

Minerals Council South Africa



EXAMINATION PAPER

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS SUBJECT CODE: COMCSCM EXAMINATION DATE: 7 MAY 2019 TIME: 14:30 – 17:30	EXAMINER: JC. VAN ZYL MODERATOR: P. COUTO TOTAL MARKS: [100] PASS MARK: (60%)
NUMBER OF PAGES: 6	
THIS IS NOT AN OPENBOOK EXAMINATION – ONLY REFERENCES PROVIDED ARE ALLOWED SPECIAL REQUIREMENTS: All candidates must complete Questions 1 to 3. Answer the questions <u>legibly</u> in English. Complete only one of the following questions (4, 5 or 6) in relation to your specific field of study. Question 4: Narrow Tabular Hard Rock Question 5: Surface mines; Question 6: Massive Mining - 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. - Show all calculations and check calculations on which the answers are based. - Hand-held electronic calculators may be used for calculations. Reference notes may not be programmed into calculators. - Write legibly in ink on the right-hand page only – left hand pages will not be marked. - Illustrate your answers by means of sketches or diagrams wherever possible. Final answers must be given to an accuracy which is typical of practical conditions. However, be careful not to use too few decimal places (minimum 2) during your calculations, as rounding errors may result in incorrect answers. NB: Ensure that the correct unit of measure (SI units) is recorded as marks will be deducted from answers if the incorrect unit is used (even if the calculated value is correct). - In answering the questions, full advantage should be taken of your practical experience as well as data given. - Please note that you are not allowed to contact your examiner or moderator regarding this examination. - Cell phones are NOT allowed in the examination room.	

1 Question 1 – Rock Strength and Rock Mass Classification: (31 marks)

Knowledge of the engineering properties of the rock types on a mine is the basis for sound design of the excavations, whilst used as input parameters for numerical software and in rock mass classification systems.

1.1 Define the following terms, and where relevant, give the SI unit and symbol: (10)

- a) Strain;
- b) Deformation
- c) Rock mass;
- d) Intact rock;
- e) Uniaxial compression

1.2 A standard UCS test was carried out on a quartzite specimen. The initial specimen dimensions were 52mm in diameter and 104mm in length. The load-deformation record showed that the specimen deformed in a perfect elastic manner. The compressive strength at failure was 380kN. The Young's modulus, $E = 50\text{GPa}$, and Poisson's ratio, $\nu = 0.2$.

Calculate:

- 1.2.1 The stress at failure (4)
- 1.2.2 The axial strain at failure (3)
- 1.2.3 The lateral strain at failure (3)
- 1.2.4 The modulus of rigidity (shear modulus), G (3)

1.3 Rock mass classification systems attempts to define the characteristics of the rock mass based on a simplified assessment of critical rock mass parameters. List the four components that are found in most classification systems. (4)

1.4 List at least four rock mass classification systems. (4)

2 Question 2: Stope Support (22 marks)

- 2.1 There are many stratigraphic, structural and stress-induced features together with the potential of seismicity, which in a combination could define a particular GCD. **Table** the factors that govern the support system choice delineating the specific ground control districts (GCD's) within a given mining environment under the following two headings: (10)
- 2.1.1 Support System Specifications;
- 2.1.2 Governing Geotechnical Factors.
- 2.2 List and explain four support characteristics? (8)
- 2.3 Explain the difference between Passive and Active support and give examples of each. (4)

3 Question 3: Shafts and Seismicity (27 marks)

- 3.1 List the advantages and disadvantages of early shaft pillar removal. (10)
- 3.2 List the process of conducting a Rock Burst Investigation? (7)
- 3.3 List and explain five parameters that are used to quantify Seismic sources. (10)

Note: Candidates may only select one of the following option questions

4 Question 4: Ledging and Raising (20 marks) (Narrow Tabular Hard Rock Candidates)

- 4.1 Several methods have been used in the past to cater for various geotechnical conditions. List at least three types of ledging methods? (3)
- 4.2 What type of ledging method would you consider in poor ground conditions? (1)
- 4.3 List the advantages of carrying the ledging along with a wide heading? (6)
- 4.4 Illustrate by means of sketches / diagrams five appropriate gully configurations for high stress conditions. (10)

5 Question 5: Slope stabilization (20 marks) (Surface mine candidates)

- 5.1 Rock Slope stabilization and protection can be achieved by? Explain and discuss the options and solutions available to a Geotechnical Engineer. Present your answer in a logical table format sub-divided into two categories: Stabilization and Protection measures. (20)

6 Question 6: Massive mining (20 marks) (Massive mine candidates)

- 6.1 List and explain the factors to be considered when Massive Mining is to be implemented within an orebody? (20)

Formulas:

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

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

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

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

$$m_b = m_i \exp\left(\frac{GSI - 100}{28}\right)$$

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

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

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

$$\sigma_{im} = 0 \quad \sigma_{cm} = 0$$

$$\sigma_{ci} > 100 \text{ MPa} \quad E_m \text{ (GPa)} = 10^{\left(\frac{GSI-10}{40}\right)}$$

$$\sigma_{ci} < 100 \text{ MPa} \quad E_m \text{ (GPa)} = \sqrt{\frac{\sigma_{ci} \text{ (MPa)}}{100 \text{ (MPa)}}} 10^{\left(\frac{GSI-10}{40}\right)}$$

$$\tau = \sigma_n \tan \left[\phi_a + JRC \log_{10} \left(\frac{JCS}{\sigma_n} \right) \right] \quad A = \frac{\pi D^2}{4}$$

$$\begin{aligned}\varepsilon_{xx} &= \frac{1}{E} \{ \sigma_{xx} - \nu(\sigma_{yy} + \sigma_{zz}) \} & \gamma_{xy} &= \frac{1}{G} \tau_{xy} & \varepsilon_{xy} &= \frac{1}{2G} \tau_{xy} & G &= \frac{E}{2(1+\nu)} \\ \varepsilon_{yy} &= \frac{1}{E} \{ \sigma_{yy} - \nu(\sigma_{xx} + \sigma_{zz}) \} & \gamma_{yz} &= \frac{1}{G} \tau_{yz} & \varepsilon_{yz} &= \frac{1}{2G} \tau_{yz} & K &= \frac{E}{3(1-2\nu)} \\ \varepsilon_{zz} &= \frac{1}{E} \{ \sigma_{zz} - \nu(\sigma_{xx} + \sigma_{yy}) \} & \gamma_{zx} &= \frac{1}{G} \tau_{zx} & \varepsilon_{zx} &= \frac{1}{2G} \tau_{zx}\end{aligned}$$

$$\begin{aligned}\sigma_{xx} &= \lambda \Delta + 2G \varepsilon_{xx} & \tau_{xy} &= G \gamma_{xy} & \tau_{xy} &= 2G \varepsilon_{xy} & \Delta &= \varepsilon_{xx} + \varepsilon_{yy} + \varepsilon_{zz} \\ \sigma_{yy} &= \lambda \Delta + 2G \varepsilon_{yy} & \tau_{yz} &= G \gamma_{yz} & \tau_{yz} &= 2G \varepsilon_{yz} & \lambda &= \frac{E\nu}{(1+\nu)(1-2\nu)} \\ \sigma_{zz} &= \lambda \Delta + 2G \varepsilon_{zz} & \tau_{zx} &= G \gamma_{zx} & \tau_{zx} &= 2G \varepsilon_{zx} & E &= \sigma/\varepsilon\end{aligned}$$

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

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

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

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

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

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