First Semester Examination
2020/2021 Academic Session

February 2021

EAG245 – Soil Mechanics

Duration : 2 hours

Please check that this examination paper consists of **TEN (10)** pages of printed material including appendix before you begin the examination.

Instructions: This paper contains **FOUR (4)** questions. Answer **ALL** questions.

All questions **MUST BE** answered on a new page.

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1. (a). A concrete slab for a new walkway at the School of Civil Engineering Laboratory, USM, will be built on the fine-grained soil. Given the liquid limit, LL, and Plastic limit, PL obtained from the Atterberg limit test, 280%, and 60%. The water content of the soil obtained at the site is 85%. The clay content from the soil sample obtained from X-ray diffraction analysis is 65%.

(i). Calculate the Plasticity Index, PI, and the activity of soil.

[4 marks]

(ii). Based on the calculation obtained in (i) and the information given in **Appendix 1**, interpret the soil state at the site.

[5 marks]

(iii). The maximum groundwater table might reach 0.5 m below the concrete slab during the rainy season and as low as 2 m during the dry season. With the help of sketches, examine the common condition that might happen to the concrete slab after two years.

[6 marks]

(b). A fall cone test was carried out on the marine clay obtained at the construction site of the new McDonald's restaurant at Batu Kawan. The result of the test is given in **Table 1**.

Table 1

Liquid Limit (Fall Cone Test)				
Container No.	1	2	3	4
Penetration (mm)	12.3	17.4	21.9	27.1
Mass of wet soil + container (g)	19.70	22.50	25.80	33.10
Mass of dry soil + container (g)	18.50	20.10	21.70	25.20
Mass of container (g)	9.9	9.9	9.9	9.9

(i). Determine the moisture content for all the soil samples

[6 marks]

(ii). Plot the results of the Fall Cone test and determine the liquid limit of the soil

[4 marks]

2. (a). A soil sample taken during the earthwork for the new development KXP Airport at Kulim, Kedah, is used to classify the soil further. The result of one of the sieve analyses is given in **Table 2**.

Table 2

Sieve No.	**Sieve Size (mm)**	**Weight Retained (g)**
4	4.750	94.3
8	2.360	53.6
16	1.180	55.2
30	0.600	105.2
40	0.425	66.1
50	0.300	68.3
100	0.150	107.8
200	0.075	30.8
Pan	-	18.5

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(i). Calculate the percent finer (%) from the amount of weight retained (g) given in **Table 2**. From the result, plot the grain size distribution curve.

[8 marks]

(ii). Describe the soil's drainage condition based on the calculated uniformity coefficient, $C_{u,}$ and coefficient of curvature, C_c.

[4 marks]

(iii). Classify the soil using the Unified Soil Classification System (USCS) (**Refer to Appendix 2**)

[5 marks]

(b). A site investigation was conducted in a new development area near Simpang Lima, Parit Buntar, Perak, to study soil conditions at a construction site. A soil sample was collected using a cylinder with a volume of 0.000196 m^3, 1.5 m below the ground. Given the bulk unit weight of the soil, γ_b, 14.91 kN/m^3, water content, 65%, and specific gravity, G_s, 2.5.

(i). Determine the weight of the solid, W_s

[4 marks]

(ii). Determine the volume of air (V_a)

[4 marks]

3. A compaction work is conducted for a development project in the city area. Based on the current earthwork, the dry density of the soil is 1.555 g/cm^3. **Table 3** shows the result of the standard compaction for the sample taken from the site prior to earthwork.

Table 3

Bulk Unit Weight (kN/m^3)	15.0	16.5	18.5	18.5	18.0
Water Content (%)	10.0	12.5	15.0	17.5	20.0

(a). Based on the result of standard compaction test given in **Table 3,**

(i). Determine whether the current dry density exceeds the maximum dry density of the soil.

[5 marks]

(ii). Determine unit weight and water content at 95% standard compaction.

[4 marks]

(iii). Explain how the obtained 95% standard compaction value is to be used by the contractor for the earthwork and the consultant in approving the compaction work.

[10 marks]

(b). Explain **ONE (1)** method of obtaining dry unit weight by field test with the help of a sketch.

[6 marks]

4. (a). Starting from a phase diagram and the other basic theory of consolidation, define the relationship between the consolidation settlement with the other basic parameters.

[5 marks]

(b). Explain one of the methods used to obtain the value of Degree of Consolidation starting from laboratory testing.

[5 marks]

(c). During the construction of a highway bridge, it is expected that the average permanent load on a clay layer will increase by about 180 kPa. The average effective overburden pressure at the middle of the clay is 200 kPa. Given stratum thickness, H_c= 7 m, Consolidation Coefficients, C_v = 0.38 m^2/month, Initial void ratio, e_o = 0.98, Compression Index, C_c = 0.45 and the clay is normally consolidated.

(i). Determine the surcharge needed to eliminate the entire primary consolidation in 8 months. Use **Appendix 3** below to solve the problem.

[10 marks]

(ii). Suggest **ONE (1)** best method to reduce the time and amount of surcharge to eliminate the entire primary consolidation.

