CHAMBER OF MINES OF SOUTH AFRICA

EXAMINATION PAPER

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN STRATA CONTROL – METALLIFEROUS **SUBJECT CODE: COMCSCM**	**EXAMINER:** J. VAN ZYL **MODERATOR:** P. COUTO
EXAMINATION DATE: 10 OCTOBER 2017	**TOTAL MARKS:** [100]
TIME: 14:30 – 17:30	**PASS MARK:** (60%)

NUMBER OF PAGES: 6

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

SPECIAL REQUIREMENTS:

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

1 Question 1: General (10 marks)

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

1.1 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)

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

(a) Metamorphic
(b) Ultra-paleo
(c) Igneous
(d) Sedimentary
(e) None of these are correct (1)

1.3 The mass of a rock sample is 200 kg. The sample is placed on a flat surface and an object that exerts a force of 10 N is placed on top of the rock. Assume that g =9.81 $m.s^{-2}$. The normal downward force (in Newtons) experienced by the flat surface is:

(a) 1972 N
(b) 210 N
(c) 2010 N
(d) 190 N
(e) None of these are correct (2)

1.4 A method for determining the indirect tensile strength of a material is referred to as:

(a) Geo-hammer
(b) Ground Penetrating Radar
(c) Brazilian disk
(d) Uniaxial Compressive Strength
(e) None of these are correct (1)

1.5 If the virgin stress in 20 MPa and the induced stress is 10 MPa, the field stress in MPa is:
(a) 10
(b) 30
(c) 15

(d) 20
(e) None of these are correct (2)

1.6 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)

2 Question 2: Testing and Monitoring Methods (30 marks)

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

- 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 behavior and its design performance.

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

- Stick load cell and closure meter / logger

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

- Location (X Y Z), Time, Energy, Moment

2.4 Describe two shortcomings of the Hoek-Brown criterion. (4)

- It is like the M-C criterion, shear based and therefore if the failure is for example brittle in nature, then the H-B is not appropriate to described failure.
- Only sigma1 and sigma3 is considered and not the sigma2
- It applies only to well jointed rockmasses where joints control the behavior rather than the rock material or individual planes of weakness.
- Not applicable to massive rock or discontinuums (large blocks and wedges)

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

- Establish trend and patterns whereby major events may be anticipated.
- Construct critical design parameters (such as critical remnant dimensions, unfavorable face orientations, etc).
- Locate unknown seismically active faults in unmined portions of a mine, making it possible to amend layouts and support design strategies timeously.
- Measure rock burst control interventions put in place by comparison of the seismicity level before implementation as well to surrounding regions.
- To detect and locate dynamic rockmass instabilities, alert management to potential rock related accidents and assist in possible rescue operations. (
- Quantify the exposure to seismicity, confirm the rockmass stability assumptions made during the design process and enable an audit of and corrections to the particulars of a given design while mining.
- To detect pre-defined spatio-temporal patterns in seismic parameters that can be related to the stability of deformation and / or integrate recorded information with suitable numerical models to enhance their predictive capabilities in the short to medium term.
- To detect unexpected strong changes in the spatial and temporal behavior of seismic parameters that could lead to instability affecting working places immediately or in the short term.
- To improve the efficiency of both the design and monitoring process for stability of mine workings. Particularly important is thorough and objective back analysis of larger rockmass instabilities even if they did not result in injuries or loss of life. This should form the basis of regular critical review of the applied seismic risk management strategy, including guidelines, methodologies and procedures for seismic monitoring.

2.6 Define the following:

2.6.1 Convergence (2)

- Is the **amount** by which the cross-sectional **dimension** of an excavation (usually working height of a stope) is **reduced** as a result of **elastic deformation** of the rock mass.

2.6.2 Closure (2)

- Is the **amount** by which the cross-sectional **dimension** of an excavation (usually working height of a stope) is **reduced** as a result of **elastic and in-elastic** movement of the surrounding rock mass.

