UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2010/2011

COURSE NAME	:	FOUNDATION ENGINEERING
COURSE CODE	:	BFC 4043
COURSE	:	4 BFF
EXAMINATION DATE	:	NOVEMBER / DECEMBER 2010
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER FOUR QUESTIONS: QUESTION **Q1** AND ANY OTHER **THREE (3)** QUESTIONS.

THIS PAPER CONSISTS OF (20) 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 **FOUR (4)** type of ground improvement.

(8 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 200,000m^3. The borrow material is a 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 19kN/m^3 at a water content of 17.5%.

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

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

(8 marks)

(c) A highway will be constructed over a soft marine clay deposit with high water content, associated with high settlement after construction. As an engineer, evaluate the benefits that will be gained by these **TWO (2)** options that listed below, as one only of the options will be chosen for soil improvement of the site.

(i) With or without preloading.

(ii) Preloading with or without vertical drains.

One should answer the question from the perspective of soil mechanics by illustration of relevant sketch.

(9 marks)

Q2. (a) 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.

Describe the various tests that can be carried out on the disturbed and undisturbed samples and the usage of the results in the design of geotechnical structures.

(8 marks)

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

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

(7 marks)

(c) **Table 2** shows the result of a seismic refraction field work of a proposed site for a building project.

Table 2: Result of a seismic refraction field survey

Distance from the point of impact (metres)	Time of first arrival of seismic wave (milliseconds)
2.5	10
5	24
7.5	34
10	42.
15	51
20	57
25	65
30	69
35	71
40	75
50	77

(i) Determine the seismic velocity and thickness of the materials encountered from the survey

(4 marks)

(ii) Referring to Figure **Q2(c)** , state the probable earth materials for the layers

(3 marks)

(iii) Express your opinion regarding the advantages and disadvantages of seismic refraction technique in the site investigation works.

(3 marks)

Q3. (a) For the footing shown in **Figure Q3(a)**, the vertical load including column load, surcharge weight and weight of footing is 600 kN. The horizontal load is 500 kN and a moment 67.5 kN.m is also imposed on the foundation. Determine:

(i) the soil pressure and draw the soil contact pressure diagram

(4 marks)

(ii) factor of safety against overturning

(3 marks)

(iii) factor of safety against sliding if the coefficient of friction between soil and the base of the footing is 0.60

(3 marks)

(iv) factor of safety against bearing capacity

(8 marks)

(b) Compute the ultimate bearing capacity of dense sand as shown in **Figure Q3(b):**

(i) water table at 1m depth

(2 marks)

(ii) water table at 3m depth

(2 marks)

(iii) water table at 10m depth

(2 marks)

(iv) comment to your answer

(1 marks)

Q4. (a)

(i) The most common function of piles is to transfer load that cannot be adequately supported at shallow depths to a depth where adequate support becomes available. Hence, piles can be categorized based on their functions.

Briefly describe with relevant sketches **FIVE (5)** functions of piles.

(5 marks)

(ii) Piles can also be classified according to their effects to soil due to their installation. Write short notes on the meaning of '*Displacement Pile*' and '*Non-displacement Pile*'. Give **ONE (1)** example of each class of pile.

(5 marks)

(b) A square 400mm x 400mm reinforced concrete pile 20 m long was driven through 6m of loose fill having unit weight of 13 kN/m^3 to penetrate into 14m of underlying stiff saturated clay having saturated unit weight of 17 kN/m^3. The ground water table was found at a depth of 2m below ground surface.

Determine the ultimate load capacity, Q_{ult}, of the pile if the undrained cohesion of the clay increases linearly with depth from 60 kN/m^2 at the top of the stiff clay to 120 kN/m^2 at a depth of 14m below the surface of the clay. The skin frictional capacity of the loose fill is negligible.

(10 marks)

(c) Assuming that it is necessary to provide a number of such piles to carry a greater foundation load at different location, with the help of relevant sketches explain how the load capacity of the pile group is determined.

(5 marks)

Q5. (a) Recently, reinforced earth commonly used in the construction and design of retaining wall.

Explain in detail why reinforced earth is more economical compare to conventional retaining wall.

