UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2018

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

[Three Hours]

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

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

a) Draw the structure contours of siltstone-shale and shale-grit boundaries on the geological map.

[2.0 Marks]

b) Determine the true thickness of the shale bed.

[2.0 Marks]

c) Draw the geological cross-section along AB line by defining the vertical exaggeration.

[4.0 Marks]

d) Mark the anticline axis and syncline axis on the geological map.

[2.0 Marks]

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

Q2. a) What are the important information denoted from the strike and the dip of a rock?

[1.0 Marks]

b) The seismographic data of an earthquake at a particular location is shown in Figure Q2.1. The time-distance curve for earthquake waves is depicted in Figure Q2.2. Calculate the distance to the epicenter of the earthquake. Briefly explain would you be able to exactly locate the epicenter from the calculated distance?

[3.0 Marks]

c) What kind of structural features can weaken a metamorphic rock?

[1.0 Marks]

d) List two examples for industrial applications of minerals mainly based on its hardness.

[2.0 Marks]

e) During a borehole investigation at a particular project, the groundwater level was found at a depth of 5 m. Further drilling up to 20 m, there was a continuous groundwater flow through the borehole. Core log illustrated that drilling has penetrated a 2 m thick clay layer at the depths of 18 m to 20 m. Briefly explain this subsurface formations with the aid of a sketch.

[3.0 Marks]

Q3. The sub surface soil profile at a site consists of a 4.0 m thick silty sand layer followed by a 6.0 m thick stiff clay layer. Highly weathered rock is below the stiff clay layer. The water table is 2.0 m below the ground surface. The dry unit weight and saturated unit weight of silty sand were found to be 16.0 kN/m^3 and 18.0 kN/m^3, respectively. In order to find the physical properties of stiff clay, an undisturbed sample of volume 100 cm^3 and mass of 200 g was obtained from the field. After oven drying the sample for 24 hours, the mass has reduced to 160 g. Specific gravity of the soil grain was found to be 2.65. The coefficient of lateral earth pressure of silty sand and stiff clay can be taken as 0.5 and 0.4, respectively. The unit weight of water is 9.81 kN/m^3.

a) Draw the phase diagram and derive following equations with usual notations. Hence, determine void ratio and saturated unit weight of stiff clay.

i) Void ratio $e = \frac{G_s \gamma_w}{\gamma_d} - 1$

ii) Degree of saturation $S = \frac{wG_s}{e}$

ii) Saturated unit weight $\gamma_{sat} = \frac{(G_s + e)\gamma_w}{(1+e)}$

[4.0 Marks]

b) Draw the total vertical stress, pore water pressure and effective vertical stress distribution to a depth of 10.0 m from the ground surface.

[2.5 Marks]

c) What would be the total lateral stress at a depth of 10.0 m from the ground surface?

[1.5 Marks]

d) There is a proposal to place 2.0 m thick fill above the existing ground surface. The unit weight of the fill material is 20 kN/m^3.

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

[1.0 Marks]

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

[1.0 Marks]

Q4. According to the construction specification of expressway project, maximum dry unit weight of the soil use for embankment construction should be greater than 16.0 kN/m^3 whereas liquid limit and plasticity index should be less than 40% and 15%, respectively. In order to select suitable soils for embankment construction, Modified Proctor Compaction test was performed in the laboratory on a soil sample obtained from a borrow 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) Compare the differences between Standard Proctor Compaction test and Modified Proctor Compaction test with respect to energy per unit volume.

[1.0 Marks]

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

[3.0 Marks]

iii) What would be the air content and the void ratio at the maximum dry unit weight if the specific gravity of the soil is 2.65?

[2.0 Marks]

b) The finished volume of the embankment at a particular section of the expressway is 60,000 m^3. The natural soil from the borrow area has a bulk unit weight of 18.0 kN/m^3 at moisture content of 13.5 %. The transporting vehicle has a capacity of 10 m^3 and the truck loaded to fill capacity with moist soil is 15 tons. It is assumed that moisture content will be reduced by 20% during the transport of soil from borrow pit to construction site due to evaporation.

i) Determine the number of truck loads required to construct the embankment.

[2.5 Marks]

ii) How many liters of water should be added to each truck load before compaction?

[1.5 Marks]

Q5. In an earth dam construction project, it is necessary to select low permeable soils for core and shell to reduce seepage.

a) To find the clay content present in the soil, which is selected as the core material, it is necessary to carry out the hydrometer analysis test.

i) List four number of assumptions made in hydrometer analysis test.

[2.0 Marks]

ii) Why is it important to apply "Dispersing agent correction" in the hydrometer analysis test? Briefly describe a method to determine dispersing agent correction.

[1.0 Marks]

ii) What is "Meniscus error" in the hydrometer analysis test? Briefly describe a method to determine meniscus correction.

