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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CEX5232/CVX5532 Engineering Geology**
Academic Year	: 2017/18
Date	: 17th January 2019
Time	: 0930-1230hrs
Duration	**: 3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Three (3)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Relevant charts/ codes are provided.
6. This is a Closed Book Test(CBT).
7. Answers should be in clear hand written.
8. Do not use Red colour pen.

Q1. Most of the rocks underlain in the Jaffna Peninsula is **"Miocene Limestones".**

(a). Definewhat is meant by**Miocene**? (4 marks)

(b). State the textural features of and the origin of limestone (8 marks)

(c). Classify the rock type stated as the answer to Q1 (b). (8 marks)

Q2. Weathering changes engineering properties of rocks.

(a). Describe the different types of weathering processes. (6 marks)

(b). Discuss about the different factors that contributes to mechanical weathering. (6 marks)

(c). Select whether following geologic formations are favourable or unfavourable, based on the ***type*** and the ***orientation***for given engineering applications.

Application and location of the formation	Type	Orientation	State where **favorable** or **unfavorable**
1.Cut-slope of a road	Feldspar band	Dipping towards dip-slope of the cut	
2.Proposed reservoir bed	Dolomite band	Horizontally bedded	
3.Dam foundation	Quartzite intrusion	Dipping towards upstream	
4.Roof of a railway tunnel	Mica band	Dipping against the direction of the excavation	

(8 marks)

Q3. Write Short Notes on Following.

(a). Unconformity (4 marks)

(b). Perched water table (4 marks)

(c). Hydrogeological boundaries. (4 marks)

(d) Alluvial fans and cones (4 marks)

(e) Vertical Electrical Sounding (VES) method (4 marks)

Q4. Rock Joint and other rock mass characteristics given in Table Q4 (1) were reported during a **4.00m** length rock core-run (shown in Figure Q4)(1) carried out as site investigation program for a Bridge foundation.

Table Q4 (1): Discontinuity (Joint)and rock mass properties

Joint Characteristics						
Joint Set No.	Dip angle	Length	Separation	Roughness	Infilling	Weathering
01	60^0	1.60m	0.56mm	Slickensided	Hard filling<5mm	Slightly weathered
02	45^0	0.20m	0.02mm	Slightly rough	None	Fresh
Rock Mass Parameters						
Average Uniaxial Compressive Strength of rock cores						125MPa
Groundwater condition						Wet

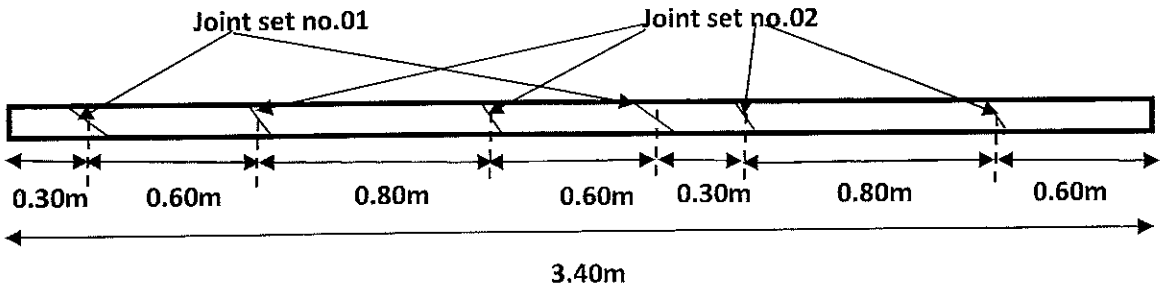

Figure Q4 (1): Schematic diagram of recovered rock core and discontinuity orientations

With the above given information in Table Q4 (1), Figure Q4 (1) and with the help of attached Table Q4 (2) to Table Q4 (9), answer following questions.

