SOUTH AFRICAN NATIONAL INSTITUTE OF ROCK MECHANICS

CHAMBER OF MINES OF SOUTH AFRICA
CERTIFICATE IN ROCK MECHANICS

PART 3-2

SOFT ROCK TABULAR MINING

SYLLABUS

CONTENTS

PREAMBLE

TOPICS COVERED

This is a specific mining type paper covering rock mechanics practice applicable in tabular, soft rock mining environments at all depths.
The rock engineering knowledge required here is thus of a specific nature, relating to the mining of tabular orebodies in soft rock at shallow, moderate and great depth.

CRITICAL OUTCOMES

The examination is aimed at testing the candidate's abilities in the six cognitive levels: knowledge, comprehension, application, analysis, synthesis and evaluation. Thus, when being examined on the topics detailed in this syllabus candidates must demonstrate their capacity for :

- Comprehending and understanding the general rock engineering principles covered in this syllabus and applying these to solve real world mining problems
- Applying fundamental scientific knowledge, comprehension and understanding to predict the behaviour of rock materials in real world mining environments
- Performing creative procedural design and synthesis of mine layouts and support systems to control and influence rock behaviour and rock failure processes
- Using engineering methods and understanding of the uses of computer packages for the computation, modelling, simulation, and evaluation of mining layouts
- Communicating, explaining and discussing the reasoning, methodology, results and ramifications of all the above aspects in a professional manner at all levels.

PRIOR LEARNING

This portion of the syllabus assumes that candidates have prior learning and good understanding of :

- The field of fundamental mechanics appropriate to this part of the syllabus
- The application and manipulation of formulae appropriate to this part of the syllabus as outlined in the relevant sections of this document
- The terms, definitions and conventions appropriate to this part of the syllabus as outlined in the relevant sections of this document.

STUDY MATERIAL

This portion of the syllabus assumes that candidates have studied widely and have good knowledge and understanding of :

- The reference material appropriate to this part of the syllabus as outlined in the relevant sections of this document
- Other texts that are appropriate to this part of the syllabus but that may not be specifically referenced in this document
- Information appropriate to this part of the syllabus published in journals, proceedings and documents of local mining, technical and research organisations.

SYLLABUS

2 GEOTECHNICAL CHARACTERISTICS

2.1 GEOLOGY

2.1.1 GEOLOGICAL SEQUENCES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Identify and describe the rock types associated with tabular, soft rock orebodies
- Describe, explain and discuss how the rock types associated with tabular, soft rock orebodies were formed
- Sketch, describe and discuss the geological sequences associated with tabular, soft rock orebodies.

2.1.2 GEOLOGICAL STRUCTURES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe and discuss major geological structures associated with tabular, soft rock orebodies
- Sketch, describe and discuss geological structures that impact upon mining, such as interbedded hard rock layers and sills
- Describe, discuss and explain the effect on mining and mine stability of such geological phenomena.

2.2 ROCK STRENGTH

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Discuss the relative strengths of rock types associated with tabular, soft rock orebodies
- Describe and discuss the geotechnical characteristics of rock types associated with tabular, soft rock orebodies

- Apply the above knowledge to the design of total extraction workings such as:
  Longwall mining, Shortwall mining, etc
- Apply the above knowledge to the design of partial extraction workings such as :
  Room and pillar mining, Pillar extraction,
  Partial pillar extraction, etc.

2.3 ROCKMASS CHARACTERISTICS

2.3.1 GEOTECHNICAL ROCKMASS CLASSIFICATION

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, discuss and apply rockmass classification techniques for the selection of soft rock tabular mining methods
- Describe, discuss and apply standard rockmass classification and assessment systems to predict excavation stability
- Describe, discuss and apply the rockwall condition factor (RCF) to predict tunnel stability and support requirements
- Apply Barton's Q system to classify a rockmass
- Apply Bieniawski's RMR system to classify a rockmass
- Apply Laubscher's MRMR system to classify a rockmass
- Apply the CMRR system to classify a rockmass
- Apply rockmass classification results to determine the stability of unsupported spans
- Apply rockmass classification results to determine the stability of unsupported rockslopes
- Apply rockmass classification results to determine support requirements for various situations
- Determine rockmass 'm' and 's' parameters for the Hoek and Brown criterion based upon rockmass classification results
- Determine rockmass deformability from joint stiffness and rockmass classification results.

