UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2009/2010

November 2009

EAG 345/3 – Geotechnical Analysis

[Analisis Geoteknik]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **EIGHTEEN (18)** printed pages before you begin the examination.
*[Sila pastikan kertas peperiksaan ini mengandungi **LAPAN BELAS (18)** muka surat bercetak sebelum anda memulakan peperiksaan ini.]*

Instructions: This paper consists of **SIX (6)** question. Answer **FIVE (5)** questions. All questions carry the same marks.
*[Arahan: Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA(5)** soalan sahaja. Semua soalan membawa jumlah markah yang sama.]*

You may answer the question either in Bahasa Malaysia or English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

All questions **MUST BE** answered on a new page.
*[Semua soalan **MESTILAH** dijawab pada muka surat baru.]*

Write the answered question numbers on the cover sheet of the answer script.
[Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.]

In the event of any discrepancies, the English version shall be used

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai]

1. a) Briefly describe Mohr's theory of failure. State the relation between shear strength, cohesion, normal stress and friction angle.

(3 marks)

b) Triaxial test is one of the most reliable method available for determining the shear strength parameters. It is widely used in research as well as conventional testing. There are **THREE (3)** standard types of Triaxial tests that can be done in laboratory. Explain **ONE (1)** type of the tests with relevant sketches.

(4 marks)

c) A cohesionless sample was tested using direct shear test. The following data shows the results obtained from the test. Determine the value of c and ϕ for the particular soil.

(13 marks)

Test	Normal force (kg)	Shear force (kg)	Area of sample (cm)
1	4	5.9	5.5 x 5.5
2	8	6.5	5.5 x 5.5
3	12	7.86	5.5 x 5.5
4	16	9.45	5.5 x 5.5

Table 1

2. a) Identify the following equations which relate to Theory of Earth Pressure.

(5 marks)

$$i)\ K_a = (1 - sin\phi')OCR^{sin\phi'}$$

$$ii)\ z_c = \frac{2c'}{\gamma\sqrt{K_a}}$$

$$iii)\ K_p = cos\alpha \frac{cos\alpha + \sqrt{cos^2\alpha - cos^2\varphi'}}{cos\alpha - \sqrt{cos^2\alpha - cos^2\varphi'}}$$

$$iv)\ P_a = \frac{1}{2}\gamma H^2 K_a$$

$$v)\ \sigma_a = \gamma H\left[1 - \left(\frac{4c}{\gamma}H\right)\right]$$

b) For the wall shown in Figure 1, calculate the total lateral force on the wall

(5 marks)

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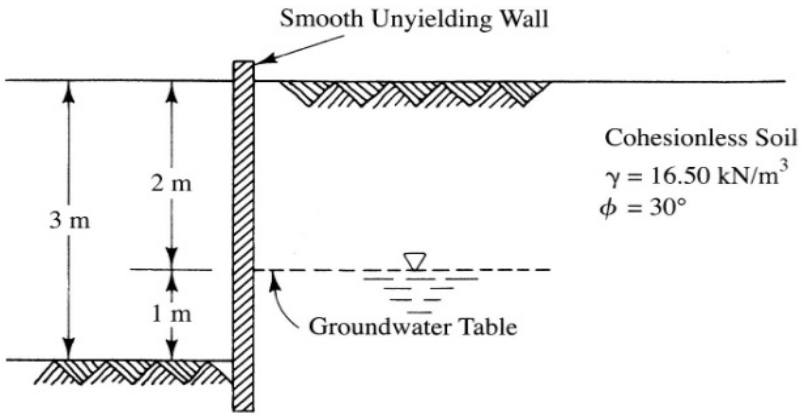

Figure 1

c) Calculate the safety factor of the reinforced concrete wall shown in Figure 2 against sliding.

(5 marks)

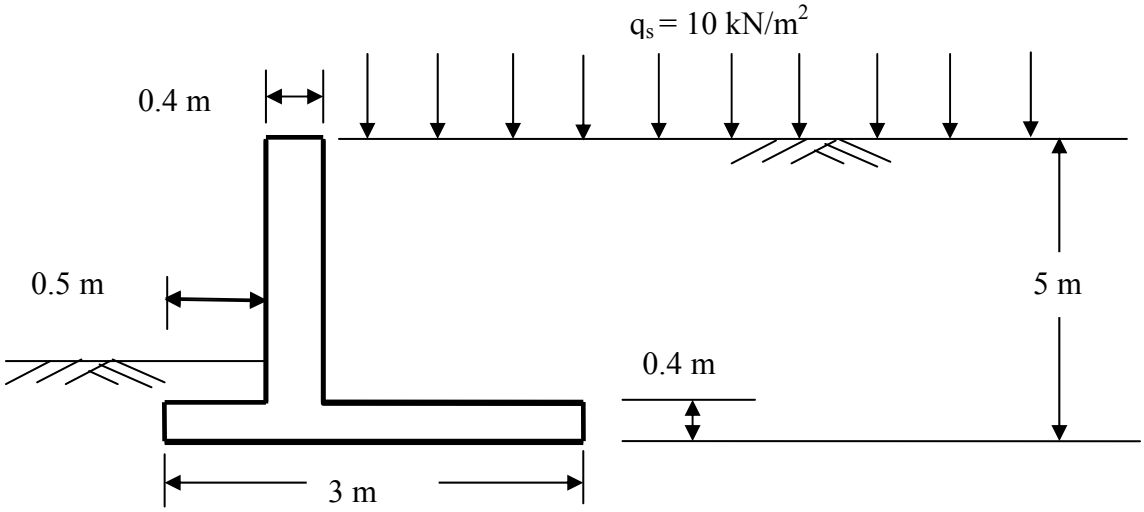

Figure 2

Given : $\gamma_{concrete}$ = 24 kN/m^3, γ_{soil} = 18 kN/m^3, ø'= 38^0, c' = 0, $q_{allowable}$ = 250 kPa, tan δ = tan ø', neglect passive resistance.

