UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2009/2010

SUBJECT	:	FOUNDATION ENGINEERING
SUBJECT CODE	:	BFC4043
COURSE	:	4 BFF
EXAMINATION DATE	:	APRIL / MAY 2010
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ONE (1)** QUESTION FROM PART A AND **ALL QUESTIONS** FROM PART B

THIS PAPER CONSISTS TWENTY FOUR (24) PAGES

PART A

Q1 (a) Briefly describe the four (4) phases of site investigation for major projects.

(4 marks)

(b) (i) Calculate the disturbance of a soil sample obtained from UTHM campus area by using thin walled sampler with the inner diameter of 38.1 mm and has the thickness of 1mm.

(2 marks)

(ii) If $A_r > 20\%$ considered disturbed, justify the sample in **Q(b)(i).**

(1 mark)

(c) (i) Calculate the undrained strength, s_{uv} of a clay sample by using Vane shear as shown in Figure **Q1(c).**

The vane tester has diameter of 100mm and height of 200mm respectively. Torque applied is 120 N.m

$$s_{uv} = \frac{12T}{\pi D^2\left[\left(\frac{D}{\cos i_T}\right)+\left(\frac{D}{\cos i_B}\right)+6H\right]}$$

(4 marks)

(ii) Liquid limit and plastic limit of the clay sample known as 84% and 32% respectively, estimate the value of corrected undrained strength, $s_{uv(corr)}$ of the clay sample if $s_{uv(corr)} = \mu . s_{uv}$.

(4 marks)

(iii) Determine the remoulded strength of clay sample in **Qc(i)** at depth of 6m if the undisturbed strength is 23.81 kPa and the sensitivity is 3.2.

(2 marks)

(d) Data from a CPT reading at the depth of 12 m is shown below. Groundwater is found at 6 m. The soil unit weight is 16.8 kN/m³ ...

APPENDIX 4

FINAL EXAMINATION

SEMESTER / SESSION : SEM 2 / 2000/2010	COURSE : 3 BFF
SUBJECT : HYDROLOGY	SUBJECT CODE : BFC 3092

Equations:

$I - O = \Delta S/\Delta t$

$W = 1/L^2$

$Q_p = \frac{1}{3.6} \times C \times i \times A$ (For SI Unit)

$P_X = \Sigma (P / W)$ / Σ W

Q2 (a) Briefly describe the technics of deep soil densification.

(5 marks)

(b) Sketch any **two (2)** of vibratory and impact compactors for shallow compaction.

(2 marks)

(c) Sketch the process of vibro-compaction method of stabilization.

(4 marks)

(d) A completed earth fill, occupies a net volume of 120,000 m^3). The borrow material that will be used to construct this fill is a stiff clay. In its "bank" condition, the borrow material has a wet unit weight,γ of (20.2 kN/m^3 or 2067kg/m^3), a water content w, of 15.4 %, and an in-place void ratio (e) of 0.620.

The fill will be constructed in layers of 18 cm depth, loose measure, and compacted to a dry unit weight,18.5 kN/m^3 at a water content of 18.2%.

(i) Determine the volume of soil required from the borrow pit.

(3 marks)

(ii) Calculate the quantity of water mass needed to be added to both fill and borrow to reach the desired fill unit weight and moisture content.

(5 marks)

(iii) Another bank density of a wet gravel is known to be 2000 kg/m^3. The soil is to be transported in loose form where the density is lowered to 1780 kg/m^3.

Calculate the percent swell and swell factor.

(4 marks)

(e) Geosynthetic drain was proven to be effective served as vertical drains. Most synthetic drains are of a strip (or band) shape.

Sketch any **two (2)** shapes of cores of non-woven geotextile filter sleeves.

(2 marks)

PART B

Q3 (a) A rectangular pad foundation as shown in Figure **Q3 (a).**

(i) Evaluate the contact pressure at right and left of the footing due to the combination of loads. Use flexural formula.
Hint : there will be a negative pressure on one side of the footing.

(4 marks)

(ii) By taking summation of vertical load and moment, modify the load so that the minimum load is set to zero.

(4 marks)

(iii) Sketch the pressure diagram

(1 mark)

(b) A rectangular of 1.5m x 1.8m foundation was constructed in the soil with the following undrained shear strength parameters of the following :

$Ø = 24°$, $c = 12$ kN/m^2, $\gamma = 15.4$ kN/m^3

Assuming using the general bearing capacity factors by Vesic', with the eccentricity, e = 0.10m in one direction only, FS = 3, and $D_f = 1.2$ m

Vesic's constant are : $N_c = 19.32$; $N_q = 9.6$; $N_\gamma = 9.44$; $\tan Ø = 0.45$; $N_q/N_c = 0.50$

Evaluate the following parameters :

(i) The ultimate bearing capacity.

(5 marks)

(ii) Allowable load on the foundation

(1 mark)

(iii) Net allowable load on the foundation

(1 mark)

(c) Analyse the allowable load on the raft footing as shown in Figure **Q3(c)** with ground water table at depth and assumption stated in **Table 1.**

Table 1

Depth,z (m)	Assumption
1.0	Local shear
2.0	Local shear
3.6	General shear

(3marks each = 9 marks)

Q4 (a) Evaluate the allowable capacity, Q_{all} of the pile in Figure **Q4(a)**. Use FS=2.5 for point capacity, Q_p and FS=2.0 for skin friction, Q_s.

(i) Analyse Q_s by assuming $L_{critical}$=15xdiameter, K=1.3 and $\delta = 0.8\phi$.

Use the following methods for finding point capacity, q_p . Assume $I_{rr} = 100$; with Ø=32°; $N_{\sigma}^{*} = 21.55$.

(4 marks)

(ii) Vesics method

(2 marks)

(iii) SPT's method (Meyerhof, 1976)

(2 marks)

Note : State your answer in term of :
(i) Q_{all} = Q_s in (i) + Q_p (vesic's) and (ii) Q_{all} = Q_s in (i) + Q_p(SPT's)

(b) (i) A spun pile with outside diameter of 300mm and thickness of 60mm is driven in a sandy soil stratum with closed end condition.

Working load, Q_w = 480kN; skin resistance take 70% of the load and point capacity take the rest. Pile length is 20m and I_{wp}=0.85.

Use $E_p = 21 \times 10^6$ kN/m², $E_s = 25 \times 10^3$ kN/m², $\mu_s = 0.32$ and $\xi = 0.68$.
Internal diameter = 0.3 – 2(0.06) = 0.18m.

Predict the settlement of the single pile in the above soil condition.

(7 marks)

(ii) Predict the elastic group settlement of a 6-P group pile, Figure **Q4(b)(ii)** constructed nearby the pile mentioned in **Q(b)(i)**. Use the same diameter as in **Q(b)(i).**

(2 marks)

(iii) Evaluate the efficiency of pile group by using Converse-Labbarre Method. Take center-to-center spacing = 3xdiameter and center of pile to pilecap edge = 2xdiameter.

(2 marks)

(c) A 4-P group pile cap was constructed in clay oil stratum as in Figure **Q4(c),** all piles are 0.35m diameter, center to center spacing is 3xdiameter and 2xdiameter for distance from center of pile to the edge of pilecap and the piles are 16.5 m long.

(i) Sketch the problem, show the pressure line using 2:1 method of analysis and the location of layer mid point where most consolidation occurs.

