

EXAMINATION PAPER

SUBJECT: CERTIFICATE IN STRATA CONTROL – METALLIFEROUS OPTION SUBJECT CODE: COMCSC EXAMINATION DATE: OCTOBER 2011 TIME: 3 Hours	EXAMINER: G KOTZE MODERATOR: DA ARNOLD TOTAL MARKS: [100] PASS MARK: 60%
--	---

NUMBER OF PAGES: 8

SPECIAL REQUIREMENTS:

1. ANSWER ALL OF THE QUESTIONS 1 TO 5. IN EACH CASE NOTE THE INSTRUCTIONS THAT APPLY
 2. ANSWER QUESTION 1 on the answer sheet and hand in with your script.
 3. Start each question on a new page.
 4. References other than those provided are not permitted.
 5. Hand-held electronic calculators may be used. Text (reference notes) may not be programmed in a programmable calculator
 6. 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.
7. **WRITE IN INK ON THE RIGHT HAND SIDE OF THE PAPER ONLY (ONLY THE RIGHT HAND PAGES WILL BE MARKED).**
 8. Show all calculations on which your answers are based.
 9. Illustrate your answers by sketches or diagrams wherever possible.
 10. In answering these questions, full advantage should be taken wherever necessary of your practical experience as well as of the data given.
 11. Answers must be given to an accuracy that is typical of practical conditions.

QUESTION 1 – GENERAL PROFICIENCIES REQUIRED BY THE SC SYLLABUS

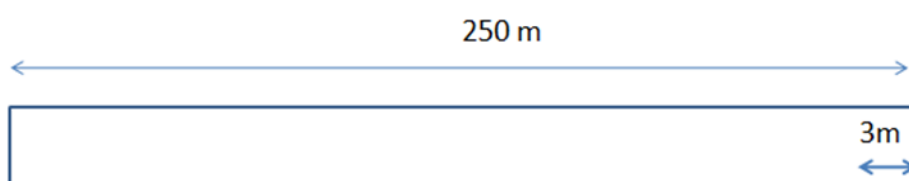
(40 MARKS, 2 MARKS EACH, 8 BONUS MARKS IF YOU SUCCESSFULLY ATTEMPT THE LAST 4 QUESTIONS AS WELL. NOT MARKING NEGATIVELY)

INSTRUCTIONS:

1. USE THE ANSWER SHEET THAT IS PROVIDED.
2. ON THE ANSWER SHEET, INDICATE THE CORRECT ANSWER WITH AN (X).
3. CHOOSE A, B, C, D OR E.
4. DO NOT WRITE DOWN THE VALUE OF THE ANSWER!
5. IT IS NOT REQUIRED TO SHOW YOUR CALCULATIONS.
6. CALCULATIONS WILL NOT BE CONSIDERED.

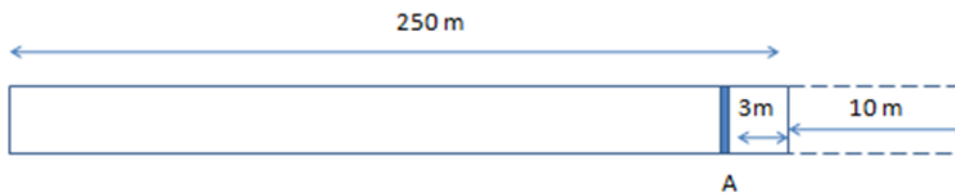
- 1.1 What is the volume of timber contained in a 55 cm x 55 cm mat pack installed in a stoping width of 1.2m?
a) 3.63 m³ b) 0.363 m³ c) 0.0363 m³ d) 0.00363 m³ e) none of the above
- 1.2 If the timber material (in question 1.1) has a density of 0.700 t/m³, what is the mass of the pack?
a) 0.254 t b) 0.254 kg c) 2.54 kg d) 0.254 kg e) none of the above
- 1.3 How many packs (in question 1.2) could theoretically be transported on a truck with a 20 t bearing capacity?
a) 7.87 b) 800 c) 78.7 d) 787 e) none of the above
- 1.4 A perfectly square shaped haulage (developed on strike) on a gold mine, is 3.5m wide. The sidewalls are 3.5m high. Calculate the area of wire mesh per meter of tunnel length that is required to support the tunnel if it extends to within 1m of the footwall.
a) 16 m² b) 1.6 m² c) 4.25 m² d) 8 m² e) none of the above
- 1.5 If the virgin stress is 30 MPa and the induced stress is -10 MPa, the new field stress in MPa is:
a) 20 b) -20 c) -10 d) 40 e) none of the above
- 1.6 The potential energy (in Joule) of a key block of mass 50 kg, that can dislodge from the hangingwall of a tabular stope of 1.5m stope width is (g=9.81 m/s²):
a) 735.8 J b) 73.58 J c) 73.58 kJ d) 735.8 kJ e) none of the above