d) For the braced cut shown (s= 3 m) in Figure 3,

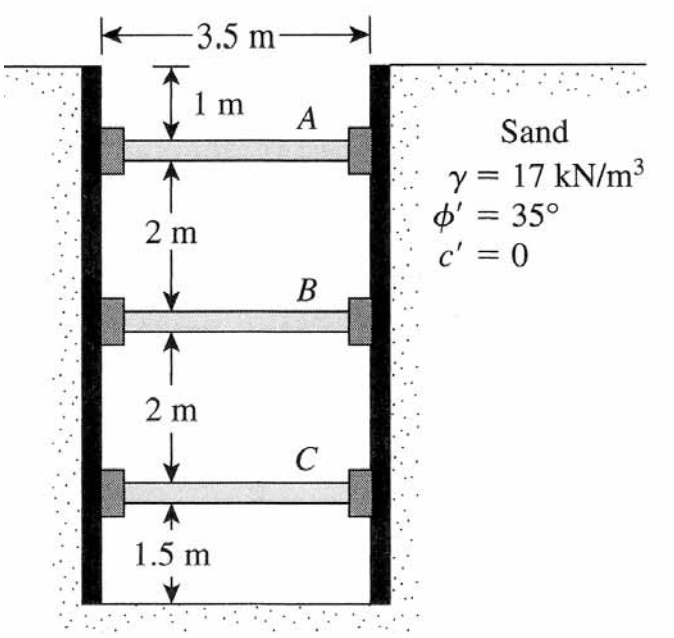

Figure 3

i. Draw the pressure envelope.

(2 marks)

ii. Determine S if M_{max} in the sheet pile is 27.03 kN-m, and σ_{all}=170x10^3 kPa.

(1 marks)

iii. Determine S for the wales at B if the reaction = 90.4 kN, and σ_{all}= 170x10^3 kN/m^2

(2 marks)

3. A soil investigation is conducted for commercial building project and below is the borelog information from 21.50 meter depth until 29.00 meter. The soil unit weight for hard clay is 21 kN/m^3 and for very dense sand is 23 kN/m^3. Ground water is at 3.00 meter below ground level.

Depth (m)	**Description**	**SPT Blow Count**		
		1st 0.15 m	**2nd 0.15 m**	**3rd 0.15 m**
21.50	Hard, grey sandy CLAY	13	14	17
23.00		14	16	15
24.50		11	17	18
26.00	Dense, grey clayey SAND	12	18	21
27.50	Very dense, grey clayey SAND	11	22	28/80 mm
29.00		13	25	25/60 mm

Table 2

a) Discuss **THREE (3)** reasons why site investigation need to be carried out at the proposed site besides to know the condition of soil for design purpose of the proposed project.

(9 marks)

b) What is the Standard Penetration Test N field value at 23.00 meter and 27.50 meter depth.

(2 marks)

c) What does 25/60 mm in 3rd 0.15 m record at depth 29.00 meter means and should this borehole drilling be continued or stoped.

(3 marks)

d) Does Standard Penetration Test N value at 23.00 meter and 27.50 meter depth need to be corrected. Discuss briefly why Standard Penetration Test N value is needed to be corrected.

(6 marks)

4. a) i) Give **FIVE (5)** types of slope failures which are commonly found

ii) What factors cause slope failure?

iii) What is an infinite slope failure?

iv) What are the methods of analysis used to estimate the factor of safety of a slope?

(8marks)

b) Dry sand is to be dumped from a truck on the side of a roadway. The properties of the sand are $ø'=30º$, $\gamma=17kN/m^3$ and $\gamma_{sat} = 17.5kN/m^3$. Determine the maximum slope angle of the sand in (a) the dry state, (b) the saturated state, without seepage and (c) the saturated state if ground water is present and seepage were to occur parallel to the slope. What is the safe slope in the dry state for a factor of safety of 1.25?

(12 Marks)

5. The column load on a footing has been calculated as 1.0 MN. You need to design a square pad footing to cater 3 times of the given column load, i.e., FOS = 3.0. You have decided to place the footing at 1.5 m below ground, exactly at where the water table is. The material above footing level has a bulk unit weight of 18 kN/m^3 and below footing level 20 kN/m^3. A schematic diagram of the case is given in Figure 4. Terzaghi's equation for ultimate bearing capacity, q_{ult}, for square foundation is given by: $q_{ult} = 1.3cN_c + 0.4B\gamma N_\gamma + qN_q$. An associated chart is given in Figure 5

a) Assuming the soils are all clayey with cohesion value of 100 kPa, determine the required size of the footing to ensure that it is safe against general shear.

(5 marks)

b) Assuming the soils are all clayey with cohesion value of 100 kPa, determine the required size of the footing to ensure that it is safe against local shear.

(5 marks)

c) Assuming the soils are all sandy with ø value of 35^o, determine the required size of the footing to ensure that it is safe against general shear.

(5 marks)

d) Assuming the soils are all sandy with ø value of 35^o, determine the required size of the footing to ensure that it is safe against local shear.