(5 marks)

(b) Figure **Q5(b)** shows a braced cut system in sandy soil. The struts are spaced at 3 m center to center.

(i) Draw the earth pressure envelope

(3 marks)

(ii) Determine the struct loads at each level.

(6 marks)

(c) Determine the theoretical depth and actual depth for sheet pile wall as shown in Figure **Q5(c)**. Use $D_{actual} = 1.5\ D_{theory}$

(11 marks)

S1. (a) Pembaikan tanah adalah pengubahan keadaan, sifat semulajadi dan ciri tanah secara terkawal bagi memenuhi kehendak sesuatu projek yang sedia ada ataupun yang sedang dirancang.

Bincangkan **EMPAT (4)** jenis kaedah pembaikan tanah.

(8 markah)

(b) Suatu kerja penambakan tanah perlu dijalankan untuk sebuah projek perumahan di Parit Raja. Setelah siap, tambakan ini akan meliputi isipadu bersih sebanyak 200,000m^3. Tanah tambakan yang digunakan adalah tanah liat padat yang diimport daripada Air Hitam. Pada keadaan asal, tanah liat padat itu mempunyai berat unit pukal,γ_b bernilai 17kN/m^3, kandungan air (w %) 15%, dan nisbah lompang in-situ (e) setinggi 0.60. Tanah tambakan itu akan dipadatkan secara berlapisan di mana setiap lapisan adalah setebal 200mm, diletak secara longgar, dan dipadat kepada berat unit kering (γ_d) setinggi 19kN/m^3 dengan kandungan air setinggi 17.5%.

(i) Tentukan isipadu tanah yang perlu dikorek daripada Air Hitam dalam m^3.

(ii) Apakah nilai faktor pengecutan akibat daripada pemadatan?

(8 markah)

(c) Satu lebuhraya akan dibina melintas tanah liat marin yang lembut dan kandungan air yang tinggi, yang biasanya dijangka akan mengalami enapan yang besar selepas pembinaan. Sebagai seorang jurutera, nilaikan kebaikan yang boleh dicapai dengan menilai **DUA (2)** pilihan yang disenaraikan di bawah sebagai satu langkah untuk pembaikan tanah.

(i) Dengan prapembebanan atau tanpa prabebanan,

(ii) Prabeban dengan saliran tegak atau tanpa saliran tegak

Berikan pandangan anda dari aspek mekanik tanah dan geoteknik, penerangan hendaklah berserta lakaran yang bersesuaian.

(9 markah)

S2. (a) Dalam penyiasatan tapak konvensional menggunakan teknik 'wash boring', sample yang diperolehi dari berbagai kedalaman boleh dikelaskan sebagai terganggu dan tidak terganggu.

Huraikan berbagai ujian yang boleh dijalankan keatas sampel-sampel terganggu dan tidak terganggu serta kegunaan keputusan-keputusan ujian tersebut dalan rekabentuk struktur-struktur geoteknik

(8 markah)

(b) Ujian Penusukan Piawai (SPT) adalah ujian lazim di lapangan atau di tapak bina yang dijalankan di dalam lubang jara pada berbagai kedalaman.

Terangkan Ujian Penusukan Piawai , nyatakan alatan, proses, jenis keterangan yang boleh didapati serta contoh –contoh kegunaan keputusan ujian tersebut dalam rekabentuk struktur-struktur geoteknik.

(7 markah)

(c) **Jadual 2** menunjukan keputusan dari satu kerja lapangan pembiasan seismik di atas satu tapak cadangan sebuah projek bangunan.

Jadual 2: Keputusan pembiasan seismik

Distance from the point of impact (metres)	Time of first arrival of seismic wave (milliseconds)
2.5	10
5	24
7.5	34
10	42.
15	51
20	57
25	65
30	69
35	71
40	75
50	77

(i) Tentukan halaju seismik dan ketebalan lapisan bahan-bahan yang ditemui dari kerja tersebut.

(4 markah)

(ii) Dengan merujuk kepada Rajah **Q1**, nyatakan kemungkinan jenis bahan lapisan tersebut.