[1.0 Marks]

b) The plasticity characteristics of the above soil are determined using Atterbeg Limit test.

i) Fine grained soils can exist in four states depending on the amount of water in the soil system. Draw the variation of volume versus water content of fine grained soil illustrating different soil states.

[1.0 Marks]

ii) The liquid limit and plastic limit of the soil are 42% and 30%, respectively. The percentage volume change from liquid limit to shrinkage limit is 35% of the solid volume. Similarly, the percentage volume change from plastic limit to shrinkage limit is 22% of the solid volume. Determine the shrinkage limit.

[2.0 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 (USC) chart and Plasticity chart are shown in Table 5.1.

[3.0 Marks]

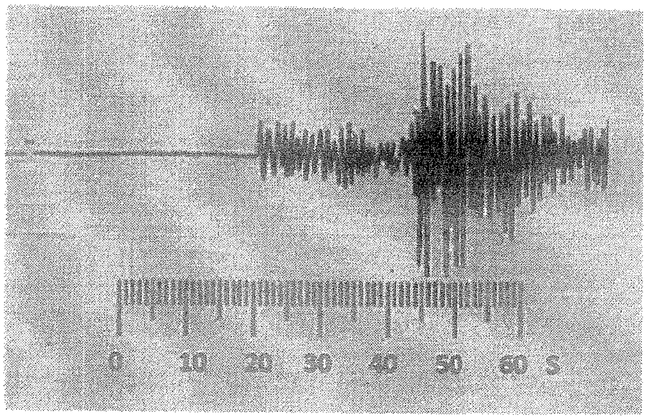


Figure Q2.1 Seismograph data of the Earthquake (scale is given in seconds)

