Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: MINERALS COUNCIL OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS **SUBJECT CODE: COMCSCM** **DATE – 04 OCTOBER 2022** **TIME**: **14H30 TO 17H30**	**EXAMINER:** MH NGWENYA **MODERATOR:** L VAN ASWEGEN **TOTAL MARKS:** [100] **PASS MARK:** (60%)

NUMBER OF PAGES: 9

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 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 by means of sketches or diagrams wherever possible.
7. **Final answers** 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.

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 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.

QUESTION 1

MULTIPLE CHOICE

Chose the correct answer from the four options provided. Only write the letter a, b, c or d next to each question number. DO NOT write down the value of the answer. Show calculations ONLY where required.

1.1 With reference to Figure 1 below. With the show of calculations, If the perimeter of the square element is 8 cm, then the area hedged in red equals to

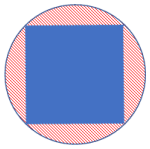

Figure 1: A square enclosed by a circle.

a. 6.28 cm^2
b. 2.82 cm^2
c. 2.28 cm^2
d. 2.51 cm^2

(3)

1.2 Assume a force of 13 kN is exerted normal to the surface area of the square element shown in figure 1 above. With the show of calculations, the normal stress acting on the square element is

a. 32.5 MPa
b. 57.0 MPa
c. 46.1 MPa
d. 51.8 MPa

(1)

1.3 Longitudinal seismic wave particle motions is

a. Normal to direction of propagation
b. Parallel to direction of propagation
c. Elliptical retrograde
d. Parallel to surface, normal to direction of propagation

(1)

1.4 A geological discontinuity with zero displacement is referred to

a. Fault
b. Joint
c. Parting plane
d. Dyke (1)

1.5 A rock sample peak strength under zero confinement is referred to

a. Triaxial compressive strength
b. Uniaxial compressive modulus
c. Uniaxial compressive strength
d. Plastic strain

(1)

1.6 Suppose a rock mass strength is given by Hoek-Brown failure criterion. If a uniaxial compressive strength of a rock mass of quality 's' is required, which parameter must be set to zero

a. The Hoek-Brown quality parameter 's'
b. The intact compressive strength 'σ_{ci}'
c. A reduced value 'm_b' of the material constant m_i
d. The confining stress 'σ_3'

(1)

1.7 Which Mine layout design criteria is a measure of rockburst hazard in longwall mining

a. The excess shear stress (ESS)
b. The energy release rate (ERR)
c. The average pillar stress (APS)
d. The stope closure

(1)

1.8 Stresses that are known to promote bed-separation and the potential for massive collapses in the hanging wall of the excavation are known as

a. Shear stresses
b. Normal stresses
c. Vertical tensile stresses
d. Horizontal dilational stresses

(1)

1.9 The term which refers to the extent by which an instrument can reproduce a certain reading for the same input is

a. Accuracy
b. Precision
c. Resolution
d. Sensitivity

(1)

1.10 The shear resistance at zero normal stress is

a. Shear stress
b. Principal stress
c. Cohesion
d. Support resistance (1)

1.11 The state in which the material continues to deform indefinitely whilst sustaining a constant stress is

a. Deformation
b. Plasticity
c. Continuity
d. Resistance

(1)

1.12 The differential lateral movement between the hanging wall and footwall is

a. Strain
b. Closure
c. Ride
d. Deformation

(1)

1.13 A sensor converting ground velocity into an electric signal is s

a. Strain gauge
b. Load cell
c. Geophone
d. Extensometer

(1)

DEFINITIONS

Define the following terms and where applicable give units:

1.14 Tensile stress (2)

1.15 Principal stress (2)

1.16 Triaxial compression (2)

1.17 Elasticity (2)

1.18 Mohr envelope (2)

Total [25]

QUESTION 2 – Regional and support pillars

You are working in a Platinum Mine which utilizes Hedley and Grant formular for pillar design and you are given the following information:

Dip centre spacing = 11 m
Strike centre spacing = 11 m
Square pillars with length = 5 m
Depth below surface = 300 m
Unit weight of overburden = 31 kN/m^3
Mining height = 2 m
Design rockmass strength (DRMS) or K-value = 55 MPa
Dip of the reef = 0^o
K-ratio = 1.2

