Ques

CHAMBER OF MINES OF SOUTH AFRICA

WRITTEN EXAMINATION FOR THE CERTIFICATE IN ROCK MECHANICS

METALLIFEROUS & COAL OPTIONS

PART 1 - THEORY 11 May 1998

EXAMINER: Mr GS Esterhuizen

MODERATOR: Mr KR Noble

Maximum time allowed 3 hours (09:00 - 12:00)

ANSWER ALL QUESTIONS

A pass mark is 60 per cent.

EXAMINATION INSTRUCTIONS

1. References are not permitted.

2. Hand-held electronic calculators may be used. **(NO PRE-PROGRAMMING).**

3. 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 appear on any answer book or loose sheets.

4. Write in ink on one side of the paper only.

5. Show all calculations on which your answers are based.

6. In answering these questions, full advantage should be taken wherever necessary of your practical experience as well as of the data given.

7. Graph paper is available from the invigilator.

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QUESTION 1

(i) Sketch a beam built in at both ends and indicate the areas of maximum shear and maximum tension in the beam. If the beam is assumed to be vertically jointed, explain how it could stabilise in the absence of tensile strength across the joints. There are no external horizontal stresses acting on the beam.

5 marks

(ii) Shear along joints or other fractures in rock is associated with dilation. Make use of a sketch to explain how the dilation is caused and how it could assist in improving the stability of the unsupported area between a gold mine stope face and the first row of support.

5 marks

(iii) Brittle failure of rock commences by the propagation of micro cracks in rock. If the rock is under uniaxial compression, explain how the cracks are able to propagate

5 marks

(iv) Calculate the strength of failed rock for confining pressures of 5, 10, 20, 40 MPa if it has the following properties for the Hoek-Brown equation: m = 1,5, s = 0.0, the uniaxial compressive strength of the intact material is 180 MPa. Plot your results on the graph paper, because you will need them for the next question. Also, explain what is the mechanism that allows the failed rock to develop strength under confinement?

5 marks

(v) Assume the failed rock in the above question contains a natural discontinuity whose normal makes an angle of 62,5 ° to the direction of the major principal stress (Note this is the most unfavourable orientation for Coulomb shear). The sample may therefore fail either by sliding along the discontinuity or by failing according to the Hoek-Brown equation. Make use of the Coulomb equation to determine at what confining pressure the rock will cease to slide along the discontinuity and rather fail according to the Hoek-Brown equation. The discontinuity friction angle is 35 ° and the cohesion is 5 Mpa.

10 marks

TOTAL **30 marks**

QUESTION 2

(i) A vertical shaft with a diameter of 6 m has been excavated by a boring machine. It is intended to drill vertical ore passes close to this shaft. You have told the mine design staff that the ore passes should be at least 20 m away from the shaft. However, they are reluctant to abide by your recommendation and want to place the ore passes 10 m away from the

QUESTION 2 (cont.)

shaft (skin to skin) as shown in figure 2.1. Make use of the equations for the stresses around circular excavations to demonstrate that your recommendation is valid. The following data are available. Horizontal k-ratio = 1 (Hydrostatic), horizontal stress = 50 MPa, estimated large scale uniaxial compressive strength of rock = 105 MPa, maximum tangential stress at boundary of circular excavation: (see equation book)
The proposed layout is as shown in figure 2.1
The equations for stresses at a point in the rock mass near a circular excavation for a hydrostatic stress field are:

where q is the field stress, r is the radius of the excavation and R is the radial distance to the point of interest.

10 marks

(ii) Assume that the stresses at the proposed ore pass position are high enough to cause rock failure, sketch the approximate location and type of failure of the surrounding rock that can be expected, also explain why this failure would have more serious consequences in the ore pass than in a tunnel for example.

5 marks

(iii) You intend to model the above shaft and ore pass using a two-dimensional elastic numerical model. State briefly the shortcomings of such a model and also state how the extent of potential failure around the excavations can be determined using the elastic model.

5 marks

TOTAL 20 marks

QUESTION 3

(i) Determine the maximum principal stresses in two dimensions and their directions relative to the x-axis if the following deformations were measured in the x-y plane:

$ux = 3{,}2 \times 10^{-4}$ m
$uy = 5{,}7 \times 10^{-4}$ m
$y = 5{,}0 \times 10^{-4}$ radians

the elastic modulus is 68 GPa and the Poisson's ratio is 0,21.

7 marks

(ii) Draw a free hand sketch to illustrate the principal stresses and the stresses in the x-y plane using a Mohr circle diagram.

3 marks

QUESTION 3 (cont.)

(iii) Determine the strain energy stored in a cubic metre of rock at a depth of 2500m below surface, where the horizontal stress is 0,5 times the vertical stress. The vertical stress is equal to the overburden stress. The average density of the rock is 2700 kg/m^2.

2 marks

(iv) If the cube of rock in the above example were to convert all its stored strain energy into kinetic energy, what would the velocity be that the block will achieve?

3 marks

TOTAL **15 marks**

QUESTION 4

(i) Explain the role of joint roughness in the developement of shear strength of joints. Also show why the roughness diminishes as the confining stress increases.

