FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF MINING ENGINEERING

ROCK MECHANICS

EMI 3201

Final Examination Paper

AUGUST 2021

This examination paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Mr B MLAMBO

INSTRUCTIONS

1. **Answer all questions from section A and any TWO (2) from section B**
2. Each question carries 25 marks
3. Use of calculators is permissible

Additional Requirements

Graph paper

Calculator

MARK ALLOCATION

Question 1 to 5	**Total 25 marks**
Part Questions	**As shown in each part question**
Total Attainable	**100 marks**

SECTION A: ANSWER ALL QUESTIONS

QUESTION 1

(a) Elaborate on how the mechanical behavior of a rock is different from any other solid engineering materials like steel? **[5]**

(b) Sketch a typical stress-strain graph during a uniaxial compression test. What physical processes are occurring in the sample as the curve manifests significant gradient changes? **[10]**

(c) A cylindrical rock sample is subjected to Uni-axial loading. The sample has a diameter of **50mm** and an axial length of **125 mm**. Similar tests have shown that the Young's Modulus for intact rock is **75 GPa** and axial strain is **4** times lateral strain.

At one point during the test, the strain gauges indicate a strain of 3×10^{-3}

(i) Calculate the distance the sample has to be compressed to reflect a strain of this magnitude **[2]**

(ii) What is the horizontal strain at this point in the test? **[2]**

(iii) What is the new sample height and width at this point of the test? **[2]**

(iv) Calculate the average axial stress in the sample at this point **[2]**

(v) Calculate the lateral stress developed in the sample **[2]**

QUESTION 2

(a) *"The ambient state of stress in an element of rock in the ground subsurface is determined by both the current loading conditions in the rock mass and the stress path defined by its geologic history."*
Briefly explain any 5 factors affecting the overall stress levels in a rockmass. **[10]**

(b)

$$\sigma_r = \frac{1}{2}q(1+k)\left(1-\frac{R^2}{r^2}\right)-\frac{1}{2}q(1-k)\left(1-\frac{4R^2}{r^2}+\frac{3R^4}{r^4}\right)\cos 2\theta$$

$$\sigma_\theta = \frac{1}{2}q(1+k)\left(1+\frac{R^2}{r^2}\right)+\frac{1}{2}q(1-k)\left(1+\frac{3R^4}{r^4}\right)\cos 2\theta$$

$$\tau_{r\theta} = \frac{1}{2}q(1-k)\left(1+\frac{2R^2}{r^2}-\frac{3R^4}{r^4}\right)\sin 2\theta$$

Making use of the above ***Kirsch equations***, determine the radial and tangential stresses along a circular tunnel with diameter **4.0m** situated at a depth of **1800m** below surface in quartzite. The Poisson's ratio is **0.33**. The major stress component acts perpendicular to the excavation and is a product of the virgin stress components only. Determine the radial and tangential stress components on the edge of the excavation as well as for points **0.5m 1.0m 1.5m and 2.0m** into the solid along the excavation. Expect that the rock reacts elastically.

[15]

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION 3

(a) The following strain components were measured at a point in a rock

$\varepsilon_x = 0.003$ **$\varepsilon_y = 0.00012$** **$\gamma_{xy} = 0.0005$**

Determine the principal stresses in the x-y plane given that the modulus of elasticity is 72 GPa and the Poisson's ratio is **0.2**. **[10]**

(b) The following stress state exists at a point in rock

$\sigma_x = 20$ MPa **$\sigma_y = 40$ MPa** **$\tau_{xy} = 10$ MPa**

Make use of the Mohr circle diagram to depict the stress state, indicate the maximum and minimum principal stresses. **[8]**

(i) Indicate on the diagram how you would determine the normal and shear stresses on a plane whose normal makes an angle of 15^o, measured anti-clockwise with the x-axis. **[3]**

(ii) Make a free-hand sketch to illustrate the orientation of the principal stresses relative to the x-y axes. **[2]**

(iii) During the elastic part of the stress strain behavior of rock, does the volume of the rock increase or decrease? Make use of an example calculation to show the effect of Poisson's ratio on the change in volume. **[2]**

QUESTION 4

a) Give three **(3)** conditions of rock masses that the Hoek-Brown criterion can be used. **[3]**

b) The generalised Hoek-Brown failure criterion given below was used in Phase2D numerical software program for stress and displacement evaluations in a tunnel construction project.

$$\sigma'_1 = \sigma'_3 + \sigma_{ci}\left[m_b \frac{\sigma'_3}{\sigma_{ci}} + s\right]^a$$

(i) Identify each parameter in the failure criterion **[6]**

(ii) As the Geotechnical Engineer working on the project, briefly describe how you would determine the following parameters for you to be able to satisfactorily run your model in the software:

σ_{ci} **[4]**

m_b, s and **a.** **[12]**

QUESTION 5

Define and write a few notes on the following physical properties of rocks:

(a) Specific Gravity of Solids, $\mathbf{G_s}$

(b) Unit Weight, $\boldsymbol{\gamma}$

(c) Porosity, **n**

(d) Water content

(f) Void ration, **e**

(g) Permeability

[25]

END OF EXAMINATION