First Semester Examination
Academic Session 2018/2019

December 2018/January 2019

EAG245 – Soil Mechanics
(Mekanik Tanah)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **SEVENTEEN (17)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH BELAS (17)** 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.]*

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

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

(1). (a). The water content of one of the saturated clay samples from the new Parit Buntar Hospital, Simpang Lima construction site had changed due to the improper sealing during the transportation of the soil samples from the site to the Geotechnical Laboratory, School of Civil Engineering. From the initial tests carried out, the void ratio of the soil is 0.7 and the specific gravity is 2.65.

Kandungan air salah satu sampel tanah tepu dari tapak pembinaan Hospital Parit Buntar, Simpang Lima telah berubah disebabkan oleh pengedap yang tidak sempurna semasa pengangkutan sampel tanah tersebut daripada tapak ke Makmal Geoteknik, Pusat Pengajian Kejuruteraan Awam. Dari ujian awal yang telah dijalankan, nisbah lompang tanah tersebut, 0.7 dan graviti tentu, 2.65.

(i) Draw **TWO (2)** different phase diagrams for 3-phase system of the unsaturated soil sample by deriving the equations of weight-volume relationships for each of the soil phase. Assumed $V_s = 1$ and V=1.

*Lakarkan **DUA (2)** gambarajah fasa yang berlainan bagi sistem 3-fasa sampel tanah tidak tepu tersebut dengan menerbitkan persamaan hubungan berat-isipadu bagi setiap fasa tanah. Andaikan $V_s = 1$ dan V=1.*

[8 marks/*markah*]

(ii). Determine the change in degree of saturation of one of the soil sample if its water content had changed from 26% to 21% during the transportation of the soil samples.

Tentukan perubahan darjah ketepuan bagi salah satu sampel tanah tersebut jika kandungan airnya telah bertukar daripada 26% kepada 21% semasa pengangkutan sampel tanah tersebut.

[4 marks/*markah*]

(b). A fall cone test was carried out on the clay obtained at the construction site of new condominium in Batu Kawan, Penang. The result of the test is given in **Table 1**.

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

Table 1/*Jadual 1*

Penetration / *Penusukan* (mm)	8	13	19	27
Water content / *Kandungan Air* (%)	42.0	51.5	59.0	66.0

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

Plot keputusan ujian 'Fall Cone' dan tentukan had cecair tanah tersebut.

[4 marks/*markah*]

(ii). Assuming the water content of the soil at site is 52%, calculate the Liquidity Index of the soil.

Dengan mengandaikan kandungan air tanah di tapak adalah, 52%, tentukan indeks kecairan tanah tersebut.

[4 marks/*markah*]

(2). (a). A soil sample taken during the earthwork for new highway project is used to further classify the soil. The result of one of the sieve analysis test is given in **Table 2**.

Sampel tanah yang diambil semasa kerja-kerja tanah untuk pembinaan lebuhraya baru digunakan untuk mengelas tanah tersebut. Keputusan salah satu ujian analisis ayakan diberikan di ***Jadual 2.***

Table 2/ *Jadual 2*

Sieve No. ***Nombor Ayakan***	**Sieve Size (mm)** ***Saiz Ayakan (mm)***	**Weight Retained (g)** ***Berat Tertahan (g)***
4	4.75	0
10	2.00	15
20	0.850	98
40	0.425	90
100	0.150	182
200	0.075	109
Pan	-	6 (Silt- ML or MH)
Non-Plastic / *Bukan Plastik*		

(i). Plot the grain size distribution curve from the sieve analysis given in **Table 2**.

Plot lenkungan agihan saiz butiran daripada analisis ayakan yang diberikan di ***Jadual 2.***

[6 marks/*markah*]

(ii). Calculate the Uniformity coefficient, C_u and Coefficient of Curvature, C_c of the soil.

Kirakan pekali keseragaman, C_u dan pekali kelengkugan, C_c tanah tersebut.

[4 marks/*markah*]

(b). A soil sample from a road construction site is obtained from the borehole investigation. The details of the sieve analysis results are given in **Table 3**. Classify the soil using AASHTO Classification system **(Refer to Attachment 1)**.

