

## EXAMINATION PAPER

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| <b>SUBJECT:</b><br><br>CERTIFICATE IN STRATA CONTROL (COAL)<br><br><b>SUBJECT CODE:</b><br><br><br><b>EXAMINATION DATE:</b><br><br>OCTOBER 2012<br><br><b>TIME:</b> | <b>EXAMINER:</b><br><br>D. NEAL<br><br><b>MODERATOR:</b><br><br>B. MADDEN<br><br><b>TOTAL MARKS:</b> [100]<br><br><b>PASS MARK:</b> 60% |
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| <b>NUMBER OF PAGES:</b> 4 |
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### SPECIAL REQUIREMENTS:

1. Answer **ONLY FIVE** questions
2. References other than those provided are not permitted.
3. Hand-held electronic calculators may be used.
4. 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.**

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

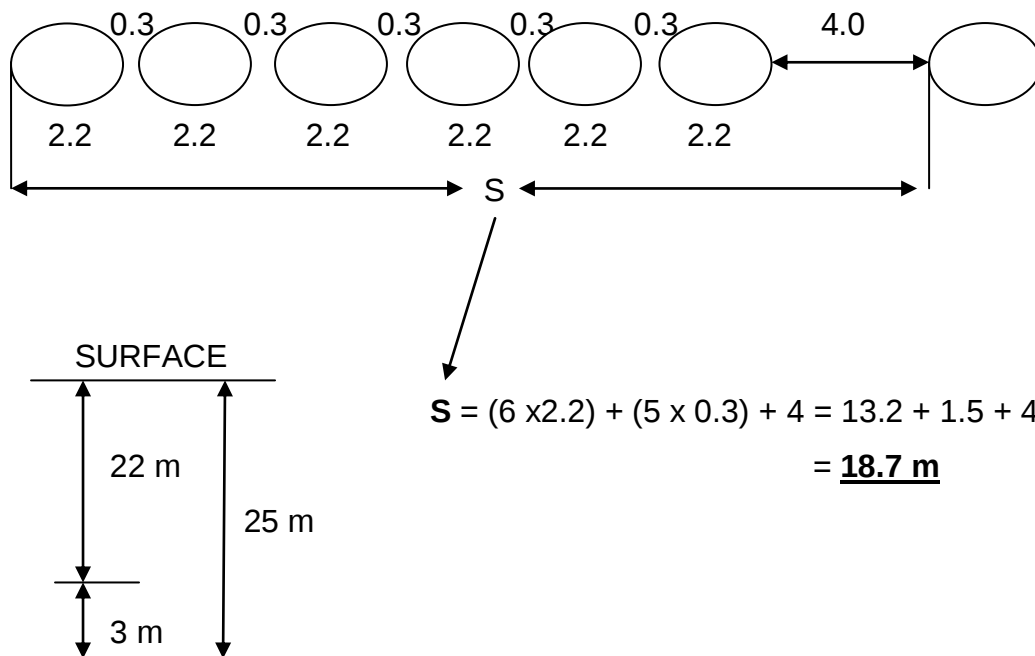
## CERTIFICATE IN STRATA CONTROL (COAL)

### QUESTION 1

A coal seam is auger mined on a highwall. The seam is 3m thick and the highwall is 25m from surface to the base of the seam. Auger hole of 2.2m diameter are drilled each separated by 0.3m. After a set of 6 auger holes a pillar 4m wide is left. All holes are 200m deep.

- 1.1 Calculate the volume and mass of coal (RD=1.5) from a set of holes (5)
- 1.2 Calculate the percentage extraction of the coal seam (5)
- 1.3 Calculate the pillar safety factor (6)
- 1.4 Comment safety around the working area during and after mining (4)

### ANSWERS



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$$\begin{aligned} 1.1 \text{ A. Volume of one hole} &= \frac{\pi}{4} D \times l \\ &= \frac{\pi}{4} (2.2 \text{ m})^2 \times 200 \text{ m} \\ &= \underline{760.364 \text{ m}^3} \end{aligned}$$

$$\begin{aligned} \text{B. Total Volume} &= \text{Volume of one hole} \times 6 \\ &= 760.362 \text{ m}^3 \times 6 = \underline{4562.184 \text{ m}^3} \end{aligned}$$

$$\begin{aligned} \text{C. Mass} &= \text{Volume} \times \text{RD} \\ &= 4562.184 \text{ m}^3 \times 1.5 = \underline{6843.276 \text{ tonnes}} \end{aligned}$$

### 1.2

$$\begin{aligned} \% \text{ Extraction} &= \frac{\text{Volume Mined}}{\text{Volume Available}} \times 100 \\ \% \text{ Extraction} &= \frac{4562.184 \text{ m}^3}{18.7 \times 3 \times 200 \text{ m}^3} \times 100 \\ \% \text{ Extraction} &= 40.66 \end{aligned}$$

