Minerals Council South Africa

QUESTION PAPER

SUBJECT:	**EXAMINER**: MW WIGGINS
MINERALS COUNCIL OF SOUTH AFRICA	**MODERATOR**: R ARLOW
CERTIFICATE IN STRATA CONTROL –	**TOTAL MARKS**: 100
METALLIFEROUS	**PASS MARK:** 60%
SUBJECT CODE: COMCSCM	
DATE: 07 OCTOBER 2025	
TIME: 14H00 TO 17H00	

NUMBER OF PAGES: 10 (including this one)

EXAMINATION FORMAT: CLOSED BOOK. NO REFERENCES OTHER THAN WHAT ARE PROVIDED ARE ALLOWED.

SPECIAL REQUIREMENTS:

1. Answer all the questions in legible English.
2. Write your ID number (no names) on the outside cover page of each script used and on any graph paper or other loose sheets handed in.
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 black 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 with 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 used, as marks will be deducted if the incorrect unit is used, even if the calculated value is accurate.
8. In answering the questions, full advantage should be taken of your practical experience as well as the data given.
9. You are not allowed to contact your examiner or moderator regarding this examination.
10. Cell phones and other smart devices are not allowed on your person and must be handed to the invigilators or left in your vehicle.

QUESTION 1. GENERAL KNOWLEDGE

Multichoice (15 Marks)

1.1 The Mohr–Coulomb failure criterion is expressed as:

a) $\tau = c + \sigma_n \tan \varphi$

b) $\sigma_1 = \sigma_c + m\sigma_3$

c) $\sigma_t = \sigma_c / 10$

d) $\tau = \sigma_1 - \sigma_3$

1.2 Convergence in a stope is best defined as:

a) Lateral displacement of hangingwall beams

b) Closure of excavation height between hangingwall and footwall

c) Shearing along bedding planes

d) Yielding of pillars

1.3 The critical value of Energy Absorption Capacity (EAC) for support is measured in

a) J/m^3

b) kN/m

c) MJ/m^2

d) kJ/m

1.4 A yield pillar is primarily designed to:

a) Increase local support resistance

b) Allow controlled energy dissipation through deformation

c) Increase extraction ratio

d) Prevent backbreak

1.5 Which of the following is a primary seismic hazard in tabular stopes?

a) Ventilation blockage

b) Rock burst due to dynamic loading

c) Convergence creep

d) Support corrosion

1.6 The vertical stress at depth is calculated by:

a) $\sigma_v = \rho gh$

b) $\sigma_v = \sigma_1 - \sigma_3$

c) $\sigma_v = \sigma_c \ (W/H)^{0.5}$

d) $\sigma_v = k.\sigma_h$

1.7 Hoek–Brown is generally more applicable to:

a) Intact specimens

b) Jointed rock masses

c) Support elements

d) Soil

1.8 The k-ratio in mining stress analysis is defined as:

a) σ_1/σ_3

b) σ_h/σ_v

c) τ/σ_n

d) σ_c/σ_t

1.9 The Energy Release Rate (ERR) is best described as:

a) Elastic strain energy per unit volume

b) Energy dissipated in support systems

c) Energy released per unit mining advance area

d) Stress concentration factor

1.10 A prerequisite for energy-absorbing support is:

a) High stiffness with brittle failure
b) Controlled yield and stable post-yield capacity
c) Zero elongation
d) Only corrosion resistance

1.11 In Barton–Choubey, JRC means:

a) Joint Reactivity Coefficient
b) Joint Roughness Coefficient
c) Joint Rock Constant
d) Joint Residual Cohesion

1.12 Which of the following is a method for controlling rock burst damage?

a) Square panel design
b) Using shorter blasts
c) Increasing pillar width indefinitely
d) Yielding support installation

1.13 The typical uniaxial compressive strength (σ_c) of hard quartzites is in the range:

a) 20–50 MPa
b) 50–100 MPa
c) 100–300 MPa
d) 300–500 MPa

1.14 The most important geometric factor influencing pillar strength is:

a) Width-to-height ratio (W/H)
b) Depth of mining
c) Extraction ratio
d) Pillar orientation

1.15 Which technique is used to destress the ground in highly seismic areas?

a) Hydraulic fracturing
b) Grouting
c) Pre-conditioning blasting
d) Increasing support stiffness

<u>Definitions (10 Marks)</u>

1.16 Define the following:

a) Pore pressure
b) Induced stress
c) Safety factor
d) Geophone
e) Hypocentre (Seismic)

Total [25]

