



EXAMINATION PAPER

SUBJECT: CERTIFICATE IN ROCK MECHANICS RMC PAPER 3.4 : OPEN PIT SUBJECT CODE: COMRMC EXAMINATION DATE: 12 MAY 2022 TIME: 14:30 – 17:30	EXAMINER: Anton Gregory MODERATOR: Peter Terbrugge TOTAL MARKS: [100] PASS MARK: 60%
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NUMBER OF PAGES: 7

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 and other smart devices e.g. Smartwatches are **NOT** allowed in the examination room.

OPEN PIT

QUESTION 1

You are the Principal Geotechnical Engineer for Exceldrion open pit mine, which in the last three years has experienced an increasing number of failures which are linked to geological structures. The root cause of the problem is that the geotechnical and geological department does not map the pit faces and hence the structures cannot be included in the slope designs. You have been instructed by Head Office to address the problem.

You have decided that the best solution is to write a cell mapping procedure (standard operating procedure) which will be rolled down to the Strata Control Officers on the mine. Prepare a standard operating procedure for cell mapping based on the following template:

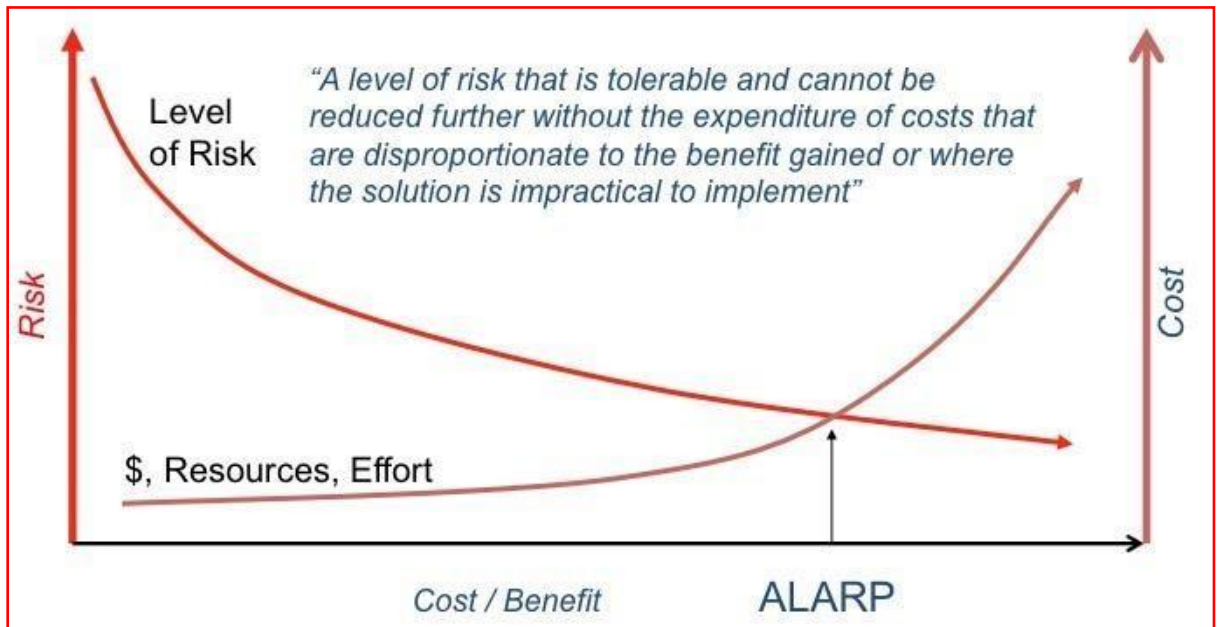
- a. Introduction – to include:
 - i. The principle of cell mapping
 - ii. Other techniques that can be considered
- b. Definitions must include:
 - i. geological structure
 - ii. fractures/joints
 - iii. major structures
 - iv. rock fabric
 - v. intermediate structures,
 - vi. regional structures, and
- c. structural domains. Safety considerations while cell mapping.
- d. Cell mapping procedure (step by step guide, including data to be collected)
- e. Cell mapping data sheet
- f. Data interpretation and further processing

[20 MARKS]

QUESTION 2

Define and discuss the following (use sketches and diagrams where possible/applicable):

- a. As Low as Reasonably Practicable (ALARP) [4]



- b. In terms of numerical modelling, define and discuss the following:

- i. Ubiquitous joint model [3]
- ii. Strain softening model [3]
- iii. Boundary conditions [5]
- iv. Back Analysis [5]

[20 MARKS]

OPEN PIT

QUESTION 3

You are the newly appointed geotechnical engineer for a large open pit operation in the tropical regions of central Africa. The following information has been supplied by the previous geotechnical engineer prior to fleeing the country following a series of large undetected failures:

- Pit is rectangular in shape and with its long axis orientated NE-SW
 - There is a single access ramp into the pit.
 - Pit depth – 500m
 - Overall slope angle - 42 deg
 - Bench height 15m
 - Bench face angle – 80 deg
 - Stack height - 60m
 - Stack angle - 55 deg
 - Upper 50m of the slope will be constructed in highly weathered material
 - Remainder of the rock mass has an average RMR of 67 and may be regarded as brittle.
 - The average joint spacing is 20cm
 - Several large scale faults pass closely behind the pit slope and it is believed that smaller sympathetic faults may daylight in the slope.
 - Several large wedges were identified from orientated core and stereographic analysis
 - The pit is situated in an active rift valley.
 - Annual rain fall of 2500mm with over 200 days of rain per year
 - Dense fog is experienced in the early morning during the winter months
 - On average it takes 12 days travel to site from Johannesburg
 - The cash flow constraint does not allow for large capital (> USD 300 000, ZAR R5 000 000).
- a. Devise a monitoring strategy for the pit and pay particular attention to the failure mode, expected movements and system accuracies. Detail at least five methods that you would use to monitor the pit. List the advantages and disadvantages of each of the methods that you describe. [15]
- b. Based on your strategy, devise a Trigger Action Response Plan (TARP) for at least two of your monitoring methods. [10]

[25 MARKS]

QUESTION 4

The feasibility study into a new mine off the coast of Utopia has concluded that the project has an NPV of R70,000,000; this is however considered to be unattractive to the shareholders and potential investors. All of the technical specialists have been requested to revisit the pre-feasibility study and indentify opportunities for optimisation and cost reduction (in the potential operating mine) in order to make the project more economically attractive.

Discuss how you as a geotechnical engineer can contribute to making the project more economically attractive. Be sure to focus on all aspects of the mining value chain where geotechnical data may be applied. In giving your answer be clear to mine management about the risks and rewards of each of your suggestions.

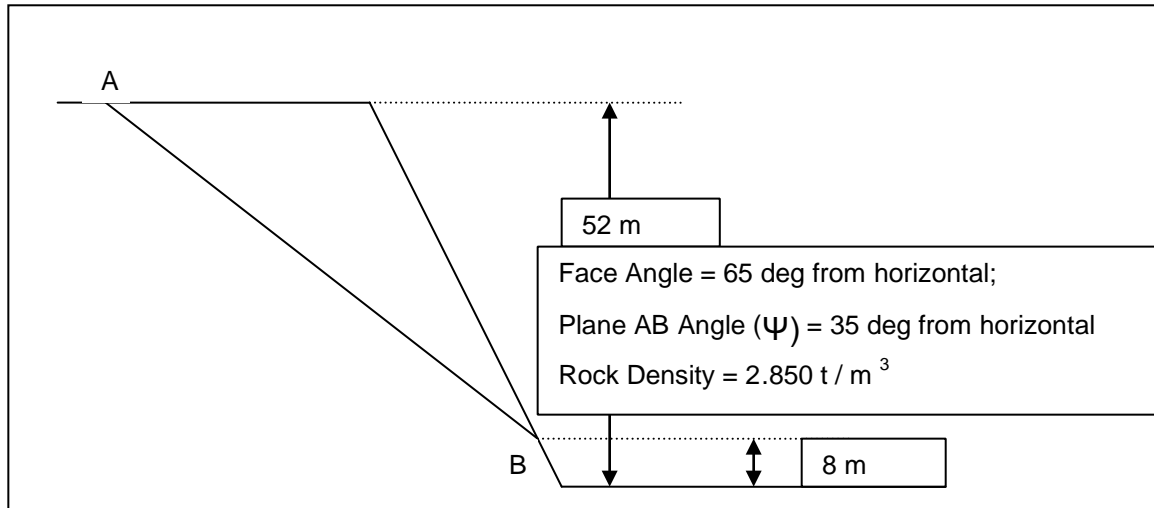
[15 MARKS]

OPEN PIT

QUESTION 5

Figure 1 illustrates the geometry of a potential planar slope failure which contains a talc filled fault (AB). The slope is regarded to be dry.

Figure 1



You have requested that ten shear strength tests be performed on the plane. Dr Jen from Pick n' Lab performed the test and the table below summarise the results.

	n	Mean	Std Deviation	Coefficient of Variation
Cohesion (MPa)	10	0.0153	0.0031	20%
Friction (deg)	10	16.8	1.48	8%

Note: the distributions of the random variables can be regarded as truncated normal with the cohesion ranging from the mean by +33% and -34.4% and the friction angle by +15.3% and -16.8%.

The General Manager of the mine is pressurising you for an answer as production has been suspended until such time as you have completed your stability assessment.

Using the formulas provided calculate:

- a. The factor of safety at the average values for cohesion and friction.

- b. The probability of failure of the slope using Harr's point estimate method with the distributions provided.

List any other assumptions you have to make, comment on the results obtained and make a recommendation to the General Manager.

Formulae

Factor of Safety

$$F = (cA + (W\cos\beta)\tan\Phi) / W\sin\beta$$

Point Estimate Method Formulation.

$P_F = \sum F / (1 - \text{std dev } F)$ where F is derived for the values of the distributions of c and Φ .

$$\sigma_F^2 = \underline{F^2} - (\underline{F})^2$$

[20 MARKS]

[100 MARKS]