UNIVERSITI MALAYSIA PERLIS

Peperiksaan Akhir Semester Pertama
Sidang Akademik 2024/2025

Januari - Februari 2026

AMJ30104 – Geotechnical Engineering
[*Kejuruteraan Geoteknikal*]

Masa : 3 jam

Please make sure that this question paper has **FOURTEEN (14)** printed pages including this front page before you start the examination.
*[Sila pastikan kertas soalan ini mengandungi **EMPAT BELAS (14)** muka surat yang bercetak termasuk muka hadapan sebelum anda memulakan peperiksaan ini.]*

This question paper has **TWO (2)** sections, **SECTION A** and **SECTION B**. Answer **ALL** questions from **SECTION A** and any **ONE (1)** question from **SECTION B**. Each question contributes 20 marks.
*[Kertas soalan ini mengandungi **DUA (2)** bahagian, **BAHAGIAN A** dan **BAHAGIAN B**. Jawab **SEMUA** soalan daripada **BAHAGIAN A** dan mana-mana **SATU (1)** soalan dari **BAHAGIAN B**. Markah bagi tiap-tiap soalan adalah 20 markah.*

SECTION A: This section has **4** questions. Please answer **ALL** questions.
***BAHAGIAN A**: Bahagian ini mengandungi 4 soalan. Sila jawab **SEMUA** soalan.*

Question 1
[Soalan 1]

a) Site investigation refers to a systematic process of subsurface exploration involving drilling, sampling, in-situ testing and laboratory analysis to obtain reliable geotechnical data for safe, practical and economical design. Based on your knowledge in Geotechnical Engineering, explain how the objectives of a site investigation are applied to ensure safe and efficient construction planning.
[Penyiasatan tapak ialah proses sistematik penerokaan bawah permukaan yang merangkumi kerja penggerudian, pensampelan, ujian in-situ dan analisis makmal bagi memperoleh data geoteknik yang boleh dipercayai untuk reka bentuk yang selamat, praktikal dan ekonomik. Berdasarkan pengetahuan anda dalam Kejuruteraan Geoteknik, jelaskan bagaimana objektif penyiasatan tapak diaplikasikan untuk memastikan perancangan pembinaan yang selamat dan berkesan.]

(6 Marks/*Markah*)

b) A 1.7 m × 1.7 m foundation is designed to support an inclined load at 20° on soil with a cohesion of 5 kN/m² and an internal friction angle of 30°, as shown in Figure Q1. The foundation base is located at 1.2 m below the ground surface, and the groundwater table is at 0.7 m below the ground surface. The soil has a unit weight of 16.7 kN/m³ and a saturated unit weight of 18.0 kN/m³. Using Meyerhof's method with a factor of safety of 2.5, calculate the allowable bearing capacity, Q_{all} for this foundation.
[Sebuah asas berukuran 1.7 m × 1.7 m direkabentuk untuk menampung beban condong pada sudut 20° di atas tanah yang mempunyai kohesi 5 kN/m² dan sudut geseran dalaman 30°, seperti yang ditunjukkan dalam Rajah Q1. Tapak asas terletak pada 1.2 m di bawah permukaan tanah, manakala paras air bawah tanah berada pada kedalaman 0.7 m dari permukaan tanah. Tanah mempunyai berat unit sebanyak 16.7 kN/m³ dan berat unit tepu sebanyak 18.0 kN/m³. Gunakan kaedah Meyerhof dengan faktor keselamatan 2.5, kirakan beban galas yang dibenarkan, Q_{all} untuk asas ini.]