(5 marks)

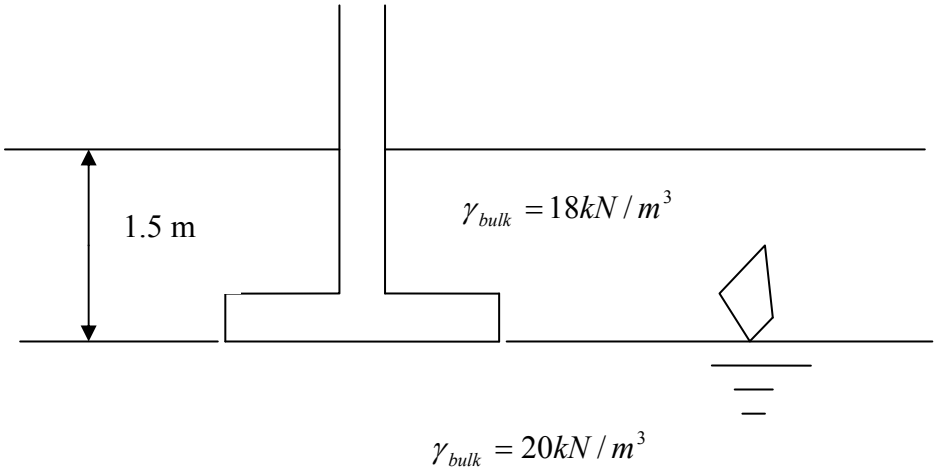

Figure 4 – Pad foundation in clayey/sandy ground

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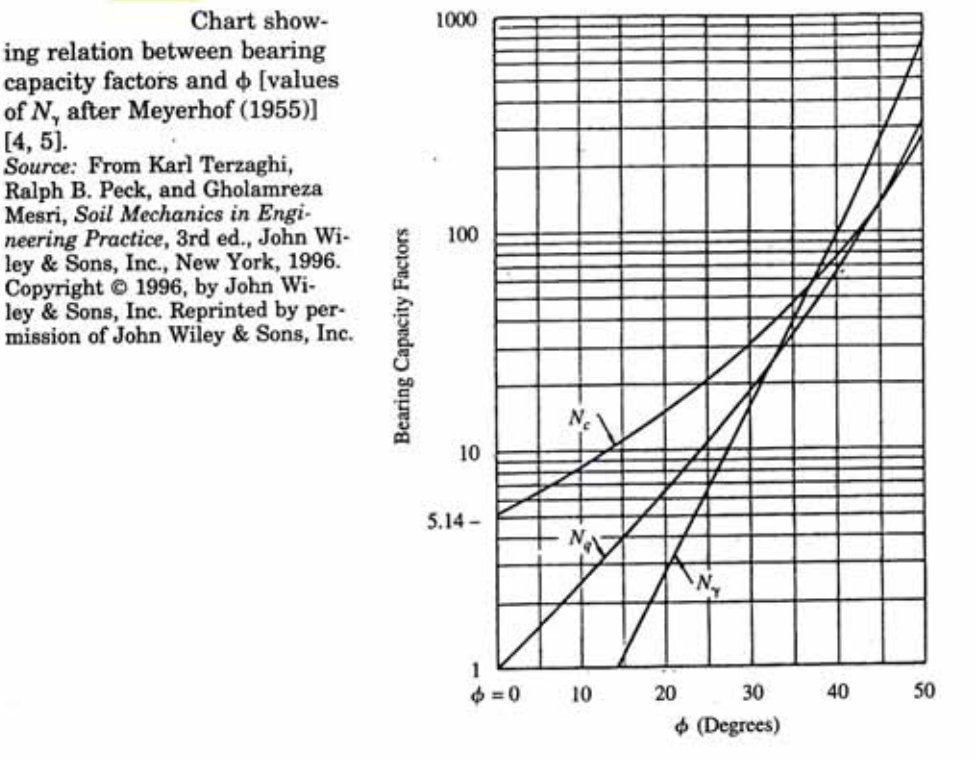

Chart showing relation between bearing capacity factors and ϕ [values of N_γ after Meyerhof (1955)] [4, 5].
Source: From Karl Terzaghi, Ralph B. Peck, and Gholamreza Mesri, *Soil Mechanics in Engineering Practice*, 3rd ed., John Wiley & Sons, Inc., New York, 1996. Copyright © 1996, by John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.

Figure 5 – Chart associated with Question 5.

6. The column load on a footing has been calculated as 1.0 MN. You need to design a pile foundation to cater 3 times of the given column load, i.e., FOS = 3.0. You have decided to have at least 2 piles for each column, each pile is concrete, and 0.1m in diameter. The water table is 1.5m below ground surface. The material above the water table has a bulk unit weight of 18 kN/m^3 and below water table, 20 kN/m^3. A schematic diagram of the case is given in Figure 6.

The following equations are given, in case of clayey soils:

i) Shaft friction is given by $f.A_{surface} = \sum_{d=0}^{depth}(\alpha c)dA$; associated chart is given in Figure 7.

ii) End Bearing is given by $Q_{ult} = A_p q_{ult} = A_p c N_c = A_p c(9)$

iii) Total foundation capacity is sum of capacities of all individual piles.

The following equations are given, in case of sandy soils:

i) Shaft friction is given by $f.A_{surface} = \sum_{d=0}^{depth}(\tan\delta.\sigma_h)dA$; $\tan\sigma$ = 0.45 (for sand/concrete)

ii) End Bearing is given by $Q_{ult} = A_p q_{ult} = A_p p_v N_q^*$, associated chart is given in Figure 8.

iii) Total foundation capacity is sum of capacities of all individual piles.

a) Assume the soils are all clayey with cohesion value of 100 kPa, determine the required length of each pile.

