

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2083 Baishakh

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering (Elective I) (CE72508)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.



1. What are the important of rock engineering in hydropower development? Draw a layout of hydropower plant with its main element. List any three problems caused by groundwater in rock engineering projects. Also, mention one method for estimating or measuring groundwater inflow in tunnels. [8]
2. Explain the intact rock and rock masses on the basis of Hudson and Harrison. What are the factors that affect the physical properties of rock mass? How can you utilize the generalized Hoek-Brown criterion for the strength of rock mass properties? List the different physical properties of rock mass and explain any two briefly. [8]
3. Explain the origin of in-situ rock stresses and describe how these stresses affect the stability of underground openings. Write down the different stability problems due to stresses. From the parameters given below, find the magnitude of tangential stress at the roof and wall of an unlined pressure shaft. Roof factor = 3.5, Wall factor = 2.5, Vertical stress = 12 MPa, Poisson's ratio (ν) = 0.25. [8]
4. Calculate the water flow into tunnel for following conditions: [8]
Length of tunnel = 1840 m; Active head = 0.86 MPa; Distance between length axis and groundwater table = 92 m; Unit weight of water = 9.81 kN/mm^3 ; Equivalent radius = 5.54 m and Hydraulic conductivity = 10^{-13} m/s
5. Why engineering geological investigation is necessary for underground structures? What are the activities that should be carried out during construction phase investigation? [8]
6. What is the purpose of rock mass classification in underground construction? Write down the RMR-support method in brief. For a new road cut, an engineering geological survey determined the following parameters for the rock mass. Calculate the RMI value from the observed value: Intact Rock UCS (σ_c) = 80 MPa Joint Condition Factor (j_c) = 1.4 Volumetric Joint Count (J_v) = 14 joints/ m^3 . [8]
7. Describe about the shallow seated opening for underground. What are the challenges in shallow seated underground opening and its associated problems? What type of the main slope failure occurs in Nepal? What are the general conditions for sliding and toppling of a block on an incline plane? [8]
8. Briefly describe the commonly used rock support methods in underground structures. Mention any two methods used to achieve improved and cost-saving solutions in the construction of underground high-pressure tunnels and shafts. Draw the distribution of tangential stress surrounding the circular opening of tunnel for the following conditions and critically discuss the influence of rock stress anisotropy for above planned structure. [8]
 - a) $\sigma_1/\sigma_3 = 16/16$ (MPa)
 - b) $\sigma_1/\sigma_3 = 16/10$ (MPa)
 - c) $\sigma_1/\sigma_3 = 16/4$ (MPa)

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2082 Bhadra

Exam.	Regular	
Level	BE	Full Marks 80
Programme	BCE	Pass Marks 32
Year / Part	IV / I	Time 3 hrs.

Subject: - Rock Engineering (Elective I) (CE72508)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.
- ✓ Sterionet and tracing paper attached herewith.

1. Why rock engineering is important for the civil engineering in Nepal? Describe about the Louis-equation. Is the Louis equation provides important information for understanding the basic features of water flow through rock joints? Mention some effects of water in rock engineering projects. [8]
2. What do you mean by intact rock and rock masses? Write about physical properties of rock. Why it is important to know the physical properties of the rock mass? Explain in brief the different properties associated with rock mass. [8]
3. What are the primary sources of rock stress beginning? Explain about the Kirsch's equations for tangential stresses. What are the stability problems caused by stress? Estimate the magnitude of tangential stress at the roof and wall of an unlined pressure shaft having roof factor = 3.6; Wall factor = 2.2; poisson's ratio = 0.25 and vertical stress = 32 MPa. [8]
4. Calculate the water flow into tunnel for following conditions: [8]
 - Length of tunnel = 1,230 m
 - Active head = 0.65 MPa
 - Distance between length axis and-groundwater table = 65m
 - Unit weight of water = 10 kN/m³
 - Equivalent radius = 3.25 m
 - Hydraulic Conductivity = 10-13 m/sec
5. What is engineering geological investigation? How do you prepare a detailed investigation report? List the heading only. Why tunnel mapping is required in construction phase activity? [8]
6. List the rock mass classification system and explain the Q system of rock mass classification with civil engineering application. For a new road cut, an engineering geological survey determined the following parameters for the rock mass. Calculate the Rmi value. [8]
 - Intact rock UCS (σ_c) = 60 MPa
 - Joint condition factor (j_c) = 1.2
 - Volumetric joint count (J_v) = 15 joints/m³
7. Explain the characteristics of shallow-seated and deep-seated underground openings. What are the problems associated with shallow-seated underground openings? Also, explain the solution to such problems. [8]

8. List the support method and principles. What are the purposes of support system in tunneling? What are the major points to be considered in designing low-cost hydropower plants? Draw the distribution of tangential stress surrounding the circular opening of tunnel for the following conditions and critically discuss the influence of rock stress anisotropy for above planned structure.