....3/-

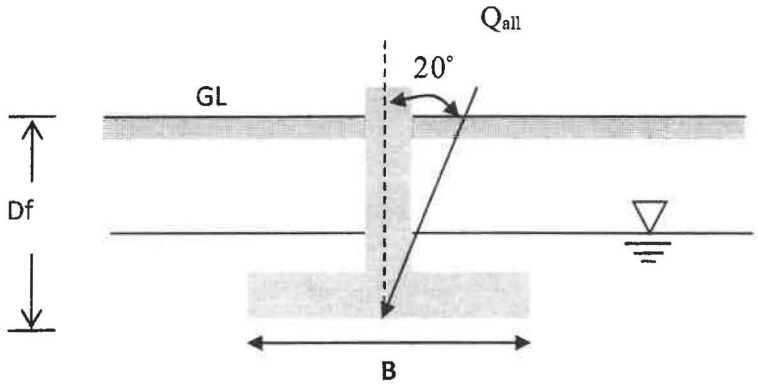

Figure Q1:A square foundation

[Rajah Q1: Asas segi empat]

(14 Marks/*Markah*)

Question 2
[Soalan 2]

A concrete pile with 0.5 m diameter is driven to a depth of 20 m below the ground surface in a medium dense sand layer. Given the unit weight for sand, $\gamma = 19$ kN/m^3; and soil friction angle, $\phi' = 32^o$.
[Cerucuk konkrit dengan diameter 0.5 m di pacu ke kedalaman 20 m di bawah permukaan tanah di lapisan berpasir separa kasar. Diberi berat unit bagi pasir, $\gamma = 19$ kN/m^3; dan sudut geseran tanah, $\phi' = 32^o$.]

a) Estimate the ultimate point, Q_p by using;
[Anggarkan titik muktamad, Q_p dengan menggunakan;]

i) Meyerhof's method
[Kaedah Meyerhof]

ii) Vesic's method. Use m = 350
[Kaedah Vesic. Guna m = 350]

iii) Coyle and Castello's method
[Kaedah Coyle dan Castello]

(12 Marks/ *Markah*)

b) Determine the frictional resistance, Q_s. Use K = 1.2 and $\delta' = 0.8\phi$.
[Tentukan rintangan geseran, Q_s. Guna K = 1.2 dan $\delta' = 0.8\phi$.]

(5 Marks/ *Markah*)

c) Based on the results of Q2a), adopt a relevant value for ultimate point in order to calculate the allowable bearing capacity, Q_{all} of the pile. Use FOS = 3.
[Berdasarkan keputusan di Q2a), gunapakai nilai yang munasabah bagi titik muktamad untuk mengira keupayaan galas cerucuk, Q_{all} yang dibenarkan. Guna FOS = 3]

(3 Marks/ *Markah*)

....5/-

Question 3
[Soalan 3]

a) A 5.5 m high retaining wall as shown in Figure Q3(a) has been proposed for a residential project which is an embankment area. As a geotechnical engineer, check the stability of the retaining wall against sliding and overturning.
[Sebuah tembok penahan setinggi 5.5 m seperti yang ditunjukkan dalam Rajah Q3(a) telah dicadangkan untuk sebuah projek kediaman yang merupakan kawasan timbunan. Sebagai seorang jurutera geoteknikal, periksa kestabilan tembok penahan terhadap kegelinciran dan keterbalikan.]