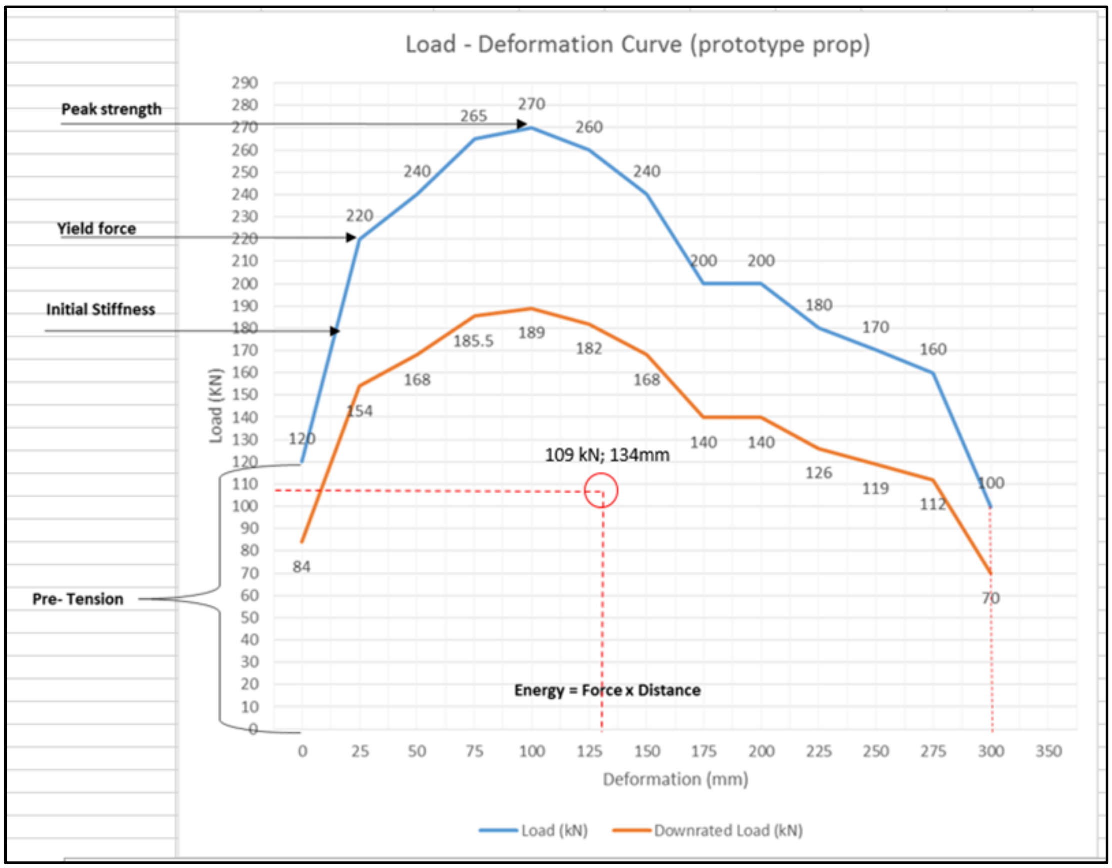
2.7 Laboratory test results are summarised in annexure 1 for a prototype elongate currently being tested on your mine. Plot the curve on the graph paper provided in the answer book and:

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

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

Deformation (mm)	Load (kN)	Downrated Load (kN)
0	120	84
25	220	154
50	240	168
75	265	185.5
100	270	189
125	260	182
150	240	168
175	200	140
200	200	140
225	180	126
250	170	119
275	160	112
300	100	70

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

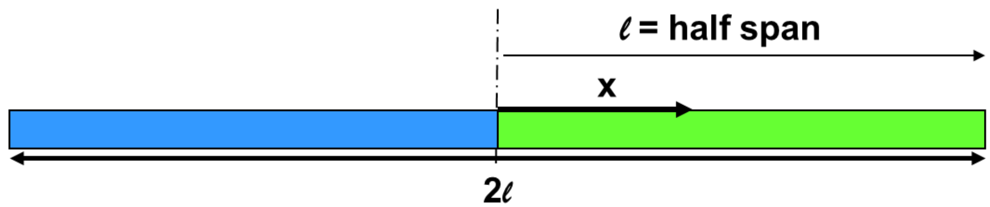


3 Question 3: Support Design (20 marks)

3.1 From the formulae given below, name all the input parameters and basic SI units for each parameter. (6)

$$s_z = \frac{2(1-\nu)q}{G}\sqrt{\ell^2 - x^2}$$

- Sz = Vertical convergence. (mm)
- V = Poisson's ratio
- q = Vertical stress component (MPa)
- G = Modulus of rigidity. (GPa)
- l = Half-span - 2l is the full span excavated. (m)
- x = Point of interest, measured from the half span position. (m)



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.
(14)