[8]

- Major principal stress / Minor principal stress = 12/12 (MPa)
- Major principal stress / Minor principal stress = 12/8 (MPa)
- Major principal stress / Minor principal stress = 12/3 (MPa)

9. The three discontinuity sets represent an area given below. Find mode of failure direction of failure and angle of potential failure plane if angle of slope face is 64 degrees in the dip direction of 334 degrees. Analyses the result in your own view with theoretical background.

[16]

Joint set number	Dip/Dip direction (degree)	Friction angle (degree)
1. Foliation (J_1)	66/184	28
2. Joint (J_2)	84/344	
3. Joint (J_2)	72/286	

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Subject: - Rock Engineering (Elective I) (CE72508)

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- Define rock mass with a neat sketch. What are the factors affecting rock properties? List out different rock properties and describe briefly. [1+2+5]
- What are the different stresses in rock? Describe topographic stress and gravitational stress with neat sketches. Calculate the magnitude of tangential stress at roof and wall of an unlined pressure shaft using following parameters: [2+2+4]
 - Roof factor (A) = 4
 - Wall factor (B) = 3
 - Vertical stress = 18 Mpa
 - Assume poisons ratio.
- Write down the methods of field measurements of ground water. Introduce briefly Calculate the water flow into the tunnel for following situations [2+6]
 - Length of the tunnel = 1200m
 - Hydraulic conductivity = 10^{-13} m/s
 - Active head = 0.65 MPa
 - Equivalent radius = 3.5 m
 - Distance between length axis of tunnel and ground water table = 55 m
- What are the main objectives of geological investigation? Describe briefly about surface and subsurface investigation. Describe the construction phase investigation. List the components of Engineering Geological Report. [8]
- Write down the formula for obtaining Q value of a rock mass. Describe all the parameters in the formula. Describe the RMR system of classification and compare the Q system of classification. [4+4]
- Discuss the design procedure of underground opening. What are the differences between shallow seated and deep-seated openings? [2+6]
- Enlist different support methods and principles used in underground excavations and describe them. What are the different types of stability problems in rock slope? Write the assumption of toppling failure. [4+4]
- Find the mode of failure, direction of failure and angle of potential failure plane if slope face is inclined at 65 degree and dip direction is 185 degrees. [8+8]

Joint set number	Dip/Dip direction
J ₁ Foliation	45/95
J ₂ Joint	75/240
J ₃ Joint	20/190

9. Discuss the design criteria for unlined high-pressure tunnels and discuss the importance and suitability of high pressure tunnels in Nepal.

[3+5]

Draw distribution of tangential stress surrounding the circular opening of a tunnel for the following conditions of major and minor principal stress and critically discuss the influence of rock stress anisotropy for planned surface.

- $\sigma_1/\sigma_3 = 12/12$ MPa
- $\sigma_1/\sigma_3 = 12/6$ MPa
- $\sigma_1/\sigma_3 = 12/3$ MPa

Exam.	Regular	
Level	BE	Full Marks 80
Programme	BCE	Pass Marks 32
Year / Part	IV / I	Time 3 hrs.

