

EXAMINATION PAPER

SUBJECT: CERTIFICATE IN STRATA CONTROL – METALLIFEROUS OPTION SUBJECT CODE: COMCSC EXAMINATION DATE: 17 MAY 2011 TIME: 14:30 – 17:30	EXAMINER: G KOTZE MODERATOR: DA ARNOLD TOTAL MARKS: [100] PASS MARK: 60%
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NUMBER OF PAGES: 7

SPECIAL REQUIREMENTS:

1. Answer all of the Questions 1 to 5

2. Start each question on a new page.
3. References other than those provided are not permitted.
4. Hand-held electronic calculators may be used. Text (reference notes) may not be programmed in a programmable calculator
5. 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.

6. Write in ink on the RIGHT HAND SIDE of the paper only (only the right hand pages will be marked).

7. Show all calculations on which your answers are based.
8. Illustrate your answers by sketches or diagrams wherever possible.
9. In answering these questions, full advantage should be taken wherever necessary of your practical experience as well as of the data given.
10. Answers must be given to an accuracy that is typical of practical conditions.

Question 1 – General

In each case, write down the correct answer. It is not required to show your calculations

- 1.1 The peak stress of a cylindrical rock sample, which is subjected to a UCS test is 165 MPa. The strain at this point is 3×10^{-3} . The elastic modulus (E) in GPa is:
a) 55 b) 5.5 c) 550 d) 3 e) none of these are correct (2)
- 1.2 The radius of the above sample is 24.1 mm and its height is 0.0974 m. The volume of the specimen in m^3 is:
a) $1.78\text{E-}04$ b) 0.178 c) 1.78 d) $1.78\text{E-}06$ e) none of these are correct (2)
- 1.3 The mass of a rock sample is 200 kg. The sample is placed on a flat surface and an object that exerts a force of 10 N is placed on top of the rock. Assume that $g=9.81 \text{ m.s}^{-2}$. The normal downward force (in Newtons) experienced by the flat surface is:
a) 1972 b) 210 c) 2010 d) 190 e) none of these are correct (2)
- 1.4 The k-ratio is 0.7. If the horizontal virgin stress is 30 MPa, the vertical virgin stress in MPa is :
a) 42.86 b) 21 c) 23.33 d) 15.00 e) none of these are correct (2)
- 1.5 If the virgin stress is 20 MPa and the induced stress is 10 MPa, the field stress in MPa is:
a) 10 b) 30 c) 15 d) 20 e) none of these are correct (2)

- 1.6 The following lengths of individual pieces of core is recovered out of a total length of drill run of 3m: 0.1 m, 0.3 m, 0.7 m, 0.3m. The RQD is
a) 1.4% **b)** 35% **c)** 47% **d)** 1% **e)** none of these are correct (2)
- 1.7 A dyke is an example of the following type of rock:
a) Metamorphic **b)** Ultra-paleo **c)** Igneous **d)** Sedimentary **e)** none of these are correct (2)
- 1.8 The capacity of a support type is 20 units. The demand on the support unit is 15 units. Therefore the factor of safety is:
a) 0.75 **b)** 1.33 **c)** 1.0 **d)** 300 **e)** none of these are correct (2)
- 1.9 The prevailing stress value in a particular direction is 20 MPa. The effect of pore pressure that was induced can be expressed as 10 MPa. The effective stress (MPa) is:
a) 30 **b)** 10 **c)** 15 **d)** 40 **e)** none of these are correct (2)
- 1.10 A method for determining the indirect tensile strength of a material is referred to as:
a) Geo-hammer **b)** GPR **c)** Brazillian disk **d)** UCS **e)** none of these are correct (2)
- [20]**