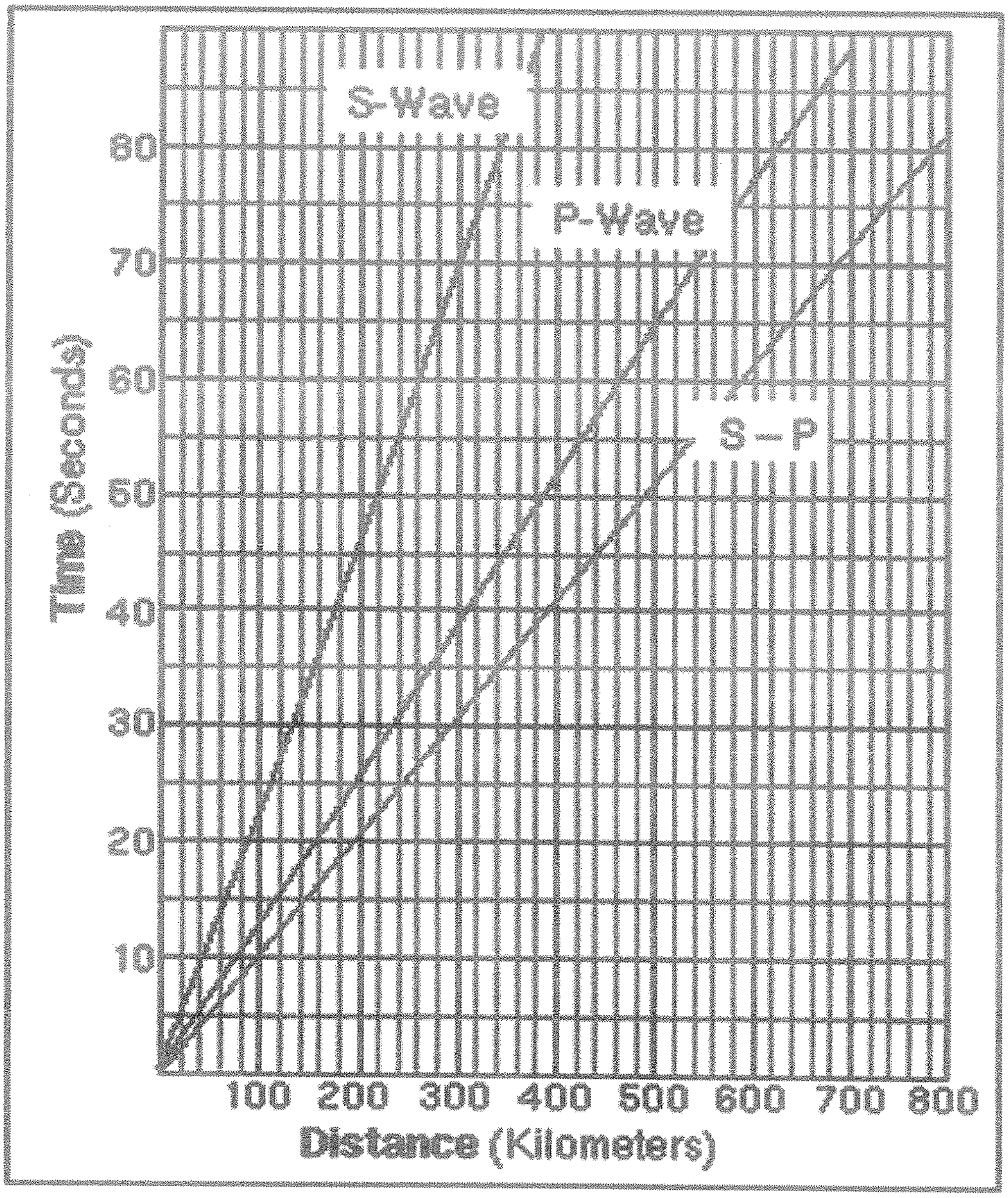


Figure Q2.2 Time-Distance curve for earthquake waves

Table Q4.1 Modified Proctor Compaction test results

Water content (%)	10.8	13.7	16.8	20.8	25.1	27.7
Mass of soil (g)	1584	1754	1947	2038	1957	1911

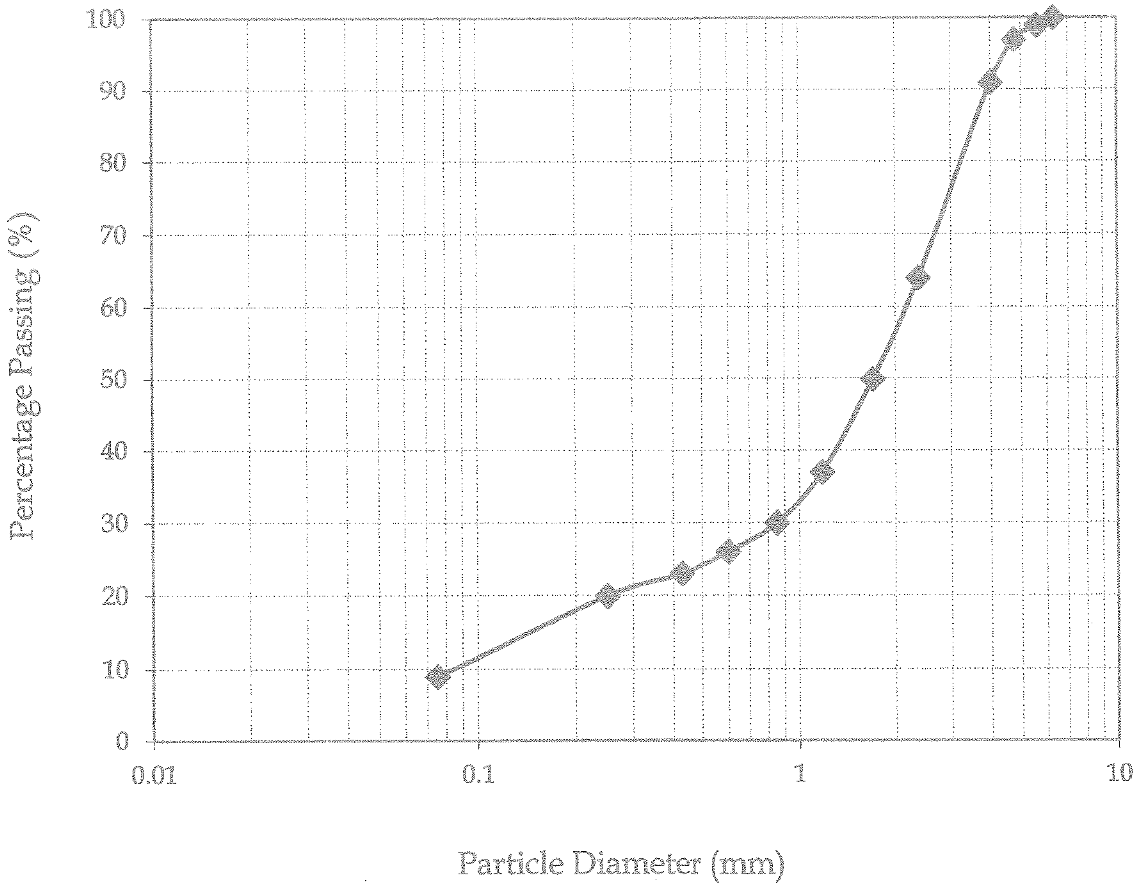
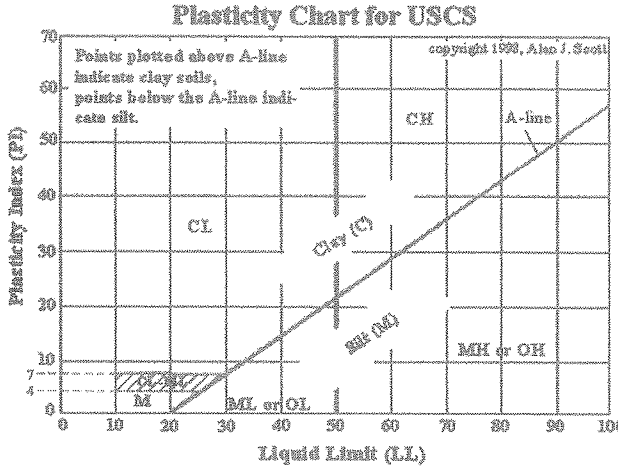


