SULIT

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENGAJIAN POLITEKNIK
KEMENTERIAN PENDIDIKAN MALAYSIA

JABATAN KEJURUTERAAN AWAM

PEPERIKSAAN AKHIR

SESI 2 : 2016/2017

BCT 6033: FOUNDATION ENGINEERING

TARIKH : 07 JUN 2017
MASA : 9.00 AM – 12.00 PM (3 JAM)

Kertas ini mengandungi **SEPULUH (10)** halaman bercetak.
JAWAB SEMUA SOALAN
Dokumen sokongan yang disertakan : Kertas Graf, Formula

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

INSTRUCTION:

This section consists of **FOUR (4)** structured questions. Answer **ALL** questions.

ARAHAN :

Bahagian ini mengandungi ***EMPAT (4)*** *soalan berstruktur. Jawab* ***SEMUA*** *soalan.*

QUESTION 1

SOALAN 1

CLO2
C2

(a) With the help of sketches, describe the theories of :

i. Lateral earth pressure at rest

ii. Active earth pressure

iii. Passive earth pressure

Dengan berbantukan lakaran jelaskan teori-teori berikut:

i. Tekanan sisi tanah keadaan rehat

ii. Tekanan sisi tanah aktif

iii. Tekanan sisi tanah pasif

(5 marks)

(5markah)

CLO2
C3

(b) A retaining wall as shown in **Figure 1(b)** is required to retain soil. The unit weight of the soil is γ = 17 kN/m^3 and the shear strength parameter are, ϕ = 40^o and c = 35 kN/m^2. Water level is located far below the base of the wall. The friction angle at the base of the wall is 30^o. Calculate the stability of the wall against overturning, sliding and bearing capacity failure.

Tembok penahan seperti yang ditunjukkan dalam ***Rajah 1(b)*** *diperlukan untuk menyokong tanah. Berat unit tanah adalah γ = 17 kN/m^3 dan kekuatan ricih tanah adalah, ϕ= 40^o dan c=35kN/m^2. Paras air berada jauh di bawah permukaan dasar tembok. Sudut geseran di tapak tembok adalah 30^o. Kirakan kestabilan dinding penahan dalam aspek kegagalan terbalik, gelangsar dan kegagalan galas.*

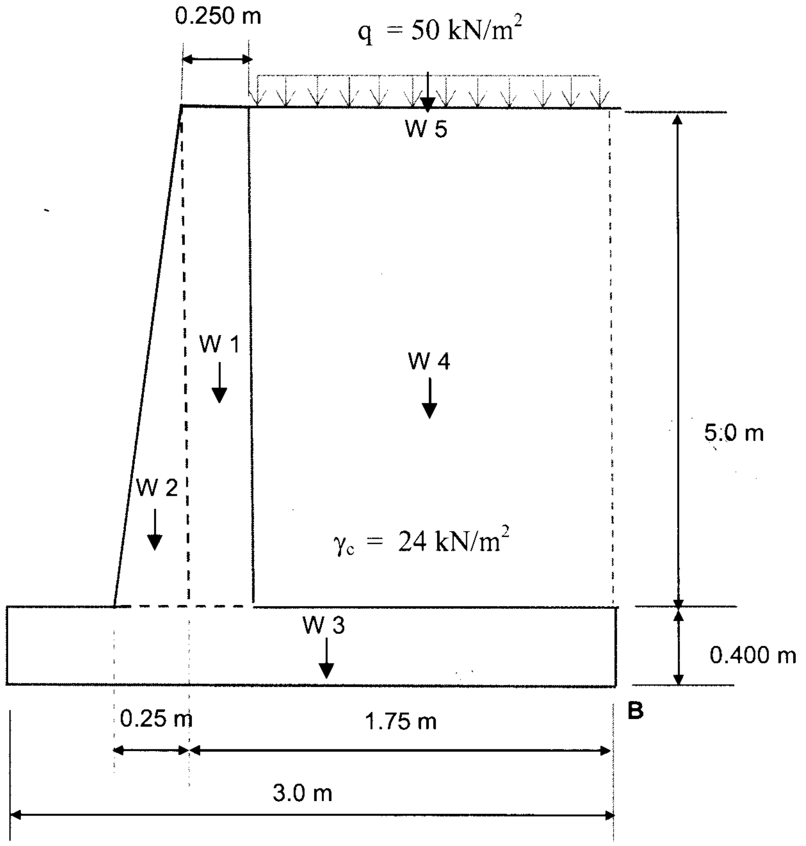


Figure 1(b)/***Rajah 1(b)***

[10 marks]
[*10 markah*]

CLO2
C4

(c) Recalculate the stability of analysis from **Figure 1(b)** by assuming the increment of the water level at the soil surface. Given sand saturated unit weight is 19 kN/m^3. Explain how the increments of ground water level affect the results.

Kira semula analisis kestabilan asas dari ***Rajah 1(b)*** *dengan menganggap kenaikan paras air pada permukaan tanah. Diberi unit berat tepu tanah pasir ialah 19 kN/m^3. Terangkan bagaimana peningkatan paras air boleh memberi kesan kepada keputusan tersebut.*

[10 marks]
[*10 markah*]

QUESTION 2

SOALAN 2

CLO2 C3

(a) With the help of sketches explain **THREE (3)** mode of shear failure for shallow foundation design.

