UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2009/2010

SUBJECT	:	FOUNDATION ENGINEERING
CODE	:	BFC 4043
COURSE	:	4 BFF
DATE	:	NOVEMBER 2009
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ONE (1)** QUESTION FROM PART (A), AND **ALL** QUESTIONS FROM PART (B).

THIS QUESTION BOOK CONTAINS TWENTY THREE (23) PAGES

PART A

Q1 (a) Design of a foundation for Civil Engineering structures cannot be made intelligently unless a geotechnical engineer has at least reasonably accurate information of the soils at the construction site. The information required can be achieved by conducting a site investigation of the proposed site.

As a geotechnical engineer, discuss the objectives of site investigation and the major steps that should be taken in arriving at these objectives.

(6 marks)

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

(i) List briefly the process of retrieving both the disturbed and undisturbed samples.

(ii) Describe the purpose and usage of disturbed and the undisturbed samples in preparing a detailed site investigation report.

(6 marks)

(c) Describe briefly **TWO (2)** of the following site investigation methods that can be used to compliment the boring method, which can costly and time-consuming.

(i) Seismic method

(ii) Resistivity method

(iii) Cone penetration test (CPT) method

(8 marks)

Q2 (a) List **FOUR (4)** characteristics of vibrating rollers that can affect the compaction effort on soil surface.

(2 marks)

(b) Discuss the importance of vibratory compaction in the stabilization of sand and clay soils in terms of :

(i) the process involved; and

(ii) the application of vertical stress.

(4 marks)

(c) Given the required thickness as 0.1 m, drum width 1.8m, efficiency 75% and rolling speed at 10 km/h.

Determine the production rate with 12 passes.

(4 marks)

(d) UTHM is located on a 10 m thick deposit of soft clay and preloading with vertical drain is a popular ground improvement method in such soil.

Describe this method for a proposed embankment to be constructed in the campus area.

Appropriate sketches that contribute to your explanation are encouraged.

(10 marks)

PART B

Q3 (a) Explain what is meant by the 'ultimate bearing capacity' of soil. Indicate how the ultimate bearing capacity of a shallow foundation in a given soil can be calculated from the strength characteristics of the soil.

(5 marks)

(b) A 1.6 m by 1.6 m square footing is shown in **Figure Q3(b)**. Centric column load on the footing is 350 kN. Unit weight of the soil is 18.50 kN/m^3 and unit weight of the concrete is 24.5 kN/m^3. The soil is cohesive soil with the cohesion value of 160 kN/m^2.

Calculate the following :

(i) soil contact pressure,
(ii) factor of safety against bearing capacity failure, and;
(iii) settlement due to primary consolidation of the normally consolidated clay.

(10 marks)

(c) A rectangular foundation has to carry a gross allowable total load (including base, column and soil above base) of 160 kN. The depth of the foundation is 0.75 m. The total load is inclined at an angle of 15° to the vertical as shown in **Figure Q3(c).**

Assuming the length L of the foundation is 1.2B and by taking a factor of safety of 3.0, determine the size of the foundation according to Meyerhof's bearing capacity equation, use **Table 1**.

(10 marks)

Q4 (a) (i) List **FOUR (4)** factors affecting the distribution of lateral earth pressure on a retaining wall.

(4 marks)

(ii) Define 'earth pressure at rest'.

(2 marks)

(b) A cantilever sheet pile wall is required to support 5.5 m thick of sand backfill, with $\phi' = 35^{o}$ and $\gamma = 21$ kN/m^3. By using horizontal equilibrium only, determine the length of sheet pile to achieve a safety factor of 2.0 applied to the passive pressure.

(8 marks)

(c) Referring to **Figure Q4(c)**, a 6 m high concrete gravity wall is retaining a granular backfill of $\gamma_b = 18$ kN/m^3, c = 0 and $\phi' = 30^{o}$. The wall-soil friction, δ is found to be 29^{o}. Also given that unit weight of the wall material is 23.5 kN/m^3 and the foundation soil's ultmate bearing capacity is 620 kN/m^2.

Determine the wall's stability against overturning and sliding. Both factors of safety must be ≥1.5.

Given: $$P_a = \frac{1}{2}\gamma H^2 \cos\beta \frac{\cos\beta - (\cos^2\beta - \cos^2\phi)^{1/2}}{\cos\beta + (\cos^2\beta - \cos^2\phi)^{1/2}}$$

(11 marks)

Q5 (a) Explain using Meyerhof's method for estimating pile point capacity, q_p for the following :

(i) sand (SI unit only)

(ii) using SPT reading.

(2 marks)

(b) Static load tests are traditionally used by engineers to counter check the bearing capacity of piles.

Explain the ultimate failure load criteria of a pile based on the static load test.

(3 marks)

(c) A footing weighting 5 MN (including the pile cap) is seated on 2 m of recently placed loose fill, as shown in **Figure Q5(c).**

The groundwater table is found at a depth of 1 m below ground surface.