Depth = 2400m
Stope height = 1.1m
G = 30 GPa
V = 0.3
Rock density = 2750 kg/m^3
Closure at maximum span = 102%
Support spacing = 1.5m x 1.5m
Fallout height = 1.8m

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. (5)

Note: Candidates should have calculated the critical half span or assumed a half span. Marks were allocated as long as the half span (l) and point of interest (x) were correct. (x value should have been 10m less than the half span value)

Assumed half span = 100m

Then:

Calculate the convergence at that point …

$$S_z = \frac{2(1-v)q}{G} \times \sqrt{L^2 - X^2}$$

$$S_z = \frac{2(1-0{,}3)(2750 \times 9{,}81 \times 2400)}{30 \times 10^9} \times \sqrt{100^2 - 90^2}$$

$$S_z = 0{,}132m = 132mm$$

Closure = 132 x 102% = 134.64mm

Compression of a support unit will be 134.64mm
Length at that point will be 1,1 – 0,134 = 0,966m

Rho	2750	Distance from face	10	m			
g	9.81	Closure	1.02				
h	2400	m					
q	64746000	Pa					
L	364.06	m					
X	354.06	m					
v	0.3						
G	30000000000	Pa					
Sz	0.256	m	256.0461	mm	lc=	364.06	m
Closure	0.261	m	261.1671	mm			
Sm	1.1						
New length	0.838832936						
F	109.1475	kN					

$$\ell_c = \frac{s_m G}{2(1-\nu)q}$$

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

SR_{req} = p g h (h = fallout height = 1.8m)
= 2750 kg/m^3 x 9.81 m/s^2 x 1.8m
= 48.56 kN/m^2

SR = F/A
F = SR x A
F = 48.56kN/m^2 x 1.5m^2
F **= 109.26 kN**
Plot point 134mm / 109 kN on graph

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)

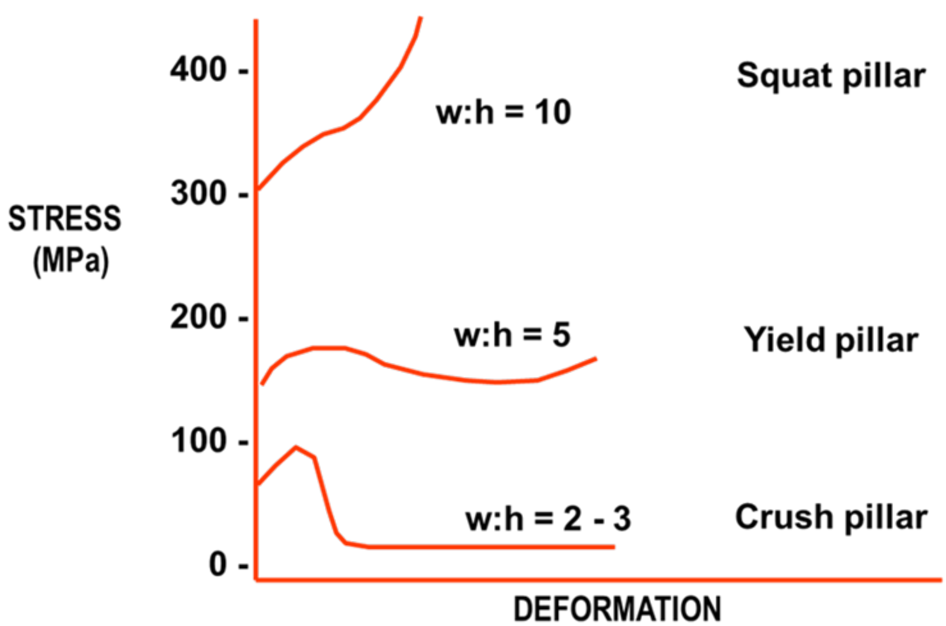
- A minimum support resistance of 50kN/m^2 is required for static conditions. From the downgraded test results, the support unit capacity installed at 10m back from the face is approximately 180kN. Considering a support spacing of 1.5m x 1.5m the support system will still deliver 80kN/m^2. Unit still effective, load bearing and have not failed. Standards can be amended to move the back area barricade and sweepings up to 10.0m back from the face.

4 Question 4: Pillar Support (15 marks)

4.1 Which factors need to be taken into account when designing a support system? (7)

- The volume of rock to be supported.
- The integrity and degree of fracturing of the hangingwall strata.
- The influence of local geology.
- The amount and rate of stope closure.
- The size and shape of the excavation.
- The probability of rockbursts, and
- The purpose and period for which the support is required.

