Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: MINERALS COUNCIL OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS **SUBJECT CODE: COMCSCM** **DATE – 10 MAY 2022** **TIME**: **14H30 TO 17H30**	**EXAMINER:** JC VAN ZYL **MODERATOR:** L VAN ASWEEGEN **TOTAL MARKS:** [100] **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 **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. GENERAL

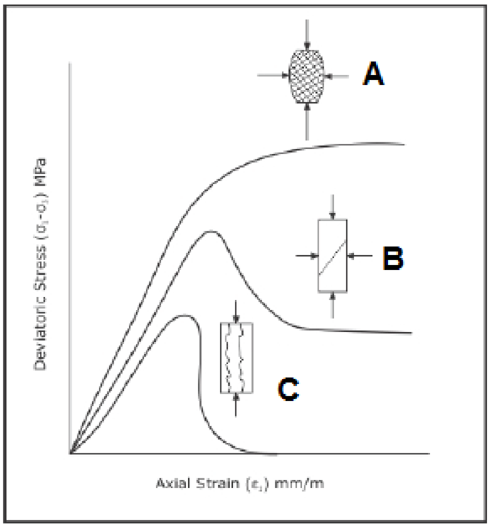
Define the following terms and where applicable give units:

1.1. Virgin stress (2)
1.2. APS (2)
1.3. Bedding planes (2)
1.4. Joints (2)
1.5. Ride (2)

MULTIPLE CHOICE

Complete the questions below. There is only one correct answer for each question.

1.6. Provide the correct set of annotations for the stress strain curves at increasing confinement. (2)



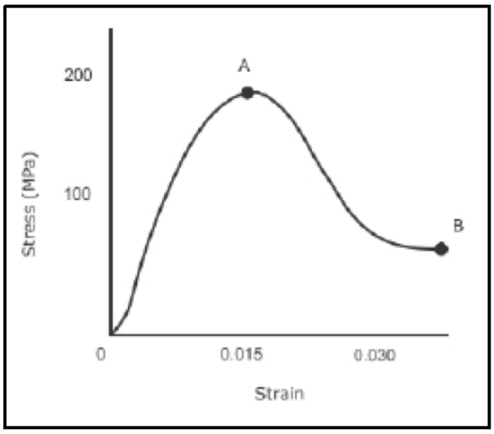
a) A = shear fracture; B = axial splitting; C = multiple shear fractures
b) A = multiple shear fractures; B = axial splitting; C = fracture
c) A = multiple shear fractures; B = shear fracture; C = axial splitting
d) None of the above

1.7. In which area of the stress-strain curve is Young's modulus defined? (2)

a) strain hardening
b) peak stress
c) elastic deformation
d) plastic strain

1.8. The Hoek-Brown failure criterion is best applied to one of the following conditions: (2)

a) Swelling of weathered rock
b) Brittle failure of intact rock
c) Shear failure of jointed rock
d) Creep of intact rock

1.9. Which of the following does not influence joint strength? a) Joint spacing b) Joint length c) Joint wall condition d) Joint water content	(2)
1.10. What behaviour is represented by the segment AB in the test graph?  a) on-linear elastic b) Strain hardening c) Elasto-plastic d) Strain softening	(2)
1.11. Around a circular excavation, where the major applied stress is vertical and no internal pressure is applied, the normal stress σrr at the periphery of the excavation is equal to? a) 2 x Virgin stress b) 1x Virgin stress c) maximum tangential stress d) zero	(2)
1.12. Using the Hoek-Brown relationship, calculate the peak strength of a sample if m = 15, s = 1.0, UCS = 200 MPa and confinement is 20 MPa. a) 265 MPa b) 336 MPa c) 6 325 MPa d) 161 Mpa	(3)
	[25]

QUESTION 2. SUPPORT and CONVERGENCE

2.1	With reference to Annexure 1, answer the questions below. Annexure 1 represents a Histogram of fall out thickness in metres (for rock falls and rock bursts) and a line graph of cumulative fallout thickness (for rock falls and rock bursts). Determine the 95% cumulative fallout height making use of the graph provided and state your answer and submit the graph with your answer book.	(2)