Design the proper pile arrangement with reinforced concrete piles of 350 mm x 350 mm and 24 m long, to carry the structure load based on the assumptions as stated below :

- The frictional capacity of recently placed loose fill is negligible,
- Determine the ultimate bearing capacity, Q_{ult} of the piles based on the given formula,
- The pile group system should be based on the guidelines specified in **Figure Q5(c)(ii).**
- The group efficiency, $\eta = 0.7$
- Minimum edge distance from centre of pile = 2 D
- Maximum spacing for centre to centre of pile = 3 D
- The piled foundation is subjected to vertical load only with no eccentricity

Given that:-

$$Q_p = N_c^* c_u A_p = 9 c_u A_p \; ; \; Q_s = \sum fp\Delta L = \sum \alpha c_u p \Delta L$$

(9 marks)

(d) Verify the stability control by using the conventional rigid method, if the pile foundation subjected to a vertical load as determined earlier in **Q5(c),** and a moment with respect to the y-axis of 250 kNm.

Given that:-

$$Q_m = \frac{Q}{n} \pm \frac{M_y x}{\sum(x^2)} \pm \frac{M_x y}{\sum(y^2)}$$

(5 marks)

(e) A 6P pile cap with the same soil profile is adjacent to the pile cap in **Q5(d).**

Calculate the settlement at the middle of the hard clay layer for $e_0 = 0.7$ and $C_c = 0.2$.

(6 marks)

(f) A precast concrete pile, with cross section of 250 mm x 250 mm was driven in sandy soil at a wrong location and need to be pulled out. If the length of pile is 10 m and assuming : $\gamma_{sand} = 14.5$ kN/m^3, $\emptyset_{sand} = 32°$, $D_r = 60\%$,

Calculate the pullout capacity if FS=4.

Note : this case is **NOT** related to case (a) to (e)

(5 marks)

BAHAGIAN A

S1 (a) Reka bentuk sesebuah asas dalam struktur Kejuruteraan Awam tidak boleh dilakukan secara bijaksana oleh jurutera geoteknik tanpa mengetahui secara lengkap maklumat tanah di tapak. Maklumat yang diperlukan boleh didapati secara melakukan penyiasatan tapak di tapak cadangan projek.

Sebagai seorang jurutera geoteknik, bincangkan objektif penyiasatan tapak dan langkah-langkah penting untuk mencapai objektif-objektif ini.

(6 markah)

(b) Dalam kaedah penyiasatan tapak menggunakan kaedah gerekan basuh, sampel – sampel tanah yang di perolehi dari kedalaman berbeza di tapak boleh dikelaskan sebagai sampel terganggu dan tidak terganggu.

(i) Senaraikan dengan ringkas proses mendapatkan sampel terganggu dan tidak terganggu ini.

(ii) Terangkan tujuan dan penggunaan sample-sampel terganggu dan tidak terganggu dalam menyediakan laporan penyiasatan tapak yang terperinci.

(6 markah)

(c) Bincangkan **DUA (2)** dari kaedah penyiasatan berikut yang boleh digunakan sebagai tambahan kepada kaedah pengorekan yang kebiasaannya lebih mahal dan memakan masa yang lama :

(i) Kaedah *seismic*

(ii) Kaedah *resistivity*

(iii) Kaedah penembusan kon (CPT)

(8 markah)

S2 (a) Senaraikan **EMPAT (4)** ciri-ciri penggolck bergetar yang memberi kesan kepada kerja pemadatan ke atas permukaan tanah.

(2 markah)

(b) Bincangkan kepentingan pemadatan bergetar dalam penstabilan pasir dan tanah liat dari sudut :

(i) Proses yang terlibat

(ii) Kenaan tegasan pugak

(4 markah)

(c) Jika ketebalan yang diperlukan ialah 0.1 m, kelebaran 1.8 m, keberkesanan 75% dan kelajuan ialah 10 km/h.

Tentukan kadar pengeluaran untuk 12 larian.

(4 markah)

(d) UTHM terletak di atas mendakan tanah liat lembut setebal 10 m dan pra-bebanan serta saliran pugak ialah kaedah yang popular untuk pembaikan bagi tanah seperti itu.

Terangkan kaedah ini untuk cadangan tambakan yang akan dibina di dalam kawasan kampus.

Lakaran yang boleh membantu kepada penerangan anda adalah digalakkan.

(10 markah)

BAHAGIAN B

S3 (a) Terangkan ungkapan '*keupayaan galas muktamad'* tanah. Nyatakan bagaimana nilai keupayaan galas muktamad tanah untuk asas cetek untuk sesuatu jenis tanah boleh dikira dari ciri kekuatan tanah tersebut.

(5 markah)

(b) Sebuah asas segi empat sama berukuran 1.6m X 1.6m seperti yang ditunjukkan dalam **Rajah Q3 (b)**. Beban tiang ke atas tapak sebanyak 350 kN dikenakan. Berat tentu tanah ialah 18.50 kN/m^3 dan berat tentu konkrit ialah 24.5 kN/m^3. Tanah ialah jenis jelekit dan nilai kejelekitan ialah 160 kN/m^2.

Kirakan
(i) Tekanan sentuh tanah
(ii) Faktor keselamatan menentang kegagalan keupayaan galas.
(iii) Enapan disebabkan oleh pengukuhan primer untuk tanah liat terkukuh biasa.

(10 markah)

(c) Sebuah asas segiempat yang menanggung jumlah beban yang dibenarkan (termasuk penapak, tiang dan tanah kambus balik) sebanyak 160 kN. Kedalaman asas ialah 0.75 m dan beban condong pada sudut 15 darjah dari pugak seperti yang ditunjukkan dalam **Rajah Q3(c)**.