QUESTION 2 – ROCK STRENGTH

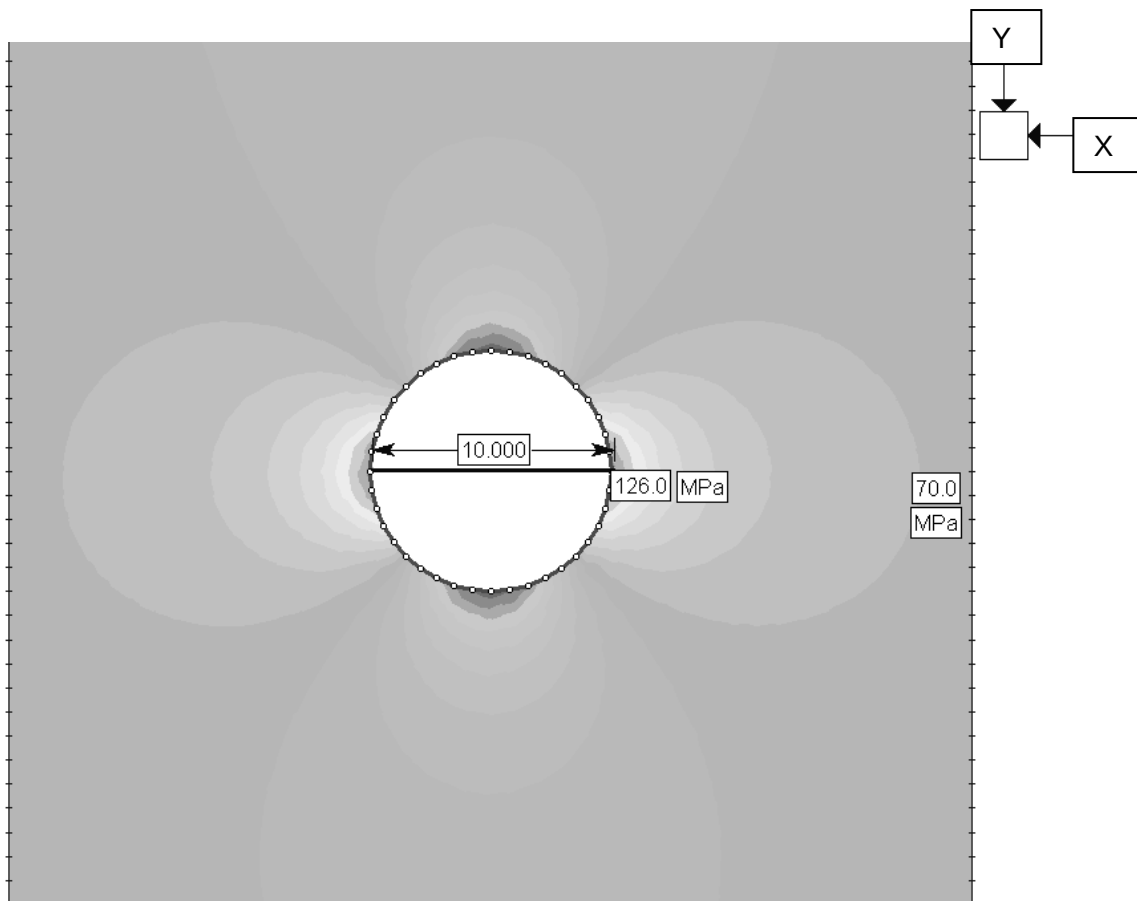
- 2.1. Explain the differences between a strength criterion and a constitutive relation (4)
- 2.2. Give examples of two constitutive relations and describe each relation. Include a graph in your descriptions for each (8)
- 2.3. Describe the Hoek-Brown criterion (3)
- 2.4. Describe two shortcomings of the Hoek-Brown criterion (4)
- 2.5. Name one other strength criterion (1)
- [20]**

QUESTION 3 – EXCAVATION STABILITY, PILLAR STRENGTH AND LOADING

- 3.1. The following equation is given:

$$\sigma_{\theta\theta} = \frac{1}{2} q(1+k) \left(1 + \frac{R^2}{r^2} \right) + \frac{1}{2} q(1-k) \left(1 + \frac{3R^4}{r^4} \right) \cos 2\theta$$

- 3.1.1 Which quantity is expressed by this equation and for which type of excavation is it valid? (2)
- 3.1.2. (a) Does the equation provide a solution for a 2D or a 3D state of stress or strain. (1)
(b) Provide the terminology which describes the special state of stress or strain contemplated by the equation? (1)
- 3.1.3. Simplify the equation above for the case when horizontal virgin stress is equal to vertical virgin stress. (3)
- 3.1.4. The plot below was obtained from a 2D boundary element numerical modelling program. The quantity that is contoured is the vertical stress around the tunnel (section view) at a depth of 2400m below surface. The value of the vertical stress in the skin of the excavation is indicated. The diameter is also given in meters. Compare the value of stress in the skin as indicated by the modelling with a calculation that you must perform using the simplified equation in 3.1.3. Assume that $g = 9.81 \text{ m/s}^2$, the density of the rock = 2700 kg/m^3 and $E = 70 \text{ GPa}$. (5)



- 3.2. What is meant by the term tributary area theory? (3)
- 3.3. A hard rock, tabular orebody is mined using a regular board and pillar layout. The mine plan indicates an area at a certain depth below datum where an APS of 10 MPa was calculated. The collar elevation of the shaft is 20m below datum. The boards are 10 m wide and the square pillars are 15 m wide, respectively. Assume that the density of the rock is 3000 kg.m^{-3} . Assume $g = 10 \text{ m.s}^{-2}$.
- 3.3.1 Calculate the depth of the orebody below surface. (3)
- 3.3.2 If the pillar strength is 15 MPa, calculate the factor of safety. (2)
- [20]

