CHAMBER OF MINES OF SOUTH AFRICA

EXAMINATION PAPER

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

NUMBER OF PAGES:

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

SPECIAL REQUIREMENTS:

1. Answer **Questions 1, 2, 3, 4, 7 and 8** and **chose any one** of **Questions 5 or 6**. (ie. Answer seven questions in total). 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) 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 The P-wave of a seismic event always arrives

a. before

b. at the same time as

c. after

the S–wave

1.2 RQD stands for

a. Rock Quality Deficiency

b. Rock Quality Designation

c. Rock Quantity Designation

d. Rock Quality Deficiency

1.3 Determine the RQD of the rock if the core recovered from a 13m borehole is retrieved in the following core lengths:

- 3 x 24 mm
- 4 x 30.5 cm
- 9 x 12 mm
- 4 x 7.5 cm
- 6 x 350 mm
- 14 x 5.5 cm
- 16 x 25 cm
- 12 x 330 mm
- 1 x 47mm

a. 93.32

b. 78.34

c. 86.77

d. 92.45

1.4 A body with a force F is resting on a surface inclined at 30˚ to the horizontal. The force S parallel to the inclined surface is:

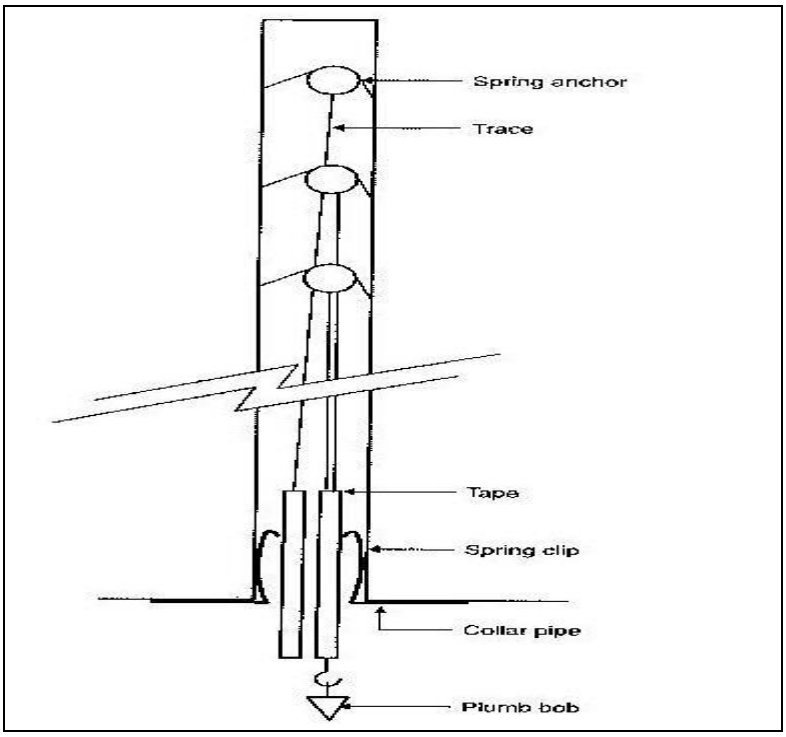
a. F cos 30˚

b. F sin 30˚

c. F tan 30˚

d. F $\sin^{-1}$ 30˚

1.5 Name the instrument in the next figure:



a. Rod extensometer
b. Wire extensometer
c. Venier extensometer
d. Probe extensometer

1.6 RCF is used to describe the ground conditions of

a. Gullies
b. Tunnels
c. Massive stopes
d. Tabular stopes

1.7 What is the generally accepted unit for ERR?

a. Nm/m^2
b. MJ/m^2
c. Mpa
d. Has no unit

1.8 A pillar system designed to yield must incorporate barrier pillars.

a. True
b. False

1.9 What is the (max) height of the tensile zone if the stope span is 210m at a depth of 310m below surface?

a. 48.63m
b. 86.21m
c. 87.12m
d. 67.32m

Are you using Formula 10 from your sheet? If so, it is circular.

