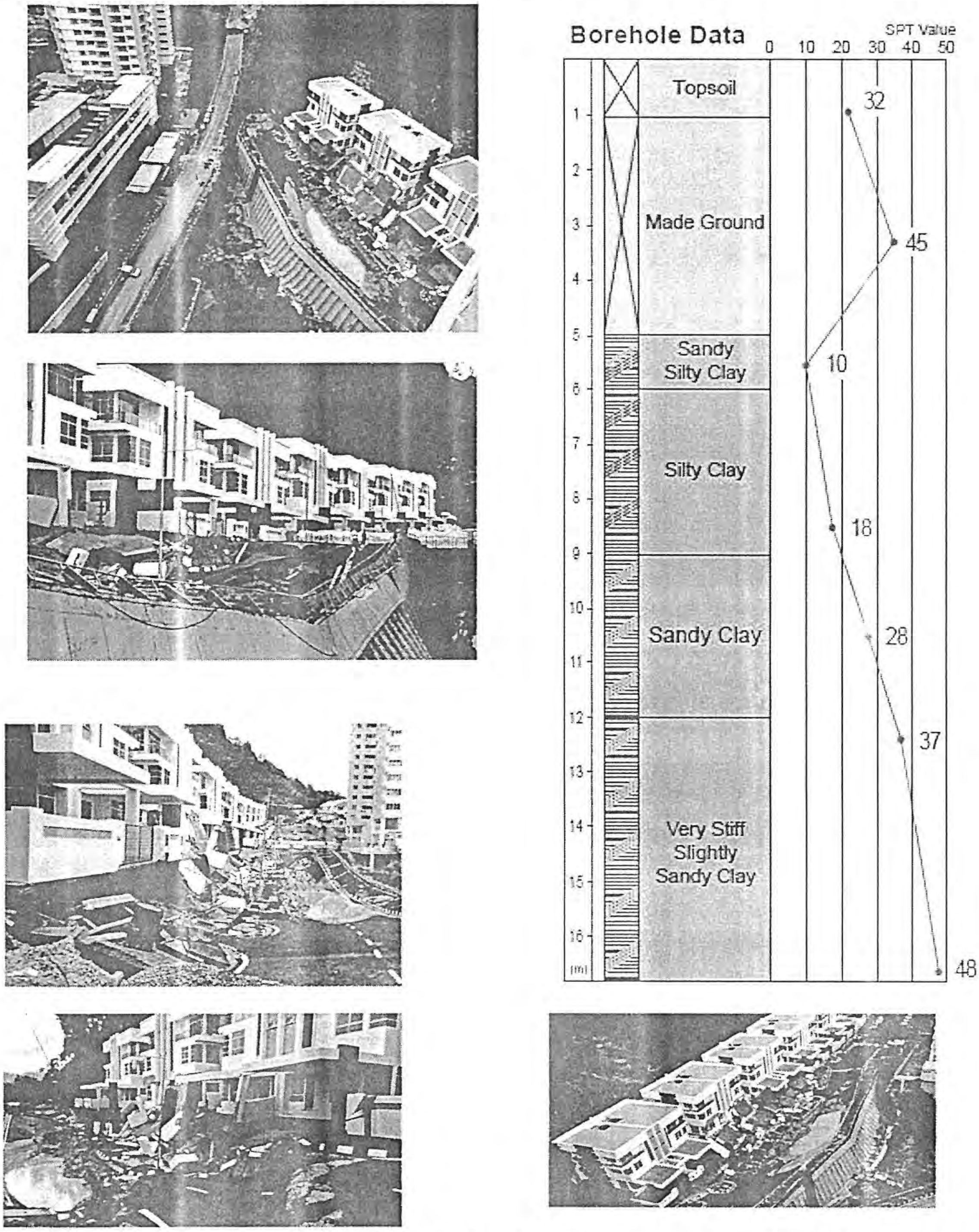

Figure Q2: Construction of a newly developed housing project affected by landslide