*Sampel tanah dari satu tapak pembinaan jalan diperolehi daripada penyiasatan lubang gerek. Perincian keputusan analisis ayakan tersebut diberikan di **Jadual 3**. Kelaskan tanah tersebut dengan menggunakan sistem pengelasan AASHTO **(Rujuk Lampiran 1).***

Table 3/*Jadual 3*

Sieve No. / *No. Ayakan*	**Percent Passing / *Peratus melepasi (%)***
No 4 sieve	92
No 10 sieve	87
No 40 sieve	65
No 200 sieve	30
Liquid limit /*Had cecair*	22
Plasticity index /*Indeks keplastikan*	8

[4 marks/*markah*]

(c). The following results from Atterberg limit test on a soil sample collected from a soil boring investigation on a local site investigation at USM Engineering Campus are, LL = 50% and PL = 23%.

Keputusan daripada ujian Had Atterberg terhadap sampel tanah yang diperolehi daripada ujian lubang gerek di tapak Kampus Kejuruteraan USM adalah, LL = 50% and PL = 23%.

(i). Determine the Plasticity index of the soil.

Tentukan indeks keplastikan tanah tersebut.

[2 marks/*markah*]

(ii). If the soil is fine grained, classify the soil based on the USCS group symbol. (**Refer to Attachment 2**).

*Jika tanah tersebut adalah berbutir halus, kelaskan tanah tersebut berdasarkan simbol kumpulan USCS. (**Rujuk Lampiran 2**).*

[2 marks/*markah*]

(iii). If the soil had a natural water content of 56% prior to the Atterberg Limit test, explain the consistency condition of the soil at site.

Jika tanah tersebut mempunyai kandungan air semulajadi pada tahap 56% sebelum ujian Had Atterberg, jelaskan keadaan kekonsistenan tanah tersebut di tapak.

[2 marks/*markah*]

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(3). Continuous water resource is very important for urban water supply and in order to meet population growth demand, a ground water resource has been proposed for water supply. A site investigation has been conducted for this project, and a confined aquifer was found 20 meter below the ground level as shown in **Figure 1**. The ground water table was found at 8 meter underground.

Sumber air tanpa gangguan adalah sangat penting bagi bekalan air dan untuk memastikan bekalan yang cukup berdasarkan perkembangan populasi, sumber air bawah tanah telah dicadangkan sebagai bekalan air. Penyiasatan tapak telah dijalankan bagi projek ini, dan akuifer tertutup telah dijumpai pada kedalaman 20 meter dari permukaan tanah seperti ditunjukkan dalam ***Rajah 1****. Air bawah tanah mula dijumpai pada kedalaman 8 meter di bawah tanah.*

