

SYLLABUS AND REFERENCES FOR THE  
STRATA CONTROL CERTIFICATE

**COAL MINING OPTION**

1. PART 1 : THEORY

1.1 Basic principles of rock engineering

1.1.1 Terms, definitions and basic quantities:

- Define, explain, and where applicable give the units of:  
Mass, gravity, density, force, stress, strain, deformation, displacement, elasticity, Uniaxial tension, uniaxial compression, triaxial compression, shear stress, virgin stress, induced stress, principal stress, k-ratio of stresses, coefficient of friction, Friction angle, cohesion, safety factor, rock mass, intact rock, rock quality designation (RQD).
- Calculate areas of the following shapes:  
Square, rectangle, triangle, circle, cylinder
- Calculate the areal and volumetric percentage extraction for square or rectangular pillars in a regular bord and pillar layout.
- Calculate the volume and mass (given the density) of prisms with square, rectangular, triangular or circular cross sections

1.1.2 Intact rock strength

- Explain what is meant by each of the following:  
Rock fracture, peak strength, residual strength, brittle failure, ductile deformation, Yield, effective stress, pore pressure.
- Describe the following behaviour of rock in principle:
  - The stress-strain behaviour of brittle rock in uniaxial compression
  - The effect of confinement on rock strength
  - The effect of confinement on stress-strain behaviour of rock samples – pay particular attention to what happens to rock after it has reached its peak stress.
- Explain the basis of the Coulomb and the Hoek-Brown criteria for intact rock strength.
- Explain the significance of each parameter in the Coulomb and Hoek-Brown criteria.
- Calculate the strength of intact rock using the Coulomb and Hoek-Brown criteria

### 1.1.3 Rock joints and rock mass strength

- Describe the occurrence of rock joints on your mine, number of sets and their orientations.
- Explain how the following factors affect the strength of rock joints - infilling type, infilling thickness, roughness, friction angle, water pressure.
- Explain in principle the shear box test for determining joint strength
- Explain the implications of rock joints on rock mass strength
- Explain how joints may affect excavation stability
- Use the equation of Barton and Choubey to calculate the strength of a joint.
- Explain the significance of each parameter in the Barton and Choubey equation for joint shear strength.
- Apply the Rock Mass Rating (RMR) and the Q-system to classify rock masses.
- Apply the RMR system together with the Hoek-Brown criterion to determine the strength of a rock mass.

### 1.1.4 Stresses and rock behaviour around excavations

- Make use of analytical equations to calculate the stresses at a point near a circular opening in rock
- Make use of analytical equations to calculate the stresses on the boundary of a circular opening in rock
- Describe the stress concentration, directions of principals stresses and potential orientation of fractures around square, rectangular, circular, elliptical and tabular openings.
- Describe the effect of the k-ratio on stress distributions around the above openings, e.g. do the stresses become greater or do they decrease when the k-ratio changes.
- Discuss the effect of high stresses, tensile stress zones and rock fractures on excavation stability and displacement in the excavation walls.
- Explain the effect of a free surface (ground surface) on the stress distribution around a tabular excavation and its effect on rock behaviour in the roof.

### 1.1.5 Beam behaviour

- Describe how shear and tensile stresses are distributed in a cantilever, a simply supported beam and a fixed beam;
- Explain the mechanism of arch formation in a cracked beam.
- Explain the effect of an increase in bord width on beam stability
- Explain the effect of layer thickness on beam stability
- Explain how the above knowledge may be used to improve the stability of the roof in bord and pillar workings.