*Dengan berbantukan lakaran terangkan **TIGA (3)** jenis mod kegagalan ricih dalam merekabentuk asas cetek.*

[5 *marks*]

[*5 markah*]

CLO2 C4

(b) A square foundation with a depth of 3 meter is located in granular soil with unit weight of 18 kN/m^3. The foundation is design to carry a 200 kN load with factor of safety of 3.0. Determine the size of foundation if the ground water table is located 1 meter below the ground level. Given :

$c' = 0$ $\phi = 35^o$ $\gamma_{sat} = 20$ kN/m^3

Sebuah asas segiempat sama berkedalaman 3.0 meter terletak di atas tanah berpasir dengan berat unit tentu 18 kN/m^3. Asas tersebut akan menanggung beban sebanyak 200 kN dengan faktor keselamatan sebanyak 3.0. Tentukan saiz asas tersebut sekiranya aras air bumi terletak pada kedalaman 1 meter di bawah permukaan tanah. Diberi :

$c' = 0$ $\phi = 35^o$ $\gamma_{sat} = 20$ kN/m^3

[10 marks]

[10 markah]

CLO2
C5

(c) A footing was proposed to be constructed in a layer of saturated clay as illustrated in **Figure 2(c).** Using the Terzaghi's bearing capacity equation with a safety factor is 3.0, estimate;

i. the net allowable load under total stress analysis assuming the ground water table is far below the ground surface.

ii. the net allowable load under effective stress analysis assuming the ground water table is at the ground surface.

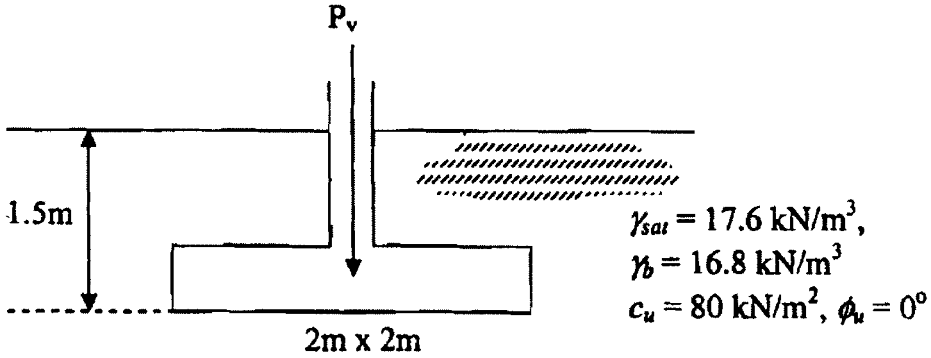
iii. the net ultimate bearing capacity if the water table is located 1 m below the ground surface.

Sebuah asas dicadangkan untuk dibina dalam lapisan tanah liat tepu seperti yang ditunjukkan dalam ***Rajah 2(c).*** *Menggunakan persamaan Terzaghi dengan faktor keselamatan 3.0, anggarkan;*

i. beban bersih dibenarkan menggunakan analisis tegasan jumlah dengan menganggap paras air tanah berada jauh di bawah permukaan tanah.

ii. beban bersih dibenarkan menggunakan analisis tegasan berkesan dengan menganggap kedudukkan paras air tanah berada pada permukaan tanah.

iii. keupayaan galas muktamad bersih apabila kedudukan paras air terletak 1 m di bawah permukaan tanah.



[10 marks]

[10 markah]

QUESTION 3

SOALAN 3

CLO2 C3

(a) A 45 cm diameter concrete pile is driven into a 12 m long dense cohesionless soil with a friction angle of 30°. The void ratio and specific gravity of the soil is 0.48 and 2.65 respectively. The water level is at the ground surface. Use Meyerhof's critical depth method to determine the allowable load with factor of safety 2.5.

Sebatang cerucuk konkrit berdiameter 45cm dipacu masuk kedalam tanah padat tidak berjelekit sepanjang 12 m dan mempunyai sudut geseran 30°. Nisbah lompang dan graviti tentu tanah masing-masing adalah 0.48 dan 2.65. Paras air berada pada permukaan tanah. Gunakan kaedah Meyerhof dengan kedalaman kritikal untuk menentukan beban yang dibenarkan dengan faktor keselamatan 2.5.

[5 marks]

[*5 markah*]

CLO2
C4

(b) **Figure 3(b)** shown a circular concrete pile of 35 cm diameter is driven to a depth of 5.0 m through a layered system of various soils. Determine allowable load if factor of safety is 2.5.

Rajah 3(b) *menunjukkan cerucuk konkrit berdiameter 35 cm dipacu pada kedalaman 5.0 m melalui pelbagai tanah yang berlapis. Tentukan beban yang dibenarkan jika faktor keselamatan 2.5.*