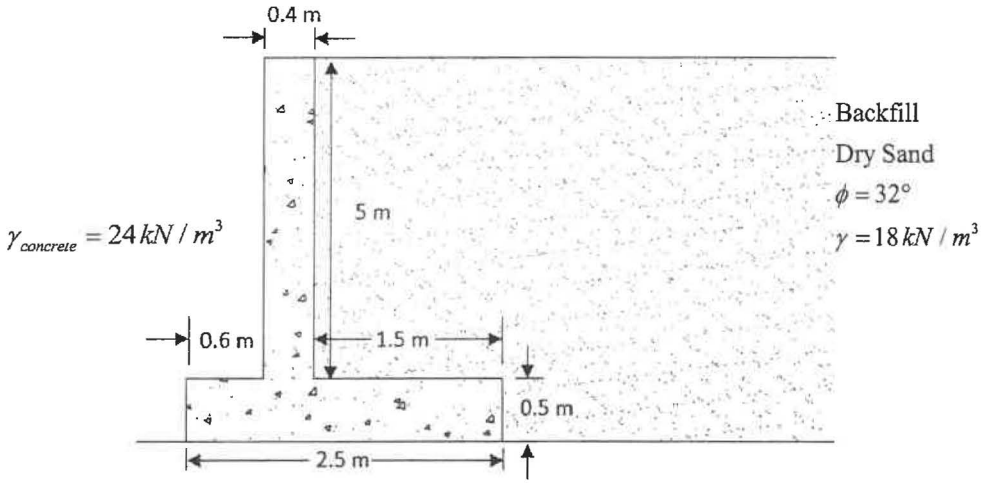

Figure Q3(a): Cross section of retaining wall
[Rajah Q3 (a): Keratan reantas tembok penahan]

(12 Marks/ *Markah*)

b) The properties of the soil retained behind a smooth retaining wall are shown in Figure Q3(b). Determine the total active earth thrust acting on the back of the wall using a pressure distribution diagram.
[Sifat-sifat tanah yang tersimpan di sebalik tembok penahan yang licin ditunjukkan dalam Rajah Q3(b) Tentukan jumlah tujahan tanah aktif yang bertindak di bahagian belakang tembok menggunakan gambarajah taburan tekanan.]

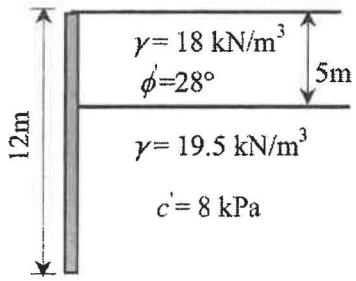

Figure Q3 (b): Soil profile
[Rajah Q3 (b): Profil tanah]

(8 Marks/ *Markah*)

....6/-

Question 4
[Soalan 4]

The pile foundation has been constructed in saturated clay as shown in Figure Q4. Diameter of the pile is 500 mm. The value of undrained cohesion, c_u and unit weight, γ for the clay are shown in the Figure Q4. The groundwater table is located at 3 m below the ground surface.
[Asas cerucuk telah dibina dalam tanah liat tepu seperti yang ditunjukkan dalam Rajah Q4. Diameter cerucuk adalah 500 mm. Nilai kohesi yang tidak tersalir, c_u dan berat unit, γ untuk tanah liat ditunjukkan dalam rajah di bawah. Aras air bawah tanah terletak di 3 m di bawah permukaan tanah.]

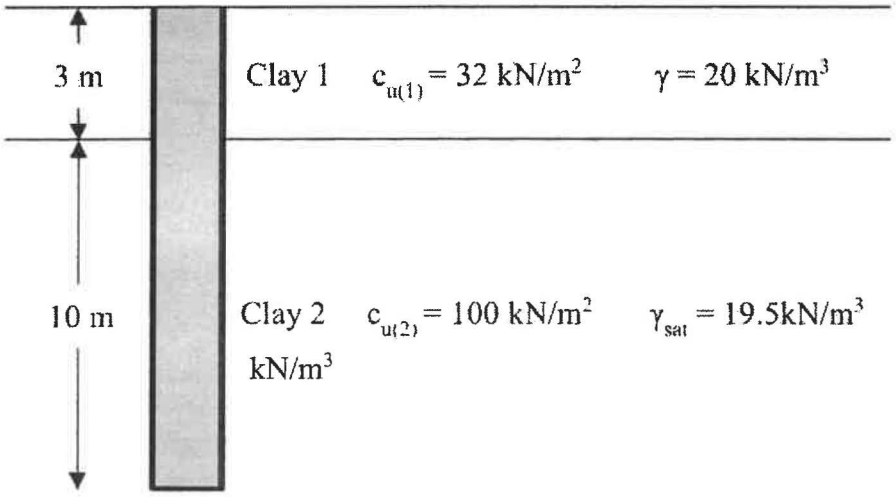

Figure Q4: Pile foundation embedded in saturated clay
[Rajah Q4: Asas cerucuk tertanama dalam tanah liat tepu]

a) Calculate the ultimate point load, Q_p by using Meyerhof's method and Janbu's method.
[Kirakan beban titik muktamad, Q_p dengan menggunakan kaedah Meyerhof dan kaedah Janbu.]

