CHAMBER OF MINES OF SOUTH AFRICA

EXAMINATION PAPER

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS	**EXAMINER:** Y Jooste
SUBJECT CODE: COMCSC	**MODERATOR:** DA Arnold
EXAMINATION DATE:	**TOTAL MARKS:** [100]
TIME: 14:30 – 17:30	**PASS MARK:** (60%)

NUMBER OF PAGES:

THIS IS NOT AN OPENBOOK EXAMINATION – ONLY REFERENCES PROVIDED ARE ALLOWED

SPECIAL REQUIREMENTS:

1. Answer all the questions. Answer the question **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) 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 are **NOT** allowed in the examination room.

QUESTION 1

1.1 Overstoping is an effective method of protecting off-reef excavations from the effects of large mining induced stress changes.

a. True
b. False

1.2 APS stands for:

a. Apparent pillar stress
b. Average pack stress
c. Ambient pillar stress
d. Average pillar stress

1.3 What is the surface area of a mine pole with radius 105mm and length 2.2m?

a. 1.40m^2
b. 1.52m^2
c. 0.89m^2
d. 1.98m^2

1.4 The virgin vertical stress at a depth of 3200 m below surface where the k-ratio is 0.5 and the rock density is 2750 Kg/m^3 is:

a. 43.16 MPa
b. 86.32 kN
c. 86.32 MPa
d. 42.12 kN

1.5 Stope closure continues to take place even if there is no further face advance.

a. True
b. False

1.6 This type of rock is formed from a body of magma that cools down and solidifies.

a. Sedimentary rock
b. Igneous rock
c. Metamorphic rock

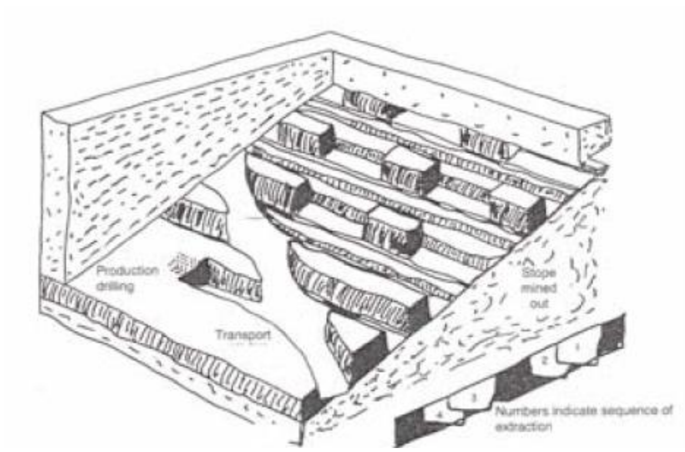
1.7 Packs should be built perpendicular to the reef dip.

a. True
b. False

1.8 Under-burdened blast holes means that holes are drilled too far apart from each other.

a. True
b. False

1.9 Name the mining method in the figure below:



a. Bord and pillar mining
b. Sub level stoping
c. Cut and fill mining
d. Step room and pillar mining

1.10 Buckling potential decreases if elongate length to diameter ratio is more than 10.

a. True
b. False

[10]

QUESTION 2 – Definitions

Define the following terms and where applicable give units:

2.1 Virgin stress – the **stresses which exists** in the rock mass **prior to mining**

2.2 APS – is the **average** stress carried by a pillar in a given mining **environment**

2.3 Bedding planes – are the **contact surfaces** between adjacent strata in a sequence of **sedimentary** rocks

2.4 Joints – are **natural occurring planar geological** discontinuities across which there is **no displacement**

2.5 Ride – is the differential **lateral movement** between **hanging wall and footwall**.

[10]

QUESTION 3 – Force and Stress

3.1 Calculate the load in kN at which a 20mm diameter rock bolts will fail, assuming that the tensile strength of steel is 450Mpa.

