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Examination Paper • Eksamenvraestel

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA CERT. IN ROCK MECHANICS – PAPER 1	**EXAMINER:** M HANDLEY
SUBJECT CODE: COMRME	**MODERATOR:** J KLOKOW
EXAMINATION DATE: 25 OCTOBER 2004	**TOTAL MARKS:** [100]
TIME: 09h00 - 12h00	**PASS MARK:** 60%

NUMBER OF PAGES: 4

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.

ROCK MECHANICS PAPER 1 (COAL AND METALLIFEROUS OPTIONS)

QUESTION 1

The following corrected strain components were measured at the flattened end of a horizontal borehole (assume the x-axis is horizontal and the y-axis vertical):

$$\epsilon_{xx} = 0.677 \times 10^{-3},\ \epsilon_{yy} = 1.12 \times 10^{-3},\ \epsilon_{xy} = 0.550 \times 10^{-3}$$

a) Determine the principal stresses and their directions in the x-y plane given that the modulus of elasticity is 45 GPa and the Poisson's ratio is 0.3. Show the orientations of the principal stresses in the x-y plane in a diagram.

(10)

b) The borehole is 2000 m below surface. Assuming an average rockmass density of 3000 kg/m^3, and the gravitation constant g = 9.81 m/s^2, do the results obtained agree with the expected vertical stress due to the overburden? Explain your answer, and use calculations to support your explanation.

(10)

c) Are strain reliefs measured in a single flat-ended borehole sufficient to determine the in-situ stress state in the rockmass? Justify your answer with a description of acceptable in-situ stress measurement procedures.

(5)

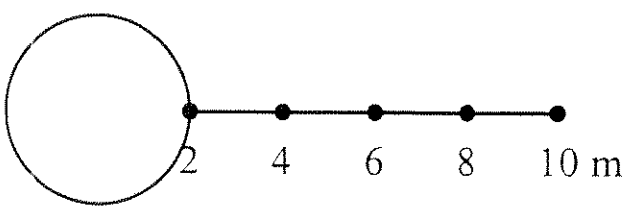
TOTAL: 25 MARKS

QUESTION 2

A horizontal circular tunnel with a 4.0 m diameter is bored in hard rock 800 m below surface, where the major principal stress is horizontal and equal to twice the overburden weight asssuming a density of 3000 kg/m^3, and the minor principal stress is vertical and equal to the overburden weight.

a) Calculate the radial and tangential stresses in the sidewall of the tunnel at the points illustrated below, and plot the stress component profiles graphically.

(10)



b) Calculate the strains at the same points using E = 60 GPa and v = 0.30. Plot the strain component profiles graphically.

(5)

c) If the rock fails in tension at –0.2 millistrains, show, using the above plotted profiles, where you would expect spalling in the tunnel sidewalls.

(5)

d) Explain how a tensile strain can develop in rock in compression.

(5)

TOTAL: 25 MARKS

QUESTION 3

The following stress state exists at a point in rock:

σ_{xx} = 40 MPa
σ_{yy} = 70 MPa
σ_{xy} = 10 MPa

a) Make use of the Mohr circle diagram to plot the stress state, indicating the maximum and minimum principal stresses. Calculate the principal stresses, and the angle that the major principal stress makes with the x-axis.

(5)

b) Indicate on the diagram how you would determine the normal and shear stress on a plane whose normal makes an angle of 15°, measured anti-clockwise with the x-axis. Use the diagram to calculate the stress components, and confirm your answer using the appropriate equations on the accompanying equation sheet.

(10)

c) Measurements in the laboratory on sandstone samples yield a cohesion of 8 MPa and an angle of internal friction of 30°. A stress analysis program indicates that the stress state in the sandstone at a point near to a pillar in a coal mine is given by: σ_1 = 30 MPa, σ_2 = 2 MPa. Assuming that the sandstone will fail according to a Mohr-Coulomb failure criterion, determine whether the sandstone is in a state of failure or not at this point. Give your answer in the form of a diagram with calculations.

(5)

d) During the elastic part of the stress-strain behaviour of rock, does the volume of rock increase or decrease? Make use of an example calculation to show the effect of the Poisson's ratio on the change in volume.

(5)

TOTAL: 25 MARKS

QUESTION 4

a) Define plane strain.

(2)

b) Define strain energy.

c) Define principal stress. (2)

d) Describe the Hoek-Brown failure criterion. (2)

e) Explain strain hardening. (4)

f) Five cylindrical samples of rock are tested in compression in a rock-testing machine under triaxial loading conditions. The first sample is tested uniaxially, the other four with increasing compressive confinement, namely 5 MPa, 10 MPa, 20 MPa and 40 MPa. All samples showed brittle behaviour in the post-failure regime, and the uniaxial strength was found to be 200 MPa. Draw the five stress-strain curves on one graph that you expect the samples to have, annotating features such as peak strength, strain hardening, strain softening, and residual strength. (2)

g) If one of the samples tested had Hoek-Brown m and s values of 15 and 1.0 respectively, what would the peak strength be if confinement were 20 MPa? (10)

TOTAL: 25 MARKS (3)

QUESTION 5

a) Describe monitoring in one short sentence. (2)

b) Name the four main reasons why monitoring is undertaken in underground mines. (8)

c) Name five quantities associated with rock stress and movement that could be monitored in a large underground excavation to ensure its safety and stability, and briefly describe how each may be measured. (15)

TOTAL: 25 MARKS