Chamber of Mines of South Africa

# EXAMINATION PAPER

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| **SUBJECT:**<br>CHAMBER OF MINES CERTIFICATE IN<br>ROCK MECHANICS:PAPER 2<br>**SUBJECT CODE:**<br>COMRMC2<br>**EXAMINATION DATE: 9 May 2018**<br>**TIME: 14:30 – 17:30** | **EXAMINER:**<br>B VAN DER KEVIE<br>**MODERATOR:**<br>P GREYLING<br>**TOTAL MARKS:** [100]<br>**PASS MARK:** 60% |

NUMBER OF PAGES: 17(including answer sheets)

SPECIAL REQUIREMENTS:

1. Answer all questions.
2. Write your **answers for Question 1, 3.1 and 3.2 on the answer sheet provided** at the back of the question paper and submit this with your script.
3. **Select only 1 (one) correct answer for all questions in Question 1.**
4. References other than those provided are not permitted.
5. Hand-held electronic calculators may be used.
6. Write your examination 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.**

7. **Write in ink on the RIGHT HAND SIDE of the paper only (only the right hand pages will be marked).**
8. Show all calculations on which your answers are based.
9. Illustrate your answers by sketches of diagrams wherever possible.
10. In answering these questions, full advantage should be taken wherever necessary of your practical experience as well as of the data given.
11. Answers must be given to an accuracy that is typical of practical conditions.

12. Cell phones are **NOT** allowed in the examination room.

**QUESTION 1**

**TICK THE MOST CORRECT ANSWER ON THE ATTACHED SHEET PROVIDED AND HAND IN WITH YOUR EXAM BOOK. ENSURE ID NUMBER IS ON THE SHEET. SEE APPENDIX C FOR CORRECT SHEET**

*Select 1 (one) correct answer for all questions in Question 1. If more than one is selected no marks will be awarded*

1.1 Which **one** of the following rocks are not igneous rocks?

a) Dunite
b) Norite
c) Gneiss
d) Felsite
e) Pegmatite (1)

1.2 Which **one** of the following rocks are not sedimentary rocks?

a) Conglomerates
b) Breccia
c) Dolomite
d) Magnesian Limestone
e) Felsite (1)

1.3 Which **one** of the following rocks are not metamorphic rocks?

a) Hornfels
b) Slate
c) Phyllite
d) Loess
e) Marble (1)

1.4 Which **one** of the following statements is **incorrect?**

(a) The Chief Inspector of Mines of Mines must review a code of practice of a mine if requested to do so by a registered trade union with members at the mine, or a committee or a health and safety representative at the mine.

(b) An employer must prepare and implement a code of practice on any matter affecting the health or safety of employees and other persons who may be directly affected by activities at the mine if the Chief Inspector of Mines requires it.

(c) A code of practice required by the Chief Inspector of Mines must comply with guidelines issued by the Chief Inspector of Mines

(d) The employer must consult with the health and safety committee on the preparation, implementation or revision of any code of practice.

(e) Any employer may prepare and implement a code of practice on any matter affecting the health or safety of employees and other persons who may be directly affected by activities at the mine. However, as stipulated in Sect 14.8.7 of the MHSA, or if deemed un-necessary he may apply for an exemption if a risk assessment reveals it is low risk and consequently approved by the DMR.

(5)

1.5 Which **one** of the following parameters are not necessary when conducting an open pit slope design in soils or highly weathered rock?

a) Density (kg/$m^3$)
b) Cohesion (kPa)
c) Angle of internal friction (˚)
d) K - ratio
e) Safety Factor (1)

1.6 Which **one** of the following statements is **incorrect** regarding COP's?

(a) This Mandatory Code of Practice to Combat Rockfall Accidents is drawn up in terms of the sections 9(2) and (3) of the Mine Health & Safety Act 1996 (Act 29 of 1996).