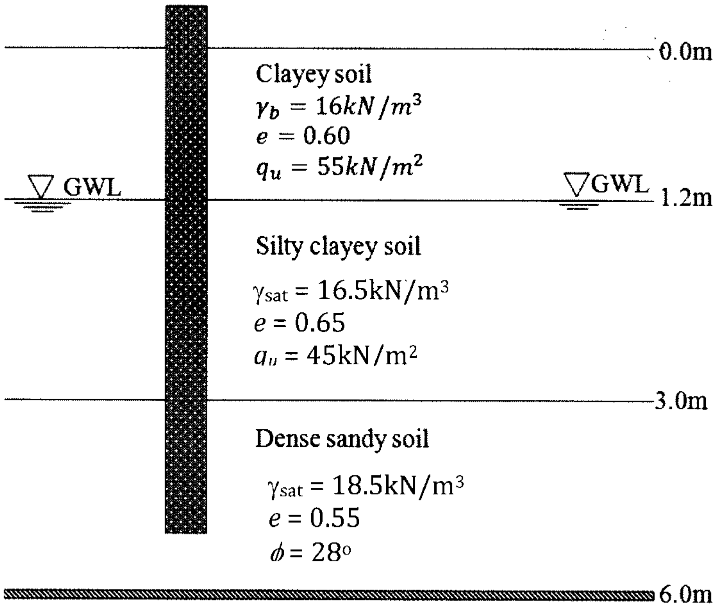


Figure 3(b)/ *Rajah 3(b)*

[10 marks]
[*10 markah*]

CLO2
C5

(c) A reinforced concrete pile of 330 mm diameter is driven into a dense sandy soil. The results of standard penetration test (SPT) in the sand are shown in **Table 3(c).** The pile is required to support a 688 kN design compressive load and to withstand a design uplift of 99.6 kN. Estimate the depth to which the pile must be driven with an overall load factor of 2.5.

*Sebatang cerucuk konkrit bertetulang berdiameter 330 mm dipacu ke dalam tanah pasir padat. Keputusan ujian tusukan piawai (SPT) pada tanah pasir adalah seperti **Jadual 3(c)**. Cerucuk diperlukan untuk menyokong beban rekabentuk mampatan sebanyak 688 kN dan menahan 99.6 kN rekabentuk bawah. Anggarkan kedalaman cerucuk yang diperlukan jika faktor beban keseluruhan adalah 2.5.*

Table 3(c)/*Jadual 3(c)*

Depth (m) *Kedalaman (m)*	0.35	0.70	1.85	2.70	4.40	6.00	7.50
N- Value *Nilai N*	7	15	26	38	50	62	75

[10 marks]
[10 markah]

QUESTION 4
SOALAN 4

CLO2
C3

(a) A group of 4 piles with 2 piles in a row is driven into a soft clay. The diameter and the length of the piles is 35 cm and 12 m respectively. The unconfined compressive strength of the clay is 60 kPa. If the piles are placed 100 cm center to center, calculate the allowable load on the pile group based on a shear failure criterion if the factor of safety 2.5.

Sekumpulan 4 batang cerucuk dengan 2 batang cerucuk dalam sebaris dipacu ke dalam tanah liat lembut. Diameter dan panjang cerucuk masing-masing 35 cm dan 12 m. Kekuatan mampatan tak terkurung tanah liat ialah 60 kPa. Jika cerucuk diletakkan 100 cm dari pusat ke pusat, kira beban yang dibenarkan ke atas kumpulan cerucuk berdasarkan kriteria kegagalan ricih jika faktor keselamatan adalah 2.5.

[10 marks]
[10 markah]

CLO2
C4

(b) A group pile in clay is shown in **Figure 4(b).** Determine the consolidation settlement of the piles. Determine the consolidation settlement of the group pile foundation if the total load imposed on the foundation is 2500 kN.

Satu cerucuk kumpulan dalam tanah liat ditunjukkan seperti ***Rajah 4(b).*** *Tentukan enapan pengukuhan cerucuk kumpulan jika jumlah beban yang dikenakan ke atas asas adalah 2500 kN.*

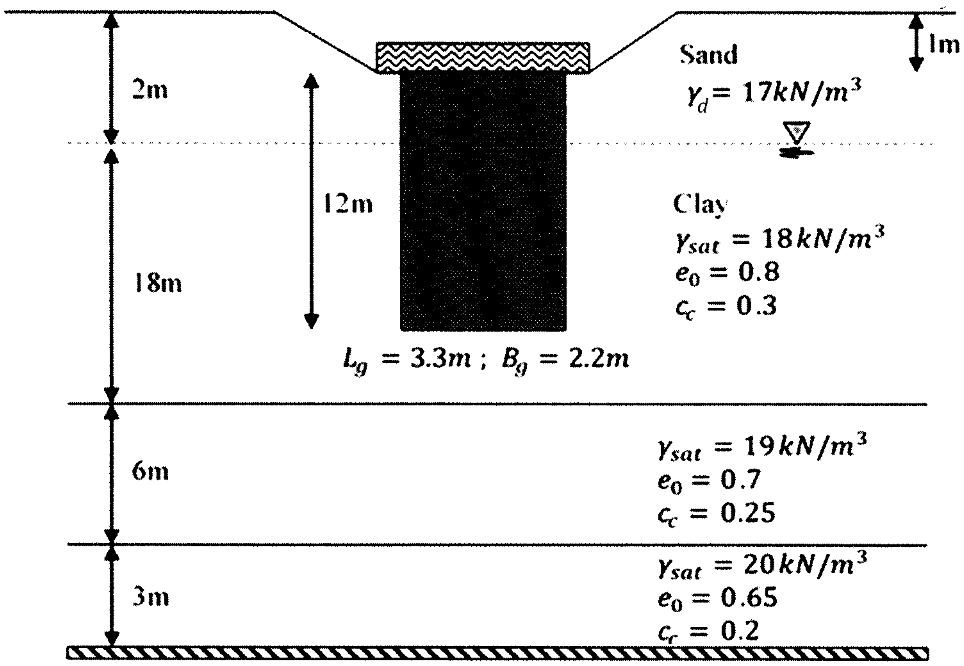


Figure 4(b)/ ***Rajah 4(b)***

[10 marks]
[10 markah]

CLO2
C5

(c) A precast concrete pile (40 cm x 40 cm) is driven by a single acting steam hammer. Estimate the allowable load using Hiley formula if the safety factor is 4.0.

