Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: MINERALS COUNCIL OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS	**EXAMINER:** MH NGWENYA
	MODERATOR: Y RAJPAL
SUBJECT CODE: COMCSCM	
DATE – 03 OCTOBER 2023	**TOTAL MARKS:** [100]
TIME: **14H30 TO 17H30**	**PASS MARK:** (60%)

NUMBER OF PAGES: 8

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

SPECIAL REQUIREMENTS:

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

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

3. Show all calculations **<u>and check calculations on which the answers are based.</u>**
4. Hand-held electronic calculators may be used for calculations. **<u>Reference notes may not be programmed into calculators.</u>**
5. Write **<u>legibly</u>** in ink on the **<u>right-hand page</u>** only – **<u>left hand pages will not be marked</u>**.
6. Illustrate your answers by means of sketches or diagrams wherever possible.
7. **<u>Final answers</u>** must be given to an accuracy which is 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.

<u>NB:</u> 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 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 **<u>NOT</u>** allowed in the examination room.

QUESTION 1

General Questions, Terms and Definitions

Show calculations.

1.1 If the outer circular surfaces of the cylindrical samples 1 and 3 with radii of 7.5 cm and 5 cm are subjected to axial stress of 11.3 MPa and 25.4 MPa respectively (see figure 1 in Appendix A), calculate the resultant axial stress acting on the circular surface of the cylindrical sample 2 whose radius is 3 cm. (4)

1.2 A cylindrical rock sample with a length to diameter (i.e., L/D) ratio of 2.5 was loaded uniaxially in the laboratory testing facility. The stress-strain curve test result is presented in figure 2 of Appendix A. Calculate the elastic modulus of the cylindrical rock sample. (1)

1.3 If the cylindrical rock sample is 9 cm long, calculate its volume. (2)

1.4 If the cylindrical rock sample weighs 300 g, calculate its density (1)

1.5 Calculate the radial deformation in millimetres of the cylindrical rock sample at the onset of permanent deformation (refer to figure 2 of Appendix A). (2)

Choose the correct answer from the four options provided. Only write the letter a, b, c or d next to each question number.

1.6 A right angled triangle has one side of length 2.5 m and a hypotenuse of length 8 m. What is the length of the remaining side? (1)

a) 7.57 m b) 57.57 m^2 c) 7.60 m d) 5.50 m

1.7 What will the average pillar stress be if the virgin stress is 70 MPa and the extraction ratio is 81%? (1)

a) 87.5 MPa b) 386 MPa c) 368 MPa d) 1939 MPa

1.8 The prevailing stress value in a particular direction is 25 MPa. The effect of pore pressure that was induced can be expressed as 7 MPa. The effective stress (MPa) is: (1)

a) 32 MPa b) 16 MPa c) 18 MPa d) 25 MPa

1.9 RCF is used to describe ground conditions of: (1)

a) Gullies b) Massive stopes c) Tabular stopes d) Tunnels

1.10 The recommended design for the width to height ratio of crush/yield pillars is: (1)

a) > 30 b) = 3 c) > 3 d) < 3

Definitions

Define the following terms:

1.11 Geophone (2)

1.12 Ground Control District (2)

1.13 Subsidence (2)

1.14 Ride (2)

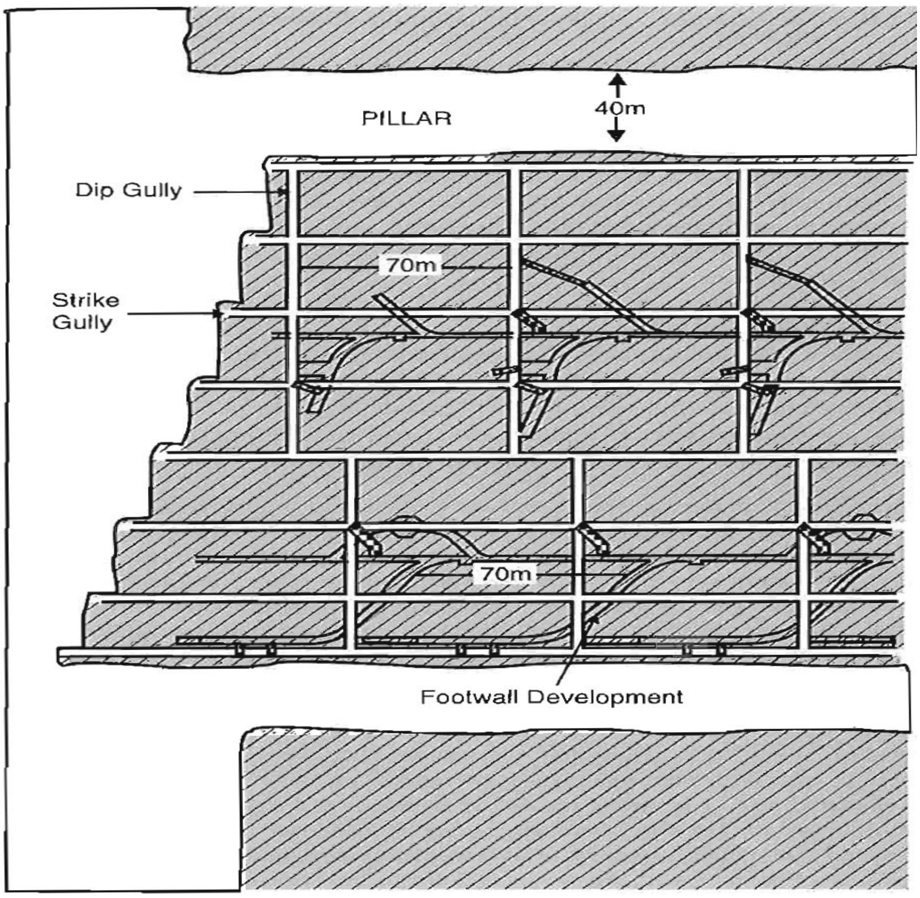
1.15 Energy release rate (2)

Total [25]

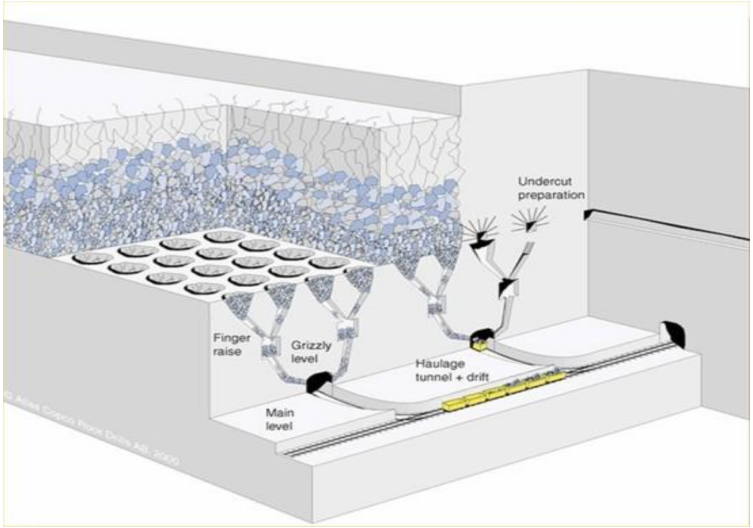
QUESTION 2

Mining methods, stresses and rock behaviour around tunnels and service excavations

2.1 Name the mining method shown below and list at least 4 major geotechnical considerations associated with the method. (3)



2.2 Name the mining method shown below and list at least 4 major geotechnical considerations associated with the method. (3)



2.3 Use a sketch and show clearly with annotation the difference between an overhand and underhand mining configuration. (2)

2.4 Define what is meant by "k-ratio". Show the fracture pattern around a socket in the stress regime with (a) a k-ratio of 1.5 and with (b) a k-ratio of 0.5. (3)