[5 marks]

APPENDIX 1

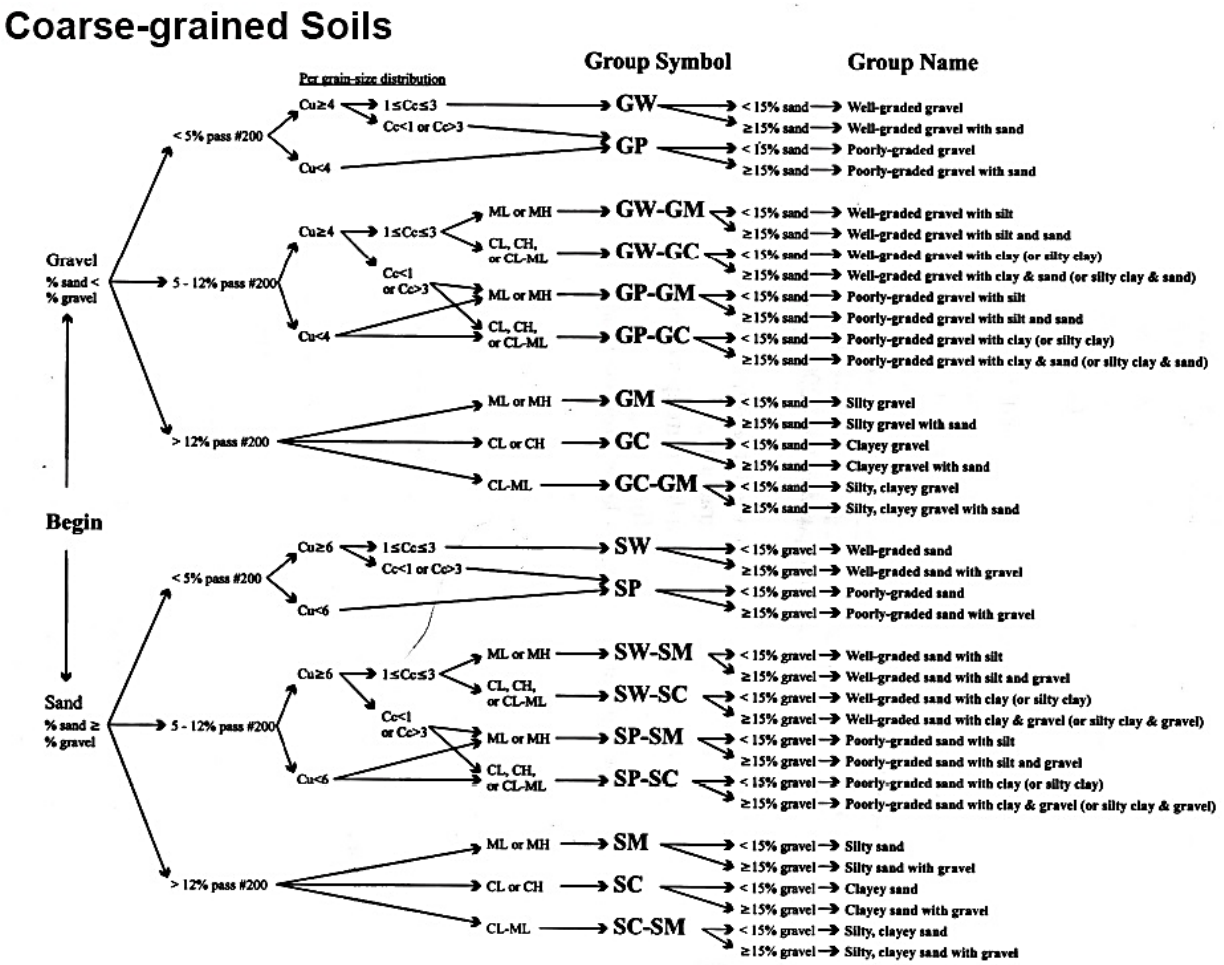
Typical Atterberg Limits for soils

Soil type	LL (%)	PL (%)	PI (%)
Sand		Nonplastic	
Silt	30–40	20–25	10–15
Clay	40–150	25–50	15–100
Minerals			
Kaolinite	50–60	30–40	10–25
Illite	95–120	50–60	50–70
Montmorillonite	290–710	50–100	200–660

The activity of clay soils

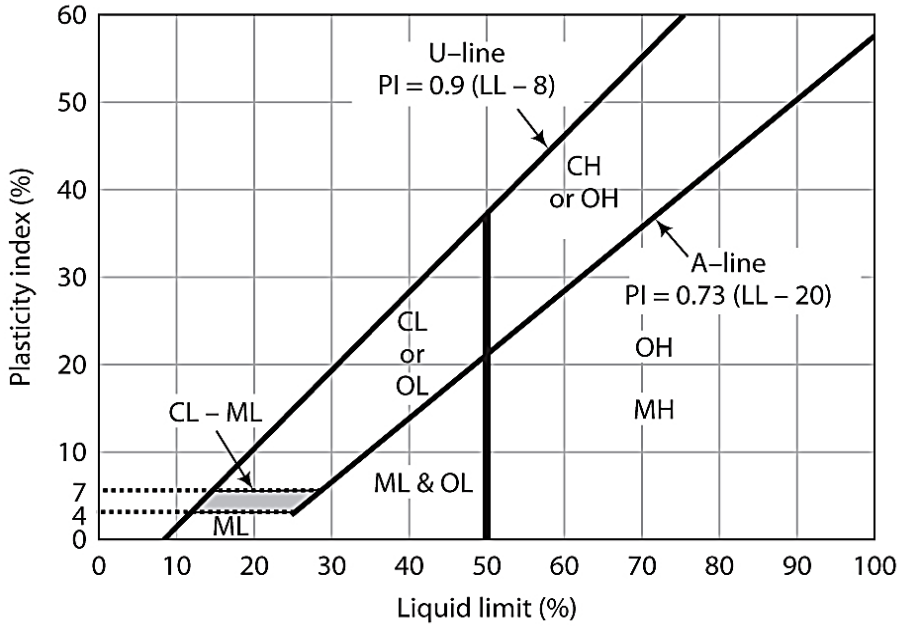
Description	Activity, *A*
Inactive	<0.75
Normal	0.75–1.25
Active	1.25–2
Very (highly) active (e.g., bentonite)	>6
Minerals	
Kaolinite	0.3–0.5
Illite	0.5–1.3
Na-montmorillonite	4–7
Ca-montmorillonite	0.5–2.0