Use following data:

Maximum rate energy	= 3400 kN/cm
Weight of hammer	= 37 kN
Length of pile	= 15 m
Efficiency of hammer	= 0.8
Coefficient of resistitution	= 0.5
Weight of pile cap	= 3 kN
No. of blows for last 25.4 mm	= 8
Modulus of elasticity of concrete	= 2×10^7 kN/m^2

Assume any other data if required. Take the weight of pile as 83.5 kN.

Sebatang cerucuk konkrit pratuang (40 cm x 40 cm) dipacu menggunakan penukul stim tindakan tunggal. Anggarkan beban yang dibenarkan menggunakan formula Hiley jika faktor keselamatan adalah 4.0.

Menggunakan data yang berikut:

Kadar tenaga maksimum	*= 3400 kN/cm*
Berat penukul	*= 37 kN*
Panjang cerucuk	*= 15 m*
Kadar kecekapan penukul	*= 0.8*
Pekali pengembalian	*= 0.5*
Berat topi cerucuk	*= 3 kN*
No. hentakan terakhir pada 25.4 mm	*= 8*
Modulus keanjalan konkrit	*= 2×10^7 kN/m^2*

Anggarkan sebarang data jika diperlukan. Ambil berat cerucuk 83.5 kN.

[5 marks]
[*5 markah*]

LAMPIRAN

FORMULA

$$\rho_b = \frac{Gs + S_r e}{1+e}\gamma_w \qquad \rho_d = \frac{\rho b}{1+w} \qquad \gamma_d = \frac{G_s\gamma_w}{\left(1+\frac{\omega G_s}{Sr}\right)} \qquad \gamma_d = \frac{Gs\gamma_w}{1+e}$$

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} \qquad K_p = \frac{1+\sin\phi}{1-\sin\phi} \qquad K_a = \tan^2\left(45^\circ - \frac{\phi}{2}\right) \qquad K_p = \tan^2\left(45^\circ + \frac{\phi}{2}\right)$$

$$K_a = \cos\beta \cdot \frac{\cos\beta - \sqrt{(\cos^2\beta - \cos^2\phi)}}{\cos\beta + \sqrt{(\cos^2\beta - \cos^2\phi)}} \qquad K_p = \cos\beta \cdot \frac{\cos\beta + \sqrt{(\cos^2\beta - \cos^2\phi)}}{\cos\beta - \sqrt{(\cos^2\beta - \cos^2\phi)}}$$

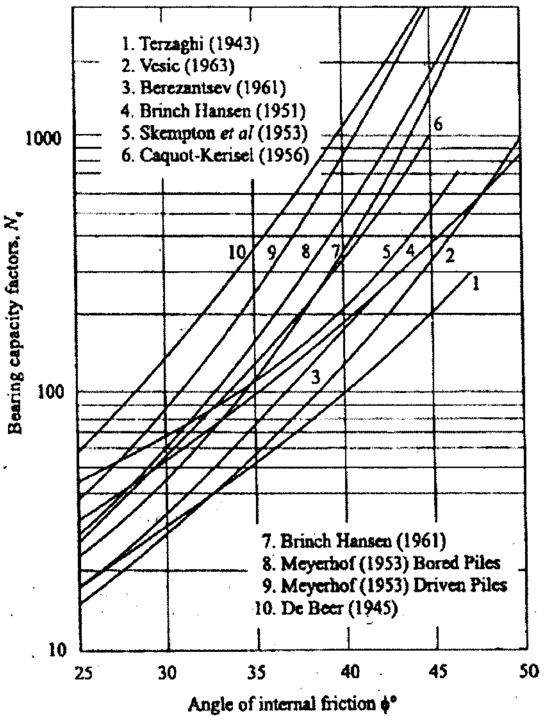
$$K_a = \frac{\sin^2(\alpha+\phi)\cos\delta}{\sin\alpha\sin(\alpha-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\beta)}{\sin(\alpha-\delta)\sin\alpha+\beta)}}\right]^2} \qquad K_a = \left[\frac{\sin\phi}{1+\sqrt{\frac{\sin(\phi+\delta)\sin\phi}{\cos\delta}}}\right]^2$$

$$q_u = c'N_c + qN_q + 0.5\gamma BN_\gamma$$

$$P_a = \frac{1}{2}K_a\gamma H^2 - 2\sqrt{K_a}\,c'H + 2\frac{c'^2}{\gamma} \qquad q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma$$

$$P_a = \frac{1}{2}K_a\gamma H^2 - 2\sqrt{K_a}\,c'H \qquad q_u = 1.3c'N_c + qN_q + 0.3\gamma BN_\gamma$$

$$P_v = \frac{Rv}{B}\left(1 \pm \frac{6e}{B}\right) \qquad FOS = \frac{Rv\tan\delta}{RH} \qquad FOS = \frac{\mu R}{\mu T} \qquad e = B/2 - \bar{X}$$