2.2 You are provided the following additional information: • Rock density = 2700kg/m^3; • The hangingwall must be brought to rest within 0.2m of downward movement; • The ejection velocity is 3m/s • Gravitational acceleration is 9.81m/s^2 • Support unit spacing of 1.0m x 1.0m	
2.2.1 Determine the rockfall support resistance criteria.	(3)
2.2.2 Determine the rockburst energy absorption criteria.	(3)
2.3 A stope is situated in an intermediate mining environment, 2000m below surface. Assume the overburden density to be 2750 kg/m^3. The Modulus of Elasticity of the rock mass is 70 GPa. The poisons ratio of the rock mass is 0.25. The span of the stope is 250m.	
2.3.1 Calculate the elastic convergence at the following points behind the stope face: 5m, 10m, 15m, 20m and 30m. **Represent your answer, both in table and graph form by plotting the closure profile of the stope.** Show all calculations. Plot your graph on the graph paper provided in the centre of the answer book.	(16)
2.3.2 The support unit type on the mine can sustain 150mm deformation up to the point of support failure. At what distance from the face would you expect the support units to fail as a result of the convergence.	(1)
	[25]

QUESTION 3. ROCK PROPRTIES and STRENGTH TESTING

3.1 A cylindrical rock sample is subjected to uni-axial loading. The sample has a diameter of 50 mm and an axial length of 125 mm. The Young's Modulus for intact rock is 70 Gpa and axial strain is 4 times lateral strain. At one point during the test, the strain gauges indicate an axial strain of 3 x 10^{-3}	
3.1.1 Calculate the distance the sample has to be compressed to reflect axial strain of this magnitude.	(2)
3.1.2 What is the lateral strain at this point in the test?	(2)
3.1.3 What is the new sample height and width at this point of the test?	(2)
3.1.4 Calculate the average axial stress in the sample at this point.	(2)
3.1.5 Calculate the lateral stress developed in the sample.	(2)
3.2 Describe the Hoek-Brown criterion	(4)
3.3 Describe two shortcomings of the Hoek-Brown criterion	(4)

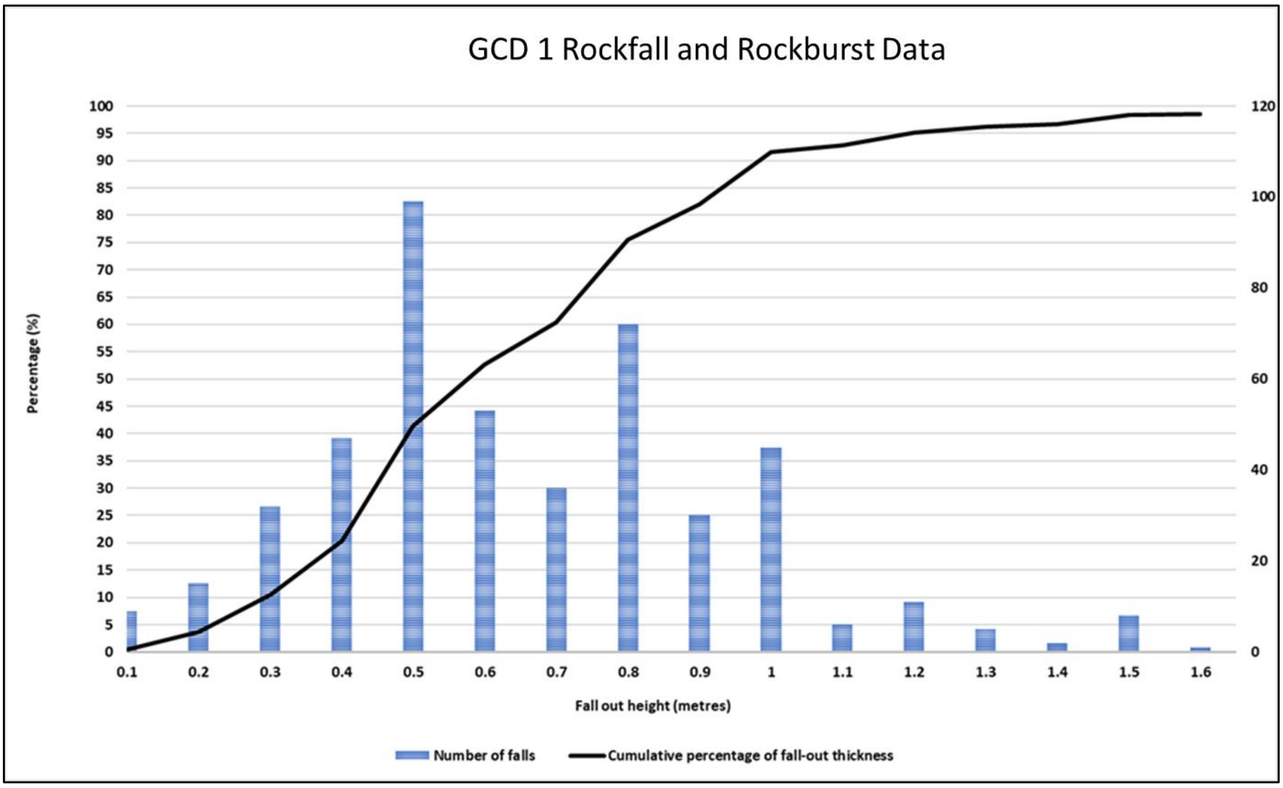
3.4	Briefly describe how a point load test is conducted, how the results are used and two advantages of this test method.	(5)
3.5	Briefly describe the purpose of the following material sample testing:	
3.5.1	Brazilian disk?	(1)
3.5.2	Shear box?	(1)
		[25]