### 1.3 Assume pillar carries full overburden load as tributary

Method 1: Consider **only pillar width** not  $W_e$  (Conservative). Consider 1 m slice

$$\text{i.e. } C_2 = w_2 = 1 \text{ m}$$

$$\text{Load} = \frac{25 H C_1}{w_1} = \frac{25 \times 25 \times 18.7}{4} = \underline{2921.875 \text{ kPa/m}}$$

$$\text{Strength} = \frac{7.2 \times w^{0.46}}{h^{0.66}} = \frac{7.2 \times 4^{0.46}}{2.2^{0.66}} = \underline{8096.198 \text{ kPa/m}}$$

$$SF = \frac{\text{Strength } h}{\text{Load}} = \frac{8096.198}{2921.875} = \underline{2.77}$$

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Method 2: Consider  $W_e$  in the strength calculation

$$W_e = \frac{4A}{P} = \frac{4(4 \times 200)}{408} = \underline{\underline{7.84 \text{ m}}}$$

$$\text{Strength} = \frac{7.2 \times W_e^{0.46}}{h^{0.66}} = \frac{7.2 \times 7.84^{0.46}}{2.2^{0.66}} = \underline{\underline{11035.673 \text{ kPa/m}}}$$

$$SF = \frac{\text{Strength } h}{\text{Load}} = \frac{11035.673}{2921.875} = \underline{\underline{3.78}}$$

1.4 a) During – Highwall stability

b) After – use of surface above wide potential failure span of 14.7 m

**[20 MARKS]**

### QUESTION 2

- 2.1 Draw a typical borehole column for a multi-seam area, with the various rock types noted on it along with typical thicknesses. (8)
- 2.2 Name the 3 main rock Group designations and give examples that are found in a coal mine environment. (6)
- 2.3 Describe with the use of sketches multiple slips including the variables that can influence their stability. (6)

### ANSWERS

2.1 Borehole for a multi-seam area hence at least two seams should be shown on the column. The column should be as close to reality as possible. Marks were given for

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the indication of alluvium (top/subsoil, realistic parting – min of 10 m between seams a basement strata unit).

2.1

|  |                     |
|--|---------------------|
|  | Alluvium - 10 m     |
|  | Sandstone - 3 m     |
|  | Mudstone - 1 m      |
|  | No. 5 Seam - 1.5 m  |
|  | Shale - 1 m         |
|  | Sandstone - 10 m    |
|  | No. 4U Seam - 0.5 m |
|  | Mudstone - 1 m      |
|  | No. 4L Seam - 4 m   |
|  | Sandstone - 10 m    |
|  | Shale - 3 m         |
|  | No. 2 Seam - 5 m    |
|  | Sandstone - 2 m     |
|  | Dwyka Tillite - 1 m |

2.2.1 Sedimentary Rocks – Sandstone, Shale, Mudstone

2.2.2 Igneous Rocks – Dolerite

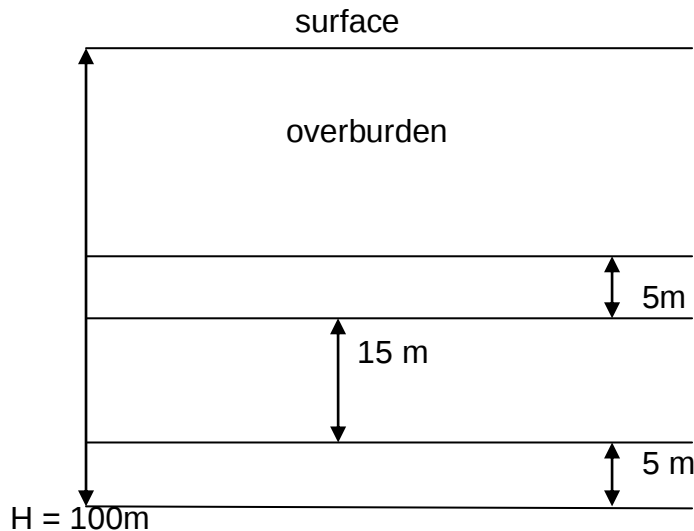
2.2.3 Metamorphic Rocks – Burnt coal

2.3 Variables – dip angle, dip direction, persistence, continuity, intersection of geol. discontinuities forming wedges, water, etc.

**[20 MARKS]**

### QUESTION 3

Two (2) seams are 5m thick, separated by a 15m parting. If the floor of the lower seam is 100m calculate the square pillar dimensions on both seams for a bord width of 7m and safety factor of 1.7. Apply Salamon's multi-seam guidelines.



| Bottom seam |       | Top seam |      |
|-------------|-------|----------|------|
| B           | 7 m   | B        | 7 m  |
| h           | 5 m   | h        | 5 m  |
| H           | 100 m | H        | 80 m |
| SF          | 1.7   |          |      |

- Iterate with different values of C or w that will maintain the required SF of 1.7

$$SF = 288 \times \frac{w^{2.46}}{H h^{0.66} C^2}$$

1. Try **C = 20 m** for Bottom seam, so w = C-B

(Parting = 0.75C)

$$SF = 288 \times \frac{13^{2.46}}{100 \times 5^{0.66} \times 20^2} = \underline{\underline{1.37}}$$

