UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2010/2011 Academic Session

April/May 2011

EAG 245/3 – Soil Mechanics
[*Mekanik Tanah*]

Duration : 3 hours
[*Masa : 3 jam*]

Please check that this examination paper consists of **SIXTEEN (16)** pages of printed material including appendix before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi* ***ENAM BELAS (16)*** *muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.*]

Instructions : This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.
[***Arahan*** *: Kertas ini mengandungi* ***ENAM (6)*** *soalan. Jawab* ***LIMA (5)*** *soalan.*

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*].

In the event of any discrepancies, the English version shall be used.
[*Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai*].

1. (a) What is the difference between total stress and effective stress? Give the equation for these two parameters by drawing the free body diagram of soil profile.

[6 marks]

(b) Based on the soil investigation at site, a soil profile as shown in Figure 1 is obtained.

(i) Plot the variations of total stress, pore pressure and effective stress with depth.

(ii) Assuming that the zone of capillary rise exists between 1.2-2.5 m, therefore the water table maybe at a different elevation than indicated in the Figure 1, calculate the effective stress at depth of 1.2 m and 2.5 m (Degree of saturation, S = 50%, specific gravity, G_s=2.6 and void ratio, e=0.6).

[14 marks]

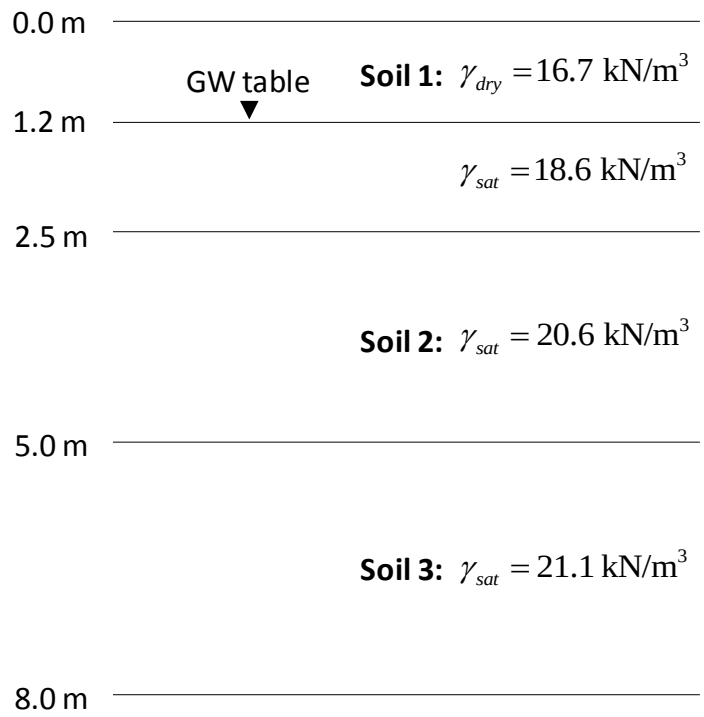