(10 marks)

b) Assume the soils are all sandy with ø value of 25^o determine the required length of each pile. Assume $\sigma_h = 0.8\sigma_v$, critical depth = 10 times diameter (loose sand).

(10 marks)

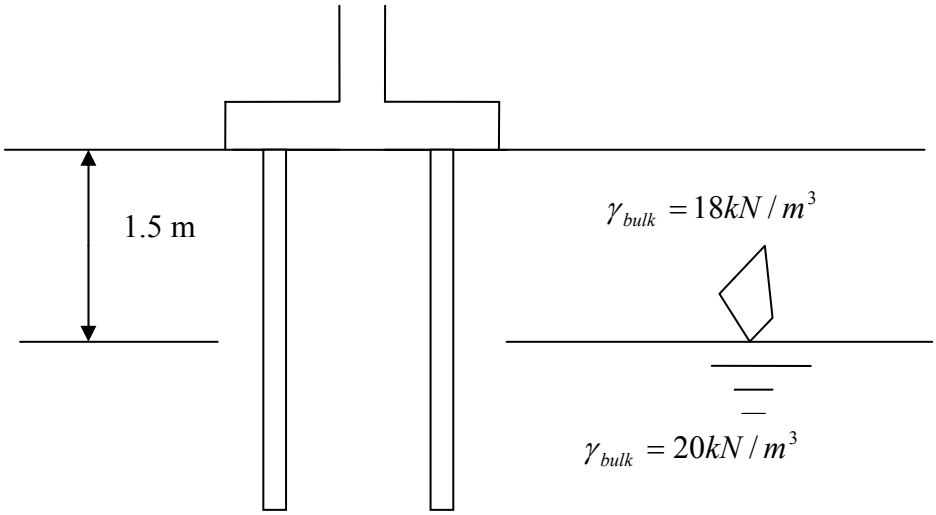

Figure 6 – Pile foundation in clayey/sandy ground

Relationship between adhesion factor, α, and unconfined compressive strength, q_u (1 ton/ft² = 95.76 kN/m²) [13].

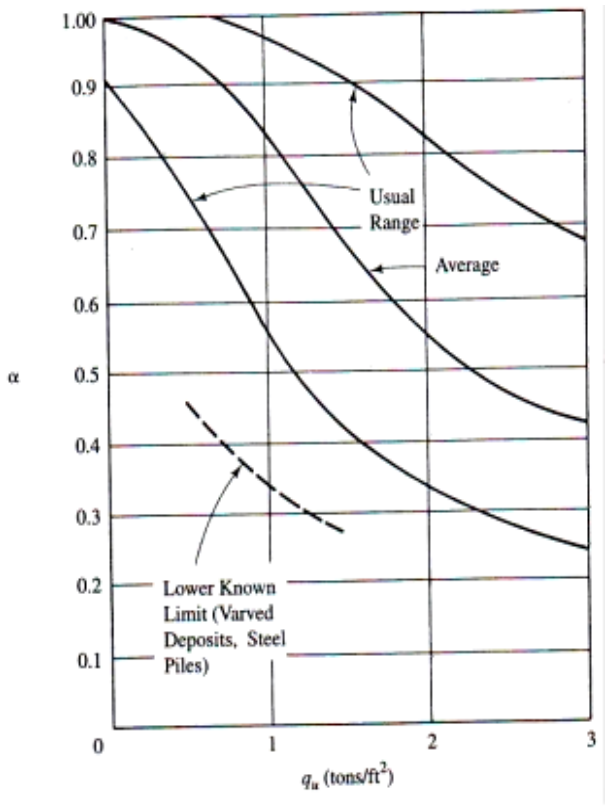

Figure 7 – Chart associated with Question 6(a)

Bearing capacity factor, N_q^*, for piles penetrating into sand [8].

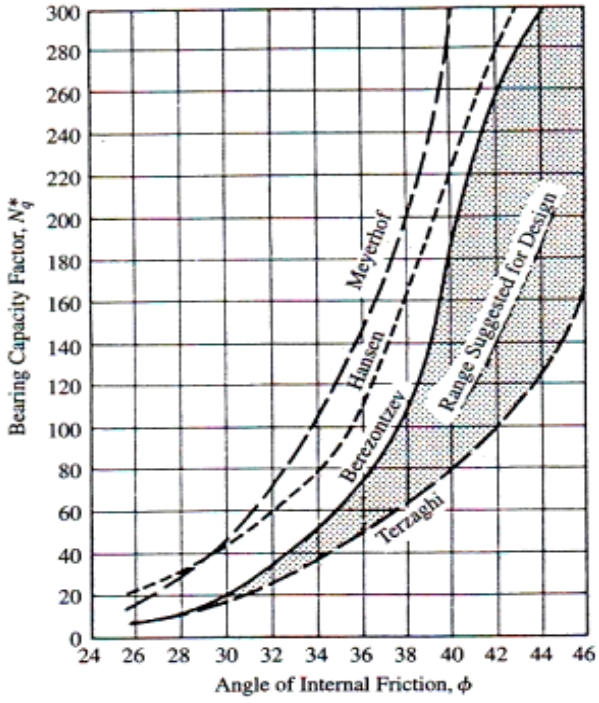

Figure 8 – Chart associated with Question 6(b)

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1. a) *Terangkan secara ringkas teori kegagalan Mohr. Nyatakan hubungan di antara kekuatan ricih, kejelekitan, tegasan normal dan sudut geseran.*

