COM Rock Mechanics Certificate
Paper 2 – October 2005
Model answers

Question 1
NB – all investigations to be conducted for both the ore body and the surrounding country rock mass (EXTRA 2 MARKS)

1.1.a – Geological investigations (ANY 6 OF THE FOLLOWING)

- Core logging
  - Basic rock type (sedimentary, igneous, metamorphic)
  - Stratigraphy
  - Weathering / oxidation
  - Presence of ground water
  - Structures
    - Faults
    - Dykes
    - Shear zones
    - Unusual features / zones
  - Ore body boundaries
- Core sampling
  - Value
  - Value distribution
  - Mineralogy
- From data gathering, produce various models (in 2- and 3-D, with dip and strike where applicable):
  - Stratigraphic column
  - Ore body sections
  - Value / grade distribution
  - Structures

1.1.b – Geotechnical investigations (ANY 8 OF THE FOLLOWING)
- Core scrutiny and logging
  - RQD
  - Rock mass ratings (extra ½ marks for sub-sections)
  - Discontinuity frequency, orientation, nature
  - Joint / fracture angle distribution
- Stratigraphy
  - Relative strengths
  - Thickness and consistency
  - Nature of boundaries / contacts
- Produce models:
  - Rose diagrams of joint / fracture angles
  - Stratigraphic isopachs
  - Geotechical zones / areas
  - Boundaries:
    - Ore body / country rock
    - Different horizons in country rock

1.1.c – Rock property tests (ANY 6 OF THE FOLLOWING)
- Field tests
  - Point load tests
  - Schmidt hammer
- Laboratory tests
  - Uniaxial Compression tests (to verify field testing)
  - Uniaxial or Induced Tension tests
  - Triaxial Compression, at 3 / 4 suitable confining pressures
  - Shear tests on joints / stratigraphic boundaries

   - If needed, swell and slake tests
- Use input from above to determine Hoek-Brown and Mohr-Coulomb failure criteria
- From laboratory tests, also determine other mechanical properties:
   - Density
   - Young's Modulus
   - Poisson's Ratio

Question 2

2.1 **Required support resistance**

$= \frac{0.8m \times 1.75m^2 \times 3000kg/m^3 \times 9.81m/s^2}{1.75m^2}$

$= 23.54\ kN/m^2$ (1)

Support capability

$= 5000kg/unit \times 9.81m/s^2$

$= 49.05\ kN\ /\ unit$ (1)

Maximum spacing of units

$= \frac{49.05kN/unit}{23.54kN/m^2}$

$= 2.08m^2/unit$ (1)

Optimal spacing of units:

Strike spacing – ideally 1 row of tendons per blast (i.e. 1.0m) (1)

Dip spacing – based on above, maximum dip spacing 2.0m (1)

But, based on fall dimensions, it may be better to reduce dip spacing to < 1.3m (blocks are 1.3m x 1.3m), to pin individual blocks.

Length and installation angles of tendons

Minimum tendon length = 0.8m fall height + bond length + additional length if angle of installation < 90 degrees. (1)

Ideal would approx 1.0m in-the-hole tendon, installed at between 70 and 90 degrees. (Marks not given if 1.2m solid tendon specified at 90 degrees, due to difficulty of installation). (1)

2.2. Possible answers:

- Mechanical end anchors, with or without grout
- Hydraulically-prestressed tendons (hydrabolts)
- Marks also given for TENSIONED resin-grouted units (1)

Units must be active, so no marks given for cement-grouted or non-tensioned resin tendons. Very few candidates bothered to motivate their choice. (2)

2.3. Required support resistance

$= \frac{3.0m \times 8.0m^2 \times 3000kg/m^3 \times 9.81m/s^2}{8.0m^2}$

$= 88.29\ kN/m^2$ (1)

Maximum spacing of units

$= \frac{450.0kN/unit}{88.29kN/m^2}$

$= 5.1m^2/unit$ (1)

Recommended dip and strike spacing of units

Given the requirement for scraper cleaning, units should be spaced a minimum of 1.5m apart on strike, with a more usual spacing being 2.0m. This results in a dip spacing of 2.5m. Given the rectangular shape of falls, closer strike spacing can be investigated, with increasing dip spacing, to achieve an optimal balance. (3)

Maximum distance from the face for installing elongates

Two possible methodologies:

- Keep elongates close to the face (6m max) to prevent layer separation and possible ground movement. As this lies within the blast damage area, it implies that prestressing units will be required for the elongates, with a cost implication.
- Based on the FOG database info, and given that the tendons are supporting the face area, remove the elongates to beyond the range of possible blast damage (8 – 10 m), eliminating the need for prestressing units. (2)

