Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: CERTIFICATE IN ROCK MECHANICS **PAPER 2:** BASIC ROCK MECHANICS PRACTICE **SUBJECT CODE: COMRMC** **DATE: 05 OCTOBER 2022** **TIME**: **14H30 TO 17H30**	**EXAMINER:** FP MOSIANE **MODERATOR:** S DURAPRAJ **TOTAL MARKS:** [100] **PASS MARK:** (60%)

NUMBER OF PAGES: 9

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

SPECIAL REQUIREMENTS:

1. **Answer All the 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.

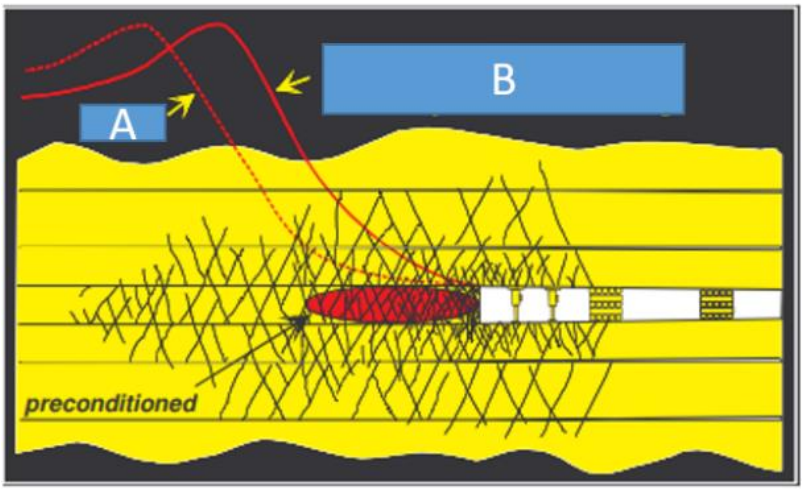
NB: Ensure that the correct unit of measure (SI unit) is recorded as marks will be deducted from answers if the incorrect unit is used even if the calculated value is correct.

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 are **NOT** allowed in the examination room.

QUESTION 1. GENERAL MULTIPLE CHOICE

1.1 Of the fundamental rock combinations given below, which group represents metamorphic rocks?				
A. Shale, sandstone, coal, dolomite	B. Gneiss, schist, quartzite, mylonite	C. Dolerite, pyroxenite, granite, kimberlite	D. Gneiss, coal, granite, mylonite	(1)
1.2 The total energy E which needs to be absorbed by the support system during a rock burst is defined by: $E = 0.5mv^2 + \boldsymbol{m}gh$ What does the "m" bolded in italics represent?				
A. Maximum downward movement of the hangingwall	B. Stoping width	C. Height of potential fall	D. Panel length	(2)
1.3 The 3-D location of a seismic event, as determined by best analysis of a seismogram is known as a:				
A. Position	B. Epicentre	C. Seismic station	D. Hypocentre	(1)
1.4 The ACRONYM "RCF" stands for				
A. Response Control Factor	B. Resultant Compressive Factor	C. Rockwall Control Fundamentals	D. Rockwall Condition Factor	(1)
1.5 What is the typical elastic modulus (E in GPa) for Pyroxenite?				
A. 80 - 110	B. 220 - 300	C. 60 - 120	D. 40 - 80	(1)
1.6 Short Encapsulation Pull Tests (SEPT) are used to determine the relationship between				
A. Rock/Resin/Bolt	B. Resin/ Rock	C. Rock/Bolt	D. Rock/Expansion shell	(1)
1.7 The modified stability number N' is calculated as: $N' = Q' \times A \times B \times C$ What does "A" represent?				
A. Ratio of the uniaxial compressive strength of the	B. Factor which allows for the strength to stress effects	C. Gravity adjustment factor	D. Factor which allows for the	(1)