3 ROCK AND ROCKMASS BEHAVIOUR

3.1 PILLAR BEHAVIOUR

3.1.1 PILLAR STRENGTH

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the effects of the following circumstances on the strength of pillars :

  Roof contact conditions, Floor contact conditions
  Coal strength, Jointing
  Pillar volume, Confinement

- Describe, explain and discuss the effects of confinement on pillar strength.

3.1.2 PILLAR STRESS

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the stress distribution in a panel of pillars with barrier pillars on either side
- Sketch, describe, explain and discuss the stress distribution at mid-height of a pillar under the following conditions :

  While the pillar behaves elastically
  When the pillar is at peak strength
  After the pillar has reached peak strength

- Sketch, describe, explain and discuss how each of the above stress distributions will affect pillar spalling
- Describe, explain and discuss how pillar width to height ratio affects pillar stiffness
- Describe, explain and discuss how variations in pillar width to height ratio will affect the loading of pillars in a panel
- Apply the above knowledge to evaluate the performance of pillars for given pillar layouts.

3.1.3 PILLAR FAILURE

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss how pillar width to height ratio affects pillar strength
- Describe, explain and discuss how pillar width to height ratio affects the post peak stress-strain behaviour of pillars
- Describe, explain and discuss the significance of pillar width to height ratio in terms of the stability of bord and pillar workings
- Describe, explain and discuss how loading system stiffness will cause pillars to fail either in a controlled fashion or violently

- Describe, explain and discuss how ashfill or sandfill will affect the behaviour of failed pillars
- Describe, explain and discuss the mechanism of pillar punching into the roof strata or floor strata
- Describe, explain and discuss the effect of pillar punching on the stability of adjacent strata
- Describe, explain and discuss the effect of pillar punching on the ultimate strength of pillars
- Apply the above knowledge to evaluate given pillar layouts and their potential for violent failure.

3.2 ROOF BEHAVIOUR

3.2.1 BEAMS AND PLATES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the phenomenon of displacements and deflections between strata layers over an excavation
- Sketch, describe, explain and discuss roof deflections in roadways of bord and pillar workings during different stages of development
- Describe, explain and discuss the significance of these deflections in terms of support requirements and support installation
- Sketch, describe, explain and discuss roof deflections at intersections of bord and pillar workings during different stages of development
- Describe, explain and discuss the significance of these deflections in terms of support requirements and support installation
- Describe, explain and discuss how beam span and beam thickness affect beam stability
- Sketch, describe, explain and discuss how horizontal compressive stresses allow cracked beams to remain stable
- Sketch, describe, explain and discuss how voussoir arch formation allows cracked beams to remain stable
- Sketch, describe, explain and discuss the differences in behaviour between rock plates and rock beams
- Describe, explain and discuss the significance of these differences in terms of the stability of intersections
- Determine the factor of safety against sliding failure of a cracked beam in the presence of horizontal stresses
- Apply the above knowledge to evaluate given situations in terms of their potential instability
- Apply the above knowledge to determine appropriate remedial measures to improve stability.

3.2.2 ROOF BEHAVIOUR DURING TOTAL EXTRACTION

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the behaviour of roof strata overlying total extraction panels in terms of :

  Caving propensity, Cave height, Swell factor, Strata overhang
  Continuous cave subsidence

- Describe, explain and discuss how factors such as the strength and bedding of roof strata affect the swell factor of strata
- Describe, explain and discuss how factors such as the strength and bedding of roof strata affect the overhang of strata
- Describe, explain and discuss how a strong sandstone beam or dolerite sill will affect the roof behaviour of total extraction panels
- Describe, explain and discuss how a strong sandstone beam or dolerite sill will affect loading of the abutments of total extraction panels
- Describe, explain and discuss recompaction behaviour of caved strata
- Describe, explain and discuss how the recompaction of caved strata affects the subsequent extraction of other seams
- Sketch, describe, explain and discuss stress distribution in the goaf from the edges of a panel to the centre of a panel
- Evaluate and predict roof caving behaviour for given sets of circumstances
- Evaluate and predict stresses in workings for given sets of circumstances

3.2.3 INFLUENCE OF DOLERITE SILLS

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the effects of dolerite sills on strata behaviour in the following mining situations :

  Bord and Pillar operations, Stooping operations,
  Longwall operations

- Describe, explain and discuss the effects of dolerite sills on stress distribution in the following mining situations :

  Bord and Pillar operations, Stooping operations,
  Longwall operations

- Describe, explain and discuss the application of Galvin's equations for determining critical spans of dolerite sills
- Describe, explain and discuss the limitations of Galvin's equations for determining critical spans of dolerite sills