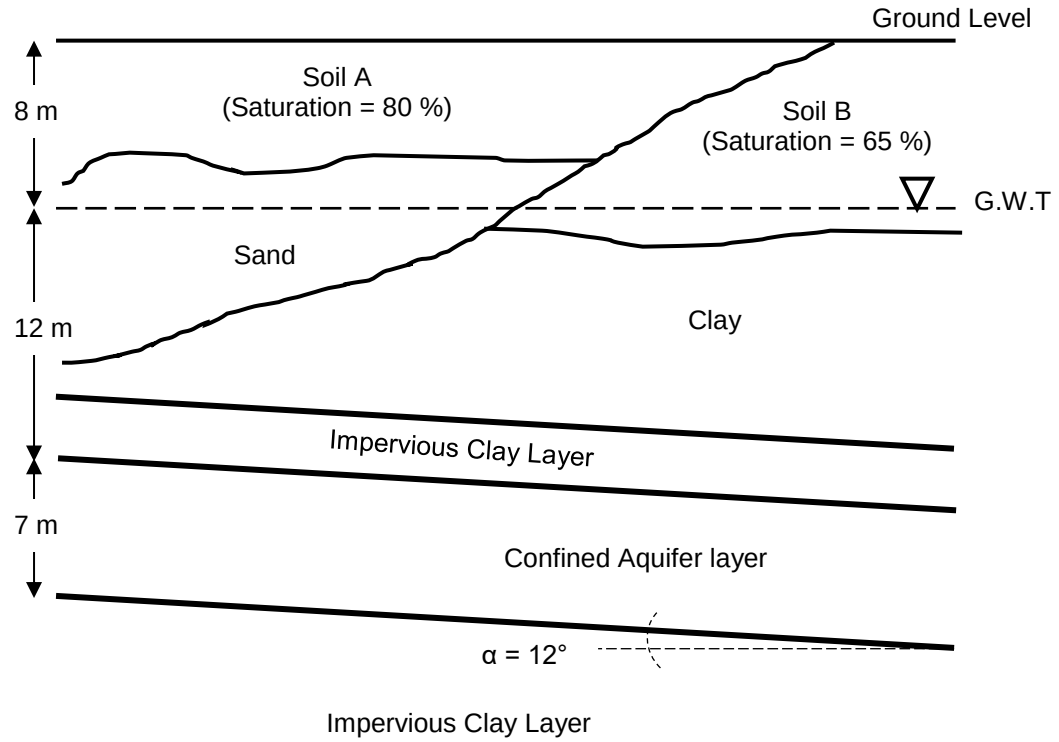


Figure 1/*Rajah 1*

(a). There are several factors affecting soil permeability and soil saturation is one of it. Between Soil A and Soil B, which soil would have a higher permeability? Discuss the mechanisms that contribute to a higher soil permeability of your chosen answer.

Terdapat beberapa faktor yang mempengaruhi ketelapan tanah dan kelembapan tanah adalah salah satunya. Antara Tanah A dan Tanah B, tanah yang manakah akan mempunyai ketelapan yang lebih tinggi? Bincangkan mekanisma yang menyumbang kepada ketelapan tanah yang tinggi bagi jawapan yang telah anda pilih.

[3 marks/*markah*]

(b). The type of soil plays important roles in estimating the range of soil hydraulic conductivity. Between Clay and Sand layer, which layer would have a higher soil hydraulic conductivity? Discuss the mechanisms that contribute to a higher soil hydraulic permeability of your chosen answer.

Jenis tanah memainkan peranan penting dalam membuat anggaran kepelbagaian kekonduksian hidraulik tanah. Antara lapisan tanah lempung dan lapisan pasir, lapisan yang manakah akan mempunyai kekonduksian hidraulik yang lebih tinggi? Bincangkan mekanisma yang menyumbang kepada kekonduksian hidraulik tanah yang tinggi bagi jawapan yang telah anda pilih.

[3 marks/*markah*]

(c). During soil investigation, a soil sample was taken from the aquifer and it is found the soil consists of course in granular. Suggest the suitable permeability test with justification of the chosen test.

Semasa penyiasatan tanah dilakukan, sampel tanah telah diambil daripada akuifer dan tanah tersebut didapati mempunyai tekstur yang berbutir. Cadangkan ujian kebolehtelapan yang sesuai dengan justifikasi pemilihan ujian tersebut.

[2 marks/*markah*]

(d). Prove that the hydraulic gradient, *i* of aquifer layer is *sin α*.

Buktikan kecerunan hidraulik, i bagi lapisan akuifer adalah sin α.

[2 marks/*markah*]

(e). Find the flow rate in m^3/sec/m length through the aquifer layer if the hydraulic conductivity is 0.005 cm/sec.

Cari kadar alir dalam m^3/saat/m panjang melalui lapisan akuifer sekiranya kekonduksian hidraulik adalah 0.005 cm/saat.

[6 marks/*markah*]

(f). Given the hydraulic conductivity of sand is 5 x 10^{-4} cm/sec. The viscosity of water at 25°C is 0.0789 x 10^{-4} g.sec.cm^2. Calculate the absolute permeability $\overline{K}$ of the sand.

Diberikan kekonduksian hidraulik bagi pasir adalah 5 x 10^{-4} cm/saat. Kelikatan air pada 25°C ialah 0.0789 x 10^{-4} g.saat.cm^2. Kira kebolehtelapan mutlak $\overline{K}$ bagi pasir.

[4 marks/*markah*]

(4). **Figure 2** illustrates **FOUR (4)** proposed sites for a housing development project.

Rajah 2 *menggambarkan* ***EMPAT (4)*** *tapak cadangan bagi projek pembangunan perumahan.*