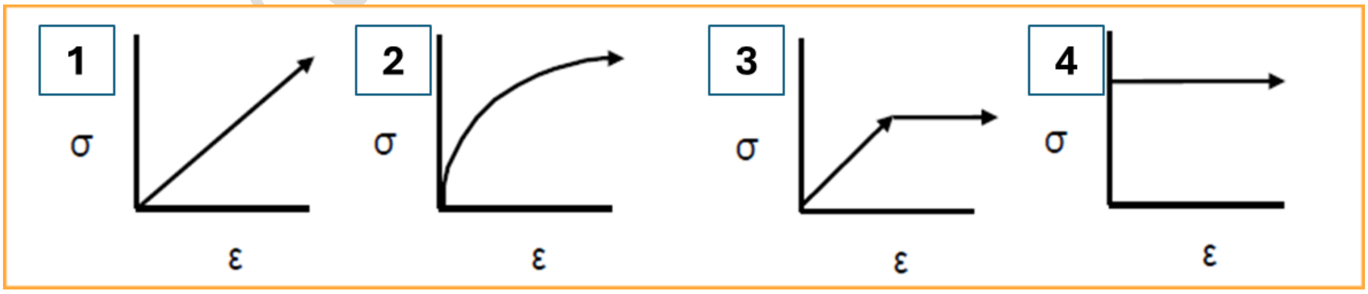
QUESTION 2. BASIC THEORY AND CALCULATIONS

2.1 Explain “Heim’s rule” with the correct formula and expected SI Unit (3)

2.2 If Vertical Stress is 70 MPa at 2500 m depth and k = 1.3, calculate the horizontal stress. (2)

2.3 Explain the concept of “dog-earing” with an annotated sketch. (2)

2.4 Annotate the following sketches to show the rock mass behaviour and deformation. List the differences between elastic and plastic rock behaviour. (4)



Total [11]

QUESTION 3. CONVERGENCE AND CLOSURE

3.1 Define stope convergence. (2)

3.2 List two common instruments for measuring stope convergence. (2)

3.3 Calculate closure for a 1.2 m stope with calculated stress at a depth of 50 MPa with Young's modulus of 70 GPa. (3)

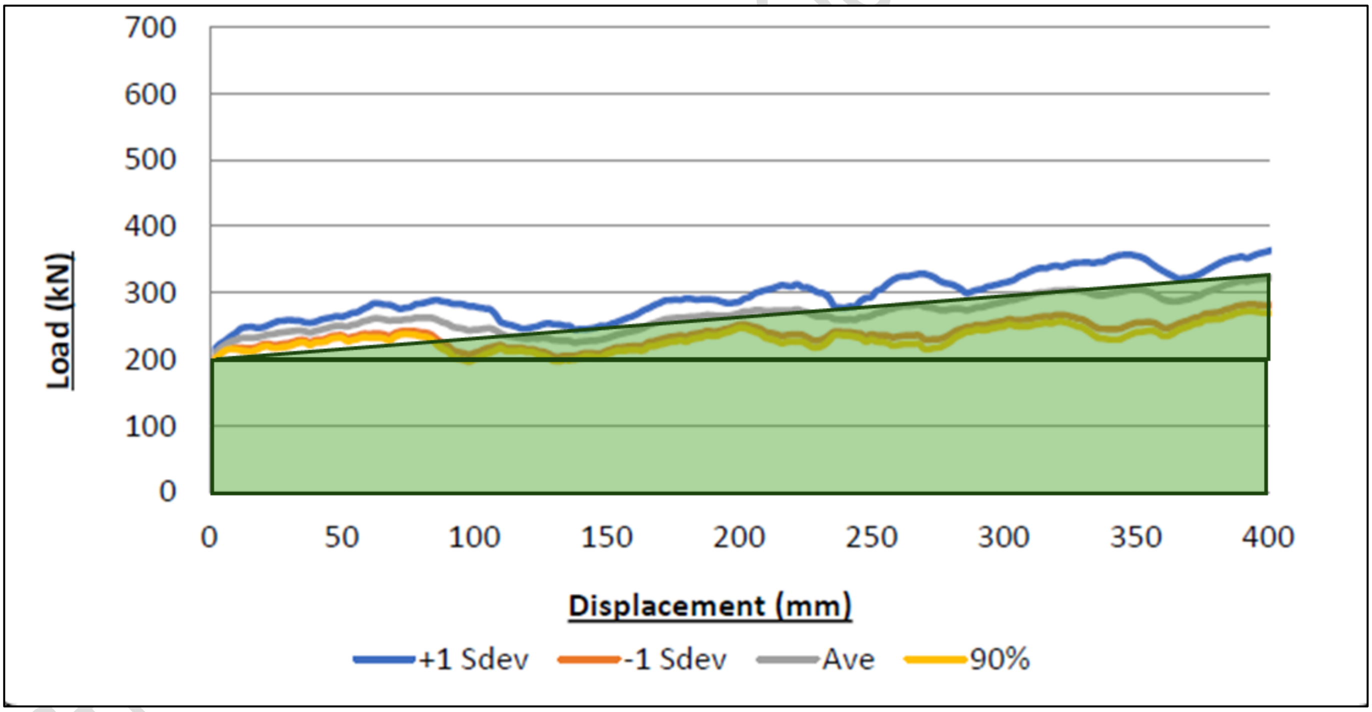
3.4 Explain the relationship between stope closure and time-dependent creep. (2)