(10 Marks/ *Markah*)

b) Given that K = 1.2 and $\delta' = 0.6\varphi'$, determine the frictional resistance, Q_s.
[Diberi K = 1.2 dan $\delta' = 0.6\varphi'$, tentukan rintangan geseran, Q_s.]

(6 Marks/ *Markah*)

c) Based on your answer in Question 4(a) and (b), if Factor of Safety (FoS) is 3, design the allowable pile capacity, Q_{all}.
[Berdasarkan jawapan anda dalam Soalan 4(a) dan (b), jika Faktor Keselamatan (FoS) adalah 3, rekabentuk keupayaan galas cerucuk yang dibenarkan, Q_{all}]

(4 Marks/*Markah*)

SECTION B: This section has **2** questions. Please answer **ONE** question only.
***BAHAGIAN B**: Bahagian ini mengandungi 2 soalan. Sila jawab **SATU** soalan sahaja.*

Question 5
[Soalan 5]

Figure Q5 illustrates a square foundation with dimensions of 2 m × 2 m, placed at a foundation depth of 1.5 m. The supporting soil has a friction angle of 25° and cohesion of c = 80 kN/m². The dry unit weight and saturated unit weight of the soil are 17.5 kN/m³ and 18.5 kN/m³, respectively. A factor of safety of 3 is adopted. The groundwater table is located 0.6 m below the ground surface. By using Terzaghi's equation:
[Rajah 5 menunjukkan asas jenis petak berukuran 2 m × 2 m yang dibina pada kedalaman 1.5 m. Tanah sokongan mempunyai sudut geseran dalaman 25° dan nilai jelekitan c = 80 kN/m². Berat unit kering dan berat unit tepu tanah masing-masing ialah 17.5 kN/m³ dan 18.5 kN/m³. Faktor keselamatan yang digunakan ialah 3. Paras air bawah tanah berada pada kedalaman 0.6 m dari permukaan tanah. Dengan menggunakan persamaan Terzaghi:]

a) Calculate the safe allowable bearing capacity of the foundation
[Kirakan keupayaan galas dibenarkan asas].

(12 Marks/ *Markah*)

b) Calculate the safe gross allowable load of this foundation if there is no presence of groundwater.
[Kira beban benarkan kasar selamat bagi asas ini sekiranya tiada kehadiran air bawah tanah.]

(8 Marks/ *Markah*)

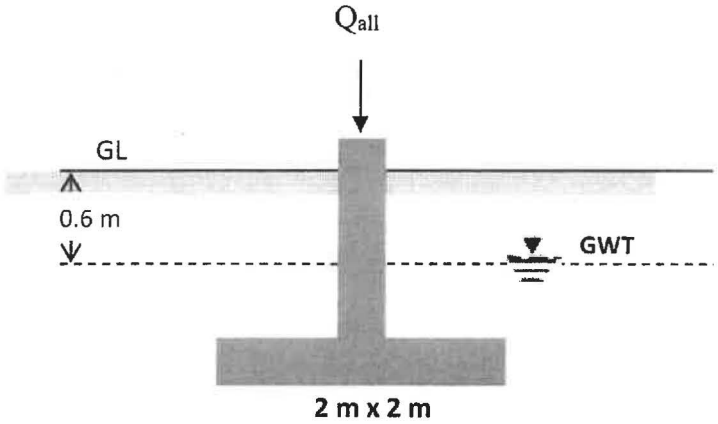

Figure Q5: A square foundation with dimensions of 2 m × 2 m
[Rajah 5: Asas segi empat dengan dimensi 2 m × 2 m]

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Question 6
[Soalan 6]

a) Climate change may lead to more precipitation, especially in Malaysia landscape. Give your comment on this factor (rainfall), as a cause of slope failure in Malaysia. Please include diagram in your explanation.
[Perubahan iklim boleh menyebabkan lebih banyak hujan, terutamanya bagi landskap Malaysia. Berikan komen anda terhadap faktor ini (hujan), sebagai penyebab terhadap kegagalan cerun di Malaysia. Sila sertakan gambar rajah dalam penjelasan anda.]