Andaikan panjang L asas sebagai 1.2B dan mengambil factor keselamatan 3.0, tentukan dimensi asas menggunakan persamaan keupayaan galas kaedah Meyerhof, gunakan **Jadual 1.**

(10 markah)

S4 (a) (i) Senaraikan **EMPAT (4)** faktor yang memberi kesan kepada taburan tekanan sisi ke atas tembok penahan.

(4 markah)

(ii) Terangkan 'tekanan sisi tanah keadaan pegun'.

(2 markah)

(b) Sebuah tembok julur diperlukan untuk menyokong kambusan pasir setinggi 5.5 m, dengan nilai $\phi' = 35^o$ and $\gamma - 21$ kN/m^3. Dengan menggunakan kaedah kestabilan ufuk sahaja, tentukan panjang cerucuk keping yang diperlukan untuk menahan tekanan pasif untuk mencapai faktor keselamatan 2.

(8 markah)

(c) Sebuah tembok konkrit graviti menahan kambusan kasar yang mempunyai parameter seperti berikut : (γ_b = 18 kN/m^3, c = 0 and $\phi' = 30^o$) seperti **Rajah Q4(c)**. Geseran tembok-tanah $\delta = 29^o$.

Diberi juga ialah berat tentu bahan tembok = 23.5 kN/m^3 dan keupayaan galas muktamad tanah dasar ialah 620 kN/m^2.

Nilaikan kestabilan tembok tersebut menentang keterbalikan dan gelangsaran. Kedua-dua factor keselamatan mesti >1.5.

Rumus : $$P_a = \frac{1}{2}\gamma H^2 \cos\beta \frac{\cos\beta - (\cos^2\beta - \cos^2\phi)^{1/2}}{\cos\beta + (\cos^2\beta - \cos^2\phi)^{1/2}}$$

(11 markah)

S5 (a) Terangkan dengan menggunakan kaedah Meyerhof untuk menilai kapasiti hujung, q_p untuk yang berikut :

(i) Tanah pasir (untuk unit SI sahaja)

(ii) Menggunakan nilai bacaan SPT.

(2 markah)

(b) Ujian beban statik secara tradisinya digunakan oleh jurutera asas untuk menyemak keupayaan galas cerucuk yang direkabentuk berdasarkan teori analisis.

Terangkan kriteria kegagalan beban muktamad cerucuk dengan mengenakan ujian beban statik.

(3 markah)

(c) Sebuah asas seberat 5 MN (termasuk tetopi cerucuk) terletak di atas 2 m tanah tambakan longgar seperti dalam **Rajah Q5(c).**

Paras air bawah tanah ialah pada 1 m dari permukaan.

Rekabentukkan susunan cerucuk dengan menggunakan cerucuk konkrit bersaiz 350 mm x 350mm dan panjang 24 m, untuk menanggung beban struktur berdasarkan beberapa andaian berikut :

- Kapasiti geseran tambakan longgar adalah diabaikan,
- Sistem kumpulan cerucuk perlu berdasarkan arahan yang dinyatakan dalam **Rajah Q5(c)(ii).**
- Keberkesanan kumpulan, $\eta = 0.7$
- Jarak minimum dari tepi ke pusat cerucuk = 2 D
- Jarak maximum untuk pusat ke pusat cerucuk = 3 D
- Keseluruhan asas hanya dikenakan beban pugak tanpa kesipian.

Diberi :-

$$Q_p = N_c^* c_u A_p = 9 c_u A_p \cdot \quad Q_s = \sum fp\Delta L = \sum \alpha c_u p \Delta L$$

Nilakan keupayaan galas muktamad, Q_{ult} untuk semua cerucuk berdasarkan rumus yang dberi.

(9 markah)

(d) Semak kawalan kestabilan dengan menggunakan kaedah '*conventional rigid*' jika asas cerucuk dikenakan beban pugak seperti di **Q5(c)** dan moment paksi y ialah 250 kN-m.

Diberi :-

$$Q_m = \frac{Q}{n} \pm \frac{M_y x}{\sum(x^2)} \pm \frac{M_x y}{\sum(y^2)}$$

(5 markah)

(e) Sebuah tetopi cerucuk 6P terletak bersebelahan dan dengan profil tanah yang sama seperti di **Q5(d).**

Kirakan enapan di tengah-tengah lapisan tanah liat keras dengan nilai $e_0 = 0.7$ dan $C_c = 0.2$.

(6 markah)

(f) Sebatang cerucuk konkrit yang bersaiz 250 mm x 250 mm telah di pacu kedalam tanah pasir pada lokasi yang salah dan perlu di cabut. Jika panjang cerucuk tersebut ialah 10m dan andaikan : $\gamma_{sand} = 14.5$ kN/m^3, $\emptyset_{sand} = 32°$, $D_r = 60\%$.

Kira : Kapasiti cabutan jika FS = 4.

Nota : kes ini **TIDAK** berkaitan dari kes (a) hingga (e).

