UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2015

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

[Three Hours]

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

Q1. Answer the following questions using the geological map shown in Figure Q1.1.

a) Draw the structure contours on the geological map and deduce the dip angle of the sandstone layer.

[3.0 Marks]

b) At what depth would the Conglomerate encountered in a borehole sunk at point **A**.

[2.0 Marks]

c) Mark the fold in the map and identify the type of the fold.

[2.0 Marks]

d) Draw a geological cross-section along PR line by defining the vertical exaggeration.

[5.0 Marks]

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

Q2. a) Draw the Rock Cycle with basic processes which operate within it and briefly describe the formation of igneous rocks.

[2.0 Marks]

b) What are faults? Briefly explain why and how they form?

[1.0 Marks]

c) Show the differences between a Normal fault and a Thrust fault with suitable sketches.

[2.0 Marks]

d) Draw a cross section of a fold and show the crest, core, limb, fold axis, angle of plunge.

[3.0 Marks]

e) Show the differences between an anticline fold and a syncline fold with suitable sketches.

[2.0 Marks]

f) Explain the following terms with suitable sketches;

i) Dykes

ii) Sills

[2.0 Marks]

Q3. A layer of silty sand extends below the ground surface to a depth of 4.0 m. Below the silty sand layer is soft clay of thickness 6.0 m. A stratum of dense sand of thickness 4.0 m is under the soft clay layer. An impermeable bed rock is 14.0 m below the ground surface. The water table is 2.0 m below the ground surface.

The dry unit weight and saturated unit weight of silty sand are 17 kN/m^3 and 18.5 kN/m^3, respectively. The saturated unit weights of clay and dense sand are 14 kN/m^3 and 20 kN/m^3, respectively. The coefficient of lateral earth pressure (at rest) of clay is 0.4. The unit weight of water is 9.81 kN/m^3.

a) Draw the total stress, pore water pressure and effective stress distribution to a depth of 14.0 m from the ground surface.

[4.5 Marks]

b) There is a proposal to construct a 4.0 m height road embankment on this area. The unit weight of the fill material is 20 kN/m^3.

i) What would be the effective vertical stress at middle of the clay layer immediately after fill has been placed?

[1.5 Marks]

ii) What would be the effective vertical stress at middle of the clay layer many years after fill has been placed.

[1.0 Marks]

iii) What would be the pore water pressure at middle of the clay layer immediately after fill has been placed?

[1.0 Marks]

iv) What would be the pore water pressure at middle of the clay layer many years after fill has been placed?

[0.5 Marks]

v) What would be the total lateral stress at middle of the clay layer immediately after fill has been placed?

[2.0 Marks]

vi) What would be the total lateral stress at middle of the clay layer many years after fill has been placed?

[1.5 Marks]

Q4. In order to select a suitable soil for a road embankment construction, a Standard Proctor Compaction test was performed in the laboratory on a soil sample obtained from a barrow pit and test results are depicted in Table Q4.1. The volume of the mould is 944 cm^3. You may use the unit weight of water as 9.81 kN/m^3.

a) i) Draw the compaction curve and determine the maximum dry unit weight and the optimum moisture content of the soil.

[3.0 Marks]

ii) Draw the phase diagram and derive following equation with usual notations.

$$\gamma_d = \frac{(1-A)G_s\gamma_w}{(1+wG_s)}$$

[1.0 Marks]

ii) Assuming that specific gravity of the soil is 2.79, draw curves for 0 % and 10 % air voids line; hence estimate the air content corresponding to the maximum dry unit weight.

[2.5 Marks]

b) Due to heterogeneous nature of the soil at the borrow pit, site engineer has decided to develop a standard compaction curve for the same soil at the site. Even though standard Proctor hammer is available at the site, the available mould size is different from standard mould size. The volume of the mould at the site is 1500 cm^3. As you are a junior engineer at the site, how do you use the available equipment to develop the standard Proctor compaction curve? Justify your answer with suitable calculations.

[1.5 Marks]

c) Briefly describe with the aid of sketches 4 factors which affect the field compaction.

[2.0 Marks]

d) As an quality assurance, contractor has performed Sand Cone test in each compacted layer of the embankment and test results of a particular layer are depicted in Table Q4.2. Hence, estimate the degree of compaction of the soil.

[2.0 Marks]

Q5. Series of laboratory tests have been conducted to determine the physical properties of a particular soil.

a) i) Briefly describe the sample preparation procedure for the hydrometer analysis test?

[2.0 Marks]

ii) Why is it important to apply dispersing agent correction for the hydrometer reading? Briefly describe the test procedure to determine the dispersing agent correction.

[2.0 Marks]

b) Plasticity characteristics of the soil were determined using Atterbeg Limit test and test results are presented in Table Q5.1

i) What would be the Liquid Limit of the soil?

[2.5 Marks]

ii) What would be the Plastic Limit of the soil?

[1.0 Marks]

iii) Hence, determine the Plasticity Index of the soil.

