

EXAMINATION PAPER

SUBJECT:	EXAMINER:
CERTIFICATE IN ROCK MECHANICS: PAPER 2	K BRENTLEY
SUBJECT CODE:	MODERATOR:
COMRME	J LUCAS
EXAMINATION DATE:	TOTAL MARKS: [100]
26 MAY 2011	PASS MARK: 60%
TIME: 14:30 – 17:30	

NUMBER OF PAGES: 11

SPECIAL REQUIREMENTS: 1. Answer <u>ALL FIVE</u> questions 2. References other than those provided are not permitted. 3. Hand-held electronic calculators may be used. 4. Write 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. <u>Write in ink on the RIGHT HAND SIDE of the paper only (only the right hand pages will be marked).</u> 6. Show all calculations on which your answers are based. 7. Illustrate your answers by sketches of diagrams wherever possible. 8. In answering these questions, full advantage should be taken wherever necessary of your practical experience as well as of the data given. 9. Answers must be given to an accuracy that is typical of practical conditions.

QUESTION 1

Multiple Questions

1.1 During normal support design in dynamic conditions the general rule requires the support to cater for a rock travelling at:

- | | | | | |
|----|--------------|----|--------------|-----|
| a) | 30E3 mm/min | b) | 60E3 mm/min | |
| c) | 180E3 mm/min | d) | 300E3 mm/min | (2) |

1.2 What are the generally accepted units for ERR?

- | | | | | |
|----|-------------------|----|--------------------------------|-----|
| a) | mN/m ² | b) | MPa | |
| c) | MJ/m ² | d) | It has no units. It is a ratio | (1) |

1.3 According to Barton, the expression ESR is related to:

- | | | | | |
|----|--------------------------|----|-----------------------|-----|
| a) | Excavation Support Ratio | b) | Excavation Span Ratio | |
| c) | Excavation Stress Ratio | d) | Excavation Size Ratio | (1) |

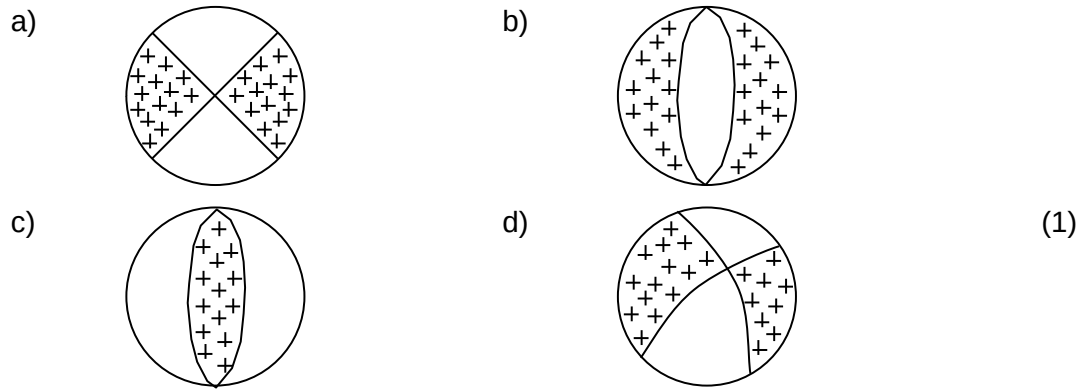
1.4 What will be the maximum vertical subsidence calculated when using the following formula:

$$\frac{S_m}{0.39(h)} = \left[\frac{W}{H} \right]^{0.32}$$

Where the stoping width is 100cm, the depth is 100m and the stoping span is 80m?

- | | | | | |
|----|--------|----|-------|-----|
| a) | 363mm | b) | 158mm | |
| c) | 4.06mm | d) | 931mm | (2) |

1.5 In seismic focal mechanisms for common faults, which of the representations represent a pure normal fault slip (shade areas are marked with +++) which denotes compression P wave motions?



