SOUTH AFRICAN NATIONAL INSTITUTE OF ROCK MECHANICS

CHAMBER OF MINES OF SOUTH AFRICA
CERTIFICATE IN ROCK MECHANICS

PART 3-1

# HARD ROCK TABULAR MINING

SYLLABUS

 

 

 

PREAMBLE

TOPICS COVERED

This is a specific mining type paper covering rock mechanics practice applicable in tabular, hard 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 hard rock at shallow, moderate and great depth.

CRITICAL OUTCOMES

The examination is aimed at testing the candidate's abilities in the six cognitive levels of 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 the main South African tabular, hard rock orebodies
- Describe, explain and discuss how the rock types associated with tabular, hard rock orebodies were formed
- Sketch, describe and discuss the geological sequences associated with tabular, hard 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 the main South African tabular, hard rock orebodies
- Describe and discuss the following aspects of major geological structures associated with the main South African tabular, hard rock orebodies :

  Origin, Genesis, Mechanism of formation
  Residual effects of formation on geotechnical behaviour
  Subsequent effects of formation on geotechnical behaviour.

 

## 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, hard rock orebodies
- Describe and discuss the geotechnical characteristics of rock types associated with tabular, hard rock orebodies
- Apply the above knowledge to the design of total extraction workings
- Apply the above knowledge to the design of partial extraction workings.

## 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 seclection of hard rock tabular mining methods
- Describe, discuss and apply standard rockmass classification and assessment systems to predict excavation stability and support requirements
- Describe, discuss and apply the rockwall condition factor (RCF) to predict tunnel stability and support requirements.

# 3 ROCK AND ROCKMASS BEHAVIOUR

## 3.1 ROCKMASS BEHAVIOUR AROUND TABULAR EXCAVATIONS

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 the rockmass around tabular excavations at shallow, intermediate and great depth
- Describe, explain and discuss the changing amount and nature of rock that needs to be supported at shallow, intermediate and great depth
- Describe, explain and discuss the different rates of deformation of the rockmass at shallow, intermediate and great depth
- Sketch, describe, explain and discuss the types of fractures found around stope faces at shallow, intermediate and great depth
- Describe, explain and discuss the effects of stope face fracturing on the stability of the stope hangingwall, stope footwall and stope face
- Sketch, describe, explain and discuss the types of fractures found around stope gullies at shallow, intermediate and great depth

 

- Describe the effects of stope gully fracturing on the stability of the gully hangingwall and sidewalls
- Sketch, describe, explain and discuss the behaviour of rock surrounding tabular excavations during seismic events
- Describe, explain and discuss typical heights of rockfalls in tabular underground gold and platinum mines in South Africa
- Describe, explain and discuss the significance of rockfall height in terms of support requirements in gravity loading conditions
- Describe, explain and discuss the significance of rockfall height in terms of support requirements in seismic loading conditions
- Evaluate given rockmass conditions and excavation dimensions to determine or predict stope stability
- Evaluate given rockmass conditions and excavation dimensions to determine remedial measures to improve stope stability
- Describe, explain, discuss and apply the following techniques to the above evaluation :

  Rockmass class, Stress analysis, Continuum mechanics,
  Discrete block kinematics, Beam theory, Failure criteria

- Sketch, describe, explain and discuss rockmass behaviour and conditions associated with stoping abutments at depth
- Sketch, describe, explain and discuss the on-reef effects associated with stoping abutments at depth
- Sketch, describe, explain and discuss the off-reef effects associated with stoping abutments at depth
- Sketch, describe, explain and discuss rockmass behaviour and conditions associated with stope pillars at shallow, intermediate and great depth
- Sketch, describe, explain and discuss the on-reef effects associated with stope pillars and/or remnants at shallow, intermediate and great depth
- Sketch, describe, explain and discuss the off-reef effects associated with stope pillars and/or remnants at shallow, intermediate or great depth
- Sketch, describe, explain and discuss the purpose, procedure and effects of rockmass pre-conditioning ahead of stopes at depth
- Sketch, describe, explain and discuss the various methods of pre-conditioning
- Describe, explain and discuss the critical features of pre-conditioning.

## 3.2 ROCKMASS BEHAVIOUR AROUND ACCESS AND SERVICE TUNNELS

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

- Describe, explain and discuss how rocks and rockmasses may be classified
- Describe, explain and discuss how rockmass classification systems may be used to predict tunnel stability at shallow, intermediate and great depths
- Describe, explain and discuss the nature of fracturing around tunnels at depth
- Describe, explain and discuss the effects and consequences of fracturing on tunnel size

 

- Describe, explain and discuss the effects and consequences of fracturing on tunnel shape
- Describe, explain and discuss the effects and consequences of fracturing on tunnel stability
- Describe, explain and discuss the phenomenon of time-dependant fracturing and deterioration
- Describe, explain and discuss the effects and consequences of time-dependant fracturing and deterioration on tunnel stability
- Describe, explain and discuss the effects of stress regime and geological structure on rock behaviour and tunnel stability
- Describe, explain and discuss the effect of tunnel size, tunnel shape and tunnel excavation technique on rock behaviour and tunnel stability
- Describe, explain and discuss the optimisation of tunnel size, shape and orientation to suit geological considerations
- Describe, explain and discuss the optimisation of tunnel size, shape and orientation to suit field stress considerations
- Describe, explain and discuss the behaviour of rock surrounding tunnels at depth during seismic events
- Describe, explain and discuss the siting of tunnels with respect to existing, current and future stoping operations
- Describe, explain and discuss the siting of tunnels with respect to geological stratigraphy and structures
- Describe how rockwall condition factor (RCF) is determined
- Describe and discuss how the rockwall condition factor may be applied to predict tunnel stability and support requirements
- Apply the rockwall condition factor to predict tunnel stability and support requirements at depth
- Evaluate given rock conditions and field stresses to predict excavation stability
- Evaluate given rock conditions and field stresses to recommend remedial measures to improve excavation stability.

