UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2016

Module Number: CE4302 Module Name: Engineering Geology and Soil Mechanics

[Three Hours]

[Answer **all questions**, each question carries ten marks]

[Use separate books to answer each section]

SECTION - A

Q1. Figure Q1 shows a geological map of an area.

a) Draw the structure contours for the bed A, B, C and F (Consider all the bed outcrops under same letter).

[3.0 Marks]

b) Find the true dip angle and dip direction of each bed (A, B, C and F)

[2.0 Marks]

c) Find the true dip and dip angle of the fault

[2.0 Marks]

d) Draw a cross section along the line XY using vertical exaggeration as 1.

[3.0 Marks]

(Note: The geological map and the geological cross-section should be attached to the answer book)

Q2.

a) What are the main rock types? Briefly describe them with formations and some examples of such rocks.

[4.5 Marks]

b) Give a brief description on rock cycle with a sketch showing basic processes which operate within it

[1.5 Marks]

c) Briefly describe the main types of rock weathering processes

[2.0 Marks]

d) Describe soil forming process and soil types based on formation

[2.0 Marks]

SECTION - B

Q3. a) Derive following equations using basic soil phase relationships. All the symbols should be in usual notations.

i) For a partially saturated soil, $e = \frac{w.G_s}{S}$

ii) At saturation moisture content, $w_{sat} = \gamma_w \left[\frac{1}{\gamma_d} - \frac{1}{\gamma_s}\right]$

iii) Dry density of soil, $\gamma_d = \frac{\gamma}{1+w}$

[1.0 Mark x 3]

b) A geotechnical laboratory report shows following results for a silt soil sample taken from a bore-hole. Do you agree with this results in this lab report? Explain the reason.
Moisture Content, w= 20% , γ_d = 18 kN/m^3 , γ_s = 27 kN/m^3

[1.5 Marks]

c) In a construction site, it was observed that in-situ dry unit weight of a soil is 17.5 kN/m^3, moisture content is 4% and specific gravity is 2.65. Determine;

i) Bulk unit weight of this soil

[1.5 Marks]

ii) Void ratio

[1.0 Mark]

iii) Degree of saturation

[1.0 Mark]

iv) The weight of water (in kN) that must be added to a cubic meter of soil to make this soil fully saturated.

[2.0 Marks]

Q4. a) An embankment of a highway (30m wide x 1.5 m thick) for 1.0 km length, is to be constructed from a sandy soil imported from a borrow pit. The water content of the sandy soil in the borrow pit is 15% and its void ratio is 0.69. The specific gravity of sandy soil was found as 2.7. Consultant engineer recommended the embankment to be compacted to a dry unit weight of 18 kN/m^3.

i) Determine the number of truck-loads of sandy soil required to construct the embankment if the volume of a truck is 10 m^3.

[2.5 Marks]

ii) Calculate the weight of soil (kN) per truck load of sandy soil

[1.5 Marks]

iii) After compaction, it was found that degree compaction of this embankment is 95%. Determine in-situ dry unit weight in compacted embankment.

[1.0 Marks]

You may use following equations if needed,

$$D_r = \frac{e_{max}-e}{e_{max}-e_{min}} \; ; \quad \gamma_d = \frac{G_s}{1+e}\gamma_w \; ; \quad n = \frac{e}{1+e} \; ; \quad \gamma_d = \frac{(1-A)G_s\gamma_w}{(1+wG_s)}$$

b) A 5m thick of sand layer overlies a 6m thick layer of clay in a construction site. The water table of this site was found as at the ground level. Permeability of this clay layer is very low. The saturated unit weight of the sand is 18 kN/m^3 and that of clay is 20 kN/m^3.

i) Determine the effective vertical stress at the center of clay layer

[2.0 Marks]

ii) A uniformly distributed load of 100 kN/m^2 is placed on the surface of this site. What is the new total stress and effective stress at the center of clay layer immediately after the fill has been placed.

[1.5 Marks]

iii) What will be the effective stress at the center of clay layer many years after the fill has been placed.