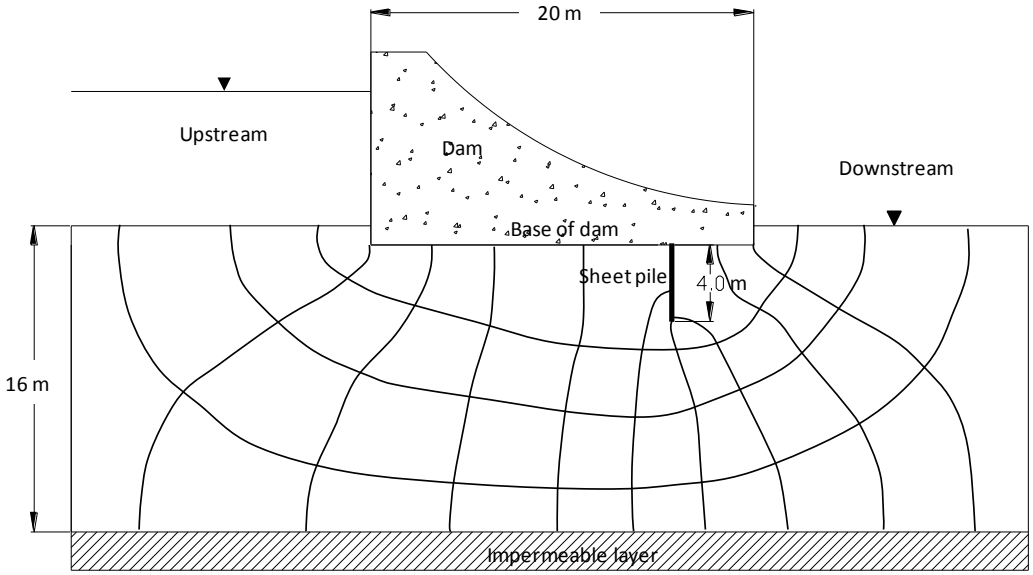
Figure 1: Soil profile

2. (a) Explain the meaning of flow net and why is it important in analyzing flow problems in soil.

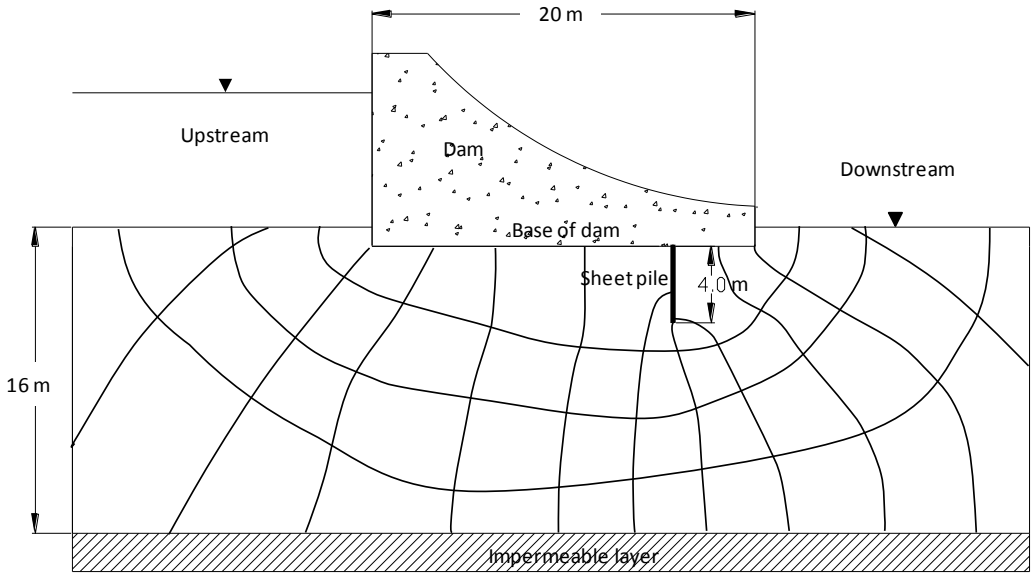
[4 marks]

(b) Based on the flow nets sketched in the permeable soil layer underneath a dam section shown in Figure 2, identify the more appropriate flow net and explain the reasons.

[4 marks]



(a)



(b)

Figure 2: Sketches of flow nets under a dam section

(c) Draw once again the flow net of Figure 2, with the level of water upstream at 8 m above the base of dam and the level of water downstream at 1 m above the base of dam. Determine the loss through seepage under the dam per year if hydraulic conductivity, $k = 4 \times 10^{-6}$ m/s and the length of the dam perpendicular to the plane of the seepage = 250 m.

[12 marks]

3. (a) Most of structures build on clayey soil consisting of minerals such as montmorillonite pose major geotechnical problems. Explain why the presence of montmorillonite influences the engineering properties of the soil?

[3 marks]

(b) From the results of laboratory tests carried out on an unsaturated clay sample, the void ratio is 0.79, the degree of saturation is 0.93, and the specific gravity of the solid is 2.70.

i) Draw the 3-phase diagram and derive the necessary equations describing the weights and volumes of air, water and solid phases (Assume $V_{solid} = 1\ m^3$).

ii) Determine the dry unit weight, bulk unit weight and the water content of the sample.

