CHAMBER OF MINES OF SOUTH AFRICA

EXAMINATION PAPER

SUBJECT: CERTIFICATE IN ROCK MECHANICS 3.2 (COAL) **SUBJECT CODE:COMRMC3.2** **EXAMINATION DATE: 10 May 2018** **TIME:** 14:30 – 17:30	**EXAMINER:** W. Mahne **MODERATOR:** L. Prinsloo **TOTAL MARKS:** [100] **PASS MARK:** 60%

NUMBER OF PAGES: 11 (Including cover page)

SPECIAL REQUIREMENTS:

NB: your name must not appear on any answer book or loose sheets.

1. **Answer *ALL* questions and read these requirements**
2. **Write in ink on the RIGHT HAND SIDE of the paper only (only the right hand pages will be marked).**
3. Answers must be given to **an accuracy that is typical of practical conditions**.
4. In presenting answers, candidates are encouraged to use **tabulations** and **diagrams** or answers must be written in **bullet** points – **No long paragraphs**.
5. References other than those provided are not permitted.
6. Hand-held electronic calculators may be used.
7. Put your ID number on the outside cover of each book used and on any graph paper or other loose sheets handed in.
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. Cell phones are **NOT** allowed in the examination room

QUESTION 1

You are working as a Rock Engineer at Pagamiza Colliery in Mpumalanga. The mine has acquired reserves adjacent to the current mine boundaries. The mine planner has asked you for a mine design based on the exploration information available. The expected Life of Mine will be approximately 25 – 30 years and permission to do high extraction has already been obtained.

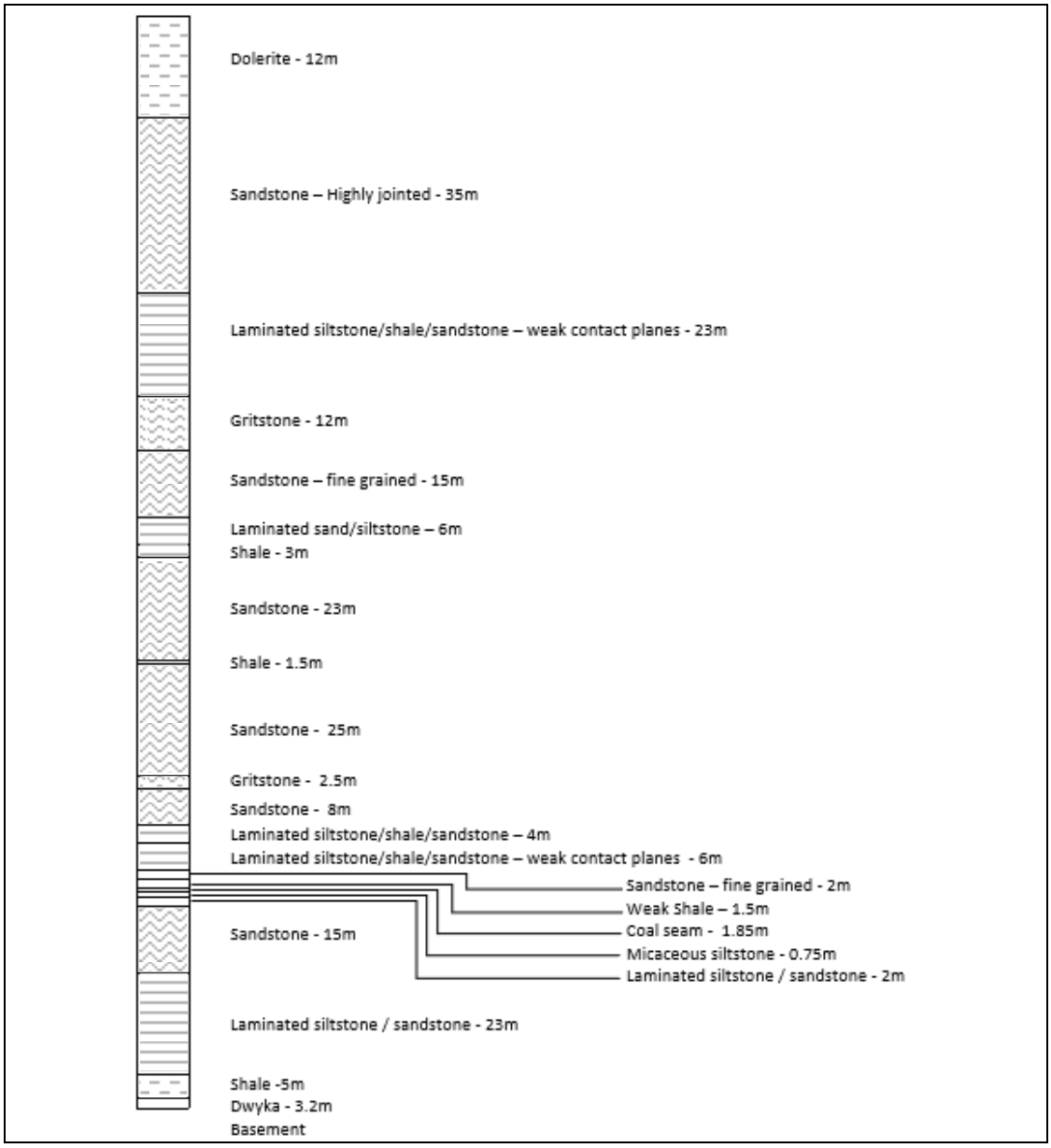
The following information is available:

- Depth of overburden to top of coal seam can be obtained from the borehole log.
- Surface restrictions:
  - A seasonal stream that runs almost diagonally across the reserve, a farmstead and a small family graveyard about 1km away from the farmstead.
  - A dirt road provides access to the farmstead.
  - Land use includes cattle farming and a couple of areas where ploughed fields, awaiting the planting season, are present.
- Mean annual rainfall (ml) 2011 - 2017

Year	Pagamiza Colliery
2011	555.0
2012	907.5
2013	915.0
2014	978.0
2015	531.6
2016	437.0
2017	790.0

- Geological overview:
  - Three aquifers are present in the overburden:
    - A shallow aquifer in the weathered Ecca sediments 5 - 15 meters below the surface.
    - An intermediate aquifer occurring in the fractured sediments of the Ecca as well as along dolerite contacts. This aquifer reaches a depth of 40m.
    - Pre-Karoo aquifers occurring in the basement of the Karoo Super group.
  - Dolerite intrusions in the form of sills and dykes – the latter have adversely affected the coal seams - are present in the area.

- This 7m to 15m thick sill comprises splits at places, occurring just below surface.
- Major dykes with a general ENE-WSW-strike and varying thickness are developed over the area. Numerous other thinner dykes occur throughout the area. Some degree of devolitilisation of the coal is present near the contacts of the latter features.
- A gräben structure is present towards the east part of the reserve and has approximately the same sub-regional strike as the major dykes mentioned. They therefore represent a prominent weak structural direction. This usually results in the development of prominent joint patterns with a similar strike.



a. Propose basic design guidelines, including the relevant safety factors, width to height ratios and other design parameters you would choose to design this mine.

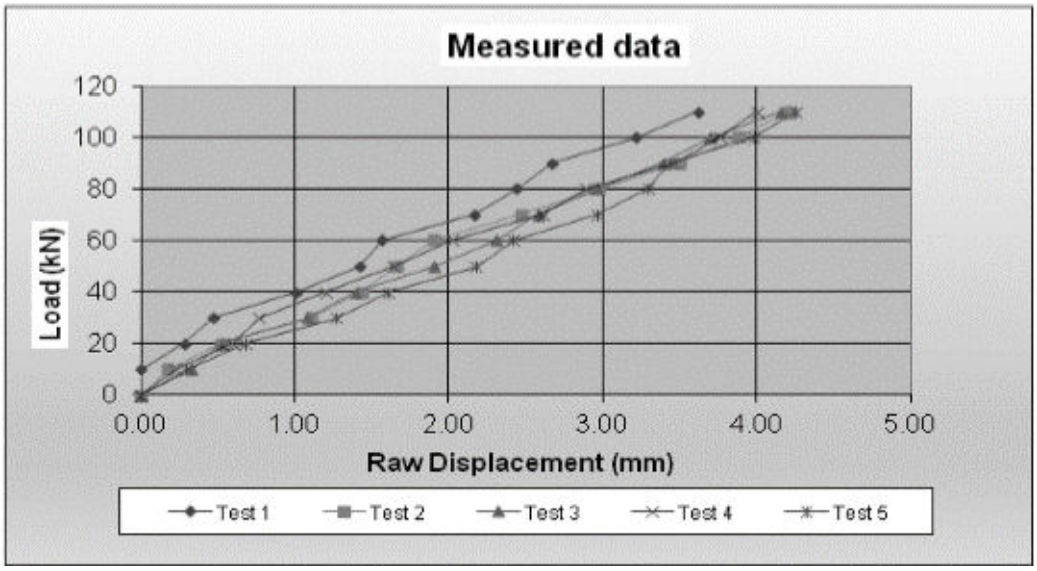
Motivate your choices. Ensure that the above information is incorporated where relevant. (No calculations are necessary).