(a). Determine the Rock Mass Rating (RMR) value of the rock mass for the particular location. (12 marks)

(b) Determine the Adjusted Rock Mass Rating (A-RMR) value of the rock mass for the particular location, based on the discontinuity orientation. (3 marks)

(c). Propose range of values to **angle of internal friction** and **cohesion** to the given rock mass. (5 marks)

Q5. Characteristics of the constituent minerals, textural features, admixtures and cementing materials play a major role in engineering properties of rocks.

(a) Briefly explain the effects of admixtures and cementing materials in sedimentary rocks on their engineering properties. (6 marks)

(b) Describe the effects of crystallization and textural features in crystalline (igneous / metamorphic) rocks on their engineering properties. (6 marks)

(c). Discusshow above mentioned (Q5 (a) and Q5 (b)) factors affect the aquifer potential of different rock types. (8 marks)

Q6. A tension crack has been observed on a rock slope during a heavy rainy season at a horizontal distance of 3.00m from the crest towards the slope face. The particular rock slope has a height of 20.00m and has a face angle of 60^0. Furthermore, a weaker slickensided joint having a dip angle of 30^0, runs through the toe of the slope and daylights behind the slope crest. This weaker joint plane dips towards the slope face and strikes parallel to it. The strength parameters of weaker joint plane are; cohesion (c) =30kPa and angle of internal friction (ø) = 45^0. The unit weight of rock mass material is 26kN/m^3 and the unit weight of water can be assumed as 9.81kN/m^3.

(a). Draw a neatly sketched diagram showing all the slope geometrical parameters pertaining to above mentioned information. (5 marks)

(b). Write down the assumptions that you would make if you solve above slope stability problem, under simple plane failure analysis. (5 marks)

(c). Estimate the minimum height of the water level in the tension crack, which may cause to destabilize the above mentioned rock slope. (10 marks)

Q7. Suppose you have been appointed as the geotechnical engineer responsible for geotechnical investigations program for a new railway track that to be constructed from Sapugaskanda to Avissawella.

(a). Explain how you are going to plan the geotechnical investigation program. (6 marks)

(b). Develop a subsurface exploratory drilling program that should be performed to obtain the geotechnical parameters mentioned in Q7 (a). In your answer following aspects should be clearly mentioned.

(i) Drilling methodology and frequency of exploratory locations

(ii) In-situ tests that will need to be performed with reasons for performing the test.

(iii) Depth of exploration.

(iv) Methods of sampling. (8 marks)

(c). Formulate a laboratory testing program that should be performed for the particular project with reasons. (6 marks)

Q8. In-situ tests carried out in the site investigations used to obtain important geotechnical parameters for substructure design.

(a). Compare and contrast the relationships between the in-situ geotechnical parameters and laboratory geotechnical parameters. (8 marks)

(b). Briefly discuss about the following in-situ tests.

(i) Standard Penetration Test (4 marks)

(ii) Field Vane Shear Test (4 marks)

(iii) In-situ Plate Load test (4 marks)

Table Q4 (2). Classification Parameters and Ratings

PARAMETER			RANGES OF VALUES						
1	Strengh of intact rock material	Point – load strength index	>10 MPa	4 -10 MPa	2-4 MPa	1-2 MPa	For this low range –uniaxial Compressive test is preferred		
		Uniaxial compressive strength	>250 MPa	100-250 MPa	50-100 MPa	25-50 MPa	5-25 MPa	1-5 MPa	<1 MPa
	Rating		**15**	**12**	**7**	**4**	**2**	**1**	**0**
2	Drill core Quality RQD		90%-100%	75%-90%	50%-75%	25%-50%	<25%		
	Rating		**20**	**17**	**13**	**6**	**3**		
3	Spacing of discontinuities		>2m	0.6-2m	200-600mm	60-200mm	<60mm		
	Rating		**20**	**15**	**10**	**8**	**5**		
4	Condition of discontinuities (see E for details)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation <1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces OR Gouge <5 mm thick OR Separation 1-5 mm Continuous	Soft gouge > 5mmThick OR Separation >5 mm Continuous		
	Rating		**30**	**25**	**20**	**10**	**0**		
5	Group Water	Inflow per 10 m tunnel length	None	<10 liters/mm	10-25 liters/mm	25-125 liters/mm	>125 liters/mm		
		Ratio = Joint water pressure / Major principal stress(σ)	0	0.0-0.1	0.1-0.2	0.2-0.5	>0.5		
		General Conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		**15**	**10**	**7**	**4**	**0**		