(3 markah)

(iii) Nyatakan pendapat anda mengenai kebaikan dan keburukan teknik pembiasaan seismik dalam kerja-kerja penyiasatan tapak.

(3 markah)

S3. (a) Sebuah papak sebagaimana Rajah **Q3(a)** menanggung beban pugak termasuk berat papak dan berat tanah tambak sebanyak 600 kN. Beban horizontal sebanyak 500 kN dan momen sebanyak 67.5 kN.m juga dikenakan pada papak ini. Tentukan:

(i) tekanan sentuh dan juga lakarkan rajah tekanan

(4 markah)

(ii) faktor keselamatan terhadap keterbalikan

(3 markah)

(iii) faktor keselamatan terhadap gelangsaran jika diberi pekali geseran antara tanah dan papak adalah 0.60

(3 markah)

(iv) faktor keselamatan terhadap keupayaan galas tanah.

(8 markah)

(b) Kirakan keupayaan galas muktamad bagi tanah pasir tumpat pada Rajah **Q3(b):**

(i) aras air bumi pada kedalaman 1 m

(2 markah)

(ii) aras air bumi pada kedalaman 3 m

(2 markah)

(iii) aras air bumi pada kedalaman 10 m

(2 markah)

(iv) berikan komen jawapan anda

(1 markah)

S4 (a)

(i) Fungsi utama cerucuk adalah memindahkan beban yang tidak dapat ditanggung pada kedalaman yang cetek kepada satu kedalaman yang mana sokongan yang cukup boleh diperolehi. Oleh itu, cerucuk boleh dikategori berdasarkan fungsi cerucuk.

Huraikan secara ringkas dengan berpandukan lakaran-lakaran yang sesuai **LIMA (5)** fungsi cerucuk.

(5 markah)

(ii) Cerucuk boleh juga dikelaskan sesuai dengan kesan pemasangan nya terhadap tanah sekeliling. Tuliskan nota pendek maksud 'cerucuk anjakan' dan 'cerucuk tak beranjakan'. Beri **SATU (1)** contoh setiap kelas cerucuk di atas.

(5 markah)

(b) Sebatang cerucuk konkrit bertetulang segiempat sama berukuran 400mm x 400mm serta panjangnya 20m telah dipacu menerusi tanah tambak yang longgar setebal 6m yang mempunyai nilai berat unit 13 kN/m³ menembusi tanah liat kukuh tepu sepenuhnya setebal 14m yang mempunyai nilai berat unit tepu 17 kN/m³. Aras air bumi ditemui berada pada kedalaman 2 m dari permukaan bumi.

Tentukan keupayaan beban muktamad ,Q_{ult}, cerucuk tersebut jika nilai kejelekitan tak tersalir tanah liat bertambah secara linear dengan kedalaman dari 60 kN/m² pada permukaan tanah liat kepada 120 kN/m² pada kedalaman 14m dibawah permukaan tanah liat. Keupayaan rintangan kulit tanah tambak longgar boleh diabaikan

(10 markah)

(c) Dengan andaian bahawa satu kumpulan cerucuk seperti di atas diperlukan untuk menanggung bebas yang lebih besar pada lokasi yang berbeza, terangkan dengan dibantu oleh lakaran yang sesuai, bagaimana keupayaan menanggung beban kumpulan cerucuk tersebut ditentukan.

(5 markah)

| **S5** (a) Pada masa kini, tanah bertetulang banyak digunakan dalam rekabentuk dan pembinaan tembok penahan

Jelaskan dengan terperinci kenapa tanah bertetulang lebih ekonomik berbanding tembok penahan konvensional.

(5 markah)

(b) Rajah **Q5(b)** menunjukkan sebuah tembok korekan berembat dalam tanah pasir. Penopang terletak sejauh 3 m pusat-ke-pusat.