[0.5 Marks]

c) Particle size distribution curve of the above soil is shown in Figure Q5.1. Classify the soil according to Unified Soil Classification System. The Unified Soil Classification chart (USC) is given Table Q5.2.

[4.0 Marks]

Table Q4.1 Standard Proctor Compaction test results

Water content (%)	9.41	12.67	17.02	19.58	24.26	26.29
Mass of soil (g)	1644	1843	1993	1998	1938	1873

Table Q4.2 Sand Cone test results

Density of sand (g/cm^3)	1.34
Weight of sand required to filled the cone (g)	396
Determination of Water Content	
Weight of can (g)	9.98
Weight of can + Wet soil (g)	112.85
Weight of can + Dry soil (g)	98.87
Determination of Dry Unit Weight	
Weight of sand + Jar before use (g)	7315
Weight of sand + Jar after use (g)	6034
Weight of container (g)	144.8
Weight of container + soil (g)	1385

Table Q5.1(a) Atterbeg Limit test results – Liquid Limit

	Liquid Limit					
Test No.	**1**	**2**	**3**	**4**	**5**	**6**
No. of Blows	51	46	37	28	20	12
Can No.	1	2	3	4	5	6
Mass container (g)	42.31	27.00	27.07	27.32	27.22	27.85
Mass of soil + container (g)	52.69	38.37	41.75	36.95	38.10	54.46
Mass of oven dried soil + container (g)	49.35	34.70	36.85	33.66	34.36	44.87

Table Q5.1(b) Atterbeg Limit test results – Plastic Limit

	Plastic Limit		
Can No.	1	2	3
Mass container (g)	15.31	15.33	17.29
Mass of soil + container (g)	23.05	23.24	25.46
Mass of oven dried soil + container (g)	21.32	21.43	23.43

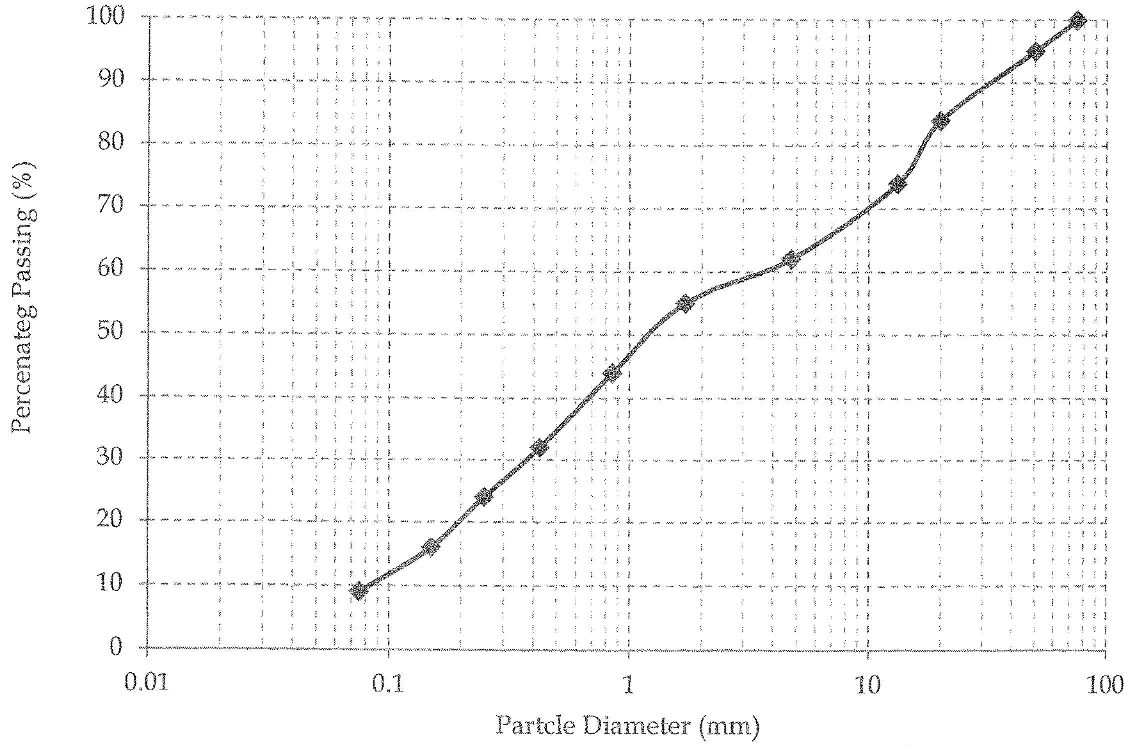
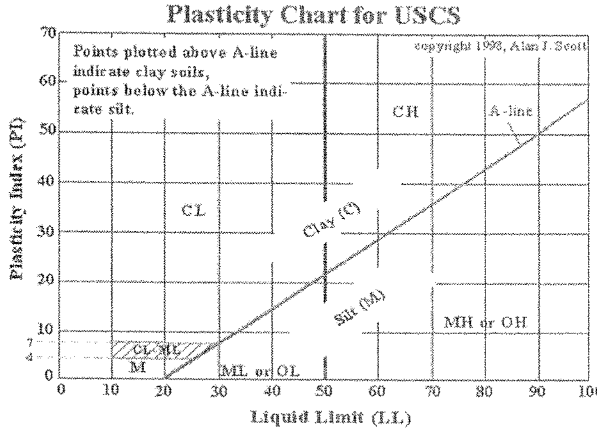