(Note : Detach this page and tie it together with your answer book)

(3 marks)

(ii) Calculate the total amount of consolidation settlement that occur using the same method. All soil parameters are as shown in the Figure **Q4(c).**

(3 marks)

Q5 (a) Describe in terms of active pressure, passive pressure and point of rotation on cantilever sheet pile penetrating sandy soil for water front structure. Properly sketch and label all information.

(5 marks)

(b) A 10 m high mechanically stabilized wall with galvanized steel-strip reinforcement in a granular backfill has to be constructed as shown in Figure **Q5(b).** Take k=2/3.

Justify the external stability of the wall in term of the following:

(i) Overturning

(4 marks)

(ii) Sliding

(2 marks)

(iii) Bearing capacity

(4 marks)

(c) Design the retaining wall in Figure **Q5(c)** using the Rankine's Method in terms of :

(i) overturning

(6 marks)

(ii) sliding

(2 marks)

(d) Suggest improvement step in case of failure in **Q5(c).**

(2 marks)

BAHAGIAN A

S1 (a) Terangkan secara ringkas **empat (4)** fasa penyiasatan tapak untuk projek utama.

(4 markah)

(b) (i) Kirakan gangguan pada contoh tanah yang diambil dari kampus UTHM dengan menggunakan pensampel dinding nipis dengan diameter dalam 38.1 mm dan ketebalan 1mm.

(2 markah)

(ii) Jika $A_r > 20\%$ di anggap terganggu, nilaikan contoh tanah di **S1(b)(i).**

(1 markah)

(c) (i) Kirakan kekuatan tak tersalir contoh tanah liat dengan menggunakan kaedah Vane seprti dalam Rajah **Q1©.**

Penguji vane mempunyai diameter berukuran 100mm dan ketinggian 200mm. Piuh yang dikenakan ialah 120 N.m.

$$s_{uv} = \frac{12T}{\pi D^2 \left[\left(\frac{D}{\cos i_T} \right) + \left(\frac{D}{\cos i_B} \right) + 6H \right]}$$

(4 markah)

(ii) Had cecair dan had □eometr contoh tanah liat diketahui sebagai 84% and 32%. Nilaikan kekuatan tak tersalir diperbetulkan, $s_{uv(corr)}$ contoh tanah tersebut jika $s_{uv(corr)} = \mu . s_{uv}$.

(4 markah)

(iv) Tentukan nilai kekuatan terganggu contoh tanah liat di (i) pada kedalaman 6m jika kekuatan tak terganggu ialah 23.81 kPa dan '*sensitivity*' nya ialah 3.2.

(2 markah)

(e) Data dari bacaan CPT pada kedalaman 12 m diberikan seperti di bawah. Air bawah tanah ialah dikedalaman 6 m. Berat tentu tanah ialah 16.8 kN/m^3. Geseran bahu kon □eometrical, a=0.75.

Geseran hujung kon, q_c = 1200 kPa
Rintangan geseran bahu, f_s = 1000 kPa
Tekanan air liang, $u_0 = 9.8kN/m^3(6m) = 58.8kPa$
Tekanan liang kon, u_2 = 120 kPa

Justifikasikan jenis tanah dengan menggunakan Rajah **Q1(d)**

(8 markah)

S2 (a) Terangkan dengan ringkas kaedah penumpatan tanah dalam.

(5 markah)

(b) Lakarkan mana-mana **dua (2)** penggetar dan pemampat impak untuk pemadatan cetek.

(2 markah)

© Lakarkan proses '*vibro-compaction*' dalam kaedah penstabilan tanah.

(4 markah)

(d) Sebuah tambakan yang sudah siap memerlukan isipadu tanah sebanyak 120,000 m^3. Bahan pinjaman yang diperlukan untuk membina tambakan ini ialah tanah liat keras.

Dalam kedaan asal, bahan pinjaman mempunyai berat tentu sebanyak ,γ of (20.2 kN/m^3), kandungan air ialah 15.4 %, dan nisbah lompang (e) ialah 0.620.

Tambakan akan dibina dalam lapisan setebal 18 cm dan dipadatkan ke berat tentu kering sebanyak,18.5 kN/m^3 pada kandungan air 18.2%.

(j) Tentukan isipadu tanah diperlukan dari lubang tanah pinjam.

(3 markah)

(ii) Kirakan kuantiti jisim air yang perlu ditambahkan kepada tambakan dan lubang pinjam untuk mendapatkan berat tentu dan kandungan air yang dikehendaki.

(5 markah)

(iii) Ketumpatan tambakan lain diketahui sebagai 2000 kg/m^3. tanah itu diangkut dalam keadaan longgar dan ketumpatan dikurangkan kepada 1780 kg/m^3.

Kirakan peratus pengembangan dan faktor pengembangan.

(4 markah)

(e) Saliran geosintetik telah terbukti berkesan sebagai saliran pugak. Kebanyakan nya dari jenis jaluran.

Lakarkan bentuk mana-mana **dua (2)** isi penapis geotekstil tidak terjalin.

(2 markah)

BAHAGIAN B

S3 (a) Sebuah asas pad segiempat tepat seperti dalam Rajah **Q3 (a).**

(i) Nilaikan tekanan sentuh pada sisi kanan dan kiri asas pad tersebut disebabkan oleh kombinasi beban. Gunakan rumus lenturan.

Petua : akan ujud tekanan negative pada satu dari sisi asas tersebut.

(4 markah)

(ii) Dengan mengambil jumlah bean pugak dan momen, ubah suai semula beban tersebut sehingga sisi minimum mendapat beban sifar.

(4 markah)

(iii) Lakarkan rajah tekanan.

(1 markah)

(b) Sebuah asas segiempat tepat berukuran 1.5m x 1.8m di bina di dalam tanah yang mempunyai parameter kekuatan tak tersalir seperti berikut :

$\text{Ø} = 24°$, $c = 12\ \text{kN/m}^2$, $\gamma = 15.4\ \text{kN/m}^3$

Andaikan penggunaan '*general bearing capacity factors*' dan formula Vesic', dengan kesipian, e = 0.10m dalam satu arah sahaja, FS = 3, dan D_f= 1.2 m.

Pekali Vesic's adalah : N_c =19.32; N_q =9.6; N_γ =9.44; tan Ø=0.45; N_q/N_c= 0.50

Nilaikan yang berikut :

(i) Keupayaan galas muktamad.

(5 markah)

(ii) Beban dibenarkan ke atas asas

(1 markah)

(i) Beban net dibenarkan ke atas asas

(1 markah)

(c) Bandingkan beban dibenarkan ke atas asas rakit seperti yang ditunjukkan dalam Rajah **Q3(c)** dengan aras air bumi seperti dalam **Jadual 1.**

Jadual 1

Kedalaman, z (m)	Andaian
1.0	*Local shear*
2.0	*Local shear*
3.6	*General shear*

(3markah x3 = 9 markah)

S4 (a) Nilaikan keupayaan dibenarkan, Q_{all} bagi cerucuk dalam Figure **Q4(a)**. Gunakan FS=2.5 untuk keupayaan hujung, Q_{tip} dan FS=2.0 untuk geseran sisi, Q_s.

Kirakan Q_s dengan andaian $L_{critical}$=15xdiameter, jika K=1.3 dan $\delta = 0.8\phi$. Guna kaedah yang berikut untuk mengira keupayaan hujung cerucuk, q_p. Andaikan $I_{rr} = 100$; dengan Ø=32°; $N_{\sigma}^{*} = 21.55$.