APPENDIX 2


Coarse-grained Soils
Group Symbol
Group Name
Per grain-size distribution
Gravel
% sand < % gravel
Begin
Sand
% sand ≥ % gravel
< 5% pass #200
5 - 12% pass #200
> 12% pass #200
Cu≥4
Cu<4
1≤Cc≤3
Cc<1 or Cc>3
Cu≥6
Cu<6
ML or MH
CL, CH, or CL-ML
CL or CH
CL-ML
GW
GP
GW-GM
GW-GC
GP-GM
GP-GC
GM
GC
GC-GM
SW
SP
SW-SM
SW-SC
SP-SM
SP-SC
SM
SC
SC-SM
< 15% sand
≥15% sand
< 15% gravel
≥15% gravel
Well-graded gravel
Well-graded gravel with sand
Poorly-graded gravel
Poorly-graded gravel with sand
Well-graded gravel with silt
Well-graded gravel with silt and sand
Well-graded gravel with clay (or silty clay)
Well-graded gravel with clay & sand (or silty clay & sand)
Poorly-graded gravel with silt
Poorly-graded gravel with silt and sand
Poorly-graded gravel with clay (or silty clay)
Poorly-graded gravel with clay & sand (or silty clay & sand)
Silty gravel
Silty gravel with sand
Clayey gravel
Clayey gravel with sand
Silty, clayey gravel
Silty, clayey gravel with sand
Well-graded sand
Well-graded sand with gravel
Poorly-graded sand
Poorly-graded sand with gravel
Well-graded sand with silt
Well-graded sand with silt and gravel
Well-graded sand with clay (or silty clay)
Well-graded sand with clay & gravel (or silty clay & gravel)
Poorly-graded sand with silt
Poorly-graded sand with silt and gravel
Poorly-graded sand with clay (or silty clay)
Poorly-graded sand with clay & gravel (or silty clay & gravel)
Silty sand
Silty sand with gravel
Clayey sand
Clayey sand with gravel
Silty, clayey sand
Silty, clayey sand with gravel

...9/-

General classification	Granular materials (35% or less of total sample passing No. 200)						
	A-1			*A-2*			
Group classification	*A-1-a*	*A-1-b*	*A-3*	*A-2-4*	*A-2-5*	*A-2-6*	*A-2-7*
Sieve analysis (percentage passing)							
No. 10	50 max.						
No. 40	30 max.	50 max.	51 min.				
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone fragments, gravel, and sand		Fine sand	Silty or clayey gravel and sand			
General subgrade rating	Excellent to good						



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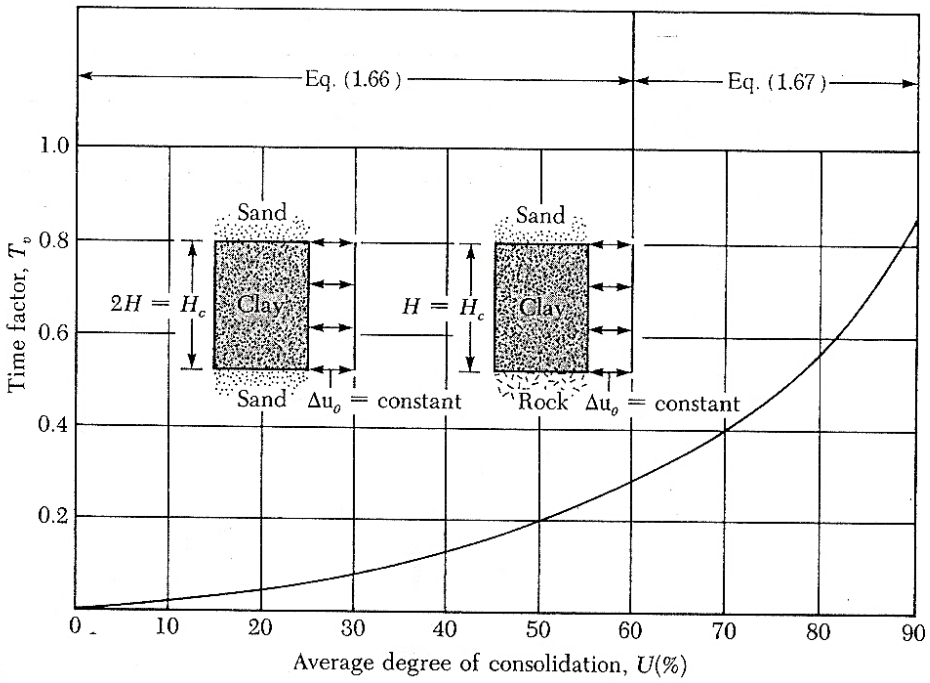
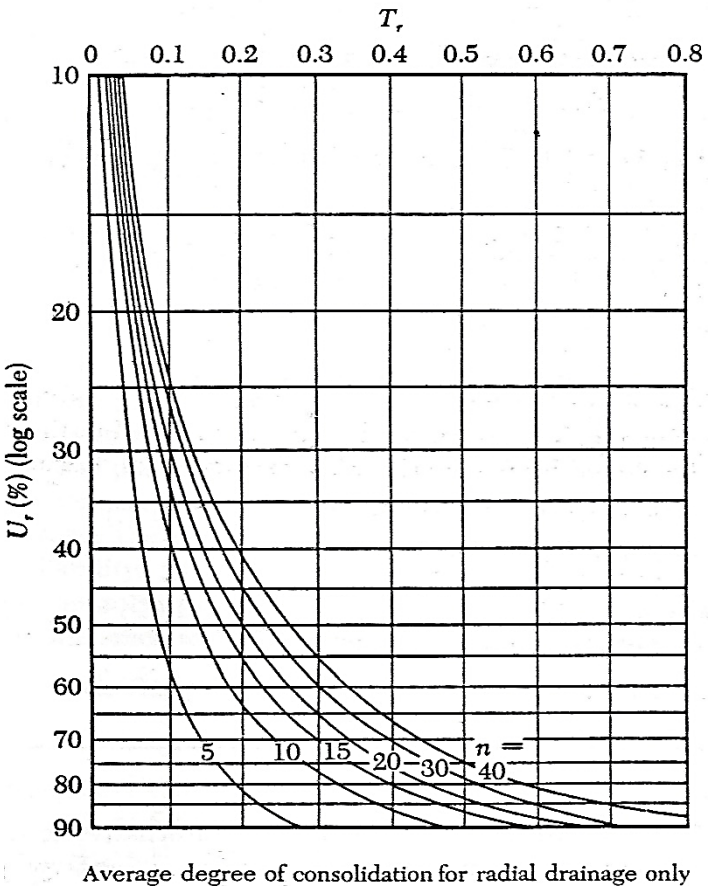
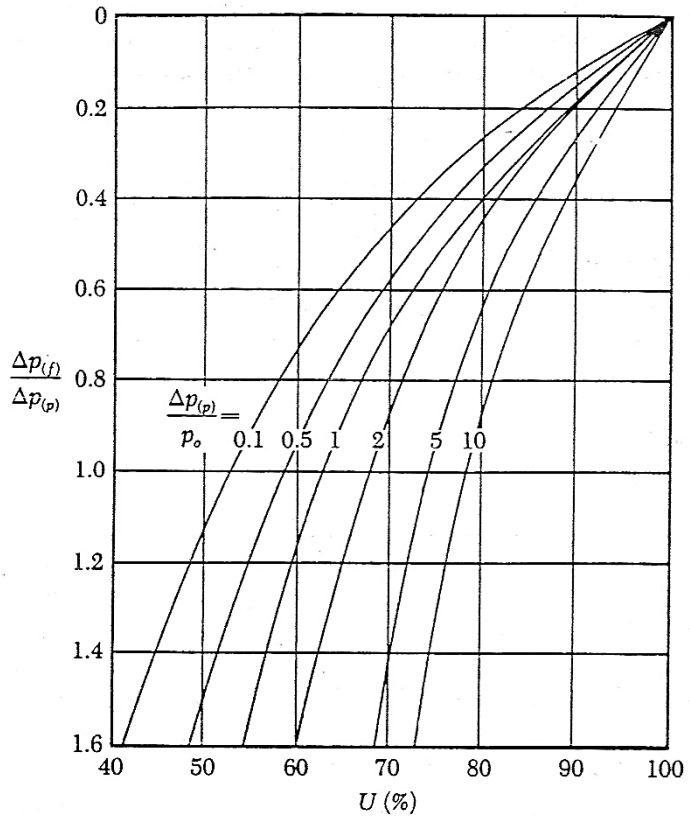
APPENDIX 3