1.10 Minsim modelling program is a

a. 2D discontinuum code
b. 3D finite element code
c. 3D displacement discontinuity codes
d. 2D plasticity code

[10]

QUESTION 2 – Definitions

Define the following terms and where applicable give units:

2.1 Support resistance

Support resistance is the concept whereby the force generated by a support unit is averaged over the tributary area of the hangingwall to be supported by that unit or a portion of a system. Unit = newton (N)

2.2 Plasticity

Property of a material to continue deforming with a constant load

2.3 Rock mass

This is defined by the rocks surrounding an excavation or in a particular part of the mine. It includes the intact rock and all the discontinuities and geological changes and features that exist.

2.4 Young's modulus

An elastic modulus, or modulus of elasticity, is the mathematical description of an object or substance's tendency to be deformed elastically (i.e., non-permanently) when a force is applied to it. The elastic modulus of an object is defined as the slope of its stress–strain curve in the elastic deformation region

2.5 Intact rock

It is defined as the rock that exists between any geological discontinuities and weaknesses. The sample is usually small and uniform. The strength of intact rock is usually higher than the rock mass.

[10]

QUESTION 3 – Rock Joints and Rock Mass Ratings

3.1 List the 6 parameters (do not supply only abbreviations) that are used to classify a rock mass according to the Bieniawski Rock Mass Rating. (6)

- **Uniaxial compressive strength of rock material.**
- **Rock Quality Designation (RQD).**
- **Spacing of discontinuities.**
- **Condition of discontinuities.**
- **Groundwater conditions.**
- **Orientation of discontinuities.**

3.2 Laubscher suggested changes to the Bieniawski Rock Mass Rating system. This system takes the basic *RMR* value, as defined by Bieniawski, and adjusts it. How did he adjust the rating system? (2)

Laubscher described a Modified Rock Mass Rating system. This system takes the basic *RMR* value, as defined by Bieniawski, and adjusts it to account for in situ and induced stresses, stress changes and the effects of blasting and weathering.

3.3 A development end on a mine has intersected poor ground which has slowed advances. A 60 m long exploration diamond drill hole, with orientated drill core, has been drilled ahead of the face to gather information on expected ground conditions. You must analyze the orientated core recovered from the hole. You record a **total** of 380 joints in the core. There appears to be two distinct sets of strike joints, dipping at roughly 20 and 80 degrees respectively. While the one set is rough and undulating, the other is smooth, planar and slickensided. Traces of micaceous filling, varying in thickness from 0 – 3 mm, are visible in the joint planes. No water seems to be present. There also appears to be a 3.0-metre thick weathered dyke running through the middle of this zone, at an angle of 45 degrees.

Calculate the rock mass quality based on the Q-system, using the tables provided in appendix 1. Motivate your reason for each value chosen for use in the rock mass rating. (7)

Q = RQD/Jn x Jr/Ja x Jw/SRF
RQD = 115 – (3.3 x (380joints / 60m)) = 94.1, can round up to 95 (1)
Jn = 4 (2 distinct joint sets) (1)
Jr = 0.5 (slickensided, planar) (1)
Ja = 2 (Joint filling > 1 mm) (1)
Jw = 1 (dry) (1)
SRF = 2.5 (One shear, fault, dyke or weakness zone) (1)
Q = 2.375 (1)

3.4 Calculate the Rock Wall Condition Factor for the following parameters:
σ_1 = 40 Mpa σ_3 = 20 Kpa σ_c = 70 Mpa and F = 1.0 (2)

$$RCF = \frac{3\sigma_1 - \sigma_3}{F\sigma_c}$$

= [2(40) – 0.2]/[1.0 x 70]

= [80 – 0.2]/70

= 1.714

3.5 What should the support recommendation be according to Rock Wall Condition Factor calculated in 4.4. (1)

Ground condition on boundaries of average and poor and support should be must be increased

3.6 List two reasons why rock mass classification is important? (2)

To Build up a picture of the composition and characteristics of a rock mass to provide initial estimates of support requirements, and
Provide estimates of the strength and deformation properties of the rock mass.