[1.5 Marks]

Q5 a) A series of liquid limit test (ASTM D4318) on a given sample of clay was carried out. The data obtained is as given below.

Table Q5: Laboratory Results of Liquid Limit test

Test No.	1	2	3	4	5
No. of Blows, (N)	10	15	20	30	45
Water Content, (%)	61	56	51	47	44

The plastic limit of the given soil has been found as 28.5 %. Draw the flow curve on semi-log paper (Figure Q5) and determine following parameters. [2.0 Marks]

i) Liquid Limit (LL)

[1.0 Marks]

ii) Plasticity Index (PI)

[1.0 Marks]

iii) Void ratio at the liquid limit if the specific gravity of the soil is 2.6. You may assume that the soil is saturated at the liquid limit.

[1.5 Marks]

(Note: The graph sheet should be attached to the answer book)

b) A sample of soil was tested in the laboratory with the following results

- D_{10} = 0.068 mm
- D_{30} = 0.095 mm
- D_{60} = 0.160 mm
- Liquid Limit = 30%
- Plastic Limit = 12%

Sieve analysis data based on US sieves:

U.S. Sieve Size	Percentage Passing, (%)
3/8 in.	100.0
No. 4	76.5
No. 10	60.0
No. 40	38.5
No. 200	16.2

i) Determine the effective size and the uniformity coefficient

[1.0 Mark]

ii) Determine the sand percentage of this soil

[1.0 Mark]

iii) Hence, classify the soil using Unified Soil Classification System (USCS). You may use Table Q4.

[2.5 Marks]

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Graph sheet for Q5

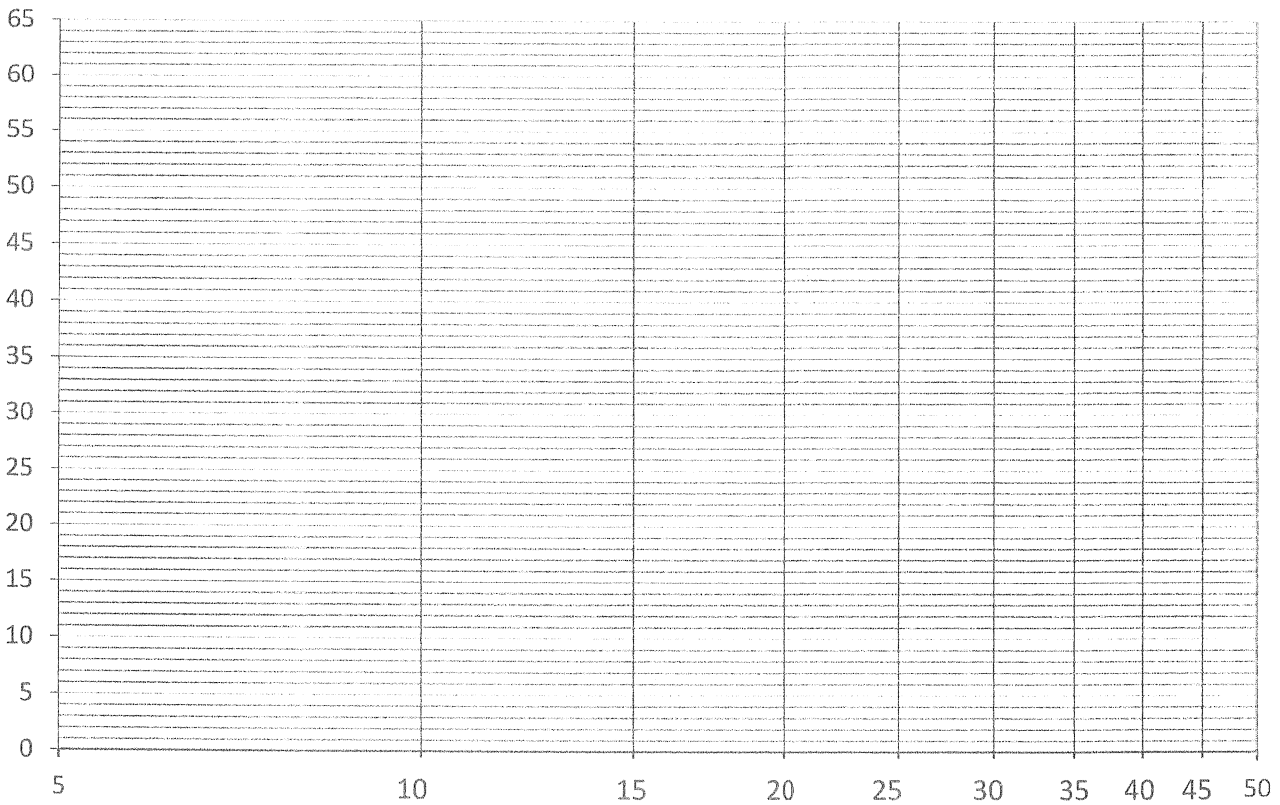
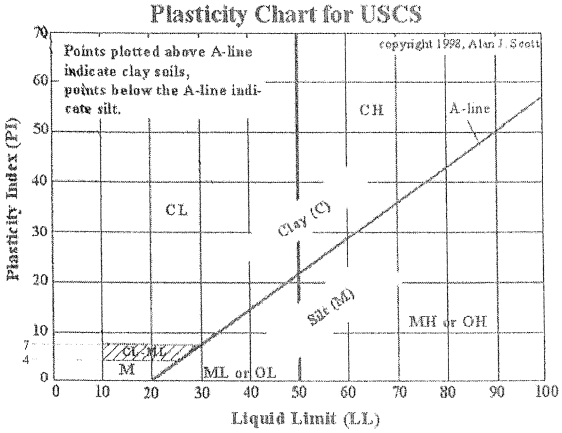