(i) Lakarkan rajah tekanan

(3 markah)

(ii) Tentukan beban bagi setiap penopang

(6 markah)

(c) Kirakan kedalaman teoritikal dan kedalaman sebenar sebuah cerucuk keping sebagaimana Rajah **Q5(c)**. Diberi $D_{sebenar} = 1.5\ D_{teori}$

(11 markah)

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2010/2011 PROGRAMME : 4 BFF
COURSE : FOUNDATION ENGINEERING COURSE CODE : BFC 4043

Type of soils/rocks	Seismic velocity (m/sec)
SOIL	
Sand, dry silt, fine grained top soil	200-1000
Alluvium	500-2000
Compacted clay, clayey gravel, dense clayey sand	1000-2500
Loess	250-750
ROCK	
Slate and Shale	2500-5000
Sandstone	1500-5000
Granite	4000-6000
Sound Limestone	5000-10000

FIGURE Q2: Seismic velocity in various soils and rocks

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2010/2011 PROGRAMME : 4 BFF
COURSE : FOUNDATION ENGINEERING COURSE CODE : BFC 4043

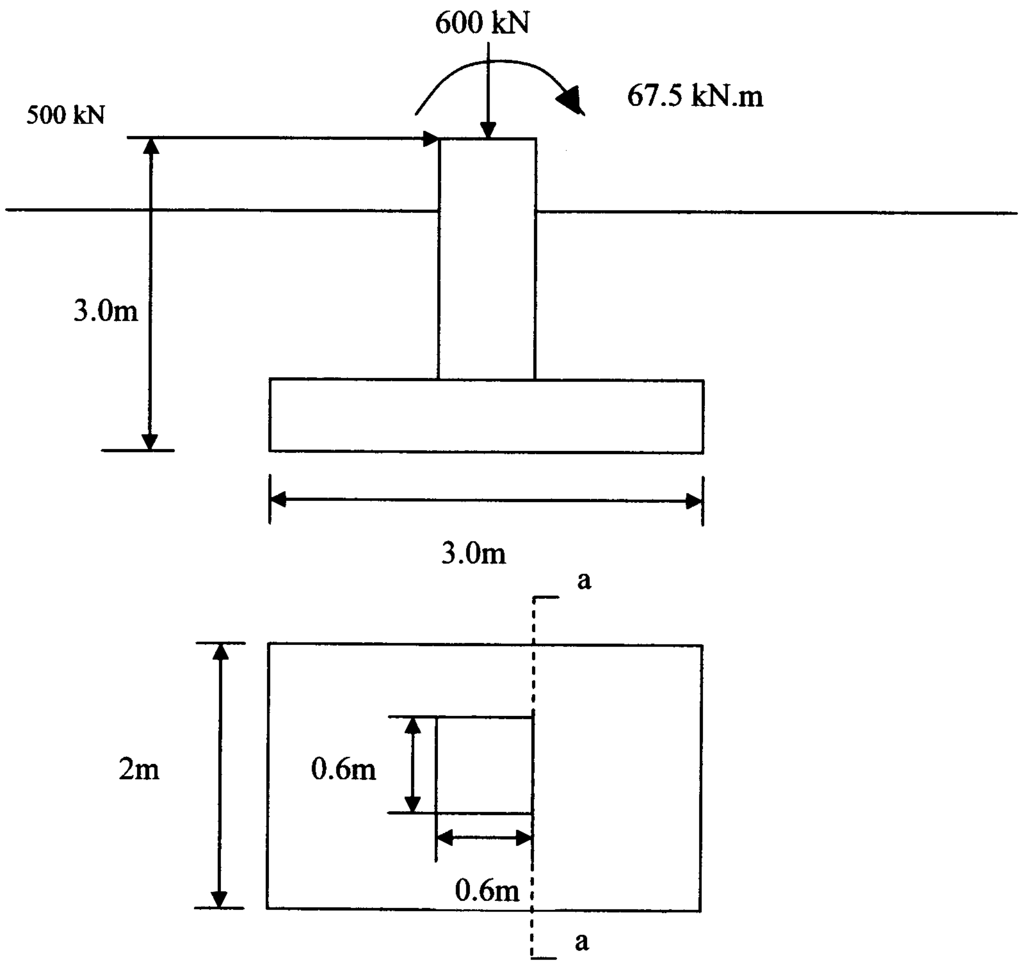


FIGURE Q3(a): Shallow foundation

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2010/2011 PROGRAMME : 4 BFF
COURSE : FOUNDATION ENGINEERING COURSE CODE : BFC 4043