(3 markah)

b) *Ujian tiga paksi adalah salah satu dari kaedah yang paling dipercayai bagi menentukan parameter kekuatan ricih. Ia umum digunakan dalam penyelidikan dan juga ujikaji konvensional. Terdapat* ***TIGA (3)*** *jenis ujian tiga paksi piawai yang boleh dilakukan di dalam makmal. Terangkan salah* ***SATU (1)*** *jenis ujikaji tersebut bersama gambarajah yang bersesuaian.*

(4 markah)

c) *Suatu sampel tanah tak jelekit telah diuji melalui ujian ricih terus. Data di bawah menunjukkan keputusan yang diperolehi dari ujian tersebut. Tentukan nilai bagi c dan ø untuk tanah tersebut*

(13 markah)

Ujian	***Daya normal (kg)***	***Daya ricih (kg)***	***Luas sample (cm)***
1	*4*	*5.9*	*5.5 x 5.5*
2	*8*	*6.5*	*5.5 x 5.5*
3	*12*	*7.86*	*5.5 x 5.5*
4	*16*	*9.45*	*5.5 x 5.5*

Jadual 2

2. a) *Kenalpasti persamaan dibawah yang berkaitan dengan Teori Tegasan Tanah.*

(5 markah)

$i) K_o = (1 - sin\emptyset')OCR^{sin\emptyset'}$

$ii) z_c = \frac{2c'}{\gamma\sqrt{K_a}}$

iii) $K_p = cos\alpha \frac{cos\alpha + \sqrt{cos^2\alpha - cos^2\varphi'}}{cos\alpha - \sqrt{cos^2\alpha - cos^2\varphi'}}$

$iv) P_a = \frac{1}{2}\gamma H^2 K_a$

$v) \sigma_a = \gamma H\left[1 - \left(\frac{4c}{\gamma}H\right)\right]$

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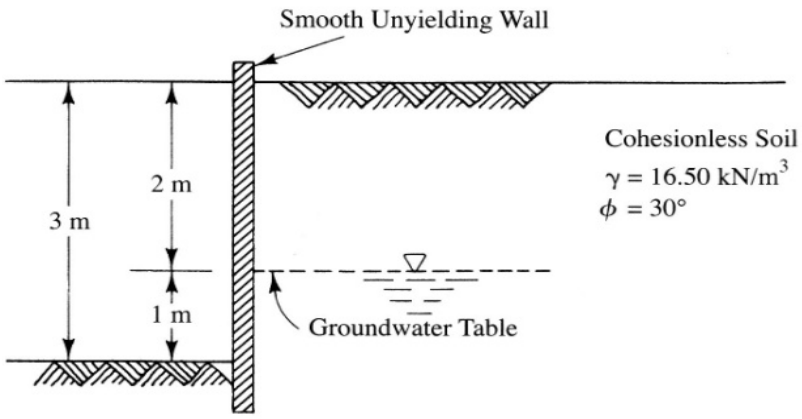
b) *Bagi tembok penahan yang ditunjukkan dalam Rajah 1, kira tekanan sisi pada dinding tersebut .*

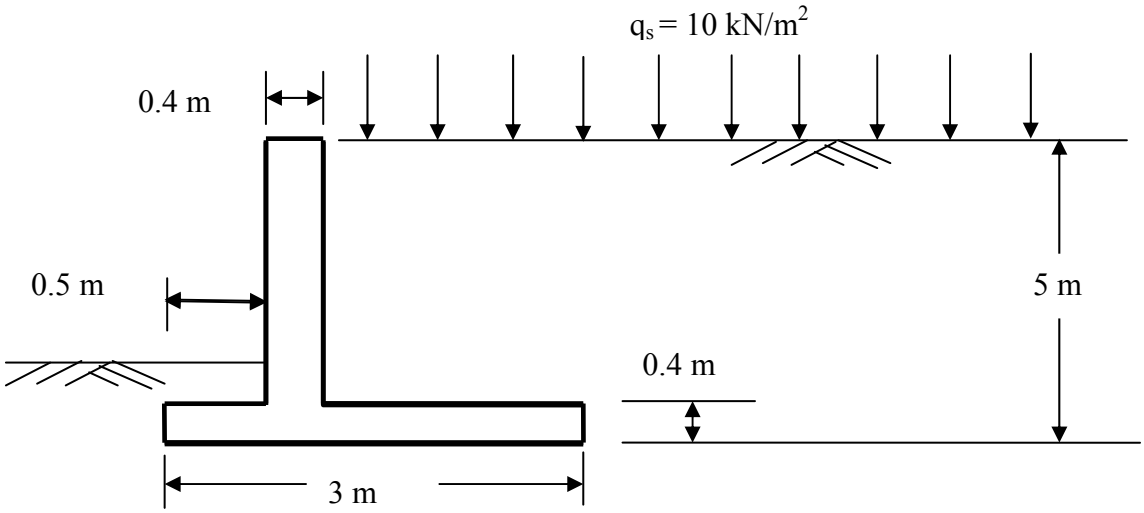
(5 markah)



Rajah 1

c) *Kira faktor keselamatan bagi tembok konkrit bertetulang seperti yang ditunjukkan dalam Rajah 2 terhadap gelinciran.*