Table Q4 (3). Rating adjustments for discontinuity Orientations (see Table Q4 (7))

Strike and dip Orientation of joins		Very favorable	Favorable	Fair	Unfavorable	Very Unfavorable
Rating	Tunnels	0	-2	-5	-10	-12
	Foundation	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	-60

Table Q4 (4). Rook Mass Classes determined from Total Ratings

Rating	100-81	80-61	60-41	40-21	<21
Class No.	I	II	III	IV	V
Description	Very good Rock	Good rock	Fair Rock	Poor Rock	Very Poor Rock

Table Q4 (5). Meaning of rock mass classes

Class No	I	II	III	IV	V
Average stand-up time	20 years for 15m span	1 year for 10m span	1 week for 5m span	10 hours for 2.5m span	30 minutes for 1m span
Cohesion of the rock mass	>400kPa	300-400kPa	200-300kPa	100-200kPa	<100kPa
Friction angle of the rock mass	>45°	35 ° -45 °	25 ° -35 °	15 ° -25 °	<15 °

Table Q4 (6). Guidelines for Classification of Discontinuity Conditions

Discontinuity Length (persistence)	<1m	1-3m	3-10m	10-20m	>20m
Rating	6	4	2	1	0
Separation (aperture)	None	<0.1mm	0.1-1.0mm	1-5mm	>5mm
Rating	6	5	4	1	0
Roughness	Very rough	Rough	Slightly rough	Smooth	Slickensided
Rating	6	5	3	1	0
Infilling (gouge)	None	Hard filling<5mm	Hard filling>5mm	Soft filling<5mm	Soft filling>5mm
Rating	6	4	2	2	0
Weathering	Unweathered	Slightly weathered	Moderately weathered	Highly weathered	Decomposed
Rating	6	5	3	1	0

Table Q4 (7). Effect of discontinuity strike and dip orientation on Rock Mass Rating values for tunnels

Strike **Perpendicular** to tunnel axis		Strike **Parallel** to tunnel axis	
Drive **with** Dip with beds dip 45⁰-90⁰	Drive **with** Dip with beds dip 20⁰-45⁰	Beds dip 45⁰-90⁰	Beds dip 20⁰-45⁰
Very Favorable	**Favorable**	**Very Unfavorable**	**Fair**
Drive **against** Dip with beds dip 45⁰-90⁰	Drive **against** Dip with beds dip 20⁰-45⁰	Beds dip 0⁰-20⁰ Irrespective of strike	
Fair	**Unfavorable**	**Fair**	

Table Q4 (8). Effect of discontinuity strike and dip orientation on Rock Mass Rating values for Foundations, when direction of the load applies vertically downwards

Joints are horizontal	Dip joints dipping <25⁰	Dip joints dipping 25⁰-50⁰	Dip joints dipping 50⁰-75⁰	Dip joints dipping >75⁰
Very favorable	**Favorable**	**Fair**	**Unfavorable**	**Very unfavorable**

Table Q4 (9). Effect of discontinuity strike and dip orientation on Rock Mass Rating values for Slopes

Strike **Parallel** to road axis		Strike **Perpendicular** to road axis	
Cut slope **with** Dip with beds dip 45⁰-90⁰	Cut slope **with** Dip with beds dip 20⁰-45⁰	Beds dip 45⁰-90⁰	Beds dip 20⁰-45⁰
Very unfavorable	**Unfavorable**	**Unfavorable**	**Fair**
Cut slope **against** Dip with beds dip 45⁰-90⁰	Cut slope **against** Dip with beds dip 20⁰-45⁰	Beds dip 0⁰-20⁰ Irrespective of strike	
Very Favorable	**Favorable**	**Fair**	