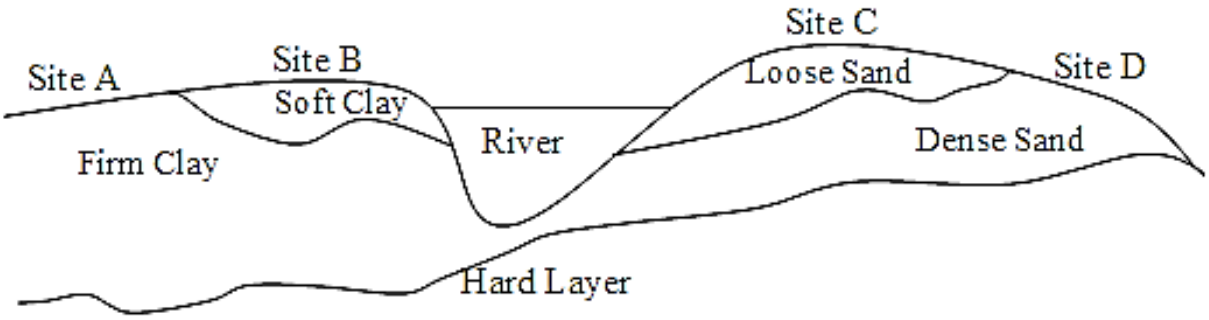


Figure 2/*Rajah2*

(a). Identify and give **ONE (1)** main reason for each site whether soil improvement using compaction is needed or not.

Kenalpasti dan berikan ***SATU (1)*** *sebab utama bagi setiap tapak sama ada pembaikan tanah menggunakan pemadatan diperlukan atau tidak.*

[6 marks/*markah*]

(b). Determine dry unit weight and water content at 95% standard compaction based on the result of a standard compaction test given in **Table 4**.

Tentukan berat unit kering dan kandungan air pada 95% pemadatan piawai berdasarkan keputusan ujian pemadatan piawai seperti di dalam ***Jadual 4.***

[8 marks/*markah*]

Table 4/*Jadual 4*

Bulk Unit Weight (kN/m^3) *Berat Unit Pukal (kN/m^3)*	20.0	20.7	21.7	21.4	21.1
Water Content (%) *Kandungan Air (%)*	8.0	9.5	11.5	12.5	13.5

(c). Describe effect of water content during compaction between 9.5% water content to 12.5% water content.

Terangkan kesan kandungan air ketika pemadatan antara 9.5% kandungan air hingga 12.5% kandungan air.

[6 marks/*markah*]

(5). A soil profile from the construction site at Gambang Industrial Zone as shown in **Figure 3** was determined from the borehole data profiling and result of laboratory.

*Sampel tanah daripada tapak pembinaan di Zon Penindustrian Gambang seperti yang ditunjukkan di **Rajah 3** ditentukan daripada data lubang jaradan keputusan ujian makmal.*

(a). Draw the phase diagram for each of the soil profiles from depth of 3-4.5 m and 4.5-7.5 m and derive the equations describing the weight-volume relationship of the soil.

Lukisan gambarajah fasa bagi setiap profil tanah pada kedalaman 3-4.5 m *dan* 4.5-7.5 m *dan terbitkan persamaan yang perlu yang menjelaskan hubungkait antara berat dan isipadu tanah tersebut.*

[8 marks/*markah*]

(b). Calculate and plot with graph paper the variation of total stress *(σ),* pore water pressure *(u)* and effective stress *(σ')* for the soil profile given in **Figure 3**.

*Kira dan plot perubahan tegasan jumlah (σ), tekanan air liang (u) dan tegasan berkesan (σ') dengan kedalaman bagi profil tanah yang diberikan di **Rajah 3**.*

[12 marks/*markah*]

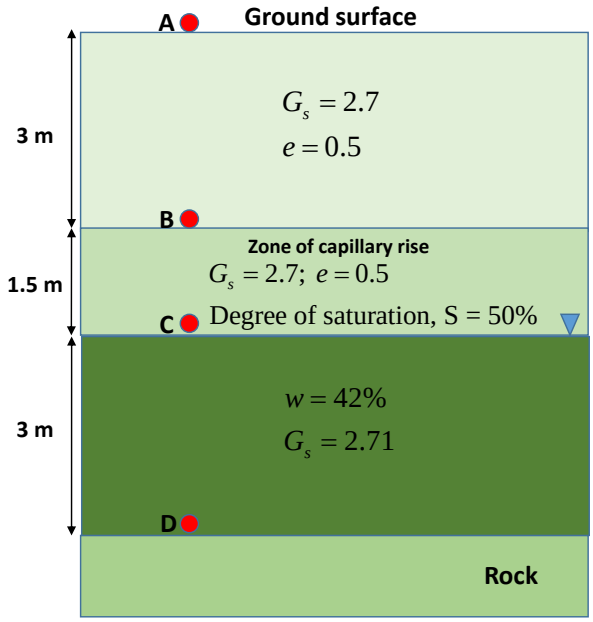


Figure 3/*Rajah 3*

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

Bermula dari gambarajah fasa tanah dan teori asas proses pengukuhan tanah, jelaskan perhubungan antara pengenapan pengukuhan dengan parameter asas pengukuhan yang lain.

