UNISA
UNIVERSITY OF SOUTH AFRICA

Examination Paper • Eksamenvraestel

SUBJECT:	EXAMINER:
CHAMBER OF MINES OF SOUTH AFRICA CERT. IN ROCK MECHANICS – PAPER 1	M HANDLEY
SUBJECT CODE:	**MODERATOR:**
COMRME	J KLOKOW
EXAMINATION DATE: **10 MAY 2004**	**TOTAL MARKS:** [100]
TIME: 09h00 - 12h00	**PASS MARK:** 60%

NUMBER OF PAGES: 7

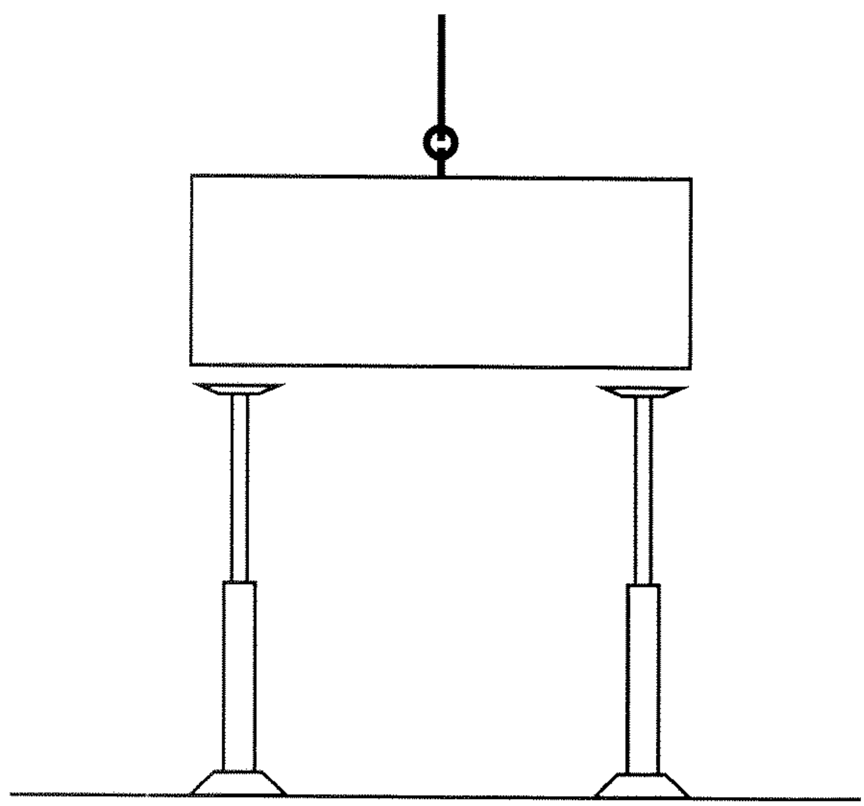
SPECIAL REQUIREMENTS:

1. **ANSWER *ANY FOUR* QUESTIONS.** Please indicate clearly which questions you have answered.
2. References other than those provided may not be used.
3. Hand-held electronic calculators may be used.
4. Put 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.**
5. Write on one side of the paper only.
6. Show all calculations on which you base your answers.
7. In answering these questions, take full advantage wherever necessary of your practical experience as well as of the data given.
8. Graph paper is available from the invigilator.
9. A list of formulae and any other essential charts and tables will be issued at time of the examination.