- Apply Galvin's equations to determine critical spans for the failure of dolerite sills
- Apply the above knowledge to the design of total extraction and room and pillar workings

3.3 SUBSIDENCE

See Sect 7

4 MINING LAYOUT STRATEGIES

4.1 SOFT ROCK TABULAR MINING METHODS

4.1.1 ROOM AND PILLAR

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the following types of room and pillar mining :

  Drilling and Blasting
  Mechanical Breaking

- Describe, explain and discuss the following aspects of each of the above methods :

  Panel layout, Ventilation method, Coal transport, Main equipment

- Describe, explain and discuss the following coal winning methods :

  Top coaling, Bottom coaling

- Determine areal and volumetric percentage extraction in room and pillar layouts
- Determine appropriate factors of safety for primary development in room and pillar layouts
- Determine appropriate factors of safety for secondary development in room and pillar layouts
- Describe, explain and discuss restrictions associated with the application of factors of safety
- Describe, explain and discuss conditions that may allow lower factors of safety to be used

- Describe, explain and discuss the purpose of barrier pillars in room and pillar workings
- Apply the above knowledge to design room and pillar mining layouts for given sets of circumstances.

4.1.2 RIB PILLAR

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the different methods of rib pillar mining
- Sketch, describe, explain and discuss the following aspects of each method :

  Panel layout, Ventilation method,
  Coal transport, Main equipment

- Sketch, describe, explain and discuss methods of stabilising the roof during rib pillar extraction
- Describe, explain and discuss how the following factors affect rib pillar extraction :

  Roof conditions, Dolerite sills, Mining height

- Apply the above knowledge to design rib pillar layouts, extraction sequences and appropriate support for given sets of circumstances.

4.1.3 STOOPING

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the following types of stooping operation:

  Drilling and Blasting
  Mechanical Breaking

- Describe, explain and discuss the functions of the following constituents in each of the above methods :

  Snooks, Breaker lines, Finger lines, Fenders

- Sketch, describe, explain and discuss roofbolt and mechanised breaker lines
- Describe, explain and discuss the conditions under which such breaker lines may be applicable
- Describe, explain and discuss how the following factors affect pillar extraction :

Roof conditions, Dolerite sills, Mining height

- Determine appropriate factors of safety for stooping under given conditions
- Sketch, describe, explain and discuss how the stress will vary on pillars during stooping operations
- Describe, explain and discuss how this stress variation may temporarily affect the factor of safety of pillars
- Determine areal and volumetric percentage extraction in stooping operations under given conditions
- Explain and discuss why these extraction percentages are rarely achieved in practice
- Apply the above knowledge to design stooping layouts, extraction sequences and appropriate support for given sets of circumstances.

4.1.4 LONGWALL

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the different methods of longwall mining
- Sketch, describe, explain and discuss the following aspects of each method :

  Panel layout, Ventilation method,
  Coal transport, Main equipment

- Sketch, describe, explain and discuss the following longwall mining terms :

  Main gate, Snaking, Web, Goaf
  Gate road support, Chock shield
  Interpanel pillar, Chain pillar, Crush pillar

- Describe, explain and discuss the difference between advance longwalling and retreat longwalling
- Sketch, describe, explain and discuss the different types of powered support for longwalling
- Describe, explain and discuss the advantages and disadvantages of each of the different types of powered support
- Sketch, describe, explain and discuss the stress distribution in the vicinity of longwall faces
- Sketch, describe, explain and discuss the effects of this stress redistribution on the stability of surrounding strata
- Sketch, describe, explain and discuss how the following factors affect the loading and choice of powered support for longwalls :

  Strength of the floor strata, Strength of the roof strata
  Massive sandstone in the roof, Dolerite sills in the roof
  Seam thickness

- Sketch, describe, explain and discuss how crush pillars may be used in longwall mining
- Describe, explain and discuss how interpanel pillars may be removed
- Describe, explain and discuss the problems associated with removing longwall equipment
- Describe, explain and discuss methods to successfully move and remove longwall equipment
- Apply the above knowledge to design longwall layouts for given sets of circumstances.

4.1.5 SURFACE / OPENCAST

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the conditions under which the following mining methods are applicable :

  Strip Mining
  Open Cast Mining

- Describe, explain and discuss the following aspects of the above mining methods :

  Method of operation, Main equipment

- Sketch, describe, explain and discuss how the following components are formed and maintained in strip mining operations :

  Box cuts, Ramps
  Spoil piles
  Coal benches, In-pit benches.

