Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: CERTIFICATE IN ROCK MECHANICS PAPER 3.1 : HARD ROCK TABULAR **SUBJECT CODE:** COMRMC **3.1** **EXAMINATION DATE:** 05 NOVEMBER 2020 **TIME**: 14:30 – 17:30	**EXAMINER:** KB LE BRON **MODERATOR:** S VAN BUUREN **TOTAL MARKS:** [100] **PASS MARK:** (60%)

NUMBER OF PAGES: 10

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

SPECIAL REQUIREMENTS:

1. Answer **ALL** the questions **legibly** in English and **in the suggested table format**.
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.

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. Basic Rock Engineering Concepts

1.1 Define the following (Marks will be allocated if described in your own words):

a) Intact rock	(1)
b) Elastic behaviour	(1)
c) Ductile behaviour	(1)
d) Residual Strength	(1)
e) Strain hardening	(1)
f) Tri-axial compression	(1)
g) Stiff loading system	(1)
h) Dynamic loading	(1)
i) Discrete fracture network (DFN)	(1)
j) Energy Release Rate	(1)

(10)

1.2 The ESS concept has been widely used in the South African mining industry.

a) Define “Excess Shear Stress” or ESS.	*(2)*
b) When is the ESS concept applied in rock engineering?	(2)
c) Explain the difference between positive and negative ESS.	(2)
d) Making use of a sketch, explain what an ESS lobe is.	(2)
e) Could the ESS lobe be linked to determine possible seismic event magnitude? Explain.	(2)

(10)

QUESTION 1 **[20]**

QUESTION 2. MINING METHODS

2.1 For each scenario below, complete the table with appropriate mining layout, anticipated closure rates, expected rock mass response and required support characteristics (re-draw the table in your answer sheet).

Scenario	Suggested Mining Layout	Closure Rates	Anticipated rock mass failure response	Main Support Characteristics	
a) Tabular orebody, highly faulted, deep level conditions, highly bedded hanging wall					(2)
b) Tabular orebody, continuous with minimal faulting, deep level conditions, massive hanging wall					(2)
c) Tabular orebody, continuous with minimal faulting, intermediate depth, rolling reef, massive hanging wall					(2)
d) Tabular orebody, continuous with minimal faulting, shallow depth, planar reef, massive hanging wall					(2)

(8)

2.2 One of the main access tunnels of a deep gold mine has been experiencing repeated dynamic loading as a result of the seismically active dyke through which it has been developed. The stopes have been mined out on both sides

along the dyke, creating what is essentially a highly stressed regional pillar. The repeated dynamic loading has resulted in the tunnel having to be rehabilitated every year due to the rock walls being ejected under high PPVs, resulting in a major production hiatus. The tunnel is supported with 4 m long cement grouted mechanical cable anchors spaced 1 m x 2 m, mesh and lace (1 m diamond pattern), Osro straps and cement grouted rock bolts.

What rehabilitation strategies would you recommend to avoid the same consequences of having to rehabilitate the tunnel on an annual basis?
Explain your answer using the following process: (i) Hazard Identification, (ii) Risk Assessment and (iii) Treatment applying the hierarchy of controls method (eliminating the hazard, implementing engineering controls, implementing administrative control, use PPE, etc.), and continuous monitoring.

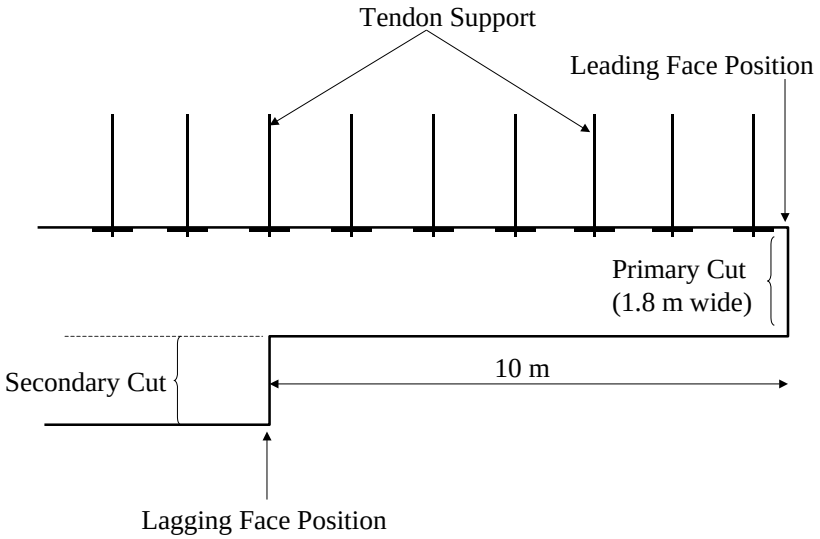
(8)