(b) This Code of Practice may be used in an accident investigation or enquiry to ascertain compliance and also to establish whether the COP is effective and fit for purpose. The Chief inspector may, if deemed necessary, instruct the employer to implement alternative standards.

(c) All managerial instructions, recommended procedures and standards on the relevant topics must comply with the Code of Practice and must be reviewed to establish compliance. It is the responsibility of the Mine Manager that procedures and mine standards are reviewed annually to establish compliance. The requirements drawn up in this Code of Practice represents the minimum requirements for each geotechnical area and do not preclude any person from taking or requesting further safety measures were considered necessary to make the mine a safer place.

(d) The Mine Manager will keep the Code of Practice on file. Copies will be issued to the Health & Safety Committee. Failure by the employee to prepare and implement a COP in compliance with this guideline is a breach of the MHSA and any inspector may make a recommendation to the principal inspector in writing that a fine be imposed on an employer who has failed to comply.

(e) A procedure must be instigated by the Mine Manager to ensure that all employees are conversant with the relevant sections of the Codes of Practice, and these relevant sections will be translated into other languages as required, in consultation with the Health and Safety Committee. (5)

1.7 What is the minimum W:H ratio of a Crown Pillar ?

a) 10
b) 5
c) 3-4
d) 10 times the stoping width
e) a and e (1)

1.8 What is the most suitable mining method for a reef-body dipping at 25 degrees with a stoping width of 3.0m at shallow depth?

a) "Double cut" Scattered mining
b) Longwall mining
c) Bord and pillar mining
d) Scattered mining
e) Sequential grid mining (1)

1.9 What is typical stope closure rates (mm/m face advance) for breast panel stoping in deep mining depths (2000m below surface.)

a) 10mm
b) 0-5mm
c) 6mm
d) >30mm
e) <20mm (1)

1.10 Which **one** of the following does not fit the question?
The rock engineering parameters to be included in the short-term hazard rating system for stoping operations that you will use to prepare for planning meetings is?

a) Panel Length
b) Dyke pillar size
c) Gully lead
d) Stope width
e) UCS of reef (1)

1.11 The stope width of a reef channel is 50cm of which 20cm is external waste. What would the channel value be in g/t if the cm.g/t value is 5000.

a) 150 g/t

b) 60 g/t

c) 166.6 g/t

d) 42.9 g/t (2)

1.12 Which **one** of the following does not fit the question?

Important considerations for preparing a rock sample for testing in a laboratory?

(a) Sample from solid, structure-free core
(b) Axial loading normal to the bedding
(c) Core diameter 34mm minimum, W:H = 0.5 or 0.33 (Must be 54mm)
(d) Sample ends square (high degree of parallelity), polished (1)

1.13 In slope stability when material is said to be in a state of "limit equilibrium", this is called the:

a) Rankine state b) Maxwell state c) Newtonian state d) Kelvin state (1)

1.14 Which failure criterion explains fracture mechanics best?

a) Mohr-Coulomb b) Hoek and Brown
c) Griffith d) Lade Empirical Strength (1)

1.15 The clear vertical distance between the top of a pile of caved ore and the in-situ cave back is called the_____.

a) Goaf b) Chimney
c) Cave boundary d) Air gap (1)

1.16 Wind-deposited clastic sediment is called:

a) Lignite b) Loess
c) Perlite d) Zedites (1)

**1.17** Quartzite was formed by:

a) Thermal Metamorphism b) Dynamic Metamorphism
c) Dynamo thermal Metamorphism (1)

1.18 On the analysis of seismicity in time, the slope of the $\Sigma V_2$ (Cumulative Apparent Volume) reflect changes in the.

a) Energy b) Viscosity
c) Stress d) Strain Rate (1)

1.19 Using your knowledge of the periodic table, which symbol represents Chrome:

a) Cr b) Ch
c) Co d) Cm (1)

1.20 What is the average rock temperature in the Witwatersrand complex at a depth of 1000m below surface?

a) 15-24°C b) 25-35°C
c) 36-44°C d) 45-54°C (1)