4.2 REGIONAL STABILITY STRATEGIES

4.2.1 PRINCIPLES OF REGIONAL STABILITY

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the concept of regional stability in the context of soft rock tabular mining operations at all depths

- Describe, explain and discuss methods of ensuring regional stability in pillared workings
- Describe, explain and discuss how barrier pillars may be used to improve the stiffness of surrounding strata
- Describe, explain and discuss how the number and geometry of pillars in a panel may affect regional stability
- Describe, explain and discuss the effects of depth and mined-out span on the stress regime above and around shallow workings
- Describe, explain and discuss how these effects may affect regional stability requirements
- Apply the above knowledge to evaluate the regional stability of given mining situations
- Apply the above knowledge to determine appropriate remedial measures to improve regional stability in given situations.

4.2.2 REGIONAL STABILITY PILLARS

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the functions of regional stability pillars at shallow to intermediate depth where in-stope pillars are not used as local support
- Sketch, describe, explain and discuss the functions of regional stability pillars at shallow to intermediate depth where in-stope pillars are used as local support
- Sketch, describe, explain and discuss the functions of regional stability pillars at great depth
- Design regional stability pillars for workings at shallow depths
- Design regional stability pillars for workings at intermediate depths
- Apply empirical criteria to design regional stability pillars.

4.3 OREBODY EXTRACTION LAYOUTS

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss orebody extraction layout strategies in respect of the following mining methods :

    Bord and pillar mining
    Rib pillar mining
    Stooping operations
    Longwall mining
    Strip mining
- Describe, explain and discuss the problems associated with ventilating goafs and the effect of this on panel layouts

4.4 SERVICE EXCAVATION LAYOUTS

4.4.1 SERVICE EXCAVATIONS

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Design stable service excavation layouts making use of rock classification and stress analysis techniques
- Assess the stability of service excavation layouts in given situations making use of rock classification and stress analysis techniques
- Determine modifications of shape and orientation to improve stability
- Determine support strategies to improve stability.

4.4.2 SHAFTS

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss expected rock conditions in vertical shafts passing through the following rock types:
- Surface weathered rock, Strongly bedded strata, Poorly bedded strata, Dolerite dyke
- Describe, explain and discuss expected rock conditions in inclined shafts passing through the following rock types:
- Surface weathered rock, Strongly bedded strata, Poorly bedded strata, Dolerite dyke
- Sketch, describe, explain and discuss stability problems commonly associated with bored shafts
- Determine the stability of the following shaft types making use of rock classification techniques :

  Conventionally sunk vertical shafts, Bored vertical shafts
  Conventionally sunk inclined shafts, Bored inclined shafts

- Determine the support requirements of the following shaft types making use of rock classification technique :

  Conventionally sunk vertical shafts, Bored vertical shafts
  Conventionally sunk inclined shafts, Bored inclined shafts.

5 MINING SUPPORT STRATEGIES

5.1 PILLAR DESIGN STRATEGIES

5.1.1 PILLAR DESIGN

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss how the following pillar equations were derived :

  Salamon and Munro pillar equation
  Squat pillar equation

- Describe the range of applications of each of the above equations
- Describe the limits of applicability of each of the above equations
- Describe, explain and discuss how the Salamon and Munro pillar equation may be modified for use with rectangular pillars
- Describe, explain and discuss how the Salamon and Munro pillar equation may be modified for use with pillars cut by continuous miner
- Describe, explain and discuss how factors of safety are selected for pillar design
- Apply the equations for pillar strength to design pillars for given sets of circumstances
- Describe, explain and discuss the concept of tributary area theory
- Describe, explain and discuss the limitations of tributary area theory.

5.1.2 PILLAR REINFORCEMENT

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss techniques to reinforce pillars using :

  Dowels,Wire mesh, Shotcrete,Fill,Other means

- Describe, explain and discuss the situations under which the different pillar reinforcement techniques are likely to be applicable
- Describe, explain and discuss the mechanisms involved in strengthening pillars in each of the different pillar reinforcement techniques
- Apply the above knowledge to evaluate given situations and determine appropriate pillar reinforcement techniques.