Subject: - Rock Engineering (CE72508) (Elective I)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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- ✓ sterionet and Tracing paper are attached herewith.
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1. Why rock engineering is important in Civil Engineering? Is there any reason delay of project in Nepal related to the rock Engineering? What are the problems caused by water in relation with rock Engineering? [8]
2. What are the factors effecting rock properties? Are you agree with the term there are different kind of properties in rock? If so, list them and explain them showing characteristics and engineering uses of any four. [8]
3. Discuss topographical and residual stresses in rock mass and explain kirsch's equation to evaluate tangential stresses for anisotropic stress conditions in a tunnel. Estimate the magnitude of tangential stress at the roof and wall of an unlined pressure shaft having roof factor = 3.6, wall factor = 2.4, poisson's ratio = 0.25 and vertical stress = 24 MPa. [8]
4. Define hydraulic conductivity and permeability of rock mass. Calculate the water flow into tunnel for following conditions: [8]
Length of tunnel = 1430 m, Active head = 0.65 MPa, Distance between length axis and groundwater table = 68 m, Unit weight of water = 10 kNmm³, Equivalent radius = 3.48 m and Hydraulic conductivity = 10⁻⁸ cm/s
5. What are the main goals of engineering geological investigations for underground hydropower plants? Describe the pre-construction phase investigation steps for a tunnel. Write the design procedures for permanent underground hydropower plants. [6+2]
6. Describe the principle of the RMR method for quality rating of rock mass and support estimation for a tunnel. What geological factors can affect tunnel stability? [8]
7. Write difference between shallow seated and deep-seated opening for underground opening. From the study of these two types opening how locate the tunnel in the field, give examples. What type of the main slope failure occurs in Nepal? What are the assumptions of toppling failure? [8]
8. Describe briefly the rock support methods that are commonly used in underground structure. Draw the distribution of tangential stress surrounding the circular opening of tunnel for the following conditions and critically discuss the influence of rock stress anisotropy for above planned structure. [8]
a) Major principal stress / Minor principal stress = 12/12 (MPa)
b) Major principal stress / Minor principal stress = 12/6 (MPa)
c) Major principal stress / Minor principal stress = 12/4 (MPa)
9. What are the objectives of rock slope stability analysis? The three discontinuity sets represent an area (ref. table below). Find the mode of failure and the angle of the potential plane if the angle of the slope face is 66 degrees in the dip direction of 332 degrees. The friction angle is 22 degrees. [16]

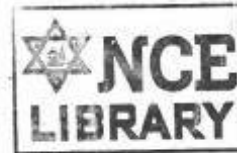
Joint set number	Dip/dip direction (deg).
Joint set (J ₁)	68/182
Joint set (J ₂)	78/350
Joint set (J ₃)	72/280

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Baishakh

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering (Elective I) (CE72508)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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- ✓ Necessary Stereonet are attached herewith.
- ✓ A4 size tracing paper will be provided if necessary.
- ✓ Assume suitable data if necessary.



1. Define Rock Engineering. What is the role of Rock Engineering in hydropower development? Briefly discuss the methods used for strength testing of rocks in field. [8]
2. Are the term intact rock and rock masses same? Explain about the important of physical properties in rock engineering. How the physical; index and engineering properties are related to the strength of rock? Explain any two with suitable example. [8]
3. What are the main types of stability problems caused by rock stresses? Discuss the basic principle of Hydraulic fracturing to obtain information about magnitude of the Principal stress. Discuss the influence of rock stress anisotropy on the distribution of a circular underground opening for following conditions:
 - Major Principal Stress/ Minor Principal Stress = 12/12 (MPa)
 - Major Principal Stress/ Minor Principal Stress = 12/6 (MPa)
 - Major Principal Stress/ Minor Principal Stress = 12/3 (MPa)

Assume that the major principle stress is approximately horizontal and perpendicular to the tunnel axis. [8]
4. Calculate the water flow into tunnel for following conditions: [8]

Length of tunnel = 1330 m; Active head = 0.61 MPa; Distance between length axis and groundwater table 64 m; Unit weight of water = 10 kN mm³; Equivalent radius = 3.44 m and Hydraulic conductivity = 10⁻¹³ m/s.
5. Why engineering geological investigation is necessary for underground structures? What are the different type of investigation carried out as per the requirement of the whole thing? Mention only the title of the engineering geological report includes. [8]
6. Define rock mass classification and list them. Why such a classification is important in the study of rock engineering? Explain any one in shortly. What type of rock support and methods are used in underground excavation? Reference them and explain according to the use of excavation. [8]

7. The attitude of discontinuous planes is given below (dip, dip direction in degrees). Present the results in a joint rosette and show the possible orientation of a deep seated tunnel. The Direction of Major Principal Stress is N 45°E. [8]

55,185	70,300
60,190	65,195
45,285	75,280
40,275	65,285
25,277	65,188
45,188	30,185
75,285	50,282
30,300	40,280
65,190	20,192
65,278	60,285
55,210	30,282
30,192	