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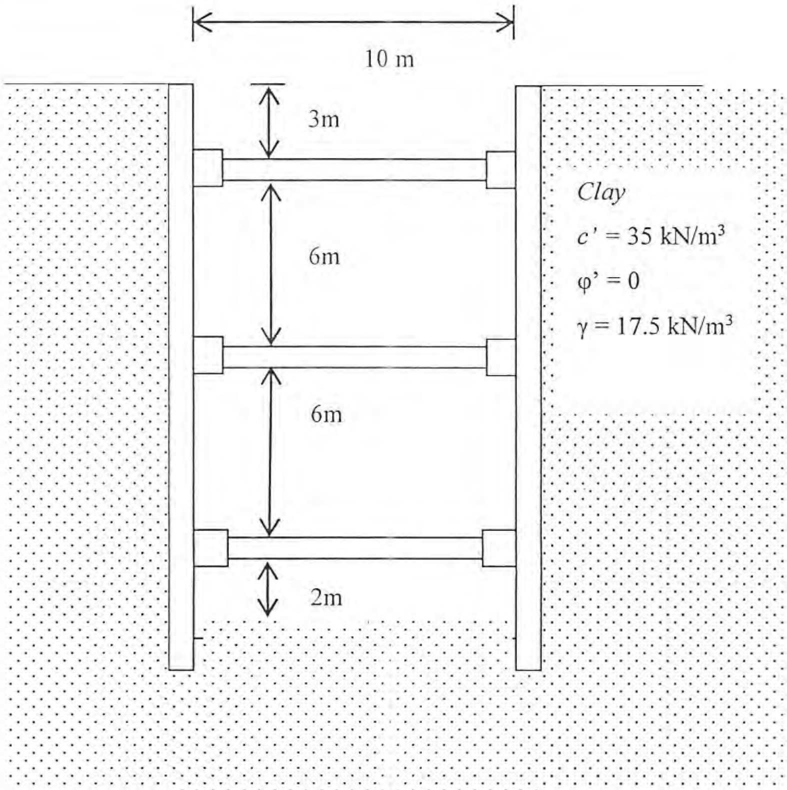

Figure Q3(c): Deep braced excavation in clay

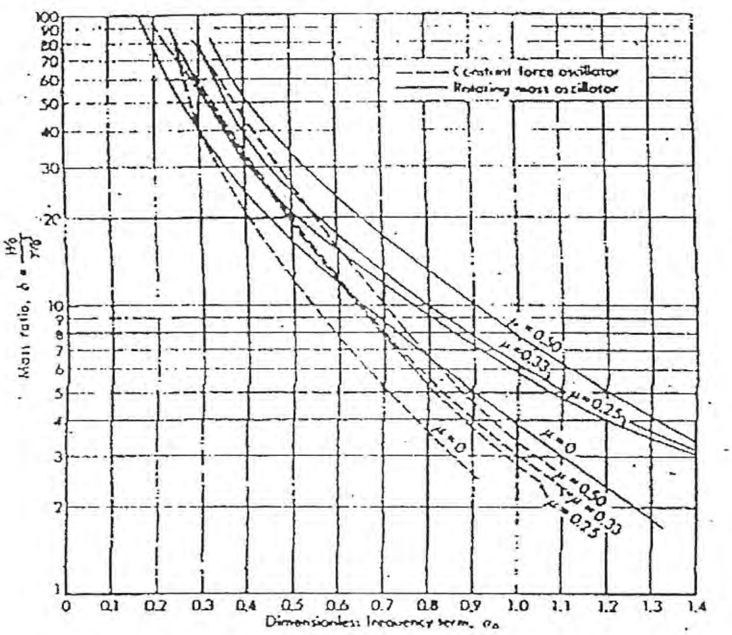

Figure Q4(c): Frequency factor vs mass-ratio relationship for several vaues of Poisson's ratio

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Factor of safety

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

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

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

Meyerhof's general bearing capacity

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

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

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

$$\frac{D_f}{B} \le 1 : \phi' = 0^\circ$$

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

$$\frac{D_f}{B} \le 1 : \phi' > 0^\circ$$

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

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cont.

Meyerhof's general bearing capacity

$$\frac{D_f}{B} > 1 : \phi' = 0^\circ$$

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

$$\frac{D_f}{B} > 1 : \phi' > 0^\circ$$

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

One way eccentricity

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

Elastic settlement for shallow foundations

$$S_e = A_1 A_2 \frac{q_o B}{E_s}$$

$$E_s = \beta c_u$$

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

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

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

Site investigations

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

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Mat foundations

$$q_{net} = \frac{N_{60}}{0.08}\left[1 + 0.33\left(\frac{D_f}{B}\right)\right]\left[\frac{S_e}{25}\right] \leq 16.63N_{60}\left[\frac{S_e}{25}\right]$$

$$q = \frac{Q}{A} \pm \frac{M_y x}{I_y} \pm \frac{M_x y}{I_x}$$

$$I_x = \left(\frac{1}{12}\right)BL^3$$

$$I_y = \left(\frac{1}{12}\right)LB^3$$

$$M_x = Qe_y$$

$$M_y = Qe_x$$

$$x^i = \frac{Q_1x_1' + Q_2x_2' + Q_3x_3' + ..}{Q}$$

$$e_x = x' - \frac{B}{2}$$

$$y^i = \frac{Q_1y_1' + Q_2y_2' + Q_3y_3' + ..}{Q}$$

$$e_y = y' - \frac{B}{2}$$

Pile Foundation

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 $Q_p = 9c_u A_p$

Vesic

Sand $Q_p = A_p q_p = A_p \bar{\sigma}_o' N_\sigma^*$

Clay $Q_p = A_p q_p = A_p c_u N_c^*$

Coyle and Castello

Sand $Q_p = q' N_q^* A_p$

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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, $Q_s = pLf_{av}$