2.4. No, it cannot. The tendons fall within the 3.0 m height supported by the elongates, and therefore do not contribute additional support capability (in fact, they only add to the mass of the beam!) (3)

Question 3

3.1 Possible mining methods as follows:

- Block 1:
  - Shrinkage
  - Long hole open stoping

  Although numerous candidates proposed cut and fill, marks were deducted if they did not acknowledge the additional dilution that this would cause. (10)

- Block 2 (all with mechanised mining methods!):
  - Post-pillar cut and fill
  - Drift and fill
  - Multi-stage room-and-pillar (10)

Marks per block were allocated as follows:

- Up to 3 marks for diagrams / sketches
- Up to 7 marks for explanation

Very few candidates answered this question in a logical, sequenced approach. Most had no idea of realistic support systems, spans or pillar types, dimensions or strategies to be adopted.

Question 4

4.1 Any three of:

- Rock is linearly elastic – i.e. has the same loading and unloading path
- Rock is infinitely strong – i.e. no yielding or failure takes place
- Rock is homogeneous – rock mass consists of the same material throughout
- Rock is isotorpic – rock mass has the same physical properties (Young's Modulus, Poisson's ratio) in all directions (6)

4.2.a - Any 3 of the following (½ mark for variable, ½ mark for criteria):

- Energy Release Rate (ERR) – value in MJ/m^2 higher than criteria established for mine by back analysis e.g 20 MJ/m^2 or similar (answers up to 40 MJ/m^2 accepted)
- Excess Shear Stress (ESS) - value in MPa higher than criteria established for mine by back analysis e.g 10 MPa or similar (answers in positive notation accepted)
- Average Pillar Stress - value in MPa higher than criteria established for mine by back analysis e.g 2.0 x UCS of host rock or similar (answers up to 2.5 x UCS accepted)
- Rockburst Hazard Index (RHI) – absolute number (3)

4.2.b - Any 2 of the following:

- Rockwall Condition Factor (RCF) – with three ranges of values:<0.7, 0.7 – 1.0, >1.0
- Changes in maximum and minimum stress levels acting on the footwall haulage during the various mining stages, as a function of the host rock UCS
- Changes in magnitude of displacement encountered by footwall drive during the various mining stages (2)

4.2.c - All 3 of the following:

- Rockwall Condition Factor (RCF) – with three ranges of values:<0.7, 0.7 – 1.0, >1.0
- Changes in maximum and minimum stress levels acting on the footwall haulage during the various mining stages, as a function of the host rock UCS

- Changes in magnitude of displacement encountered by footwall drive during the various mining stages (3)

4.3.a – Decreasing the Young's Modulus effectively "softens" the rock mass, so displacement will increase (2)

4.3.b - Increasing the Poisson's ratio again effectively "softens" the rock mass, so displacement (of the sidewalls) will again increase (2)

4.3.c - Increasing the cover load increases the resulting strains, and thus the displacements, so displacement will increase (2)

Question 5

5.1 Any 6 of the following:

- Compartmentalise the mine (1), to reduce the effect of large-scale events such as flooding or seismic activity (1)
- Reduce the open spans in stopes (1), cutting down on "seismic resonance" (1)
- Reduce face stress levels (1), the intensity of stress fracturing (1) and the potential for facebursting (1)
- Control closure levels in stopes (1), with effective reductions in energy release levels (1) and overall seismicity (1) (6)

5.2 Major aspects, other minor ones also marked correct: (10)

Aspect	**Strike pillars**	**Dip pillars**	**Backfill**
Typical application (1 mark)	Longwall mining	Sequential grid mining	Scattered mining, pillar extraction
Advantages (½ marks)	Parallel to drives, less influence on tunnels Advance concurrent with faces Constant face stress levels	Only becomes seismically active at end of stope life Greater potential to include geological structures	Less exposed span Better access control Better vent control
Disadvantages (½ marks)	Adjacent gully has consistently poor conditions Seismicity along entire length of gully – major access way	Influence on off-reef development Requires longer setup time	High capital setup cost High operating cost Water hazard Backfill placed on sweepings

5.3. Any four of:

- Better extraction as pillar sizes can be reduced
- Reduction of open stope spans
- Reduction in in-panel support requirements
- Better ventilation and access control
- Greater flexibility when planning mining operations
- Potential use of backfill "ribs", not full fill (4)