- 1.7 The key block in question 1.6, has dislodged. The kinetic energy of the key block, 50 cm above the footwall of the stope, is:
- a) 245.25 J b) 735.75 J c) 490.5 J d) 490.5 kJ e) none of the above
- 1.8 What is the value of the kinetic energy of the key block (in question 1.6) when it impacts the footwall?
- a) 73.58 J b) 735.8 J c) 735.8 kJ d) 73.58 kJ e) none of the above
- 1.9 The capacity of a tendon is 450 MPa. The demand on the tendon is 150 MPa. Therefore the factor of safety is:
- a) 30 b) 0.3 c) 1.6 d) 3 e) none of the above
- 1.10 The field stress value in a porous rock is 23 MPa. Water is then injected and all factors considered, causes a change of 13 MPa in pore pressure. The effective stress is:
- a) 36 b) 23 c) 13 d) 10 e) none of the above
- 1.11 A tectonic stress component is superimposed on a field stress in a numerical simulation. The stresses are both acting in the north direction. The value of the stresses is 10 MPa and 90 MPa, respectively. The resultant stress (in MPa) expected from the simulation is:
- a) 70 b) 100 c) 200 d) 160 e) none of the above
- 1.12 My colleague says his 'weight' is 101 kg. Given: $g=9.81 \text{ m/s}^2$, $G=6.6738 \times 10^{-11} \text{ N (m/kg)}^2$ (Universal Gravitational Constant). Determine his mass and weight:
- a) 101 kg, 991 N b) 101 kg, 101 N c) 101 kg, 101 kg d) 991 kg, 991 N e) none of the above
- 1.13 A long, tabular, horizontal stope of 250 m span and 1 m stope width is excavated in competent rock at a depth of 1360 m. The density of the rock is 2998 kg/m^3 . Assume that the rock around the stope behaves in elastic manner and that $G= 30\,000 \text{ MPa}$ as well as Poisson's ratio is 0.20. The elastic convergence in the stope at a distance of 3m behind the face (see diagram) is:



- a) 600mm b) 0.00058m c) 58mm d) 5.8mm e) none of the above

1.14 Refer to question 1.13. A timber elongate is installed 3m behind the face at point A. By how much will the elongate be compressed by the time the span has been increased a further 10 m at the one end (as indicated):



- a) 630mm b) 0.00063m c) 63mm d) 6.3mm e) none of the above

1.15 The recommended design for the width to height ratio of crush/yield pillars is:

- a) >3 b) <3 c) =3 d) >30 e) none of the above

1.16 Mat packs have a support force of 2200 kN when compressed by 200 mm. The dip x strike spacing is 2.5 m centre to centre in a tabular stope. The support resistance is:

- a) 352 kN/m² b) 352 N/m² c) 3.52 kN/m² d) 3.52 N/m² e) none of the above

1.17 Given datum = 500 m above surface, k-ratio = 0.5 and density of the overburden is 2.7t/m³. Assume g = 9.81 m/s². Calculate the virgin stress level at 2500 m below datum in MPa:

- a) 17.6 b) 105 c) 26.5 d) 52.9 e) none of the above

1.18 An example of a sedimentary rock type is:

- a) Ferrochrome b) Uranium Oxide c) Quartzite d) sandstone e) none of the above

1.19 An example of a metamorphic rock type is:

- a) Sandstone b) Mudstone c) Siltstone d) Quartzite e) none of the above

1.20 An example of an igneous rock type is:

- a) Quartzite b) Sandstone c) Dyke d) Uranium Oxide e) none of the above

1.21 The initial stiffness of a timber elongate compared to a mat pack is as follows:

- a) Lower b) Similar c) Higher d) Not reasonable to compare e) none of the above

1.22 The horizontal stress is 20 MPa and the vertical virgin stress is 50 MPa. The k-ratio is:

- a) 0.8 b) 0.4 c) 0.6 d) 20 e) none of the above

1.23 Given the Hoek-Brown criterion for a rock specimen with $\sigma_3=0$, $s=1$, $\sigma_c=180$ MPa. Calculate the peak strength of the rock (MPa).