(6 Marks/ *Markah*)

b) For a given failure surface shown in Figure Q6. The unit weight for both soils 1 and 2 is 19 kN/m^3. For soil 1, the relevant shear strength parameters are c_u = 20 kN/m^2 and ϕ_u = 0 and for soil 2, c_u = 35 kN/m^2 and ϕ_u = 0.
[Untuk permukaan kegagalan tertentu yang ditunjukkan dalam Rajah Q6. Berat unit bagi kedua-dua tanah 1 dan 2 ialah 19 kN/m^3. Bagi tanah 1, parameter kekuatan ricih yang berkaitan ialah c_u = 20 kN/m^2 dan ϕ_u = 0 dan untuk tanah 2, c_u = 35 kN/m^2 dan ϕ_u = 0.

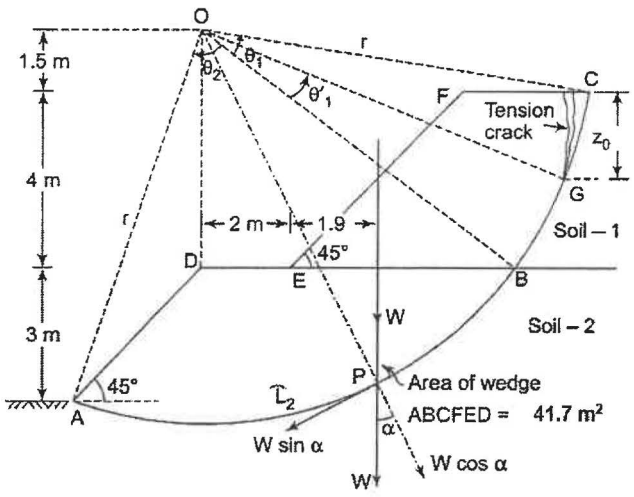

Figure Q6: Slope profile
[Rajah Q6: Profil cerun]

i. Determine the factor of safety FoS in terms of total stress.
*[Tentukan faktor keselamatan (*FoS*)dari segi jumlah tegasan.]*

(6 Marks/ *Markah*)

ii. For the same conditions as in Question 6(b)(i), calculate the factor of safety if tension crack fills with water.
[Untuk keadaan yang sama seperti dalam Soalan 6(b)(i), kirakan faktor keselamatan jika retak tegangan dipenuhi dengan air.]

(4 Marks/ *Markah*)

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iii. Comment on the safety factor derived from Questions 6(b)(i) and 6(b)(ii). Also, suggest a method that can be used to solve the problem of tension crack.
[Komen tentang faktor keselamatan yang diperoleh daripada berdasarkan Soalan 6(b)(i) dan 6(b)(ii). Juga, cadangkan kaedah yang boleh digunakan untuk menyelesaikan masalah retakan tegangan itu.]

(4 Marks/ *Markah*)

Appendices

$$q_{ult} = \frac{Q_{ult}}{BL} = cN_C + qN_q + \frac{1}{2}\gamma BN_\gamma$$

$$q_{ult} = 1.3cN_C + qN_q + 0.4\gamma BN_\gamma$$

$$q_{ult} = 1.3cN_C + qN_q + 0.3\gamma BN_\gamma$$

$$q_{ult} = \frac{Q}{BL} = cN_C s_c d_c i_c + qN_q s_q d_q i_q + \frac{1}{2}\gamma BN_\gamma s_\gamma d_\gamma i_\gamma$$