5.2 ROOF SUPPORT STRATEGIES

5.2.1 ROOM AND PILLAR ROOF SUPPORT STRATEGIES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss roof support requirements in room and pillar workings for good roof conditions
- Describe, explain and discuss roof support requirements in room and pillar workings for poor roof conditions
- Calculate and determine strata suspension and/or support requirements for given rock conditions
- Calculate and determine strata beam creation and/or support requirements for given rock conditions
- Design appropriate support systems based upon support requirement calculations.

5.2.2 PILLAR EXTRACTION ROOF SUPPORT STRATEGIES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss roof behaviour during pillar extraction operations
- Describe, explain and discuss the functions of the following components during pillar extraction :

  Snooks, Fenders, Rockbolts, Finger lines

- Sketch, describe, explain and discuss the types of roof support used in pillar extraction operations
- Sketch, describe, explain and discuss the layout of roof support used in pillar extraction operations
- Design appropriate support systems based upon assessment of given rock conditions.

5.2.3 LONGWALL ROOF SUPPORT STRATEGIES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss roof support methods used in longwall mining
- Calculate required roof support requirements for longwall shields based upon the height of caving using Wilson's method
- Compare and discuss these results with actual roof support capacities in South African longwalls

- Design appropriate support for total extraction mining operations for given rock conditions and mining layouts
- Describe, explain and discuss appropriate support installation sequences for the above designs
- Design appropriate maingate and tailgate support for longwall mining in poor roof conditions
- Design appropriate tailgate area support when crush pillars are being used
- Design appropriate support for the removal of longwall equipment.

5.3 SERVICE EXCAVATION SUPPORT STRATEGIES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss support strategies applicable to service excavation support in soft rock tabular mining operations.

5.4 SUPPORT DESIGN CRITERIA

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain, discuss and apply support design criteria applicable to excavation support in soft rock tabular mining operations.

5.5 SUPPORT AND SUPPORT SYSTEM TYPES AND CHARACTERISTICS

5.5.1 SUPPORT ELEMENTS

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the following tendon support types in the context of soft rock operations :

  Wooden dowels, Mechanically anchored bolts, Point-anchor resin bolts
  Full-column resin bolts, Cable bolts, Sand cells
  Other commonly used support types

- Characterise the following aspects of the above support types :

  Their installation method
  Their anchoring method
  Their load bearing characteristics

- Describe, explain and discuss the applicability of the above types of tendon support in differing rock types
- Describe, explain and discuss the following types of roof support in the context of soft rock operations :

    Trusses, W-straps
    Timber tapes, Headboards
    Wire mesh, Lacing, Shotcrete

- Describe, explain and discuss the applicability of the above roof support types
- Describe, explain and discuss the limitations of the above roof support types
- Describe, explain and discuss the load bearing characteristics of the following types of support :

    Mine poles, Hydraulic props, Longwall hydraulic shields
    Cluster stick packs, Skeleton packs, Mat packs, End-grain packs
    Waste-filled pigsty, Cement-based packs

- Describe, explain and discuss the applicability of the above roof support types
- Describe, explain and discuss the limitations of the above roof support types
- Describe, explain and discuss comparative testing procedures for rockbolts
- Describe, explain and discuss the various aspects of the SABS resin specification.

5.5.2 BACKFILL SYSTEMS

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the methods of placing ash fill and sand fill in underground workings
- Describe, explain and discuss the requirements to make ash filling or sand filling successful
- Sketch, describe, explain and discuss the features of ashfill or sandfill systems to service particular blocks of ground.

6 INVESTIGATION TECHNIQUES

6.1 ROCK TESTING

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss various rock testing procedures
- Interpret and incorporate test results in analysis and design.

6.2 MONITORING

6.2.1 SUBSIDENCE MONITORING

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the techniques used to measure surface subsidence
- Describe, explain and discuss the equipment used to measure surface subsidence
- Describe, explain and discuss how vertical and horizontal displacements are determined
- Describe, explain and discuss how strains and tilts may be derived from these determinations
- Calculate strain and tilt from given sets of measurements
- For given sets of underground mining and surface infrastructure conditions:
- State, describe, explain and discuss what types of measurements need to be made and monitored
- Describe, explain and discuss required monitoring station layouts
- Describe, explain and discuss appropriate monitoring programs.

6.2.2 IN-SITU STRESS MEASUREMENT AND MONITORING

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the techniques used to measure in-situ stress in the underground rockmass
- Describe, explain and discuss the equipment used to measure in-situ stress in the rockmass
- Interpret, explain and discuss given stress measurement data in terms of likely rockmass, pillar or excavation behaviour.