1.6 What criterion (for metals) states that the yielding occurs at a maximum elastic shear strain energy?

- | | | |
|-------------|--------------|-----|
| a) Fulcrum | b) Von Mises | |
| c) Voussoir | d) Lamé | (1) |

1.7 In slope stability when the material is said to be in a state of “limit equilibrium” this is called the:

- | | | |
|--------------------|------------------|-----|
| a) Rankine state | b) Maxwell state | |
| c) Newtonian state | d) Kelvin state | (1) |

1.8 The MRMR system in rockmass characterization and classification was introduced by:

- | | | |
|--------------|-----------|-----|
| a) Bienawski | b) Barton | |
| c) Laubscher | d) Hoek | (1) |

1.9 The acronym GSI for jointed rock masses developed in 2003 by Hoek refers to:

- | | | |
|-------------------------|------------------------------|-----|
| a) Ground Span Index | b) Geological Stress Index | |
| c) Ground Support Index | d) Geological Strength Index | (1) |

1.10 The clear vertical distance between the top of a pile of caved ore and the in-situ cave back is called the _____.

- | | | |
|------------------|------------|-----|
| a) Cave boundary | b) Goaf | |
| c) Air gap | d) Chimney | (1) |

1.12 Which one does not fit?

- | | | |
|-----------------------------|--------------------------|-----|
| a) Stereographic projection | b) Wulff projection | |
| c) Equal angle projection | d) Equal area projection | (1) |

1.13 Which criteria do not fit?

- | | | |
|-------------------------------------|---|-----|
| a) Griffith Crack Analysis | b) Hoek & Brown Empirical Strength criteria | |
| c) Lade Empirical Strength Criteria | d) Tresca's Criterion | (1) |

1.14 When positioning two parallel tunnels to avoid stress interaction, the rule of thumb is to place the tunnels how far apart?

- | | | |
|--|--|-----|
| a) The combined width of the tunnels | b) 3 x The width of the largest tunnel | |
| c) 2 x The combined width of the 2 tunnels | d) 3 x The combined width of the 2 tunnels | (1) |

1.15 On the analysis of seismicity in time, the slope of the $\sum V_A$ (Cumulative Apparent Volume) reflects changes in the:

- | | | |
|----------------|-----------|-----|
| a) Strain rate | b) Stress | |
| c) Viscosity | d) Energy | (1) |

1.16 When using MRMR values to determine slopes and the value calculated is 20, by using your engineering judgment, what will your anticipated overall slope angle be?

- | | | |
|--------------------|---------------------|-----|
| a) $< 35^\circ$ | b) $36 - 50^\circ$ | |
| c) $51 - 75^\circ$ | d) $76 - 100^\circ$ | (1) |

1.17 When designing shaft pillars and associated excavations, the major principal stress to limit deformation should be reduced to the critical stress which is normally given as:

- | | | |
|-------------------------|-------------------------|-----|
| a) σ_c | b) $\frac{\sigma_c}{3}$ | |
| c) $\frac{\sigma_c}{4}$ | d) $\frac{\sigma_c}{2}$ | (1) |

1.18 In monitoring and instrumentation, the deviation of the output or reading from a known input, indicates the:

- | | | |
|----------|--------------|-----|
| a) Error | b) Accuracy | |
| c) Drift | d) Precision | (1) |

1.19 The Hoek and Brown failure criteria is best suited in a discontinuum model where two fault planes are the main modes of failure.

- | | | |
|---------|----------|-----|
| a) True | b) False | (1) |
|---------|----------|-----|

[20]

QUESTION 2**SUPPORT DESIGN**

The ability of a tendon to yield under dynamic loading conditions is critical. From observations made at an underground site it is evident that a 3m wide tunnel can only be subjected to 500mm of deformation after which the movement of hoppers becomes restricted. If the energy at the maximum tolerable deformation is 25kJ:

2.1 Calculate the minimum yield force for the given displacements:

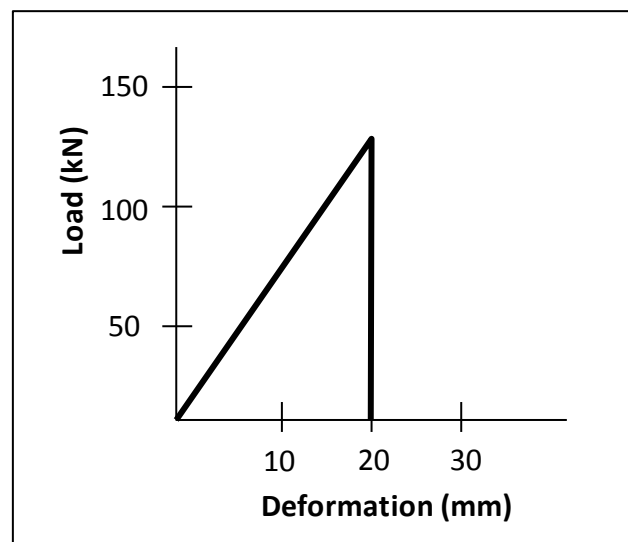
Displacement (mm)	Minimum Yield Force (kN)
100	
200	
300	
400	
500	

(3)

2.2 Plot the ground support reaction curve for the intervals as calculated above.

(3)

2.3 The load / deformation graph below is that of a 16mm diameter steel tendon. You are required to plot this onto your graph.