(4 markah)

(i) Kaedah Vesics

(2 markah)

(ii) Kaedah SPT (Meyerhof, 1976)

(2 markah)

Nyatakan jawapan anda dalam bentuk :
(i) $Q_{all} = Q_s$ dari (i) + Q_p (vesic's) dan (ii) $Q_{all} = Q_s$ dari (i) + Q_p(SPT's)

(b) (i) Sebatang cerucuk terpintal dengan diameter luar berukuran 300mm dan ketebalan 60mm telah dipacu ke dalam lapisan pasir dengan keadaan tertutup hujung.

Beban kerja, Q_w = 480kN; geseran kulit, Q_s akan menanggung 70% dari jumlah beban dan keupayaan hujung akan menanggung selebihnya. Panjang cerucuk ialah 20m dan I_{wp}=0.85. Guna $E_p = 21 \times 10^6$ kN/m^2, $E_s = 25 \times 10^3$ kN/m^2, $\mu_s = 0.32$ and $\xi = 0.68$. Diameter dalaman = 0.3 – 2(0.06)=0.18m.

Anggar enapan cerucuk untuk cerucuk tunggal jika diberi parameter berikut untuk kedua-dua cerucuk dan tanah sekeliling.

(7 markah)

(ii) Nilaikan enapan kumpulan cerucuk 6-P, Rajah **Q4(b)(ii)** yang dibina bersebelahan cerucuk yang dinyatakan dalam **S4(b)(i)** dengan menggunakan kaedah Vesic.

Berdasarkan Rajah **Q4(b)(ii)** nilaikan yang berikut :enapan kumpulan dengan menggunakan kaedah Vesic dan keberkesanan kumpulan cerucuk.

(2 markah)

(iii) Nilaikan keberkesanan kumpulan cerucuk tersebut dengan kaedah Converse-Labbarre dengan andaian jarak pusat ke-pusat = 3xdiameter dan jarak pusat ke tepi tetopi cerucuk=2xdiameter.

(2 markah)

(c) Sebuah tetopi cerucuk 4-P telah dibina di dalam lapisan tanah liat seperti Rajah **Q4(c),** semua cerucuk berdiameter berukuran 0.35m, Jarak pusat ke-pusat = 3xdiameter dan jarak pusat ke tepi tetopi cerucuk=2xdiameter. Panjang semua cerucuk ialah 16.5 m.

(i) Lakarkan masalah ini, tunjukkan garisan kaedah analisis 2:1 dan lokasi berlakunya maksimum enapan pengukuhan di pertengahan lapisan tanah liat tersebut. (Nota: Ceraikan mukasurat Rajah **Q4(c)** ini).

(3 markah)

(ii) Kirakan jumlah enapan pengukuhan yang berlaku dengan kaedah yang sama. Semua parameter adalah seperti yang ditunjukkan dalam Rajah **Q4(c).**

(3 markah)

S5 (a) Huraikan dari sudut tekanan aktif, tekanan pasif dan titik putaran ke atas cerucuk keping julur menembusi lapisan pasir untuk struktur air. Lakarkan dengan betul dan labelkan semua maklumat.

(5markah)

(b) Sebuah tembok terstabil mekanikal dengan jaluran-keluli bergalvan setinggi 10 m. Kambusan balik ialah tanah berbutiran dibina seperti dalam Rajah **Q5(b).** Ambil k=2/3.

Justifikasikan kestabilan luaran tembok tersebut dari segi yang berikut:

(i) Keterbalikan

(4 markah)

(ii) Gelangsaran

(2 markah)

(iii) Keupayaan galas

(4 markah)

(c) Rekabentukan tembok penahan pada Rajah **Q5(c)** menggunakan kaedah Rankine's dari sudut menentang :

(i) Keterbalikan

(6 markah)

(ii) Gelangsaran.

(2 markah)

(d) Cadangkan langkah pembaikan yang perlu dalam kes kegagalan dalam **S5(c).**

(2 markah)

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FORMULAE :

Q1:

$A_r = \left(\dfrac{D_{ext}{}^2 - D_{int}{}^2}{D_{int}{}^2}\right)\times 100\%$; $s_{uv} = \dfrac{12T}{\pi D^2\left[\left(\dfrac{D}{\cos i_T}\right)+\left(\dfrac{D}{\cos i_B}\right)+6H\right]}$; $q_t = q_c + u_2(1-a)$;

$Q_{cone\ tip} = \dfrac{(q_t - \sigma_t)}{\sigma'_v}$; $F_r = \dfrac{f_s}{(q_t - \sigma_t)}\times 100\%$

Q2:

$\gamma_d(borrow) = \dfrac{\gamma}{1+w}$; W=mg; $Swell\ factor = \dfrac{loose\,unit\,weight}{bank\,unit\,weight}\times 100$;

$Swell\ \% = \left(\dfrac{bank\,unit\,weight}{loose\,unit\,weight} - 1\right)\times 100$

Q3:

$q = \dfrac{Q}{A} \pm \dfrac{M_x y}{I_x} \pm \dfrac{M_y x}{I_y}$; $F_{cs} = 1 + \dfrac{B'}{L'}\dfrac{N_q}{N_c}$; $F_{qs} = 1 + \dfrac{B'}{L'}\tan\phi$; $F_{\gamma s} = 1 - 0.4\left(\dfrac{B'}{L'}\right)$; $F_{cd} = 1 + 0.4\dfrac{D_f}{B}$;

$F_{qd} = 1 + 2\tan\phi(1-\sin\phi)^2\dfrac{D_f}{B}$; $q'_u = cN_cF_{cs}F_{cd}F_{ci} + qN_qF_{qs}F_{qd}F_{qi} + \dfrac{1}{2}\gamma B'N_\gamma F_{\gamma s}F_{\gamma d}F_{\gamma i}$; $q_{all(net)} = \dfrac{q_u - q}{FS}$;

$q_u = 1.3cN_c + qN_q + 0.4\gamma BN_\gamma ....(square.foundation)$; c'=2/3c; $\gamma = \bar{\gamma} = \gamma' + \dfrac{d}{B}(\gamma - \gamma')$;

Q4:

For z = 0 : $\sigma'_v = 0; f = K\sigma'_v\tan\delta = 0$; For z = L' to L : $\sigma'_v = \gamma L'; f = K\sigma'_v\tan\delta$;

$Q_s = \left(\dfrac{f_{z=0} + f_{z=4.58m}}{2}\right)pL' + f_{z=20\,ft}\,p(L-L')$; $Q_p = A_p\sigma'_o N^*_\sigma = A_p\left[\dfrac{1+2(1-\sin\phi)}{3}\right]q'N^*_\sigma$;

$q_p(kN/m^2) = 40(N)(L/D) \le 400N$; $Q_{all} = \left(\dfrac{Q_P}{2.5}\right) + \left(\dfrac{Q_S}{2}\right)$; $s_1 = \dfrac{(Q_{wp} + \xi Q_{ws})L}{A_{concrete}E_p}$;

$s_2 = \dfrac{q_{wp}D}{E_s}(1-\mu_s^2)I_{wp}$; $I_{ws} = 2 + 0.35\sqrt{\dfrac{L}{D}}$; $s_3 = \left(\dfrac{Q_{ws}}{pL}\right)\dfrac{D}{E_s}(1-\mu_s^2)I_{ws}$; $s_{g(e)} = \sqrt{\dfrac{B_g}{D}}s$;

$E_g = 1 - \theta\dfrac{(n-1)m + (m-1)n}{90mn}$; $\Delta p_{(1)} = \dfrac{Q_g}{(B_g + z_i)(L_g + z_i)}$; $\Delta s_1 = \dfrac{C_{c(1)}H_1}{1+e_{0(1)}}\log\left[\dfrac{p_{0(1)} + \Delta p_{(1)}}{p_{0(1)}}\right]$

