Ques + Answ

CHAMBER OF MINES OF SOUTH AFRICA

WRITTEN EXAMINATION FOR THE CERTIFICATE IN ROCK MECHANICS

METALLIFEROUS OPTIONS

PART 2: APPLICATION 10 November 1998

EXAMINER: Dr J V James

MODERATOR: Mr M Roberts

Maximum time allowed 3 hours (09h00 - 12h00)

ANSWER ALL QUESTIONS

The pass mark for this paper is 60 percent.

EXAMINATION INSTRUCTIONS

1. References may not be used.
2. Hand-held electronic calculators may be used.
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 not appear on any answer book or loose sheets.
4. Write 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.

QUESTION 1

Your Mine has an intermediate pump chamber sited 800 m below surface and approximately 250 m above reef in the shaft pillar. It is sited in Ventersdorp Lava. The Pump station is 90 m long, 10m wide and 12 m high. 4 dams each 30 x 6 x 10 m and separated by 15 m pillars lead into the Pump Chamber at right angles.

The Pump station was excavated and constructed 33 years ago, and thus has corrugated iron arches covering the roof, and mass concrete sidewalls and floor.

After recent complaints from the Engineering Dept. you inspect the area making the following observations:

The concrete floor is bulging upward pushing the pumps off level and damaging them.

Horizontal cracking of the concrete side walls is present throughout and the side walls are pushing the pipework inward damaging several pipe flanges.

The hangingwall above the corrugated iron roof is undamaged as are the dam hangingwalls.

The sidewalls of the dams are severely fractured and the dams are choked with spalled rock. The dam walls at the entrances to the pump chamber are cracked vertically.

i) Discuss the mechanisms for the damage described, explaining each observation. (Make use of sketches if necessary) **8 marks**

ii) Recommend detailed remedial measures and procedures bearing in mind that at all times at least 3 dams and 4 of the 6 pumps must be in commission to prevent the mine from being flooded. (Make use of sketches to supplement your answer) **12 marks**

iii) Describe how you would have supported the same excavations if they were newly excavated. **10 marks**

TOTAL: 30 MARKS

QUESTION 2

When planning and then mining a block of reef at a depth below 3000 m, it is necessary to design and then continually adjust the mining layout to minimize seismicity, as new geological information is obtained.

i) Describe the methods of predicting and controlling seismicity, at each phase of the planning and mining process. **10 marks**

ii) It has become common practice to reduce the Young's Modulus input to routine numerical modelling, from that measured.

Explain why this is done, enlarging on the reasons why this produces better results and the values commonly used. **5 marks**

iii) Changing the Young's modulus as described may effect the values obtained for Energy Release Rates (ERR).

Discuss the consequences of this on the design process described in i) above. **5 marks**

iv) Describe and make a calculation which will estimate the effect of a reduction of Young's Modulus on ERR. **10 marks**

TOTAL 30 MARKS

QUESTION 3

i) List and describe the different discontinuities found in deep and shallow mines **6 marks**

ii) Explain why stress fractures are flat lying when ledging and in panels with excessive leads. **6 marks**

iii) The face, gully intersection, is known to be the most dangerous area in a conventional stope Discuss the factors which cause this, and describe the measures which are taken on your mine, or a mine with which you are familiar, to alleviate these factors. **8 marks**

TOTAL: 20 MARKS

QUESTION 4

Measurement of the rock mass response is crucial for calibrating numerical models, and designing support. Describe the types of instruments or techniques you would use to measure each of the following. Give a short explanation (and/or a sketch) of how each works. Where possible give alternative methods.

i) Stope closure
ii) Backfill behaviour in stope
iii) Stress changes below a longwall
iv) Large excavation, sidewall behaviour
v) Movements in a shaft.
vi) Shotcrete thickness
vii) In situ pack behaviour
viii) Bed separation above a stope

20 marks

TOTAL: 20 MARKS

ROCK MECHANICS (MEL)

Paper 2 November 1998
Model Answers

Question 1

A - Mechanisms

1 - side walls are pushing in through normal stress fractions aggravated by time dependant failure and weathering of the lava causing bulking.

2 -This movement explains - the forcing in of the side walls causing horizontal fractures and the bulging upward of the concrete slab forming the floor. It also explains the failure of the dam.

This explanation is reinforced by the spalling of the dam side walls and untouched hanging wall. To explain the excessive spalling at this depth - 800m ie 20 MPa virgin say, up to perhaps 35 MPa in the shaft pillar, one must involve either an extremely soft lava band + 100 Mpa or that stress fracturing and weathering in lava is time dependant.