2.5 A vertical raise bore hole (3.5m in diameter) is planned to be used as an orepass. The field stress is estimated to be 45 MPa in the east-west direction and 60 MPa in the north-south direction. Make use of analytical equations to calculate the radial and tangential stress in the side wall of the raise bore hole in the east west direction at the following distances: r=R, r=2R and r=3R. Assume the theta angle is 0 degrees to the east. Draw a graph showing schematically the radial and tangential stresses. (14)

Total [25]

QUESTION 3

Support

3.1 A stope is supported with timber mine poles with a load/deformation performance graph as shown in figure 3 in Appendix A. The mine standard requires the elongates to be installed at a spacing of 1.5 m on dip x 2.0 m on strike centre to centre. Given a closure rate of 2 mm per metre face advance and a support resistance criterion of 36.5 kN/m^2, determine whether the support resistance criterion is met at the sweepings line 15 m from the face if the elongates are installed 2m from the face. What changes to the support standard would you recommend, if any? (5)

3.2 Using figure 3 in Appendix A, calculate the crude estimate of the energy that would have been absorbed by the timber mine pole at the sweepings line 15 m from the face if the elongates are installed 2m from the face. (5)

3.3 Explain the difference between active support and passive support (2)

3.4 What unit can be used to make a mine pole support unit active at installation? (1)

3.5 What is the effect of excessive pre-stressing the timber mine pole unit? (1)

3.6 What effect will an increase in stoping width have on the strength of a timber mine pole? (1)

3.7 What would you do to make sure that timber mine pole support satisfies the design criteria where the panel stoping width is in excess of the support or design height? (1)

3.8 How will the support compliance and support density be affected where a number of required mine pole support units are installed but the support spacing or pattern does not satisfy the Mine's standard support pattern? (1)

3.9 If you were conducting quality control and assurance on the timber mine pole units stored at the Mine's surface timber yard, name at least six (6) items you will check. (3)

3.10 With the aid of an annotated diagram, describe the effect of loading rate on the performance of timber support units when comparing the load / deformation characteristics determined in laboratory tests to the performance under i) quasi-static (rock fall) and ii) dynamic (rock burst) conditions. (5)

Total [25]

QUESTION 4

Layouts and Monitoring Methods

4.1 Under the heading "The path to a safe gully" there are the following three criteria to consider to design a safe gully. Name six factors to consider per criteria.

a) Selection of gully geometry (3)

b) Selection of gully support (3)

c) Mining practices to ensure good gully conditions (3)

4.2 When specifying gully layouts there are nine essential dimensions which define overall gully geometry. Describe these with the aid of sketches. (9)

4.3 Name four reasons why underground monitoring is required. (4)

4.4 Describe the geophysical technique of Ground Penetrating Radar and name a typical application. (3)

Total [25]

