Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: MINERALS COUNCIL OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS **SUBJECT CODE: COMCSCM** **DATE – 09 MAY 2023** **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 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 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

General Questions

1.1 **Indicate if the following statements are True or False**

1.1.1 Brittle fracture is the process by which sudden loss of strength occurs across a plane following significantly large permanent (plastic) deformation. (1)

1.1.2 Rock material specimens tested in uniaxial tension fail at stresses an order of magnitude lower than when tested in uniaxial compression. (1)

1.1.3 Boreholes drilled in high stress intact rock exhibit immediate spalling or dog-earing. (1)

1.1.4 The P-wave of a seismic event always arrives after the S-wave. (1)

1.1.5 Anisotropy – having different properties at different points (1)

1.1.6 Isotropy – having the same properties in all directions (1)

1.1.7 Geophones measure ground acceleration (1)

1.1.8 Yield occurs when there is departure from elastic behaviour (1)

1.1.9 The act of mining causes induced stresses to be generated which, when added to the virgin stresses, result in a given state of absolute stress. (1)

1.1.10 The stress concentrations induced by mining are lowest immediately in front of stope faces. (1)

1.2 **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.**

1.2.1 The following lengths of individual pieces of core are recovered out of a total length of drill run of 4m: 0.1 m, 0.3 m, 0.7 m, 0.3m, 0.8m, 0.07m. Calculate the RQD.

a) 56.8% b) 55.0% c) 52.5% d) 54.3% (2)

1.2.2 The peak stress of a cylindrical rock sample, which is subjected to a UCS test is 180 MPa. The strain at this point is 3 x 10-3. Calculate the elastic modulus (E) in GPa.

a) 36 b) 6 c) 60 d) 540 (2)

1.2.3 Calculate the static support resistance if props, which generate a load of 20tons during press tests, are spaced 1.5m apart on dip and strike respectively. Assume that acceleration due to gravity is $10m/s^2$.

a) 196 kN/m^2 b) 88.9 kN/m c) 80 kN/m^2 d) 90 kN/m (2)

1.2.4 Calculate virgin horizontal stress levels at a depth of 1.4 km below surface where the k- ratio is 0.9, the rock density is $3100kg/m^3$ and gravitational acceleration is $10m/s^2$.

a) 39 MPa b) 43 MPa c) 38 MPa d) 42.6MPa (2)

1.2.5 Two gauge marks were made 3 cm apart along the axis of a cylindrical rock specimen 6 cm long with a cross-sectional area of 7 cm^2. The specimen is then subjected to a uniaxial compressive force of 100 kN. If the strain in the specimen is 2.38 millistrain, calculate the contraction between the gauge marks.

a) 0.14 mm b) 0.07 mm c) 0.17 mm d) 0.014 mm (2)

1.2.6 The joint shear strength in the Q System classification is represented by:

a) RQD/Jn b) Ja/Jr c) Jw/ SRF d) Jr/ Ja (1)

1.2.7 The typical ERR (MJ/m^2) values in deep mining environment ranges between:

a) 20 – 40 b) < 8 - 20 c) 8 – 40 d) 40 - 80 (1)

1.2.8 The stope closure (mm/ m advance) in the medium or intermediate mining environment is:

a) < 5 b) < 5 - 10 c) 10 – 30 d) 30 - 60 (1)

1.2.9 Typical depth for medium or intermediate mining environment ranges between:

a) 1 – 1.5 km b) 0 – 1.0 km c) 1 – 1.3 km d) 1 – 2.25 km (1)

1.2.10 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) Sensitivity d) Error (1)

Total [**25**]

QUESTION 2

Intact rock strength

2.1 The Hoek-Brown criterion is defined by the following equation:

$$\sigma_1 = \sigma_3 + \sigma_{ci}\left(m_b \frac{\sigma_3}{\sigma_{ci}} + s\right)^{0.5}$$