Total [9]

QUESTION 4. SUPPORT DESIGN

4.1 During a dynamic load deformation test, A tendon reaches 100 kN at 100 mm elongation. Calculate the energy absorption capacity of it. (2)

4.2 Based on the diagram below, calculate the total energy absorption for the support deformation graph. (2)



4.3 State two advantages of yielding elongates. (2)

4.4 Tabulate the key differences between stiff and yielding support using the following aspects: load-deformation, energy absorption, and dynamic performance. Give one example of stope support units for each. (4)

4.5 List 4 critical parameters for support design in tunnel support. In addition, tabulate passive versus active description and support examples. (6)

4.6 Calculate the critical bond length per tendon of the following support information:(4)

1.8 m fully grouted tendons installed in a tunnel. Given:

- Ultimate tendon load (F_{max}) = 120 kN
- Grout–rock bond shear strength (τ) bond = 1.5 MPa
- Hole diameter = 32 mm
- Tendon diameter = 20 mm

Total [20]

QUESTION 5. <u>PILLAR BEHAVIOUR, SEISMICITY</u>

5.1 In short, define pillar strength. How is "K" derived in pillar strength? (2)

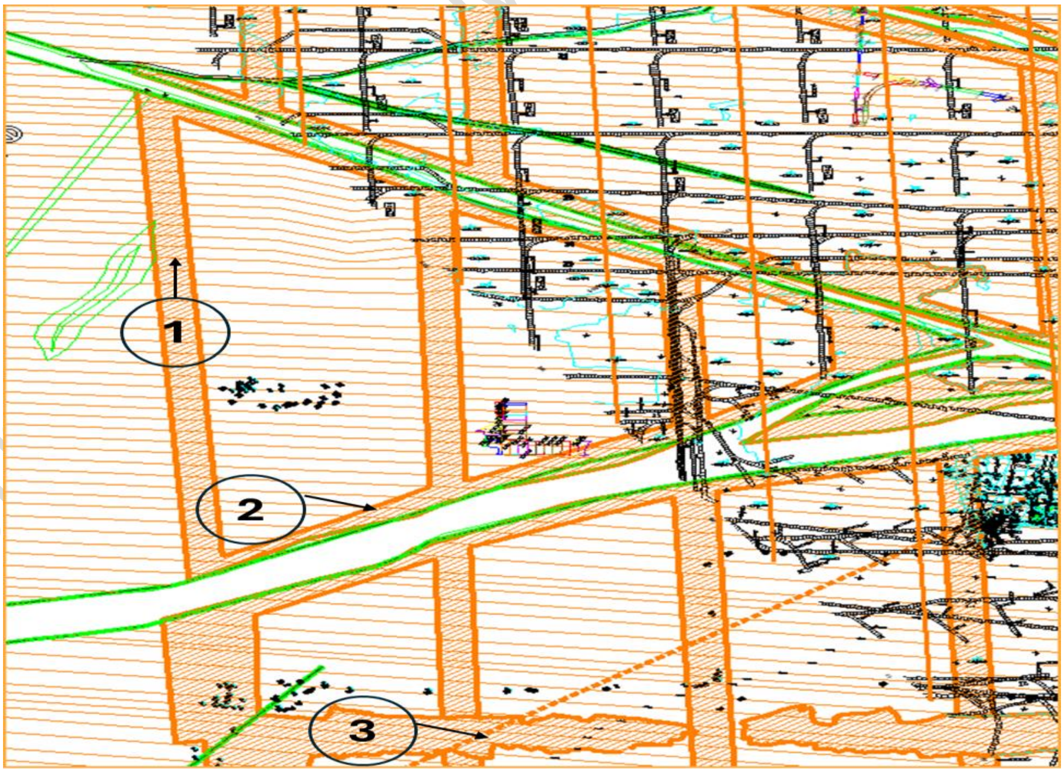
5.2 State the Hedley & Grant empirical formula. (2)