Figure Q5.1 – Particle size distribution curve

Table Q5.1 - The Unified Soil Classification (USC) chart and Plasticity chart

Description			Group symbol	Laboratory criteria: Fines (%)	Laboratory criteria: Grading	Laboratory criteria: Plasticity	Laboratory criteria: Notes
Coarse grained {more than 50% larger than 63 µm 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)

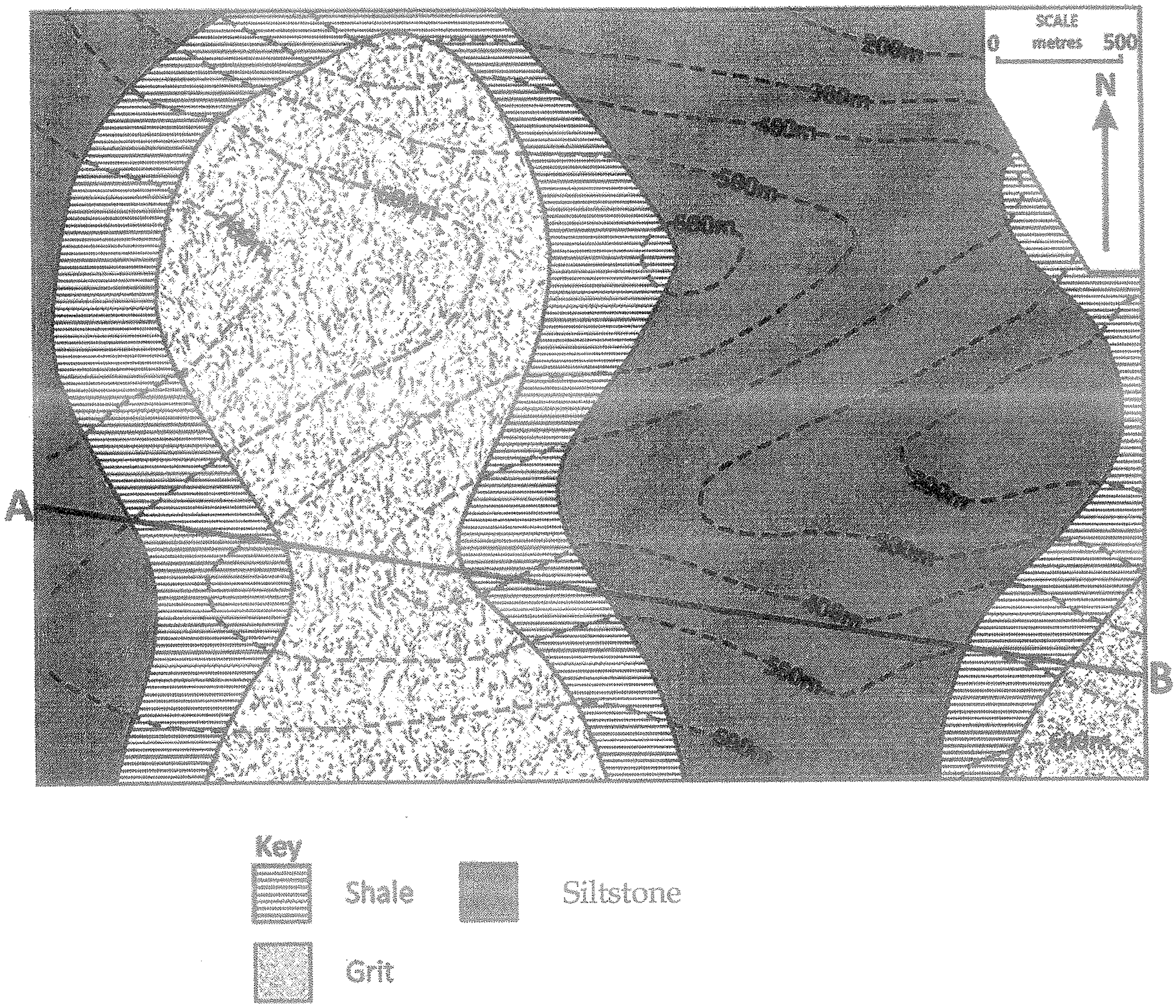


Figure Q1.1 Geological Map