[4 marks/*markah*]

(b). Explain the principles of precompression that is used to eliminate post construction settlement problem.

Terangkan prinsip pra-pengukuhan yang digunakan untuk menghapuskan masalah pengenapan selepas pembinaan.

[4 marks/*markah*]

(c). During the construction of a housing project, it is estimated that the average permanent load on a clay layer located at 6 m below ground surface will increase by about 200 kPa. The average effective overburden pressure at the middle of the 4.5 m thick clay is 100 kPa. The result from soil sampel testing givens the consolidation parameters e_o = 0.96, C_c = 0.45, C_v = 2.5 m^2/year, and the clay is in normally consolidated condition.

Semasa pembinaan satu projek perumahan, dianggarkan purata beban kekal ke atas lapisan tanah lempung yang berada 6 m di bawah paras permukaan tanah akan meningkat sebesar 200 kPa. Purata tekanan tanggungan atas di pertengahan lapisan tanah lempung tersebut setebal 4.5 m pada masa tersebut adalah adalah 100 kPa. Hasil Ujian ke atas sampel tanah memberikan nilai parameter pengukuhan tanah sebagai $e_o = 0.96$, $C_c = 0.45$, $C_v = 2.5\ m^2$*/tahun dan tanah lempung adalah dalam keadaan terkukuh biasa.*

(i) Estimate the total consolidation settlement that will happen and the time taken to achieve 90% consolidation stage.

Anggarkan jumlah pengenapan pengukuhan yang akan berlaku ke atas tanah lempung tersebut dan masa untuk mencapai tahap 90% pengukuhan

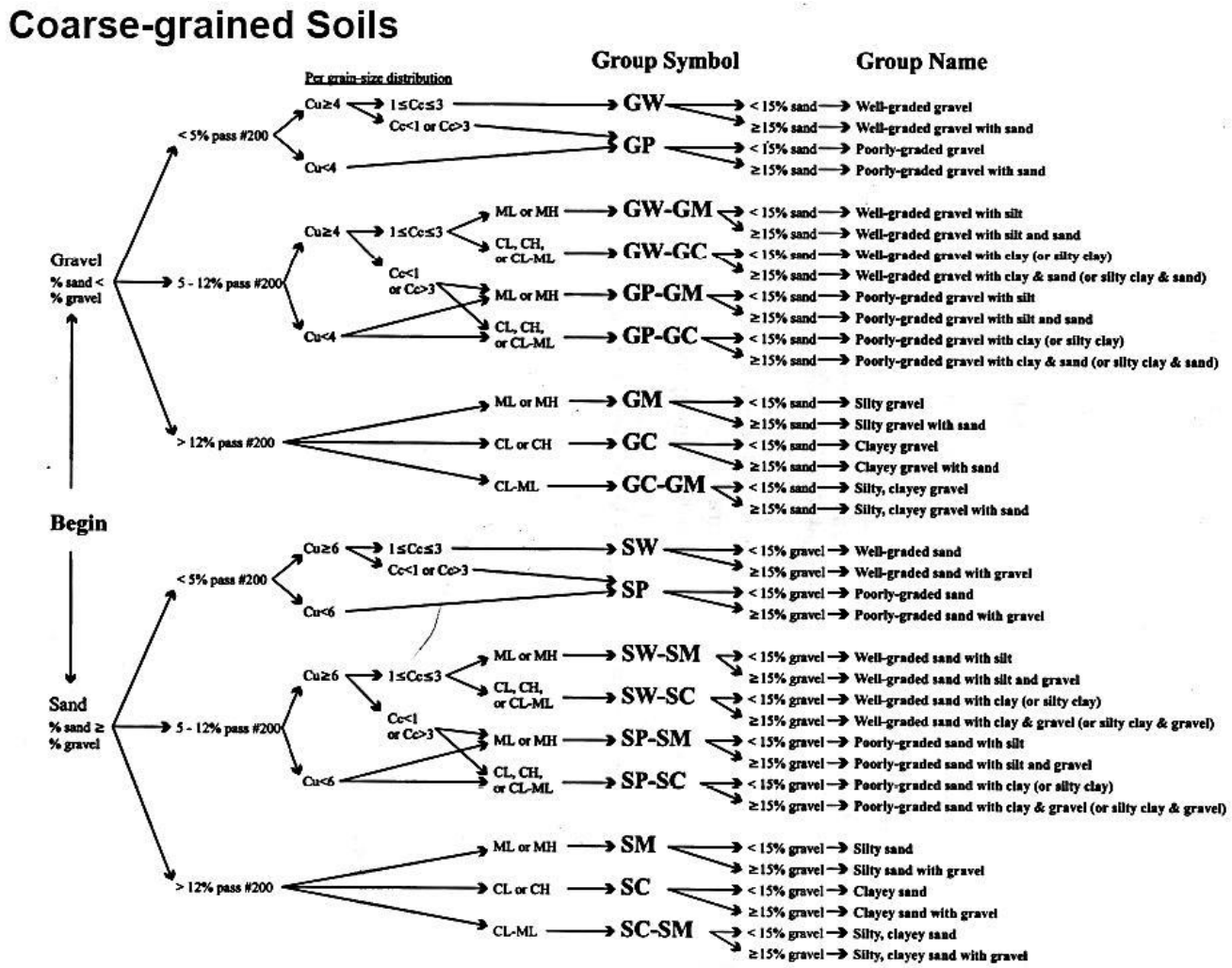
[8 marks/*markah*]