(5 markah)

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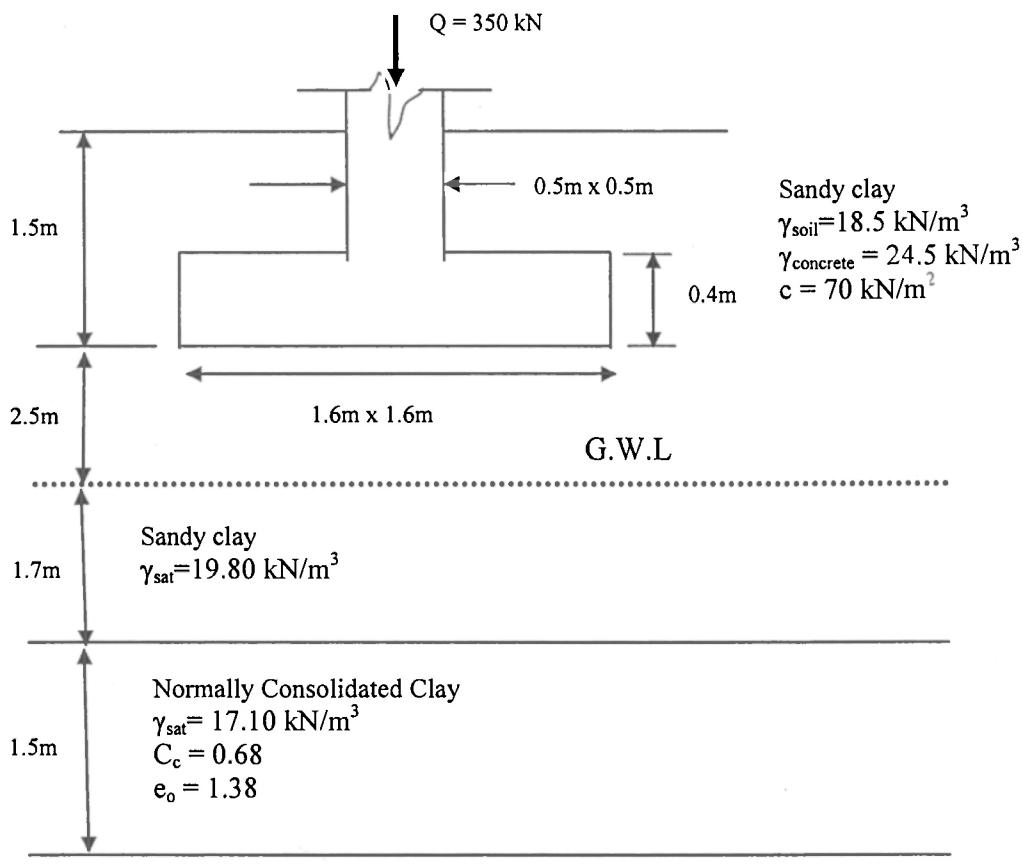