Diameter of bolt – 20mm
Area = $3.14 \times d^2 / 4 = 3.14 \times (0.02)^2 / 4 = 3.14 \times 10^{-4}$ m^2
Load = stress x area but at failure stress of 450 MPa

Load = 450×10^6 Pa $\times 3.14 \times 10^{-4}$ m^2 = 141 kN (3)

3.2 [swap] Consider a point at a crosscut position that is 2000m below surface, 100m below the reef plane and 100m ahead of a longwall stope. Assume a k-ratio of 0.5.

3.1.1 Calculate the vertical and horizontal primitive stress at this point.

$\sigma v = \rho gh = 2700 \times 9.8 \times 2000 = 53$MPa
$\sigma h = (0.5)\sigma v = 26.5$ MPa (4)

3.1.2 Assume that the stoping induced stress increases this value by a factor of 1.5. Calculate the field stress in which the crosscut is situated.

Fields stress σv = (1.5) 53MPa = 79.5 MPS
Field stress σh= (0.5)(1.5) (53) = 39.8 MPa (2)

3.1.3 Calculate the total stress in the sidewall of the crosscut assuming a stress concentration factor of 2.

Total stress = 2 x 79.5 = 159 MPa (1)

[10]

QUESTION 3 – Pillars

3.1 Draw the stress-strain behaviour graphs of the following hard rock pillar types:

- Non-yield
- Yield
- Crush

Indicate the typical operating points of these pillar types. (9)

Figure 3.4.2, 3.4.4 and 3.4.5 p 78,79 and 80 in Jager and Ryder

3.2 What is the fundamental assumption of the tributary area theory? (2)

Tributary area theory assumes that the weight of the overburden is carried by the pillars in proportion to the mined out area surrounding the pillars.

3.3 A system of regular pillars are planned for mining at a depth of 700m below surface in a rock density of 2800 kg/m^3. The stoping width will be 3.1m, and 8m wide bords and 6m wide square pillars are planned. The in situ cube strength of the host rock was determined to be 145 MPa. Determine the safety factor of the system.

$e = \frac{\text{Area Total - Area Pillar}}{\text{Area Total}}$ = (196-36)/196 = 81.6% (2)

APS = qv/(1-e) = 19.23/0.184 = 104.51 Mpa (3)

$Ps = K\, w^{0.5} / h^{0.75}$ = $145(6^{(0.5)}/3.1^{(0.75)})$ = 152.03 MPa (3)

SF = Strength/Stress = 152.03/104.51 = 1.45 (1)

(some downgrade the K value which is correct but I did not take it into account here although I gave them all the marks away)

[20]

QUESTION 4 – SUPPPORT

4.1 The table below lists a number of support types. State which support type is active and which is passive at the time of initial installation. Also classify them in terms of what conditions they best operate in?

Support unit	**Active/Passive**	**Dynamic/static conditions**
End-anchor bolts	Active	Static
Grouted Ripple bar	Passive	Dynamic
Pre-stressed mat pack	Active	Static
Rapid yielding hydraulic prop	Active	Dynamic
Crush Pillar	Active	Dynamic
Shotcrete	Passive	Passive
Mesh and lace	Passive	Dynamic
Rock prop	Active	Dynamic
Cemented backfill	Passive	Static
Timber Sets	Passive	Static

(10)

4.2 Some important rock and support related issues need to be considered before a support system is designed by a rock engineer. List 5 geotechnical factors you would consider important when designing a support system for a mining excavation.

- Depth
- Rock strength
- Stresses at the location of the excavation
- Rock types
- Geological weaknesses

- Other excavations close by
- Dip of reef
- Seismicity
- Mining method (5)

4.3 What geotechnical aspects would you as a rock engineer consider in order to ensure that energy release rates on your deep level mine are controlled?