(ii) Suggest the best method to expediate consolidation process so as the construction project can be urgently implemented.

Berikan cadangan terbaik untuk mempercepatkan proses pengukuhan ini agar projek pembinaan dapat segera dilaksanakan.

[4 marks/*markah*]

ATTACHMENT 1/*LAMPIRAN 1*



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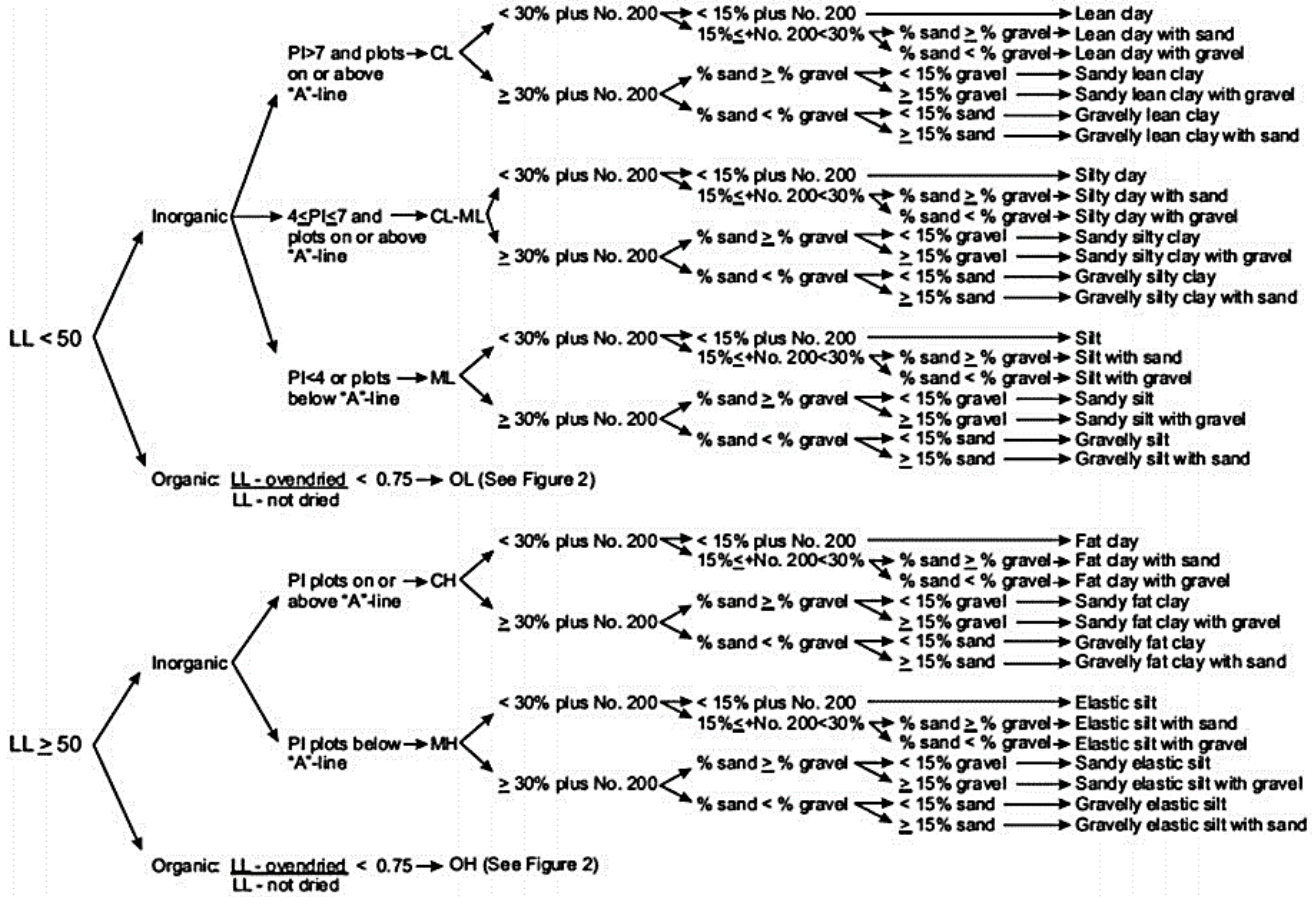
LL < 50
Inorganic
PI>7 and plots on or above "A"-line → CL
< 30% plus No. 200
< 15% plus No. 200 → Lean clay
15%≤+No. 200<30%
% sand ≥ % gravel → Lean clay with sand
% sand < % gravel → Lean clay with gravel
≥ 30% plus No. 200
% sand ≥ % gravel
< 15% gravel → Sandy lean clay
≥ 15% gravel → Sandy lean clay with gravel
% sand < % gravel
< 15% sand → Gravelly lean clay
≥ 15% sand → Gravelly lean clay with sand
4≤PI≤7 and plots on or above "A"-line → CL-ML
< 30% plus No. 200
< 15% plus No. 200 → Silty clay
15%≤+No. 200<30%
% sand ≥ % gravel → Silty clay with sand
% sand < % gravel → Silty clay with gravel
≥ 30% plus No. 200
% sand ≥ % gravel
< 15% gravel → Sandy silty clay
≥ 15% gravel → Sandy silty clay with gravel
% sand < % gravel
< 15% sand → Gravelly silty clay
≥ 15% sand → Gravelly silty clay with sand
PI<4 or plots below "A"-line → ML
< 30% plus No. 200
< 15% plus No. 200 → Silt
15%≤+No. 200<30%
% sand ≥ % gravel → Silt with sand