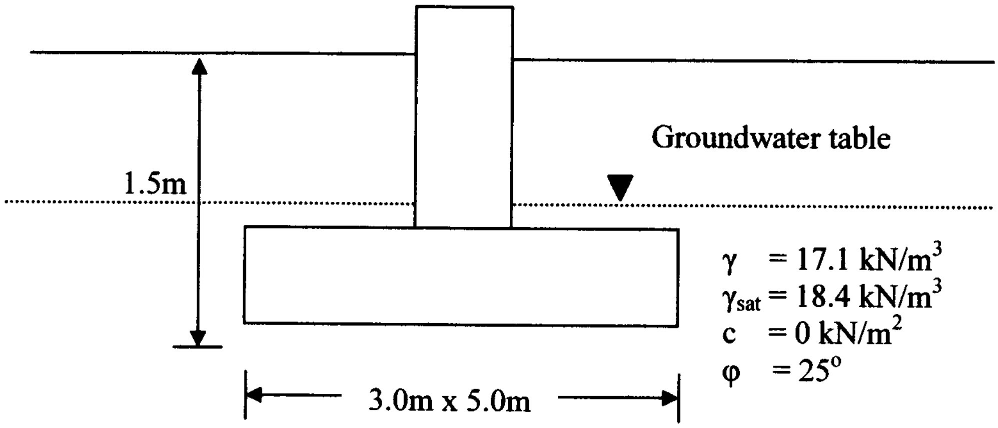


FIGURE Q3(b): Shallow foundation with ground water table

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2010/2011 PROGRAMME : 4 BFF
COURSE : FOUNDATION ENGINEERING COURSE CODE : BFC 4043

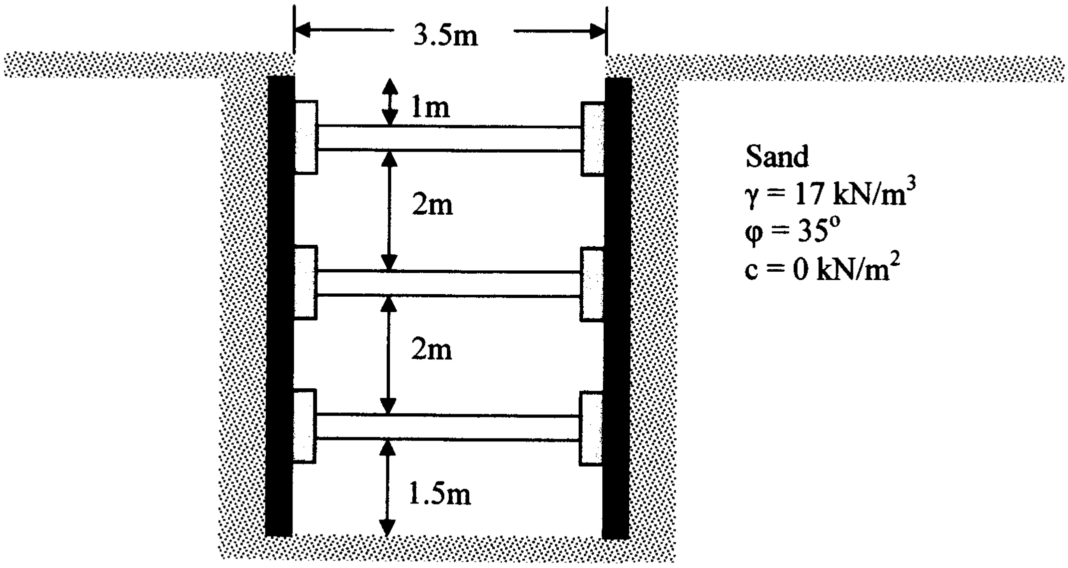


FIGURE Q5(b): Braced Cut in Sand

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2010/2011
PROGRAMME : 4 BFF
COURSE : FOUNDATION ENGINEERING
COURSE CODE : BFC 4043