- Mining span
- Stoping width
- Blasting/Preconditioning
- Installation of backfill
- Regional Pillars
- Support type and spacing (5)

[20]

QUESTION 5 – SEISMIC MONITORING

5.1 Name the two types of body waves commonly detected and used in mine seismicity monitoring, and state their typical propagation velocities?
S wave (3600m/s) and P wave (5900m/s) (2)

5.2 Define the difference between a seismic event and a rock burst? (4)
Seismic event is a sudden inelastic deformation of the rockmass that radiates kinetic energy in the form of seismic waves. Rock burst is a seismic event that results in damage

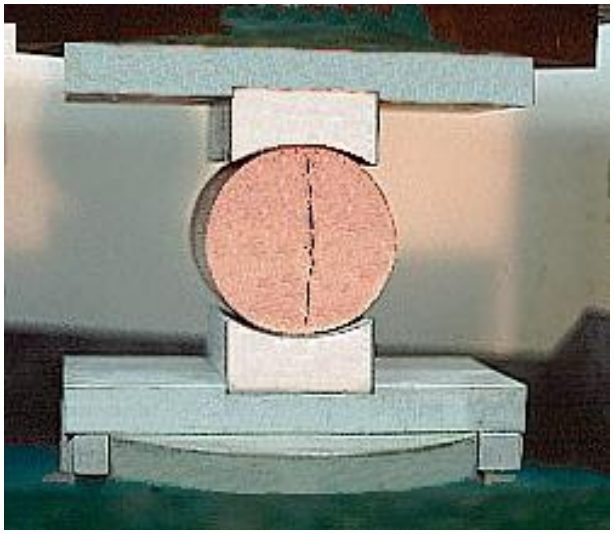
5.3 What 4 parameters can be obtained instantly from a seismic monitoring system when a seismic event occurs?
Date, time, location and magnitude (4)

[10]

QUESTION 6 - MONITORING

6.1 Name the testing method illustrated in the figure below and briefly describe how it is done.

(3)



Brazilian test method - This test is used for the indirect determination of the tensile strength of rock. If a circular cylindric specimen is compressed along its diameter, failure occurs by an extension fracture in the loaded diametral plane (see image) at some value of the applied load. With this load and the dimensions of the specimen the uniaxial tensile strength can be estimated.

6.2 Why do we need to do rock engineering monitoring ?

- To record the natural values and variations in geotechnical parameters before the start of a mining project
- To ensure safety during mining by giving warning of excessive deformations.
- To check the validity of assumptions and modelling used in design calculations
- To monitor support behaviour and it's design performance (4)

6.3 A standard uni-axial compression test was carried out on a specimen of kimberlite. The initial dimensions were 47.2mm in diameter and 96,4mm in length. The load-deformation record showed that the specimen deformed in a perfectly elastic manner and that it had been compressed to a length of 96.21mm when failure occurred at a load if 213 kN. The lateral strain at this stage was 0.00058. Calculate:

Get diameter at failure:

$$\varepsilon_L = \frac{D_0 - D}{D}$$

Rearrange: $D = \frac{D_0}{\varepsilon_L + 1} = \frac{47.2x10^{-3}}{0.00058+1} = 47.17\ x\ 10^{-3}\ m$

Thus area at failure: $Area\ at\ failure = \pi r^2 = \pi\ x\ (\frac{47.17\ x\ 10^{-3}}{2})^2 = 1.75\ x\ 10^{-3}\ m^2$

Thus: $\sigma = \frac{F}{A} = \frac{213\,kN}{1.75\ x\ 10^{-3}\ m^2} = 121.87\ MPa$

6.3.2 The axial strain at failure

Axial strain = $l_o - l/l$ = (94.4 x10^{-3} – 96.21 x 10^{-3})/96.4 x 10^{-3} = 1.97 x 10^{-3}

6.3.3 The lateral deformation at failure

As calculated in 6.3.1

6.4.4 The Poisson's ratio

$$\upsilon = \frac{\varepsilon_r}{\varepsilon_a} = \frac{0.00058}{1.97x\ 10^{-3}} = 0.29$$

6.4.5 The modulus of elasticity, E (Young's modulus)

$E = \frac{\sigma}{\varepsilon_a} = \frac{121.87\ MPa}{1.97x\,10^{-3}} = 61.83\ GPa$

6.4.6 The shear modulus, G

G=E/(2(1+v) = 61.83GPa/(2 x 1.29) = 23.89 Gpa

(13)

[20]

TOTAL MARKS: [100]

$$Ps = K\, {w^{0.46}}\big/{h^{0.66}}$$

$$Ps = K\, {w^{0.5}}\big/{h^{0.75}}$$