Average degree of consolidation for radial drainage only



Plot of $\Delta p_{(f)}/\Delta p_{(p)}$ against U for various values of $\Delta p_{(p)}/p_o$

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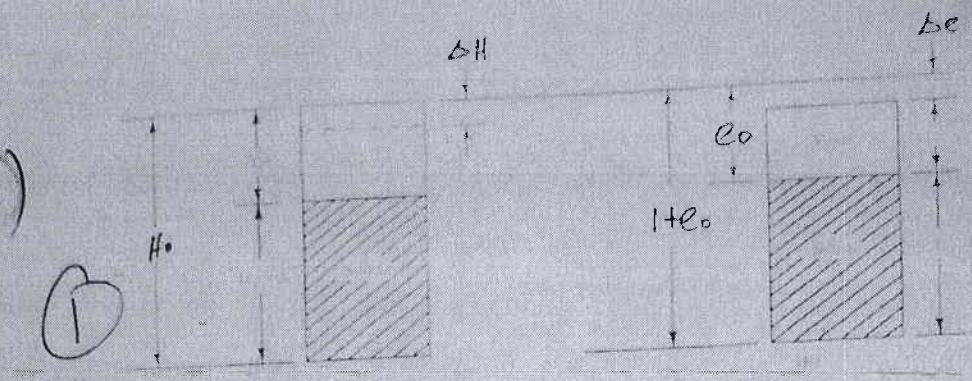
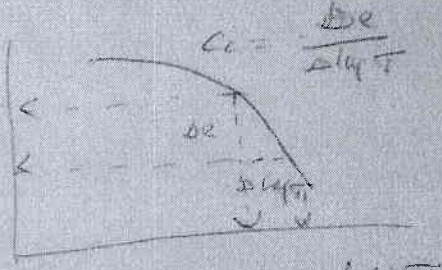
EAG 245

1 a)



(a) (b)

$$\frac{\Delta H}{H_0} = \frac{\Delta e}{1+e_0}$$



$$\therefore \Delta H = \frac{\Delta e}{1+e_0} H_0 \quad \cdots (1)$$

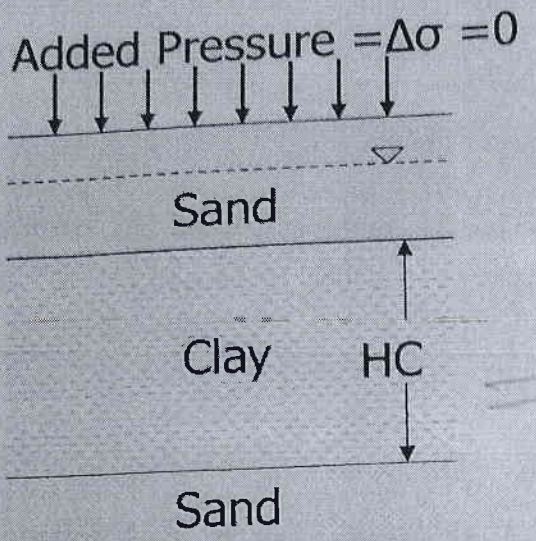
From $e - \log \sigma'$ Curve.