5 marks

(ii) Determine whether slip will occur along a fault under the following conditions:

Joint roughness coefficient(JRC) = 12
Joint wall strength = 28 MPa
Base friction angle = 32^0
Stresses : $\acute{o}_x$ = 63 MPa, $\acute{o}_y$ = 21 MPa, $\hat{o}_{xy}$= 6 MPa
Horizontal stress = 21 MPa
Fault dip = 72^0 measured from x to y-axis.

10 marks

$$\tau = \sigma_n \tan\left[JRC \log\left(\frac{JCS}{\sigma_n}\right) + \phi_r\right]$$

(iii) Joints often occur in sets and these sets may be identified on a stereonet by plotting poles to the joints. Make a sketch to illustrate what is meant by a joint pole and show how you would identify a joint set using the poles.

5 marks

TOTAL **20 marks**

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QUESTION 5

(i) Explain two different techniques of measuring stresses in rock, sketch the measuring equipment and state the shortcomings of each method.

10 marks

(ii) Mining is planned to occur near a vertical shaft in a mine which is likely to affect the stability of the shaft through increased stresses over the next six months. You have been requested to monitor the stabilty of the shaft. The shaft is supported by a concrete lining and has unmodified steelwork in it. No seismicity is expected. Explain what would you attempt to monitor and why? Also state the type of instruments you would use, the location of monitoring points and the frequency of measurements in and around the shaft.

10 marks

(iii) A tunnel is being developed into the rock mass adjacent to a large underground stoping excavation. You think the rock mass may be "failed" owing to the previous stoping and is causing poor conditions in the tunnel. What would you look for to determine whether the rock mass has actually failed, what would the signs be?

5 marks

TOTAL **25 marks**

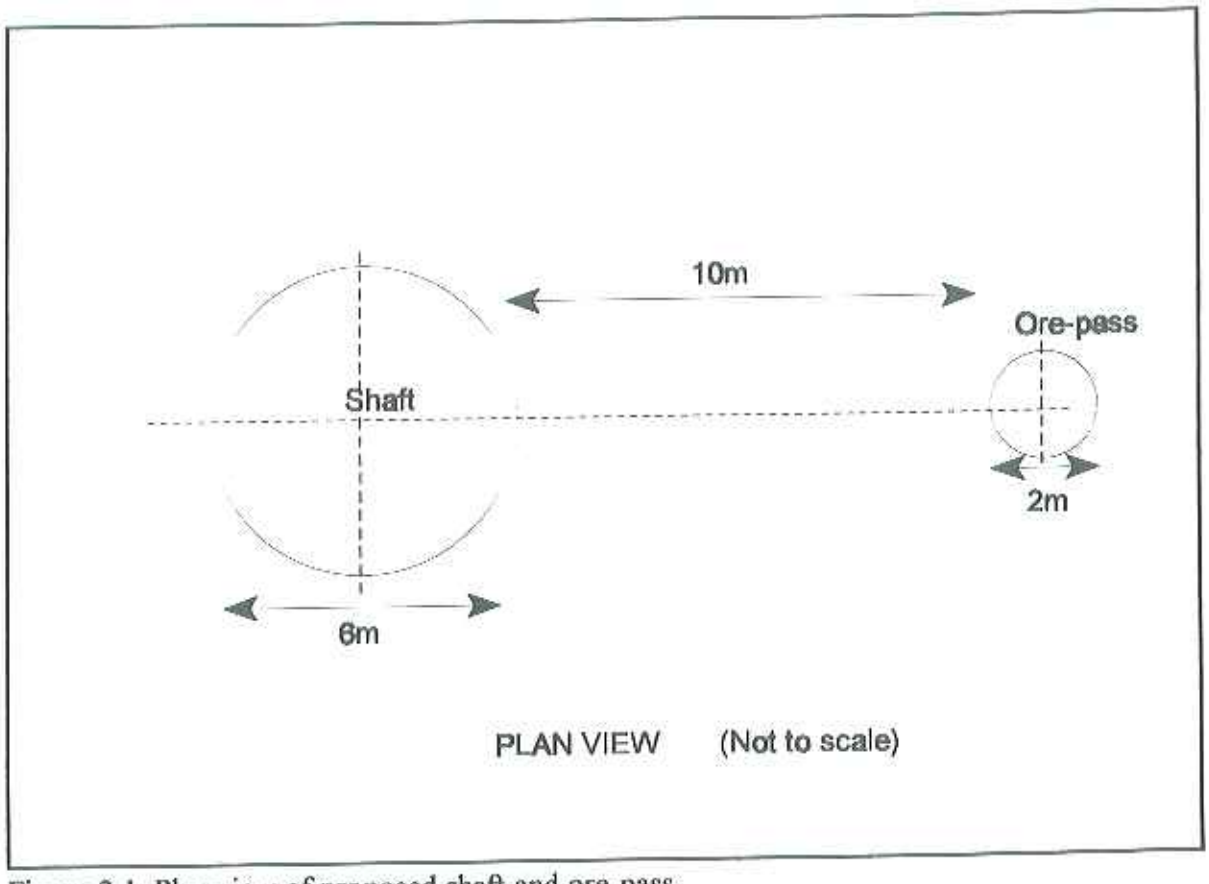

Figure 2.1 Plan view of proposed shaft and ore-pass