Question 4 – TESTING AND MONITORING METHODS (20 MARKS)

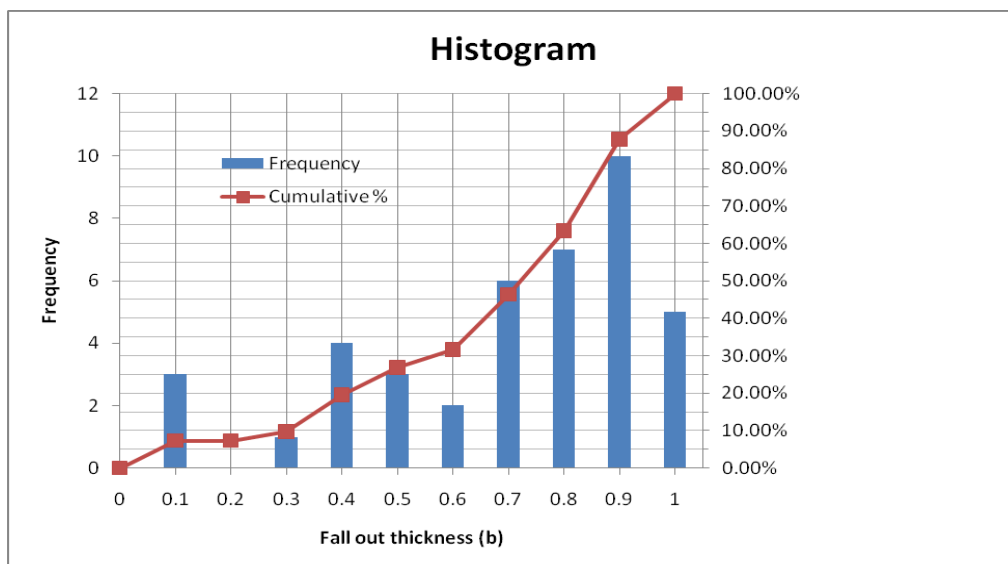
- 4.1 Describe the geophysical technique of Ground Penetrating Radar, and name a typical application. (3)
- 4.2 State the six parameters that uniquely characterise a seismic event. (6)
- 4.3 State whether the following statements are true or false. If false, indicate a reason to motivate your answer:
- 4.3.1 When determining the orientation of a feature through a borehole camera inspection, strike and dip uniquely describe the orientation of such a geological feature. (2)
- 4.3.2 Normal faulting results in a loss of ground due to the displacement of the reef. (2)
- 4.3.3 Geophones measure ground acceleration. (2)

- 4.3.4 Geological discontinuities such as joints and faults increase rock mass strength (2)
- 4.3.5 A joint plane which is exactly orientated in the plane of the major and the minor principle stress is contributing towards stability of the ground conditions. (2)
- 4.4 Give one example of an instrument that can be used to monitor in-situ load deformation characteristics of an elongate support unit (1)

[20]

QUESTION 5 – MINING (ROCK BREAKING) AND STOPE SUPPORT DESIGN

- 5.1. When breaking rock by means of explosives, some factors need to be considered in the design of the blast. Explain each of the following terms and indicate their role: stemming; burden; hole diameter. (6)
- 5.2. (a) You are provided with the composite graph below which represents a Histogram of fall out thickness in metres (for rock falls and rock bursts) and a line graph of cumulative fallout thickness (for rock falls and rock bursts). Determine the 95% cumulative fallout height under both rockfall and rockburst conditions from the graph below. (1)



(b) You are also given the following additional information:

- Rock density = $2\,650\text{kg/m}^3$;
- The hangingwall must be brought to rest within 0.2m of downward movement;
- The ejection velocity is 3m/s;

Determine rockfall support resistance and rockburst energy absorption criteria. (4)

- 5.3 Describe the term 'bedding in' in timber based support units. (2)
- 5.4 Describe the effect of loading rate on the performance of timber support units when comparing the load / deformation characteristic determined in laboratory tests to the performance under i) quasi-static (rockfall) and ii) dynamic (rockburst) conditions. You must include a graph as an aid to your description. (5)

- 5.5 Laboratory press test results yield the following information about a prototype elongate support unit:

Force (kN)	Deformation (mm)
500	38
1 000	54
1 500	70
2 000	100
2 500	168
3 000	240

The rock engineer has designed an elongate support layout such that each of these prototype elongates will support 5 m^2 . With the aid of the laboratory test data, determine how much deformation would be measured on the elongate if the dead weight created by a 5m thick hangingwall beam is to be supported? The density of the hangingwall rock is 2700 kg/m^3 and you can assume that $g = 9.81 \text{ m/s}^2$.

(2)

[20]

TOTAL MARKS : 100