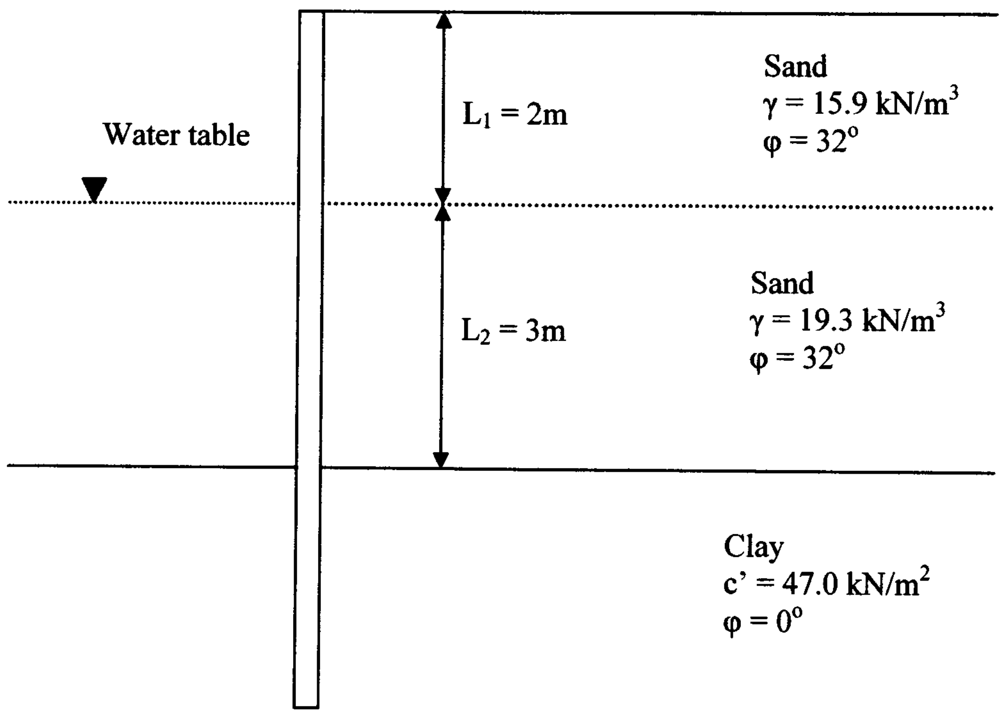


FIGURE Q5(c): Sheet pile retaining wall

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2010/2011 PROGRAMME : 4 BFF
COURSE : FOUNDATION ENGINEERING COURSE CODE : BFC 4043