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FORMULAE :

Q5:

$$FS_{(overturning)} = \frac{W_1 x_1}{P_a z'}; \; W_1 = \gamma_1 HL; \; K_a = \tan^2\left(45 - 34/2\right) = 0.29; \; P_a = ½\gamma_1 K_a H^2$$

$$FS_{(sliding)} = \frac{W_1 \tan(k\phi_1)}{P_a}; \; q_{ult} = c_2 N_c + \tfrac{1}{2}\gamma_2 L' N_\gamma; \; e = \frac{L}{2} - \frac{M_R - M_O}{\sum V}; \; FS_{(bearingcap)} = \frac{q_{ult}}{\sigma_{v(H)}}$$

$$K_a = \frac{1 - \sin\phi_1}{1 + \sin\phi_1} = \tan^2\left(45° - \frac{\phi_1}{2}\right); \; K_p = \frac{1 + \sin\phi_2}{1 - \sin\phi_2} = \tan^2\left(45° + \frac{\phi_2}{2}\right); \; \sum M_O = P_h\left(\frac{H'}{3}\right);$$

$$FS_{(overturning)} = \frac{\sum M_R}{\sum M_O} = \frac{M_1 + M_2 + M_3 + M_4 + M_5 + M_6 + M_v}{P_a \cos\alpha (H'/3)};$$

$$FS_{(sliding)} = \frac{\left(\sum V\right)\tan(k_1\phi_2) + Bk_2 c_2 + P_p}{P_a \cos\alpha}$$

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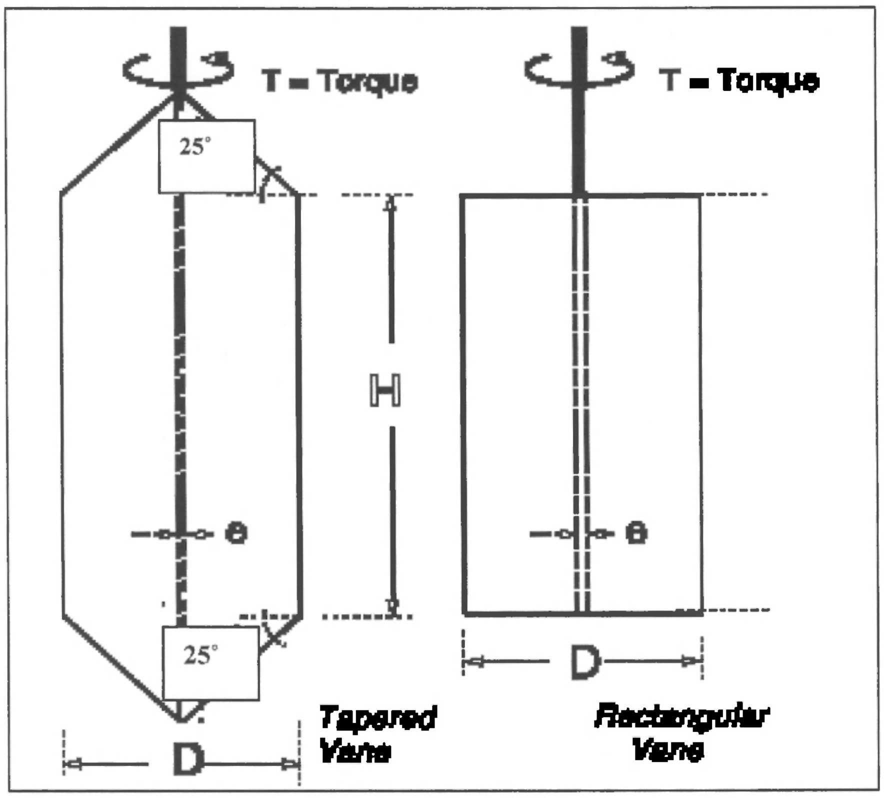

Figure Q1 (c)(i)

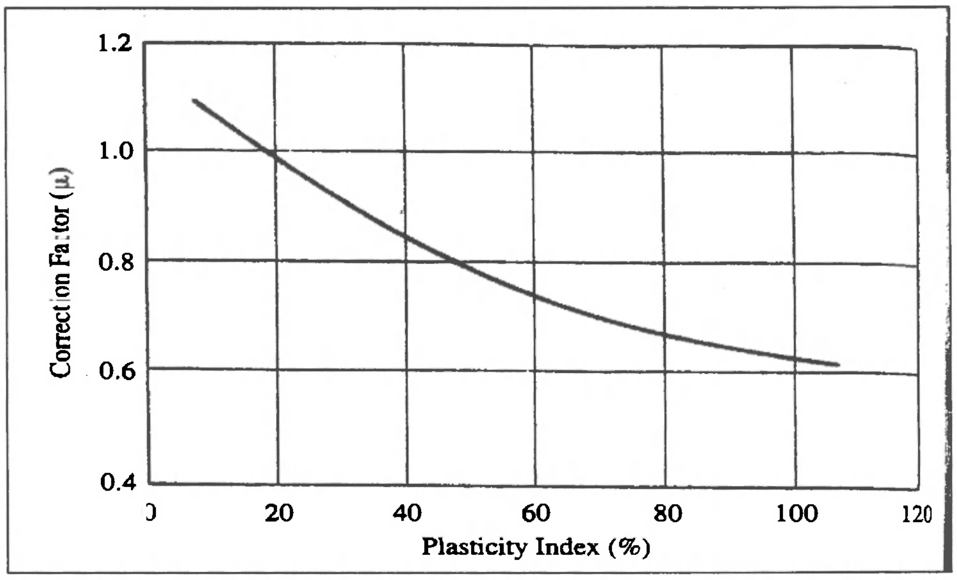

Figure Q1 (c)(ii)

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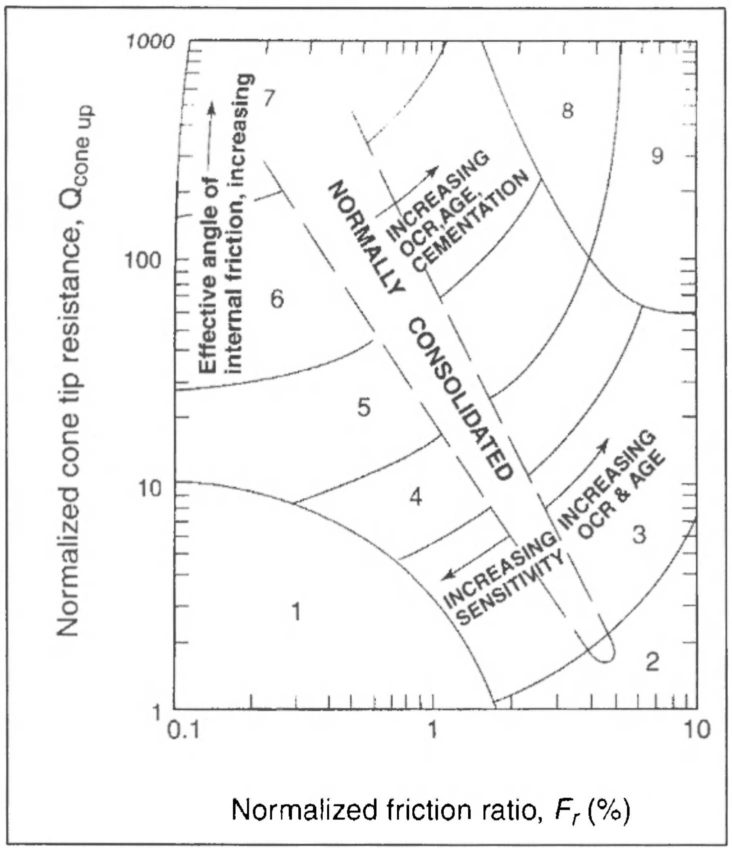