Figure Q3 (b) Shallow foundation

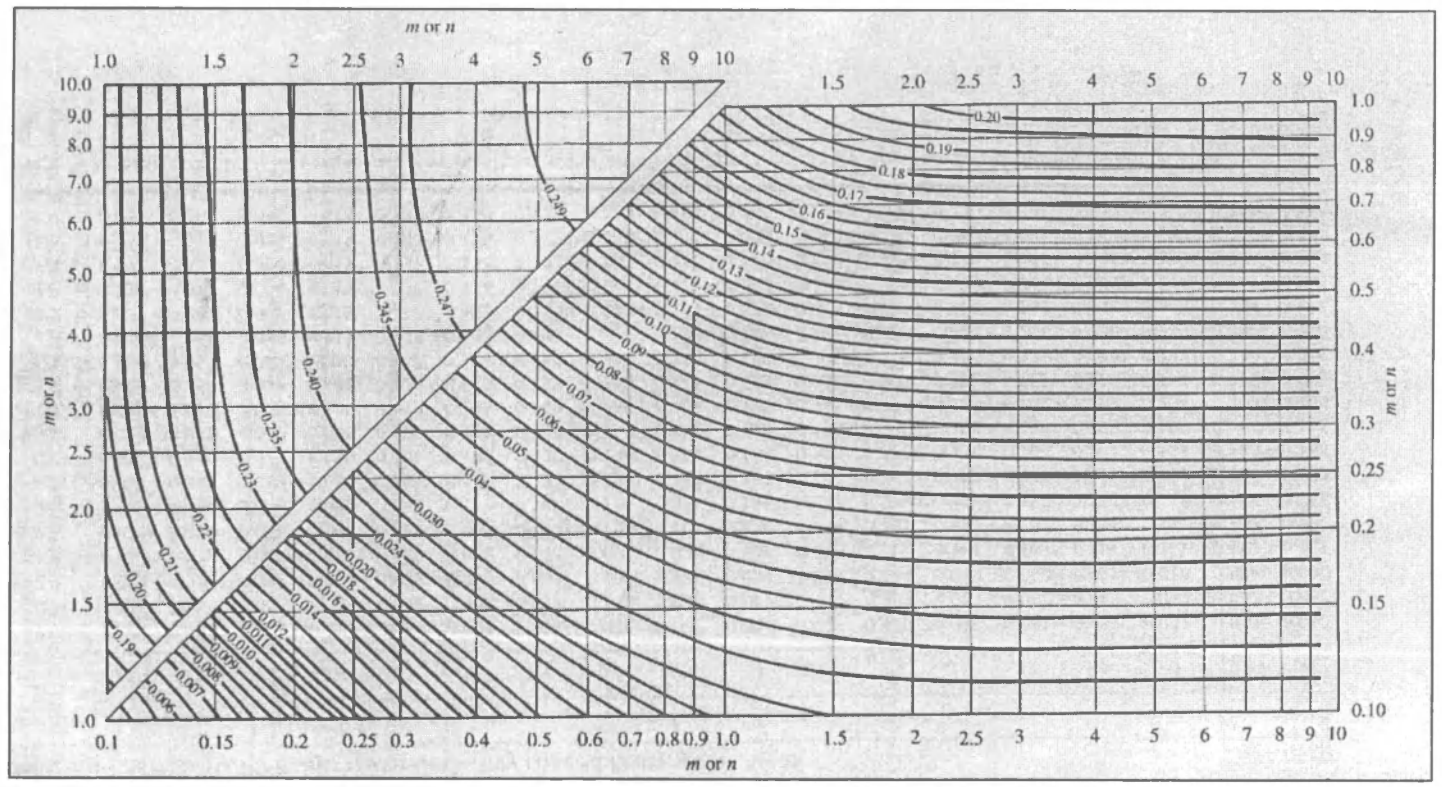

Figure Q3(b)(iii) Griffith's chart for the value of I_0

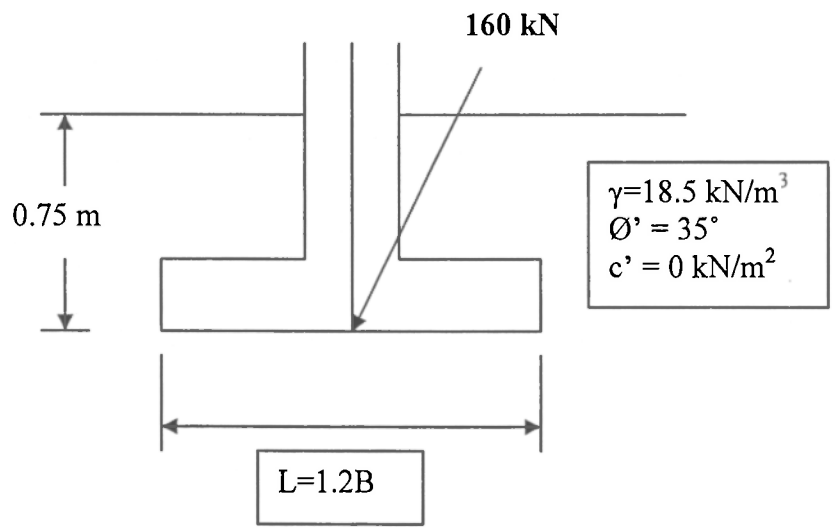

Figure Q3(c) Rectangular shallow foundation with inclined load

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Table 1 : 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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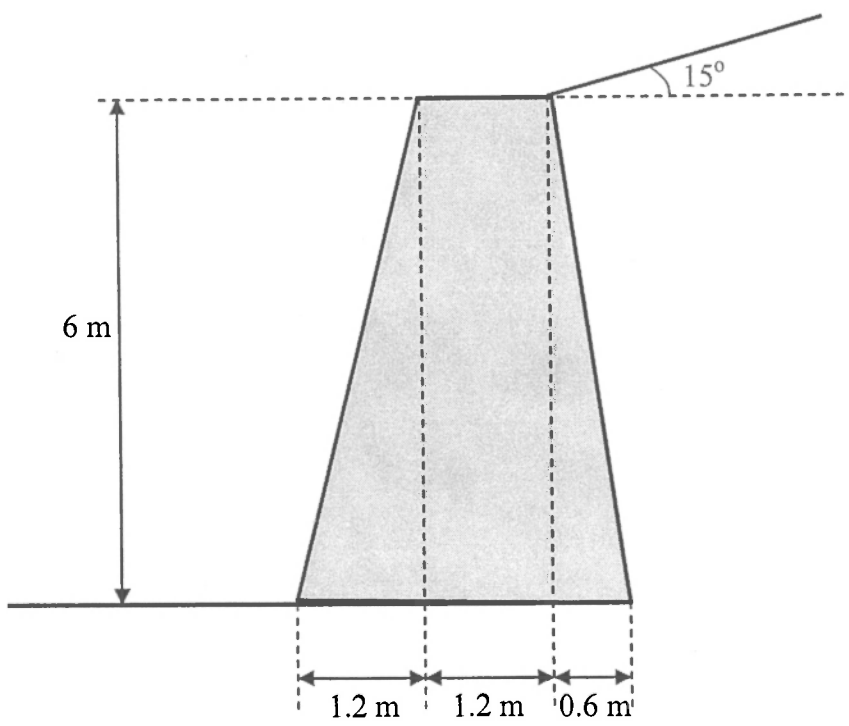

Figure Q4(c)