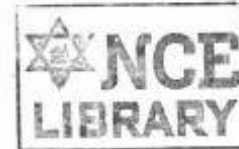
8. Write difference between shallow seated and deep seated openings for underground openings with location of tunnel axis. Mention support methods used in underground tunnel. Why support and linings are necessary during underground excavation? [8]
9. The three discontinuity sets represent an area given below. Find mode of failure direction of failure and angle of potential failure plane if angle of slope face is 68 degrees in the dip direction of 332 degrees. Friction angle = 23°. [16]

Joint set number	Dip/Dip direction (Degree)	Joint Spacing (cm)	Roughness
1. Foliation (J ₁)	66/182	1-2	Planner to undulating
2. Joint (J ₂)	80/350	18-40	undulating
3. Joint (J ₂)	75/280	8-30	undulating

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering (Elective I)(CE72508)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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- ✓ Necessary Stereonet are attached herewith.
- ✓ A4 size tracing paper will be provided if necessary.
- ✓ Assume suitable data if necessary.



1. Why rock engineering is important in hydropower development? Is there any reason delay of hydropower related to the rock engineering? Discuss briefly, problem caused by water in designing underground structures. [8]
2. What are your observation about the intact rock and rock masses? Are you agree with the term there are different kind of properties in rock? If so list them and explain them showing characteristics and engineering uses of any four. [8]
3. What do you mean by rock stress? Explain about the origin and magnitude of rock stress situation surrounding underground opening. What are the stability problem due to stresses? Calculate the magnitude of tangential stress by the Hoek and Bray practical method at the roof and wall of an unlined pressure shaft having Roof factor = 3.8; Wall factor = 2.4 and vertical stress = 30 MPa. [8]
4. Estimated the water flow into tunnel by the Tokheim and Janbu method from the following data: [8]
 Length of tunnel = 1845 m; Active head = 0.75 MPa; Distance between length axis and groundwater table = 66 m; Unit weight of water = 10 kNmm³; Equivalent radius = 3.6 m; Hydraulic conductivity = 10⁻¹³ m/s.
5. Describe in detail stages and substages of geological investigation for underground hydropower plants. Write contents of engineering geological report from the define plan study investigations. [8]
6. Describe the Q-method for quality rating of rock mass and support estimation for a tunnel. Briefly discuss support methods which are commonly used in the hydropower tunnels. [8]
7. Write difference between shallow seated and deep seated opening for underground opening. From the study of these two types opening how you locate the tunnel in the field give examples. What type of the main slope failure occurs in Nepal? What are the assumption of plane failure? [8]
8. a) What are the major points to be considered in designing low cost hydropower plants? Explain briefly. Draw the distribution of tangential stress surrounding the circular opening of tunnel for the following conditions and critically discuss the influence of rock stress anisotropy for above planned structure. [8]
 - i) Major principal stress/Minor principal stress = 12/12 (MPa)
 - ii) Major principal stress/Minor principal stress = 12/8 (MPa)
 - iii) Major principal stress/Minor principal stress = 12/3 (MPa)
- b) Find the potential mode of failure, direction of failure and angle of failure of a rock slope having with following input data: [16]
 - Joint Set 1: 50/340 degrees (dip/dip direction)
 - Joint Set 2: 58/280 degrees (dip/dip direction)
 - Joint Set 3: 15/080 degrees (dip/dip direction)
 - Slope angle: 60/320 degree (dip/dip direction)

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Ashwin

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering (Elective I) (CE72508)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Sterionet and tracing paper are attached herewith.
- ✓ Assume suitable data if necessary.

- What are the important of rock engineering in hydropower development? Draw a layout of hydropower plant with its main element. [4]
- Define joint set. What do you mean by joint mapping? List the physical characteristics of rock and explain any three with example. [8]
- What do you mean by rock stress? Discuss the origin and magnitude of rock stress situation surrounding underground openings. [4]
- Calculate the water flow into tunnel for following conditions: [8]
 - Length of tunnel = 1230 m
 - Active head = 0.65 MPa
 - Distance between length axis and groundwater table = 65m.
 - Unit weight of water = 10 kNmm³
 - Equivalent radius = 3.25m
 - Hydraulic conductivity = 10⁻¹³ m/s
- Discuss briefly, problems caused by water in designing underground structures. Do you think it is important part for design of underground structures? [4]
- What are the objectives of engineering geological investigation? List the activities that should be carried out during preconstruction and construction phase investigation. [8]
- Define rock mass classification and its objectives. What are commonly used methods in rock classification describe them? [8]
- Write difference between shallow seated and deep seated opening for underground opening. Also mention the main goals of design consideration for underground openings. [6]
- Why support and lining are necessary during underground excavation? Describe briefly the rock support methods that are commonly used in underground structure. [6]
- What are the factors affecting slope stability? What type of the main slope failure occurs in Nepal? Describe them with neat sketches. [6]
- What are the major points to be considered in designing low cost hydropower plants? [6]
- The three discontinuity sets represents an area (ref. table below). Find mode of failure direction of failure and angle of potential failure plane if angle of slope face is 66 degree in the dip direction of 342 degree. [12]