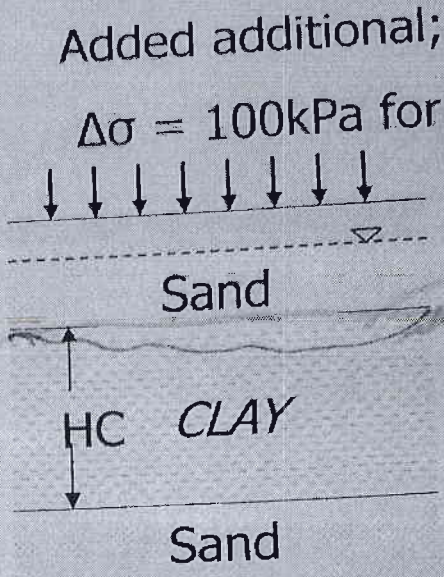
$$C_c = \frac{e_0 - e_1}{\log \sigma_1 - \log \sigma_0} = \frac{\Delta e}{\log(\sigma_1/\sigma_0)} \quad \cdots (2)$$

$$(2) \rightarrow (1): \quad \Delta H = \left(\frac{H_0}{1+e_0}\right) C_c \log \frac{\sigma_1}{\sigma_0}$$

Y MARKAH

1b





1.Original condition – without surcharge – subject to high settlement and will take a very long time to achieve 90% consolidation

2. AFTER ADDITIONAL SUCHARGE– WILL REDUCE THE TIME to achieve 90% consolidation

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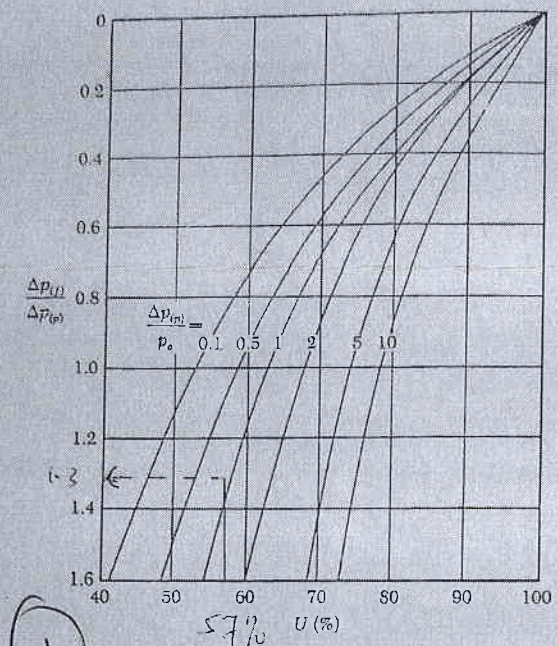
(1 c)



Plot of $\Delta p_{(t)}/\Delta p_{(s)}$ against U for various values of $\Delta p_{(s)}/p_o$

(1)

$c_v = 0.32 m^2/bulan$

$P_o' = 200 kPa$

$\Delta P_P = 180 kPa$

$T_V = \frac{c_v \cdot t}{H_d^2}$ (2)

for 90% consolidation

$t_{90} = \frac{0.848 \times 3.5^2}{0.38}$ bulan

$= 27.737$ bulan.

$\frac{\Delta P(t)}{P_o} = \frac{180}{200} = 0.90$

for $t = 8$ Months (2)

$T_V = \frac{0.38 \times 8}{3.5^2} = 0.248$

$\Rightarrow T_V = 0.248 \Rightarrow U = 57\%$

For $U = 57\%$, $\frac{\Delta P_P}{P_o} = 0.90$ (3)

$\Rightarrow \frac{\Delta P(t)}{\Delta P(p)} = 1.7$

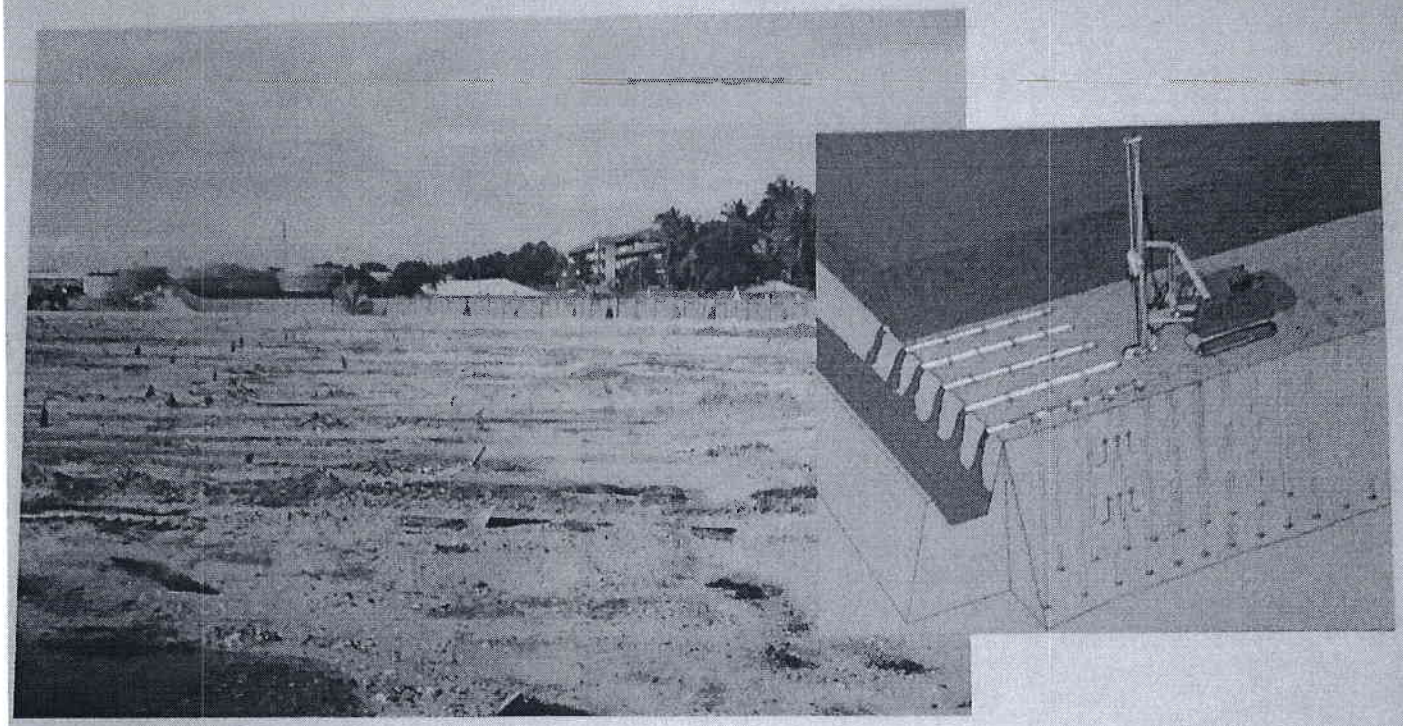
$\therefore \Delta P(t) = 1.7 \times 180$