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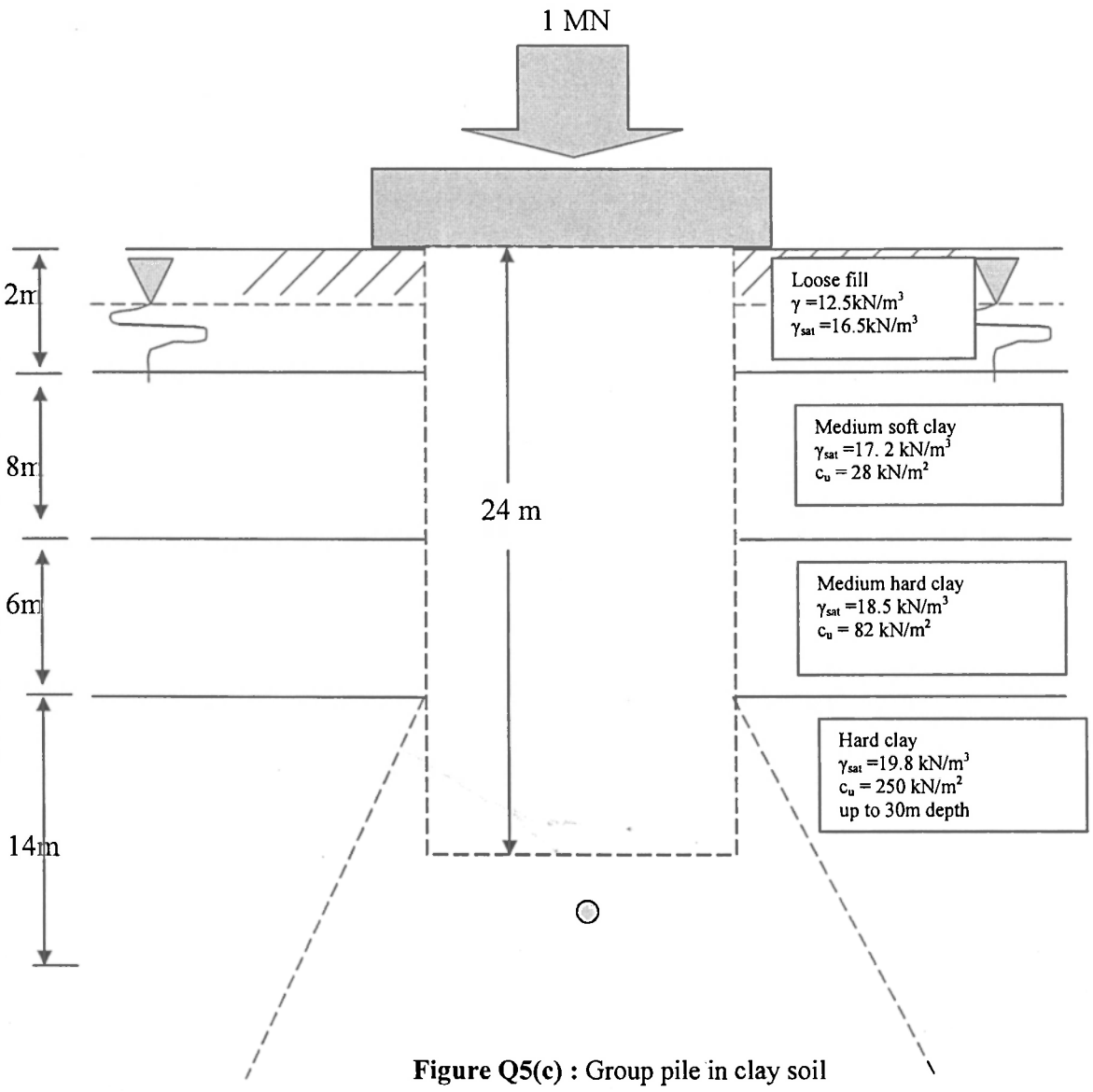

Figure Q5(c) : Group pile in clay soil

(Figure not to scale)

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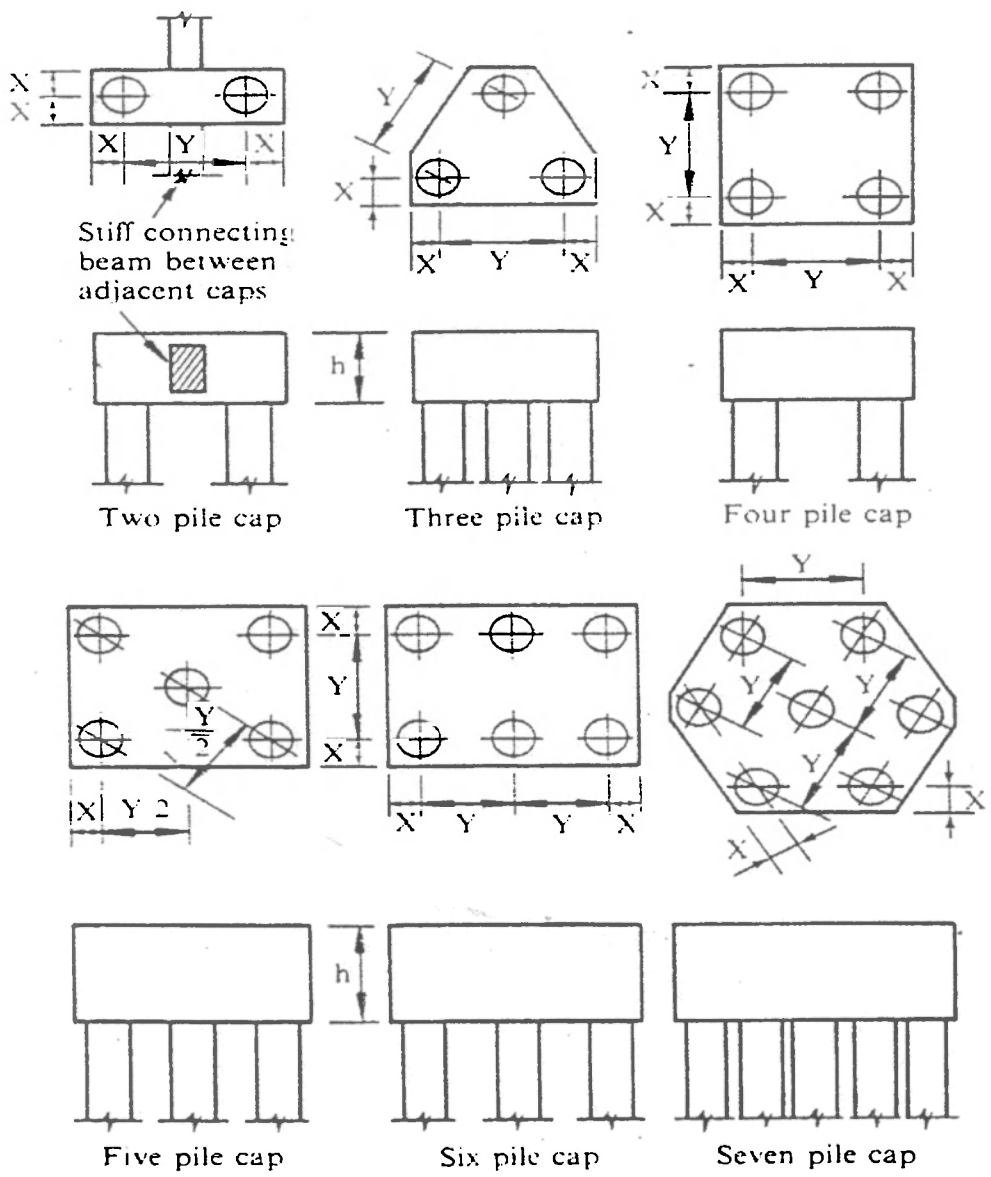