$$\sigma_1 = \sigma_3 + \sqrt{m\sigma_c\sigma_3 + s\sigma_c^2}$$

- a) 90 b) 225 c) 180 d) 30 e) none of the above

1.24 The k-ratio in the Bushveld Complex is typically:

- a) =1 b) >1 c) <1 d) -1 e) none of the above

QUESTION 2: DEFINITIONS AND TERMINOLOGY (15 MARKS, 5 BONUS MARKS IF YOU SUCCESSFULLY ATTEMPT 2.6 AND 2.7 AS WELL)

INSTRUCTIONS:

- 1. DEFINE OR ALTERNATIVELY IN EACH CASE, CLEARLY DESCRIBE THE FOLLOWING TERMS**
- 2. GIVE UNITS OF MEASUREMENT.**
- 3. IF NO UNIT OF MEASUREMENT APPLIES, YOU MUST STATE IT CLEARLY. MARKS WILL NOT BE AWARDED IF YOU ARE NOT CLEAR IN YOUR ANSWER ABOUT THE UNITS.**

- 2.1. RCF (3 marks)
- 2.2. Stope convergence (3 marks)
- 2.3. Stope Closure (3 marks)
- 2.4. Poisson's ratio (3 marks)
- 2.5. Gravitational acceleration (3 marks)
- 2.6. Shear stress (3 marks)
- 2.7. Gravity (2 marks)

QUESTION 3: ROCK TESTING (20 MARKS)

3.1. Two gauge marks 3 cm apart are made along the axis of a cylindrical rock specimen of length 6 cm and 7 cm² cross-sectional area. The specimen is subjected to uni-axial compressive loading of 100 kN along the long axis of the specimen. Assume that the tests are done under elastic conditions. Therefore assume, $E = 60 \text{ GPa}$ and $\nu = 0.3$. Find:

3.1.1 Stress in the specimen; (3 marks)
142.86 MPa

3.1.2 Strain in the specimen; (3 marks)
0.00238

3.1.3 Contraction (reduction along axial direction) between the gauge marks (3 marks);
 $7.14 \times 10^{-5} \text{ m}$

3.1.4 Total contraction (reduction along axial direction) of the specimen (3 marks).
 $1.428 \times 10^{-4} \text{ m}$

3.2. Explain with the aid of a diagram the difference between uni-axial and tri-axial loading. (3 marks)

Graphs of uniaxial tests and triaxial tests showing a stress strain curve for each scenario OR drawings showing a cylindrical sample loaded axially and triaxially (stresses or forces indicated in 1D AND 3D, respectively) accompanied by an explanation were accepted.

Keywords :

Uniaxial loading= load of sample along single axis

Triaxial loading= load of sample along three perpendicular axis.

3.3. Draw the complete stress-strain curve of a hard rock specimen under uni-axial compression. Assume that there is residual strength left in the specimen towards the end of the loading process. Indicate the following:

3.3.1. Portion of the curve that is used to calculate the Young's Modulus

3.3.2. Yield point

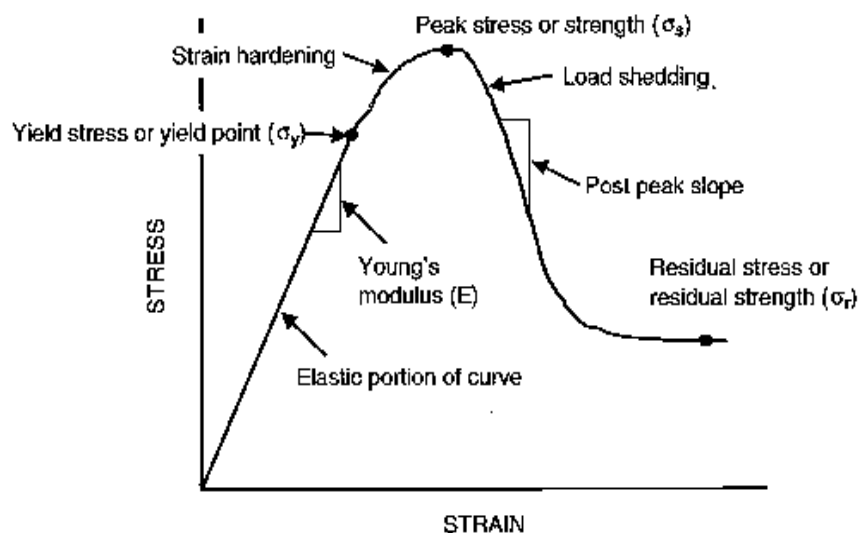
3.3.3. Strain hardening

3.3.3. Strain softening

3.3.4. Residual strength portion of the curve.

(5 marks)