QUESTION 4. ROCKBURST CONTROL: PRECONDITIONING and BLASTING PRACTICE

4.1	What are the three (3) factors of critical importance when drilling blast holes?	(3)
4.2	What are four (4) main causes of incorrect hole burdens?	(4)
4.3	What are the two primary configurations / techniques for carrying out preconditioning in narrow tabular stopes?	(2)
4.4	What are the benefits of preconditioning? (Provide five (5) benefits)	(5)
4.5	By means of a sketch, illustrate the stress profile before and after preconditioning.	(3)
4.6	Name three (3) perimeter blasting techniques.	(3)
4.7	List five (5) advantages of perimeter blasting	(5)
		[25]

Total Mark = [100]

ANNEXURE 1 **EXAMINATION NUMBER**_______________________________



ANNEXURE 2: FORMULA SHEET

$$Q = \frac{RQD}{J_n}\frac{J_r}{J_a}\frac{J_w}{SRF} \qquad RMR = 9\log_e Q + 44$$

$$\sigma_1 = \sigma_3 + \sigma_{ci}\left(m_b\frac{\sigma_3}{\sigma_{ci}} + s\right)^a \qquad \sigma_1 = \sigma_3 + \sigma_{ci}\sqrt{m_i\frac{\sigma_3}{\sigma_{ci}} + 1}$$

$$GSI > 25 \quad GSI = RMR_{76} \qquad GSI = RMR_{89} - 5$$

$$GSI < 25 \quad Q' = \frac{\mathrm{RQD}}{\mathrm{J_n}}\frac{J_r}{J_a} \qquad GSI = 9\log_e Q' + 44$$

$$m_b = m_i\exp\left(\frac{GSI - 100}{28}\right) \qquad RQD = 115 - 3.3\,x\,Jv$$

$$GSI > 25 \quad s = \exp\left(\frac{GSI - 100}{9}\right) \quad a = \frac{1}{2} \quad \sigma_1 = \sigma_3 + \sigma_{ci}\sqrt{m_b\frac{\sigma_3}{\sigma_{ci}} + s}$$

$$\sigma_{tm} = \frac{\sigma_{ci}}{2}\left(m_b - \sqrt{m_b^2 + 4s}\right) \qquad \sigma_{cm} = \sigma_{ci}\sqrt{s}$$

$$GSI < 25 \quad s = 0 \quad a = 0.65 - \frac{GSI}{200} \quad \sigma_1 = \sigma_3 + \sigma_{ci}\left(m_b\frac{\sigma_3}{\sigma_{ci}}\right)^{0,65 - \frac{GSI}{200}}$$

$$\sigma_{tm} = 0 \qquad \sigma_{cm} = 0$$

$$\sigma_{ci} > 100\ \mathrm{MPa} \qquad \mathrm{E_m\,(GPa)} = 10^{\left(\frac{\mathrm{GSI-10}}{40}\right)} \qquad Ps = K\,w^{0.46}/h^{0.66}$$

$$\sigma_{ci} < 100\ \mathrm{MPa} \qquad \mathrm{E_m\,(GPa)} = \sqrt{\frac{\sigma_{ci}\,(MPa)}{100(MPa)}}\,10^{\left(\frac{\mathrm{GSI-10}}{40}\right)} \qquad Ps = K\,w^{0.5}/h^{0.75}$$

$$\tau = \sigma_n\tan\left[\phi_a + JRC\log_{10}\left(\frac{JCS}{\sigma_n}\right)\right] \qquad \mathrm{Sz} = \frac{2(1-v)\mathrm{q}}{\mathrm{G}} \times \sqrt{l^2 - x^2}$$

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

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

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

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

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

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

$$A = \frac{\pi D^2}{4}$$

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

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

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

$$\varepsilon_{zz} = 0 \quad \sigma_{zz} = \nu(\sigma_{xx} + \sigma_{yy}) \qquad SF = \frac{Strength}{Load} \qquad \mathbf{APS = q_u/(1\text{-}e)}$$

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

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

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