FIG. 13. Pile group systems

Figure Q5 (c)(i) Arrangement of pile in group

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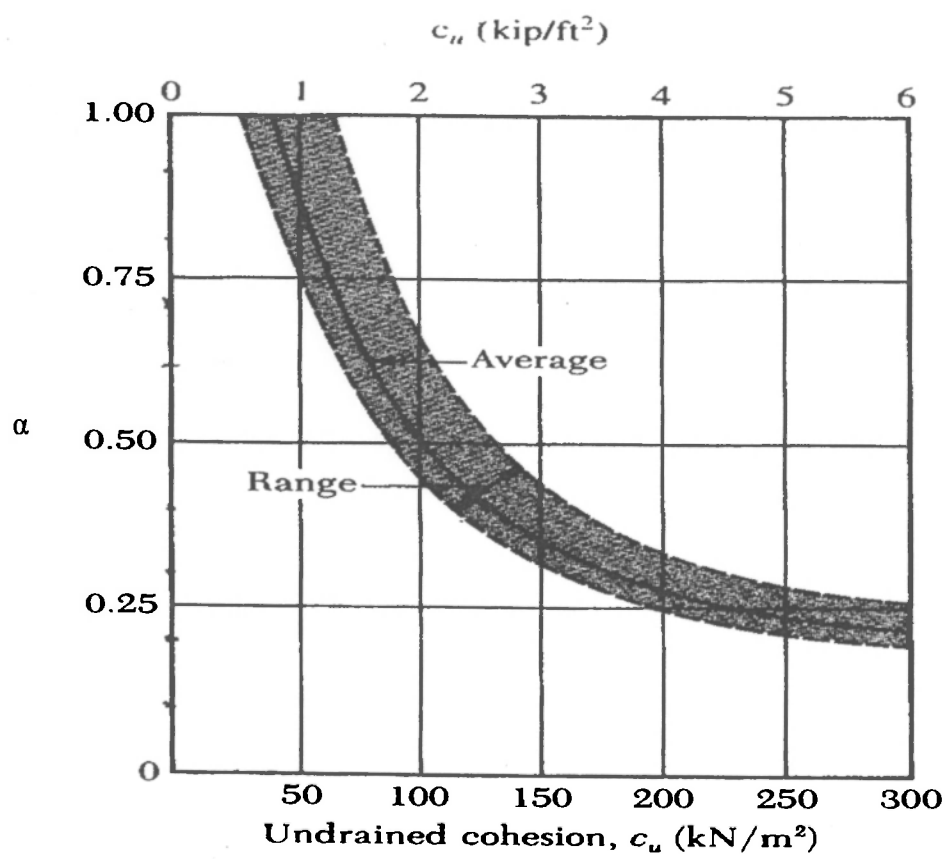