Notes: Candidates that used a point to indicate a phenomenon over a range of stress – strain values were penalised. E.g. Strain hardening occurs over a portion of the curve not at a point



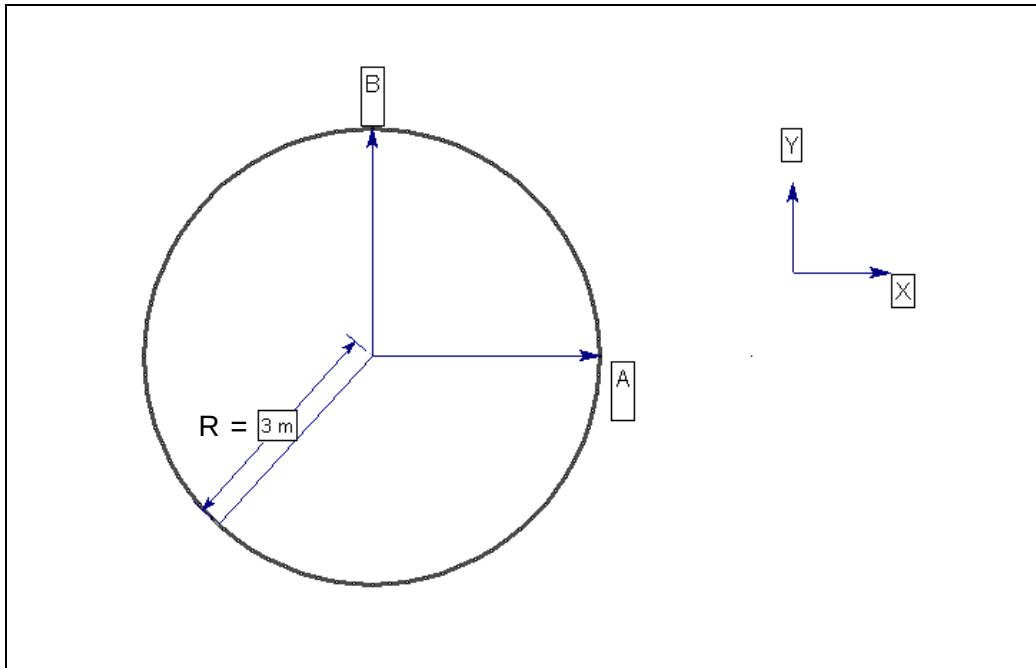
QUESTION 4: EXCAVATION STABILITY (20 MARKS)

4.1. The following equations and diagram are provided:

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

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

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



For the circular excavation shown above, at a depth of 1900 m (k-ratio=0.5), calculate the following (assume: $g = 9.81 \text{ ms}^{-2}$, $\rho = 2750 \text{ kg.m}^{-3}$):

4.1.1 The tangential stress at point A on the perimeter. (7 marks)

Virgin stress correct at 51.23 MPa (2 marks)

$\sigma_{\theta\theta} = 128.14 \text{ MPa}$

4.1.2. The radial stress at point B on the perimeter. (7 marks)

$\sigma_{rr} = 0 \text{ MPa}$

4.1.3. The induced stress at point B on the perimeter in the Y-direction. (3 marks)

$\sigma_{rr} - \text{Virgin vertical stress} = 0 - 51.23 \text{ MPa} = -51.23 \text{ MPa}$

4.2. Describe the phenomenon of 'gothic arching' observed in the tunnels of some mines in the Bushveld Complex with the aid of a sketch, clearly indicating the direction of principle stresses. Make reference to k-ratio in your answer. (3 marks)

A break out occurs in the hangingwall of the tunnel due to high horizontal stresses. K-ratio is greater than 1.5 typically in Bushveld and therefore this phenomenon is common.

This explanation accompanied by a simple diagram got the candidate full marks.

See drawing on :P201 Jager and Ryder

QUESTION 5: MONITORING (5 MARKS)

State and briefly describe the objectives of monitoring in the rock engineering design process.

Answer:

- To record the natural values of, and variations in, geotechnical parameters before the start of a project.
- To ensure safety during mining by giving warning of unexpected or excessive deformations/parameters
- To confirm the validity of assumptions and modeling used in design calculations.
- To confirm support and layout performance in particular environments.