1.21 In monitoring and instrumentation, the deviation of the output or reading from the known input indicates the instrument's _____?

a) Drift b) Error
c) Accuracy d) Precision (1)

1.22 In a stereographic projection, a line passing through the centre of the sphere in a direction perpendicular to the plane, pierces the sphere at two diametrically opposite points which is called the _____ of the great circle representing the plane.

a) Direction points
b) Plane
c) Centre points
d) Poles (1)

1.23 You are provided with graph (Appendix A) which represents the cumulative fallout thickness as determined for your mine, following an analysis of the fall of ground accidents.

What is the Required Support Resistance?

Where: Density = 2650 kg/m³

Peak ground velocity = 2.5m/s

Deformation limit of support during dynamic event = 150mm

a) 17.6 kN/$m^2$

b) 18.197 kN/$m^2$

c) 181 kN/$m^2$

d) 175 kN/$m^2$ (3)

1.24 What is the energy absorption requirements for the values in 1.23?

a) 8.2 kJ/$m^2$

b) 8.526 kJ/$m^2$

c) 13.98 kJ/$m^2$

d) 3.97 kJ/$m^2$ (7)

1.25 Using the formula RMR =9lnQ+44 calculate the Q-rating for the lava zone?

| Zone | UCS Rating | RQD Rating | Spacing of Joints Rating | Joint Condition Rating | Ground Water Rating | RMR Rating |
|---|---|---|---|---|---|---|
| Lava | 12 | 13 | 10 | 30 | 15 | 80 |

a) 1.386

b) 0.602

c) 54.6

d) 1.66

e) 0.72 (2)

1.26 You have a development end on your hard rock mine. Use the geotechnical data below to answer the questions

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

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

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

Density of rockmass: 3000kg/m³

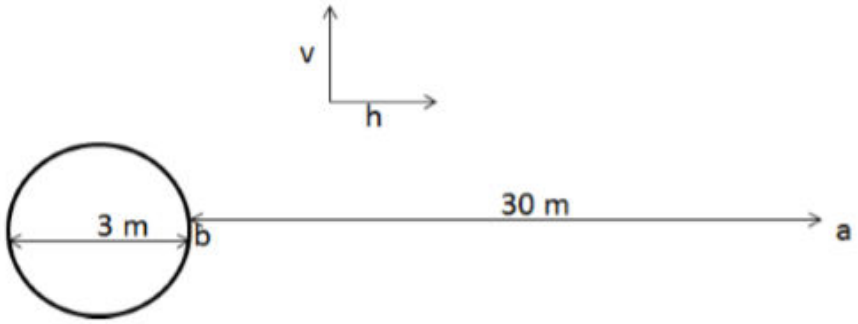
Gravitational acceleration: 9.81m/s²

UCS of host rock: 100 MPa

UCS of soft erosion channel: 20 MPa

UCS of stiff dyke: 200 MPa

Deep area depth: 3000 mbs and k-ratio: 0.5




For a 3.0m diameter circular tunnels being developed in deep area, calculate the stress at positions a.

a) σv = 44.2 Mpa ; σh = 88.3 Mpa

b) σh = 44.2 Mpa ; σv = 88.3 Mpa

c) 88.3 Mpa

d) 264.9 Mpa

e) 0 Mpa (5)

1.27 What is stress at position b:

a) 88.3 Mpa
b) 44.2 Mpa
c) σh = 0 Mpa
d) σv =264.9 Mpa
e) c and d (2)

**Total: 50**

**QUESTION 2**

You are the consulting Rock Engineer on a Chrome mine on the Eastern Bushveld. The mine has a greenfields project where they want to mine the LG2 reef. The reef dips @ 25 degrees and is directly overlain by 14m of homogeneous weathered Pyroxenite. Above the Pyroxenite is 36.0m of overburden soil classified as Clay-Loam. The Manager wants to mine this low grade LG2 and you are designated to do a conceptual design of the open-pit. The slope is fully drained and no water is behind the slope rockmass. There are no major structural features that may influence slope stability.