Figure Q5 (c)(ii) α Value

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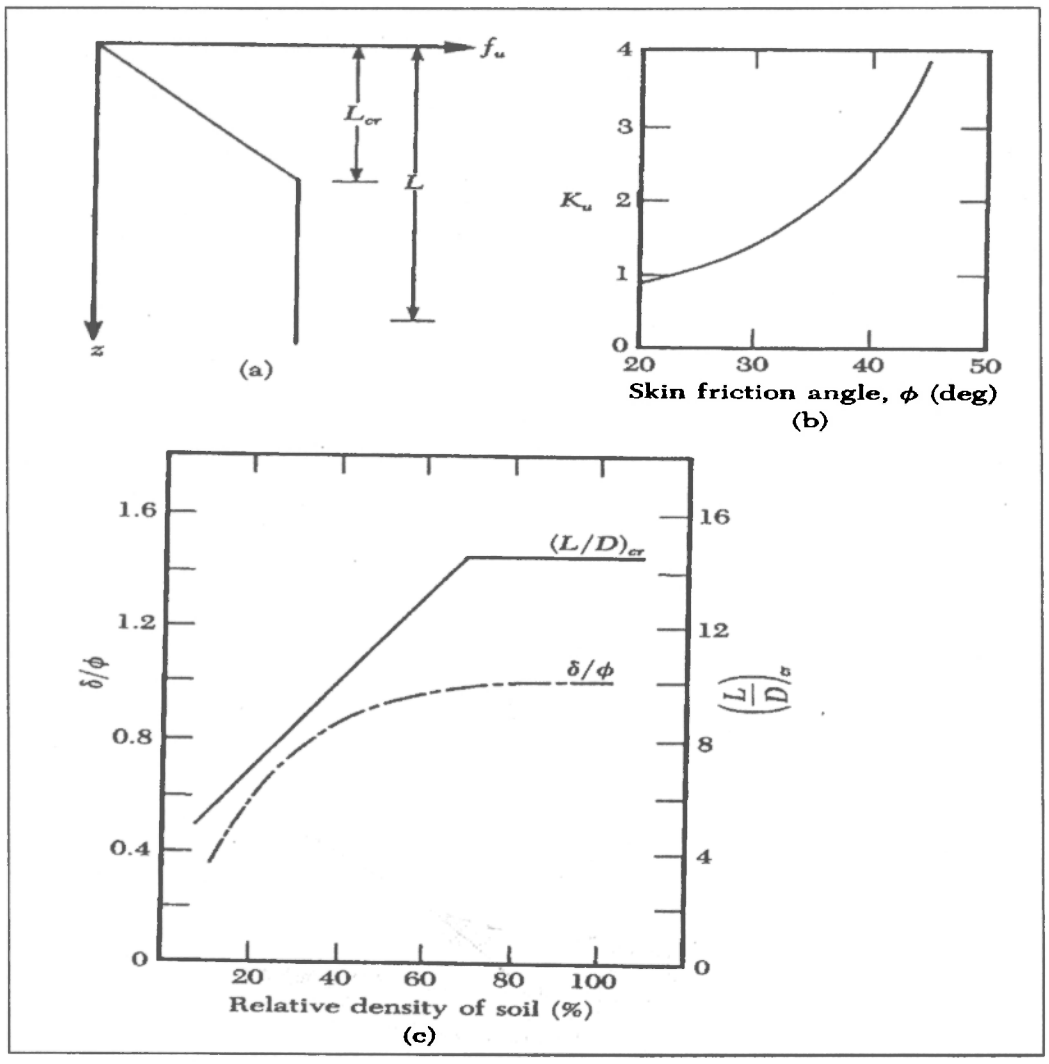

Figure Q5 (f) Value of K_u, $(L/D)_{cr}$ and $(\delta/\emptyset)$

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FORMULAE :

Q3 : $q_{ult} = c\,N_c + q\,N_q + 0.5\,\gamma\,B\,N_\gamma$; $q = \frac{Q}{A} \pm \frac{M_y x}{I_x} \pm \frac{M_x y}{I_y}$; $S_c = C_c\left(\frac{H}{1+e_0}\right)\log\frac{p}{p_0}$

$q_{ult} = q\,N_q\,F_{qs}\,F_{qd}\,F_{qi} + 0.5\,\gamma\,B\,N_\gamma\,F_{\gamma s}\,F_{\gamma d}\,F_{\gamma i}$; $F_{qs} = 1 + (B/L)\tan Ø'$;
$F_{qd} = 1 + 2\tan Ø'(1-\sin Ø')^2\,Df/B$; $F_{qi} = (1 - \beta/90)^2$; $F_{\gamma s} = 1 - 0.4(B/L)$; $F_{\gamma i} = (1 - \beta/Ø')^2$

Q4 : $P_a = \frac{1}{2}\gamma(H+d)^2 K_a$; $P_p = \frac{1}{2}\gamma d^2 K_p$; $P_a = \frac{1}{2}\gamma H^2 \cos\beta \frac{\cos\beta - (\cos^2\beta - \cos^2\phi)^{1/2}}{\cos\beta + (\cos^2\beta - \cos^2\phi)^{1/2}}$

$FS_{overturning} = \frac{M_r}{M_o}$; $FS_{sliding} = \frac{\tan\delta\,\Sigma V}{P_h}$

Q5 : $Q_p = N_c^* c_u A_p = 9c_u A_p$; $Q_s = \sum fp\Delta L = \sum \alpha c_u p \Delta L$; $Q_m = \frac{Q}{n} \pm \frac{M_y x}{\sum(x^2)} \pm \frac{M_x y}{\sum(y^2)}$;

$\Delta p_i = \frac{Q_g}{(B_g + z_i)(L_g + z_i)}$; $\Delta s_1 = \frac{C_{c(1)} H_1}{1 + e_{0(1)}} \log\left[\frac{p_{0(1)} + \Delta p_{(1)}}{p_{0(1)}}\right]$;

$T_{un} = \frac{1}{2} p\gamma L_{cr}^2 K_u \tan\delta + p\gamma L_{cr} K_u \tan\delta (L - L_{cr})$; $T_{u(all)} = \frac{T_{ug}}{FS}$