[10 marks]

(c) From the laboratory test results, the maximum and minimum void ratios for a coarse-grained soil are 0.820 and 0.520 respectively. In the meantime, a field density test performed on the same soil has given the following results; $\gamma_{bulk} = 17.5\ kN/m^3$; $w = 11.3\%$ and $G_s = 2.6$. Calculate the relative density of the soil and state the qualitative description of the soil deposit.

[7 marks]

4. (a) Explain the purpose and importance of soil classification in geotechnical engineering. Why a soil classification system based on grain size alone is a poor method of classifying soils for engineering purposes?

[5 marks]

(b) What are the main criteria required for the AASHTO classification system?

[3 marks]

(c) From the results of sieve analysis, the liquid and plastic limits of the soil given in Table 1:

(i) Plot the grain-size distribution curve

(ii) Determine the uniformity coefficient (C_u)

(iii) By comparing the uniformity coefficient (C_u) obtained in (ii) with C_u= 2.8 which is of another soil sample, choose the soil that have a better drainage condition and explain the reason.

(iv) Classify the soil in Table 1 by the AASHTO classification system. Refer Table 2

Table 1: Results of a sieve analysis, liquid and plastic limits of soil

Grain size (mm)	Sieve size	Percent passing
2.00	10	100
0.850	20	99
0.425	40	91
0.250	60	61
0.150	100	25
0.075	200	15
0.0065	-	3
0.001	-	0.5
For this soil, LL = 27% and PI = 15%		

[12 marks]

Table 2: Classification of soils and soil aggregate mixture by AASHTO Classification System

General classification	**Granular materials (35% or less passing No. 200)**							**Silty-clay materials (More than 35% passing No. 200)**			
Group classification	**A-1**			**A-2**							**A-7**
			A-3					**A-4**	**A-5**	**A-6**	**A-7-5**
	A-1-a	**A-1-b**		**A-2-4**	**A-2-5**	**A-2-6**	**A-2-7**				**A-7-6**
Sieve analysis: % passing											
No. 10 (2.00 mm)	50max	--------	-------	-------	-------	-------	-------	-------	-------	-------	-------
No. 40 (425µm)	30max	50max	51min	-------	-------	-------	-------	-------	-------	-------	-------
No. 200 (75 µm)	15max	25max	10max	35max	35max	35max	35max	36min	36min	36min	36min
Characteristics of fraction passing No. 40 (425µm)											
Liquid limit	--------		--------	40max	41min	40max	41min	40max	41min	40max	41min
Plasticity index	6max		N.P	10max	10max	11min	11min	10max	10max	11min	11min
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30

5. (a) For each compaction procedure, there is an optimum moisture content, which corresponds to the maximum dry unit weight or maximum state of compactness. With the help of sketches, explain why moisture content is very important in a soil compaction.

[4 marks]

(b) Every soil type behaves differently with respect to maximum dry unit weight and optimum moisture content when compacted. With the help of sketches, explain the effects of different soil types on compaction.

[4 marks]

(c) The results of a standard proctor compaction test using 2.5 kg hammer are given in Table 3. The weight of the compaction mould is 11.1 N and the volume is 994 cm^3 (Specific gravity of the soil, $G_s = 2.70$).

(i) Plot the curve of dry unit weight against moisture content and determine the optimum moisture content.

(ii) If the natural moisture content in the field is 11.5%, what will be the possible maximum dry unit weight if the soil is compacted with its natural moisture content?

(iii) If 95% of standard proctor compaction is needed for the earthwork, determine the dry unit weight and moisture content from the results of Table 3.

(iv) When the compaction work is completed at the site with same soil as above, it was found that the dry unit weight of the soil, γ_d = 16.0 kN/m^3. As an engineer at site, decide whether further compaction is needed or not if 95% of standard compaction for the earthwork as stated in the JKR standard is used.

Table 3: Result of a standard proctor compaction test

Weight of mould + wet soil (N)	27.3	30	31.6	32.2	31.9	31.4
Moisture content (%)	8.1	9.9	12.0	14.3	16.1	18.2

[12 marks]

6. (a) List down **FOUR (4)** main parameters in the calculations involving consolidation and describe the techniques related to each of those parameters. Use Sketches and diagram to support your explanation.