Table: Discontinuity sets.

Joint set number	Dip/Dip direction (Degree)	Joint Spacing (cm)	Roughness
1. Foliation (J ₁)	65/185	1-2	Planner to undulating
2. Joint (J ₂)	72/355	18-40	Undulating
3. Joint (J ₂)	75/280	8-30	Undulating

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering (Elective I) (CE72508)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. What makes rock engineering unique in the complexity and uncertainty involved when interacting with the natural geological environment. [8]
2. Write short notes on: [4+4]
 - i) Generalized Hoek-Brown Failure criterion
 - ii) Shear strength of joints
3. What do you mean by rock stress? Explain with suitable example the different type of rock stresses which are faced by rock. [4]
4. Calculate the water flow into tunnel for the following conditions: [8]

Length of tunnel = 1330 m
 Active head = 0.64 MPa
 Distance between length axis and groundwater table = 62m.
 Unit weight of water = 10 kNmm³
 Equivalent radius = 3.3 m
 Hydraulic conductivity = 10⁻¹³ m/s
5. What is engineering geological investigation? How do you prepare a detailed investigation report? Illustrate it with example. [10]
6. What is rock mass? Explain how the quality of rock mass can be rated and support system can be estimated by RMR system. [10]
7. State the characteristics of shallow-seated and deep-seated openings. Explain orientation of length axis of tunnel with respect to surrounding joints and principal stresses. [4+4]
8. Describe briefly the rock support methods that are commonly used in underground structure. Why support and lining are necessary during underground excavation. [6]
9. Why hydropower construction is being costly and time consuming in Nepal? Can you make hydropower construction be economical if so how? [6]
10. The three discontinuity sets represents an area (ref. table below). Find mode of failure direction of failure and angel of potential failure plane if angle of slope face is 68 degree in the dip direction of 332 degree. [12]

Table: Discontinuity sets.

Joint set number	Dip/Dip direction (Degree)	Joint Spacing (cm)	Roughness
1. Foliation (J ₁)	66/185	1-2	Planner to undulating
2. Joint (J ₂)	75/355	18-40	Undulating
3. Joint (J ₂)	70/280	8-30	Undulating

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering (Elective I) (CE72508)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Necessary Equal Area Net and Tracing Paper (A4 size) are attached herewith.
- ✓ Assume suitable data if necessary.

1. What do you mean by Geological and Geotechnical engineering? [4]
2. Why it is important to measure the rock stress? How can we measure the rock stress? Explain any one method of rock stress measurement. [8]
3. Define Joint Rosset. Differentiate between intact rock and rock mass. [2+2]
4. Calculate the water flow into tunnel for the following conditions: [10]
 - Length of tunnel = 1320 m
 - Active head = 0.7 MPa
 - Distance between length axis and groundwater table = 80 m
 - Unit weight of water = 10 kN/m³
 - Equivalent radius = 3.2 m
 - Hydraulic conductivity = 10⁻¹³ m/s
5. What are the different stages of geological investigation for an underground structure? At what stage tunnel mapping is done? Explain the tunnel mapping with neat sketch. [8]
6. Estimate the magnitude of tangential stress at the roof and wall of an unlined pressure shaft using following input parameter: [8]
 - Roof factor = 3.8
 - Wall factor = 2.6
 - Vertical stress = 18 MPa
7. Find the time required for water, subjected to a 18 m head difference to pass horizontal through (a) a 8 m length of intact quartz which has an isotropic hydraulic conductivity of 1×10⁻² m/s and (b) through a 6 m length of fracture rock with an isotropic hydraulic conductivity of 1×10⁻⁴ m/s? [10]
8. State the characteristics of shallow-seated underground openings. Write down the associated stability problems and its solution. [4+4]
9. The three discontinuity sets represents an area (ref. table below). Find mode of failure direction of failure and angle of potential failure plane if angle of slope face is 60° in the dip direction of 320°. [10]