Appendix A

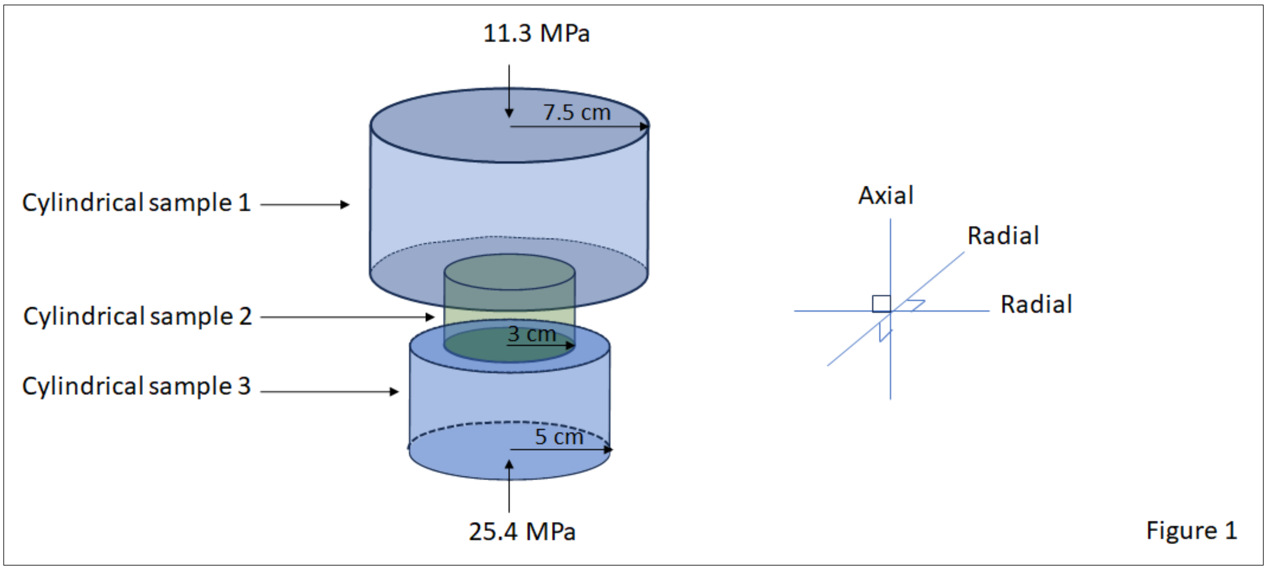


Figure 1 Uniaxial loading on a cylindrical samples in contact with each other.