[5 marks]

(b) Starting from a phase diagram and on with other basic theories of consolidation, describe relationships between consolidation settlement and other basic consolidation parameters.

[5 marks]

(c) A site for construction of a housing project in Seri Ampangan, Pulau Pinang needed an enormous fill to provide the required embankment for a foundation. The initial stress on the clay layer before any construction of an embankment was found to be 120 kN/m^2. An additional stress to the clay layer due to the construction of the embankment is estimated to be around $80kN/m^2$. The thickness of the clay layer was 6 m and overlaid and under laid by thick sand layers. If the initial void ratio of the clay layer is 0.98, coefficient of consolidation is 0.54 m^2/month and the compressibility index is 0.30, determine :-

(i) The total settlement due to the consolidation process of the clay layer from construction of the embankment.

[3 marks]

(ii) Estimate the time to achieve 50 %, 75 % and 90 % consolidation.

[3 marks]

(iii) The time to achieve 125 mm settlement after construction of the embankment.

[4 marks]

1. (a) *Apakah perbezaan diantara tegasan jumlah dan tegasan berkesan? Berikan persamaan untuk kedua-dua parameter tersebut dengan melukis gambarajah jasad bebas untuk profil tanah.*

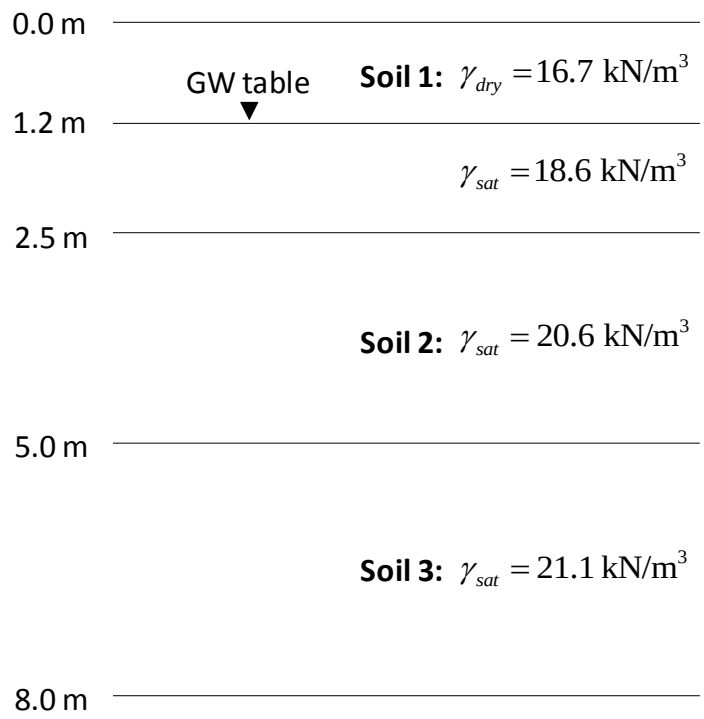
[6 markah]

(b) *Berdasarkan kepada penyiasatan tapak di lapangan, profil tanah sebagaimana yang ditunjukan pada Rajah 1 diperolehi.*

(i) *Plotkan variasi tegasan jumlah, tekanan liang dan tegasan berkesan dengan kedalaman*

(ii) *Dengan mengandaikan kewujudan zon kenaikan rerambut diantara 1.2-2.5 m, oleh itu kedudukan paras air mungkin berada disuatu kedudukan lain daripada yang ditunjukkan di Rajah 1, kira tegasan berkesan pada kedalaman 1.2 m dan 2.5 m (Darjah ketepuan, S = 50%, graviti tentu, G_s=2.6 dan nisbah lompang, e=0.6)*

[14 marks]