Table Q4: USCS

Description			Group symbol	Laboratory criteria			
				Fines (%)	Grading	Plasticity	Notes
Coarse grained {more than 50% larger than No. 200 US sieve size} > 0.075 mm	Gravels {more than 50% of coarse fraction of **gravel** size} > 4.75 mm	Well graded gravels, sandy gravels, with little or no fines	GW	0 - 5	$C_u > 4$ $1 < C_c < 3$		Dual symbols. If 5 -12 % fines. Dual symbols if above A-line and $4 < PI < 7$
		Poorly graded gravels, sandy gravels, with little or no fines	GP	0 - 5	Not satisfying GW requirements		
		Silty gravels, silty sandy gravels	GM	> 12		Below A-line or PI < 4	
		Clayey gravels, clayey sandy gravels	GC	> 12		Above A-line and PI > 7	
	Sands {more than 50% of coarse fraction of **sand** size} 4.75 – 0.075 mm	Well graded sands, gravelly sands, with little or no fines	SW	0 - 5	$C_u > 6$ $1 < C_c < 3$		
		Poorly graded sands, gravelly sands, with little or no fines	SP	0 - 5	Not satisfying SW requirements		
		Silty sands	SM	> 12		Below A-line or PI < 4	
		Clayey sands	SC	> 12		Above A-line and PI > 7	
Fine grained {more than 50% smaller than No. 200 US sieve size} < 0.075 mm	Silts and Clays {Liquid Limit less than 50}	Inorganic silts, silty or clayey fine sands, with slight plasticity	ML	Use plasticity chart			
		Inorganic clays, silty clays, sandy clays of low plasticity	CL	Use plasticity chart			
		Organic silts and organic silty clays of low plasticity	OL	Use plasticity chart			
	Silts and Clays {Liquid Limit greater than 50}	Inorganic silts of high plasticity	MH	Use plasticity chart			
		Inorganic clays of high plasticity	CH	Use plasticity chart			
		Organic clays of high plasticity	OH	Use plasticity chart			
Highly organic soils		Peat and other highly organic soils	Pt				

Plasticity Chart for USCS



Primary letter		Secondary letter	
G	Gravel	W	Well graded
S	Sand	P	Poorly graded
M	Silt	M	With non-plastic fines
C	Clay	C	With plastic fines
O	Organic soil	L	Of low plasticity (LL < 50)
Pt	Peat	H	Of high plasticity (LL > 50)

Figure Q1: Geological Map

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