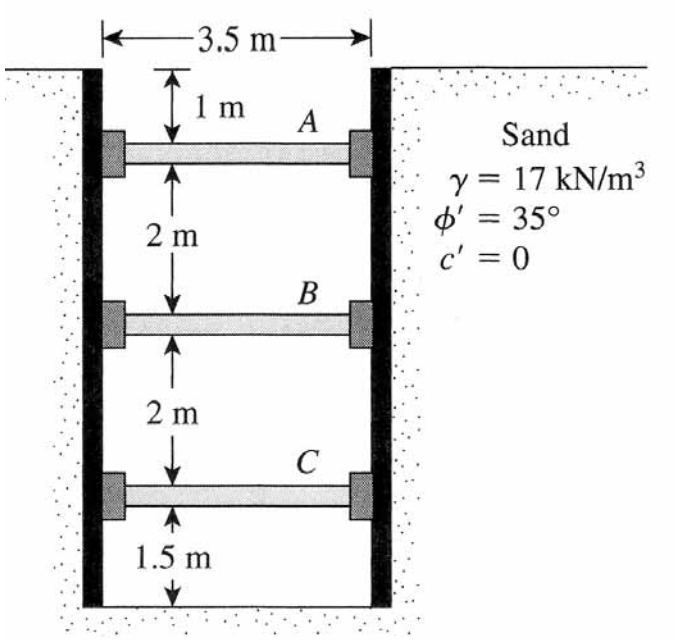
(5 markah)



Rajah 2

Diberi : $\gamma_{concrete} = 24$ kN/m^3, $\gamma_{soil} = 18$ kN/m^3, ø'= 38^0, c' = 0, $q_{allowable}$ = 250 kPa, tan δ = tan ø', abaikan rintangan pasif.

d) Bagi potongan topang yang ditunjukkan (s = 3m) dalam gambarajah 3



Rajah 3

i) Lukis sampul tekanan.

(2 markah)

ii) Tandakan S jika M_{max} pada cerucuk keping adalah 27.03 kN-m, dan $\sigma_{all}=170x10^3$ kPa.

(1 markah)

iii) Tentukan S bagi "wales" di B jika reaksi = 90.4 kN, dan $\sigma_{all}= 170x10^3$ kN/m^2

(2 markah)

3. Satu penyiasatan tapak telah dijalankan untuk projek bangunan perniagaan dan di bawah adalah maklumat log lubang jara daripada 21.50 meter sehingga 29.00 meter. Berat unit tanah bagi lempung keras ialah 21 kN/m^3 dan pasir sangat padat ialah 23 kN/m^3. Aras air bumi terletak 3.00 meter di bawah permukaan tanah.

Depth (m)	***Description***	***SPT Blow Count***		
		1st 0.15 m	***2nd 0.15 m***	***3rd 0.15 m***
21.50	*Hard, grey sandy CLAY*	*13*	*14*	*17*
23.00		*14*	*16*	*15*
24.50		*11*	*17*	*18*
26.00	*Dense, grey clayed SAND*	*12*	*18*	*21*
27.50	*Very dense, grey clayed SAND*	*11*	*22*	*28/80 mm*
29.00		*13*	*25*	*25/60 mm*

Jadual 1

*a) Bincangkan **TIGA (3)** sebab mengapa penyiasatan tapak perlu dijalankan di tapak projek selain daripada untuk mengetahui keadaan tanah bagi tujuan rekabentuk bagi projek yang dicadangkan.*

(9 markah)

b) Apakah nilai N tapak Ujian Penusukan Piawai pada kedalaman 23.00 meter dan 27.50 meter.

(2 markah)

c) Apakah yang dimaksudkan dengan 25/ 60 mm seperti direkodkan di ketiga 0.15m pada kedalaman 29.00 meter dan perlukah pegerudian lubang jara ini dilanjutkan atau diberhentikan.

(3 markah)

d) Adakah nilai N Ujian Penusukan Piawai pada kedalaman 23.00 meter dan 27.50 meter perlu diperbetulkan. Bincangkan secara ringkas mengapa nilai N Ujian Penusukan Piawai perlu diperbetulkan.

(6 markah)

*4. a) i) Beri **LIMA (5)** jenis kegagalan cerun yang biasa terjadi*

ii) Apakah faktor penyebab kegagalan cerun

iii) Apakah kegagalan cerun infiniti?

iv) Apakah kaedah-kaedah analisis yang digunakan untuk anggar faktor keselamatan keceruanan?

(8 markah)

b) *Pasir kering yang akan di timbunkan di sebelah jalan dari trak. Kandungan pasir terdiri dari pasir ø'=30º, γ=17kN/m^3 dan γ_{sat} = 17.5kN/m^3. Tentukan sudut kecerunan maksimum pasir tersebut sekiranya dalam (a) keadaan kering, (b) keadaan tepu tanpa resapan dan (c) keadaan tepu dan kehadiran air bumi yang selari dengan cerun.*

Apakah cerun yang selamat dalam keadaan kering sekiranya faktor keselamatan 1.25?

(12 markah)

5. *Suatu tiang mempunyai beban 1.0 MN. Anda dikehendaki merekabentuk tapak segi empat sama bagi menyokong 3 kali beban tiang tersebut, iaitu FS = 3.0. Tapak terletak di kedalaman 1.5 m dan di situ jugalah kedudukan paras air. Berat unit pukal tanah di atas paras air 18 kN/m^3 dan di bawah paras air 20 kN/m^3. Kes di atas ditunjukkan di Rajah 1. Persamaan Terzaghi bagi Keupayaan Galas Muktamad, q_{ult}, bagi tapak segi empat sama diberi sebagai: $q_{ult} = 1.3cN_c + 0.4B\gamma N_\gamma + qN_q$. (Rujuk carta di Rajah 2).*

a) *Dengan mengaggap tanah semuanya lempung, dengan nilai kejelekitan 100 kPa, tentukan saiz tapak agar ia selamat daripada kegagalan umum.*