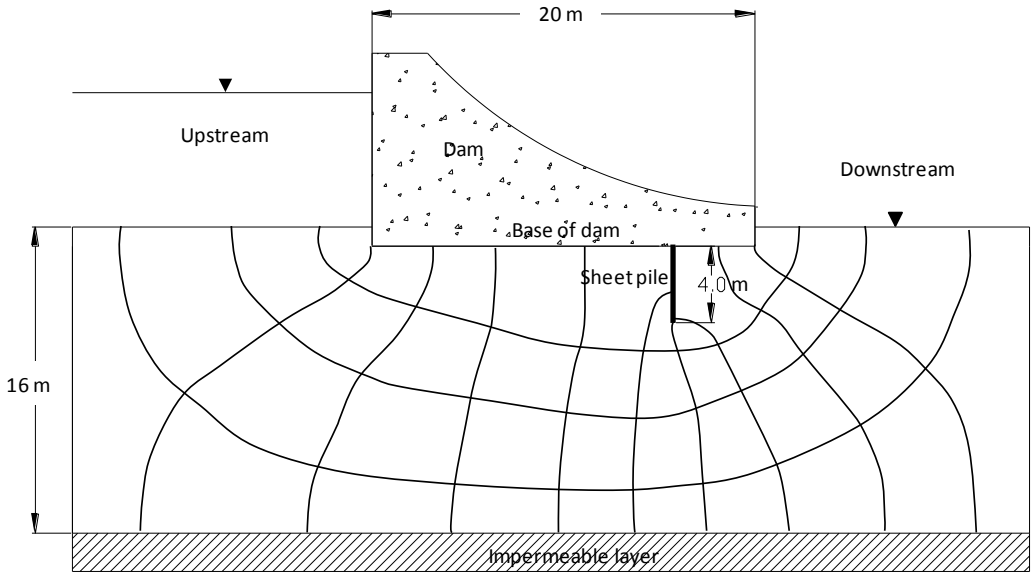
Rajah 1: Profil tanah

2. (a) *Jelaskan apakah yang dimaksudkan dengan jaringan aliran dan kenapa ianya penting di dalam analisa permasalahan aliran di dalam tanah.*

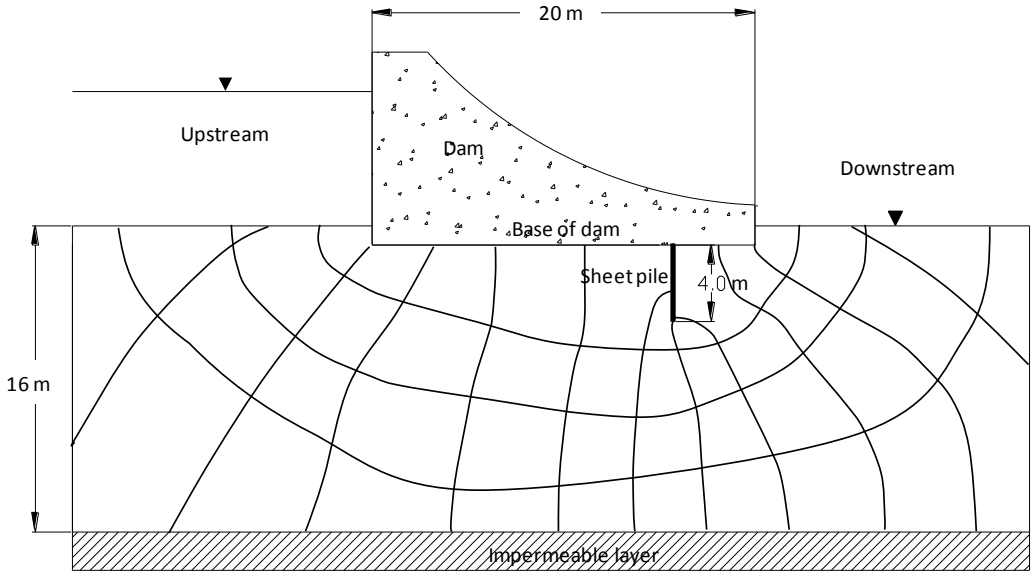
[4 markah]

(b) *Antara dua jaringan aliran yang dilakarkan di dalam lapisan tanah boleh telap di bawah keratan empangan di Rajah 2, yang mana satu jaringan aliran yang lebih sesuai dan jelaskan sebabnya.*

[4 markah]



(a)



(b)

