00204

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	: 2019/20
Date	: 02nd October 2020
Time	: 0930-1230 hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Seven (7)** 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. "Sandstone" is a type of sedimentary rock found in the Earth crust.

(a). State three (03) possible textural features of sandstone in;

(i) Intact form (3 marks)

(ii) Rock mass form (3 marks)

(b). Discuss the impact of above-mentioned textural features on the engineering properties of intact as well as rock mass form of the sandstone formation. (14 marks)

Q2. Weathering causes to produce different effects on bedrock formations.

(a). State four (04) types of common weathering effects that can be observed in bed rock formations (4 marks)

(b). Discuss impact of the above-mentioned effects on;

(i) Stability of a slope (4 marks)

(ii) Groundwater potential (4 marks)

(iii) Rock anchoring potential (4 marks)

(iv) Bearing capacity of a shallow foundation (4 marks)

Q3. Write short notes on following geological phenomenon.

(a). Fault mountains (4 marks)

(b). Convergent boundaries (4 marks)

(c). Solid products of a volcanic eruption (4 marks)

(d) Stabilisation of borehole walls (4 marks)

(e) Double tube core barrels used in rock-coring (4 marks)

Q4. The information shown below in Table Q4 (1) were reported during an engineering geological site investigation program for a 15-storied building that is proposed to be constructed on an exposed rock.

With the above given information in Table Q4 (1) and with the help of attached Table Q4 (2) to Table Q4 (9), answer the 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 a foundation construction. (3 marks)

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

Table Q4 (1)

Item No.	Rock Mass Parameter Description		Rock Mass Parameter
01	Drill quality of rock mass		Core Recovery= 100% Rock Quality Designation= 80% Fracture Index= 1/m
02	Discontinuity spacing		1.4 m
03	Discontinuity orientation		Dips at an average dip angle of 40^0
04	Discontinuity condition	Length	4.50 m
		Separation	0.45 mm
		Roughness	Rough
		Infilling	Soft filling
			Thickness- 4. 5mm
		Weathering	Moderately weathered
05	Groundwater condition		Damp
06	Average Uniaxial Compressive Strength of rock cores		75 MPa

Q5. Groundwater potential of a particular rock mass mainly depends on its geological characteristics and the different geological processes undergone during its history.

(a) State four (04) different types of geological formations of groundwater and arrange it in an ascending order based on groundwater availability (4 marks)

(b) Describe the effects of different mineralogy in different rock types and its effects on the weathering that leads to differ in groundwater potential of different rock types. (10 marks)

(c). Discuss how brittle structures of rocks (joints, discontinuities etc.) will affect the groundwater potential of different rock masses. (6 marks)

Q6. A bridge abutment given in Figure Q6 (1), is to be placed on an excavated rock slope with a face angle of 60^0 and a slope height of 15.00 m. Furthermore, a weaker foliation plane 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. In order to improve the safety of the abutment, a rock bolt is proposed to be installed perpendicular to the slope face. The design load that will be imposed from the bridge to the abutment footing is 600 kN and the designers assume that the water level of the river will always below the toe of the slope face. The strength parameters of weaker joint plane are; effective cohesion (c') =60 kPa and effective angle of internal friction (ø') = 45^0. The unit weight

of rock mass material is 26 kN/m^3 and the unit weight of water can be assumed as 9.81 kN/m^3. 00204

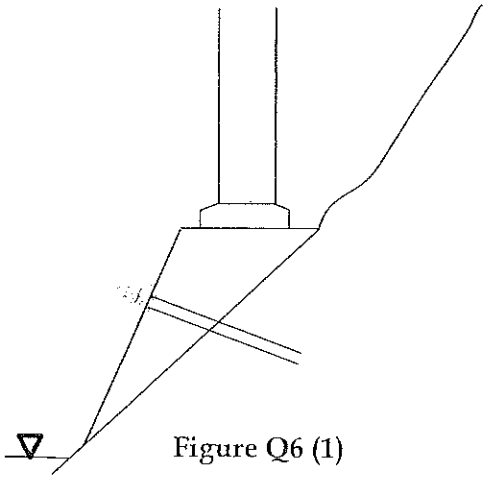

Figure Q6 (1)

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

(b). Write down the assumptions if you would address the slope stability problem mentioned above, using simple plane failure analysis. (5 marks)

(c). Estimate the capacity of the rock bolt to be installed to maintain a factor of safety of **3** against a possible slope failure of the abutment, under extremely saturated conditions. (10 marks)

Q7. Ground movements due to various geological occurrences and processes causes large amount of geotechnical engineering problems.

(a). State **four (04)** types of geological occurrences/ processes that causes ground movements and write down the corresponding ground movement process. (08 marks)

(b). Briefly describe the activities that will specially need to be performed to address the problems mentioned in [Q7 (a)] during the geotechnical design process. (12 marks)

Q8. Proper geotechnical investigation programme shall provide accurate and sufficient geotechnical parameters for a reliable geotechnical engineering design.

(a). State the steps that will need to be performed at each stage of a geotechnical investigation programme. (8 marks)

(b). Briefly describe the outcomes of the works that you have stated under [Q8 (a)]

(12 marks)

Table Q4 (2). Classification Parameters and Ratings

PARAMETER			RANGES OF VALUES						
1	Strength 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 45^0-90^0	Drive **with** Dip with beds dip 20^0-45^0	Beds dip 45^0-90^0	Beds dip 20^0-45^0
Very Favorable	**Favorable**	**Very Unfavorable**	**Fair**
Drive **against** Dip with beds dip 45^0-90^0	Drive **against** Dip with beds dip 20^0-45^0	Beds dip 0^0-20^0 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 <25^0	Dip joints dipping 25^0-50^0	Dip joints dipping 50^0-75^0	Dip joints dipping >75^0
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 45^0-90^0	Cut slope **with** Dip with beds dip 20^0-45^0	Beds dip 45^0-90^0	Beds dip 20^0-45^0
Very unfavorable	Unfavorable	Unfavorable	Fair
Cut slope **against** Dip with beds dip 45^0-90^0	Cut slope **against** Dip with beds dip 20^0-45^0	Beds dip 0^0-20^0 Irrespective of strike	
Very Favorable	Favorable	Fair	