Memorandum

Rock Mechanics Paper 2: Coal Option May 2005

1. Question 1 (a)

To mine seam A in a manner that will not jeopardise the Seam B reserves, a high safety factor is required, not less than 2.0.

Dimensions
H = 145 m
h = 3 m

Acceptable alternatives should be in the following range:

- i) Using vdM strength, B = 6 m: w = 13m, SF=1.96 C = 19 m e = 53.2%
- ii) Using Salamon strength, B = 6 m: w = 18 m SF = 2.05 C = 24 m e = 43.8%
- iii) Using vdM strength, B = 7 m : 14 m SF = 2.00 C = 21 m e = 55.6%
- iv) Using Salamon strength B = 7 m: w = 19 m SF = 1.99 C = 26 m e = 46.6%

Notes.

- If candidate included remark that wider bords = higher extraction, bonus mark awarded
- Ball-park dimensions corresponding to required SF within tolerable limits are fine

Say option ii) was chosen by candidate, then:

Total area = 2 000 ha = 2 000 x 100 x 100 = 20 000 000 m^2.
e = .438 thus recoverable area = 20 000 000 x .438 = 8 760 000 m^2
Volume = 8 760 000 x 3 = 26 280 000 m^3
Mass = 26 280 000 x 1.5 = 39 420 000 tonnes
Profit = 39 420 000 x (55-45) = R394 200 000

Question 1 (b)

The small parting, 20 m, requires that multiple seam conditions have to be considered. If parting < 0.75C, multiple seam requirements have to be met. Therefore, if C > 1.33 x parting, or C > 27 m, must super impose, etc. Candidates are expected to mention this aspect and perform the test.

If mine owns both seams, higher risk can be tolerated i.e. lower safety factor. Still assuming that candidate chose option ii) above, the following is the situation:

Seam A (h = 3 m)
w = 11.5 m C = 17.5 m e = 57%
(Note – super imposition not required)

Seam B (h = 2 m)
w = 9 m c = 15 m e = 64%
(Note – super imposition not required)

Seam A
Total area = 20 000 000 m^2
Available area = 20 000 000 x .57 = 11 400 000 m^2
Volume = 11 400 000 x 3 = 34 200 000 m^3
Mass = 34 200 000 x 1.5 = 51 300 000 tonnes

Seam B
Total area = 20 000 000 m^2
Available area = 20 000 000 x .64 = 12 800 000
Volume = 12 800 000 x 2 = 25 600 000 m^3
Mass = 25 600 000 x 1.5 = 38 400 000 tonnes

Profit from Seam A = 51 300 000 x (55-45) = 513 000 000
Profit from Seam B = 38 400 000 x (55 – 50) = R192 000 000
Total sales profit = R705 000 000

Additional cost for reserves = 20 000 000 x 2 x 1.5 x R6 = R360 000 000
Additional capital = R45 000 000
Total additional cost = R405 000 000

Remaining profit = R705 200 000 – R405 000 000 = R300 200 000

Option (a) is thus better

Notes. Candidates will not be penalised if another assumption w.r.t. bord width was chosen, as long as it was within acceptable limits, i.e. 6 to 7.5m. Using the vdM strength calculation is also acceptable, as is using the Squat Pillar formula for w:h > 5. Subtracting reasonable reserves (10 to 20%) to allow for inter panel pillars is also acceptable.

The important points are to use the appropriate safety factors, calculate the pillar widths, check for multiple seam restrictions, then use the appropriate areal extraction ratios on the two seams to calculate the tonnes and profits.

Note: If candidate understood the information given wrong, in the sense that the R6 per tonne is payable for coal extracted, the candidate will be given the benefit of the doubt. In that case:

Additional cost for reserves = 38 400 000 x R6 = R230 400 000
Additional capital = R45 000 000
Total additional cost = R275 400 000

Remaining profit = R705 200 000 – R275 400 000 = R429 600 000

Option B would then be better.

2. Question 2 Part A

(a) Calculate tensile stress in sandstone with additional load from suspended layer underneath

$$\sigma = \frac{\rho g(t_c + t_w)B^2 F}{2t_c^2}$$

$$\sigma = \frac{2480x9.81(.6+.7)6.5^2 x1.5}{2x.6^2} = 2783874 Pa = 2.78 MPa$$

Sandstone tensile strength = 5 Mpa, thus beam strong enough and weak material can be suspended.