rock material to the maximum induced compressive stress			ease of block fall out effect	
1.8 What will be the maximum vertical subsidence calculated using the formula? $S_m/0.39(h) = [W/H]^{0.32}$ Where the mining height is 2.3m, the depth is 200m and the bord width is 10m.				
A. 275m	B. 343mm	C. 287mm	D. 320m	(2)
1.9 The dilution and removal of gases from underground is one of the primary functions of which mine department?				
A. Mine Evaluation	B. Mine Ventilation	C. Mine Planning	D. Occupational Medicine	(1)
1.10 Using the equation provided below: $PPV = K/(R/W^{0.5})^{\alpha}$ Where, W is the weight of the explosive charge and R is the distance Calculate the peak particle velocity (PPV) expected underneath a tailings dam due to a stope mining 230m below surface, using 900kg of emulsion explosives. Assume K = 1200, α = 1.6				
A. 0.050 $mm.s^{-1}$	B. 0.050 $m.s^{-1}$	C. 6.3 $m.s^{-1}$	D. 6.3 $mm.s^{-1}$	(2)
1.11 In underground monitoring and instrumentation, what is defined as the measure of the ability of an instrument to reproduce a certain reading?				
A. Error	B. Accuracy	C. Precision	D. Sensitivity	(1)
1.12 What is the effective pillar width of a pillar measuring 7m x 4m?				
A. 5m	B. 3m	C. 4m	D. 6m	(2)
1.13 Which of the following is a mechanism to prevent the accumulation of strain energy ahead of the working faces, thereby minimizing the incidence of rockbursting?				
A. Wave attenuation	B. Refraction	C. Superimposing	D. Preconditioning	(1)
1.14 Which of the following is one of the functions of backfill as **regional** support?				
A. To limit the amount of elastic	B. To control gravity induced fall	C. To provide a clear escape way	D. To reduce the spacing between face	(1)

deformation of the rockmass affected by mining	outs at the face area		parallel fractures	
1.15 Consider the sketch below which shows the idealized stress profile ahead of a stope face. Which line represents the stress profile before preconditioning?  				(2)
A. None of the above	B. Combination of A and B	C. B	D. A	
				[20]

QUESTION 2. MINE SEISMICITY

South Africa suffers from the highest incidence of rockbursting experienced anywhere in the world. As such, the prevention and control of rock bursts form a crucial component of the Rock Engineering function. 2.1 Explain the difference between a seismic event and a rock burst?	(3)
2.2 Describe a methodology or procedure for the investigation of a rock burst?	(7)
	[10]

QUESTION 3. INVESTIGATION AND EVALUATION

3.1 List five primary benefits of numerical modelling?	(5)
3.2 What do the following ACRONYMS stand for? UDEC FLAC	(2)

3.3 Explain the concept of Boundary Element (BE) Methods and state their advantage and limitation?	(5)
3.4 List any 4 parameters that can be monitored **directly** in underground conditions and for each provide an example of a monitoring instrument that can be used?	(8)
	[20]