Figure Q1(d)(i)

Chart Zone and Soil Behavior Type (SBT)

1. Sensitive, fine grained
2. Organic soils — peats
3. Clays —clay to silty clay
4. Silt mixtures — clayey silt to silty clay
5. Sand mixtures—silty sand to sandy silt
6. Sands — clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clayey* sand
9. Very stiff, fine grained*

*Heavily overconsolidated or cemented

Figure Q1(d)(ii)

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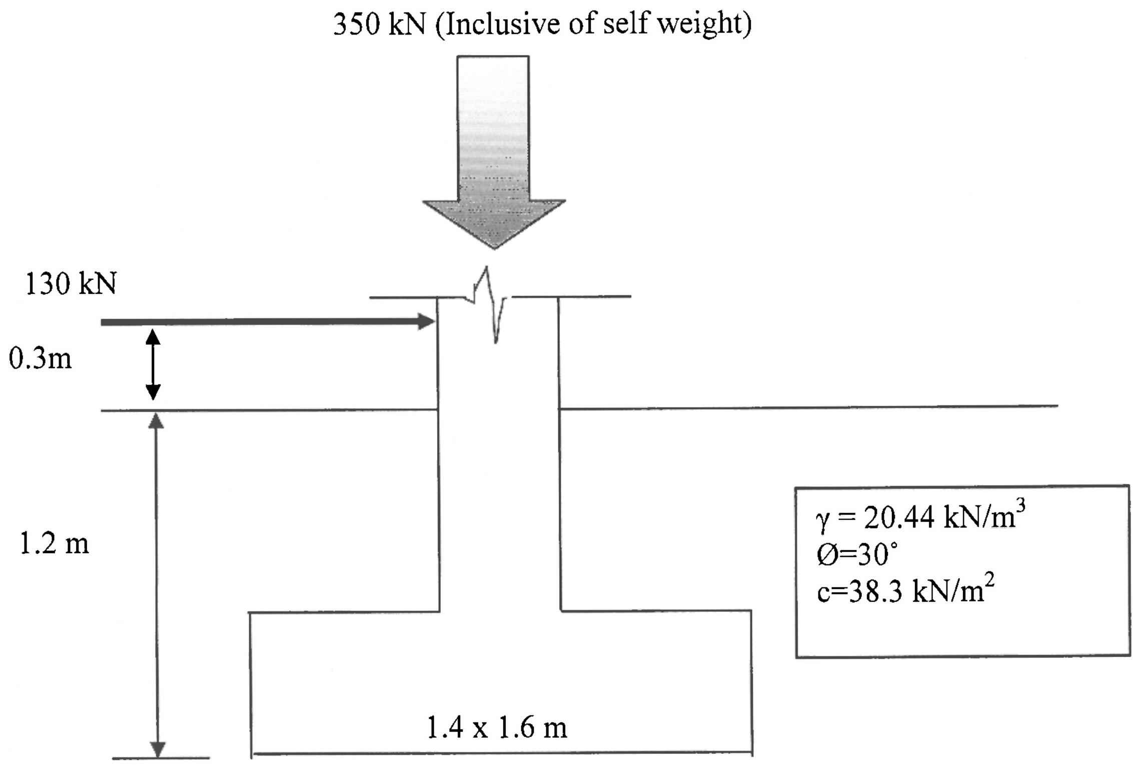

Figure Q3 (a) Shallow foundation with combination of loads

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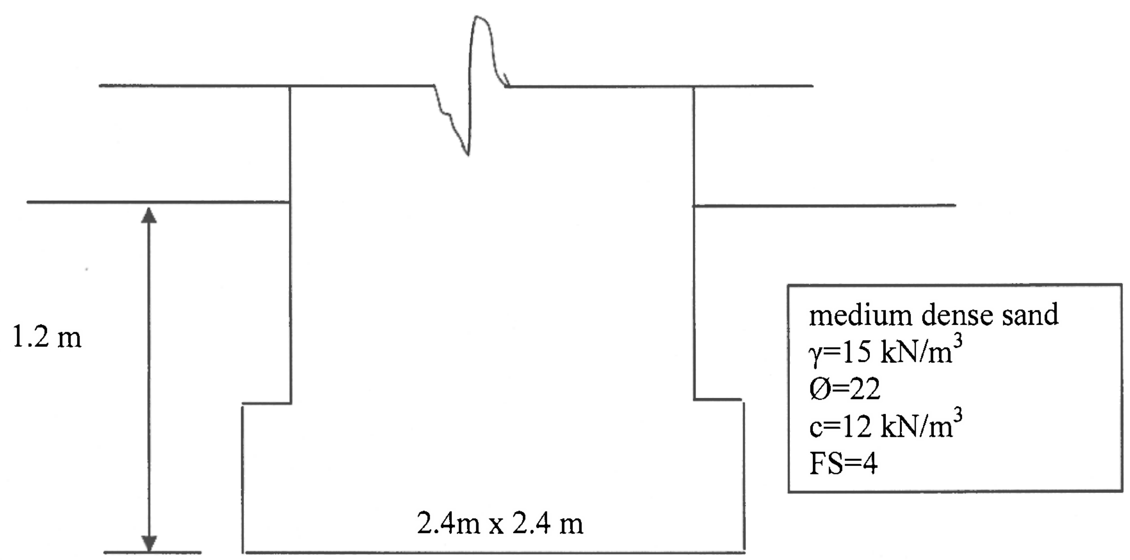

Figure Q3 (c) Raft foundation with varying water level

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Table 2 Terzaghi's Bearing Capacity's Factors

Ø	N_c	N_q	N_γ	Ø	N_c	N_q	N_γ
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				

Table 3 Terzaghi's Modified Bearing Capacity's Factors

Ø	N'_c	N'_q	N'_γ	Ø	N'_c	N'_q	N'_γ
0	5.70	1.00	0.00	26	15.53	6.05	2.59
1	5.90	1.07	0.005	27	16.30	6.54	2.88
2	6.10	1.14	0.02	28	17.13	7.07	3.29
3	6.30	1.22	0.04	29	18.03	7.66	3.76
4	6.51	1.30	0.055	30	18.99	8.31	4.39
5	6.74	1.39	0.074	31	20.03	9.03	4.83
6	6.97	1.49	0.10	32	21.16	9.82	5.51
7	7.22	1.59	0.128	33	22.39	10.69	6.32
8	7.47	1.70	0.16	34	23.72	11.67	7.22
9	7.74	1.82	0.20	35	25.18	12.75	8.35
10	8.02	1.94	0.24	36	26.77	13.97	9.41
11	8.32	2.08	0.30	37	28.51	15.32	10.90
12	8.63	2.22	0.35	38	30.43	16.85	12.75
13	8.96	2.38	0.42	39	32.53	18.56	14.71
14	9.31	2.55	0.48	40	34.87	20.50	17.22
15	9.67	2.73	0.57	41	37.45	22.70	19.75
16	10.06	2.92	0.67	42	40.33	25.21	22.50
17	10.47	3.13	0.76	43	43.54	28.06	26.25
18	10.90	3.36	0.88	44	47.13	31.34	30.40
19	11.36	3.61	1.03	45	51.17	35.11	36.00
20	11.85	3.88	1.12	46	55.73	39.48	41.70
21	12.37	4.17	1.35	47	60.91	44.45	49.30
22	12.92	4.48	1.55	48	66.80	50.46	59.25
23	13.51	4.82	1.74	49	73.55	57.41	71.45
24	14.14	5.20	1.97	50	81.31	65.60	85.75
25	14.80	5.60	2.25				