Terzaghi's Bearing Capacity Factor

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				

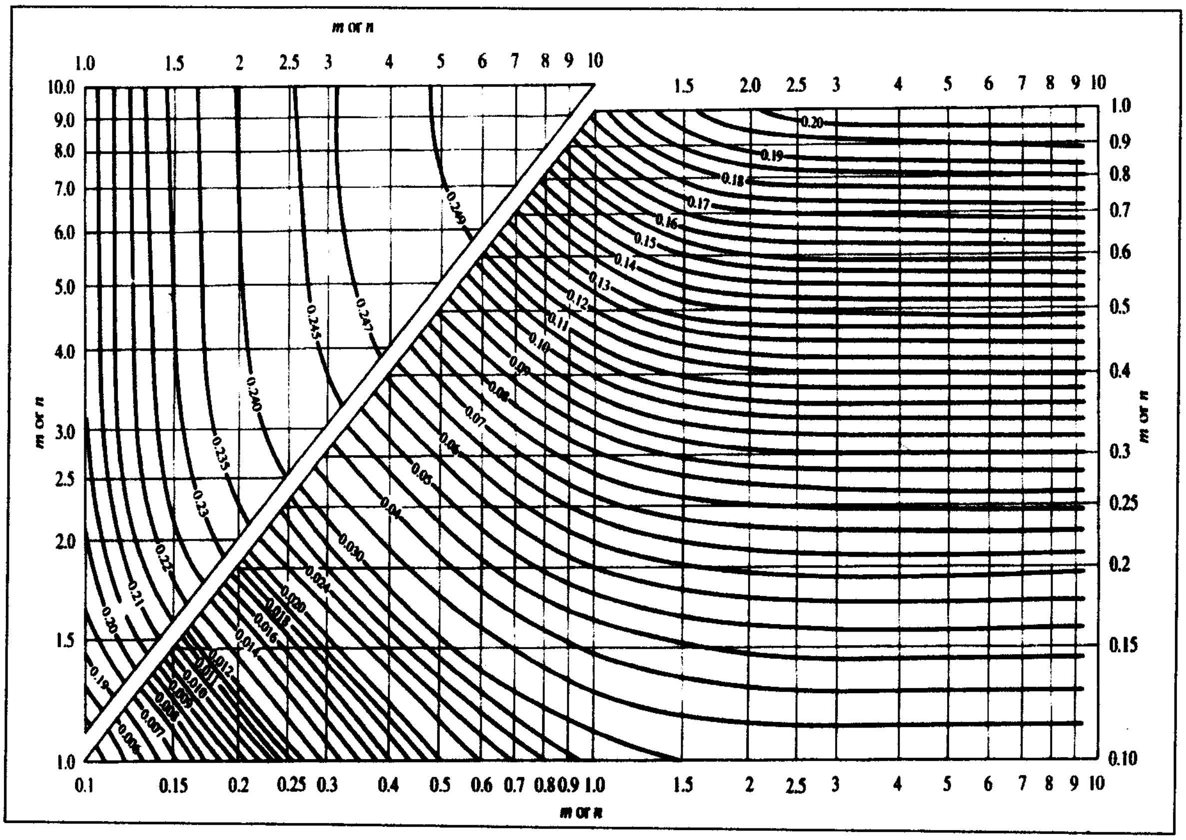
From Kumbhojkar (1993)

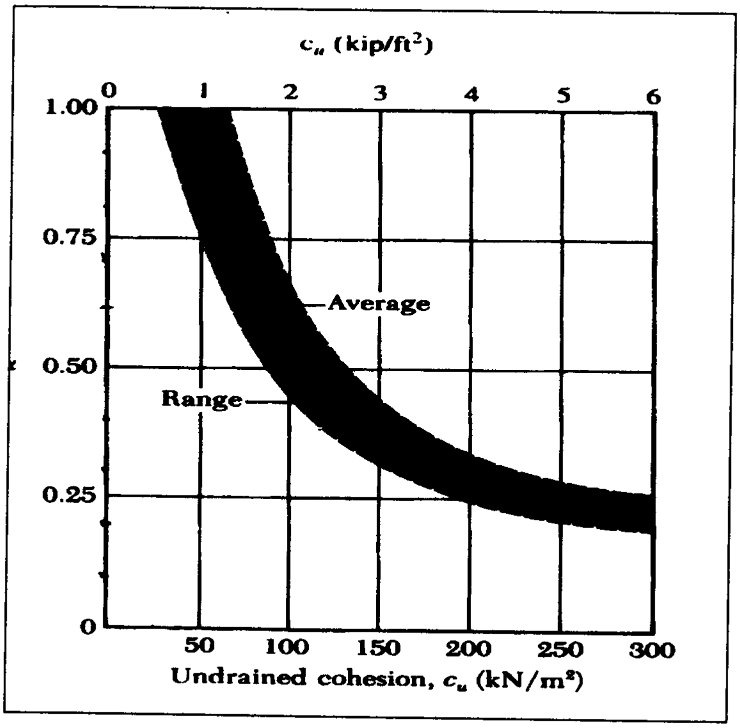
Meyerhof's Bearing Capacity Factor

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						

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2010/2011 PROGRAMME : 4 BFF
COURSE : FOUNDATION ENGINEERING COURSE CODE : BFC 4043





FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2010/2011 PROGRAMME : 4 BFF
COURSE : FOUNDATION ENGINEERING COURSE CODE : BFC 4043