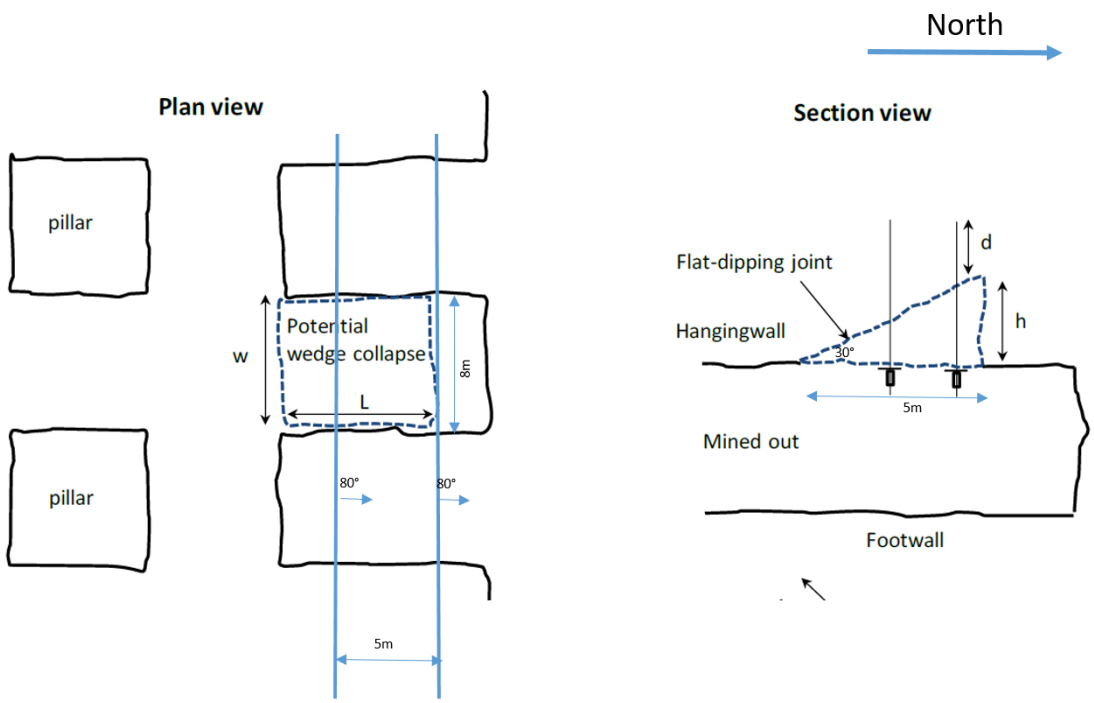
QUESTION 4. ROCKMASS CLASSIFICATION

4.1 Describe the ideal sequence of site investigation that would be required to provide data for the planning and mining of safe excavations. Consider the pre-feasibility stage through to full production.	(8)
4.2 Using the tables provided in Appendix 1, determine the RMR value for a 10m wide access tunnel that is to be driven at a 200m depth below surface through slightly weathered granite with a dominant joint set dipping at 60° against the direction of the drive. The Index testing and logging of diamond drilled core give typical point-load strength index values of 8 MPa and average RQD values of 70%. The slightly rough and slightly weathered joints with a separation of < 1 mm, are spaced at 300 mm. Tunnelling conditions are anticipated to be wet. Where required justify your value.	(11)
4.3 Based on your answer above, and referring to Table 2 in Appendix 1, what excavation sequence and excavation support would be required to stabilize the 10m excavation in this rockmass? Provide justification for the selection of the support units.	(8)
4.4 List 3 factors that affect slope stability?	(3)
	[30]

QUESTION 5. MINING SUPPORT DESIGN

5.1 "Containment or fabric" support is normally used to manage adverse conditions and includes steel mesh, shotcrete (wet or dry application), as well as shotcrete reinforced with various types of fibres. Describe the characteristics of an ideal fabric for use under rockburst conditions. Exclude Thinly Sprayed Liner (TSL) "membranous" support in the consideration of your answer.	(4)
5.2 The New Age (PTY) LTD base metal mine is a mechanised bord and pillar operation in the Eastern Bushveld Complex. The mine operates at a mining depth of 180m with the overburden material having a density of 3500kg/m^3. The environment is structurally complex with the lease area dominated by N-S trending vertical joints and faults as well as random	

low angled joints. The underground conditions may be considered as dry. Following a recent pillar optimization study conducted at the mine, the pillar material strength has been increased from 33MPa to 48MPa and this has increased the extraction ratio to 75%. The following parameters remain unchanged: Pillar length at 10.0m Mining height at 2.0m Factor of Safety at 3 As the newly appointed Rock Engineer, you have been tasked with reviewing the mine layout in line with the adjusted rockmass strengths and extraction ratio.	
5.2.1 Considering the information presented above, describe the principal driver and mechanism of rock mass and excavation instability and the support philosophy required in this environment.	(5)
5.2.2 Calculate the actual pillar width based on the revised rock mass strength, assuming the following: Gravitational constant = $9.81 m.s^{-2}$ Pillar strength = $KW_{eff}^{0.5}/H^{0.75}$ Pillar stress = $\sigma_v/(1-e)$ Factor of Safety = Pillar strength/Pillar stress	(6)
5.2.3 Bord 2A of the same mine is 8m wide and is traversed by a set of E-W trending joints with an 80° dip to the North and an average spacing of 5m as well as a random N-S trending joint dipping at 30° to the South. The intersection of the two joint sets delineates an unstable wedge with the geometry as shown in the sketch below:	