Table: Discontinuity sets:

Joint set number	Dip/Dip direction (Degree)	Joint Spacing (cm)	Roughness
1. Foliation (J1)	60/170	1-2	Planner to undulating
2. Joint (J2)	75/340	18-40	Undulating
3. Joint (J2)	65/275	8-30	Undulating

10. Write short notes on:

- i) Factors to be considered while analyzing the stability analysis of plane failure.
- ii) Rock Mass Index method of classification

[5×2]

04H

TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2072 Kartik

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering I (Elective I) (CE72508)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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- ✓ Assume suitable data if necessary.

1. What are the main elements of hydropower plants? Write down the weakness zones and faults in rock. [2]
2. What are the different origins of rock stress? What are the different ways of rock stress measurements in the field and why is it necessary to be measured? Write down the different methods for determining the rock stress in brief.
3. Why is the study of groundwater important in designing underground structure? Write down the methods of field measurement of ground water.
4. Explain preconstruction phase engineering geological investigation for tunnel. Describe the components of engineering geological report.
5. List the rock parameters that you should use in a rock mass classification? Describe RMR system of rock mass classification.
6. List out the stability problems in shallow and deep seated opening. Explain orientation of length axis of tunnel with respect to surrounding joints and principle stresses.
7. a) Why are support and lining necessary during underground excavation? List out the rock support methods.
b) What are the underground high pressure tunnels? Write down their importance.
8. a) What are the different methods of stability analysis of rock slope? Describe one of them.
b) The three discontinuity sets as presented in table below represents an area. Find mode of failure, direction of failure and angle of potential failure plane if angle of slope face is 65° in the dip direction of 185° .

Table: Discontinuity sets

Joint set number	Dip/Dip direction (Degree)	Angle of internal friction (ϕ)
Joint (J1)	45/105	20°
Joint (J2)	70/235	30°
Joint (J3)	25/356	25°

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- ✓ Attempt All questions.
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- ✓ Necessary Equal Area Net and Tracing Paper (A4 size) are attached herewith.
- ✓ Assume suitable data if necessary.

1. Define rock mass. Why it is important to know the physical properties of the rock mass? Explain in brief the different physical properties associated with rock mass. [8]
2. Define in-situ and induced rock stresses. Explain the origin of in-situ rock stresses and stress around circular opening with neat sketch. [3+5]
3. What are the different discontinuities present in the rock mass? Categorizes the discontinuity with its distinguishing features. [8]
4. From the parameter given, find the magnitude of stresses surrounding the underground opening (tangential) at the roof and the wall of an unlined pressure shaft using roof factor as 3.9, wall factor as 2.8 and vertical stress of 20MPa. Assume Poisson's ratio of 0.25. [6]
5. What is the potential mode of failure, direction of failure and angle of potential failure plane using stereopolt for the given following discontinuity sets if angle of slope face is 60 degree with dip direction of 325 degree? [10]

Features	Dip/ Dip direction in degree
Sheet joint	55/280
Joint set 1	55/335
Joint set 2	80/050
Joint set 3	70/330

6. What is Q-system in quality rating and support system estimation? Write down the RMI-support method in brief. [6+4]
7. Explain the characteristic of shallow – seated and deep – seated underground openings. What are the problems associated with shallow seated underground opening? Also explain the solution to such problems. [10]
8. Describe briefly the rock support methods that are commonly used in underground structure. [6]
9. What are the objectives of engineering geological investigation? List the activities that should be carried out during preconstruction and construction phase investigation. [4+6]
10. Why hydropower construction is being costly in Nepal. [4]

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering I (CE72505) (Elective I)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt *All* questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Necessary figures are attached herewith.
- ✓ Assume suitable data if necessary.
- ✓ Provide A-4 size Tracing paper and copy of stereonet.