2.1 What initial rockmass characterization must be done for mining and slope design. List name 6 of the main functions. (6)

2.2 A soil shear test must be done to determine the cohesion (C) and internal angle of friction ($\varphi$) of the soil for slope design. Name 4 types of tests that can be conducted to determine this? (4)

2.3 Name 2 methods to determine the density ($\rho$) of the soil? (2)

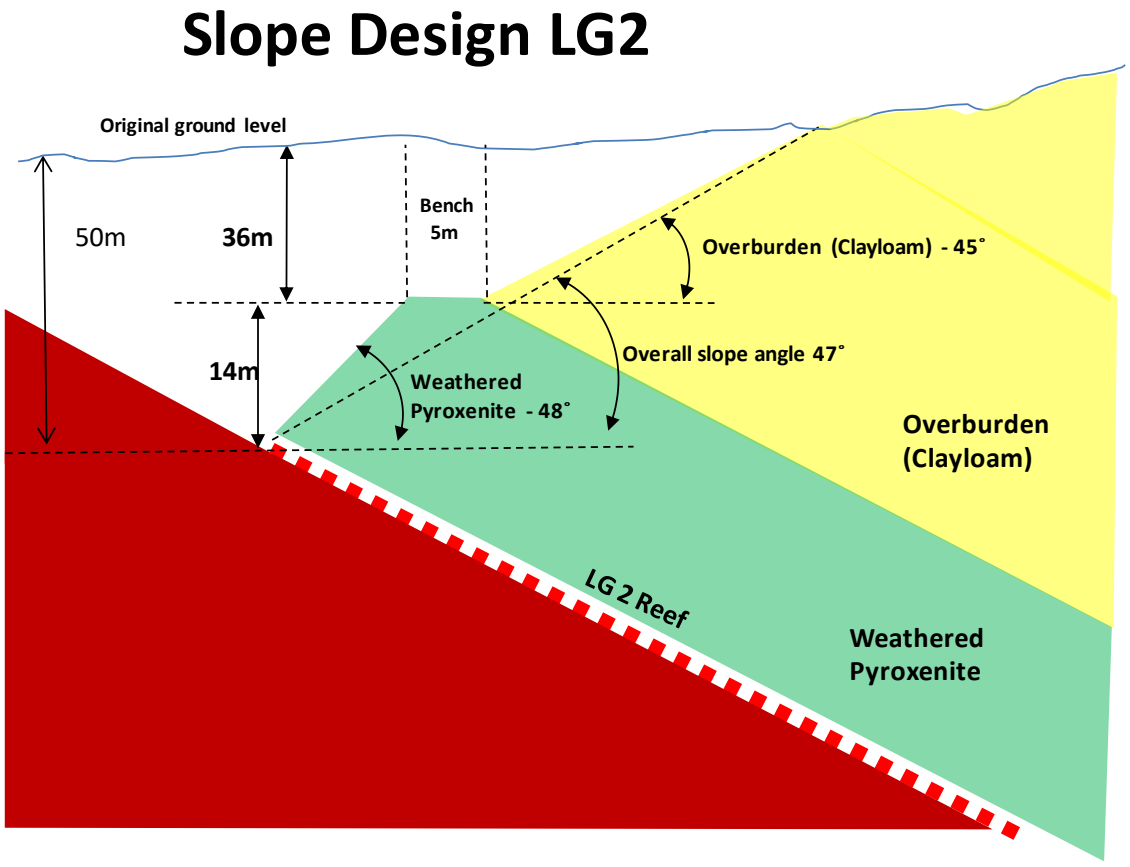
2.4 The soil properties were determined using the above procedures and is depicted in the table below.

| Soil type | Density (kN/m$^3$) | Cohesion (kPa) | Friction Angle (˚) |
|---|---|---|---|
| Clayloam | 14 | 60 | 18 |

Use the chart in Annexure B to determine the slope angle for this soil for a Factor of Safety (FOS) of 1.3. (6)

2.6 For the weathered pyroxenite without any major structural features a slope design was done using the adjusted MRMR and the resultant rating was 35 that yield an overall slope angle of 48˚. Use all of this information with other information in 2.4 and 2.5 to graphically represent the final slope design for the LG2 mining. Make use of safety benches in your design.

