EXAMINATION PAPER

METALLIFEROUS option

<table>
<tr><td>SUBJECT:

MINERALS COUNCIL OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS

SUBJECT CODE: COMCSCM
EXAMINATION DATE: 11 MAY 2021
TIME: 14:30 – 17:30</td><td>EXAMINER: JC VAN ZYL

MODERATOR: J ESTERHUYSE

TOTAL MARKS: [100]

PASS MARK: (60%)</td></tr>
<tr><td colspan="2">NUMBER OF PAGES: 10</td></tr>
<tr><td colspan="2">THIS IS NOT AN OPENBOOK EXAMINATION – ONLY REFERENCES PROVIDED ARE ALLOWED

SPECIAL REQUIREMENTS:

1. All candidates must complete Questions 1 to 4. Answer the questions <u>legibly</u> in English.
2. Write your <u>ID Number</u> on the outside cover of each book used and on any graph paper or other loose sheets handed in.
<u>NB</u>: Your name <u>must not</u> appear on any answer book or loose sheets.
3. Show all calculations <u>and check calculations on which the answers are based.</u>
4. Hand-held electronic calculators may be used for calculations. Reference notes may not be programmed into calculators.
5. Write <u>legibly</u> in ink on the <u>right-hand page</u> only – <u>left hand pages will not be marked</u>.
6. Illustrate your answers by means of sketches or diagrams wherever possible.
7. <u>Final answers</u> 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.
<u>NB:</u> Ensure that the correct unit of measure (SI units) are 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 e.g. smart-watches are <u>NOT</u> allowed in the examination room.</td></tr>
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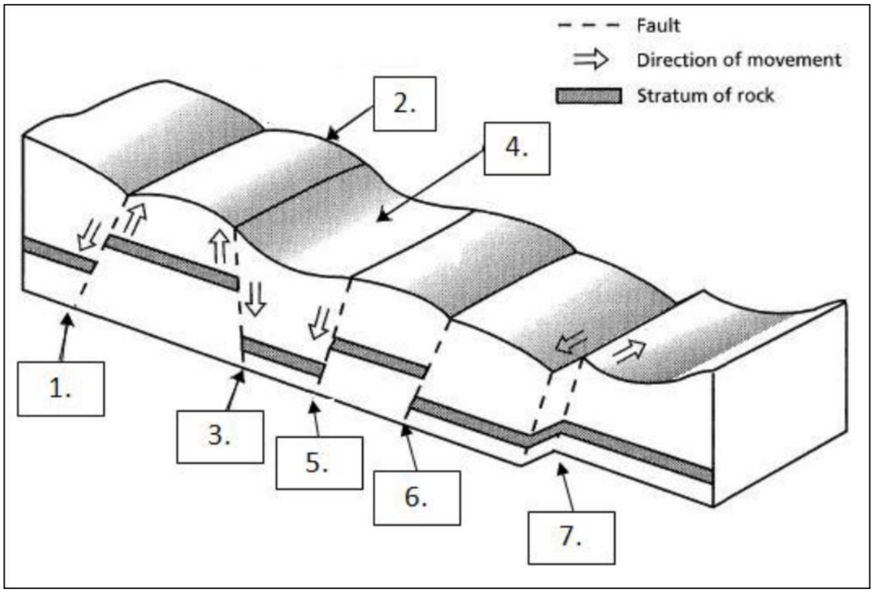
1. <u>Question 1 - General: (22 marks)</u>

1.1 The Structural geology entities **1 to 7** in the Figure below show (in sequence) the following:



A.) Normal fault, Horse, Normal fault, Valley, Normal Fault, Dip-slip fault, Strike slip fault

B.) Normal fault, Horst, Reverse fault, Graben, Normal Fault, Normal fault, transgressional fault

C.) Normal fault, Graben, Normal fault, Horst, Normal Fault, Reverse fault, Dip slip fault

D.) Normal fault, Horst, Dip-slip fault, Graben, Normal Fault, Reverse fault, Strike slip fault

(2)

1.2 Which of the following statements are **true**?

A.) In deep level mining environments, rock engineering risk related to structure is not focused on structural orientation and is only affected by over-stressing, mining geometry and/or sequencing.

B.) Geological structures like faults and dykes pose a risk to mine safety in both shallow and deep level environments; it is merely the nature of the risk they pose that may vary.