2.1.1 What is the equation used to determine? (1)

2.1.2 Explain the significance of each parameter in the Hoek-Brown criterion. (2)

2.1.3 Describe two shortcomings of the Hoek-Brown criterion. (4)

2.1.4 Obtain the uniaxial compressive strength of the intact rock from the Hoek-Brown criterion. (3)

Rock joints and rock mass strength

2.2 Barton and Choubey developed the following equation:

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

2.2.1 What is the equation used to determine? (1)

2.2.2 What does each parameter represent? (2)

2.2.3 How will you obtain the field estimate of JRC? (1)

2.2.4 How will you obtain the field estimate of JCS? (1)

2.2.5 Given the following: θ_b = 25°, JRC = 15 and JCS = 105 MPa, calculate τ when σ_n = 0.5 MPa, σ_n = 1.0 MPa and σ_n = 3.0 MPa. (3)

2.2.6 What is the effect of increasing σ_n on the joint? (1)

2.3 List the 6 parameters (do not supply only abbreviations) that are used to classify a rock mass according to the Bieniawski Rock Mass Rating. (6)

Total [**25**]

QUESTION 3 – Geology, Rock Breaking and Support

3.1 Explain sedimentary, metamorphic and igneous rocks and give an example of each one. (6)

3.2 Sketch and describe a normal fault and a reverse fault. (4)

3.3 List eight items you would check to rectify poor ground conditions in a tunnel caused by sub-standard drilling and blasting practice. (4)

3.4 Give a comparison between the function of a grouted tendon and a split set. (4)

3.5 What do you understand by the term critical bond length? (2)

3.6 According to 1534:2018 SANS Specification on Short Encapsulation Pull Tests (SEPT), the test shall be considered passed if at least four out of five samples meet the minimum load of 100kN before the 2mm displacement. When answering the following questions, refer to Figure 1 in Appendix A.

3.6.1 Which of the specimen outperformed the rest and why? (1)

3.6.2 Which specimen sustained the largest displacement? (1)

3.6.3 Which specimen sustained the least displacement? (1)

3.6.4 Which specimen has the highest energy absorption and why? (1)

3.6.5 Which specimen has the least energy absorption and why? (1)

Total [**25**]

QUESTION 4 – Support Design

4.1 A mine exploiting UG2 in tabular excavation stoping uses timber elongates and yield pillars as primary support in the UG2 stope panels. The timber elongates are installed 1.5 m on dip and 2.0 m on strike centre to centre. The corrected support resistance design chart at different closure rates for the timber elongates at 1.5 m x 2.0 m block pattern is shown Figure 2 in Appendix A. The information available to you includes the following:

- Depth of mining below surface = 1600 m
- Stoping height = 1.6 m
- Rock density = 3200 kg/m^3
- K-ratio = 1.1
- Excavation half span = 80 m
- The Poisson's ratio = 0.25
- The Young's modulus = 98 GPa
- The reef orebody dips at 18^o
- The fall out height in UG2 stopes = 1.1 m

4.1.1 Assuming a gravitational constant of 10 m/s^2, calculate the required support resistance (demand) in the stope. (1)

4.1.2 If the timber elongate is installed 4m behind the face, calculate elastic closure that the timber elongate would undergo if the face is advanced for 20 m. (10)

4.1.3 Calculate the elastic closure rate in mm/m after the face is advanced for 20 m. (1)

4.1.4 From the calculated elastic closure in question 4.1.2, use the design chart in Figure 2 to estimate the support resistance the support unit bears. (1)

4.1.5 From the calculated elastic closure in question 4.1.2, use the design chart to estimate how far back the timber elongate will be behind the face if the closure rate in the stope was 2 mm/m. (1)

4.1.6 From the calculated elastic closure in question 4.1.2, use the design chart to estimate how far back the timber elongate will be behind the face if the closure rate in the stope was 10 mm/m. (1)

4.2 Which factors need to be taken into account when designing a support system? (7)

4.3 With aid of the sketch or graph, illustrate the stress deformation of the Squat, Yield and Crush pillar. (3)

Total [**25**]