$$q_{all} = \frac{q_{ult}}{Fs}$$

$$q_{all} = \frac{Q_{all}}{Area}$$

$$c' = \frac{2}{3}c$$

$$\tan\phi' = \frac{2}{3}\tan\phi$$

$$s_c = 1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$$

$$s_q = 1 + \left(\frac{B}{L}\right)\tan\phi$$

$$s_\gamma = 1 - 0.4\left(\frac{B}{L}\right)$$

$$s_c = 1 + \left(\frac{N_q}{N_c}\right)$$

$$sq = 1 + \tan\phi$$

$$s_\gamma = 0.6$$

$$q = \gamma' D$$

$$\gamma' = \gamma_{sat} - \gamma_w$$

$$q = \gamma (Df - D) + \gamma' D$$

$$\gamma_{eq} = \gamma' + \frac{D}{B}(\gamma - \gamma') \quad (\text{For } D \le B)$$

$$\gamma_{eq} = \gamma \quad (\text{For } D > B)$$

$$d_c = 1 + 0.4\left(\frac{D_f}{B}\right)$$

$$d_q = 1 + 2\left(\frac{D_f}{B}\right)\tan\phi(1 - \sin\phi)^2$$

$$d_\gamma = 1$$

....11/-

$$d_c = 1 + 0.4 \tan^{-1}\left(\frac{D_f}{B}\right)$$

$$d_q = 1 + 2\tan\phi(1-\sin\phi)^2 \tan^{-1}\left(\frac{D_f}{B}\right)$$

$$d_\gamma = 1$$

$$Q_p = A_p q' N^*_q \leq A_p(0.5 p_a N^*_q \tan \emptyset')$$

$$Q_p = A_p \bar{\sigma'}_o N^*_\sigma$$

$$N^*_\sigma = f(I_{rr})$$

$$I_{rr} = \frac{I_r}{1 + I_r \Delta}$$

$$I_r = \frac{E_s}{2(1+\mu_s)q' \tan \emptyset'}$$

$$\Delta = 0.005\left(1 - \frac{\emptyset' - 25}{20}\right)\frac{q'}{p_a}$$

$$\mu_s = 0.1 + 0.3\left(\frac{\emptyset' - 25}{20}\right)$$

$$Q_s = \sum p \Delta L f$$

For $z = 0$ to L'

$$f = K\sigma'_o \tan \delta'$$

For $z = L'$ to L

$$f = f_{z=L'}$$

$$Q_u = Q_p + Q_s$$

$$Q_{all} = \frac{Q_u}{FOS}$$

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Table 16.1 Terzaghi's Bearing Capacity Factors N_c, N_q and N_γ Eqs. (16.3), (16.4), and (16.5)

ϕ' (deg)	N_c	N_q	N_γ	ϕ' (deg)	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 12.2 The values of N_c, N_q, and Meyerhof (M), Hansen (H) and Vesic (V) N_γ Factors

ϕ	N_c	N_q	N_γ (H)	N_γ (M)	N_γ (V)
0	5.14	1.0	0.0	0.0	0.0
5	6.49	1.6	0.1	0.1	0.4
10	8.34	2.5	0.4	0.4	1.2
15	10.97	3.9	1.2	1.1	2.6
20	14.83	6.4	2.9	2.9	5.4
25	20.71	10.7	6.8	6.8	10.9
26	22.25	11.8	7.9	8.0	12.5
28	25.79	14.7	10.9	11.2	16.7
30	30.13	18.4	15.1	15.7	22.4
32	35.47	23.2	20.8	22.0	30.2
34	42.14	29.4	28.7	31.1	41.0
36	50.55	37.7	40.0	44.4	56.2
38	61.31	48.9	56.1	64.0	77.9
40	72.25	64.1	79.4	93.6	109.4
45	133.73	134.7	200.5	262.3	271.3
50	266.50	318.50	567.4	871.7	762.84

Note: N_c and N_q are the same for all the three methods. Subscripts identify the author for N_γ.