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Table 4 Vesic's Bearing Capacity Factors for General Equation (1973)

Ø	N_c	N_q	N_γ	N_q/N_c	Tan Ø	Ø	N_c	N_q	N_γ	N_q/N_c	Tan Ø
0	5.14	1.00	0.00	0.20	0.00	26	22.25	11.85	12.54	0.53	0.49
1	5.38	1.09	0.07	0.20	0.02	27	23.94	13.20	14.47	0.55	0.51
2	5.63	1.20	0.15	0.21	0.03	28	25.80	14.72	16.72	0.57	0.53
3	5.90	1.31	0.24	0.22	0.05	29	27.86	16.44	19.34	0.59	0.55
4	6.19	1.43	0.34	0.23	0.07	30	30.14	18.40	22.40	0.61	0.58
5	6.49	1.57	0.45	0.24	0.09	31	32.67	20.67	25.99	0.63	0.60
6	6.81	1.72	0.57	0.25	0.11	32	35.49	23.18	30.22	0.65	0.62
7	7.16	1.88	0.71	0.26	0.12	33	38.64	26.09	35.19	0.68	0.65
8	7.53	2.06	0.86	0.27	0.14	34	42.16	29.44	41.06	0.70	0.67
9	7.92	2.25	1.03	0.28	0.16	35	46.12	33.30	48.03	0.72	0.70
10	8.35	2.47	1.22	0.30	0.18	36	50.59	37.75	56.31	0.75	0.73
11	8.80	2.71	1.44	0.31	0.19	37	55.63	42.92	66.19	0.77	0.75
12	9.28	2.97	1.69	0.32	0.21	38	61.35	48.93	78.03	0.80	0.78
13	9.81	3.26	1.97	0.33	0.23	39	67.87	55.96	92.25	0.82	0.81
14	10.37	3.59	2.29	0.35	0.25	40	75.31	64.20	109.41	0.85	0.84
15	10.98	3.94	2.65	0.36	0.27	41	83.86	73.90	130.22	0.88	0.87
16	11.63	4.34	3.06	0.37	0.29	42	93.71	85.38	155.55	0.91	0.90
17	12.34	4.77	3.53	0.39	0.31	43	105.11	99.02	186.54	0.94	0.93
18	13.10	5.26	4.07	0.40	0.32	44	118.37	115.31	224.64	0.97	0.97
19	13.93	5.80	4.68	0.42	0.34	45	133.88	134.88	271.76	1.01	1.00
20	14.83	6.40	5.39	0.43	0.36	46	152.10	158.51	330.35	1.04	1.04
21	15.82	7.07	6.20	0.45	0.38	47	173.64	187.21	403.67	1.08	1.07
22	16.88	7.82	7.13	0.46	0.40	48	199.26	222.31	496.01	1.12	1.11
23	18.05	8.66	8.20	0.48	0.42	49	229.93	265.51	613.16	1.15	1.15
24	19.32	9.60	9.44	0.50	0.45	50	266.89	319.07	762.89	1.20	1.19
25	20.72	10.66	10.88	0.51	0.47						

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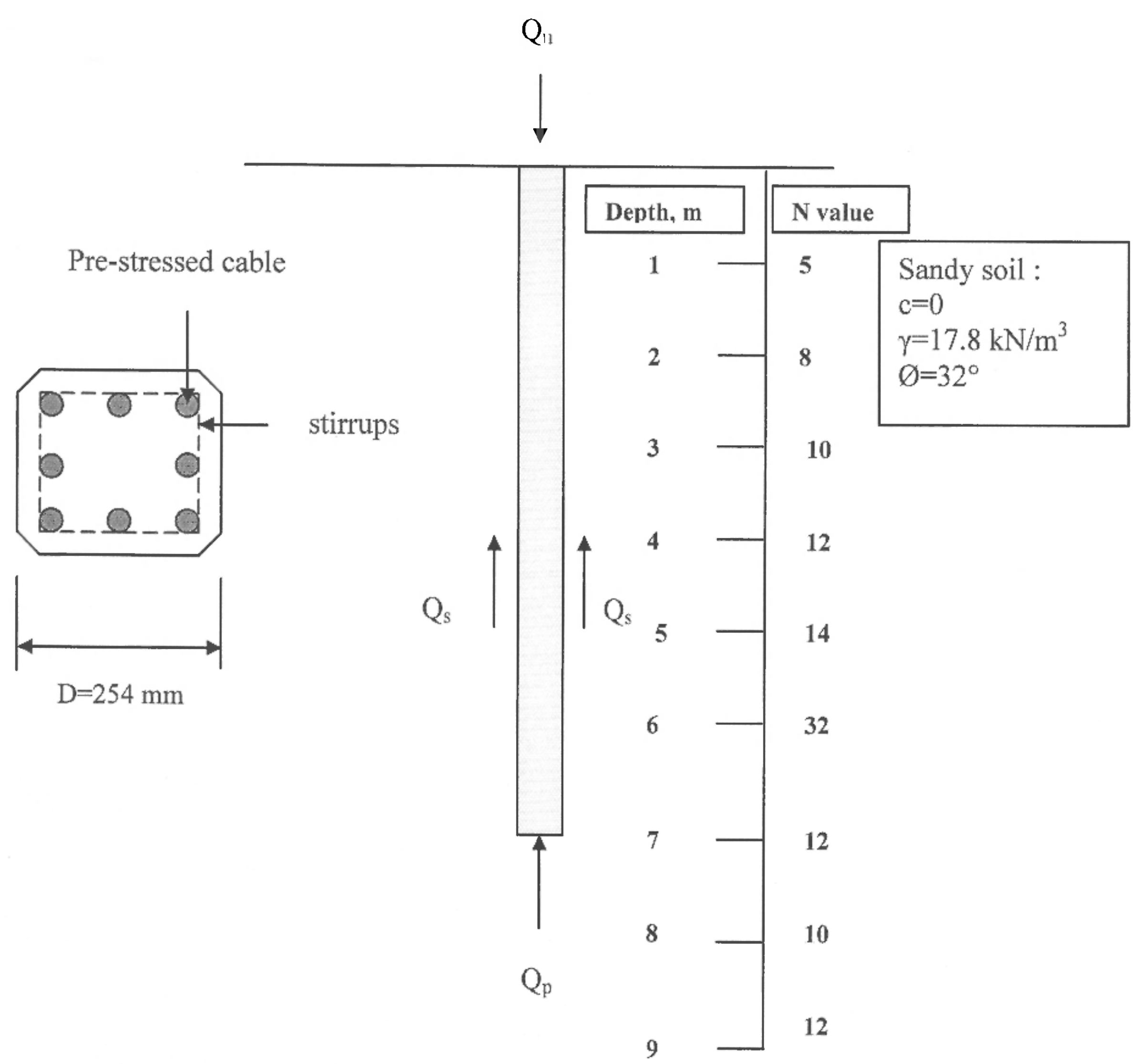

Figure Q4(a) : Pile in sandy soil.