Rajah 2: Lakaran jaringan aliran di bawah keratan empangan

(c) *Lukiskan semula jaringan aliran di Rajah 2 iaitu jaringan aliran dibawah empangan tersebut, dengan kedalaman air di bahagian hulu 8 m lebih tinggi daripada dasar empangan dan dibahagian hilir 1 m lebih tinggi daripada dasar empangan. Tentukan kehilangan air melalui resipan di bawah empangan tersebut setiap tahun jika keberaliran hidraulik, $k = 4 \times 10^{-6}$ m/s dan panjang empangan tersebut serenjang dengan satah resipan = 250 m.*

[12 markah]

3. (a) *Kebanyakan struktur yang dibina pada tanah lempung yang mempunyai mineral seperti montmorilonit mempunyai masalah geoteknikal yang serius. Jelaskan kenapa montmorilonit mempunyai pengaruh besar terhadap ciri-ciri kejuruteraan tanah tersebut?*

[3 markah]

(b) *Daripada keputusan ujian makmal yang dijalankan keatas tanah lempung tak tepu, nisbah lompang adalah 0.79, darjah ketepuan adalah 0.93, dan graviti tentu pepejal adalah 2.70.*

(i) *Lakarkan gambarajah 3-fasa yang berkaitan dan terbitkan persamaan-persamaan yang menerangkan berat dan isipadu udara, air dan pepejal (Andaikan $V_{pepejal} = 1\ m^3$).*

(ii) *Tentukan berat unit kering, berat unit pukal, dan kandungan air sampel tersebut.*

[10 markah]

(c) *Daripada keputusan ujian makmal yang dijalankan, nisbah lompang maksima dan minima untuk suatu tanah berbutir kasar adalah 0.820 dan 0.520. Pada masa yang sama ujian ketumpatan lapangan yang dijalankan pada sampel tanah yang sama memberikan keputusan yang berikut; $\gamma_{bulk} = 17.5\ kN/m^3$; $w = 11.3\%$ dan $G_s = 2.6$. Tentukan ketumpatan nisbi tanah tersebut dan perihalkan secara kualitatif endapan tanah tersebut.*

[7 markah]

4. (a) *Jelaskan tujuan dan kepentingan pengelasan tanah di dalam kejuruteraan geoteknik. Kenapakah sistem pengelasan tanah berdasarkan kepada saiz butiran semata-mata merupakan kaedah yang lemah di dalam pengelasan tanah untuk tujuan kejuruteraan?*

[5 markah]

(b) *Apakah kriteria utama yang diperlukan untuk sistem pengelasan AASHTO?*

[3 markah]

(c) *Daripada keputusan analisis ayak, had cecair dan had plastik tanah seperti diberikan pada Jadual 1:*

(i) Plotkan lengkung agihan saiz-butiran

(ii) Tentukan pekali keseragaman (C_u)

(iii) Dengan membandingkan pekali keseragaman (C_u) yang diperolehi di (ii) dengan C_u=2.8 iaitu untuk suatu sampel tanah yang lain, pilih tanah yang mempunyai saliran yang lebih baik dan jelaskan sebabnya.

(iv) Kelaskan tanah di dalam Jadual 1 dengan menggunakan sistem pengelasan AASHTO. Rujuk Jadual 2.

Jadual 1: Keputusan analisis ayak, had cecair dan had plastik tanah

Grain size (mm)	*Sieve size*	*% passing*
2.00	*10*	*100*
0.850	*20*	*99*
0.425	*40*	*91*
0.250	*60*	*61*
0.150	*100*	*25*
0.075	*200*	*15*
0.0065	-	*3*
0.001	-	*0.5*
For this soil, LL = 27% and PI = 15%		

[12 markah]

Jadual 2: Pengelasan tanah dan campuran agregat tanah oleh sistem pengelasan AASHTO