(Note: g rounded to 10 also acceptable)

(b) Calculate spacing, use f = 1.5

$$q_c = q_l - \frac{q_w E_l - q_l E_w}{E_l - E_w} = 2480x9.81x.012 - \frac{2480x9.81x.0128x15x10^9 - 2480x9.81x.012x7x10^9}{15x10^9 + 7x10^9} = .00038$$

$$s = 1.414t\sqrt{\frac{\sigma_t}{fq_c}}$$

$$s = 1.414x.012\sqrt{\frac{5}{1.5x.00038}} = 1.59m$$

(Note, if q_c was not calculated then s = 1.61m, -2 marks)

(c) Calculate length of anchor using spacing from (b)

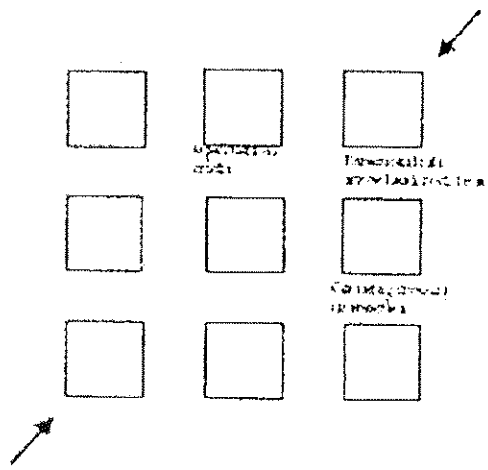
$$l_a = \frac{\rho g s^2 t_w}{\tau_c \pi d_s} - .05 = \frac{2480x9.81x1.59^2 x.7}{1200x10^3 x\pi x.025} - .05 = .65$$

Thus bolt length = 0.65 + 0.7 = 1.35 m

(Note: if spacing was incorrectly calculated no penalty for part (c) if formula applied correctly)

(d) Load on bolt = $\rho g t_w s^2$ = $9.81x2480x.7x1.59^2 = 43kN$
Stress in bolt = Load/Cross sectional area = $43x10^3/(\pi x(.018^2)/4) = 169$ MPa

Part B



Observe the following:

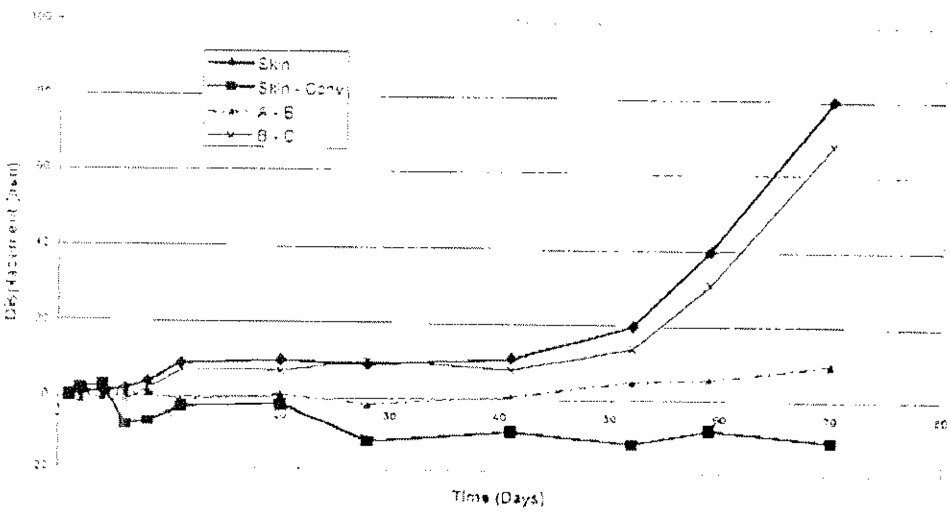
- Floor heave
- Guttering
- Open tension cracks
- Shape of roof falls (ellipsoidal or not)

If observations more or less line up linearly, almost certain that horizontal stress is a problem either due to high magnitude of stress or low strength of roof material. Highest component will be at right angels to line of gutters and long axis of roof falls, parallel to open tension cracks

3. Question 3

(a) Plot the netto displacements:

- Skin + Convergence meter = floor heave or sag
- Skin = Anchor A
- A – B = opening between A and B
- B – C = opening between B and C



(b) From the graph, the following can be seen:

- Skin movements indicate that up to 80 mm displacement has taken place in the roof, as it can be assumed that Anchor A is stable (it is in a 15 m thick sandstone layer)
- The greatest opening is seen between anchors B and C, indicating that there is a gap of 68 mm between them, i.e. at a position somewhere between 0.2 m and 0.4 m into the roof
- The floor has lifted by approximately 10 mm
- There is a small gap of 10 mm between anchors A and B