(Figure not to scale)

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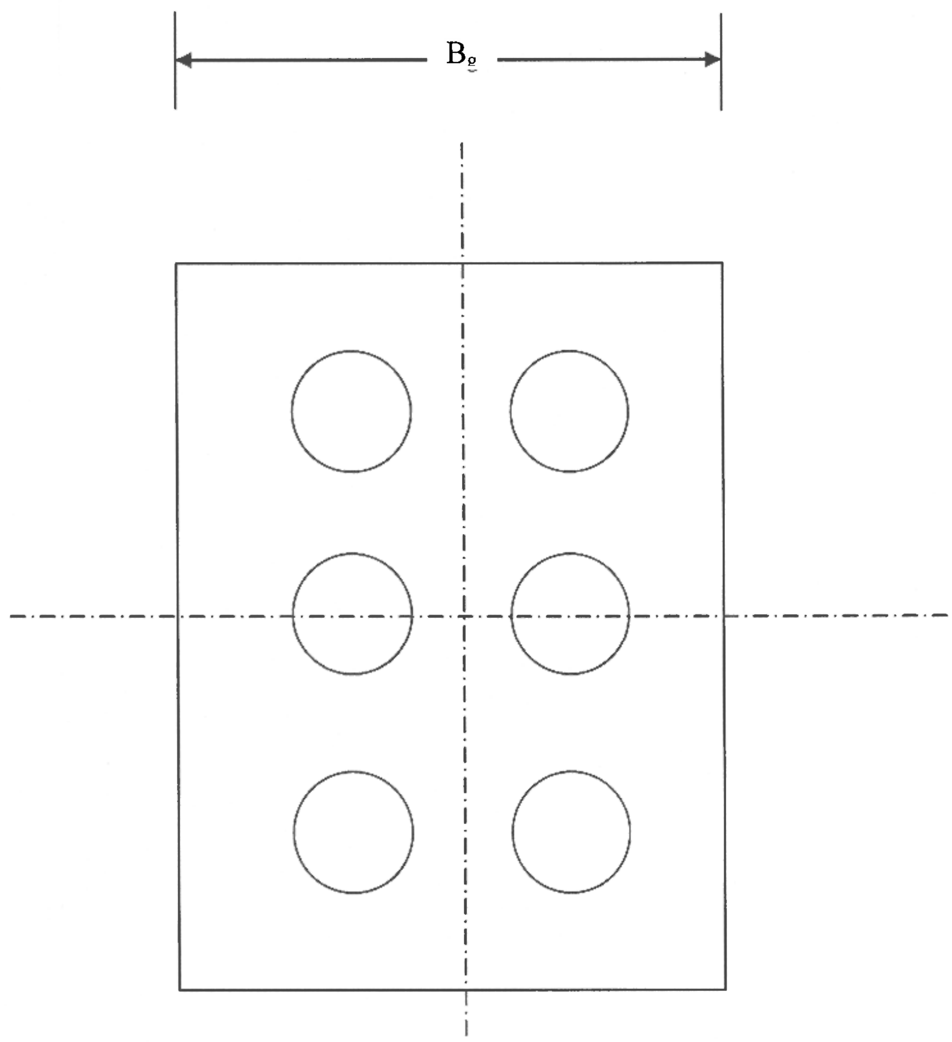

Figure Q4(b)(iii) 6P Pile cap

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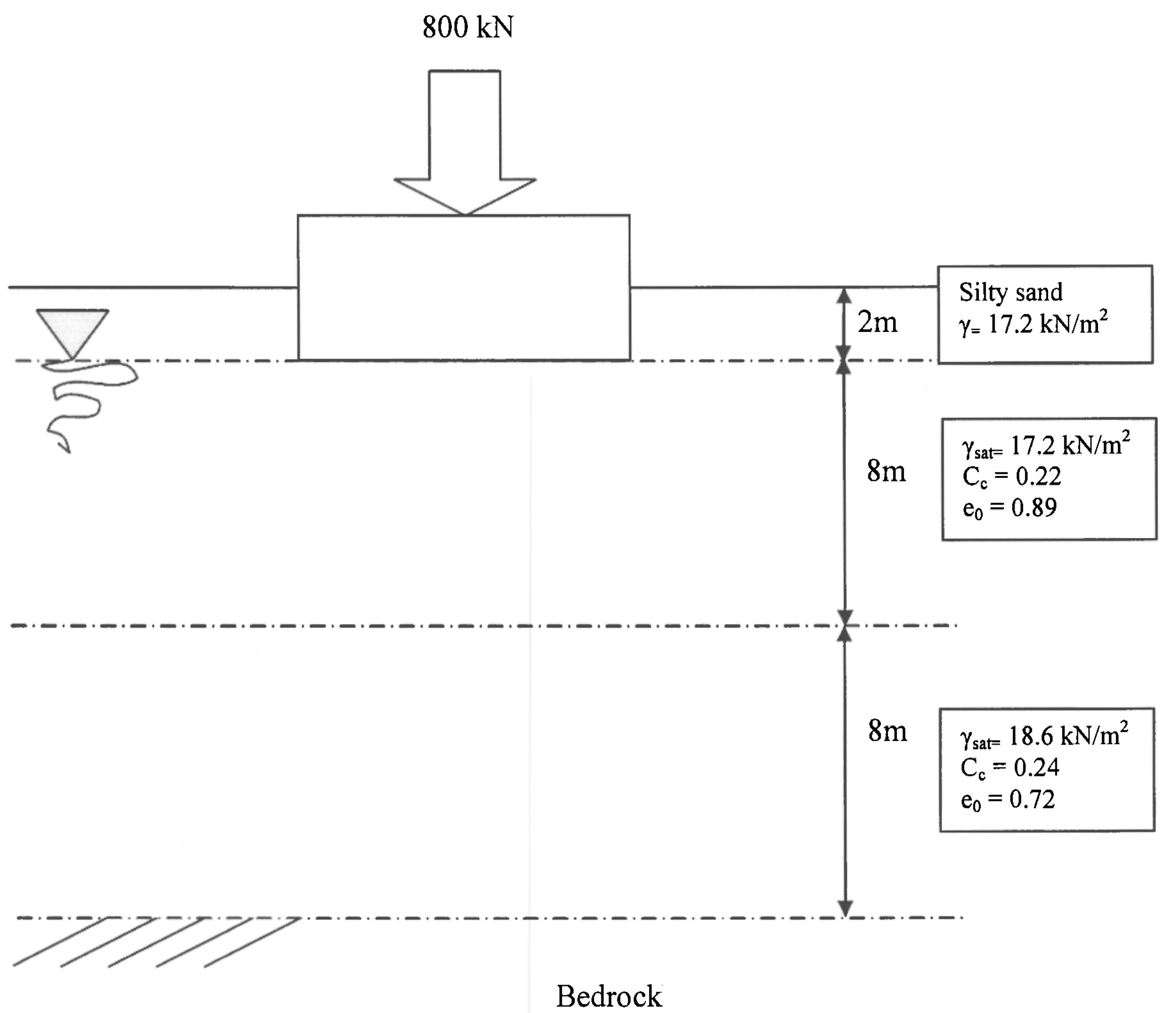

Figure Q4(c)(ii) Pile cap with four piles in clay strata.

