Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: CERTIFICATE IN ROCK MECHANICS **PAPER 3.3:** MASSIVE UNDERGROUND MINING (HARD AND SOFT ROCK) **SUBJECT CODE: COMRMC 3.3** **DATE 10 OCTOBER 2024** **TIME**: **14H30 TO 17H30**	**EXAMINER:** T S Mtshali **MODERATOR:** J Walls **TOTAL MARKS:** [100] **PASS MARK:** (60%)

NUMBER OF PAGES: 6

THIS IS NOT AN OPENBOOK EXAMINATION – ONLY REFERENCES PROVIDED ARE ALLOWED

SPECIAL REQUIREMENTS:

1. **Answer All the Questions**. Answer the questions **legibly** in English.
2. Write your **ID Number** on the outside cover of each book used and on any graph paper or other loose sheets handed in.

NB: Your name **must not** appear on any answer book or loose sheets.

3. Show all calculations **and check the calculations on which the answers are based.**
4. Hand-held electronic calculators may be used for calculations. **Reference notes may not be programmed into calculators.**
5. Write **legibly** in ink on the **right-hand page** only – **left-hand pages will not be marked**.
6. Illustrate your answers using sketches or diagrams wherever possible.
7. **Final answers** must be given to an accuracy typical of practical conditions, however, be careful not to use too few decimal places during your calculations, as rounding errors may result in incorrect answers.

NB: Ensure that the correct unit of measure (SI unit) is recorded as marks will be deducted from answers if the incorrect unit is used even if the calculated value is correct.

8. In answering the questions, full advantage should be taken of your practical experience as well as the data given.
9. Please note that you are not allowed to contact your examiner or moderator regarding this examination.
10. Cell phones AND OTHER SMART DEVICES are **NOT** allowed in the examination room.

General

Where assumptions are required, the candidate is expected to clearly state the assumptions that govern the answer(s).

Total Mark = (100)

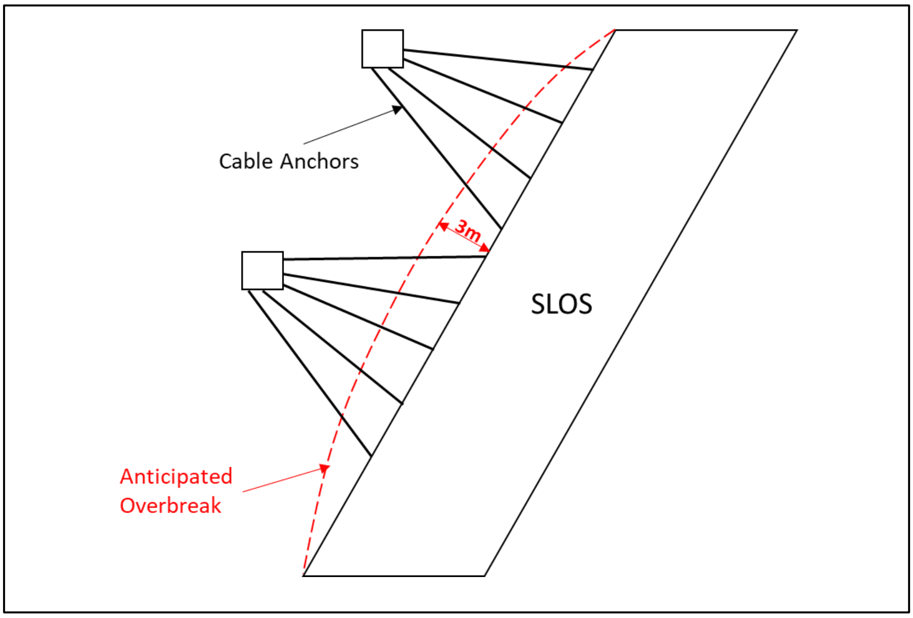
Question 1 **[25]**

1.1. Clearly define the following: (10)

- 1.1.1. Stress Caving
- 1.1.2. Empirical Design
- 1.1.3. ELOS (Equivalent Linear Overbreak Sloughing)
- 1.1.4. Primary fragmentation
- 1.1.5. Secondary Fragmentation

1.2. Name five (5) advantages of Sublevel Caving over other massive mining methods. (5)

1.3. During the design of a Sublevel Open Stope, it was determined that the average depth of overbreak along the hanging wall of the stope is anticipated to be approximately 3m. As the Rock Engineer, you decide to install cable anchors into the hanging wall of the stope, from two access drives situated in the hanging wall of the orebody, as depicted in the figure below. The host rock has a density of 3.0t/m^3.



The cable anchors used on the mine have a diameter of 16mm, a tensile strength of 380 kN and the bond strength provided by the grout is 12 MPa, after 7 days of curing. Using the formula provided below, determine the minimum depth of grout anchorage required beyond the anticipated failure zone. (5)

$$\tau_b = \frac{P_b}{\Pi d_b l_b}$$

Where: τ_b = ultimate bond strength (MPa)

P_b = maximum pull-out load of bolt (kN)

d_b = bolt diameter

l_b = bolt length

$\Pi d_b l_b$ = bonded area (m^2)

1.4. Determine the spacing of the cable anchors to prevent the anticipated overbreak. State all assumptions clearly. (5)

Question 2 **[25]**

An underground crusher is planned for Copper MineA at 1500 m below collar elevation in massive (un-bedded) rock. The crusher chamber that will accommodate the crusher is 10m wide, 10 m high and 40 m long. All other tunnels in the mine are 4 m wide and 4 m high. The vertical stress is determined by depth and rockmass density of 2700 kg/m³. Assume a k-ratio of 1.5.