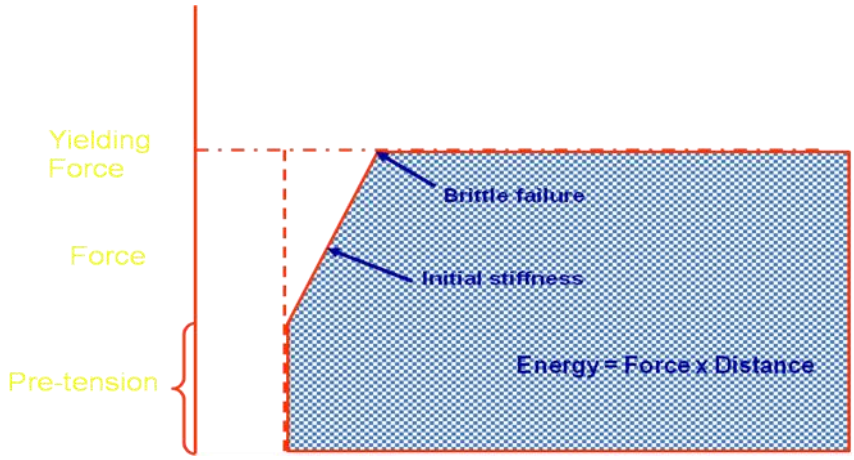
You will need to apply a bit of latitude here – other interpretations of your question may be valid.

[20]

QUESTION 4 – SUPPPORT

4.1 Show on a load/deformation graph the following support characteristics, namely:

- Pre-tension
- Yield load
- Brittle failure
- Energy absorption (10)



4.2 How can you pre-tension a support unit? Give an example. (2)

By installing an additional device that will increase the passive support system initial force , thus changing the support unit to active support, examples will include, jackpot, pre-stressing bags

Further examples would also include anchor tensioning techniques.

4.3 Give a comparison between the function of a grouted tendon and a split set. State a typical application of each. (4)

Grouted tendon

- **limit deformation of the rock mass by preventing unravelling**
- **passive support unit mostly used as permanent support in development ends.**

Split set

- **mostly used as primary support unit,**
- **lifespan limited due to corrosion,**
- **require deformation before becoming an active support unit**

4.4 Name the two general design rules for tendon support frequently used within the mining industry for the spacing and length of tendons in tunnels. (2)

Length of tendon = ½ the width of the tunnel
Spacing of tendons = ½ the length of the tendons

4.5 What do you understand by the term critical bond length? (2)
The bound length can be defined as critical when the total strength of the bond is equal to the tensile strength of the tendon. When the bonded length is less than the critical length, sliding of the tendon will occur.

[20]

QUESTION 5 – ROCK BEHAVIOUR

5.1 List five points to take into consideration when designing access tunnels in meduim to deep stress conditions. (5)

- **Size of tunnels**
- **Shape of tunnels**
- **Stress expected**
- **UCS of host rock**
- **Support**
- **Overstoping**
- **Seismicity**
- **Dip and strike of reef**
- **Proximity of other excavations**
- **Approach to geological structures.**

5.2 Show with a sketch how you would re-develop on reef in high stress conditions and indicate clearly all assumptions made. (5)

Jager and Ryder page 104 Fig 3.5.3

[10]

