FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF MINING ENGINEERING

ROCK MECHANICS

EMI 3201

Final Examination Paper

July/August 2022

This examination paper consists of **5** pages

Time Allowed: **3 hours**

Total Marks: **100**

Examiner's Name: Mr B MLAMBO

INSTRUCTIONS

1. **Answer questions ONE (1) and any other THREE (3)**
2. Each question carries **25** marks
3. Use of calculators is permissible

Additional Requirements

Calculator

MARK ALLOCATION

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

QUESTION 1

(a) How is the mechanical behavior of a rock 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) Making use of the below ***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.

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

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

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

[10]

QUESTION 2

(a) Explain in detail why you think the study of rock mechanics is of great benefit to the Zimbabwean Mining industry citing some practical examples **[10]**

(b) Explain five factors that influence pre-mining stress **[15]**

QUESTION 3

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

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

(b) Unit Weight, γ

(c) Porosity, **n**

(d) Water content

(f) Void ration, **e**

(g) Permeability

[25]

QUESTION 4

(a) Briefly describe any 5 applications of rock mechanics in mining **[10]**

(b) 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 **[3]**
(ii) What is the horizontal strain at this point in the test? **[3]**
(iii) What is the new sample height and width at this point of the test? **[3]**
(iv) Calculate the average axial stress in the sample at this point **[3]**
(v) Calculate the lateral stress developed in the sample **[3]**

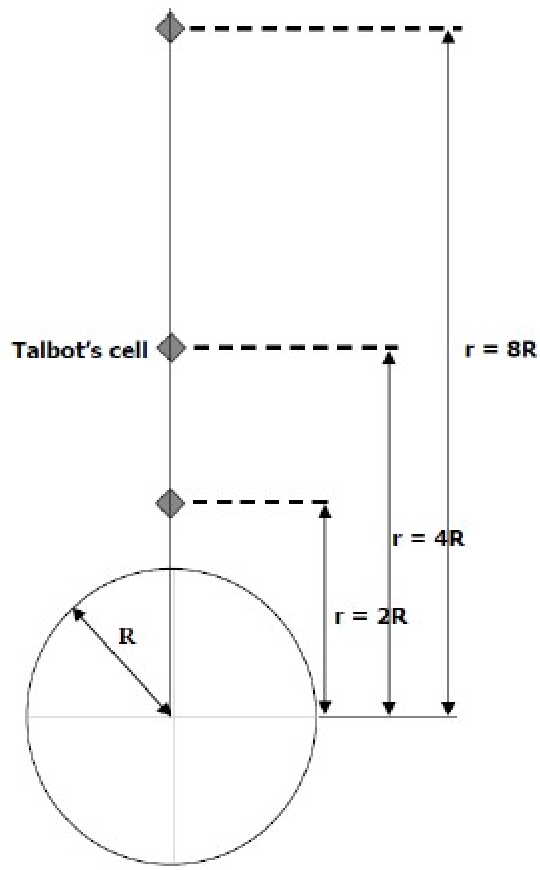
QUESTION 5

A service tunnel of 4 m diameter is to be excavated in granite using NATM. The most critical stretch of the tunnel is when it is 300 m deep below ground surface, and at this depth the prevailing major stresses are:

Vertical stress, $\sigma_V = 7.8$ MPa

Horizontal stress, $\sigma_H = 2.6$ MPa.

Computer simulation indicates that the most critical part of the tunnel at 300 m deep is its roof section. To monitor *excavation induced stress* and *thickness of yield zone* in the roof it is planned to install instrumentation right after excavation. The instrumentation consists of series of Talbot's cells installed in a borehole at orientation $\theta = 0^0$, and at depth r = 2R, r = 4R and r = 8R from the tunnel centre, as shown in figure below.



Orientation and depth of Talbot's cells from centre of tunnel

Formula:

$$\sigma_r = \frac{1}{2}(\sigma_V + \sigma_H)\left(1 - \frac{R^2}{r^2}\right) + \frac{1}{2}(\sigma_V - \sigma_H)\left(1 - 4\frac{R^2}{r^2} + 3\frac{R^4}{r^4}\right) cos2\theta$$

[where R is radius of tunnel, r is depth into the surrounding rock measured from tunnel centre]

Assumptions:

- No major discontinuities and tectonic stresses occur in the rock mass
- The rock mass is linearly elastic, homogeneous and isotropic
- Hydrostatic state of stress is applicable

- The thickness of the yield zone is equal all around the circular tunnel

(a) Along the vertical direction, the value of stress in the yield zone changes gradually to the value of stress outside the yield zone. With regard to the *excavation induced stresses* (σ_r) in the yield zone and *major stresses* (σ_V) acting on the tunnel, explain the nature of these changes

[7]

(b) Calculate the probable radial stresses σ_r (in MPa and at 2 decimal places) that will be recorded by the Talbot's cells at depth r = 4R and r = 8R m. **[12]**

(a) If the value of σ_r calculated at depth of r = 8R is assumed to be the stress just outside the yield zone, state the approximate thickness (m) of the resulting yield zone around this circular tunnel

[6]

END OF EXAMINATION