2.1 Describe the extraction and support sequence for the crusher chamber using annotated sketches to provide clarity. (6)

2.2 Describe the siting of the excavation in relation to geological features and principal stresses. (4)

2.3 Design a support strategy for the crusher chamber. In your answer briefly describe your reasoning for support type, spacing and length. (4)

2.4 During the development phase of the crusher chamber the miner complains about spitting from the development face and describes how rock fragments are ejected at high velocities from the development face, making a loud sound and often resulting in rock related injuries. Briefly describe this phenomenon in rock engineering terminology and propose a strategy to manage this risk. (4)

2.5 The manager suggests a seismic system be installed to monitor the phenomenon described in question 2.4. Briefly describe the likely monitoring objectives and instruments required for this monitoring. (6)

2.6 What other instruments can be used in the excavation to monitor deformation? (1)

Question 3 **[25]**

3.1 Only answer True or False for the following questions:

3.1.1 The Acoustic Televiewer is better suited than the Optical Televiewer in defining the fractures in a borehole. (1)

3.1.2 During the overcoring method of in-situ stress measurements, the change in stress is recorded and converted to strain using the elastic properties of the core. (1)

3.1.3 In a transverse sublevel caving layout, the production drifts are orientated across the length of the orebody. (1)

3.1.4 For the finite element method of stress analysis, the material surrounding an excavation is subdivided into discrete, interacting elements. (1)

3.1.5 Chimney caving involves the progressive migration of an unsupported mining cavity through the overlying material to the surface. (1)

3.2 A steep dipping gold-bearing lode deposit extends underneath a residential area on surface, at a maximum depth of 300m below surface. What are the legislative requirements prior to the commencement of mining underneath the residential area and clearly state where this guideline or instruction can be found? (5)

3.3 Name five geotechnical considerations when risk assessing the undermining of the residential area? (5)

3.4 A portal decline, situated at the bottom of a 42m open pit high wall, is to be tunnel bored at a diameter of 6m. The overburden material has a density of 2.7t/m3. As a tertiary support system, you decide to install steel sets, using the equation suggested below by Brady and Brown. What should the spacing of the steel sets be, considering the importance and life of mine stability of the excavation? Cleary state all assumptions. (5)

$$P_{i\ max} = \frac{17.6\ D^{-1.24}}{s}$$

Where:

Pi max – Maximum Support Pressure (MPa)

D – diameter of tunnel

s – set spacing

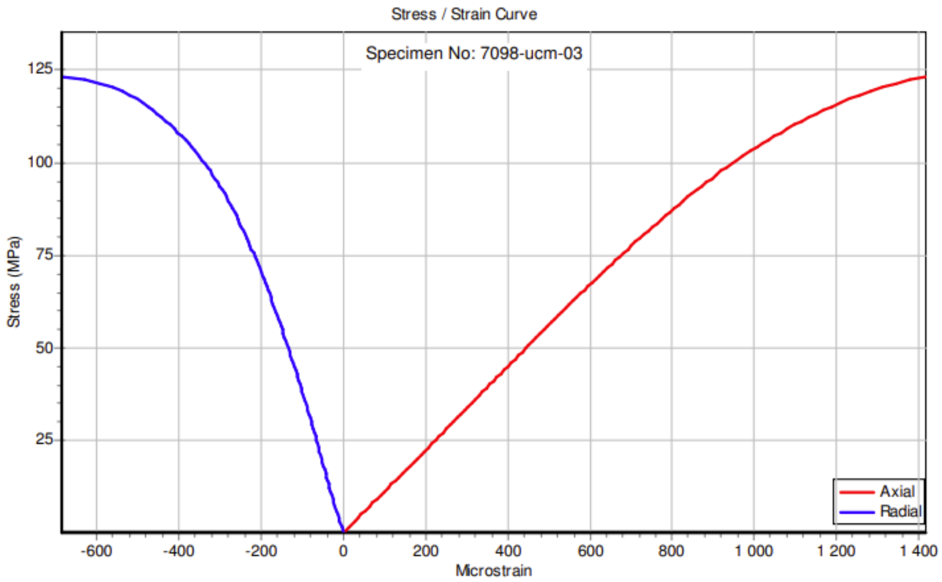
3.5 Calculate the tensile strength of the bolts and determine the critical bond length to ensure that the shear strength of the resin equals the tensile strength. The tensile strength for a 20mm diameter, 450 MPa high yield stress steel rock bolts is given. (5)

Question 4 **[25]**

4.1. As part of the geotechnical data acquisition phase for the Greenfields project of a copper deposit, laboratory strength testing on selective core samples were completed.

What is a UCM test and what sample parameters are obtained? (5)

4.2 From the Stress-strain plot depicted below for one of the samples, determine the Young's Modulus and Poisson's Ratio at 50% of the peak load? (5)



4.3 What are the main objectives of draw control in a Block Cave mining operation? (5)

4.4 Name four main purposes of geotechnical monitoring in a block cave mine? (4)

4.5 Sketch the flow ellipsoid concept. Indicate and describe the ellipsoid of motion, the limit ellipsoid and draw cone. (6)