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Table 11.5 Interpolated Values of N_q^* Based on Meyerhof's Theory

Soil friction angle, ϕ (deg)	N_q^*
20	12.4
21	13.8
22	15.5
23	17.9
24	21.4
25	26.0
26	29.5
27	34.0
28	39.7
29	46.5
30	56.7
31	68.2
32	81.0
33	96.0
34	115.0
35	143.0
36	168.0
37	194.0
38	231.0
39	276.0
40	346.0
41	420.0
42	525.0
43	650.0
44	780.0
45	930.0

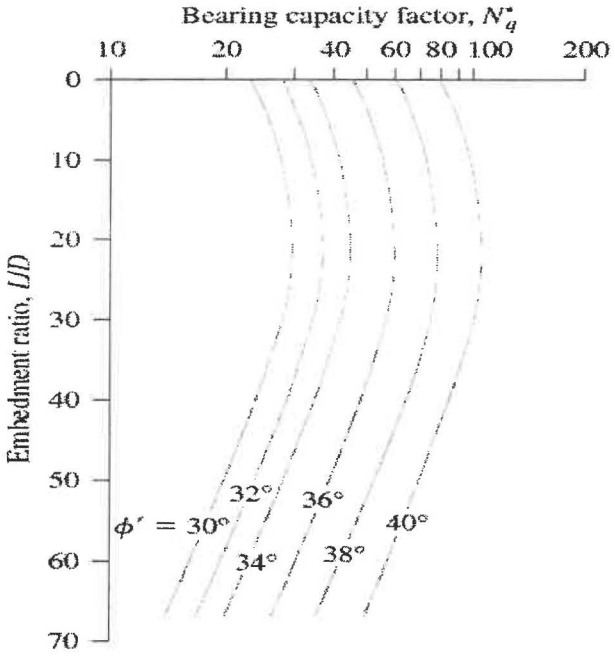

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Table 11.7 Bearing Capacity Factors N_σ^* Based on the Theory of Expansion of Cavities

	I_{rr}									
ϕ'	10	20	40	60	80	100	200	300	400	500
25	12.12	15.95	20.98	24.64	27.61	30.16	39.70	46.61	52.24	57.06
26	13.18	17.47	23.15	27.30	30.69	33.60	44.53	52.51	59.02	64.62
27	14.33	19.12	25.52	30.21	34.06	37.37	49.88	59.05	66.56	73.04
28	15.57	20.91	28.10	33.40	37.75	41.51	55.77	66.29	74.93	82.40
29	16.90	22.85	30.90	36.87	41.79	46.05	62.27	74.30	84.21	92.80
30	18.24	24.95	33.95	40.66	46.21	51.02	69.43	83.14	94.48	104.33
31	19.88	27.22	37.27	44.79	51.03	56.46	77.31	92.90	105.84	117.11
32	21.55	29.68	40.88	49.30	56.30	62.41	85.96	103.66	118.39	131.24
33	23.34	32.34	44.80	54.20	62.05	68.92	95.46	115.51	132.24	146.87
34	25.28	35.21	49.05	59.54	68.33	76.02	105.90	128.55	147.51	164.12
35	27.36	38.32	53.67	65.36	75.17	83.78	117.33	142.89	164.33	183.16
36	29.60	41.68	58.68	71.69	82.62	92.24	129.87	158.65	182.85	204.14
37	32.02	45.31	64.13	78.57	90.75	101.48	143.61	175.95	203.23	227.26
38	34.63	49.24	70.03	86.05	99.60	111.56	158.65	194.94	225.62	252.71
39	37.44	53.50	76.45	94.20	109.24	122.54	175.11	215.78	250.23	280.71
40	40.47	58.10	83.40	103.05	119.74	134.52	193.13	238.62	277.26	311.50
41	43.74	63.07	90.96	112.68	131.18	147.59	212.84	263.67	306.94	345.34
42	47.27	68.46	99.16	123.16	143.64	161.83	234.40	291.13	339.52	382.53
43	51.08	74.30	108.08	134.56	157.21	177.36	257.99	321.22	375.28	423.39
44	55.20	80.62	117.76	146.97	172.00	194.31	283.80	354.20	414.51	468.28
45	59.66	87.48	128.28	160.48	188.12	212.79	312.03	390.35	457.57	517.58

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