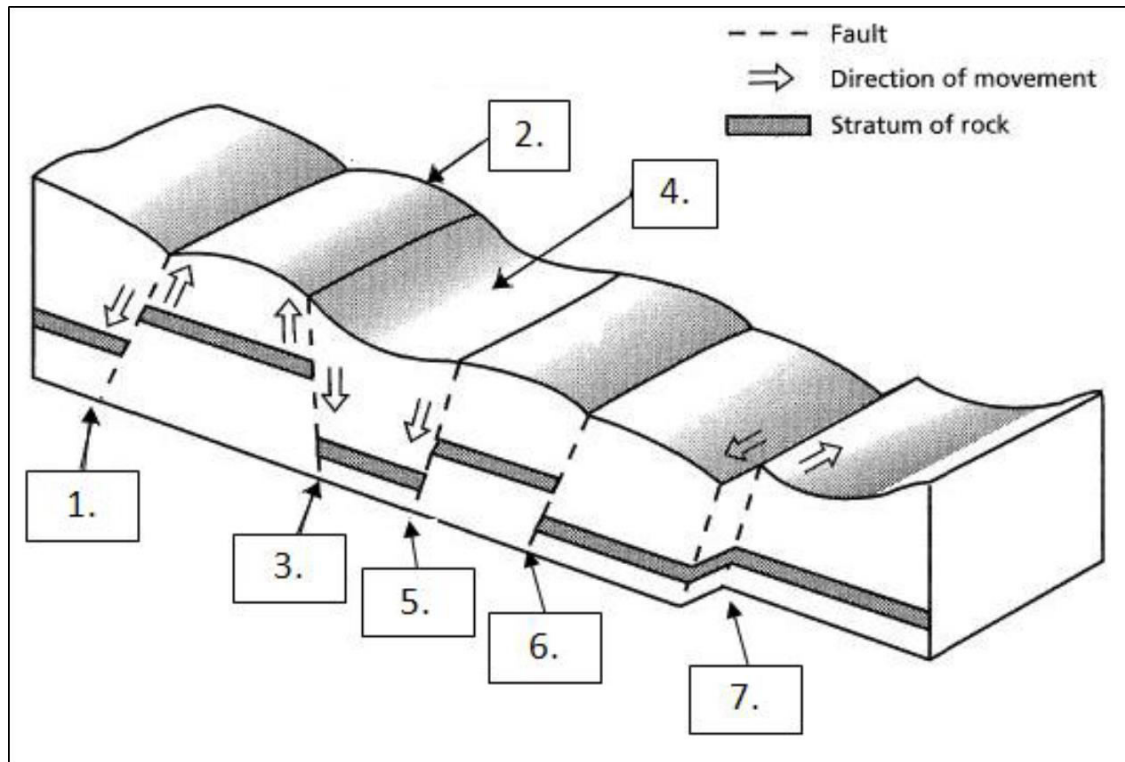


EXAMINATION PAPER

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS SUBJECT CODE: COMCSCM EXAMINATION DATE: 8 MAY 2018 TIME: 14:30 – 17:30	EXAMINER: JC. VAN ZYL MODERATOR: P. COUTO TOTAL MARKS: [100] PASS MARK: (60%)
NUMBER OF PAGES: 11	
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. Complete only one of the following QUESTIONS (5, 6 or 7) in relation to you specific field of STUDY. QUESTION 5: NARROW TABULAR HARD ROCK QUESTION 6: OPEN PIT QUESTION 7: Massive Mining 3. 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. 4. Show all calculations <u>and check calculations on which the answers are based.</u> 5. Hand-held electronic calculators may be used for calculations. Reference notes may not be programmed into calculators. 6. Write <u>legibly</u> in ink on the <u>right hand page</u> only – <u>left hand pages will not be marked.</u> 7. Illustrate your answers by means of sketches or diagrams wherever possible. 8. 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) are recorded as marks will be deducted from answers if the incorrect unit is used (even if the calculated value is correct). 9. In answering the questions, full advantage should be taken of your practical experience as well as data given. 10. Please note that you are not allowed to contact your examiner or moderator regarding this examination. 11. Cell phones are <u>NOT</u> allowed in the examination room.	

QUESTION 1 - General: (20 marks)

In each case, write down the correct answer. Show your calculations where required.