(5 markah)

b) *Dengan mengaggap tanah semuanya lempung, dengan nilai kejelekitan 100 kPa, tentukan saiz tapak agar ia selamat daripada kegagalan tempatan.*

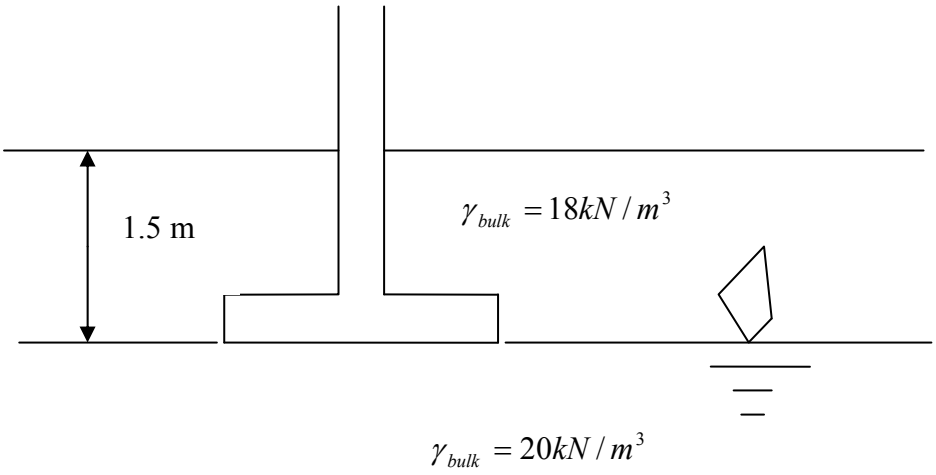
(5 markah)

c) *Dengan mengaggap tanah semuanya pasir, dengan nilai $\phi = 35^o$, tentukan saiz tapak agar ia selamat daripada kegagalan umum.*

(5 markah)

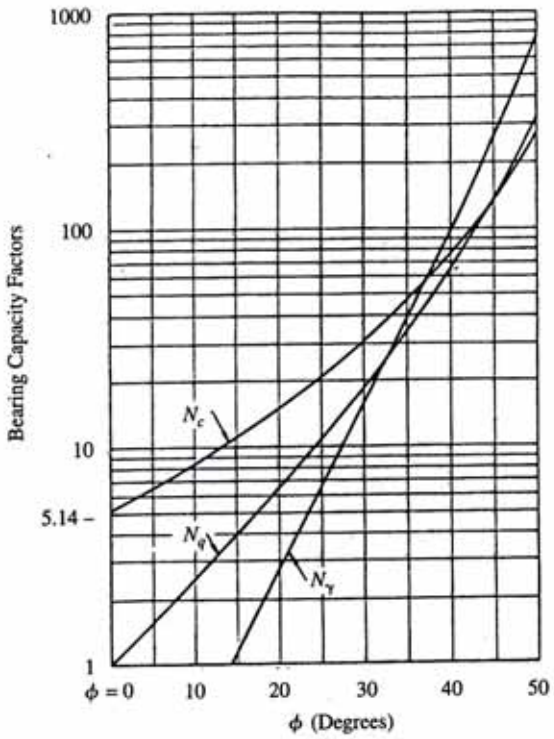
d) *Dengan mengaggap tanah semuanya pasir, dengan nilai $\phi = 35^o$, tentukan saiz tapak agar ia selamat daripada kegagalan tempatan.*

(5 markah)



Rajah. 4 – Tapak di tanah lempung/pasir

Chart showing relation between bearing capacity factors and ϕ [values of N_γ after Meyerhof (1955)] [4, 5].
Source: From Karl Terzaghi, Ralph B. Peck, and Gholamreza Mesri, *Soil Mechanics in Engineering Practice*, 3rd ed., John Wiley & Sons, Inc., New York, 1996. Copyright © 1996, by John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.



Rajah 5

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6. *Suatu tiang mempunyai beban 1.0 MN. Anda dikehendaki merekabentuk tapak cerucuk bagi menyokong 3 kali beban tiang tersebut, iaitu FS = 3.0. Dua cerucuk telah ditetapkan bagi setiap tiang, setiap satunya konkrit dan bergaris pusat 0.1 m. Paras air terletak di kedalaman 1.5 m. Berat unit pukal tanah di atas paras air 18 kN/m^3 dan di bawah paras air 20 kN/m^3. Kes di atas ditunjukkan di Rajah 6.*

Maklumat berikut boleh digunakan sekiranya tanah lempung.

i. *Geseran dinding,* $f.A_{surface} = \sum_{d=0}^{depth}(\alpha c)dA$ *; carta terlibat ditunjukkan di Rajah. 4.*

ii. *Galas hujung cerucuk,* $Q_{ult} = A_p q_{ult} = A_p cN_c = A_p c(9)$

iii. *Kekuatan kumpulan cerucuk sama dengan jumlah kekuatan cerucuk jika dicampurkan kesemuanya.*

Maklumat berikut boleh digunakan sekiranya tanah pasir.

i. *Geseran dinding cerucuk:* $f.A_{surface} = \sum_{d=0}^{depth}(\tan\delta.\sigma_h)dA$; $\tan\sigma = 0.45$ *(pasir/konkrit)*

ii. *Galas hujung cerucuk:* $Q_{ult} = A_p q_{ult} = A_p p_v N_q^*$, *lihat juga Rajah. 5.*