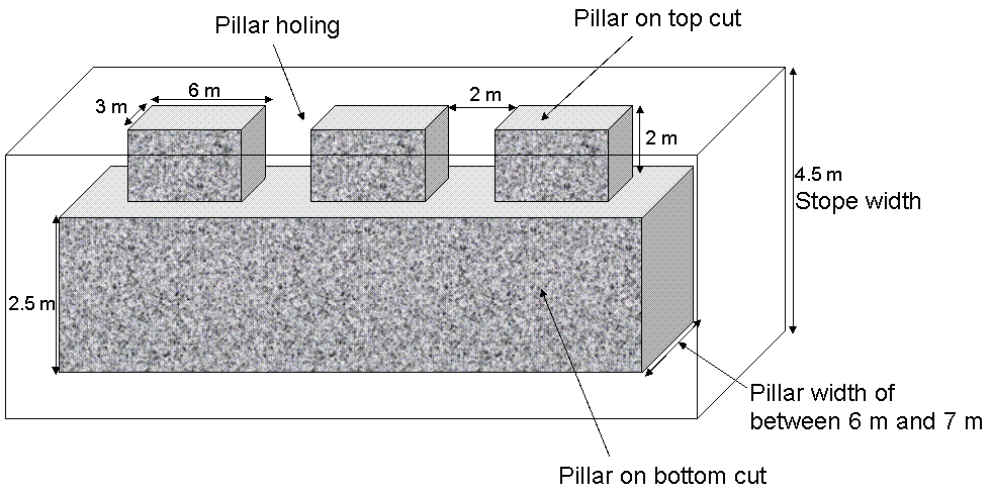
2.3 Consider the schematics below.

What type of mining layout does the schematics below present? (1)

Under which conditions would you consider implementing this layout? (2)

(3)





2.4 The horizontal stress has been measured to be greater than the vertical stress on a number of platinum mines of the western limb of the Bushveld complex. In a conventional mining section with 3 m x 4 m crush pillars spaced 30 m apart, a pothole is intersected above the main decline system at a depth of ~800 m below surface. With the horizontal stress being twice that of the vertical stress, an ad-hoc 10 m x 20 m pillar is left above the main decline at a middling of approximately 20 m above the decline. The twin decline excavations houses the conveyor belt (5.5 m width) and the chairlift (4.5 m excavation width), with a 5 m pillar between them. A maximum span on the station landing of the decline measured at 15 m, where the two declines merged over a distance of approximately 20 m. In some areas below the ad-hoc pillar, the 5 m wide pillar between the declines have fractured and scaled to the extent that the pillar was no longer in place resulting in a 15 m span across the two declines (no rock bolt support was installed into the sides of the pillar, nor was areal support applied). A large collapse occurred over a distance of ~40 m in the decline.

During the underground inspection, the chief rock engineer stated that the pillar above the decline is of no consequence as the horizontal stress is greater than the vertical stress, rather attributing the collapse to structural failure.

i. Do you agree with his assessment?

ii. Explain you answer making use of calculations.

iii. Comment on the general decline system design and middling distance.

Assume the following:

- Crush pillars have reached post-peak residual strength and no longer contribute to regional stability).
- The UCS of the rock mass in which the decline has been developed is ~120 MPa.
- Regional pillars are ~100 m away from the ad-hoc pillar.
- The stope width is 1.5 m.
- The support consist of cement grouted rock bolts only.