6.3 MODELLING

6.3.1 NUMERICAL MODELLING

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the selection of appropriate codes to tackle various problems
- Describe, explain and discuss the input of appropriate parameters to investigate various problems

- Describe, explain and discuss the interpretation of output in the investigation of various problems.

6.4 AUDITING

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the concept of monitoring for understanding, prediction and design.

7 ROCKBREAKING IN SOFT ROCK

7.1 CUTTING TECHNIQUES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the function and operation of cutters in soft rock mining operations
- Describe, explain and discuss the following aspects in respect of continuous miners and road headers in bord and pillar sections :

  The sequence of cutting, the sequence of support installation, the sequence of tramming

- Describe, explain and discuss the following aspects in respect of continuous miners and road headers in continuous haulage systems :

  The layout of mining, the sequence of mining.

7.2 DRILLING TECHNIQUES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the mechanism of rock breaking by pick, chisel or button bit in soft rock mining operations
- Describe, explain and discuss the following drilling methods and associated equipment in soft rock mining operations :

  Percussion drilling, Rotary drilling, Diamond drilling, Raise boring, Tunnel boring

- Sketch, describe, explain and discuss the different rounds used in shaft sinking

- Describe, explain and discuss the different cuts used in shaft sinking
- Describe, explain and discuss the types of initiation used in the above rounds
- Describe, explain and discuss the sequence of initiation of blast holes used in the above rounds
- Sketch, describe, explain and discuss the different rounds used in tunnel development
- Describe, explain and discuss the different cuts used in tunnel development
- Describe, explain and discuss the types of initiation used in the above rounds
- Describe, explain and discuss the sequence of initiation of blast holes used in the above rounds
- Sketch, describe, explain and discuss blast hole layouts in drill and blast sections
- Describe, explain and discuss the direction of drilling of blast holes in drill and blast sections
- Describe, explain and discuss the explosive charge in blast holes in drill and blast sections
- Describe, explain and discuss the sequence of initiation of blast holes in drill and blast sections
- Describe, explain and discuss the importance of blast-hole drilling accuracy in the following applications :

  Shaft sinking, Chamber excavation, Tunnel development, Ore extraction
  Cushion blasting, Smooth blasting.

7.3 BLASTING PRACTICE

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the effect of the following parameters on blast damage:
- Explosive type, Initiation method, Initiation sequence, Hole orientation
- Describe, explain and discuss the objectives and effects of de-coupling explosives
- Describe, explain and discuss the methods by which de-coupling of explosives is achieved
- Describe, explain and discuss the following excavation cushion blasting and smooth blasting techniques :

  Pre-splitting, Concurrent smooth blasting, Post-splitting

- Describe, explain and discuss the methodologies and typical applications of each technique
- List and discuss the advantages and disadvantages of these techniques
- Evaluate and determine blasting requirements for tunnels making use of knowledge of explosives

- Evaluate and determine appropriate blasting rounds to suit given conditions in tunnels
- Evaluate and determine appropriate explosive types to suit given conditions in tunnels
- Evaluate and determine blasting requirements for headings in soft rock making use of knowledge of explosives
- Evaluate and determine appropriate blasting rounds to suit given conditions in soft rock
- Evaluate and determine appropriate explosive types to suit given conditions in soft rock
- Evaluate and determine blasting requirements for headings in coal rock making use of knowledge of explosives
- Evaluate and determine appropriate blasting rounds to suit given conditions in coal
- Evaluate and determine appropriate explosive types to suit given conditions in coal
- Describe, explain and discuss the role of coal cutters in colliery blasting operations
- Describe, explain and discuss how coal cutters in colliery blasting operations fit into the production cycle.

8 SURFACE AND ENVIRONMENTAL EFFECTS

8.1 SURFACE EFFECTS

8.1.1 PRINCIPLES OF SUBSIDENCE ENGINEERING

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the following terms in the context of surface subsidence :

  Angle of draw, Curvature, Tilt, Critical span
  Horizontal strain, Vertical subsidence, Differential subsidence

- Describe, explain and discuss the following surface expressions of subsidence :

  Tension cracks, Compression humps, Ridges, Thrusts

- Describe, explain and discuss how mining height to depth ratio affects the type and severity of surface subsidence
- Describe, explain and discuss the effects of dolerite dykes and other geological structures on surface subsidence.