General classification	Granular materials (35% or less passing No. 200)							Silty-clay materials (More than 35% passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7 A-7-5 A-7-6
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				
Sieve analysis: % passing											
No. 10 (2.00 mm)	50max	--------	-------	-------	-------	-------	-------	-------	-------	-------	-------
No. 40 (425µm)	30max	50max	51min	-------	-------	-------	-------	-------	-------	-------	-------
No. 200 (75 µm)	15max	25max	10max	35max	35max	35 max	35max	36min	36min	36min	36min
Characteristics of fraction passing No. 40 (425µm)											
Liquid limit	--------		--------	40max	41min	40max	41min	40max	41min	40max	41min
Plasticity index	6max		N.P	10max	10max	11min	11min	10max	10max	11min	11min
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30

5. (a) *Bagi setiap tatacara pemadatan, terdapat kandungan lembapan optimum yang menghasilkan berat unit kering maksima atau keadaan kepadatan maksima. Dengan bantuan lakaran, jelaskan kenapa kandungan lembapan amat penting di dalam pemadatan tanah.*

[4 markah]

(b) *Setiap jenis tanah berkelakuan berbeza dengan merujuk kepada berat unit kering maksima dan kandungan lembapan optimum apabila dipadatkan. Dengan bantuan lakaran, jelaskan kesan jenis tanah yang berbeza terhadap pemadatan.*

[4 markah]

(c) *Keputusan ujian pemadatan piawai proctor dengan menggunakan 2.5 kg tukul diberikan seperti di dalam Jadual 3. Berat acuan pemadatan 11.1 kN dan isipadunya 994 cm^3. (Graviti tentu tanah tersebut, G_s = 2.70).*

(i) *Plot lengkungan berat unit kering melawan kandungan lembapan dan tentukan kandungan lembapan optimum.*

(ii) *Jika kandungan lembapan asli di lapangan 11.5%, apakah kemungkinan berat unit kering maksima jika tanah tersebut dimampatkan dengan kandungan lembapan aslinya?*

(iii) *Jika 95% pemadatan piawai diperlukan untuk kerja tanah, tentukan berat unit kering dan kandungan lembapan daripada keputusan ujian pemadatan piawai yang diberikan di dalam Jadual 3.*

(iv) *Apabila kerja pemadatan terhadap tanah yang sama seperti di atas selesai, didapati bahawa berat unit kering tanah tersebut,* γ_d *= 16.0 kN/m*^{3}*. Sebagai jurutera tapak, tentukan samada pemadatan tambahan diperlukan atau tidak sekiranya 95% pemadatan piawai untuk kerja tanah seperti yang dinyatakan di dalam piawaian JKR digunakan.*

Jadual 3: Keputusan ujian pemadatan proctor piawai

Weight of mould + wet soil (N)	*27.3*	*30*	*31.6*	*32.2*	*31.9*	*31.4*
Moisture content (%)	*8.1*	*9.9*	*12.0*	*14.3*	*16.1*	*18.2*

[12 markah]

6. (a) *Senaraikan Empat (4) parameter utama pengukuhan dan jelaskan teknik-teknik yang digunakan untuk memperolehi setiap parameter tersebut. Gunakan lakaran dan rajah untuk menyokong huraian anda.*

[5 markah]

(b) *Bermula daripada gambarajah fasa tanah dan teori asas proses pengukuhan tanah yang lain, nyatakan perhubungan di antara enapan pengukuhan dengan parameter-parameter asas yang lain.*

[5 markah]

(c) *Satu tapak pembinaan untuk suatu projek perumahan di Seri Ampangan, Pulau Pinang memerlukan suatu tambakan tanah yang besar sebagai asas. Tegasan awal pada lapisan lempung sebelum kerja-kerja tambakan tanah dijalankan adalah sekitar 120 kN/m^2. Tegasan tambahan ke atas tanah lempung disebabkan oleh tambakan tanah tersebut adalah dianggarkan sebesar 80 kN/m^2 . Lapisan tanah lempung adalah setebal 6 m yang dilapisi dan terdapat lapisan pasir diatas dan bawahnya. Sekiranya nisbah lompang asal tanah lempung adalah 0.98, pekali pengukuhan tanah adalah 0.54 m^2/bulan dan indek kebolehmampatan tanah lempung adalah 0.30, tentukan:-*

(i) *Jumlah enapan pengukuhan yang akan berlaku keatas lapisan tanah lempung disebabkan oleh kerja-kerja penambakan tanah.*