C.) A normal fault and a dip-slip fault explicitly refer to the same geological entity.

D.) B and C above (2)

1.3 Which of the following statements are **False**?

A.) Convergence and closure are not the same thing. In a mine where bedding planes, jointing and fracturing exist, convergence can be many times larger than the elastic closure.

B.) When conducting pillar design, it is acceptable practice, when mining to a uniform or repeatable layout, to determine pillar stresses using the "Tributary Area Theory".

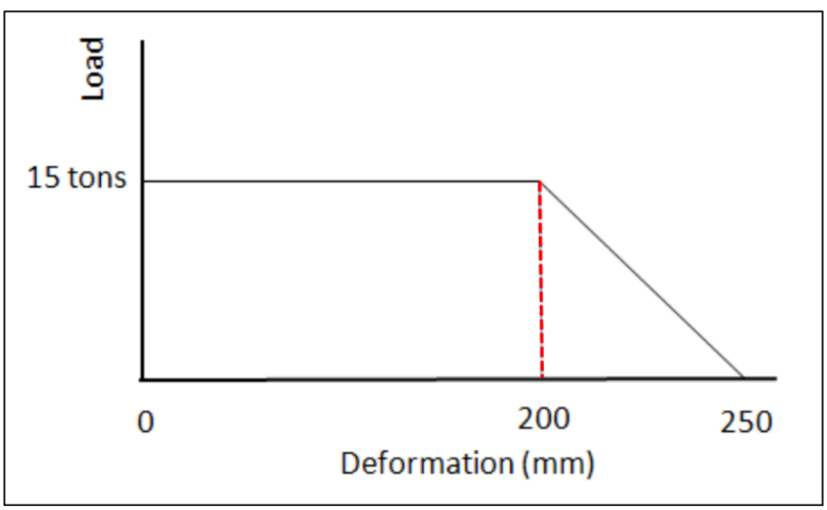
C.) In the Hoek-Brown failure criterion, the m and s parameters are material constants that depend upon the properties of the rock and upon the extent to which the rock has been broken before being subjected to the stresses respectively.

D.) When designing support, a generally accepted rule of thumb is that support units should be, in length, ½ the excavation span and should be spaced ½ the length of tendon apart. (2)

1.4 An elongate (200mm in diameter) yields at **20 tonnes**. If units are installed on a 2.0m x 1.5m centre-to-centre spacing, what is the support resistance offered by the system? Assume **$g=9.81\ m/s^2$**

A.) 196.2 kN/m² **B.)** 212.21 kN/m² **C.)** 65.4 kN/m² **D.)** 52.5 kN/m²
(2)

1.5 An installed support unit has been subjected to **80mm** of yield. Given the following support characteristics, what is the energy absorption capacity of the unit currently? (Assume **$g=10\ m/s^2$**)



A.) 33.75 kJ ; **B.)** 3 Joules; **C.)** 2 1.75 Nm; **D.)** 21 750 Nm **E.)** 21. 75 MPa
(2)

1.6 A tape readout (ruler scale) closure meter would be an example of instrumentation that has……….

A.) Low accuracy, reasonable precision, high resolution and a sensitivity of about 1mm.
B.) High accuracy, precision to 1mm, a low resolution but high sensitivity.
C.) Low to moderate accuracy, reasonable precision, a resolution of about 1 mm and medium to high sensitivity.
D.) Accuracy to about 1mm, reasonable precision, high resolution and a medium to high sensitivity. (2)

1.7 An electronic readout closure logger is capable of digitally recording continuous readings (1 reading every 5 minutes). Readings are recorded and reported to the nearest $1/10^{th}$ of a millimetre. The instrument is however in desperate need of recalibration. This would be an example of an instrumentation that has ……….