QUESTION 6– MASSIVE MINING

Define the following massive mining terms

6.1 Drawpoint – **Place where ore is loaded and removed**

6.2 Drift – **Horizontal or near horizontal underground opening**

6.3 Ramp –**Inclined underground access way to stopes, usually driven downward**

6.4 Slot – **vertical or inclined opening in ore, excavated to provide an initial free face for stope blasting**

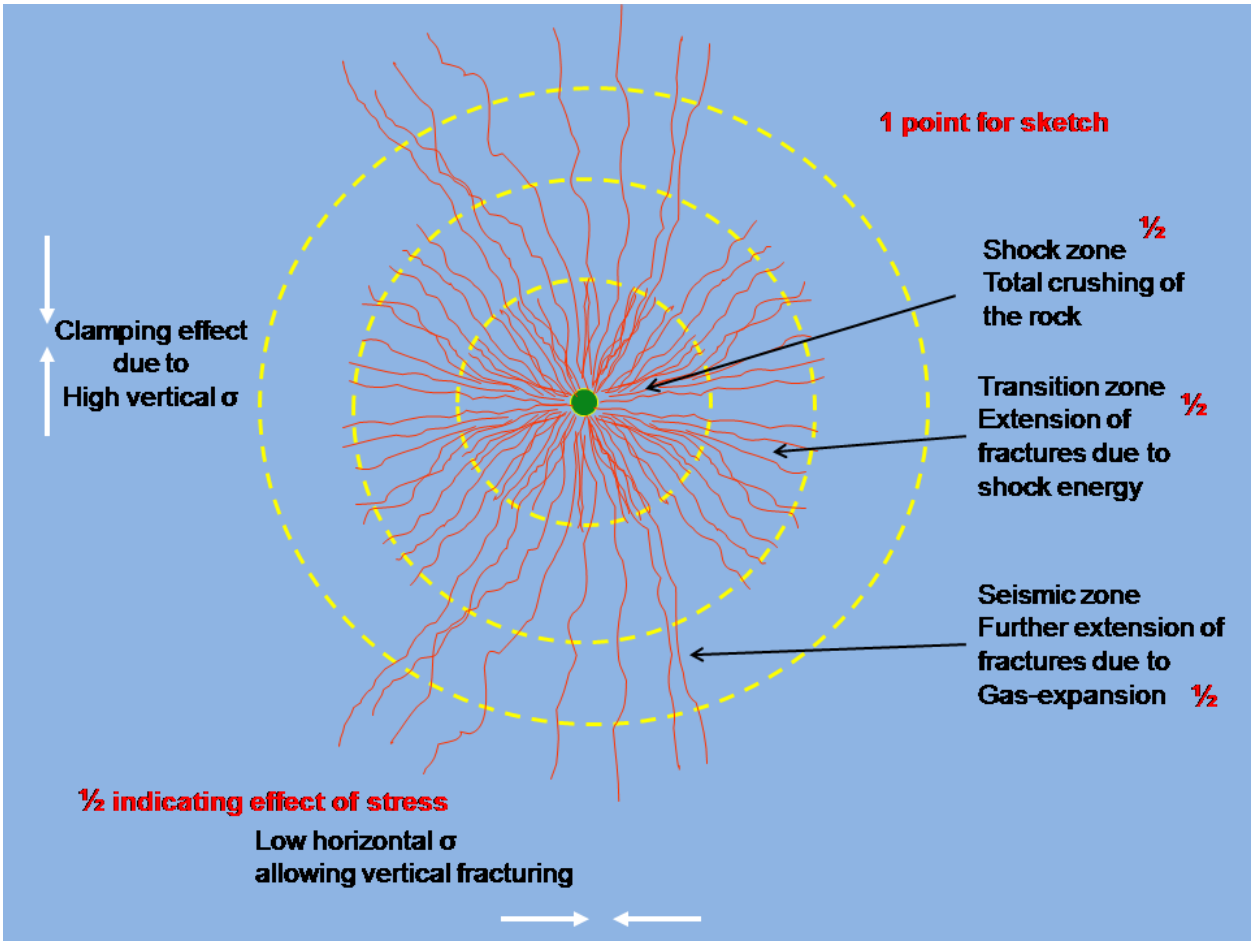
6.5 Sub-level – **system of horizontal underground workings, normally used for ore production**.

[10]

QUESTION 7 – ROCK BREAKING

7.1 With the aid of a sketch, list the mode of action of explosives with reference to the shock wave and gas pressure assuming a high vertical stress. (4)

At first I only wanted a sketch but if the writing explained it correct I gave marks for that as well.



7.2 List two underground observations that would indicated poor blasting practise? (2)

(any two)

- **Extension fractures running into the hanging wall**
- **Burdens to small/large**
- **Large fragmentation of blasting rock**
- **Long sockets left after face being blasted**
- **Irregular face shape**
- **Damaged support**

7.3 What is pre-splitting and how is it used? (2)

Pre-splitting involves loading a single row of hole that has been drilled along a desired excavation boundary with small decoupling charges. These charges reduce the crushing effect around the borehole and are shot before the production shot. Idea is to reduce over breaking of the main blast and to produce to smooth rock wall.