(6)




2.7 Calculate the overall slope angle of the pit? (2)

**Total: 25**

QUESTION 4

**State whether the following statements are true or false and use the attached sheet in Appendix D to fill in your answers.**

4.1 Pyroxenite is an intrusive igneous rock normally found in the Bushveld Complex and is composed out of pyroxene and plagioclase. It normally has a high RQD, indicating that significant jointing could be expected. Grain sizes are small, indicating slow cooling rates.

4.2 The Karoo Sedimentary Sequence underlies approximately 50% of the total area of South Africa. In the southern parts of the country, the full sequence is present (approximately 8000m thick), but it thins out towards the north overlapping pre-Karoo material.

4.3 The Transvaal Sequence underlies the Karoo sedimentary Sequence and includes outcrops from Botswana, across Gauteng and Mpumalanga, towards Swaziland. The Transvaal Sequence includes the basin-like Bushveld Complex, while it is caught up in the Witwatersrand Basin towards the south.

4.4 Laubscher developed the Mining Rock Mass Rating (MRMR) system. The intention of this 'modified' or 'mining' rock mass rating was to cater for the differences in surface mining and civil excavations. This system takes into account the same parameters as the Geomechanics system but combines the groundwater and Stress Reduction Factor (SRF).

4.5 We do stereographic projections to estimate from the friction angle (cones and daylight envelopes) the potential for instability of rock blocks.

4.6 Rockbursts are a sub-set of seismic events in that they include only those events that result in damage to excavations or injury to people. For seismic events to take place, usually some of the following must be present: A moderate to high (shear) stress level, brittle rock types, and a weak shear zone with insufficient cohesion or pillars left too small. Once dynamic failure has occurred, and the released elastic strain energy has resulted in damage, one can speak of a 'rockburst'.

4.7 Magnitude, especially, can be defined and calculated in a number of different ways, which results in a range of different interpretations of this parameter. As examples, consider Richter magnitude, moment magnitude, duration and body wave magnitude and others.

4.8 Channel width normally refers to the width of the channel that is mined, which excludes the internal waste.

4.9 Mine call factor is a factor used on mines to determine the effectiveness of their mining process and is given as a percentage (%). It is a measure of the actual product recovered from the processing plant to the product still underground in the back area.

4.10 A datum in survey terms is an imaginary horizontal line from where depths (z-coordinates) are measured, i.e. the z-coordinate of a datum line is zero. This line can be 'at sea level' or a 'local datum' line.

4.11 Track-bound: Ore is scraped along the mining face and into the strike gullies; then it is scraped along the strike gully towards the raise / centre gully and into ore passes. In the footwall tunnels, ore is drawn through box-front construction into trucks, taken to main ore pass systems and then removed from the mine either by 'skips' in a vertical shaft or conveyor belt system via an incline shaft.

4.12 Mines are usually divided into sections or ventilation districts, and the main air supply must be "split" between the various districts. To ensure sufficient air for each district, regulators and doors are installed in these districts, or booster fans are installed in districts receiving insufficient air.

4.13 Carbon monoxide has a RD of 0.97 and can explodes at 12-72%.

4.14 When the ventilation air's temperature becomes excessively high (due to heat pick-up as it flows through the working places), it will lose its ability to reduce temperatures in working places and it is required to cool the air down again, using chilled water or ice plants, cooling chambers or heat exchangers.