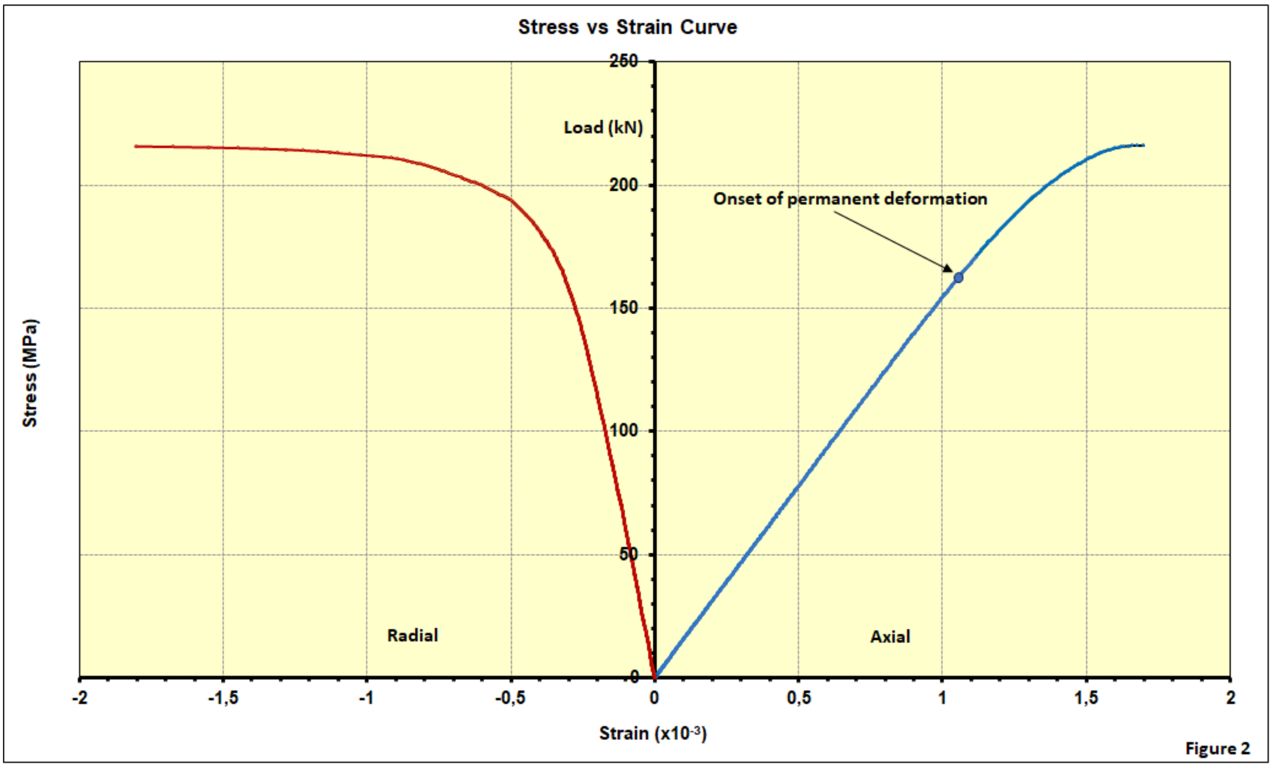


Figure 2 The stress-strain curve from a rock sample that was loaded uniaxially.