(11)

QUESTION 2 **[30]**

QUESTION 3. ROCK ENGINEERING DESIGN

3.1 You are appointed as the rock engineer on a greenfields project where the multi-reef orebodies outcrop on surface. In the valley, the weathered zone extends to a depth of approximately 40 m, with the first 10 m below surface being soil material, whilst the weathered zone is reduced to ~1 m at the koppie ~100 m north of the outcrop. The middling between the orebodies is 15 m. The deepest point to which mining is planned is 1500 m below surface. Surface infra-structure such as workshops, metallurgical plant, and office buildings are planned to be built on-site.

a) Explain the difference between greenfields and the brownfields. (2)

b) List what you consider necessary data to be gathered in order to address the following: (4)

i) Box cut design;

ii) Decline shaft location;

c) Where would you locate the box-cut and decline? Explain. (4)

d) Propose what you consider to be appropriate support for the following, motivate each answer: (4)

i) Box cut;

ii) Decline shaft;

e) With the aid of a sketch, indicate the likely box cut design (use a section and include any support you feel is necessary. (2)

f) What would be your main concern when mining close to surface and how would you reduce the risk? (2)

g) On what basis would you define the different ground control districts? (2)

(20)

QUESTION 3 **[20]**

QUESTION 4. MODELLING TOOLS AND INTERPRETATION

4.1 Is the following statement True of False:

Static failure may be separated into stress driven failure and structural failure due to the presence of pre-mining geological structures.	(1)
	(1)

4.2 Describe each of the following geotechnical modelling software through their capabilities and limitations:

a) MAP3D	(3)
b) FLAC3D	(3)
c) 3DEC	(3)
	(9)

4.3 Interpret the following plots in terms of (i) type of static failure modelled, (ii) elastic or inelastic software, (iii) likelihood of failure (using the low, moderate or high classification – highlight specific flaw/s in these layouts, if any, to motivate your answer), (iv) state whether the layout will be stable or unstable, and (v) provide recommendations on possible layout changes and/or areas that may require *additional* support, if any:

a) MAP3D: Excess principal stress plot - A1	(5)
b) FLAC3D plot of pillar stresses - A2	(5)
c) 3DEC plot of 8 m bord width - A3	(5)
d) 3DEC plot of 6 m bord width - A4	(5)
	(20)