2.1 Explain the assumption of the tributary area theory on the loads acting on pillars. (3)

2.2 Calculate the vertical and horizontal virgin stress (1)

2.3 Calculate the average pillar stress (APS) (2)

2.4 Calculate the pillar strength (2)

2.5 What is the factor of safety on the pillars? Comment on the stability of the pillars. (1)

2.6 List any three (3) factors that could affect the pillar strength (3)

2.7 The Mine Manager calls you to his office and argues that the pillars are large and should be reduced before he establishes a new South section. He proposes that the pillar strike width should be 4m wide instead of 5m, but he reckons the bords should remain unchanged. Considering his proposal,

2.7.1 Calculate the extraction ratio? (1)

2.7.2 Calculate the new average pillar stress (APS) (2)

2.7.3 Calculate the new pillar strength (3)

2.7.4 What is the factor of safety on the pillars? Comment on the stability of the pillars. (1)

2.8 What are the functions of these pillars:

2.8.1 Barrier pillar (2)

2.8.2 Boundary pillar (2)

2.8.3 Bracket pillar (2)

Total [25]

QUESTION 3 – Excavation Stability

3.1 The following equation is given:

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

3.1.1 Which quantity is expressed by this equation and for which type of excavation is it valid? (2)

3.1.2 Does the equation provide a solution for a 2D or a 3D state of stress or strain. (1)

3.1.3 Provide the terminology which describes the special state of stress or strain contemplated by the equation? (1)

3.1.4 Simplify the equation above for the case when horizontal virgin stress is equal to vertical virgin stress. (3)

3.1.5 From the simplified equation obtained in 3.1.3, give the approximation of $\sigma_{\theta\theta}$ when radial distance is 5R. (2)

3.1.6 The plot in figure 2 (refer to appendix 1) was obtained from a 2D boundary element numerical modelling program. The quantity that is contoured is the major principal stress around the tunnel (section view) at a depth of 2800m below surface. The values of the major principal tress in the skin of the excavation on sidewall and on the crown are indicated at point A and B respectively. The principal stress values are in MPa. Compare the value of stresses in the skin as indicated by the modelling with the calculations that you must perform, beginning with point A and thereafter point B. Assume that g = 9.81 m/s^2, the density of the rock = 2700 kg/m^3, k = 0.5 and E = 70 GPa. (10)

3.1.7 From the modelling results, which side of the excavation do you expect to fracture the most? (1)

3.1.8 Name and draw the tunnel profile that would exist as a result of the stress fracturing (5)

Total [25]

QUESTION 4 – Support of Excavations and Reporting of FOG

4.1 Name 5 types of tendons commonly used in a Mine (5)

4.2 Backfill is a support system that is used to address various rock engineering problems. List two advantages of backfill when used for:

4.2.1 local mining conditions. (2)

4.2.2 regional mining conditions. (2)

4.3 According to the Department of Minerals and Energy, mine-based rock engineers must report certain dangerous rock related occurrences.

4.3.1 What types of occurrences must be reported? (2)

4.3.2 Which forms need to be completed? (1)

4.3.3 Describe three classes/sizes with their minimum dimensions (6)

4.4 Draw a load deformation graph showing the following: (6)

- Yield load
- Yieldability
- Brittle failure
- Initial stiffness
- Energy absorption
- Pretension

4.5 What instrument will you use to measure continuous closure? (1)

Total [25]

Total Mark = [100]