### 1.1.6 References

Brady & Brown. 2<sup>nd</sup> ed. Rock mechanics for underground mining.  
Chapman & Hall. 1993.  
Chapter 3,4 and 8  
Buddery. Fundamental principles of roofbolting in SA Collieries.  
SANGORM Symp. Advances in rock mechanics in underground coal  
mining. Witbank. 1989

## 1.2 Pillar stability

### 1.2.1 Functions of pillars

Explain the functions of:

- Panel pillars
- Barrier pillars
- Crush pillars
- Interpanel pillars
- Rib pillars in rib pillar mining

### 1.2.2 Pillar strength and loading

- Describe the effect of volume on the strength of coal
- Describe the effect of width to height ratio on the strength of a coal pillar
- Explain how the Salamon & Munro pillar strength equation was derived
- Explain the assumptions of the tributary area theory and apply it to determine the stress in a system of pillars
- Calculate the factor of safety for square pillars using the Salamon & Munro and squat pillar equations.
- You should know the limitations for the application of the above strength equations
- Explain the meaning of the factor of safety in pillar design and comment on acceptable factors of safety for stable pillar systems
- Know the recommended factors of safety for primary development secondary development, stooping, top coaling and bottom coaling on your mine.
- Describe the stress changes a pillar will go through during stooping

### 1.2.3 Pillar failure

- Sketch the stress distribution in a pillar at different loading stages up to the point of failure and residual strength
- Sketch the complete stress-strain graph for a coal pillar at width of height ratios of 2,4,6 and 8 and comment on the expression of failure around the perimeter of the pillar at each stage

#### 1.2.4 References

Madden, B J. A review of collapsed coal pillar geometry's, 1904-1988. SANGORM Symp. Advances in rock mechanics in underground coal mining, Witbank. 1989

Madden, B J. Squat pillar design in SA Collieries. SANGORM Symp. Advances in rock mechanics in underground coal mining. Witbank. 1989

Van der Merwe. The dynamic factor of safety concept in high extraction coal mining. SANGORM Symp. Advances in rock mechanics in underground coal mining, Witbank, 1989.

### 1.3 Mining

#### 1.3.1 Mining methods

Explain the layout, mining sequence, equipment and rock mechanics implications of each of the following mining methods:

- Bord and pillar mining - drill & blast and continuous miners
- Stopping
- Rib pillar mining
- Longwall mining

#### 1.3.2 Rock breaking

- Describe the different types of explosives used on your mine, the method of detonation and the different rounds used to break the coal or rock (if appropriate).
- Describe the rock/coal breaking action of a pick and the method of dust suppression used on your mine (if appropriate)

#### 1.3.3 Mine standards and codes of practice

- Explain in detail the codes of practice and mine strata control on your mine
- Describe the functions and responsibilities of the rock engineering staff as defined in the code of practice of your mine.

#### 1.3.4 Suggested references

Department of Minerals and Energy. 1996. Guidelines for the compilation of a mandatory Code of Practice to combat rock fall and rock burst accidents in metalliferous mines and mines other than coal mines. 1996.

Hoek E & Brown ET. Underground excavations in rock. IMM London, 1980, Chapter 10.

## 1.4 Geology

### 1.4.1 Rock types

Identify the following common rock types associated with coal bearing strata, discuss their

- Relative strengths and explain how they were formed:
- - Sedimentary rocks: Sandstone, shale, interlaminated sandstone/shale, coal,
- coarse grained sandstone, micaceous sandstone, glauconitic sandstone, carbonaceous
- sandstone, sandy shale
- Metamorphic rocks: Slates, burnt coal
- Igneous rocks: Felsites, dolerite, olivine-rich dolerite, granite

### 1.4.2 Rock structures

- Know what the following rock structures are, explain how they affect the stability of excavations
- And know how they were formed:
- Strata, bedding plane, cross bedding, ripple marks, folding, dykes, sills, normal fault, reverse
- Fault, slickensides, cleats, mylonite, gouge, stringers, striations.

### 1.4.3 Local geology

- Sketch the geological sequence at your local mines and describe the major structures.

### 1.4.4 References

Lurie J. South African geology. Revised edition, 1987. Part A, Chapter 1 to 6.

## 1.5 Support of excavations

### 1.5.1 Principles of roof support

- Describe the principles of roof suspension and beam formation
- Explain the relative merits of rock reinforcement methods (eg bolts) against
- rock support methods (e.g. steel arches).