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

- A.)** Normal fault, Horst, 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

(3)

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, $\frac{1}{2}$ the excavation span and should be spaced $\frac{1}{2}$ 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 **$g=9.81 \text{ m/s}^2$**

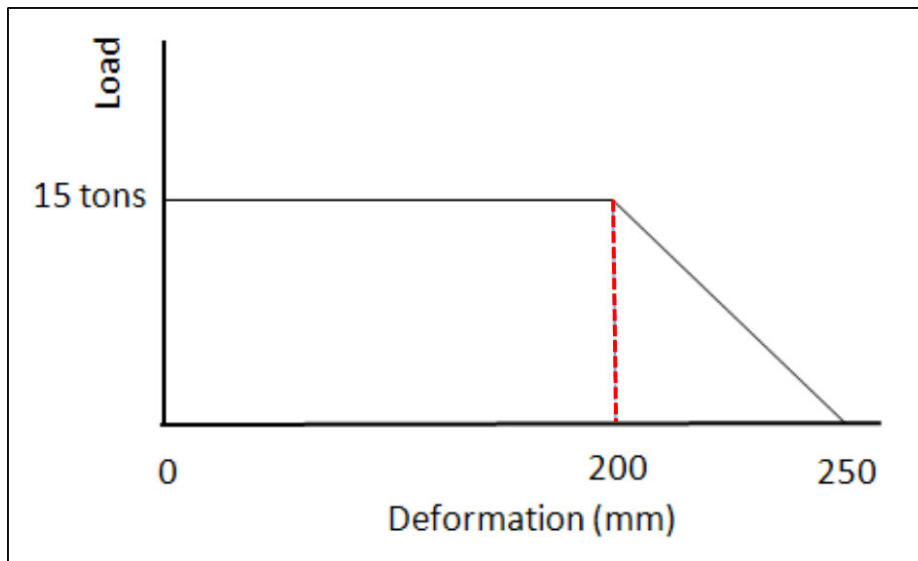
A.) 196.2 kN/m²

B.) 212.21 kN/m²

C.) 65.4 kN/m²

D.) 52.5 kN/m² (3)

- 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 $g=10 \text{ m/s}^2$)



- A.) 33.75 kJ
 B.) 3 Joules
 C.) 2 1.75 Nm
 D.) 21 750 Nm
 E.) 21. 75 MPa
- (4)
- 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 $1/10^{\text{th}}$ 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)

QUESTION 2: Mining Strategies (26 marks)

- 2.1 Complete Table 1 attached (Annexure 1) and indicate the values of parameters associated with different mining depths.

(12)

Parameter	Shallow	Intermediate	Deep	Ultra - Deep
Typical Depth (m)				
Typical ERR (MJ/m ²)				
Vertical Virgin Stress (MPa)				
Stress fracturing				
Stope closure rate (mm/m face advance)				
Rock burst hazard				

NB! Write only your exam number on Annexure 1 and submit it with your answer book.

- 2.2 Describe with the aid of a sketch or diagram what is your understanding of the Face Shape Index (FSI) criterion.

(8)

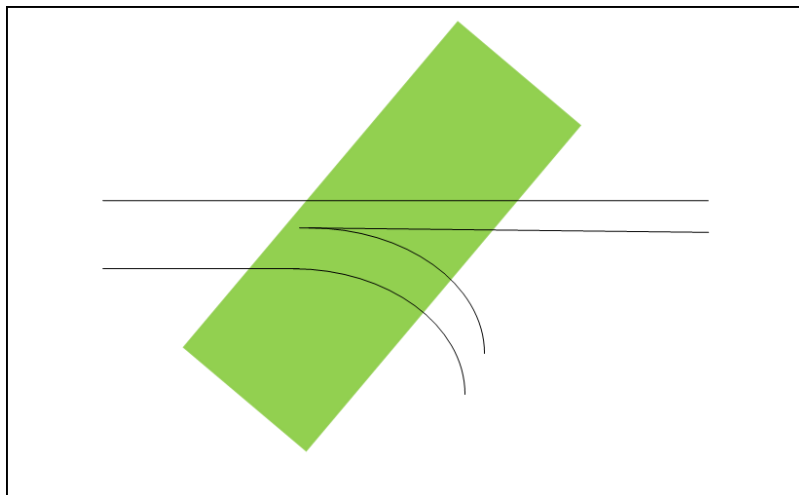
- 2.3 Describe the parameters of the RCF criterion [$RCF = (3\sigma_1 - \sigma_3) / (F \sigma_c)$] for tunnel and support design and list the RCF values for good, average and poor ground conditions.