[10]

b. Determine the mining parameters for the primary development.

[5]

c. With regards to underground quality control, Short Encapsulated Pull Tests are widely performed to ascertain the effectiveness of the support system.



- Give a short description of how underground Short Encapsulated Pull Tests should be performed for a Spin and Hold and a Spin to Stall support system.
- Analyse the raw data in the graph and comment on the effectiveness of the support system (If necessary show all calculations).

[10]

d. Based on your mine design (use SEPT results is necessary), do a roof support design for the normal ground classification. Show all calculations and motivate your design.

Also state what systems to be put in place to ensure health and safety of the employees.

[10]

e. Compile a quality control system w.r.t. the support system recommended. Ensure to incorporate the DMR guidelines (16/3/2/1-A4) for the Mandatory Code of Practice to Combat Roof Fall Accidents in Underground Coal Mines.

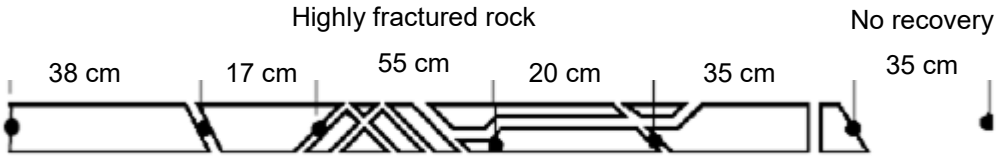
[5]

[40]

QUESTION 2

a. Determine the RQD of the rockmass in the following cases.

i. When a core sample is available (Deere 1989).



ii. When no core sample is available (Palmström 1982).

[5]

b. Name the parameters used RMR classification system.

[3]

c. Describe the Q system used in rock mass rating.

$$Q = \frac{RQD}{J_n}\ x\ \frac{J_r}{J_a}\ x\ \frac{J_w}{SRF}$$

[3]

d. Describe Barton's method to estimate the shear strength along a discontinuity.

$$\tau = \sigma_n\ tan\left(\phi_b + JRC log_{10}\left(\frac{JCS}{\sigma_n}\right)\right)$$

[15]

QUESTION 3

On the mine where you have been appointed as the Rock Engineer you were asked to design and assess the stability of a decline development between the numbers 4 and 2 seams, which was mined in the early 40's. Due to financial decisions the mining of the 2 seam was stopped. A decision was made to mine the remainder of the reserves left on the 2 seam. As the 2 seam is flooded a decision was made to access the reserves by developing a decline from the 4 seam reserves where current mining is taking place.

To ensure optimal extraction of 2 seam coal reserves the decline will be placed 5 m above the 2 seam mining horizon.

The following information is available.

- The interburden between the seams are approximately 14 m.
- Depth to floor of the 2 seam is 64 m.
- Top coaling was done on the 2 seam which resulted in a mining height of 4.1 m.
- Approximately 2 m of coal was left in the roof according to the borehole logs.
- Spot bolting was done on the 2 seam at the time of mining.
- According to a borehole log in the vicinity of the decline position there is 5.6 m of shale above the 2 seam coal with 5 m sandstone band above the shale.

a. Determine the stability of the parting between the decline and the mining 2 seam mined out panels. Use industry accepted rock mass parameters.

The following information is available for the equipment that will be moved down to the 2 seam.

- Mass 67.5 tons.
- Contact of the crawler tracks on the ground surface is 3.5 m x 1.1 m.

The thickness of the beam can be determined by using the following formula.