$= 324 kPa$

9 MARKAH

(1 cm)

Solution....
Ground Improvement
One of it is Prefabricated Vertical Drains



- Explain concept of Ventical drain Techniques

4 MARKAH

ANSWER EAG245 SEM I 2020/2021 Harris Ramli

Question 1

a) the correct answer is 1.04 $x10^3$ cm/sec
if the answer is 1.45 $x10^3$ cm/sec, is wrong because using falling-head;

b) The correct test is constant-head because it is suitable for coarse size grain
calculate using q = kiA;

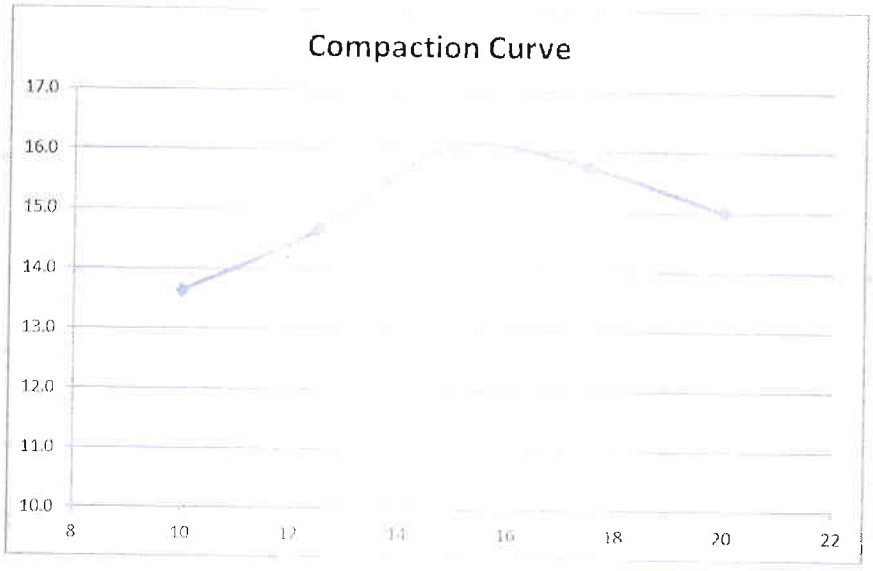
c) calculate using k = (Yw/n) $\overline{K}$
answer 8.19 $x10^9$ M^2

d) Soil Site C because have higher saturation. High saturation allow water easily flow between soil pores.

Question 2

(a) i) Max Dry Unit weigt

Water Content	Bulk Density	Dry Density
10	15.0	13.6
12.5	16.5	14.7
15	18.5	16.1
17.5	18.5	15.7
20	18.0	15.0



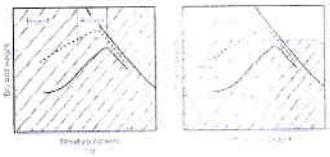
ii) Dry unit weight at 95%

At 95%, Dry density = 16.1 x 0.95 = 15.3 kN/m3

ii) Quality control during compaction work

Compaction Quality Control

- It is important that compaction of the fill ground is done properly.
- Normally the degree of compaction is clearly stated in the specification.
- The degree of compaction is normally defined as a percentage of the maximum dry density.



B) Any One field test;

Sand Cone – requires hole excavated weigh the soil removed and determine the volume of the hole with sand. This is done by filling the hole with a sand of known density.

Balloon Test – test apparatus consists of a graduated cylinder with a centrally placed balloon. The cylinder is filled with water to invert the balloon to fill the hole.

Nuclear Density meter - uses a radioactive source and "counter" to determine soil density. This method has fast results with the potential for a large number of tests in a short time.

Soil Mechanics - EAG 245

By: Dr. Mohd Ashraf Mohamad Ismail

Question 1

a) A concrete slab for a new walkway at the School of Civil Engineering Laboratory, USM, will be built on the fine-grained soil. Given the liquid limit, LL, and Plastic limit, PL obtained from the Atterberg limit test, 280%, and 60%. The natural water content of the soil obtained at the site is 85%. The amount of clay content from the soil sample obtained from X-ray diffraction analysis is 65%.

Papak konkrit untuk laluan pejalan kaki baharu akan dibina di Makmal Pusat Pengajian Kejuruteraan Awam, USM diatas tanah berbutir halus. Diberi, had cecair dan had plastik yang diperolehi daripada ujian had Atterberg, 280% dan 60%. Kandungan air semulajadi tanah tersebut di tapak 85%. Kandungan lempung sampel tanah tersebut diperolehi daripada analisis belauan sinar-X, 65%.

i. Calculate the Plasticity Index, PI, and the activity of soil. (4 marks)
Kirakan Indeks Keplastikan, PI dan aktiviti tanah tersebut. (4 markah)

$PI = LL-PL$

$PI = 280-60$

$PI = 220$

$$A = \frac{PI}{(\%\text{ of clay-size fraction by weight})}$$

$A = 220/65$

$A = 3.38$

ii. Based on the calculation obtained in (i) and the information given in Attachment 1, interpret the soil's soil state at the site. (5 marks)
Berdasarkan kepada pengiraan yang diperolehi di (i) dan maklumat yang diberikan di Lampiran 1, tafsirkan keadaan tanah tersebut di lapangan. (5 markah).

