RM Oct 2010 Model Answers

Q1

A fatal Fall of Ground accident occurred as a result of a failure in an intersection of bord and pillar workings. Detail the facts to be considered and recorded by the rock engineer when investigating the roof fall accident on site. (12)

Model Answer.

In-Situ Examination.

- Description of site, Section, Panel Name, Mine, Seam, Mining Method, designed bord, Centre, mining height, Working Plan,
- Waiting Place, Support Rules, Fireman's Report- any comments on changes or support required,
- Actual accident site, support installed, spacing, sketch, strata type, discontinuities, water, size of FOG, volume of block, who was injured, where were they standing,
- Roofbolter, drill bit size, drill rod length, resin type, resin expiry date, roofbolts being used, diameter, length, timing light in order.

Additional Information.

- Rockfall COP up to date, effective in light of incident,
- Strata Control Training given to personnel involved in accident,
- Last Rock Engineer or Strata Control Practitioner's report,
- Geological Borehole logs,
- Pre-Emptive Risk Assessment for panel,
- Design of support report,
- Shift Overseer Logbook, reference to instructions re strata,
- Resin pull tests, roof support quality control system, test certificates,
- Torque test for roofbolter,
- Survey plan of accident site.

FOG Report.

- Background, site description, design & actual parameters,
- Strata Conditions, Support installed, prior to accident and at accident site,
- FOG, volume, dimensions, weight, comment on effectiveness of support to hold block,
- Mechanism and cause of FOG,
- Additional information could be included here,
- Suggested changes to Rockfall COP and Procedures,
- Suggestions to prevent a similar event from occurring.

Q 2

- **Canopy**-makes direct contact with the roof and conveys and resist loading to and from the roof.
- **Hydraulic leg**- the power source, converts fluid power into mechanical power that lifts/lowers the chock and provides support resistance.

- **Caving shield**- resist horizontal forces, both transversely na longitudinaly and biaxial loading and also prevents caved rock fragments from getting into the face area(bears the load from caved rock)
- **Leminiscate links**-allows the canopy to move up or down vertically within a certain range of mining height , thus controlling the tip to face distance through out the operation range.
- **Double – Acting Ram**-Used to advance the pans and pull the shields forward a pre-determined distance9normally equivalent to the shearer cutting web) and to keep the pans and shields in two seperate straight lines parallel to the face line.

- 708tonnes
- gurantees that the available system pressure is delivered to the leg cylinders. If pumps deliver lower pressure to the legs the corresponding achieved loads will be lower.
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Load= $L*B*h*\rho = 708t$ $h = 708/B*L*\rho = \frac{708}{4.2*1.75*2.5} = 38m$

$$Supportresistence = \frac{708}{1.75*4.2} = 96 \, tonnes/m^2$$

- (goaf stress, entry stress, pillar stress, abutment stress and virgin stress)

Q3a
b =7,2 m
h = 3,0 m
w_{ep} = b/sin α = 7,2/sin 70 = 7,66 m
Shallow Guidelines w/h min 2,2, h = 3,0 m therefore w min = 6,6 m but
b = 7,66 m & e% 75% max. Therefore w min = 7,66 m (w/h = 2,55)

w_{ep} = (2 w1 w2 sin α)/(w1 +w2) = 7,2 m

Pillar Strength = $(7,2\ (7,2)^{0,46})/3^{0,66}$ = 8,65 MPa

Load = $(0,025\ H\ C^2)/w^2 = (0.025\ 39\ (15,32)^2)/7,66^2$ = 3,96 MPa

Safety factor = 8,65/3,96 = 2,18

Q3b
Bord = 7,2 m
Assume σ_t = 6 MPa
SF = 1,5
ϒ = 0,025
L =7,2 m
n_q = 1 + (t soft/t stiff) = 1 +(0,5/0,6) = 1.833

Require t = $(\eta_1\ L^2\ ϒ\ SF)/(2\ \sigma_{t)}$
$(1,83\ 7,2^2\ 0,025\ 1,5)/(2 * 6)$ = 3,5575/12 = 0,2965 m

SS thickness 0,6 m therefore suspension can be applied.

<u>Option 1</u>

Bolt Spacing S_b =Square root (2 tavg $\sigma_{t)/(}$ n_q ϒ SF)

Where t avg = 0,02 (20 mm mudstone layers)

σ_t = 2 MPa (Mudstone tensile strength)

n_q = 1,83 m

ϒ = 0,025

SF = 1,5

Sb = Square root((2 * 0,02 * 5)/(1,83 * 0,025 * 1,5) = 1,71 m.

Bolt Length = $l_b = t_{lm}[1 + (\Upsilon * S_b^2)/(\pi * d * \sigma_t)$

= 0,5[1 + (7 *0.025 * $1{,}71^2$)/(22 * 0,025 * 2) = 0,73 m

<u>Option 2</u>

No of Bolts required = η = (t * ϒ *g * SF)/P_f

Where t = thickness t b suspended 0,5 m

ϒ = 2 500 kg/m^3

g = gravity = 9,81 m/sec^2

SF (Safety Factor) = 1,5

P_f = 140 kN Design strength of 20 mm diam bolt.