Tensile analysis

$$b = \sqrt{\frac{3p\ell^2}{2aF_{max}}}$$

Where p is the bearing pressure, ℓ is the span, a is unit width and F_{max} is the maximum tensile strength.

Shear analysis

$$b = \frac{3p\ell}{2\tau_{max}}$$

τ_{max} is the maximum shear strength.

[6]

b. Discuss the expected failure mechanism of the beam be if it is not designed correctly?

[2]

c. Discuss the minimum thickness of the barrier pillar between the old 2 seam workings and the newly planned panels.

[2]

[10]

QUESTION 4

a. A strip mining operation in the Witbank coalfields will commence. Discuss the design and mining of the box cut. Use an annotated sketch to explain how a box cut is formed where the floor of the bottom seam is 35 m below surface. Only 2 minable seams are available (2 and 4 seams). The interburden between the 2 seams is 15 m.

[10]

b. Discuss modelling packages that you will use to determine the probability of the all the different failure mechanisms you could encounter at the operation when mining commence.

[5]

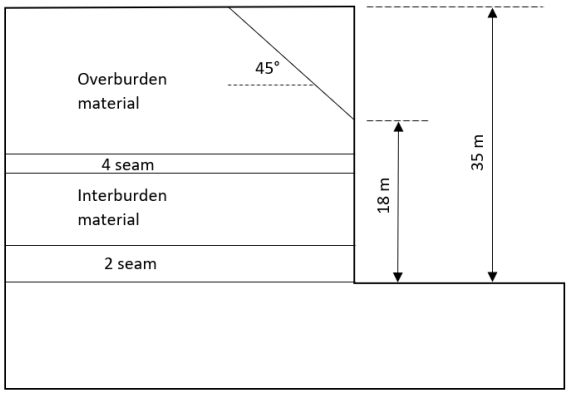
c. Discuss the monitoring methods you can employ at the operations to give early warning of rock mass movement.

[5]

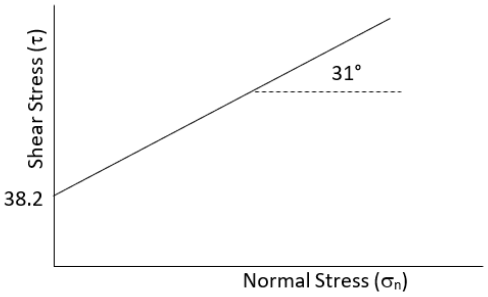
d. From the mohr-coulomb criterion indicated below determine the safety factor of the slip joint plane in the diagram below.

$$FS = \frac{(W\ cos\theta\ )tan\phi + C}{W\ sin\theta}$$

Highwall with discontinuity



Mohr-Coulomb criteria



[10]

[30]

TOTAL MARKS: [100]

Equation Sheet

Candidates may find some of the following equations useful, although other equations may also be used.

Pillars

$$\sigma = 7{,}2\frac{w^{0{,}46}}{h^{0{,}66}}$$

$$\sigma = 5.47\frac{w^{0{,}8}}{h}$$

$$\sigma = 6.61\frac{w^{0{,}5}}{h^{0.7}}$$

$$\sigma = 4{,}3\left(0{,}64 + 0{,}36\frac{w}{h}\right)$$

$$\sigma = 3.5\frac{w}{h}$$

$$\sigma = k\frac{R_0^b}{V^a}\left\{\frac{b}{\varepsilon}\left[\left(\frac{R}{R_0}\right)^{\varepsilon} - 1\right] + 1\right\}$$

$$\sigma = \frac{.0786}{V^{0.0667}}\left\{R^{2.5} + 181.6\right\}$$

$$w_e = \frac{4A}{C}$$

$$SF_{cm} = SF\left(1 + \frac{0.6}{w}\right)^{2.46} \quad SF_{cm} = SF\left(1 + \frac{0.6}{w}\right)^{3}$$

$$SF' = SF\left(\frac{w - \Delta w}{w}\right)^{2.46} \quad SF' = SF\left(\frac{w - \Delta w}{w}\right)^{3}$$

$$SF'' = \left(\frac{h}{h + \Delta h}\right)^{0.66} \quad SF'' = \left(\frac{h}{h + \Delta h}\right)$$