Description	Activity, *A*
Inactive	< 0.75
Normal	0.75–1.25
Active	1.25–2
Very (highly) active (e.g., bentonite)	> 6
Minerals	
Kaolinite	0.3–0.5
Illite	0.5–1.3
Na-montmorillonite	4–7
Ca-montmorillonite	0.5–2.0

Soil type	LL (%)	PL (%)	PI (%)
Sand		Nonplastic	
Silt	30–40	20–25	10–15
Clay	40–150	25–50	15–100
Minerals			
Kaolinite	50–60	30–40	10–25
Illite	95–120	50–60	50–70
Montmorillonite	290–710	50–100	200–660

Based on the PI = 220 and activity = 3.38, the clay mainly consists of Montmorillonite with active clay that susceptible to high swelling and shrinkage capacity. This might pose a significant problem to the structure founded on it.

iii. The maximum groundwater table might reach -0.5 m below the concrete slab during the rainy season and as low as -2 m during the dry season. With the help of a sketch, examine the common condition that might happen to the concrete slab after two years. (6 marks)

Paras airbumi maksimum akan naik sehingga -0.5 m dibawah papak konkrit tersebut semasa musim hujan dan serendah -2 m semasa musim kering. Dengan berbantukan lakaran, periksa kemungkinan keadaan yang mungkin terjadi terhadap papak konkrit tersebut selepas dua tahun. (6 markah)

Due to the high plasticity clay and the montmorilonite clay mineral's presence, the fine-grained soil might significantly shrink and swell. The higher the water content may cause the fine-grained soil to consolidate with time when put on loading by the concrete slab. The walkway will eventually settle, and cracking may occur due to the expandable montmorillonite clay as the foundation to the unstable foundation for the concrete slab.

b) A fall cone test was carried out on the marine clay obtain at the construction site of the new McDonald's restaurant at Batu Kawan. The result of the test is given in Table 1.

Ujian 'Fall Cone" telah dijalankan terhadap lempung laut yang diperolehi dari tapak pembinaan Restoran Mcdonald baharu di Batu Kawan, Pulau Pinang. Keputusan ujikaji tersebut diberikan di Jadual 1.

Table 1/*Jadual 1*

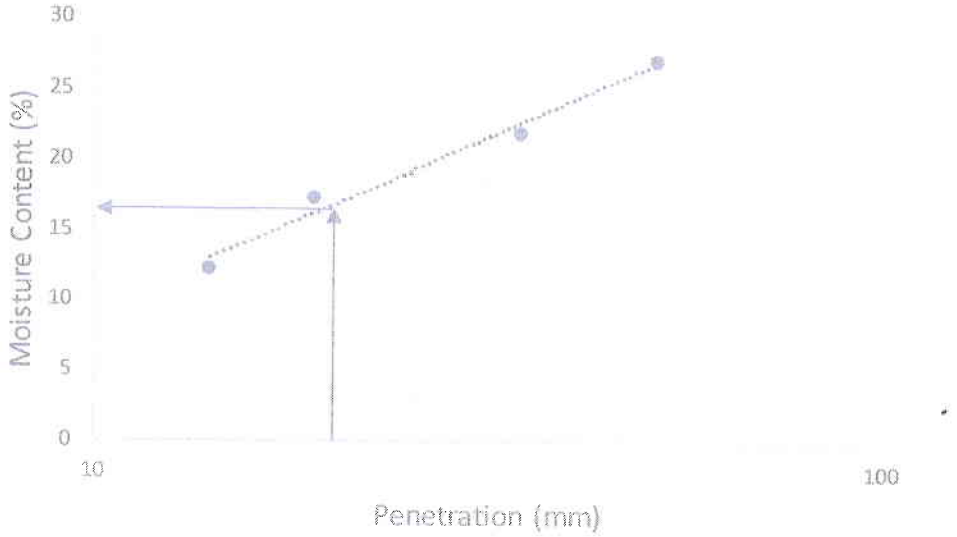
Liquid Limit (Fall Cone Test) *Had cecair (Ujian Tusukan Kon)*				
Penetration *Tusukan*	12.3	17.4	21.9	27.1
Container No. No. Bekas	1	2	3	4
Mass of wet soil + container (g) *Berat tanah lembab + bekas (g)*	19.70	22.50	25.80	33.10
Mass of dry soil + container (g) *Berat tanah kering + bekas (g)*	18.50	20.10	21.70	25.20
Mass of Container (g) *Berat Bekas* (g)	9.9	9.9	9.9	9.9

i. Determine the moisture content for all the soil samples (6 marks)

Tentukan kandungaan lembapan bagi kesemua sampel tanah tersebut.(4 markah)

Liquid Limit (Fall Cone Test) *Had cecair (Ujian Tusukan Kon)*				
Penetration *Tusukan*	12.3	17.4	21.9	27.1
Container No. No. Bekas	1	2	3	4
Mass of wet soil + container (g) *Berat tanah lembab + bekas (g)*	19.70	22.50	25.80	33.10
Mass of dry soil + container (g) *Berat tanah kering + bekas (g)*	18.50	20.10	21.70	25.20
Mass of Container (g) *Berat Bekas* (g)	9.9	9.9	9.9	9.9
Mass of solid (g)	8.6	12.6	11.8	15.3
Mass of water (g)	1.2	2.4	4.1	7.9
Water content, w (%)	14.0	19	34.7	51.6

ii. Plot the results of the Fall Cone test and determine the liquid limit of the soil (4 marks)
Plot keputusan ujian Tusukan Kon dan tentukan had cecair tanah tersebut. (4 markah)



LL = 17% at 20 mm penetration

Question 2

a) A soil sample taken during the earthwork for the new development KXP Airport at Kulim, Kedah, is used to classify the soil further. The result of one of the sieve analyses is given in Table 2.