(6)

QUESTION 3: General (10 marks)

- 3.1 Why is the following layout not recommended, sketch, describe and explain your reasoning?

(6)



- 3.2 Explain the difference between active and passive support by means of a Load / Deformation graph. Ensure that the graph is correctly labelled. (4)
- 3.3 **Bonus Question: Name 3 MOSH Leading Practices** (3)

QUESTION 4: Stresses (24 marks)

- 4.1 With the aid of a diagram, illustrate the complete state of stress at a point in the rockmass in 2 dimensions. (3)
- 4.2 Describe / define the following terms:
- A.) Virgin Stress (3)
 - B.) K-Ratio (2)
 - C.) Induced Stress (3)
 - D.) Field Stress (2)
- 4.3 You are a newly appointed Strata Control Officer on a shallow platinum mine. Your Rock Engineer has requested you to do a preliminary analytical assessment of a planned vertical raisebore silo excavation. Determine the radial and tangential stress components on the edge of the excavation as well as for points 0.5m, 1.0m and 2.0m into the solid along the excavation. The excavation will be developed within Pyroxenite at a diameter of 5.0m. The mining depth is 500m below surface and the K ratio is 1.8. Assume the theta angle is 0° (11)

List your results in Table 2 attached in Annexure 1

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

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

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

NOTE: CANDIDATES MAY ONLY SELECT ONE OF THE FOLLOWING OPTION QUESTIONS

QUESTION 5: Rockmass Strength (20 marks)

(Narrow Tabular Hard Rock Candidates ONLY)

- 5.1 Give a brief description of the fracture zone surrounding an excavation and to what extent the fractures can extend ahead of a stope face in an intermediate to deep mining environment. (3)

- 5.2 Using the Hoek and Brown failure criterion, determine if failure of the silo excavation sidewalls will occur and to what extent / depth given the following information:

$$\sigma_1 = \sigma_3 + \sqrt{m\sigma_c\sigma_3 + s\sigma_c^2}$$

The UCS of the host rock is 114 MPa.

Assume an m value of 0.2 and an S value of 0.005.

The confining pressure (σ_3) is 0 MPa on the edge of the excavation, 5 MPa at 0.5m; 10 MPa at 1.0m and 15 MPa at 2.0m into the solid along the excavation.

(8)

- 5.3 Compare your Hoek and Brown results with the tangential stress results calculated in question 4.3 and comment up to which extent you may expect failure.

(4)

List your results in Table 3 attached in Annexure 1

- 5.4 Graphically represent your results on the graph paper provided and generate the Hoek and Brown failure envelope in principal stress space. Comment on the graph where you expect failure and no failure of the rock mass given the stress state calculated above. (5)

QUESTION 6: Open Pit (20 marks)

(Open Pit Candidates ONLY)

- 6.1 Name the three categories of stability evaluation which follow directly from rock mass characterization. (6)
- 6.2 Name and describe by means of sketches the 4 types of failures you can find in slope stability? (8)
- 6.3 Give a brief description of each of the following monitoring systems and what are they used for?
- A) Movement and Survey Radar
 - B) GeoMos System
 - C) Piezometers
- (6)

QUESTION 7: Massive Mining (20 marks)

(Massive Mining Candidates ONLY)

- 7.1 Describe the concept of hydraulic radius? (2)
- 7.2 List at least four characteristics for the following mining methods: **Sub level open stoping, shrinkage stoping, vertical crater retreat and cut and fill.** (8)
- 7.3 List five factors to consider during the design of draw points. (10)

TOTAL MARKS: 100

Annexure 1

Examination Number: _____

Table 1: Question 2.1

Parameter	Shallow	Intermediate	Deep	Ultra - Deep
Typical Depth (m)				
Typical ERR (MJ/m ²)				
Vertical Virgin Stress (MPa)				
Stress fracturing				
Stope closure rate (mm/m face advance)				
Rock burst hazard				

Table 2: Question 4.3

Distance into sidewall	R (m)	r (m)	Tangential Stress (MPa)	Radial Stress (MPa)
0	2.5			
0.5	2.5			
1	2.5			
2	2.5			

Examination Number: _____

Table 3: Question 5.3

Distance in Sidewall	3 (MPa)	Hoek- Brown Strength (MPa)	☐ Tangential Stress (MPa)	Failure Yes / No
0	0			
0.5	5			
1	10			
2	15			