A.) Low accuracy, reasonable precision, poor resolution and a sensitivity of 100 microns.
B.) Acceptable levels of accuracy, precision, resolution and sensitivity.
C.) Possibly a low level of accuracy, reasonable to high precision, a resolution of 100 microns and suitably matched instrument sensitivity.
D.) Good accuracy, possibly a low level of precision, a resolution of 100 microns and sensitivity to well below a millimetre. (2)

1.8 Which of the following is not a method of rockmass classification?

A.) The Geomechanics Classification **B.)** The Hoek-Brown criterion
C.) Barton's Q system **D.)** Rockwall Condition Factor (2)

1.9 Calculate the δv assuming the following parameters:
g = ?
h = 2250 mbs
ρ = Platinum Mine
δv = ?

A.) 70.6 KPa **B.)** 706 MPa **C.)** 70.6 MPa **D.)** None of the above (2)

1.10 The following lengths of individual pieces of core have been recovered from a total length of drill run of 3m: 0.1 m, 0.3 m, 0.7 m, 0.3m. The RQD is

A.) 1.4% **B.)** 35% **C.)** 47% **D.)** 1% **E.)** None of these are correct (2)

1.11 A dyke is an example of the following type of rock:

A.) Metamorphic **B.)** Ultra-paleo **C.)** Igneous **D.)** Sedimentary (2)

2 <u>Question 2: Testing and Monitoring Methods (26 marks)</u>

2.1 Name four reasons why monitoring is required. (4)

2.2 Give an example of instruments that can be used to monitor in-situ load deformation characteristics of an elongate support unit. (1)

2.3 State the four parameters that uniquely characterise a seismic event. (4)

2.4 Name and explain the operational benefits associated with seismic monitoring? (6)

2.5 Define the following:

2.5.1 Convergence (2)

2.5.2 Closure (2)

2.6 A prototype timber elongate is currently trailed on your mine. Laboratory test results for the elongate is summarised in annexure 1. The loading rate was 30mm / min. Plot the curve on the graph paper provided in the answer book and:

2.6.1 Clearly annotate the graph and indicate the Pre-tension, Initial stiffness, Yield force, Peak strength and Energy.

2.6.2 Downgrade the laboratory test results as per industry norm and plot the curve on the same chart. (7)

3 Question 3: Support Design (24 marks)

3.1 Provide the formula for elastic convergence given and name all the input parameters and basic SI units for each symbol. (6)

3.2 You have successfully tested and implemented the prototype unit mentioned in question 2 above at your mine. The Mine Manager has further discovered that this support unit outperforms the previous elongates used on the mine and has requested that you investigate the possibility of moving the back area barricade and sweeping standard up to 10.0m from the face due to cleaning constraints in a particular section of the mine. You also have the following workplace information of the affected area.

Depth = 2400m
Stope Span = 200m
Stope height = 110cm
E = 78000 MPa
V = 0.3
Rock density = 2750 kg/m^3
Closure at maximum span = 102%
Support spacing = 1.5m x 1.5m
Fallout height = 1800cm

3.2.1 What will the closure be 10m back from the face and how will this affect the support units? Show all your calculations. (9)

3.2.2 Calculate the force if the support units are spaced 1.5m apart on dip and strike? **Plot your results on the same graph used for question 2.7 on the graphing paper provided.** (5)

3.2.3 Provide your manager with feedback stating if the standard can be amended or not and motivate your answer, assuming static conditions. (4)

4 Question 4: Shafts and Seismicity (28 marks)

4.1 List the advantages and disadvantages of early shaft pillar removal. (5)

4.2 List the aspects to be taken into account or be considered on whether to have a shaft pillar or to immediately remove the shaft reef. (9)

4.3 List the process of conducting a Rock Burst Investigation? (7)

4.4 List and explain five parameters that are used to quantify Seismic sources. (7)

Annexure 1

Examination Number: ______________________________

Table 1: Laboratory test results

Deformation (mm)	Load (kN)	Downrated Load (kN)
0	120	
25	220	
50	240	
75	265	
100	270	
125	260	
150	240	
175	200	
200	200	
225	180	
250	170	
275	160	
300	100	

Formulas:

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

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

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

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

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

$$\sigma_{zz}=\lambda\Delta+2G\varepsilon_{zz}\quad \tau_{zx}=G\gamma_{zx}\quad \tau_{zx}=2G\varepsilon_{zx}\qquad E=\sigma/\varepsilon$$

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

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

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

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

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

$$\varepsilon_{yy}=\frac{1}{E}\{(1-\nu^2)\sigma_{yy}-\nu(1+\nu)\sigma_{xx}\}\quad s_z=\frac{2(1-\nu)q}{G}\sqrt{\ell^2-x^2}$$

$$q=\rho gH\quad \sigma_v=q\quad \sigma_h=kq$$

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

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

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

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

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

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

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

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

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

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

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

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