- Given that this tendon is used in the 3m tunnel, do you think it will satisfy the energy criteria of 25kJ? (2)
- 2.4 Calculate the energy of the tendon for the load and displacement indicated on the graph. (2)
- 2.5 Calculate the distance the tendon will be required to yield in order to satisfy the 25kJ criteria at a load of 125kN. (2)
- 2.6 List, sketch and describe two yielding type grouted tendons generally used in the mining industry with the installation of mesh and lace type support. Show a typical load displacement graph for each unit. (8)

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QUESTION 3**Support Assessment**

You have been requested to assess the primary hangingwall and sidewall support design of an underground tunnel. You are given the following information:

- 95% of the cumulative fallout thickness of the hangingwall was calculated at 1.5m.
- Accident statistics revealed that the fallout width from the sidewalls is 0.5m
- The tunnel dimensions are 5.0m wide and 3.0m high.
- Density is 2.71 tons/m³
- Primary roof and sidewall support consists of 120 kN x 1,8m long-end anchored rockstuds spaced 2.0m x 2.0m apart.
- Gravity is 9.81m/s²

- 3.1 Calculate the support resistance and factor of safety for both the hangingwall and sidewall. (8)
- 3.2 Based on the factor of safety, comment on the support installed. (2)
- 3.3 Considering that you are unable to change the support type, length and load, what will you recommend as a spacing to achieve a factor of safety of 2 (two) for the hangingwall? (5)
- 3.4 Do you consider the hangingwall primary support to be adequate? Motivate your answer. (2)
- 3.5 The excavation is planned to be a long-term return airway. What additional support recommendations would you consider? Motivate your answer. (2)
- 3.6 Describe a quality control method used to ensure long-anchors are properly tensioned. (1)

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QUESTION 4**General Mining**

You are the rock engineer on a mine that practices shrinkage as a mining method. Following a serious fall of ground accident that occurred in one of the draw points, you have been requested to draw up a check list that will be used by the production supervisors to audit the draw points and surrounding tunnels on the mine.

- 4.1 Draw a typical shrinkage stoping operation with annotations. (2)
- 4.2 List and briefly discuss rock related aspects you will consider for the audit check list. (10)
- 4.3 Pre-conditioning is commonly used in deep, hard rock mining to control face bursting.
- (i) Briefly describe how pre-conditioning assists in reducing the hazard of face strain bursts. (2)
- (ii) List the two pre-conditioning methods with advantages and disadvantages. (6)

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QUESTION 5

General

5.1 Fill in the missing words:

- i) A seismic event is the result of _____ accumulation in rock due to stress. (1)
- ii) The _____ and _____ released by a mine seismic event can be calculated directly from geophone data. (2)
- iii) Two types of body waves are generated during a seismic event. Only the _____ wave can be transmitted in solid materials, gases and liquids. (1)
- iv) The formula: $4 \times \text{pillar area} / \text{pillar perimeter}$ is the formula for _____ . (1)
- v) The mapping of unknown structures based on a rapid, non-destructive, high resolution, electromagnetic reflection is generally referred to as _____ . (1)
- vi) Geologists use a reliable diagnostic test of relative hardness to identify minerals in the field. This is called the _____ Scale of Mineral Hardness. (1) [7]

5.2 For a square excavation in a caving operation the stable hydraulic radius calculated is at 5.0. What is the length of the excavation in meters? (3)

5.3 Explain shortly what the difference between closure and convergence is. (2)

5.4 What type of wood is normally used in mining timber applications? (1)

5.5 What is the standard strength, in MPa, of the steel that is normally used in the manufacturing of steel tendons for support purposes? (1)

5.6 Sketch and annotate a section of a Horst and Graben structure and show relative displacements. (3)

5.7 Using your knowledge of a periodic table, write down the correct symbol for the following minerals:

- a) Gold
 - b) Copper
 - c) Lead
 - d) Silver
 - e) Platinum
 - f) Iron
- (3)

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TOTAL MARKS : 100