1. Define shallow seated and deep seated opening for underground structure? Describe the main engineering design procedure for underground opening. (8)
2. Estimate the magnitude of tangential stress at a roof and wall of an unlined pressure shaft using following input parameters (6)

Roof factor = 3

Wall factor = 2.5

Vertical stress = 18 MPa
3. a) Recently you completed an engineering geological survey of an area. Write down contents that should be incorporated in the report. (4)
- b) What are the comments the classification system for rock support estimates. (4)
4. Calculate the water flow into a tunnel in lit/minute for following situations. (8)

Length of tunnel = 350 m

Specific permeability = 10^{-15} m^2

Active head = 3 MPa

Equivalent radius = 4.0 m

Distance between the length axis of excavation and ground water table = 20m
5. Write the main goals of engineering geological investigation. List the activities which should be carried out during preconstruction and construction phase investigation. (8)
6. Explain stress surrounding circular underground opening. (6)
7. Discuss support methods which are commonly used in underground structures (6)
8. Write short notes on: (6*2)
 - a) Q- method for rating of the rock mass quality
 - b) Design criteria for unlined high pressure tunnel and shaft (two rules of thumb).

9. The three discontinuity sets represents an area (ref. table 1). Find mode of failure and angle of potential failure plane if angle of slope face is 65° in the dip direction of 185°

Table 1 Discontinuity sets

(10)

Joint set number	Dip/Dip direction	Joint spacing (cm)	Roughness
Foliation (J_1)	58/168	1-2	Planar to undulating
Joint (J_2)	52/342	18-40	undulating
Joint (J_3)	58/276	8-30	undulating

10. Plot the joint Rosette with following dip/dip direction (degrees) of discontinuities (ref table 2)

(8)

Dip/dip direction

40/300	55/07	15/290
25/025	70/075	78/340
20/29	15/330	65/08
75/165	25/280	22/285
10/280	12/280	83/09
80/100	70/08	75/140
65/07	75/200	75/190
80/190	30/290	80/340
80/200	20/330	20/320
75/060	68/070	78/060
75/240	25/290	78/200
45/290	82/160	22/280
78/090	30/290	80/110

Table 2

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering I (Elective I) (CE72505)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Necessary Equal Area Net and Tracing Paper (A4 size) are attached herewith.
- ✓ Assume suitable data if necessary.

1. Define rock engineering. Enumerate the physical properties of rock. Describe one of them. [2+6]
2. What is rock stress? Discuss the origin and magnitude of rock stress for underground structure. Explain the stress situation surrounding underground opening. [4+6]
3. Explain different methods of field measurements to estimate ground water leakage in tunnel. [8]
4. What are the stages of Engineering Geological investigation? Describe the activities that are carries out in the construction phase investigation. [10]
5. What are the Rock class classification systems? Describe Q method of rock class classification. [10]
6. What are the differences between shallow seated and deep seated openings for underground opening? Enlist the general recommendations for deep seated opening. [8]
7. a) Explain different methods to evaluate the support requirements in underground excavation. [4]
b) What are the cost saving solutions in Tunnel construction? Write down the importance of shafts. [4]
8. a) What are the basis for classification of stability problems? Write down the factors affecting the stability of rock slopes. [8]
b) The three discontinuity sets represent an area. Find mode of failure and angle of potential failure plane if angle of slope face is 60° in the dip direction of 320° . [10]

Discontinuity sets

Joint set number	Dip/Dip direction (Degree)	Joint spacing (cm)	Roughness
Joint set 1 (J_1)	57/167	1-2	Plannar to undulating
Joint set 2 (J_2)	51/342	18-40	Undulating
Joint set 3 (J_3)	58/276	3-30	Undulating

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering I (Elective I) (CE72505)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. Enumerate the main elements of underground hydropower with neat sketch. [2]
2. List out different laboratory testing methods most commonly used to measure strength of rocks. Explain any one of them. [8]
3. What are the stresses surrounding underground openings? Calculate the magnitude of tangential stress at the roof and wall of an unlined pressure shaft using following parameters: Roof factor (A) = 4, Wall factor (B) = 3, Vertical stress = 18 Mpa. Assume Poisson's ratio. [10]
4. Define permeability and hydraulic conductivity. How can water leakage in underground opening be estimated using basic flow theory? [8]
5. What are the different stages of engineering geological investigation? How do you investigate the site during the construction of an underground structure? Explain. [10]
6. What is rock mass? Explain how the quality of rock mass can be rated and support system can be estimated by RMR system. [10]
7. State the design principle for unlined high pressure tunnel. Write down the rules of thumb to design unlined high pressure tunnel with neat picture. [8]
8. What are the different methods of support in underground excavations? Illustration of them. [4]
9. a) What are the most common slope failures in rock slopes. Write down the methods of rock slope stability analysis. Explain probabilistic method. [8]
- b) For adjoining figure, calculate T, Factor of safety = 1.5 against sliding. Given, W = 500 kN, $\psi=50^\circ$ and $\theta=25^\circ$, $\phi = 42^\circ$ and C = 15 kN/m, sliding area, A = 8 m². [8]
10. What are high pressure tunnels? Is this possible in Nepal? Give your opinion. [4]

Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering (Elective I) (CE725)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Necessary figures are attached herewith.
- ✓ Assume suitable data if necessary.