Chapter 1

$$v = \sqrt{\frac{E}{\left(\frac{\gamma}{g}\right)} \frac{(1-\mu)}{(1-2\mu)(1+\mu)}} \qquad Z_1 = \frac{1}{2}\sqrt{\frac{v_2 - v_1}{v_2 + v_1}}x_c$$

$$z_2 = \frac{1}{2}\left[T_{i2} - 2Z_1 \frac{\sqrt{v_3^2 - v_1^2}}{v_3 v_1}\right]\frac{v_3 v_2}{\sqrt{v_3^2 - v_2^2}}$$

Chapter 2

$$q_u = \frac{2}{3}cN'_c + qN'_q + 0.5\gamma BN'_\gamma ....(strip.foundation)$$
$$q_u = 0.867cN'_c + qN'_q + 0.4\gamma BN'_\gamma ....(square.foundation)$$
$$q_u = 0.867cN'_c + qN'_q + 0.3\gamma BN'_\gamma ....(circular.foundation)$$

$$q_u = cN_c F_{cs} F_{cd} F_{ci} + qN_q F_{qs} F_{qd} F_{qi} + \frac{1}{2}\gamma BN_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma i}$$

$$F_{cs} = 1 + \frac{B}{L}\frac{N_q}{N_c} \qquad F_{qs} = 1 + \frac{B}{L}\tan\phi \qquad F_{\gamma s} = 1 - 0.4\frac{B}{L}$$

if $D_f/B \le 1$

$$F_{cd} = 1 + 0.4\frac{D_f}{B} \qquad F_{qd} = 1 + 2\tan\phi(1-\sin\phi)^2\frac{D_f}{B} \qquad F_{\gamma d} = 1$$

if $D_f/B > 1$

$$F_{cd} = 1 + (0.4)\tan^{-1}\left(\frac{D_f}{B}\right) \qquad F_{qd} = 1 + 2\tan\phi(1-\sin\phi)^2\tan^{-1}\left(\frac{D_f}{B}\right) \qquad F_{\gamma d} = 1$$

$$F_{ci} = F_{qi} = \left(1 - \frac{\beta^\circ}{90^\circ}\right)^2 \qquad F_{\gamma i} = \left(1 - \frac{\beta}{\phi}\right)^2 \qquad q = \frac{Q}{A} \pm \frac{M_x y}{I_x} \pm \frac{M_y x}{I_y}$$

Chapter 3

$$Q_u = Q_p + Q_s$$

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

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2010/2011 PROGRAMME : 4 BFF
COURSE : FOUNDATION ENGINEERING COURSE CODE : BFC 4043

Chapter 4

$K_a = \tan^2(45 - \phi/2)$ for the granular backfill

$p_1 = \gamma L_1 K_a$ and $p_2 = (\gamma L_1 + \gamma' L_2) K_a$

$P_1 = \frac{1}{2} p_1 L_1 + p_1 L_2 + \frac{1}{2}(p_2 - p_1) L_2$ and $\bar{z}_1 = \frac{\sum M_E}{P_1}$

1. (**use:** $D = \frac{-b \pm \sqrt{(b^2 - 4(a)(c))}}{2(a)}$)

$$D^2[4c - (\gamma L_1 + \gamma' L_2)] - 2DP_1 - \frac{P_1(P_1 + 12c\bar{z}_1)}{(\gamma L_1 + \gamma' L_2) + 2c} = 0$$

$$L_4 = \frac{D[4c - (\gamma L_1 + \gamma' L_2)] - P_1}{4c}$$

$p_6 = 4c - (\gamma L_1 + \gamma' L_2)$ and $p_7 = p_p - p_a = 4c + (\gamma L_1 + \gamma' L_2)$

$D_{actual} = 1.4 ... to ... 1.6D$

Chapter 5

Gallons = desired dry density pounds per cf (pcf)

$$\times \frac{\text{(desired water content \%)} - \text{(water content borrow \%)}}{100}$$

$$\times \frac{\text{compacted vol. of soil (cf)}}{\text{8.33 lb per gal}}$$ **[4.**

Gallons per square yard =

$$\text{desired dry density of soil (pcf)} \times \frac{\text{(\% moisture added or removed)}}{100}$$

$$\times \text{ lift thickness (ft) (compacted)} \times \frac{\text{9 sf/sy}}{\text{8.33 lb/gal}}$$ **[**