5.3 Calculate the strength of a 5 × 5 m pillar, height = 2.5 m, σc = 200 MPa, k = 0.64. (3)

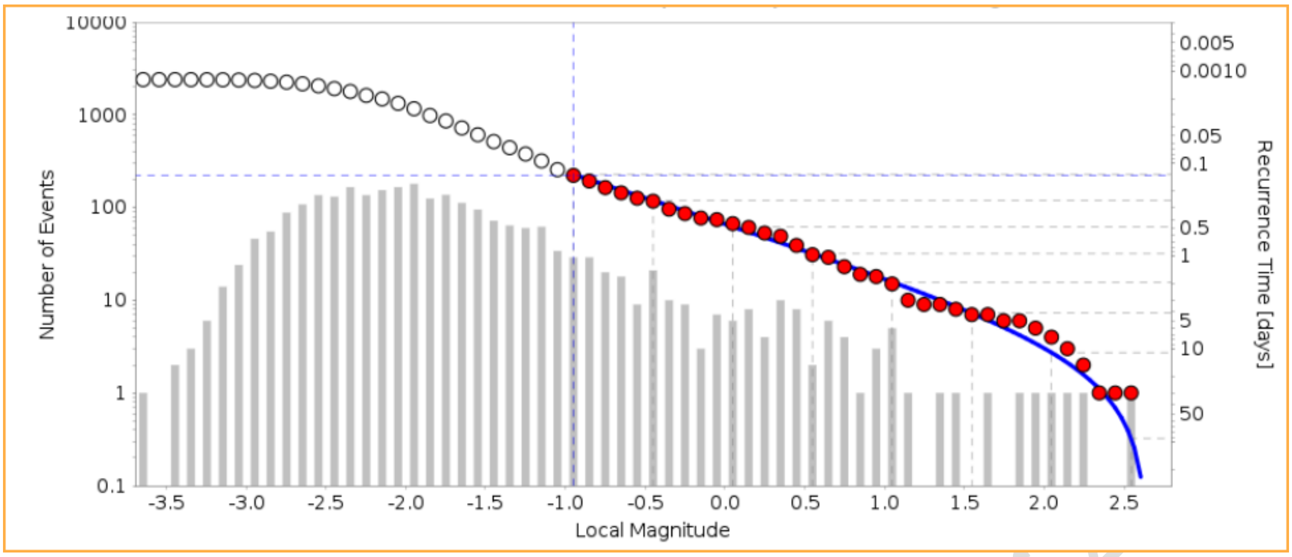
5.4 Explain why slender pillars may be burst-prone. (2)

5.5 Describe three (3) functions of barrier pillars. (3)

5.6 Refer to the figure below (plan of an underground mine) and name 3 types of pillars typically found on a conventional intermediate depth operation? (3)



