NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

# FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

## DEPARTMENT OF CIVL, MINING AND PROCESS ENGINEERING

| QUALIFICATION : BACHELORS OF ENGINEERING IN MINING ENGINEERING | |
|---|---|
| QUALIFICATION CODE: 08BMEG | LEVEL: 7 |
| COURSE CODE: RMC711S | COURSE NAME: ROCK MECHANICS |
| SESSION: JUNE 2023 | PAPER: THEORY |
| DURATION: 2.5 HOURS | MARKS: 80 |

| FIRST OPPORTUNITY QUESTION PAPER | |
|---|---|
| EXAMINER(S) | Mallikarjun Rao Pillalamarry |
| MODERATOR: | Prof. Mapani Benjamin |

| INSTRUCTIONS |
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| 1. Answer all questions.<br>2. Read all the questions carefully before answering.<br>3. Marks for each question are indicated at the end of each question.<br>4. Please ensure that your writing is legible, neat and presentable. |

## PERMISSIBLE MATERIALS

1. Examination paper.
2. Graph Papers
3. Mathematical Instruments

**THIS QUESTION PAPER CONSISTS OF 3 PAGES** (Including this front page)

**Instructions: Answer all questions.**

**Time allowed: 2.5 hours**

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**Question 1** An opening is made to access the orebody in an underground mine. The opening was intersected by a fracture as shown in Figure. In order to assess the stability of the opening the stresses acting parallel and perpendicular to the fracture must be known. State of stress near the fracture (A) is given in the Figure. Determine following quantities. (20)

a) Shear stress acting parallel to the fracture.

b) Normal stress acting perpendicular to the fracture.

c) Draw the state of stress element along the discontinuities.

d) Determine principal stresses and major principal direction with respect to the fracture.

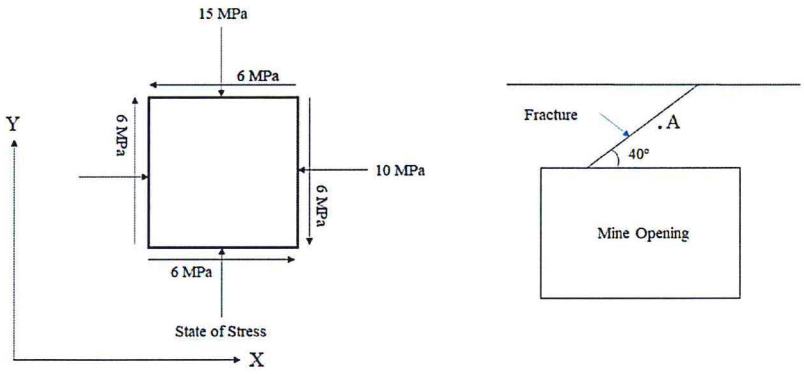


Figure 1

**Question 2** A series of triaxial stresses test of shale reveals the following results. Determine (20)

| Test No | Confining Pressure (MPa) | Failure Stress (MPa) |
|---|---|---|
| 1 | 2 | 45 |
| 2 | 4 | 56 |
| 3 | 6 | 63 |
| 4 | 8 | 75 |

a) Mohr Coulomb failure envelope

b) Uniaxial compressive strength of shale

c) Tensile strength of shale

d) If the state of stress at a point is expressed as $\sigma_3$ = 1.5 MPa and $\sigma_1$ = 55 MPa, determine whether the point is safe

**Question 3** Briefly describe measurement of Rock Quality Designation (RQD) with the help of figures. (20)

**Question 4**

a) Briefly discuss the in-situ stress measurement with hydraulic fracturing method. (10)

b) The stress in a granitic rockmass has been measured by the hydraulic fracturing technique. Two tests are conducted in a vertical borehole. One test at a depth of 800 m and the other test at a depth of 1200 m. The results are as follows: (10)

| Depth (m) | Breakdown Pressure ($P_B$) (MPa) | Shut-in Pressure ($P_s$) (MPa) |
|---|---|---|
| 800 | 14 | 7.0 |
| 1200 | 24.5 | 19.0 |

Given the tensile strength of the rock is 10 MPa, estimate and list the values of major, intermediate and minor principal stresses at two depths. Average unit weight of the rockmass is 26 kN/m$^3$.

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## ADDITIONAL INFORMATION

## RMC711S June/July Exam

Plane Stresses

Normal stresses

$$\sigma_n = \left(\frac{\sigma_{xx} + \sigma_{yy}}{2}\right) \pm \left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right) \cos 2\theta \pm \tau_{yx} \sin 2\theta$$

Shear Stress

$$\tau = -\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right) \sin 2\theta + \tau_{yx} \cos 2\theta$$

Principal stress direction

$$\theta = \frac{1}{2} \tan^{-1} \left[\frac{2\tau_{xy}}{(\sigma_{xx} - \sigma_{yy})}\right]$$

Direction of maximum shear stress

$$\theta = \frac{1}{2} \tan^{-1} \frac{-(\sigma_{xx} - \sigma_{yy})}{2\tau_{xy}}$$

Mohr Coulomb Failure Criteria

$$\sigma_1 = \frac{2c \cos \emptyset + \sigma_3(1 + \sin \emptyset)}{1 - \sin \emptyset}$$

In-situ stresses measurement using hydraulic fracturing

Major horizontal stress ($\sigma_H$) = $3\sigma_h$-$P_B$+$\sigma_t$