B Remedial Measures

1) Removal of the concrete sidewalls and then scaling. Support plus tendons - temporary support preceeds roof support
2) Slotting of floor slab and removal, possibly tendons in floor.
3) Barring and shotcreting of dams - marks lost for wire mesh because of corrosion etc tendon support of dams.
4) Tendon lengths and strengths and efficiency must be appropriate ad described ie pump station - 10 m wide - minimum length 5m - 30 ions and smaller units dams ?m - 3m units
5) Sequencing must be described.

C New Design

Pump station

a) integrated tendon support of hangingwall and side walls - appropriate sizes and spacings
b) skin support lacing and mesh
   - mesh and shotcrete
   - steel fibre reinforce shotcrete

c) No concrete or corrugated iron

Dams

a) integrated tendon support hangingwall and sidewall
b) Skin support - steel fibre shotcrete
   - mesh and shotcrete
   - lacing only

unprotected mesh is out because of corrosion.

Extra marks if redesign with individual pump chambers and smaller excavation is suggested.

Question 2

i)

- Long term - ERR / VESS - face, stope configuration Pillar spacing
- As geology is determined - ESS - orientation to faulting
- Dykes
- Mining and planning ESS and measurement of Seismicity
  - measurement to show seismic areas
  - prediction
  - orientation to faults

ii) Values of - 70 reduced to 40 - 50

1) Research work has shown that the convergence predicted is closer to that measured - especially with backfill - this either accounts for inelastic movement or for the averall rockmass

2) Off-reef movements in shafts have also shown larger than predicted movements with measured Youngs Modulus of 70 - often better at lower Youngs Modulus down to 18.

iii) ERR is the Energy factor produced by multiplying convergence by stress /2
Then if E is smaller ERR will be greater for a given situation

Thus if modelling is done using a E of 50 GPa rather than the 70 GPa which was the Industry norm when the Empirical relationship between ERR and seismicity was deduced, using a lower modulus will increase the calculated ERR for any given situation. This will make seismic predictions and layout conservative and cause excessive ore' tie-up in pillars etc.

iv) Most successful candidates used a calculation similar to the following using the 2D formula for which is considerably simpler and more elegant than the answer I formulated. This assumed a stope face with a 10m mining step and calculated average stress and strain changes for 50 m above and below the reef.

Question 3

i.

Deep	Shallow
Faults Joints Dykes Sills Bedding partings Extension fractures Shear fractures Blast fractures	Faults Joints Dykes Sills Bedding partings Bed separation Blast fractures

A short description of the features of each type of discontinuity is required

ii. The explanation should show that flat lying fractures are generally formed in comparatively low stress and confined areas e.g. leading faces and gullies where sufficient stress concentration to cause extension fracturing occur closer to the excavation. This leads to increased curvature of the maximum stress loci which the fractures follow. This leads to shallow angled fractures in the hanging.

iii. The following factors cause the high accident rates in the gully face area:
- A.S.G. orientated stress fracturing, combined with face parallel stress fracturing
- Low angle stress fractures due to leads and lags.
- Scraping out of support
- Poor support densities due to the need to clean the face and reluctance to keep gully support close to the face.
- High worker densities at the most busy part of a stope.

Alleviating measures should include:
- Limiting or forbidding A.S.G.s
- Wide headings
- Roofbolt or similar support of gullies
- Reduction of gully spans
- Decreased support to face spacings using blast on units
- Temporary support.

Question 4

i. Stope Closure - vernier Closure meters, pack measurement
ii. Backfill behavior - Closure meters, flatjacks at right angles, remote read out.
iii. Stress Changes - Stress measurement using overcoring, ongoing stress change measurement using CSIRO cells, leveling of under or overlying excavations.
iv. Sidewall behavior - Tape extensiometer, vibrating wire extensiometers Borehole petroscope, survey profiling, borehole C.C.T.V
v. Shaft movements - Tape extensiometers, plumb bob or laser and offsets, routine guide and bunton measurement,
vi. Shotcrete thickness - drilling test holes, continuing probe testing during application
vii. In situ pack behavior - flatjack between rigid plates, closure meter.
viii. Bed separation - vibrating wire extensiometers, wire extensiometer, Borehole petroscope, borehole C.C.T.V.

All instruments and their application to the particular measurement should be briefly described.