Appendix 1

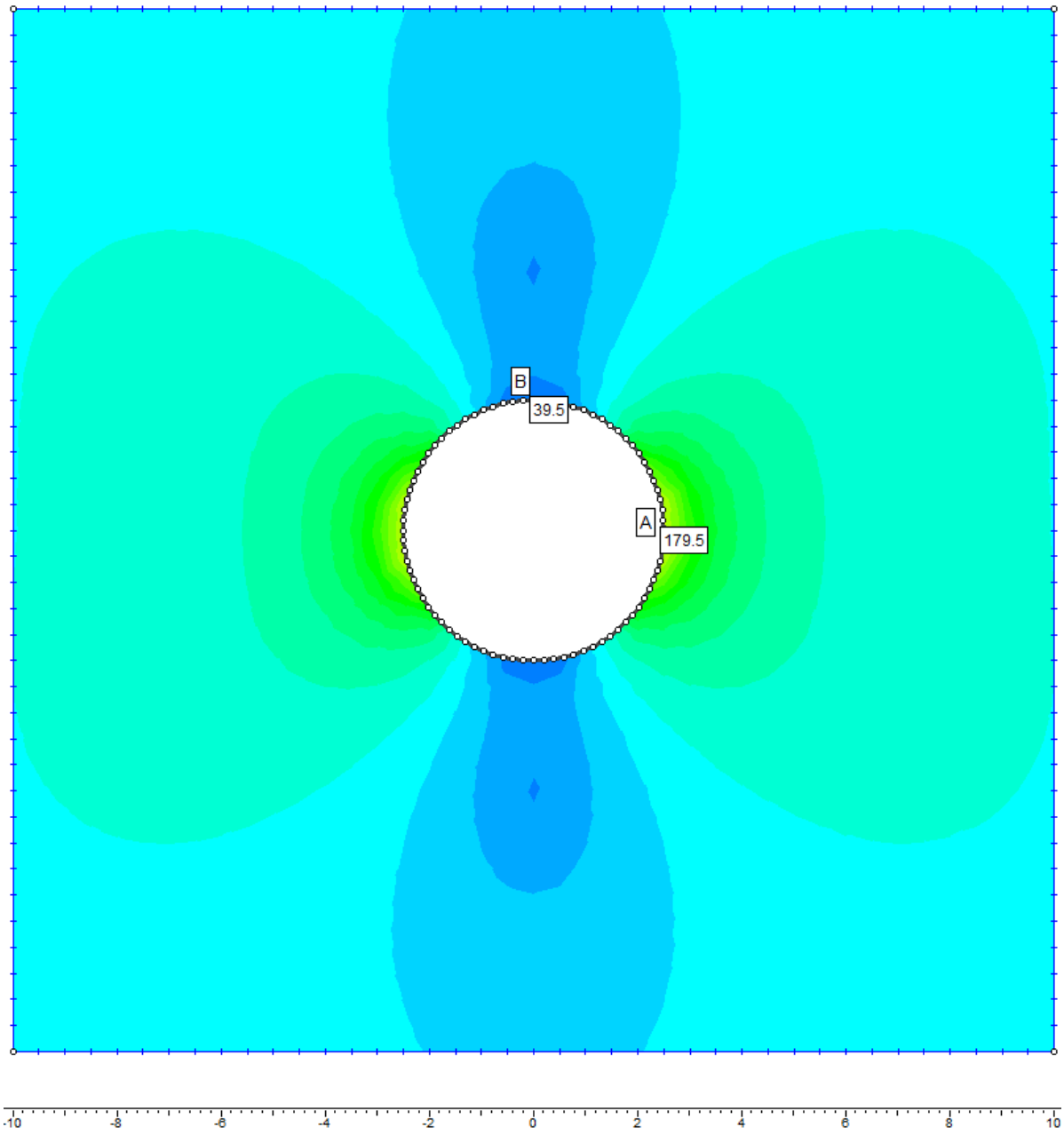

Figure 2 Contour of major principal stress around an excavation.

FORMULE SHEET

1. Total Energy = ½ m v^2 + mgh
2. $s_z = \frac{2(1-\nu)q}{G}\sqrt{l^2 - x^2}$
3. $l_c = \frac{s_m G}{2(1-\nu)q}$
4. $\sigma_s = 7.2\frac{R_0^{0.5933}}{V^{0.0667}}\left\{\frac{0.5933}{\varepsilon}\left[\left(\frac{R}{R_0}\right)^{\varepsilon} - 1\right] + 1\right\} MPa$
5. $e = 1 - \frac{w_1 w_2}{C_1 C_2}$
6. $ERR = \frac{\Delta U_m}{\Delta A} = \frac{\pi(1-\nu)lq^2}{2G}$
7. $v_p = \sqrt{\frac{\lambda + 2G}{\rho}} \qquad v_s = \sqrt{\frac{G}{\rho}}$
8. $RCF = \frac{3\sigma_1 - \sigma_3}{F\sigma_c}$
9. $RQD = \frac{\sum lenght\ of\ core\ pieces > 10cm}{total\ lenght\ of\ core}\ x\ 100$
10. $\frac{h}{s} = \frac{1}{\sqrt{\frac{8h}{s} - 6}}$
11. Q = RQD/Jn x Jr/Ja x Jw/SRF
12. G = $\frac{E}{2(1+v)}$
13. $\tau = \sigma n\ tan(\emptyset + JRC\ 10\ \log \tan(^{JCS}/\sigma n\ ))$
14. APS = $q_v/(1-e)$
15. $\varepsilon = \Delta\ell / L$
16. $E = \sigma/\varepsilon$
17. $\nu = \varepsilon_r / \varepsilon_a$
18. $Ps = K w^{0.46} / h^{0.66}$
19. $Ps = K w^{0.5} / h^{0.75}$