4.15 Paste backfill is a high density backfill that uses full plant tailings and means that the water content of the material is very low compared to slurry backfill. Paste fill systems are generally regarded as the "Rolls Royce" of backfill systems and their popularity is increasing.

4.16 The point load strength tests are intended to be an index test for the strength classification of rock materials and can be used to predict uniaxial tensile and compressive strengths of the materials tested. Core and/or lumps of rock can be used for this test.

4.17 Boundary element solutions are codes where all results at all points in the model are calculated. The model creates a mesh (grid) throughout the whole modelled area. These grids or mesh can have various shapes and orientations and impact on the accuracy of the model. Too large mesh sizes will reduce accuracy as will poorly-shaped mesh.

4.18 Anfex is water resistant and has a high VOD giving good fragmentation.

4.19 Powergel is not water resistant and the VOD is 4000m.s$^{-1}$

4.20 The throw capacity of the explosive is a function of the gas pressure created by the explosive.

4.21 Post-splitting isolates the blasting area from the rest of the rock formation by creating an artificial crack along the theoretical excavation plane. This is achieved by drilling a single row of relatively closely-spaced holes along the perimeter of the blast. The post-splitting holes are fired before the rest of the round.

4.22 A Continuous risk assessment is done on new equipment or machinery, changes in work processes, incident and accident analysis and new information becoming available.

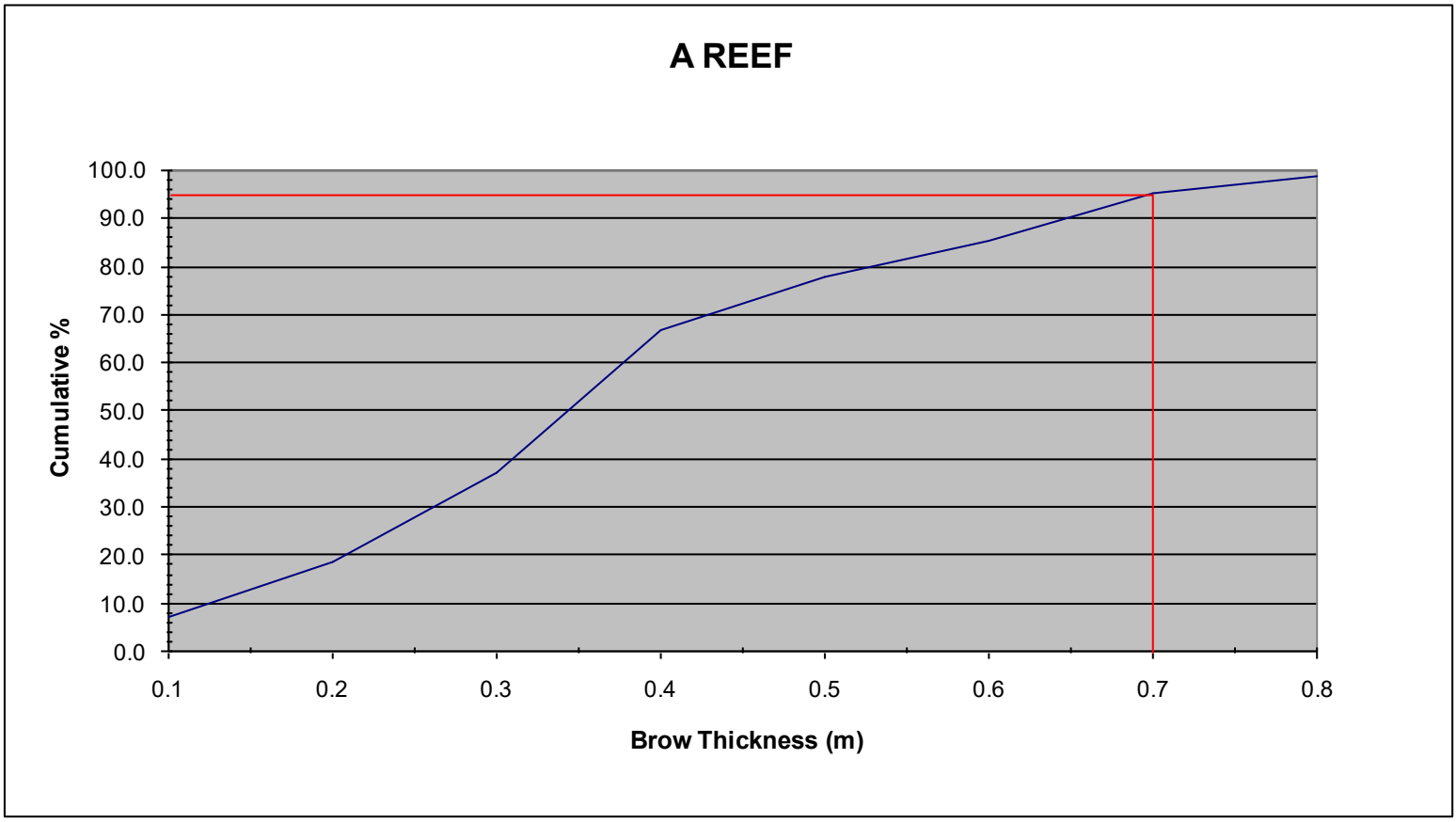
4.23 Tripartite institutions are the MHSC (including its permanent committees comprising of MRAC, SIMRAC & MOHAC) and MQA.