4.2 With the aid of a sketch or graph, illustrate the stress deformation behavior of a Squat, Yield and crush pillar (5)



4.3 Give a description why we use barrier pillar`s. (3)

These pillars are often used for "**compartmentalisation**" in shallow mines. They are the final line of defence against **regional collapse**. They are used to **resist surface subsidence and strata movements** in all non-deep mines, especially those using crush or yield pillars. Rule of thumb for the maximum span between barrier pillars is:

Span < (¼ - ½). Depth

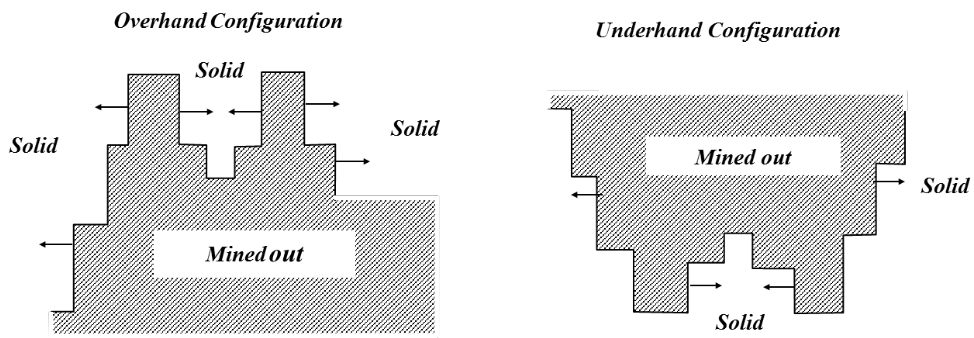
5 Question 5: General (25 marks)

5.1 List six advantages of perimeter blasting. (6)

- In permanent openings, lower support costs are achieved.
- In temporary openings, reduced maintenance costs are achieved.
- Development rates improve.
- Reduced overbreak.
- Less rock to load.
- Less rock to transport
- Better ventilation flow.
- Excavation life is increased.

5.2 Demonstrate your knowledge of the following terms be means of a description and a sketch?

a. Overhand mining Vs Under hand mining (3)

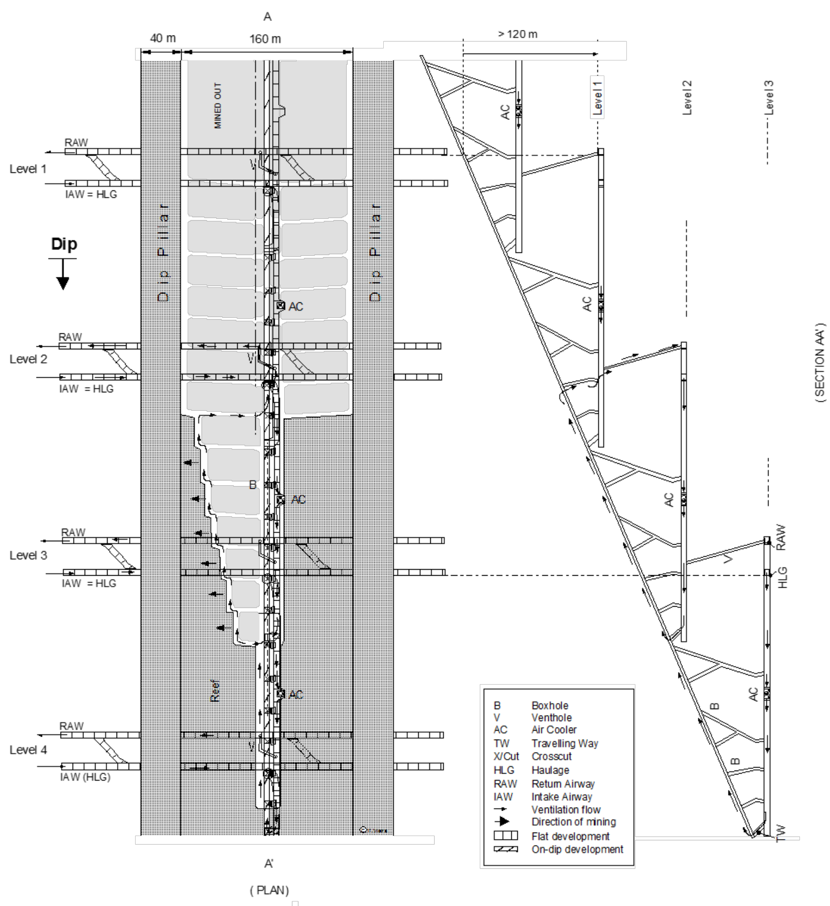


When mining overhand, start mining at the bottom and when mining underhand, start mining at the top.