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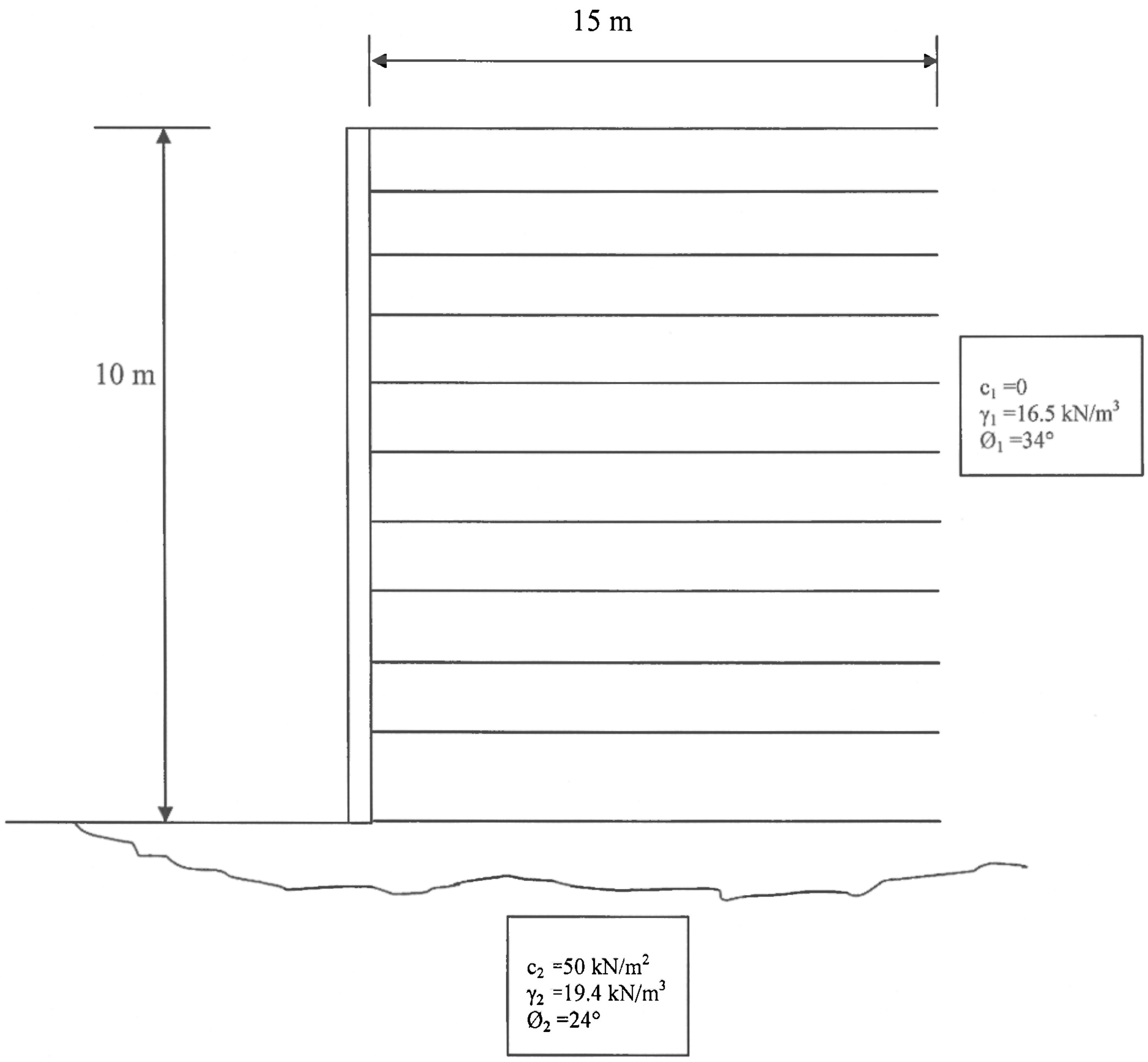

Figure Q5 (b) Retaining wall with galvanized steel

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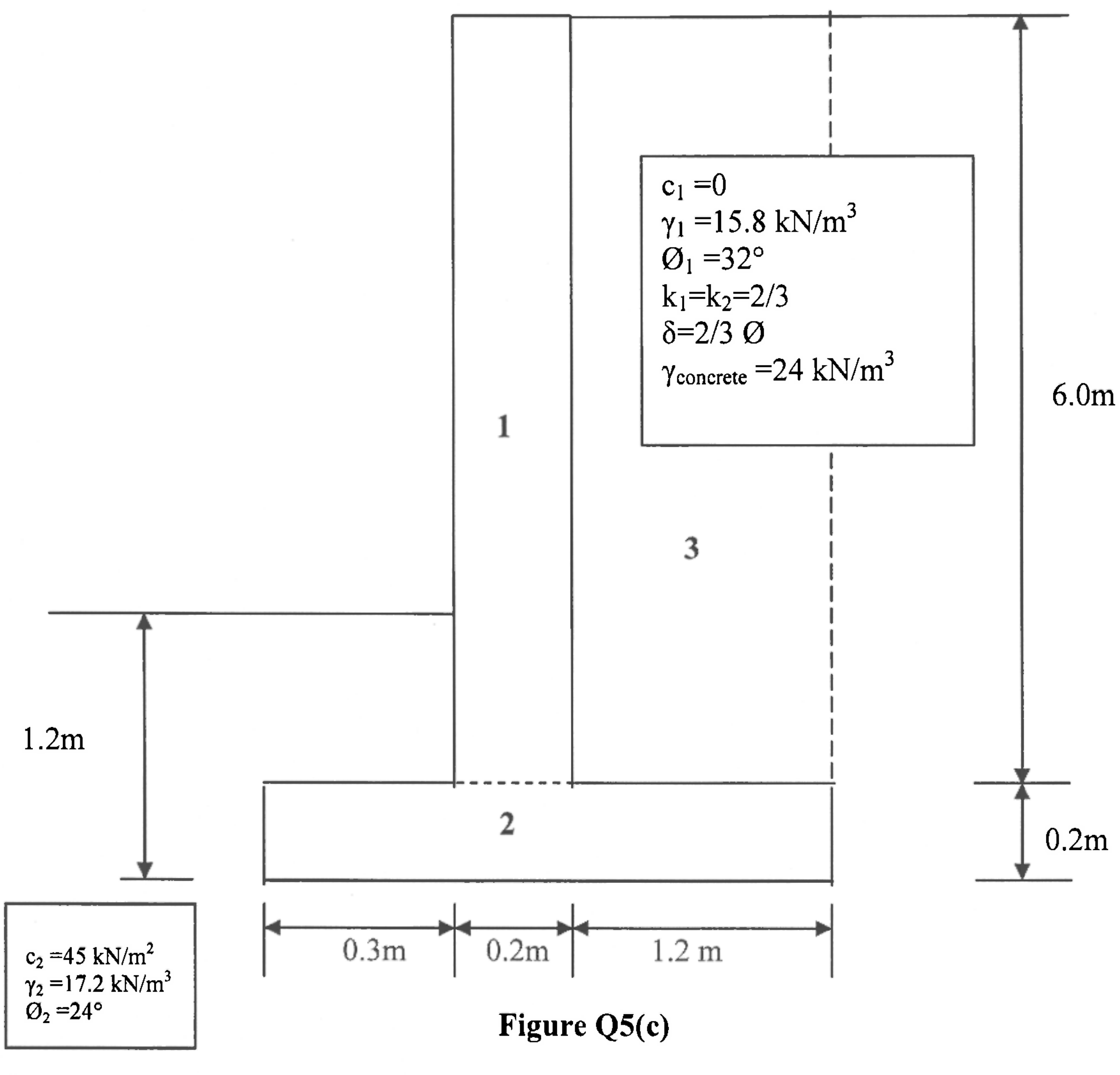

Figure Q5(c)