### 1.5.2 Roof support units

- Describe the support principle of:  
full column resin bonded & grouted bolts, end anchored bolts, friction bolts (split sets) and roof trusses, steel arches, wooden dowels.
- Explain how you would test the shear strength of resin and determine the critical bond length

- Describe how point anchor and full column resin bolts should be installed
- Describe how mechanical anchor bolts should be installed
- Describe the function of w-straps, tapes, wooden headboards and steel straps and when you would use them
- Describe the load deformation characteristics of timber poles, clusterstick packs, mat packs, skeleton packs and waste filled packs and the implications of these characteristics on their efficiency as roof support

### 1.5.3 Roof support design

- Design support length and spacing for simple suspension of a weak layer from a stronger layer in the roof.
- Evaluate the appropriateness of a given support system for the prevailing conditions.
- Pillar support and reinforcement
- Describe methods of sidewall support such as wooden dowels and wire mesh
- Explain the objectives of sand and ash filling and when these methods may be applicable
- Explain the basic layout for the placement of ash or sand in the underground workings of a mine.

### 1.5.5 References

Brady & Brown. 2<sup>nd</sup> ed. Rock mechanics for underground mining.. Chapman & Hall, 1993. Chapter 11.  
 Lear & Hill. Systematic sidewall support of coal pillars at depth SANGORM Symp. Advances in rock mechanics in underground coal mining. Witbank. 1989.

## 1.6 Testing and monitoring methods

### 1.6.1 Rock strength tests

You should be able to describe, in principle, the testing equipment, method of sample preparation and testing procedure for:

- Uniaxial compression tests on rock samples
- Point load testing
- Brazilian indirect tensile strength
- Triaxial compressive strength tests

### 1.6.2 Monitoring

- Describe the objectives of monitoring
- Describe in principle how you would monitor surface subsidence, roof deflection in a roadway, pillar sidewall dilation and fracturing in a pillar.
- Describe each of the following instruments, explain what they measure and how it is measured:
- Tape, rod and wire extensometers, doorstopper and triaxial stress cells, closure meter, borehole-scope.
- Know how to install and take readings of monitoring equipment used on your mine.
- Interpret data obtained from the above monitoring equipment to identify impending instability, rock failure, opening of fractures in rock, loosening of rock.

### 1.6.3 References

Brady & Brown. 2<sup>nd</sup> ed. Rock mechanics for underground mining.  
Chapman & Hall, 1993. Chapter 4 & 18.

## 2. PART 2 : PRACTICAL

### 2.1 Mine plans and inspection of workings

#### 2.1.1 Plan interpretation

- Identify the plan symbols which are used on your mine
- Explain the co-ordinate system used on your mine
- Plot off-set measurements on mine plans
- Draw sections through mine plans to show changes in elevation of seams and effect of geological structures such as faults or dykes.
- Transfer information between plans of different scales.
- Determine the mean dip and strike of a seam using peg elevations on mine plans.
- Locate yourself and determine orientations in underground workings using mine plans.

#### 2.1.2 Underground inspection

- Identify dangerous roof conditions, brows, slips and faults and indicate what support is required.
- Identify conditions which may result in dangerous intersections and suggest remedial.
- Assess installed support and possible remedial measures if inadequate.
- Assess the performance of pillars in workings
- Identify failure of rock and comment on the causes of failure

### 2.2 Support units

#### 2.2.1 Support installation

- Indicate correct location and orientation of support for headings and intersections.
- Indicate the correct location of temporary support near the face.
- Demonstrate the correct method of installation of support tendons.
- Identify departures from recommended support.
- Identify difficulties which may have necessitated departures from recommended support.
- Identify poor installation of support and recommend remedial measures.
- Recommend additional support in areas where mine standards are inadequate.
- Identify failed support and the mode of failure.

### 2.3 Practical geology

- Identify samples of the main rock types found on your mine and classify them into igneous, sedimentary or metamorphic.
- Identify the main rock types in underground workings
- Point out weak layers and other important horizons in underground workings.

### 2.4 Monitoring

- Install monitoring equipment used on your mine.
- Take measurements on monitoring equipment used on your mine.