% sand < % gravel → Silt with gravel
≥ 30% plus No. 200
% sand ≥ % gravel
< 15% gravel → Sandy silt
≥ 15% gravel → Sandy silt with gravel
% sand < % gravel
< 15% sand → Gravelly silt
≥ 15% sand → Gravelly silt with sand
Organic: LL - ovendried / LL - not dried < 0.75 → OL (See Figure 2)
LL ≥ 50
Inorganic
PI plots on or above "A"-line → CH
< 30% plus No. 200
< 15% plus No. 200 → Fat clay
15%≤+No. 200<30%
% sand ≥ % gravel → Fat clay with sand
% sand < % gravel → Fat clay with gravel
≥ 30% plus No. 200
% sand ≥ % gravel
< 15% gravel → Sandy fat clay
≥ 15% gravel → Sandy fat clay with gravel
% sand < % gravel
< 15% sand → Gravelly fat clay
≥ 15% sand → Gravelly fat clay with sand
PI plots below "A"-line → MH
< 30% plus No. 200
< 15% plus No. 200 → Elastic silt
15%≤+No. 200<30%
% sand ≥ % gravel → Elastic silt with sand
% sand < % gravel → Elastic silt with gravel
≥ 30% plus No. 200
% sand ≥ % gravel
< 15% gravel → Sandy elastic silt
≥ 15% gravel → Sandy elastic silt with gravel
% sand < % gravel
< 15% sand → Gravelly elastic silt
≥ 15% sand → Gravelly elastic silt with sand
Organic: LL - ovendried / LL - not dried < 0.75 → OH (See Figure 2)

...17/-

ATTACHMENT 2/*LAMPIRAN 2*

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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