b. Sequential grid mining (4)

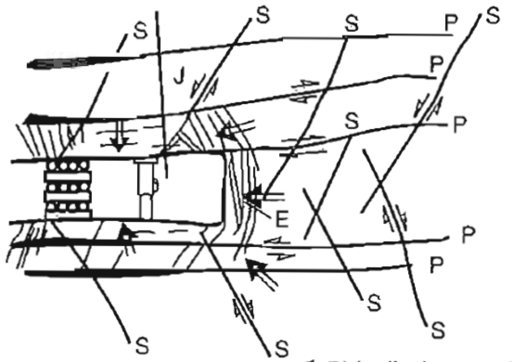
- Applied where the reef is narrow and tabular.
- Suitable for both shallow and deep level mining.
- Combination of scattered and longwall mining principles.
- Dip stability pillars are used, typically spaced 160m – 180m apart, reducing the length of mined out spans and introducing a better load spread over the pillars.
- The extraction of the ore body results in lower stress levels and better control over rock falls and rock bursts.

- Extraction is very important, as is the adherence to the design and layout.
- The ore body is opened up by means of pre-developed drives and raises and dip pillars are placed halfway between raises.
- Lower stress levels result in lower energy release rate (ERR) and improved mining conditions.
- More flexibility than longwall mining methods and can therefore be used to mine the payable sections of the ore body only.
- Where possible, faults and dykes are included in stabilizing pillar system as bracket pillars improving the overall extraction ratio.



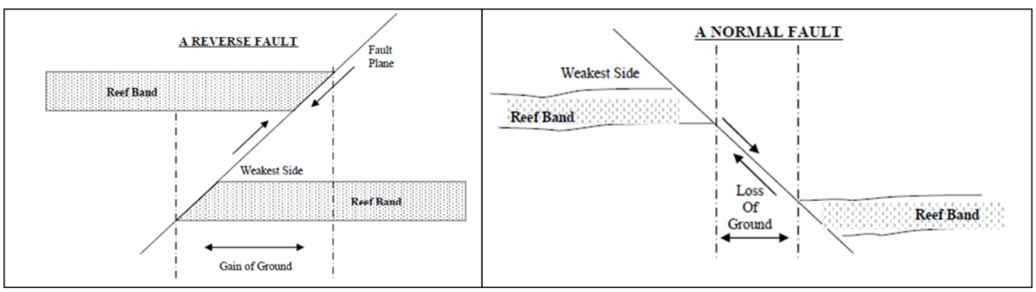
c. Sectional representation of fracturing in a narrow tabular stope with closure and ride (4)

- Pre-existing parting planes (P) and joints (J) are generally present.
- Mining induced shear fractures (S) form well in front of the face (10m) and can extend up to 10-30m above and below the stope horizon.
- Extension fractures (E) form at or very near to the face

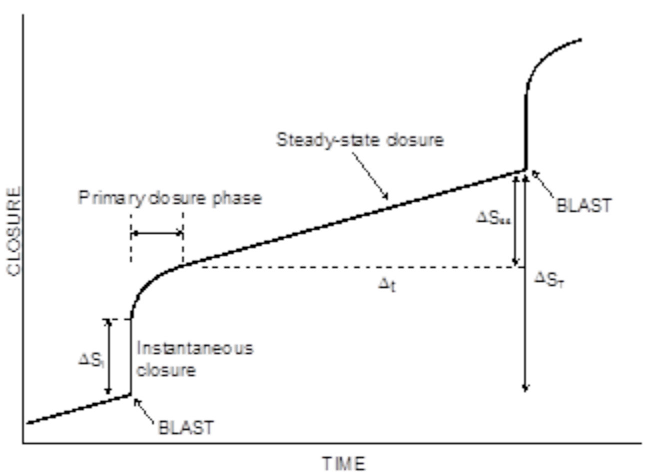


(b) Section

d. Reverse faulting and normal faulting (4)



e. Stope closure recorded and plotted by a closure meter after a before and after a blast (4)



TOTAL MARKS: 100