4.24 SIMRAC must advise the Council on: Criteria for determining funding on health research, the need for research into health and safety at the mine and research projects, including prioritising, costs, assessments and implementation.

4.25 When the appointed CEO representing the employer is out of SA, he/she must delegate his/her duties to another employer representative who would be in SA.

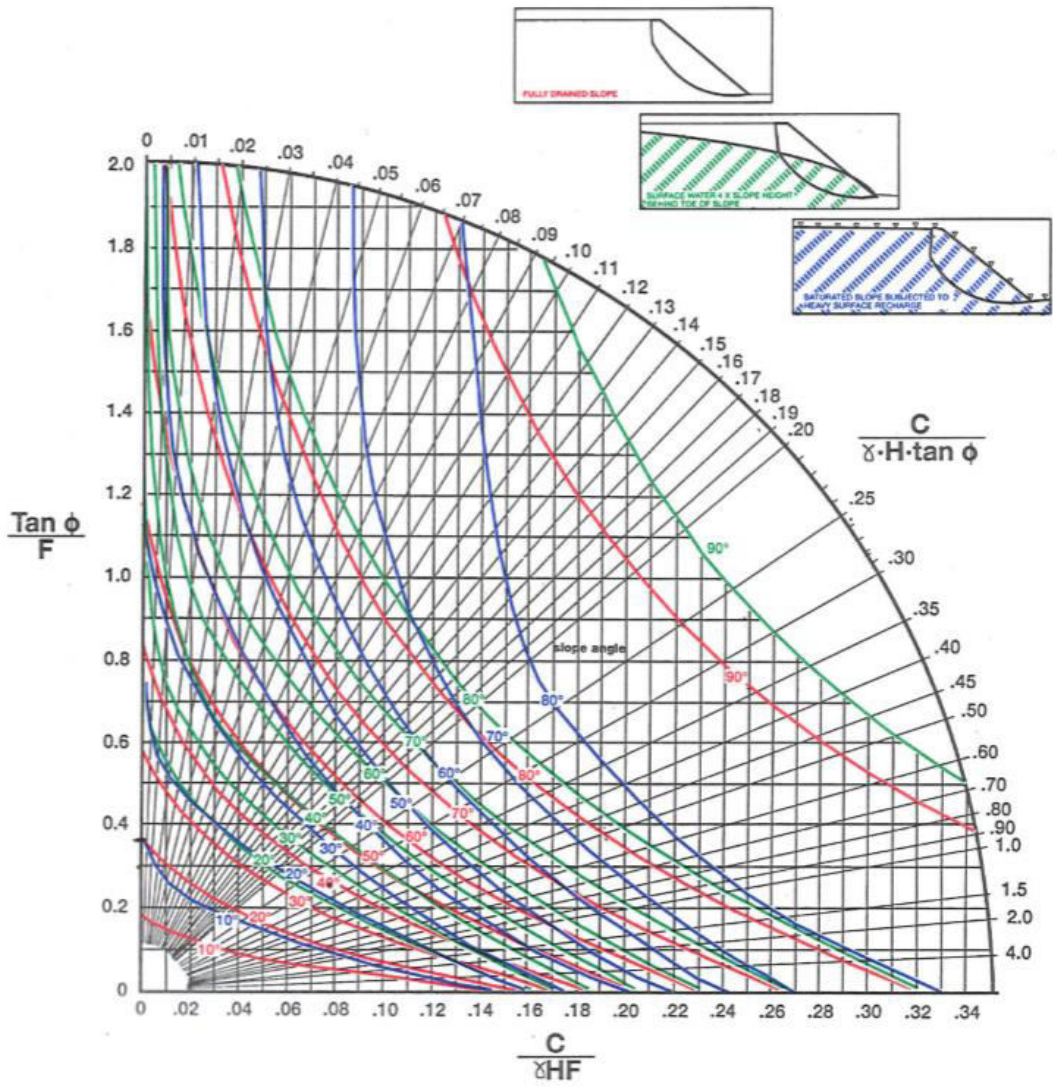
**TOTAL 25**

Appendix A


A REEF
Cumulative %
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Brow Thickness (m)

**Appendix B** **Question 2**

**ID Number**



# Appendix C

**Answer sheet multiple choice (Question 1)**
**May 2018 Paper 2**

ID Number

| | a | b | c | d | e |
|---|---|---|---|---|---|
| 1.1 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.2 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.3 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.4 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.5 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.6 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.7 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.8 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.9 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.10 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.11 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.12 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.13 