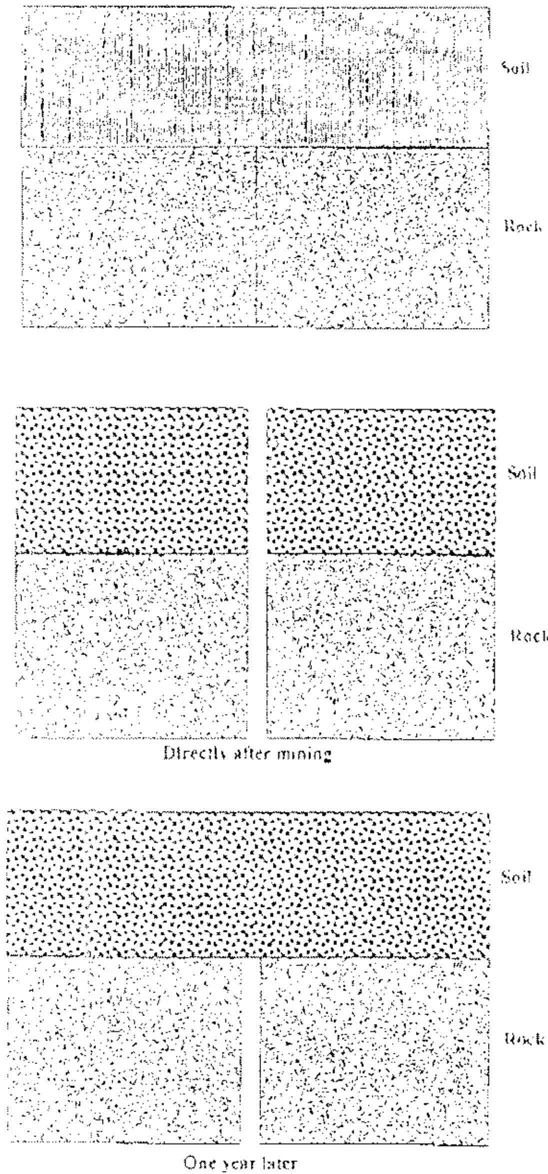
(c) The floor has stabilised, as ever since day 28 there has been no further significant displacement

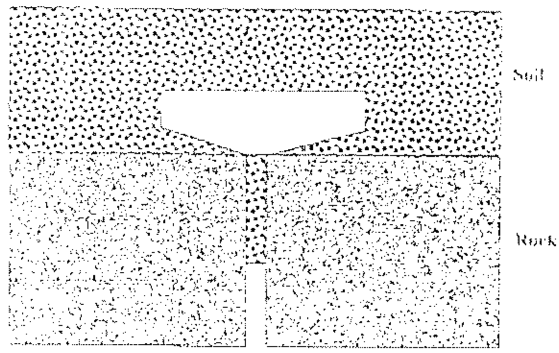
There is a constant rate of displacement between A and B, not yet indicating imminent instability

The point of instability between A and B could still be reached if the continuing displacement exceeds the maximum bending that the roof layer can tolerate.

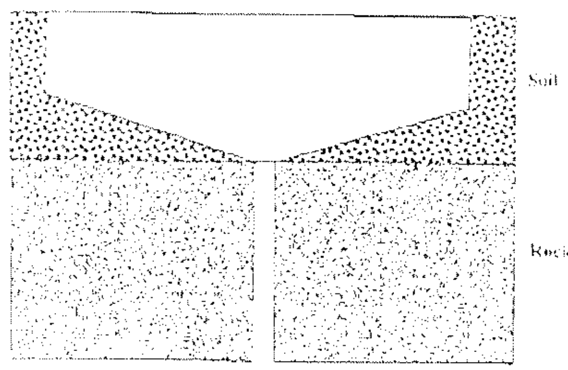
The displacement between B and C continues to accelerate, strongly indicating that a fall will occur soon.

4. Question 4


Soil
Rock
Soil
Rock
Directly after mining
Soil
Rock
One year later



Months to years later



Years to decades later

- During the active subsidence phase, cracks form on surface by the opening of pre-existing joints
- Within a year, the cracks disappear, having been filled in by soil through wind and water
- The crack in the rock remains open
- As time goes by, soil is eroded into the open crack in the rock by water flowing through the soil
- This forms a cavity in the soil over the crack
- Eventually, the cavity becomes wide enough to break through to the surface in the form of a pot-hole.
- The pot-holes are most likely to form at positions where cracks were present during the active subsidence phase and where the rock cracks are most likely to remain open, i.e. predominantly around the edges of the panels (or intact pillars in stooping).

5. Question 5

Question	TRUE	FALSE
a) The Slake Durability Test …..		
i)		x
ii)	x	
iii)		x
iv)		x
b) The MRMR-rating……		
i)	x	
ii)	x	
iii)	x	
iv)		x
c) Swellex bolts and split sets		
i)		x
ii)		x
iii)		x
iv)	x	
d) Surface cracks on a subsided area…		
i)		x
ii)		x
iii)	x	
iv)		x
e) The stiffness of a roof support system….		
i)	x	
ii)		x
iii)	x	
iv)	x	
f) The South African National Institute ……		
i)		x
ii)		x
iii)		x
iv)	x	
g) The "Effective width" for rectangular….		
i)	x	
ii)		x
iii)		x
iv)	x	
h) The Coal Mine Roof Rating…..		
i)		x
ii)		x
iii)		x
iv)		x
i) Long term pillar stability… …		
i)		x
ii)		x
iii)		x
iv)	x	
j) Mining under surface water courses…..		
i)		x
ii)		x
iii)		x
iv)		x