QUESTION 1

1.1 Explain the concept of a soft and stiff testing machine, and describe one method that can be employed to make a soft testing machine behave like a stiff one. (10)

1.2 A 20-tonne block of rock is suspended above four Camlok props, as shown in the schematic diagram below.



If the Camloks are 1.3 m tall, calculate the exact height above the floor the bottom of the block will settle if it is gently lowered onto the props until they support equal proportions of its full weight. Assume a stiffness for each prop of 7.5 MN/m, and that the floor is rigid. (10)

1.3 If we assume that the two surfaces of a joint are not welded together (that is there is no resistance if you pull the two surfaces apart), explain how it is possible for this joint to have cohesion. (5)

25 marks

QUESTION 2

2.1 Define stress and provide units. (2)

2.2 Define strain and how it is related to displacement, providing units for both. (4)

2.3 Plot a Mohr Circle on the graph paper provided using the stress tensor components given below:

$$\begin{bmatrix} \sigma_{xx} & \sigma_{xy} \\ \sigma_{yx} & \sigma_{yy} \end{bmatrix} = \begin{bmatrix} 20 & -10 \\ -10 & 40 \end{bmatrix} \text{MPa}$$

a) Determine the principal stresses from your diagram. (2)

b) Determine the angle the principal stresses make with the x-y axes (assuming x is horizontal, and y vertical) and provide a freehand sketch showing how the principal stress axes are orientated in relation to the x-y axes. (4)

c) Determine the shear stress on a plane whose normal makes an angle of 15°, measured anti-clockwise from the x-axis, using the Mohr Circle. Is the shear stress positive or negative? (4)

d) Determine, from the diagram, the normal stress acting on the plane as defined in question 2.3 (c). (2)

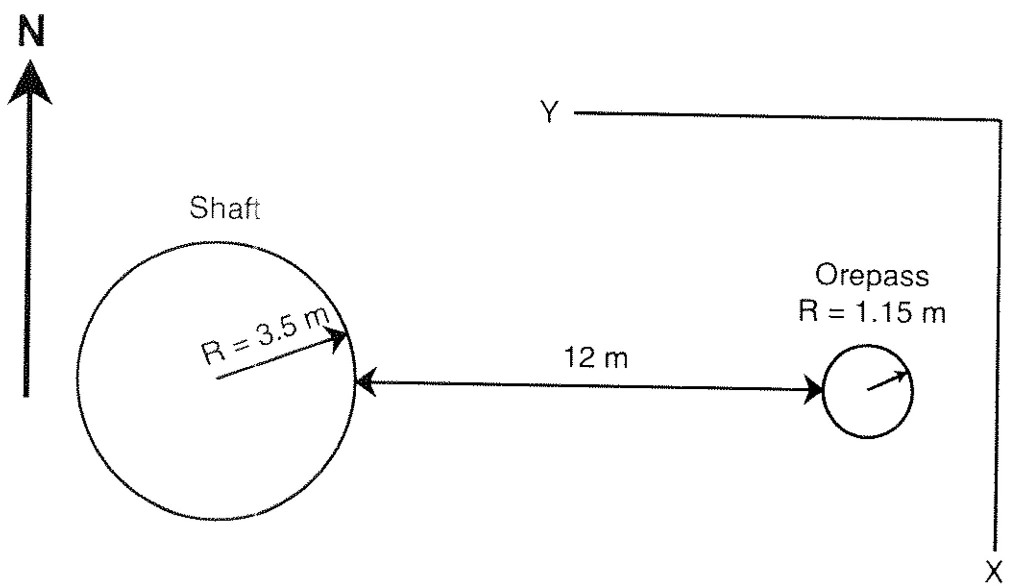
e) If the plane has cohesion of 1 MPa and a friction angle of 30°, will it be stable? (2)

2.4 During the elastic part of a stress-strain curve in a uniaxial compressive strength test, does the rock volume increase or decrease? Assume a Poisson's ratio of 0.2 and frictionless contact between platens and sample. (5)

25 marks

QUESTION 3

A 2.3 m diameter orepass is planned to connect 100 Level to 110 Level. It passes closest to the shaft at 105 Level, as shown in plan below.