η = (0,5 * 2500 * 9,82 * 1,5)/140000 = 0,13138 bolts/m^2

Area per bolt = 1/ η = 7,61135 m^2

Spacing between bolts = square Root A = 2,75 m

Bolts	m^2	divided by bord (7,2)
3	19,029	2,64 m between rows
2	12,686	1,76 m between rows

Bolt length minimum of 0,5 m into Sandstone therefore 1,0 m min therefore 1,2 m bolt.

Taking Resin Shear Strength $\tau = P_f /(\pi * d * L_b)$

Where τ is the rock-resin shear strength (assume 3 500 kPa for Sandstone)

P_f = 140 kN Design strength of 20 mm diam bolt.

d = hole diameter assume 26 mm 25 drill bit + 1,0 mm reaming)

L_b = resin bond length

Therefore $L_b = (P_f /(\pi * d * \tau)$ = (140 * 7)/(22 * 0.026 * 3 500) = 0,4895 m

Bond Length = 490 mm

Required Resin Capsule Length (L_c) can be found from $L_b = (d_c^2 * L_c)/(D^2 - d^2)$

Where d_c = resin capsule diameter, 23 mm for a 20 mm bolt

L_c = resin capsule length

D = diameter of the roofbolt hole, assume 26 mm

d = diameter of the roofbolt, 20 mm diam.

$Lc = (L_b * (D^2 - d^2))/ d_c^2 = (490 *(26^2 – 20^2))/23^2$ = 255,65 mm say 300 mm (smallest available)

Full column resin anchorage = $L_b = (d_c^2 * L_c)/(D^2 - d^2)$

Assume L_b = 1,2 m roofbolt, 80 mm extends outside hole therefore hole length is 1 120 mm

$Lc = (L_b * (D^2 - d^2))/ d_c^2 = (1\ 120 *(26^2 – 20^2))/23^2$ = 584 mm say 600 mm

Capsule 23 diam x 600 mm.

<u>Q4</u>
w = 17,5 m, bord = 7,5 m, mining height (h) 4,0 – 4,5 m, depth 125 + h =129 – 129,5 m.

Pillar Strength = $(7.2 *17,5^{0,46})/4^{0,66}$ = 10,756 MPa if h = 4,5 m 9,954 MPa
Load = $(25 * H * C^2)/w^2 = (25 * 129 *25^2)/17,5^2$ = 6,582 MPa if h = 4,5 m 6,607 MPa

h = 4,0 m		h = 4,5 m	
SF	10,758/6,582	SF	9,954/6,607
	1,63		1,51
w/h	4,375	w/h	3,89

Both Safety Factors are below 1,8 however the w/h ratios are high, pillar extraction could be considered after investigation, eg modelling, actual conditions however, dolerite in overburden and less than 1,8 Safety Factors would be negative factors.

Not full Tributary Load as Panel Width is 90 m and Panel Depth is 129 m, W/H = 0,6976.

Will dolerite fail?
Method by van der Merwe
L_c =2T Square root(k +(β/D)) + (2*(H-D)Tanϑ)

Where β = (1,53/ϒ $_m$) -0,8 and ϒ $_m$ = (0,025*((D-T)/D) + 0,03(T/D)
Where ϑ is the goaf angle taken a 15^0 from the vertical
k = ratio of horizontal to vertical stress taken as 2,0
D is the depth to the base of the dolerite sill, 87,9 m
T is the thickness of the dolerite 16,2 m
H is the depth of mining 130 m.

ϒ $_m$ = (0,025*((D-T)/D) + 0,03(T/D) = (0,025 *(87,9 – 16,2)/87,9)) + 0,03*(16,2/87,9)
= 0,0204 + 0,00553 = 0,259

ϒ $_m$ = 0,259

Where β = (1,53/ϒ $_m$) -0,8 = (1,53/0,0259) – 0,8 = 59,07 - 0,8 = 58,27 m

L_c = 2T * Square root(k +(β/D)) =2(H-D)Tanϑ
= 2 * 16,2 * Square root(2 +(58,27/87,9) + (2(130 – 87,9)Tan15
= 32,4 * 1,6318 + 84,2 * 0,268
= 75,4 m
As the Panel Width is 90 m the dolerite sill should break.

Per Cent extraction.

$e\% \quad = (1 – (w^2/C^2) * 100$

$= (1 – (17{,}5^2/25^2) = 51\ \%$

Remaining 49 % @ 50% = 24,5 % = 75,5 % with checkerboard, assuming complete extraction of the pillar.

Checkerboard Load = $(25 * H * C_1 * C_2)/(w_1 * w_2) = (25 * 129 * 37{,}5 * 25)/17{,}5^2 = 9{,}8725$ MPa

Mining height	Pillar strength	Load	SF	w/h
4,0 m	10,758	9,8725	1,09	4,375
4,5 m	9,954	9,8725	1,01	3,889

Comment remaining pillars after checkerboard could fail due to low Safety Factors, however high w/h ratio therefore controlled failure likely. Ryder and Ozbay found by numerical modelling that a 4,01 w/h is required for non-violent failure.