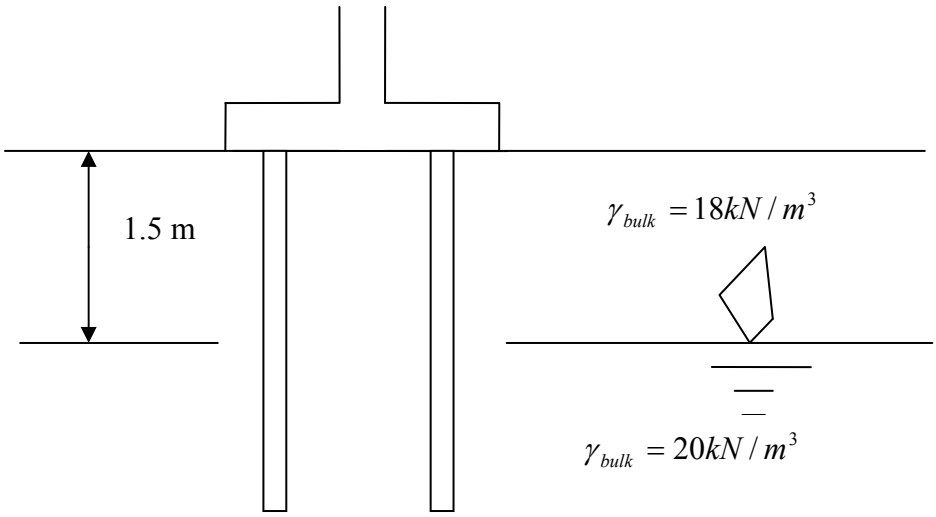
iii. *Kekuatan kumpulan cerucuk sama dengan jumlah kekuatan cerucuk jika dicampurkan kesemuanya.*

a) Dengan mengaggap tanah semuanya lempung, dengan nilai kejelekitan 100 kPa, tentukan panjang cerucuk yang diperlukan bagi setiap satunya.

(10 markah)

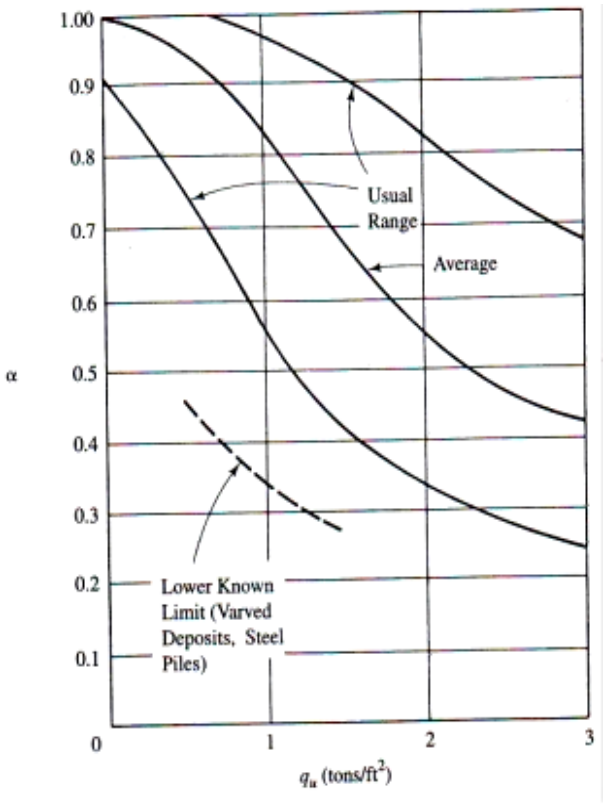
b) Dengan mengaggap tanah kesemuanya pasir dengan nilai $\phi = 25^o$*, tentukan panjang cerucuk yang diperlukan bagi setiap satunya.. Anggap* $\sigma_h = 0.8\sigma_v$*, kedalaman kritikal = 10 kali garis pusat (pasir longgar).*

(10 markah)



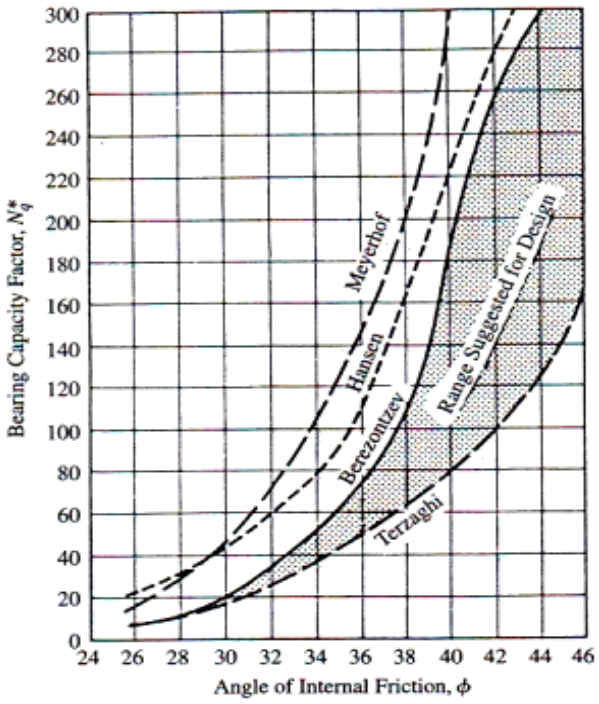
Rajah 6 – Cerucuk di tanah lempung/pasir

FIGURE 10–10
Relationship between adhesion factor, α, and unconfined compressive strength, q_u (1 ton/ft² = 95.76 kN/m²) [13].



Rajah 7 – Carta bagi soalan 6(a)

FIGURE 10–2 Bearing capacity factor, N_q^*, for piles penetrating into sand [8].



Rajah 8 – Carta bagi soalan 6(b)

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