Not to scale

5.2.3.1 Assume a density of 3500kg/m^3 and gravitational acceleration of 9.81 m.s^{-2}. Calculate the mass of the unstable wedge, using the provided sketch as a guide.	(2)
5.2.3.2 Assuming a factor of safety of 1.2, calculate the total force that the installed support needs to exert to stabilize the wedge.	(1)
5.2.4 Define the term “critical bond length”.	(1)
5.2.5 Assuming a critical bond length (d) of 350mm, determine the minimum support length required to suspend the unstable wedge.	(1)
	[20]

Total Mark = [100]

Appendix 1

Table 1: Rock Mass Rating System (After Bieniawski1989)

Parameter			Ranges of Values						
1	Strength of Intact rock material	Point load strength index	>10 MPa	4-10 MPa	2-4 MPa	1-2 MPa	For this low range – uniaxial compressive test is preferred		
		Uniaxial compressive strength	>250 MPa	100-250 MPa	50-100 MPa	25-50MPa	5-25 MPa	1-5 MPa	<1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core quality *RQD*		90%-100%	75%-90%	50%-75%	25%-50%	<25%		
	Rating		20	17	13	8	3		
3	Spacing of joints		>2m	0.6-2m	200-600mm	60-200mm	<60mm		
	Rating		20	15	10	8	5		
4	Condition of joints		Very rough surface Not continuous No separation Weathered wall Rock	Slightly rough Surfaces Separation <1mm Slightly weathered Walls	Slightly rough Surfaces Separation <1mm Highly weathered Walls	Slickensided surfaces, or Gouge<5mm thick, or Separation 1-5mm continuous	Soft gouge >5mm thick, or Separation >5mm continuous		
	Rating		30	25	20	10	0		
5	Groundwater	Inflow per 10m Tunnel length (l/min)	None	10	10-25	25-125	>125		
		Joint water press-ure/major principal stress	0	0.0 – 0.1	0.1-0.2	0.2-0.5	>0.5		
		General Conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		
6	Strike and dip orientations of joints*		Very favourable	Favourable	Fair	Unfavourable	Very unfavourable		
	Rating		0	-2	-5	-10	-12		

*The Effect of Joint Strike and Dip Orientation in Tunnelling

Strike perpendicular to excavation axis				Strike parallel to excavation axis		Dip 0° -20° irrespective of strike
Drive with dip		Drive against dip				
Dip 45° - 90°	Dip 20° - 45°	Dip 45° - 90°	Dip 20° - 45°	Dip 45° - 90°	Dip 20° - 45°	
Very favourable	Favourable	Fair	Unfavourable	Very unfavourable	Fair	Fair

Table 2: Guidelines for excavation and support of 10m span rock tunnels in accordance with RMR system (After Bieniawski 1989)

Rock mass class	Excavation	Rock bolts (20 mm diameter, fully grouted)	Shotcrete	Steel sets
I - Very good rock *RMR*: 81-100	Full face, 3 m advance.	Generally no support required except spot bolting.		
II - Good rock *RMR*: 61-80	Full face , 1-1.5 m advance. Complete support 20 m from face.	Locally, bolts in crown 3 m long, spaced 2.5 m with occasional wire mesh.	50 mm in crown where required.	None.
III - Fair rock *RMR*: 41-60	Top heading and bench 1.5-3 m advance in top heading. Commence support after each blast. Complete support 10 m from face.	Systematic bolts 4 m long, spaced 1.5 - 2 m in crown and walls with wire mesh in crown.	50-100 mm in crown and 30 mm in sides.	None.
IV - Poor rock *RMR*: 21-40	Top heading and bench 1.0-1.5 m advance in top heading. Install support concurrently with excavation, 10 m from face.	Systematic bolts 4-5 m long, spaced 1-1.5 m in crown and walls with wire mesh.	100-150 mm in crown and 100 mm in sides.	Light to medium ribs spaced 1.5 m where required.
V – Very poor rock *RMR*: < 20	Multiple drifts 0.5-1.5 m advance in top heading. Install support concurrently with excavation. Shotcrete as soon as possible after blasting.	Systematic bolts 5-6 m long, spaced 1-1.5 m in crown and walls with wire mesh. Bolt invert.	150-200 mm in crown, 150 mm in sides, and 50 mm on face.	Medium to heavy ribs spaced 0.75 m with steel lagging and forepoling if required. Close invert.