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.14 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.15 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.16 | ☐ | ☐ | ☐ | ☐ | ☐ |

| | a | b | c | d | e |
|---|---|---|---|---|---|
| 1.17 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.18 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.19 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.20 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.21 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.22 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.23 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.24 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.25 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.26 | ☐ | ☐ | ☐ | ☐ | ☐ |
| 1.27 | ☐ | ☐ | ☐ | ☐ | ☐ |

# Appendix D

**Answer sheet multiple choice (Question 3)**
**May 2018 Paper 2**

ID Number

| | True | False |
|---|---|---|
| 1.1 | ☐ | ☐ |
| 1.2 | ☐ | ☐ |
| 1.3 | ☐ | ☐ |
| 1.4 | ☐ | ☐ |
| 1.5 | ☐ | ☐ |
| 1.6 | ☐ | ☐ |
| 1.7 | ☐ | ☐ |
| 1.8 | ☐ | ☐ |
| 1.9 | ☐ | ☐ |
| 1.10 | ☐ | ☐ |
| 1.11 | ☐ | ☐ |
| 1.12 | ☐ | ☐ |
| 1.13 | ☐ | ☐ |
| 1.14 | ☐ | ☐ |
| 1.15 | ☐ | ☐ |
| 1.16 | ☐ | ☐ |

| | True | False |
|---|---|---|
| 1.17 | ☐ | ☐ |
| 1.18 | ☐ | ☐ |
| 1.19 | ☐ | ☐ |
| 1.20 | ☐ | ☐ |
| 1.21 | ☐ | ☐ |
| 1.22 | ☐ | ☐ |
| 1.23 | ☐ | ☐ |
| 1.24 | ☐ | ☐ |
| 1.25 | ☐ | ☐ |