QUESTION 4 **[30]**

TOTAL MARKS **[100]**

Appendix A – Question 4

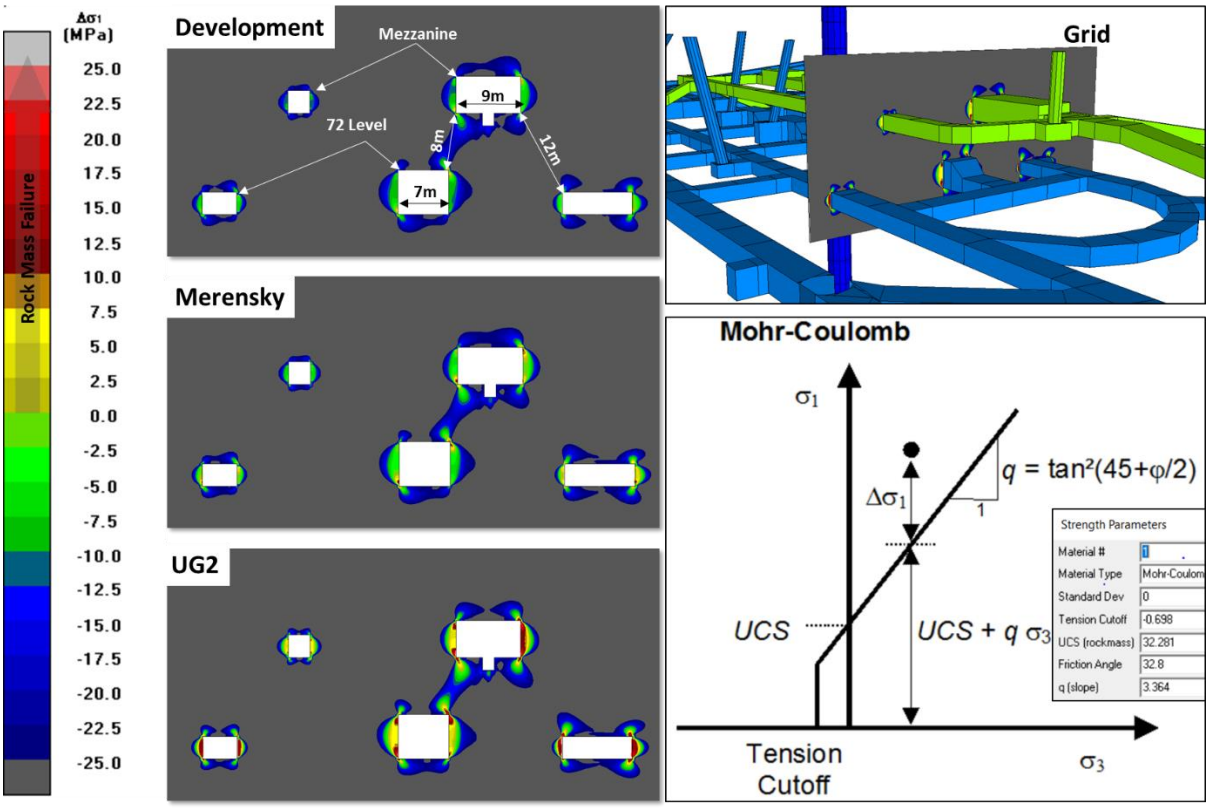


Figure A1. MAP3D plot of a platinum mine's shaft pillar infra-structure at 700 m below surface

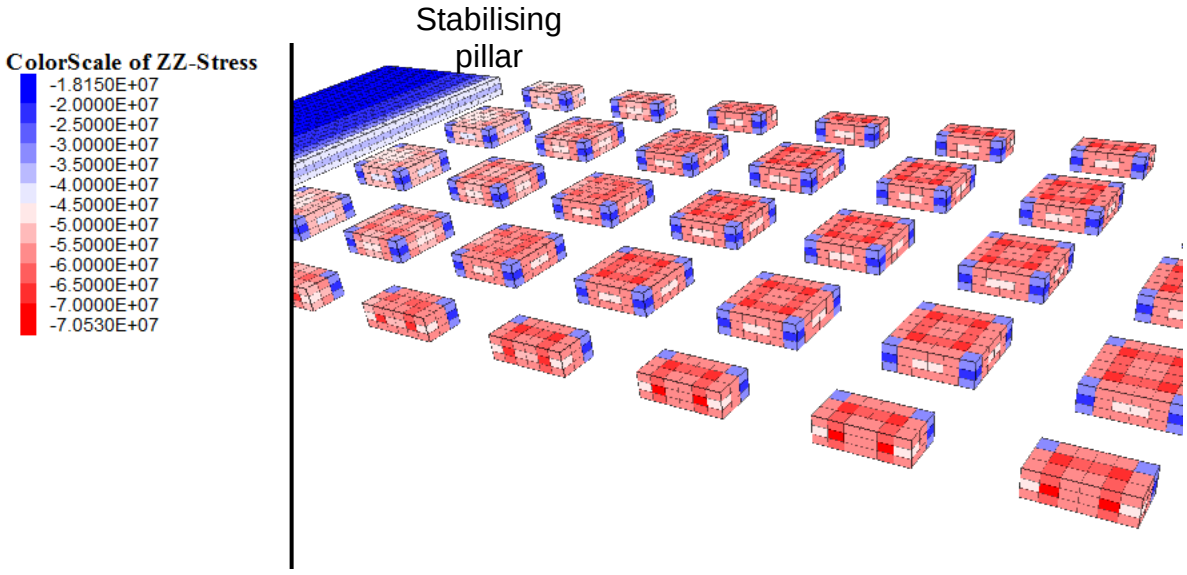


Figure A2. FLAC3D plot of 6 m x 6 m pillars with 6 m bords at 350 m below surface – LG6 chrome seam