[3 markah]

(ii) *Masa untuk mencapai 50 %, 75 % and 90 % pengukuhan*

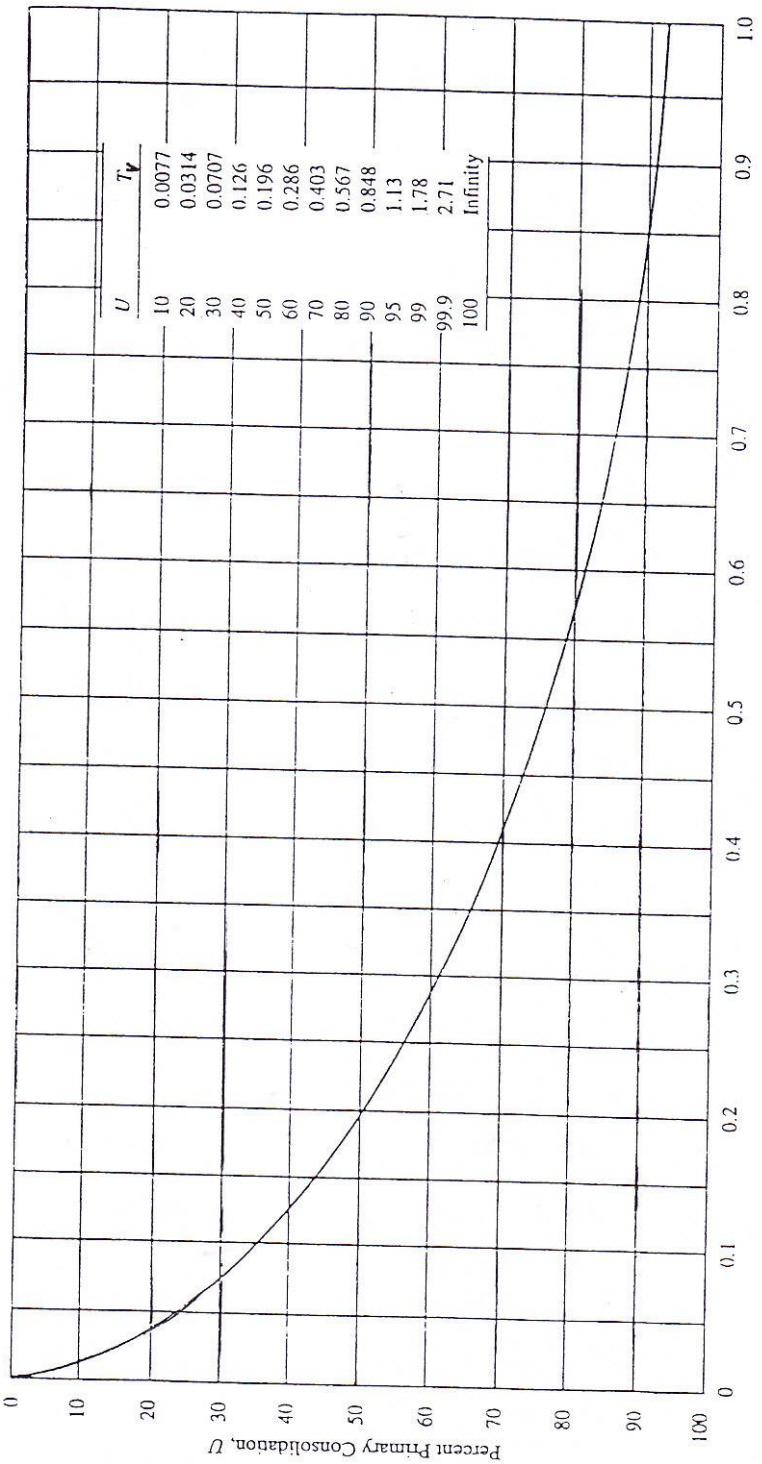
[3 markah]

(iii) *Masa untuk mencapai 125 mm enapan selepas kerja-kerja penambakan tanah.*

[4 markah]

Appendix

Lampiran



Time factor as a function of percentage of consolidation

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