Appendix A

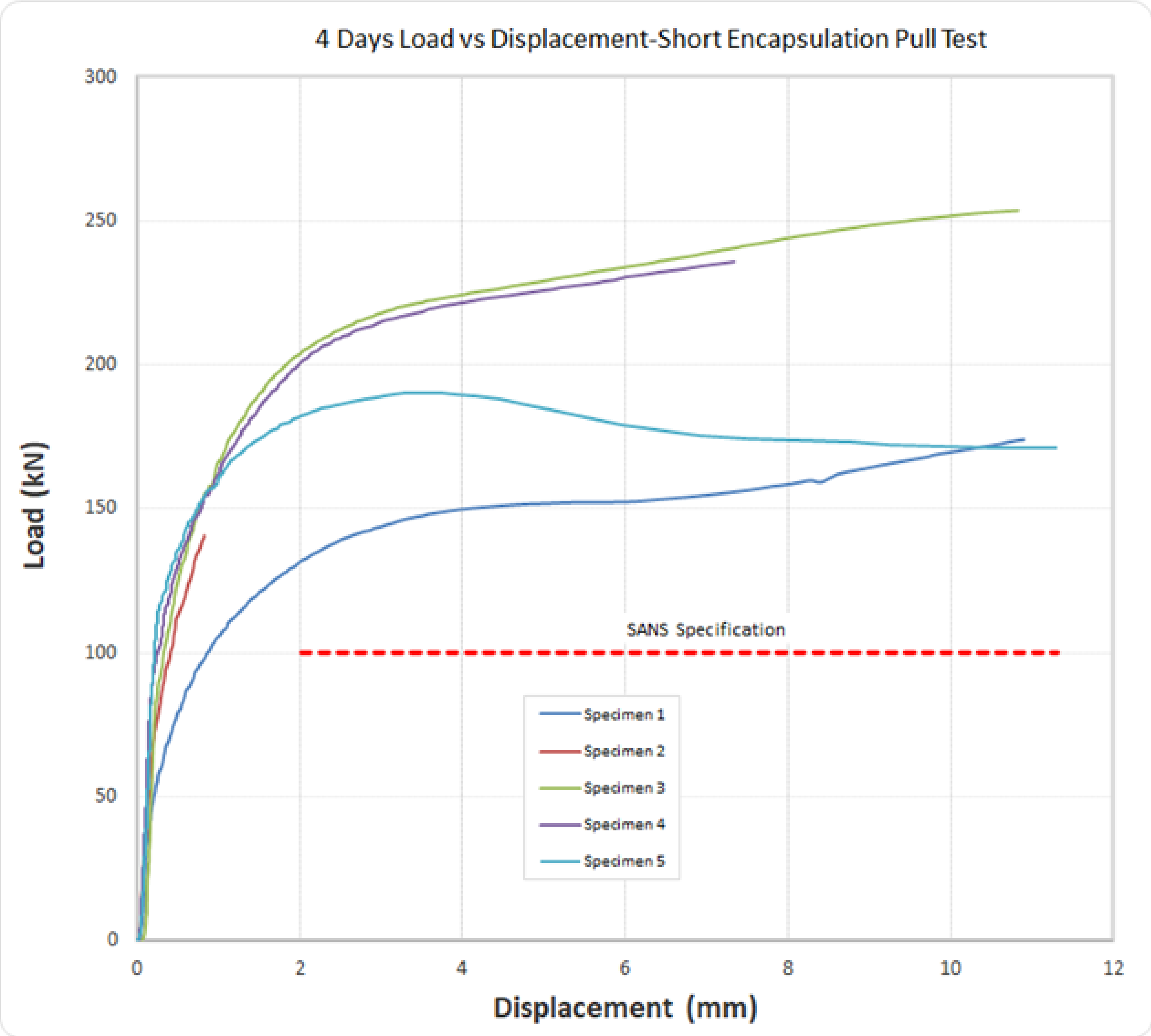

Figure 1 Short Encapsulation Pull Test of the Resin Bolt System

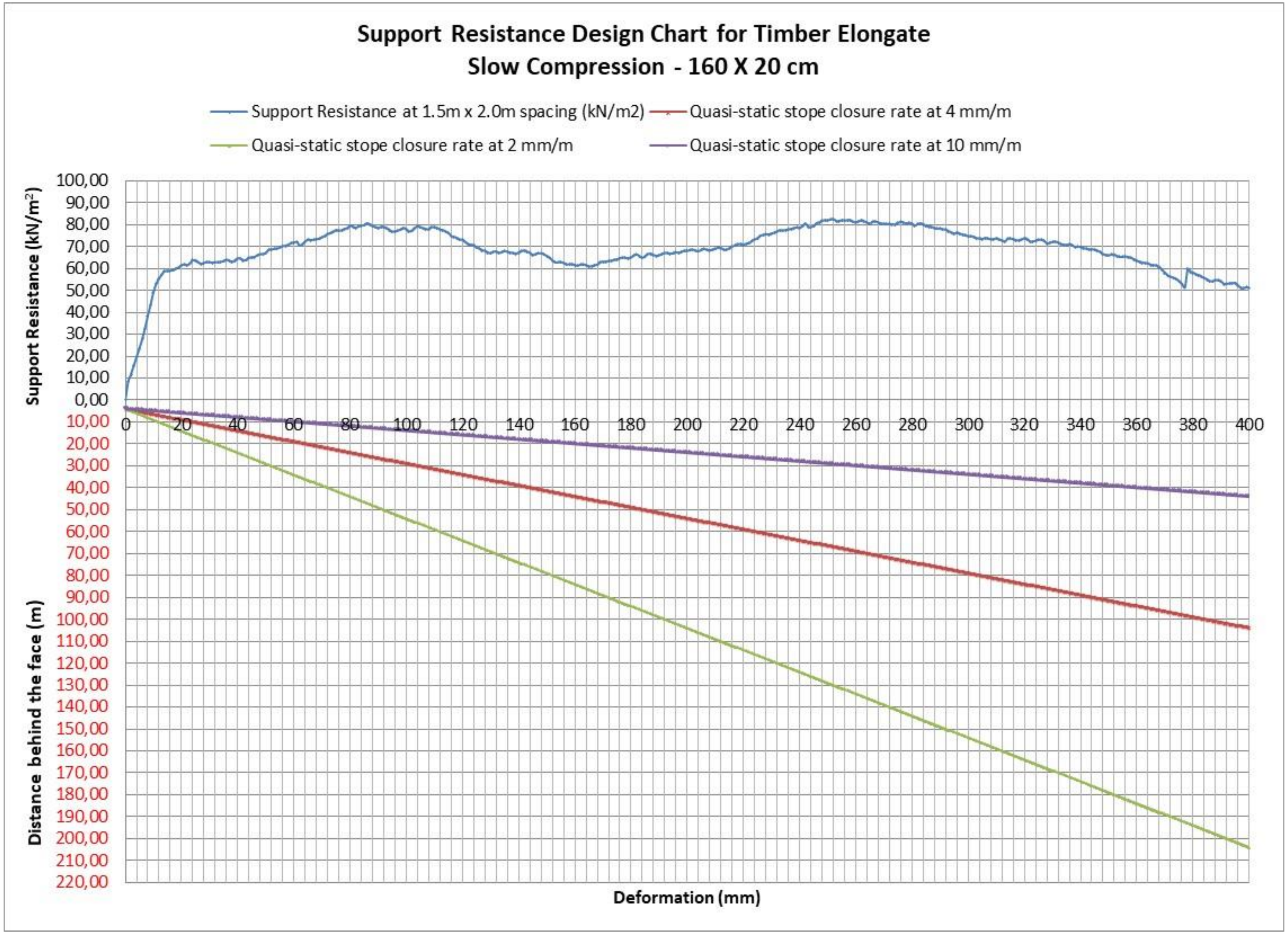

Figure 2 Support Resistance Design chart of the Timber Elongate with different closure rates.

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. $l_e = \frac{s_m G}{2(1-\nu)q}$
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. $v_p = \sqrt{\frac{\lambda + 2G}{\rho}}$ $\quad v_s = \sqrt{\frac{G}{\rho}}$
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. $\tau = \sigma n \tan(\varnothing + JRC\ 10 \log \tan(^{JCS} / \sigma n\ ))$
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. $Ps = K\, w^{0.5} / h^{0.75}$
20. $Q_{zz} = \frac{1}{2} q_v [(1+k) + (1-k) \cos 2\alpha]$
21. $Q_{zx} = \frac{1}{2} q_v (1-k) \sin 2\alpha$
22. $Q_{xx} = \frac{1}{2} q_v [(1+k) - (1-k) \cos 2\alpha]$