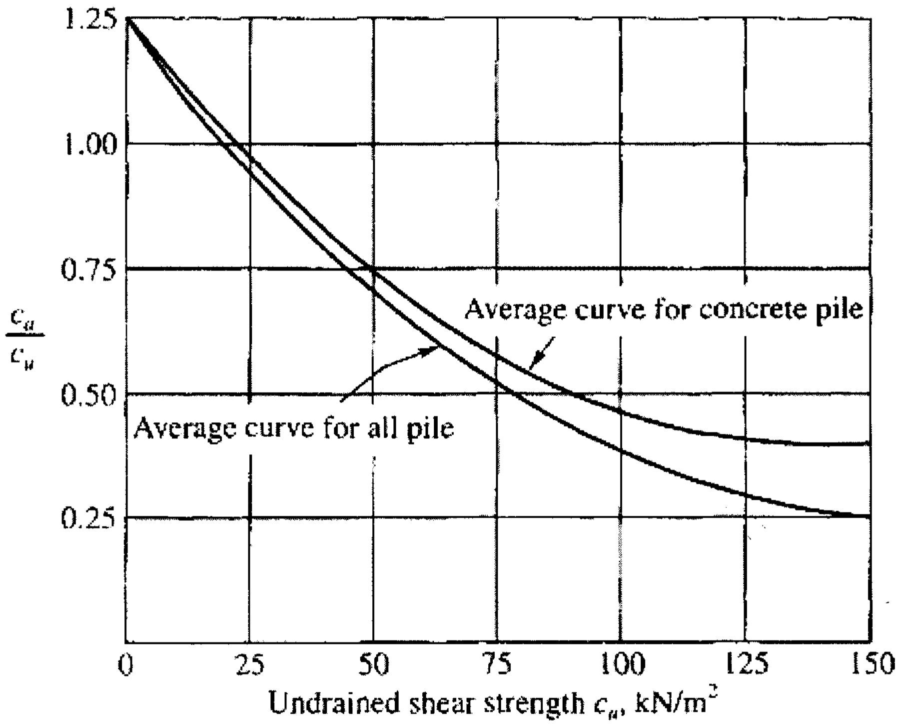
. 8.8 Bearing capacity factors for circular deep foundations (after Kézdi, 1975)

Table 16.1 Terzaghi's Bearing Capacity Factors—N_c, N_q and N_γ—Eqs. (16.11), (16.12), and (16.13), respectively

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	16.90	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	116.31
16	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	161.95	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	416.14	1072.80
25	25.13	12.72	8.34				

N_γ values from Kumbhojkar (1993)

Pile material	δ	Value of k_s — Relative desity: loose	dense
Steel	20^o	0.5	1.0
Concrete	$\frac{3}{4}\phi^o$	1.0	2.0
Timber	$\frac{2}{3}\phi^o$	1.5	4.0



1. *Elastic compression c_1 of cap and pile head*

Pile Material	Range of Driving Stress kg/cm²	Range of c_1
Precast concrete pile with packing inside cap	30-150	0.12-0-50
Timber pile without cap	30-150	0.05-0.20
Steel *H*-pile	30-150	0.04-0.16

Pile-hammer efficiency

Hammer Type	η_h
Drop	1.00
Single acting	0.75–0.85
Double acting	0.85
Diesel	1.00

Coefficient of restitution C_r

Material	C_r
Wood pile	0.25
Compact wood cushion on steel pile	0.32
Cast iron hammer on concrete pile without cap	0.40
Cast iron hammer on steel pipe without cushion	0.55

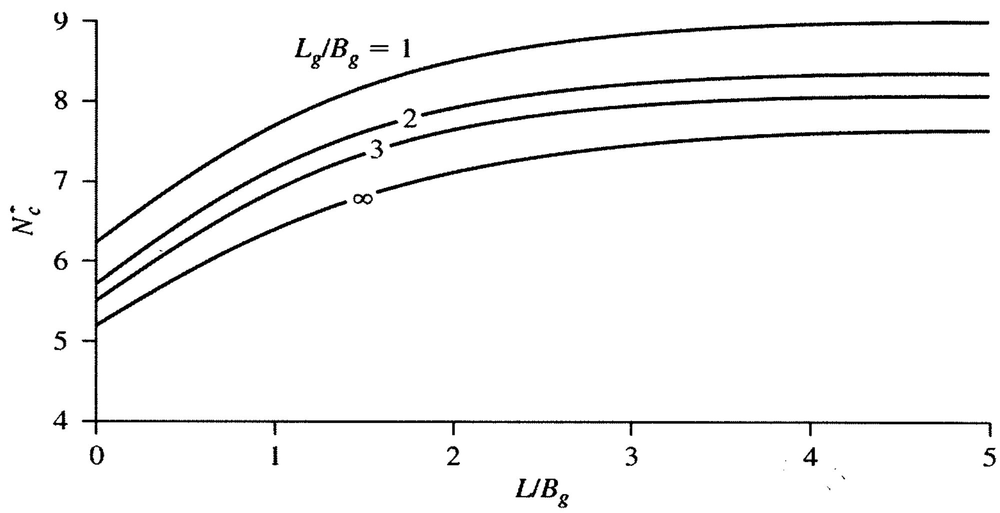


Table 11.10 Variation of α (interpolated values based on Terzaghi, Peck and Mesri, 1996)