Appendix A

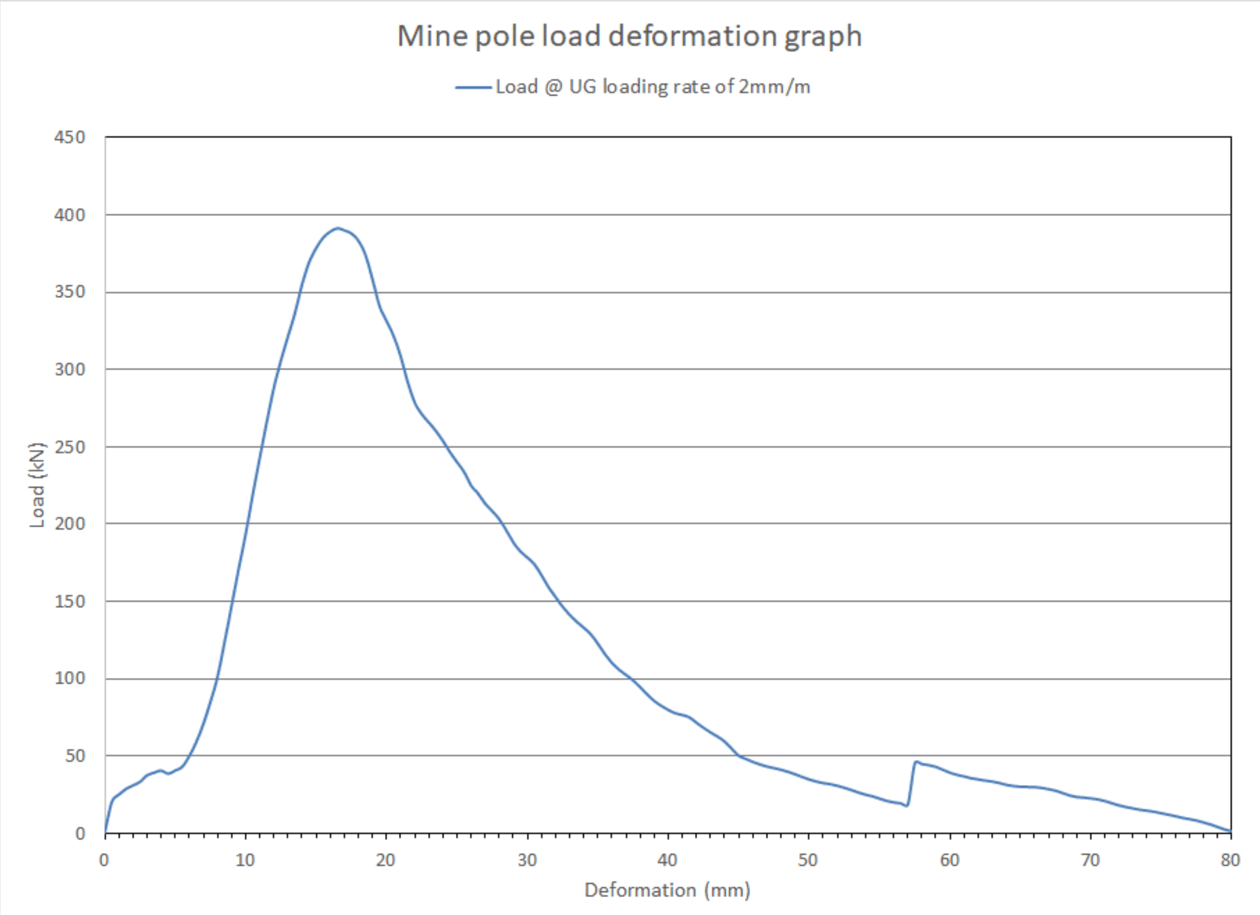


Figure 3 Timber mine pole load-deformation curve

FORMULE SHEET

$$\varepsilon_{xx} = \frac{1}{E}\{\sigma_{xx} - \nu(\sigma_{yy} + \sigma_{zz})\} \quad \gamma_{xy} = \frac{1}{G}\tau_{xy} \quad \varepsilon_{xy} = \frac{1}{2G}\tau_{xy} \quad G = \frac{E}{2(1+\nu)}$$

$$\varepsilon_{yy} = \frac{1}{E}\{\sigma_{yy} - \nu(\sigma_{xx} + \sigma_{zz})\} \quad \gamma_{yz} = \frac{1}{G}\tau_{yz} \quad \varepsilon_{yz} = \frac{1}{2G}\tau_{yz} \quad K = \frac{E}{3(1 - 2\nu)}$$

$$\varepsilon_{zz} = \frac{1}{E}\{\sigma_{zz} - \nu(\sigma_{xx} + \sigma_{yy})\} \quad \gamma_{zx} = \frac{1}{G}\tau_{zx} \quad \varepsilon_{zx} = \frac{1}{2G}\tau_{zx}$$

$$\sigma_{xx} = \lambda\Delta + 2G\varepsilon_{xx} \quad \tau_{xy} = G\gamma_{xy} \quad \tau_{xy} = 2G\varepsilon_{xy} \quad \Delta = \varepsilon_{xx} + \varepsilon_{yy} + \varepsilon_{zz}$$

$$\sigma_{yy} = \lambda\Delta + 2G\varepsilon_{yy} \quad \tau_{yz} = G\gamma_{yz} \quad \tau_{yz} = 2G\varepsilon_{yz} \quad \lambda = \frac{E\nu}{(1+\nu)(1-2\nu)}$$

$$\sigma_{zz} = \lambda\Delta + 2G\varepsilon_{zz} \quad \tau_{zx} = G\gamma_{zx} \quad \tau_{zx} = 2G\varepsilon_{zx} \qquad E = \sigma/\varepsilon$$

$$\sigma_{zz} = 0 \quad \varepsilon_{zz} = -\frac{\nu}{E}(\sigma_{xx} + \sigma_{yy}) \qquad \upsilon = \varepsilon_r/\varepsilon_a$$

$$\varepsilon_{xx} = \frac{1}{E}(\sigma_{xx} - \nu\sigma_{yy}) \quad \gamma_{xy} = \frac{1}{G}\tau_{xy} \quad \sigma_{xx} = \frac{E}{1-\nu^2}(\varepsilon_{xx} + \nu\varepsilon_{yy}) \quad \tau_{xy} = G\gamma_{xy}$$

$$\varepsilon_{yy} = \frac{1}{E}(\sigma_{yy} - \nu\sigma_{xx}) \quad \sigma_{yy} = \frac{E}{1-\nu^2}(\varepsilon_{yy} + \nu\varepsilon_{xx})$$

$$\varepsilon_{zz} = 0 \quad \sigma_{zz} = \nu(\sigma_{xx} + \sigma_{yy})$$

$$\varepsilon_{xx} = \frac{1}{E}\{(1-\nu^2)\sigma_{xx} - \nu(1+\nu)\sigma_{yy}\}$$

$$\varepsilon_{yy} = \frac{1}{E}\{(1-\nu^2)\sigma_{yy} - \nu(1+\nu)\sigma_{xx}\}$$

$$q = \rho g H \quad \sigma_v = q \quad \sigma_h = kq$$

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

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

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