The stress tensor has been measured at 105 Level with the following results:

$$\begin{bmatrix} \sigma_{xx} & \sigma_{xy} & \sigma_{xz} \\ \sigma_{yx} & \sigma_{yy} & \sigma_{yz} \\ \sigma_{zx} & \sigma_{zy} & \sigma_{zz} \end{bmatrix} = \begin{bmatrix} 35 & 10 & 0 \\ 10 & 55 & 0 \\ 0 & 0 & 85 \end{bmatrix} \text{MPa}$$

3.1 Calculate the principal stresses and their directions in the horizontal plane on 105 Level (as a result of the presence of the shaft), at the centre of the planned orepass position. (10)

3.2 Use the Kirsch equations to estimate the highest compressive stress in the orepass sidewall and use the Hoek-Brown failure criterion to determine whether scaling as a result of the field stress at the orepass position will occur or not. Assume m = 15, and s = 0.1. If the orepass scales, indicate which directions you would expect it to scale. (15)

25 marks

QUESTION 4

4.1 Define ERR with units, and explain why it is an approximate measure of seismic activity in a deep level hard rock mine. (5)

4.2 Calculate and plot the ERR for a parallel-sided horizontal longwall at a depth of 2000 m, assuming a stoping width of 1 m, E = 50 GPa, Poisson's Ratio = 0.2, and rockmass density is 3300 kg/m^3, versus half-spans from 0 to 1500 m, at 100 m intervals. (10)

4.3 A flat parallel-sided longwall in a platinum mine is using yielding props for permanent support on the centre gully, which will be kept open for the life of the longwall. Assuming that the props were installed 0.5 m beyond each shoulder of a 2 m wide centre gully when the ledge half-span was 5 m, how far can the longwall faces advance from the longwall centreline before the gully support props need to be replaced if they fail after they have yielded a distance of 30% of their original length? Assume rockmass properties and stope dimensions given in 4.2 above. (10)

25 marks

QUESTION 5

A manganese mine has been exploiting a tabular sedimentary manganese- and iron-rich ore body for the past thirty years. The ore body can be considered to be flat, 5 m thick, and on average 320 metres below surface (take the footwall contact of the ore body to be at this depth). The immediate hangingwall consists of a massive banded ironstone formation about 30 m thick, above that a massive quartzite about 50 m thick, then a 205 m thick succession of sediments, topped by 30 m of sand at the surface. The footwall consists of a massive banded ironstone formation as well. The average UCS of the immediate hangingwall, footwall, and ore body rocks is 360 ± 60 MPa. In the early stages of mining near the shaft, the pillars were initially 12 by 12 m square with 8 m bords, but these were subsequently found to be too large, so they underwent secondary extraction by taking 6m wide cuts through the pillars. Then the pillar design was revised to the current system, where the mine uses a bord and pillar layout in which the bords are 8 m wide, the pillars are square, and 8 m wide. Assume that the new geometry was only introduced once the mining and secondary extraction using the old geometry was complete. The mining geometry is shown in the figure overleaf.

Sketch/plan?

Comment on the following stating your assumptions, backing all your comments with calculations using tributary area theory and the formula:

$$Pillar\ Strength = 0.3UCS\left(\frac{w^{0.5}}{h^{0.75}}\right)MPa$$

Assume the Young's modulus of the pillar material is 60 GPa, the average overburden unit weight is 29000 kN/m^3, and that from an underground visit you observed that none of the pillars show any signs of excessive stress, nor are there any signs of hangingwall or footwall instability in either the 3 m or 8 m wide pillar areas.

5.1 Comment on the stability of the central area, when supported by the original 12 m pillars. (5)

Question 5.2/...

QUESTION 5 (CONTINUED)

5.2 Evaluate the stability of the 3 m pillars after the secondary extraction was complete, and before mining had commenced with the new geometry. (5)

5.3 After mining with the new geometry had reached horizontal spans far in excess of the depth. (5)

5.4 Evaluate the stability of the 8 m bord and pillar geometry about 300 m from the boundary between the 3 m and 8 m pillars. (5)

5.5 Evaluate the stability of the 8 m pillars on the boundary of the 3 m pillar area. (5)

Matthew, this question is not very clear. Please check with John. Could maybe use a borehole sketch instead of long paragraph.

25 marks

TOTAL MARKS: [100]