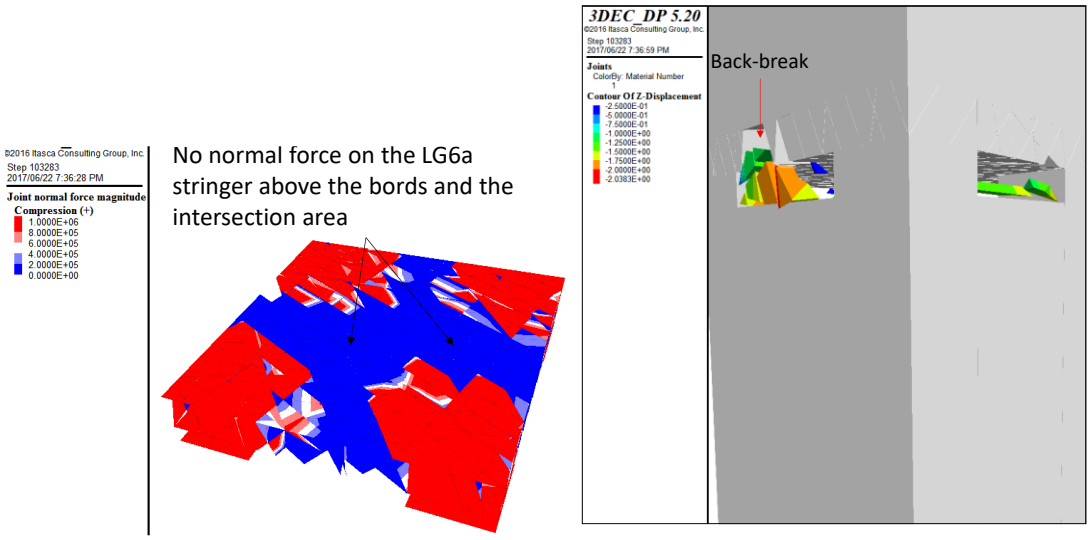


Figure A3. 3DEC plot of 8 m bord width – MG1 chrome seam

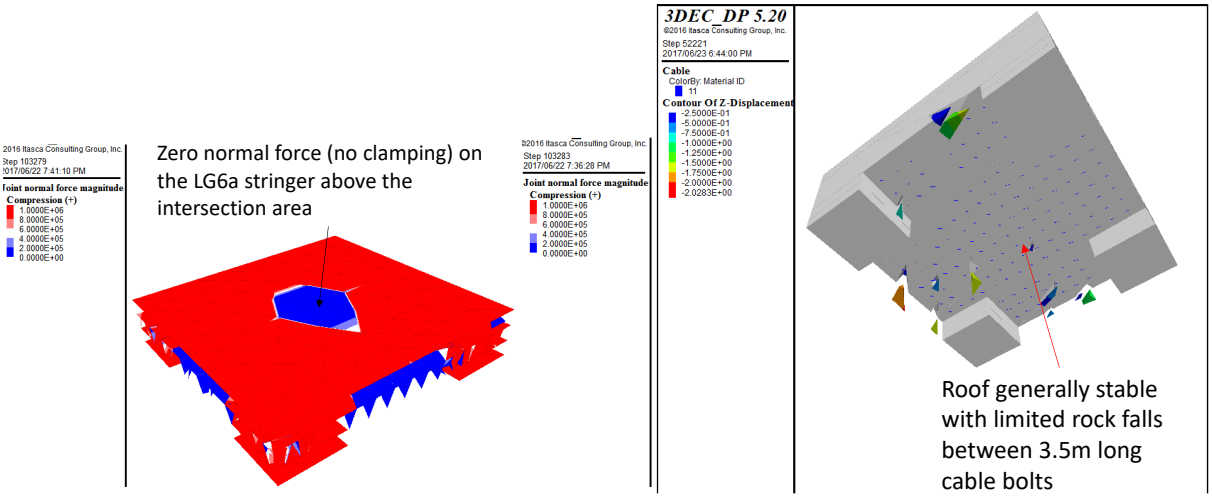


Figure A4. 3DEC plot of 6 m bord width – MG1 chrome seam