8.1.2 SUBSIDENCE ON SOUTH AFRICAN COLLIERIES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Sketch, describe, explain and discuss the typical subsidence trough over a longwall panel
- Describe, explain and discuss the difference between dynamic and static subsidence profiles
- Describe, explain and discuss the relationship between maximum subsidence and mining height
- Describe, explain and discuss how multiple seam extraction affects surface subsidence
- Describe, explain and discuss techniques for reducing subsidence humps by interpanel pillar extraction
- Describe, explain and discuss techniques for reducing subsidence humps by interpanel crush pillars
- Describe, explain and discuss the results of using the above two techniques to reduce subsidence humps
- Sketch, describe, explain and discuss the differences in total subsidence associated with the following mining methods :

  Longwall operations
  Bord and Pillar operations
  Pillar Extraction operations

- Determine the following quantities for given mining depths and mining heights using Schumann's empirical relationships :

  Maximum subsidence, Surface strain, Surface tilt.

8.1.3 SURFACE PROTECTION

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss how the following surface features are affected by subsidence :

  Roads, Buildings, Pylons, Lands, Streams, Pans

- Describe, explain and discuss possible remedial measures that may be applied to surface structures to limit subsidence damage
- Describe, explain and discuss possible changes that may be made to underground mining layouts to reduce subsidence damage
- Determine potential subsidence damage to the following types of structure for given mining depths and mining heights using published damage tables :

Roads, Buildings, Pylons.

8.2 ENVIRONMENTAL EFFECTS

8.2.1 LONG-TERM STABILITY AND THE ENVIRONMENT

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the possible effects and consequences of given mining methods on the following issues :

  Long-term stability of the ground surface
  Groundwater
  Ultimate closure of the mine

- Describe, explain and discuss the possible effects and consequences of given factors of safety on the following issues :

  Long-term stability of the ground surface
  Groundwater
  Ultimate closure of the mine.

9 MINING STRATEGIES IN DIFFICULT CIRCUMSTANCES

The candidate must be able to demonstrate knowledge and understanding of the above subject area by being able to :

- Describe, explain and discuss the geotechnical aspects of dealing with the following difficult circumstances :

  Mining through dykes
  Mining through burnt coal
  Mining under dolerite sills
  Mining thick seams
  Mining multiple seams
  Mining shallow seams (<40mbs)

References

1 GEOLOGY

9.2 GEOLOGICAL SEQUENCES

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 2
Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapter 2
Lurie J 1987 South African Geology for Mining, Metallurgical, Hydrological and Civil Engineering Lexicon Publishers Jhb Chapter 9

9.2.1 GEOLOGICAL STRUCTURES

Lurie J 1987 South African Geology for Mining, Metallurgical, Hydrological and Civil Engineering Lexicon Publishers Jhb Chapter 6
vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb
Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapters 2, 3

9.3 ROCK STRENGTH

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 2
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 1
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 1
vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 1
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 4
Obert L & Duvall WI 1967 Rock Mechanics and the Design of Structures in Rock John Wiley & Sons New York Chapters 10, 11
Jaeger JC & Cook NGW 1969 Fundamentals of Rock Mechanics Chapman & Hall London Chapter 4, 6
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapter 2

9.4 ROCKMASS CHARACTERISTICS

9.4.1 GEOTECHNICAL ROCKMASS CLASSIFICATION

Stacey TR 2001 Best Practice Rock Engineering Handbook for 'Other' Mines SIMRAC Jhb Chapter 2
vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 2
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 2
Hoek E & Brown ET 1980 Underground Excavations in Rock IMM London Chapter 2
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 3

10 ROCK AND ROCKMASS BEHAVIOUR

10.1 PILLAR BEHAVIOUR

10.1.1 PILLAR STRENGTH

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 4
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 2
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 2
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 13
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapters 1, 2

10.1.2 PILLAR STRESS

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 4 Chapter 1
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 2

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 2
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 13
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapters 1, 2

10.1.3 PILLAR FAILURE

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 4
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 2
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 2
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 13
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapters 1, 2

10.2 ROOF BEHAVIOUR

10.2.1 BEAMS AND PLATES

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 3
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 3
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 2

10.2.2 ROOF BEHAVIOUR DURING TOTAL EXTRACTION

Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapter 4
vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 3, 5 and 6
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 4

10.2.3 INFLUENCE OF DOLERITE SILLS

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 3
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 4
Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapter 4
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 5

10.3 SUBSIDENCE

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 9
see Sect 7 van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 5
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 16
Obert L & Duvall WI 1967 Rock Mechanics and the Design of Structures in Rock John Wiley & Sons New York Chapter 18
Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapter 4
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 7