7.4 List and describe one main characteristic of two types of explosives used in the mining industry. (2)

(any two)
Nitro-glycerine based explosives (Dynagel)

- **These are highly adaptable cartridge explosives, which have wide use in the industry.**
- **In general these explosives have shock energy lower than watergels or emulsions but higher than ANFO.**
- **These explosives have high water resistance.**
- **Characteristic problems are 'Powder headaches" and excessive blasting fumes.**

ANFO (Low VOD)

- **A low cost, high power, relatively safe pourable explosive made from porous ammonium nitrate and fuel oil.**
- **It has no water resistance and produces large amounts of gas energy.**
- **Due to different loading densities, consistent loading of holes is often difficult and overcharging may occur.**
- **ANFO is a suitable explosive for use in a wide range of rock mass conditions.**

Water–based ammonium nitrates (watergels and emulsions)

- **These are essentially ANFO's made water resistant by adding water and forming either gel or stable oil/water emulsion.**
- **Emulsions tend to have the highest shock energies and velocities of detonation but produce little gas energy.**
- **Powergel, a high VOD explosive, delivers more shock wave energy and the remaining gasses are at lower pressure.**

[10]

QUESTION 8

You are the appointed rock engineer on a moderately deep mine. An incident occurred on your mine that resulted in three fatalities. Initial reports from underground suggest that there was an extensive fall of ground in the face area and some of the crew members reported that they felt a seismic event. You must visit the accident scene and investigate the accident.

8.1 List and describe briefly five underground observations that you would make that would assist with the understanding of the accident. (8)

- **Hangingwall conditions – presence of joints/fractures/freshly created surface**
- **Face condition – stoping width**
- **Nature of fog – Size, origin, description**
- **Position of support – distance from face (temp and perm), spacing**
- **Condition of support – damage or not (temp and perm), appropriate for sw/conditions**
- **Geologocal features – dykes/fault**

- **Location of casualties/activities of accident**
- **Distribution/orientation of stress induced fractures**
- **Signs of blasting damage**
- **General quality of mining**
- **Amount of closure/ signs of rapid closure**

8.2 How can you verify if a seismic event was the cause of the accident? (2)

Dynamic damage to the support/ underground observations

Seismic event recorded on the seismic system

8.3 Underground observations indicate that bursting of the face was the main cause of the accident. What would you do to minimize the damage of a similar accident in future? (3)

Face nets
Preconditioning
I also gave a halve point of they suggested backfill

8.4 What instruments are used to detect a seismic event? (1)

Geophone, accelerometer

8.5 A report on the FOG needs to be compiled. Briefly list the headings and describe the layout of your report. (6)

- **Background of area and site description,**
- **Strata Control conditions**
- **Geological conditions**
- **Support installed and condition of support**
- **FOG, volume, dimensions, weight**
- **comment on effectiveness of support to hold block,**
- **Cause of FOG**
- **Suggestions/recommendations to prevent a similar event from occurring**

[20]

TOTAL MARKS: [100]

Appendix 1

	STRESS REDUCTION FACTOR	
A	No shear, faults, dyke or weakness zone	1
B	One shear, fault, dyke or weakness zone	2.5
C	One shear, fault, dyke or weakness zone with blocky ground conditions	4
D	Curved joints or dome structure approaching a pothole, reef roll or OPL's	7.5
E	Curved joints or dome structure approaching a pothole, reef roll, OPL's with blocky ground conditions	8
F	Many faults, dyke and weakness zones.	9
G	Wide shear zone	10

	JOINT ALTERATION NUMBER	
A	Tightly healed, hard rockwall joints, no filling	0.5
B	Slight infill, coating < 1mm	1
C	Joint filling > 1 mm	2
D	Joint filling > 3 mm	4
E	Zones or bands of disintegrated or crushed filling, open joints.	8

	JOINT SET NUMBER	
A	Massive, no to few joints	1
B	One joint set	2
C	One joint set plus random joints	3
D	Two joint sets	4
E	Two joint sets plus random joints	6
F	Three joint sets	9
G	Three joint sets plus random joints.	12
H	Four or more joint sets, random, heavily jointed.	15
I	Crushed rock	20

	JOINT WATER	
A	Dry	1
B	Dripping water	0.5

	JOINT ROUGHNESS NUMBER		
A	Discontinuous joints		4
B	Rough or irregular	undulating	3
C	Smooth	undulating	2
D	Slickensided,	undulating	1.5
E	Rough or irregular	planar	1.5
F	Smooth	planar	1
G	Slickensided	planar	0.5