$\frac{c_u}{p_a}$	α
≤ 0.1	1.00
0.2	0.92
0.3	0.82
0.4	0.74
0.6	0.62
0.8	0.54
1.0	0.48
1.2	0.42
1.4	0.40
1.6	0.38
1.8	0.36
2.0	0.35
2.4	0.34
2.8	0.34

Note: p_a = atmospheric pressure $\approx 100\ \text{kN/m}^2$

Coefficient of restitution C_r

Material	C_r
Wood pile	0.25
Compact wood cushion on steel pile	0.32
Cast iron hammer on concrete pile without cap	0.40
Cast iron hammer on steel pipe without cushion	0.55

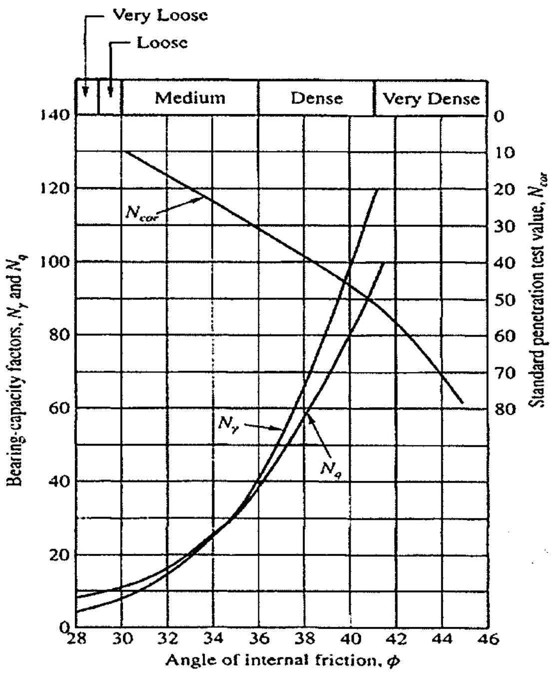


TABLE 4-4

Bearing-capacity factors for the Meyerhof, Hansen, and Vesić bearing-capacity equations

Note that N_c and N_q are the same for all three methods; subscripts identify author for N_γ

ϕ	N_c	N_q	$N_{\gamma(H)}$	$N_{\gamma(M)}$	$N_{\gamma(V)}$	N_q/N_c	$2\tan\phi(1-\sin\phi)^2$
0	5.14*	1.0	0.0	0.0	0.0	0.195	0.000
5	6.49	1.6	0.1	0.1	0.4	0.242	0.146
10	8.34	2.5	0.4	0.4	1.2	0.296	0.241
15	10.97	3.9	1.2	1.1	2.6	0.359	0.294
20	14.83	6.4	2.9	2.9	5.4	0.431	0.315
25	20.71	10.7	6.8	6.8	10.9	0.514	0.311
26	22.25	11.8	7.9	8.0	12.5	0.533	0.308
28	25.79	14.7	10.9	11.2	16.7	0.570	0.299
30	30.13	18.4	15.1	15.7	22.4	0.610	0.289
32	35.47	23.2	20.8	22.0	30.2	0.653	0.276
34	42.14	29.4	28.7	31.1	41.0	0.698	0.262
36	50.55	37.7	40.0	44.4	56.2	0.746	0.247
38	61.31	48.9	56.1	64.0	77.9	0.797	0.231
40	75.25	64.1	79.4	93.6	109.3	0.852	0.214
45	133.73	134.7	200.5	262.3	271.3	1.007	0.172
50	266.50	318.5	567.4	871.7	761.3	1.195	0.131

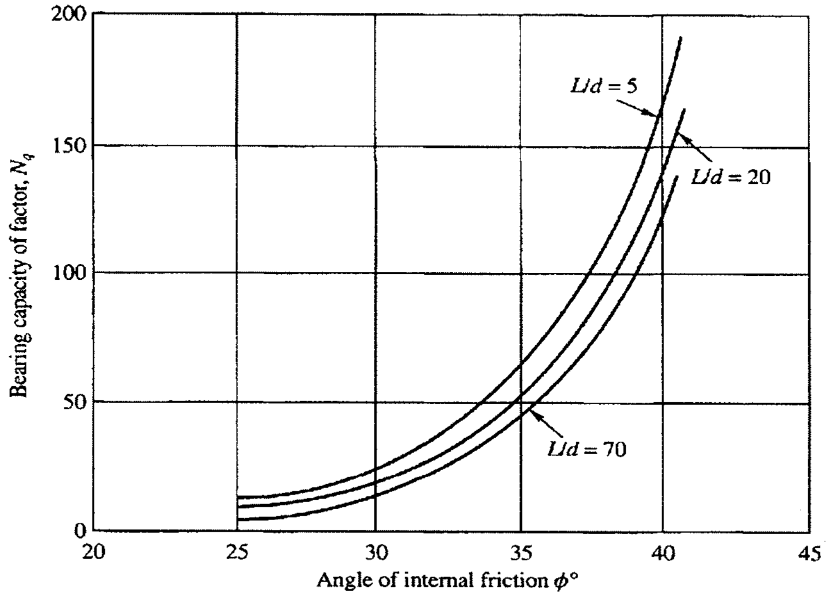


Figure 15.9 Berezantsev's bearing capacity factor, N_q (after Tomlinson, 1986)