1. Define rock mass. What are common methods that are used in rock strength test? Define briefly. [2+6]
2. a) Write down the different stability problems due to stresses? [4]
b) From the parameter given below. Find the magnitude of tangential stress at roof and wall of unlined pressure shaft. [8]
Roof factor = 3.5
Wall factor = 2.5
Vertical stress = 12 Mpa
 $\nu = 0.25$
3. Calculate the hydraulic conductivity of an array of parallel fractures in the direction parallel to the plane of a rock mass with a fracture frequency of one fracture per meter and with fracture apertures of 0.01 mm, the hydraulic conductivity is 8.3×10^{-10} m/s. [6+2]
4. What are the different stages of geological investigation for an underground structure? At what stage tunnel mapping is done? Explain the tunnel mapping with neat sketch. [12]
5. A rock mass classification system is required for assessing the suitability of different rock formations for storing compressed domestic gas in unlined rock caverns along the route of a main gas transmission line. Describe the rock parameters that you would use in a rock mass-rock engineering classification scheme for this objective. [12]
6. A 15 m high rock slope has been excavated at a face angle of 65° and is horizontal at the ground surface. The rock in which this cut has been made contains persistent bedding planes that dip at an angle of 32° in to the excavation. The 5.85 m deep tension crack is 4.5 m behind the crest, and is filled with water to the height of 4 m above the sliding surface. The strength parameters of the sliding surface are as follows: cohesion is 25kPa, friction angle is 37° , take the unit weight of rock as 26 kN/m^3 and the unit weight of water as 10 kN/m^3 . (a) Calculate the factor of safety of the slope for the conditions given above. (b) Determine the factors of safety if the tension crack were completely filled with water due to run off collecting on the crest of the slope. [6+6]
7. a) Describe briefly the rock support methods that are commonly used in underground structure. [4]
b) What are high pressure tunnels and shafts? Why are these structures developed? [4]
8. Find mode of failure, direction of failure and angle of potential failure if slope face is 65° degree in the dip direction 185° from the three discontinuity set given below: [8]

Table: Discontinuity set

Joint set number	Dip / Dip direction
J_1 Foliation	45/95
J_2 Joint	75/240
J_3 Joint	20/190

Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Rock Engineering (Elective I)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. Explain the role of rock engineering in hydropower development in Nepal. [2]
2. What is strength of rocks? How do the joints on rock mass affect its strength? Explain the affect of faults in brief. [8]
3. Define in-situ and induced rock stresses. Explain the origin of in-situ rock stresses and the stress around circular opening with neat sketch. [2+4+4]
4. Calculate the water flow into tunnel for following conditions: [8]
 - Length of tunnel = 1200 m
 - Active head = 0.6 Mpa
 - Distance between length axis and groundwater table = 60 m
 - Unit weight of water = 10 KN/m³
 - Equivalent radius = 3 m
 - Hydraulic conductivity = 10⁻¹³ m/s
5. What is engineering geological investigation? How do you prepare a detailed investigation report? Illustrate it with an example. [10]
6. What is Q-system in quality rating and support estimation? Write down the RMI-support method in brief. [10]
7. State the characteristics of shallow-seated underground openings. Write down the associated stability problems and its solution. [8]
8. How can you evaluate whether any support system is required in underground opening? [4]
9. The three discontinuity sets represent an area (ref. table below). Find mode of failure, direction of failure and angle of potential failure plane if angle of slope face is 60 degree in the dip direction 320 degrees. [16]

Table: Discontinuity sets

Joint set number	Dip/ Dip Direction (Degree)	Joint spacing (cm)	Roughness
1. Foliation (J ₁)	60/170	1-2	Planer to undulating
2. Joint (J ₂)	55/340	18-40	Undulating
3. Joint (J ₂)	65/275	3-30	Undulating

10. What are the pressure shafts? How can they be implemented? [4]