$$Load = \frac{\left[.025(H - T) + .03T\right]C_1C_2}{w_1w_2}$$

$$e\% = 100\left[\frac{h_m}{h_s}\left(1 - \frac{w^2}{C^2}\right)\right]\frac{W}{W + P}$$

$$E_{cp} = \frac{0{,}562w_e}{h} - 2{,}293$$

$$R = m\left[\frac{h}{T}\right]^x$$

$$d = w - \left[0{,}00714 S_{\min} HhC^2\right]^{0{,}333}$$

$$S_{\min} = 0.4$$

$$T = \left[\frac{d}{mh^x}\right]^{\frac{1}{1-x}}$$

Region	m	x
Vaal Basin, Klip River and South Rand	1,3888	0,804
Witbank No 2 and 4 Seams	0,1624	0,8135
Witbank No 5 Seam	0,105	-0,3061

Roof Support

$$\sigma_t = \frac{qB^2}{2t^2}$$

$$q = \rho g(t_s + t_w)$$

$$\sigma_t = \frac{fq_c s^2}{2t^2}$$

$$s = 1.414 t_{\min}\sqrt{\frac{\sigma_{tm}}{fq_c}}$$

$$q_c = q_l + \frac{q_u E_l - q_l E_u}{E_l + E_u}$$

$$l_a = \frac{\rho g s^2 t_w}{\tau_c \pi d_h} + .05$$

$$\eta = \frac{SF\rho g t}{P_d}$$

$$\sigma_{ts} = \frac{4W_b}{\pi d_b^2}$$

$$l_c = \frac{l_a\left(d_h^2 - d_b^2\right)}{\left(d_h - .002\right)}$$

$$t_{sb} = \frac{fk\rho gB^2}{2\sigma_{tm}}$$

$$\tau_b = \frac{3k\rho gB}{4}$$

$$\tau = C_c + C_b + \frac{F_b}{s_b^2}\tan\phi$$

$$F_b = \frac{s}{\tan\phi}\left[\frac{3\rho gkBs}{4} - \sigma_r d_h\right]$$

$$F_T = F_b \rho g k t_{sb} s^2$$

$$l_a = \frac{F_T}{\pi d_h \tau_c}$$

$$\eta = \frac{\gamma B^4}{32Et^2}$$

$$\sigma_s = \frac{4F_T}{\pi d_s^2}$$

$$\beta = \arctan\left(\frac{L/2}{\eta}\right) - \arctan\left(\frac{\eta}{L/2}\right)$$

$$R = \frac{L/2}{Cos\beta}$$

$$d\theta = \frac{\pi}{2} - \arctan\left(\frac{R - \eta - h_l}{L/2 - d}\right)$$

$$S = t_l d\theta$$

$$\sigma_r = \frac{\tau_l S_b}{d_b}$$

$$\varepsilon_r = \frac{\sigma_r}{E_r}$$

$$S_r = \varepsilon_r\left(d_h - d_b\right) + R_s$$

$$SSF = \frac{S}{S_r}$$

$$RQD = 115 - 3.3J_v$$

Subsidence

$$S_{m,he} = 0{,}39h\left(\frac{W}{H}\right)^{0{,}32}$$

$$S_{m,pf} = 0.1h_e$$

$$h_e = he$$

$$S_x = \frac{S_{\max}}{2}\left[\tanh\left(\frac{7x}{W} - 1{,}645\right) + 1\right]$$

$$L_c = 2T\sqrt{k + \frac{\beta}{D}} + 2(H - D)\tan\theta$$

$$\beta = \frac{c - b\gamma d}{\gamma_m \tan\phi} - \frac{kl}{2}$$

$$\beta = \frac{1.53}{\gamma_m} - 0.8$$

$$\gamma_m = \gamma_s \frac{D - T}{D} + \gamma_d \frac{T}{D}$$

$$\gamma_m = 0.025\frac{D - T}{D} + 0.03\frac{T}{D}$$

$$T_m = 21.6S_m + 7$$

$$\varepsilon_{m+} = 4.2S_m + 1.7$$

$$\varepsilon_{m-} = -9.1S_m - 2.8$$

Physics

$$E_k = \frac{1}{2}mv^2$$

$$v_i = \sqrt{2gd}$$