$f_{av} = \lambda(\bar{\sigma}_o' + 2c_u)$

β method $Q_s = \Sigma f p \Delta L$

$f = \beta \sigma_o'$

Correlation with Cone penetration

$Q_p = A_p q_c$

$q_p = q_c$

$Q_s = \Sigma p \Delta L f$

$f = \alpha' f_c$

$f_c = Frictional\ resistance$

Correlation with SPT

$Q_p = A_p q_p$

$q_p = 0.4 p_a N_{60} \frac{L}{D} \leq 4 p_a N_{60}$

$Q_s = pLf_{av}$

$f_{av} = 0.02 p_a N_{60}$

Conventional retaining walls

Rankine active and passive pressure

$P_a = \frac{1}{2}K_a\gamma_1 H^2$ $P_a = \frac{1}{2}K_a\gamma_1 H^2 + qK_a H$

$P_v = P_a \sin\alpha°$ $P_h = P_a \cos\alpha°$

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

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

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Factor of safety against overturning

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

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

Factor of safety against sliding

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

Retaining walls with geotextile and geogrid reinforcement

$$\sigma_o' = \sigma_{o_1}' + \sigma_{o_2}' \qquad \sigma_{o_1}' = \gamma_1 z$$

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

$$FS_B = \frac{w f_y}{\sigma_a' S_V S_H} \qquad F_R = 2 L_e w \sigma_o' \tan\phi_\mu'$$

$$\sigma_a' = \sigma_{a_1}' + \sigma_{a_2}' \qquad \sigma_{a_1}' = \gamma_1 z K_a$$

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

$$FS_P = \frac{2 L_e w \sigma_o' \tan\phi_\mu'}{\sigma_a' S_V S_H} \qquad L = \frac{H - z}{\tan(45^\circ + \frac{1}{2}\phi_1')} + \frac{FS_P \sigma_a' S_V S_H}{2 w \sigma_o' \tan\phi_\mu'}$$

overturning factor of safety

$$FS = \frac{M_R}{M_O} = \frac{(W_1 x_1 + W_2 x_2 + \ldots + qa')\left(b' + \frac{1}{2}a'\right)}{P_a z_a}$$

sliding factor of safety

$$FS = \frac{F_R}{F_d} = \frac{(W_1 x_1 + W_2 x_2 + \ldots + qa')[\tan(\phi_1')]}{P_a}$$

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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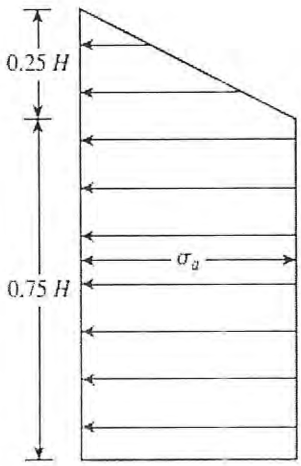
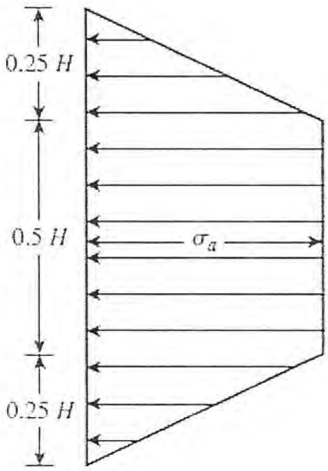


Peck's (1969) apparent-pressure envelope for cuts in soft to medium clay



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

$\sigma_a = 0.65\gamma H K_a$

$\sigma_a = \gamma H \left[1 - \left(\frac{4c}{\gamma H}\right)\right]$

and

$\sigma_a = 0.3\,\gamma H,$

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

$S = \frac{M_{max}}{\sigma_{all}}$

Equations Machine Vibrations

$W_o = W_b + W_m$

$r_o = \sqrt{\left(\frac{Area}{\pi}\right)}$

$b = \frac{W_o}{\gamma\, r_o^3}$

$f_{res} = \frac{a_o}{2\pi\, r_o}\sqrt{\frac{Gg}{\gamma}}$

$F = (F_p + F_s)\left(\frac{f_{res}}{f_o}\right)^2$

$F = 2\,me\,\omega_{res}^2$

$N' = N\left(\frac{f_o}{f_{res}}\right)^2$

$W_e = 2me$

$X = N\left(\frac{f_o}{f_{res}}\right)^2\left(\frac{W_e}{W_o}\right)$