5.7 With reference to the figure, what is this called? And what information can be obtained from it? (2)

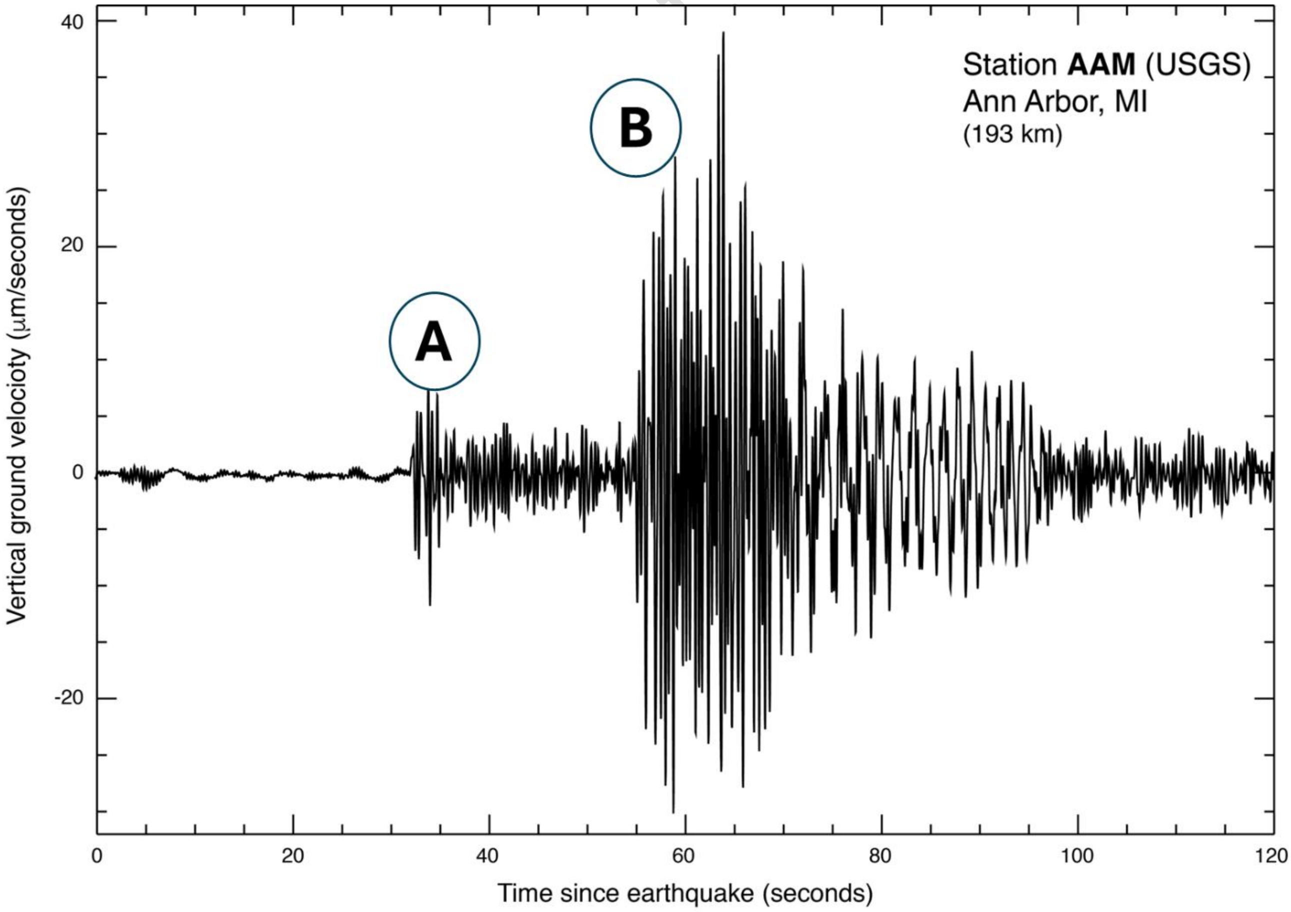


5.8 In tabulated format, give three (3) reasons for seismicity on both Shallow and Deep level metalliferous mines. (3)

5.9 With reference to the seismogram below: (2)

a) What is the typical value for point A and its name?

b) What is the typical value for Point B and its name?



Total [22]

QUESTION 6. GEOLOGY AND ROCK STRENGTH

6.1 Identify the three main classes of rocks and briefly describe how each type is formed. Give at least one example of each. (3)

6.2 Explain why understanding rock type and its mode of formation is important for strata control and support design. (3)

6.3 At your mine, the reef is hosted in quartzite with dolerite intrusions. Explain how these two rocks differ in terms of formation and expected strength. (2)

6.4 Using Barton's formula, calculate the shear strength at a normal stress of 10 MPa, given the following (2)

- $\varphi_b = 29°$
- JRC = 16.9
- JCS = 96 MPa

6.5 What are the parameter definitions for the Q (Rock Tunnelling Quality Index) (3)

$$Q = \frac{RQD}{Jn} x \frac{Jr}{Ja} x \frac{Jw}{SRF}$$

Total [13]

TOTAL [100]

FORMULAE SHEET

$$e = \frac{A_{T-}A_P}{A_T}$$

$$PS = k.\frac{w^{0.46}}{h^{0.66}}$$

$$PS = k.\frac{w^{0.5}}{h^{0.75}}$$

$$APS = \frac{\rho g h}{1 - e}$$

$$e = \frac{(b+w)^2 - w^2}{(b+w)^2}$$

$$F_s = \frac{\sigma_s}{APS}$$

$$Q = \frac{RQD}{J_n} \cdot \frac{J_r}{J_a} \cdot \frac{J_w}{SRF}$$

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

$$\tau = \sigma_n \tan\left(\theta_b + JRC \log_{10}\left(\frac{JCS}{\sigma_n}\right)\right)$$

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

$$E = \frac{\sigma}{\varepsilon}$$

$$v = \frac{\varepsilon_r}{\varepsilon_a}$$

$$RQD = \frac{\sum L}{T}\ x\ 100$$

$$\sigma_h = k.q$$

$$RCF = \frac{3\sigma_1 - \sigma_3}{F.\sigma_c}$$

$$\sigma_1 = \sigma_3 + \sigma_c(m.\frac{\sigma_3}{\sigma_c} + s)^{0.5}$$

$$C_i = \tau - \sigma_n tan\phi_i$$

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