2. Try **C = 22 m** for Bottom seam, so w = C-B

(Parting < 0.75C)

$$SF = 288 \times \frac{15^{2.46}}{100 \times 5^{0.66} \times 22^2} = \underline{\underline{1.61}}$$

3. Try **C = 23 m** for Bottom seam, so w = C-B

(Parting < 0.75C)

$$SF = 288 \times \frac{16^{2.46}}{100 \times 5^{0.66} \times 23^2} = \underline{\underline{1.72}}$$

As superimposition is needed (Parting < 0.75C) pillar centres for both seams should be **23 m.**

**[20 MARKS]**

**QUESTION 4**

A weak roof skin 0.5m thick with a density of 2200 kg/m<sup>3</sup> must be suspended onto a massive sandstone roof using full column resin anchored roof bolts. The resin pullout shear resistance in sandstone is 3000 kPa. 17 ton capacity, 20mm roof bolts are used in 26mm holes. Calculate the required bolt length and spacing to suspend the weak layer with a 1.5 safety factor.

$$\text{A. } \tau = \frac{P}{\pi D L_b}$$

(There is no safety factor in the equation, the safety factor come in with the spacing calculation)

$$L_b = \frac{170\,000\text{N}}{\pi (0.026\text{m})(3000000\text{N/m}^2)}$$

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$$l_b = \frac{170000}{3,14159 \times 0,026 \times 3000000} = \frac{170000}{245044,227} = 0,694 \text{ m}$$

**B.** Bolt length = bond length + thickness of unit to be supported

**Bolt length = 0,69 m + 0,5 m = 1,19 m therefore 1,2 m bolt.**

$$C. n = SF \frac{\rho g t}{P}$$

$$n = 1.5 \times \frac{2200 \text{ kg/m}^3 \times 9.81 \text{ m/s}^2 \times 0.5 \text{ m}}{170\,000 \text{ N}}$$

$$n = \frac{161\,86.5 \text{ N}}{170\,000 \text{ N}}$$

$$n = \mathbf{0.095 \text{ bolts/m}^2}$$

$$A = \sqrt{\frac{1}{n}} = \sqrt{\frac{1}{0.095}} = \mathbf{3.24 \text{ m}}$$

The bolt length is **1.19 m** and the spacing for suspending the weak layer is **3.24 m**

**[20 MARKS]**

**ANSWER EITHER QUESTION 5 OR QUESTION 6**

#### **QUESTION 5**

List 10 items that would be found in the mines support rule and comment on the importance of each item listed.

#### **ANSWERS**

*\*List of items only*

1. Bolt spacing
2. Bolt length and diameter
3. Full column or point anchorage
4. Dimensions of intersections
5. Support for multiple slips
6. Support for sidewalls
7. Support for single slips and/or slips occurring on adjacent sides

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8. Lumo or reflective stick on second last or last line of support
9. Support for brows, scallops, dykes, splits
10. How to cut or open up splits (swaais)
11. Protective canopy on roofbolting machines
12. Pinch bars and sounding sticks in the section
13. Replacement of defective support
14. Drilling of pilot holes and installation of tell tales at over-extended intersections and on weak sides of slips
15. Checking of torque setting on roofbolter
16. Timing lights for spin and hold times

**[20 MARKS]**

### **QUESTION 6**

List 10 items that must be included in an opencast highwall and spoils inspection list and discuss each one.

### **ANSWERS**

*\*List of items only*

1. Crest conditions
2. Soil or weathered material thickness
3. Height of the highwall
4. Highwall conditions
5. Presence of ground water
6. Presence of geological discontinuities
7. Orientation of geological discontinuities
8. Highwall lithology
9. Influence of weathering
10. Potential and existing failures
11. Undercutting of spoils
12. Height of spoils
13. Saturation of spoils
14. Demarcation of dangerous areas

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15. Presence of any loose rocks at the crest
16. Fracturing associated with dykes/sills where present
17. Check if pre-split is straight with hole correctly spaced

[20 MARKS]

### Strata Control Formulae

$$S = 7,2 \frac{w^{0,46}}{h^{0,66}}$$

$$S = 3.5 \left( \frac{w}{h} \right) (MPa)$$

$$L = \frac{25 H C^2}{w^2}$$

$$\eta = \eta_o \left( 1 + \frac{2 \Delta w_o}{w} \right)^{2,46}$$

$$n = SF \frac{pgt}{Pf}$$

$$Lb = \frac{d_c^2 Lc}{D^2 - d^2}$$

$$\tau = \frac{Pf}{\pi \cdot D \cdot Lb}$$

$$\eta = \frac{\gamma L^4}{32 E t^2}$$

$$\sigma = \frac{\gamma L^2}{2 t}$$

$$FS = 288 \frac{w^{2,46}}{Hh^{0,66} (w+b)^2}$$

$$\sigma_s = 7.2 \frac{R_o^{0,5933}}{V^{0,0667}} \left\{ \frac{0.5933}{\varepsilon} \left[ \left( \frac{R}{R_o} \right)^\varepsilon - 1 \right] + 1 \right\}$$

$$\tau = c + \sigma_n \tan \phi$$

$$V_s = \frac{4 \pi r^3}{3}$$