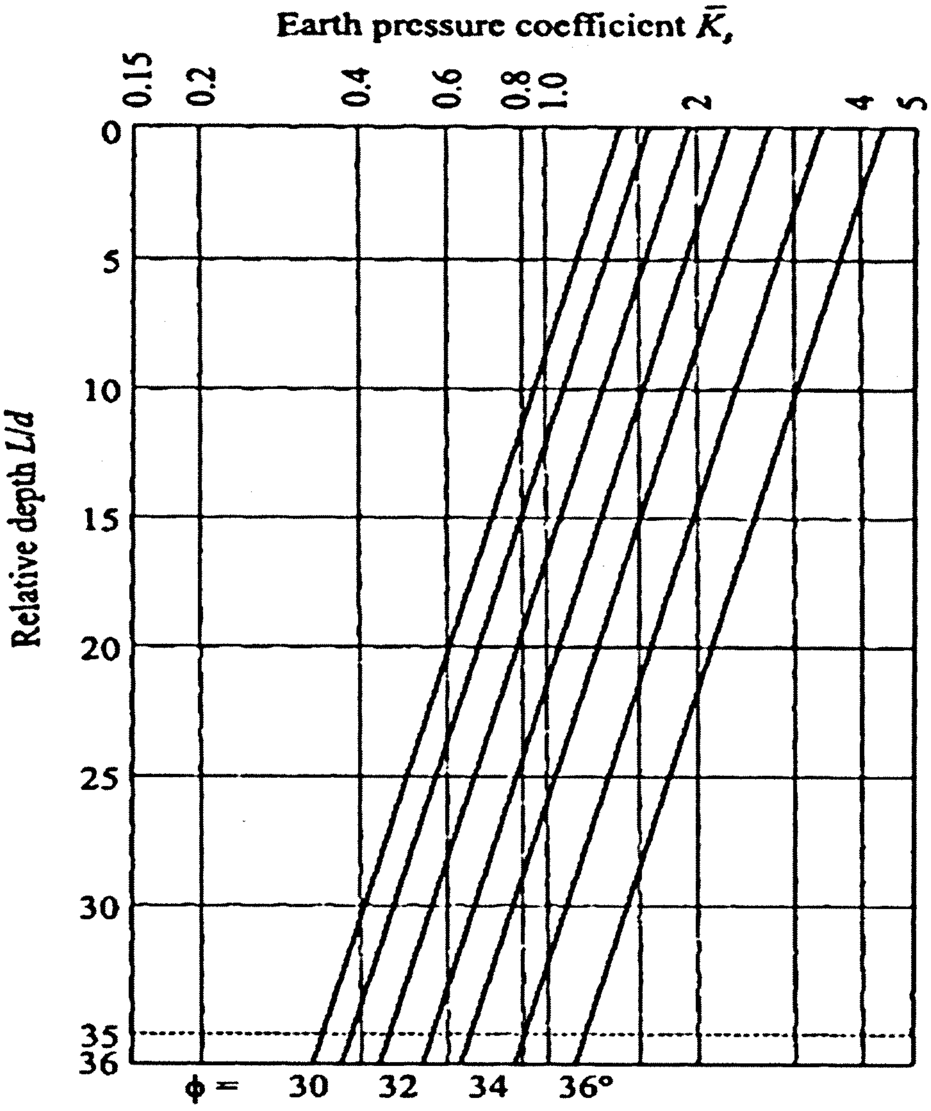


Table 9.3 N_{cor} and ϕ Related to Relative Density

N_{cor}	Compactness	Relative density, D_r (%)	$\phi°$
0-4	Very loose	0-15	<28
4-10	Loose	15-35	28-30
10-30	Medium	35-65	30-36
30-50	Dense	65-85	36-41
>50	Very Dense	>85	> 41

Table 9.4 Relation Between N_{cor} and q_u

Consistency	N_{cor}	q_u, kPa
Very soft	0-2	<25
Soft	2-4	25-50
Medium	4-8	50-100
Stiff	8-15	100-200
Very Stiff	15-30	200-400
Hard	>30	>400

where q_u is the unconfined compressive strength.

$$Q_{ult} = Q_b + Q_s$$

Displacement piles:

$$Q_b = 40N_{cor}(^L/_d)A_b \qquad Q_s = 2\bar{N}_{cor}A_s$$

H piles:

$$Q_b = 40N_{cor}(^L/_d)A_b \qquad Q_s = \bar{N}_{cor}A_s$$

Bored piles:

$$Q_b = 133N_{cor}A_b \qquad Q_s = 0.67\bar{N}_{cor}A_s$$

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

$$Q_b \leq Q_{bl} = 400N_{cor}A_b$$

$$Q_b > Q_{bl} = use\ Q_{bl}$$

$$\frac{N_{55}}{N_{70}} = \left(\frac{70}{55}\right)$$

$$Q_b = (40N_{55})\left(^L/_d\right)A_b$$

$$Q_{bl} = (400N_{55})A_b$$

Hansen's equation:

$$\bar{q} = effective\ stress$$

$$d_q = 1 + d_f \tan^{-1}\left(\frac{L}{d}\right)$$

$$d_f = 2tan\phi(1 - sin\phi)^2$$

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

$$\eta = 1.0$$

$$Q_b = \left[(cN_cd_c) + (\eta\bar{q}N_qd_q) + \left(\frac{1}{2}\gamma' dN_\gamma\right)\right]A_b$$

$$q_b\ (bored\ pile) = \frac{1}{3} q_b\ (driven\ pile)$$

Janbu's equation:

$$\bar{q} = effective\ stress$$
$$d_q = 1 + d_f \tan^{-1}\left(\frac{L}{d}\right)$$
$$d_f = 2tan\phi(1 - sin\phi)^2$$
$$d_c = 1 + 0.4\tan^{-1}\left(\frac{L}{d}\right)$$
$$\eta = 1$$
$$N'_q = \left(\tan\phi + \sqrt{1 + \tan^2\phi}\right)^2 exp(2\psi tan\phi)$$
$$N'_c = refer\ table\ vesić$$
$$N_\gamma = refer\ table\ Hansen$$
$$Q_b = \left[(cN_c d_c) + (\eta\bar{q}N_q d_q) + \left(\frac{1}{2}\gamma' dN_\gamma\right)\right]A_b$$