Sampel tanah yang diambil semasa kerja-kerja tanah untuk pembangunan lapangan terbang KXP di Kulim, Kedah digunakan untuk mengelas tanah tersebut. Keputusan salah satu ujian analisis ayakan diberikan di Jadual 2.

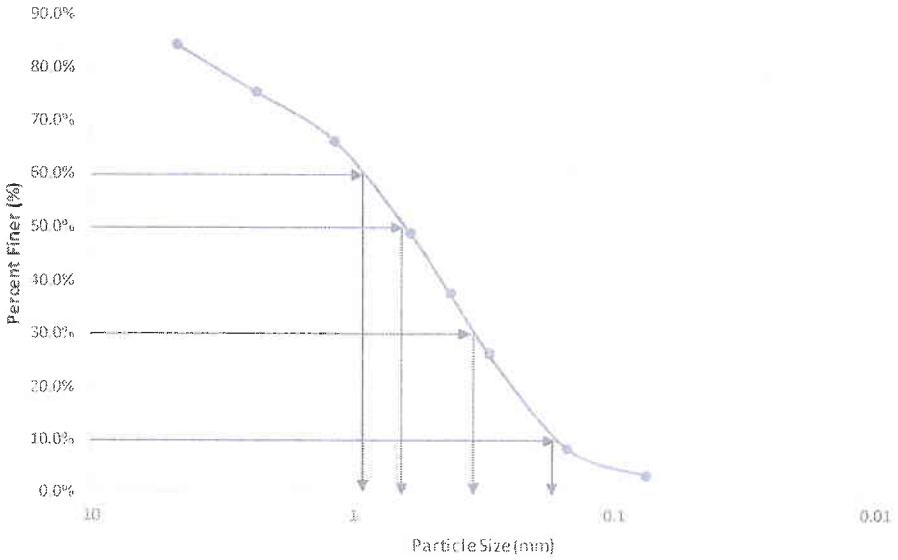
Table 2/ *Jadual 2*

Sieve No.	**Sieve Size (mm)** ***Saiz Ayakan***	**Weight Retained (g)** ***Berat Tertahan***
4	4.750	94.3
8	2.360	53.6
16	1.180	55.2
30	0.600	105.2
40	0.425	66.1
50	0.300	68.3
100	0.150	107.8
200	0.075	30.8
Pan	-	18.5

i. Calculate the percent finer (%) from the amount of weight retained (g) given in Table 2. From the result, plot the grain size distribution curve. (8 marks)

Kirakan peratus halus (%) daripada jumlah berat tertahan (g) yang diberikan di Jadual 2. Daripada keputusan yang diperolehi, plot lengkungan agihan saiz butiran.

Sieve No.	Opening size (mm)	Weight retained (g)	Cumulative weight retained (g)	Cumulative weight passing (g)	Percent Finer (%)
4	4.75	94.3	94.3	505.5	84.3%
8	2.36	53.6	147.9	451.9	75.3%
16	1.18	55.2	203.1	396.7	66.1%
30	0.6	105.2	308.3	291.5	48.6%
40	0.425	66.1	374.4	225.4	37.6%
50	0.3	68.3	442.7	157.1	26.2%
100	0.15	107.8	550.5	49.3	8.2%
200	0.075	30.8	581.3	18.5	3.1%
Pan	-	18.5	599.8	0	0.0%



ii. Describe the soil's drainage condition based on the calculated uniformity coefficient, C_u, and Coefficient of Curvature, C_c. (4 marks)

Kirakan pekali keseragaman, C_u dan pekali kelengkugan, C_c tanah tersebut. (4 marks)

$D_{10} = 0.18$

$D_{30} = 0.35$

$D_{50} = 0.65$

$D_{60} = 0.97$

$Cu = 5.4$

$Cc = 0.7$

Poorly graded sand – good drainage condition

iii. Classify the soil using the Unified Soil Classification System (USCS) (Refer to Attachment 2) (5 marks)

Kelaskan tanah tersebut dengan menggunakan Unified Soil Classification System (USCS) (Rujuk Lampiran2) (5 markah)

Poorly graded sand with gravel (SP)

b) A site investigation was conducted in a new development area near Simpang Lima, Parit Buntar, Perak, to study soil conditions at a construction site. A soil sample was collected using

a cylinder with a volume of 0.000196 m^3, 1,5 m below the ground. Given the bulk unit weight of the soil, γ_b, 14.91 kN/m^3, water content, 65%, and specific gravity, Gs, 2.5.

Penyiasatan tapak telah dijalankan di kawasan pembangunan baru berdekatan dengan Simpang Lima, Parit Buntar, Perak untuk mengkaji keadaan tanah di tapak bina. Sampel tanah telah diambil dengan menggunakan silinder dengan isipadu 0.000196 m^3, 1.5 di bawah permukaan. Diberi berat unit pukal tanah tersebut, γ_b, 14.91 kN/m^3, kandungan air, w 65% dan graviti tentu, Gs, 2.5.

i. Determine the weight of the solid, W_s (4 marks)
   Tentukan berat pepejal, W_s (3 markah)

ii. Determine the volume of air (V_a) (4 marks)
   Tentukan isipadu udara, V_a (3 markah)

Volume of sample = 0.000196 m^3

Unit weight of soil γ_b = 14.91 kN/m^3

Water content, = 65%,

Specific gravity, Gs, = 2.5

Draw the phase diagram and show the derivation to obtain the basic phase-volume relationship.

Ws= 1.77 N

Vs = 7.09x10-5

Vw = 1.153x10-4

Va = 9.81x10-6