Figure Q5.1 – Particle size distribution curve

Table Q5.2 - The Unified Soil Classification (USC) chart and Plasticity chart

Description			Group symbol	Laboratory criteria: Fines (%)	Laboratory criteria: Grading	Laboratory criteria: Plasticity	Notes
Coarse grained {more than 50% larger than 63 □m BS or 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 $C_u = \frac{D_{60}}{D_{10}}$ $C_c = \frac{D_{30}^2}{D_{10} x D_{60}}$
		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 63 µm BS or 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)

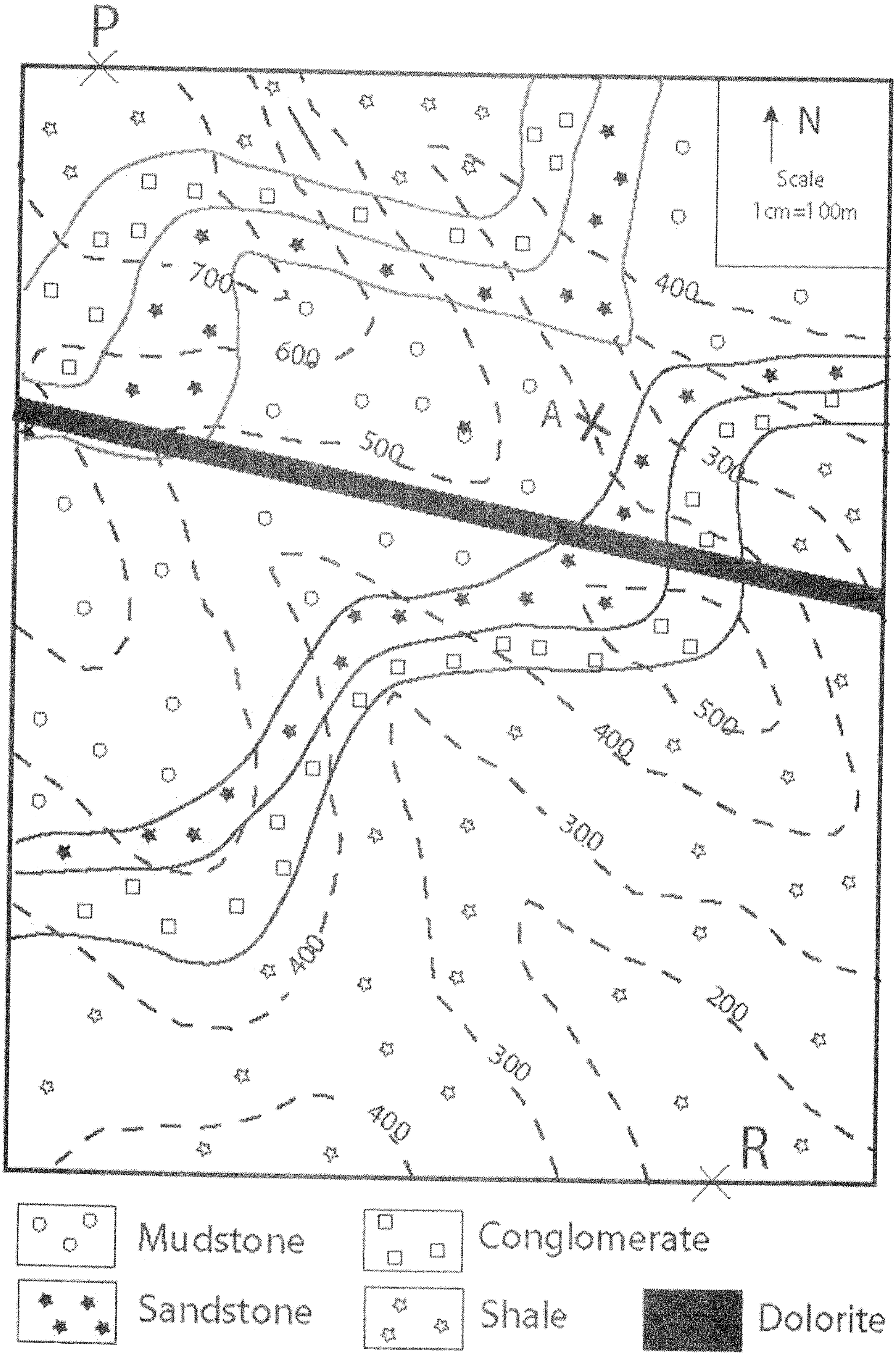


Figure Q1.1 Geological Map