11 MINING LAYOUT STRATEGIES

11.1 SOFT ROCK TABULAR MINING METHODS

11.1.1 BORD AND PILLAR

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 4
Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapters 2, 5
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapters 1, 2
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 4

11.1.2 RIB PILLAR

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 4
Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapters 5, 8

11.1.3 STOOPING

Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 4
Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapters 4, 5, 8
vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapters 5
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 4

11.1.4 LONGWALL

Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapters 5, 6, 7
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 5
vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapters 6
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 4

11.1.5 SURFACE / OPENCAST

11.2 REGIONAL STABILITY STRATEGIES

11.2.1 PRINCIPLES OF REGIONAL STABILITY

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapters 4,5,6,

11.2.2 REGIONAL STABILITY PILLARS

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb
Chapters 4

11.3 OREBODY EXTRACTION LAYOUTS

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 4,5,6

van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 4,

11.4 SERVICE EXCAVATION LAYOUTS

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb
Chapters 2 and 3

11.4.1 SERVICE EXCAVATIONS

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb
Chapters 2 and 3

11.4.2 SHAFTS

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb
Chapters 2 and 3

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 7

11.5 LAYOUT DESIGN CRITERIA

12 MINING SUPPORT STRATEGIES

12.1 PILLAR DESIGN STRATEGIES

12.1.1 PILLAR DESIGN

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 4
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 2

12.1.2 PILLAR REINFORCEMENT

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 4

12.2 ROOF SUPPORT STRATEGIES

12.2.1 ROOM AND PILLAR ROOF SUPPORT STRATEGIES

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 3
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 3
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 6

12.2.2 PILLAR EXTRACTION ROOF SUPPORT STRATEGIES

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 3,5
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapters 3, 4
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 6

12.2.3 LONGWALL ROOF SUPPORT STRATEGIES

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 6

van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapters 3, 4
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 6

12.3 SERVICE EXCAVATION SUPPORT STRATEGIES

Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 6

12.4 SUPPORT DESIGN CRITERIA

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 3 and appendix B
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 6

12.5 SUPPORT AND SUPPORT SYSTEM TYPES AND CHARACTERISTICS

12.5.1 SUPPORT ELEMENTS

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 3 and appendix B
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 3
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 6

12.5.2 BACKFILL SYSTEMS

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 7

13 INVESTIGATION TECHNIQUES

13.1 ROCK TESTING

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 2

13.2 MONITORING

13.2.1 SUBSIDENCE MONITORING

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 10
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 5

13.2.2 IN-SITU STRESS MEASUREMENT AND MONITORING

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 10

13.3 MODELLING

13.3.1 NUMERICAL MODELLING

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 8
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 8
Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 11
Lightfoot N & Maccelari MJ 1998 Numerical Modelling of Mine Workings SIMRAC Jhb Chapters 1-11

13.4 AUDITING

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 10

14 ROCKBREAKING IN SOFT ROCK

14.1 CUTTING TECHNIQUES

14.2 DRILLING TECHNIQUES

14.3 BLASTING PRACTICE

Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 17

15 SURFACE AND ENVIRONMENTAL EFFECTS

15.1 SURFACE EFFECTS

15.1.1 PRINCIPLES OF SUBSIDENCE ENGINEERING

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 9
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 5
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 16
Obert L & Duvall WI 1967 Rock Mechanics and the Design of Structures in Rock John Wiley & Sons New York Chapter 18

15.1.2 SUBSIDENCE ON SOUTH AFRICAN COLLIERIES

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 9
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 5
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 16
Obert L & Duvall WI 1967 Rock Mechanics and the Design of Structures in Rock John Wiley & Sons New York Chapter 18

Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapter 4
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 7

15.1.3 SURFACE PROTECTION

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 9
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 5
Salamon MDG & Oravecz KI 1976 Rock Mechanics in Coal Mining CoM of SA Jhb Chapter 7

15.2 ENVIRONMENTAL EFFECTS

15.2.1 LONG-TERM STABILITY AND THE ENVIRONMENT

16 MINING STRATEGIES IN DIFFICULT CIRCUMSTANCES

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb Chapter 7, Appendix C

Fauconnier CJ & Kersten RWO (ed) 1982 Increased Underground Extraction of Coal SAIMM Jhb Chapter 11
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 5
Madden BJ & Canbulat I 2005 Shallow Depth Mining Considerations SAIMM 3rd Southern African Rock Engineering Symposium Jhb