Terzaghi's equation:

$$\bar{q} = effective\ stress$$
$$d_q = 1 + d_f \tan^{-1}\left(\frac{L}{d}\right)$$
$$d_f = 2tan\phi(1 - sin\phi)^2$$
$$d_c = 1 + 0.4\tan^{-1}\left(\frac{L}{d}\right)$$
$$\eta = 1$$
$$N'_q = \frac{a^2}{a\cos^2\left(45 + \frac{\phi}{2}\right)}$$
$$a = exp\left(0.75\pi - \frac{\phi}{2}\right)\tan\phi$$
$$N'_\gamma = \frac{\tan\phi}{2}\left(\frac{k_{p\gamma}}{cos^2\phi} - 1\right)$$
$$N_c = (N_q - 1)\cot\phi$$
$$Q_b = \left[(cN_c s_c) + (\bar{q}N_q) + \left(\frac{1}{2}\gamma' dN_\gamma s_\gamma\right)\right]A_b$$

	LOOSE		MEDIUM		DENSE	
ψ =	75°		90°		105°	
ϕ°	N^*_q	N^*_c	N^*_q	N^*_c	N^*_q	N^*_c
0	1.00	5.74	1.00	5.74	1.00	5.74
5	1.50	6.25	1.57	6.49	1.64	7.33
10	2.25	7.11	2.47	8.34	2.71	9.70
20	5.29	11.78	6.40	14.83	7.74	18.53
30	13.60	21.82	18.40	30.14	24.90	41.39
35	23.08	31.53	33.30	46.12	48.04	67.18
40	41.37	48.11	64.20	75.31	99.61	117.52
45	79.90	78.90	134.87	133.87	227.68	226.68

Hiley's Formula

$$Energy\ input = Energy\ used + Energy\ losses$$

$$Energy\ used = Energy\ input - Energy\ losses$$

$$Energy\ used = Q_u s \qquad Energy\ input = \eta_h W_h$$

$$\eta_b = \frac{W + e^2 P}{W+P} - \left(\frac{W - eP}{W+P}\right)^2$$

$$Q_u = \frac{(Wh)\eta_b \eta_h}{(S + {}^{c}/_{2})}$$

$$Q_{ult} = \left[\frac{\eta_h W_h}{s + C}\right]\left[\frac{1 + (C_r)^2 R}{1 + R}\right] \qquad R = \frac{W_p}{W}$$

$$E_1 = \frac{1}{2} Q_{ult}[c_1 + c_2 + c_3] = Q_{ult} C$$

$$E_2 = W_h W_p \left[\frac{1 - (C_r)^2}{W + W_p}\right]$$

$$c_2 = \frac{Q_{ult}(L)}{AE} \qquad c_3 = 0.1\ (average)$$

BLOCK FAILURE

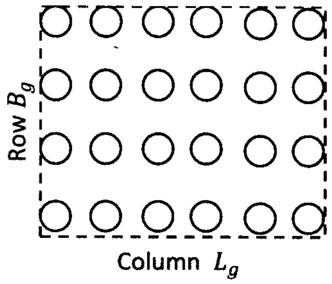
$$Q_{g_{ult}} = Q_{s_g} + Q_{b_g}$$
$$Q_{s_g} = A_{s_g} k_s q'_o \tan\delta$$
$$Q_{b_g} = A_{b_g} q'_o N_q$$
$$A_{s_g} = (2L)(B + W)$$
$$A_{b_g} = (B\ x\ W)$$
$$Q_{g_{all}} = \frac{Q_{g_{ult}}}{FOS}$$

INDUVIDUAL PILE FAILURE

$$Q_{g_{ult}} = nQ_{ult}$$
$$S_{net_{(1)}} = S_{t_{(1)}} - S_{e_{(1)}}$$

Davisson's method

$$S_u(mm) = [0.012D_r] + \left[0.1\left(\frac{D}{D_r}\right)\right] + \left[\frac{Q_u L}{A_p E_p}\right]$$



$$Q_s = \alpha C_u A_s$$

$$Q_b = C_u N_c A_b$$

$$\Delta\sigma'_i = \frac{Q_g}{(B_g - z_i)(L_g - z_i)}$$

$$\Delta S'_{c(i)} = \left[\frac{C_{c(i)} H_i}{1 + e_{0(i)}}\right] log \left[\frac{\sigma'_{o(i)} + \Delta\sigma_{(i)}}{\sigma'_{o(i)}}\right]$$

$$\Delta S'_{c(g)} = \Delta S'_{c(1)} + \Delta S'_{c(2)} + ..\Delta S'_{c(i)}$$