## 3.3 ROCKMASS BEHAVIOUR AROUND SERVICE EXCAVATIONS AND SHAFTS

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

- Describe, explain and discuss how rocks and rockmasses may be classified
- Describe, explain and discuss how rockmass classification systems may be used to predict service excavation stability at shallow, intermediate and great depths
- Describe, explain and discuss the nature of fracturing around vertical sinking shafts at depth
- Describe, explain and discuss the nature of fracturing around inclined sinking shafts at depth
- Describe, explain and discuss the nature of fracturing around rock passes at depth

 

- Describe, explain and discuss the effect of stress fracturing and geological structure on the final shape of vertical and inclined shafts
- Describe, explain and discuss the effect of stress fracturing and geological structure on the final shape of rock passes
- Describe, explain and discuss the conditions that may lead to the formation of large unstable rock wedges in vertical shaft sidewalls
- Describe, explain and discuss the conditions that may lead to the formation of instabilities in rock passes
- Describe, explain and discuss the nature of fracturing around service excavations at depth
- Describe, explain and discuss the effects and consequences of fracturing on service excavation size
- Describe, explain and discuss the effects and consequences of fracturing on service excavation shape
- Describe, explain and discuss the effects and consequences of fracturing on service excavation stability
- Describe, explain and discuss the phenomenon of time-dependant fracturing and deterioration
- Describe, explain and discuss the effects and consequences of time-dependant fracturing and deterioration on service excavation stability
- Describe, explain and discuss the effects of stress regime and geological structure on excavation stability
- Describe, explain and discuss the effects of excavation size, shape and orientation on excavation stability
- Describe, explain and discuss the effects of excavation technique on fracturing and the stability of service excavations
- Describe, explain and discuss the effects of excavation sequence on stress fracturing and the stability of service excavations at depth
- Describe, explain and discuss the effects of support sequence on stress fracturing and the stability of service excavations at depth
- Describe, explain and discuss the optimisation of service excavation size, shape and orientation to suit geological considerations
- Describe, explain and discuss the optimisation of service excavation size, shape and orientation to suit field stress considerations
- Describe, explain and discuss the behaviour of rock surrounding service excavations at depth during seismic events
- Describe, explain and discuss the siting of service excavations with respect to existing, current and future stoping operations
- Describe, explain and discuss the siting of service excavations with respect to geological stratigraphy and structures
- Describe, discuss and explain how rockmass characterisation may be applied to predict service excavation stability and support requirements
- Describe, discuss and explain how rockmass characterisation may be applied to predict service excavation stability and support requirements
- Apply rockmass characterisation techniques to predict service excavation stability and support requirements
- Evaluate given rock conditions, field stresses, geological conditions, excavation sizes, shapes and orientations to predict excavation stability

 

- Evaluate given rock conditions, field stresses, geological conditions, excavation sizes, shapes and orientations to recommend remedial measures to improve excavation stability
- Evaluate given rock conditions, field stresses and geological conditions to predict shaft stability
- Evaluate given rock conditions, field stresses and geological conditions to recommend remedial measures to improve stability.

## 3.4 MINE SEISMICITY

### 3.4.1 PRINCIPLES OF SEISMICITY

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

- Define, describe, explain and discuss the term seismic event
- Describe, explain and discuss the phenomenon of foreshocks and aftershocks
- Describe, explain and discuss the processes that give rise to violent failure and rupture in rock
- Describe, explain and discuss the rupture process in solid rock
- Describe, explain and discuss the rupture process on a pre-existing fault plane
- Differentiate between the terms seismic event and rockburst
- Define, describe, explain and discuss the term rockburst
- Identify, describe, explain and discuss the conditions required for a rockburst to occur
- Describe, explain and discuss the main mechanisms responsible for seismic events in South African mines
- Describe, explain and discuss the main mechanisms responsible for rockbursts in South African mines
- Define, describe and explain the phenomenon of seismic body waves
- Describe, explain and distinguish between different types of seismic body waves
- Define, describe and explain the phenomenon of seismic surface waves
- Describe and explain how seismic surface waves are generated
- Describe and explain how seismic surface waves are related to seismic body waves
- Describe, explain and discuss the differences between seismic body waves and seismic surface waves
- Describe, explain and discuss the factors that affect the velocity of propagation of seismic waves in rock
- Describe and explain how the rockmass environment affects the velocity of P-waves and S-waves
- State typical velocities of P-waves and S-waves in hard rock and soft rock environments

- Describe, explain and discuss how this information may be used to locate the source of seismic events
- Describe, explain and discuss how the energy of a seismic body wave is attenuated as it propagates through elastic rock
- Describe, explain and discuss how the energy of a seismic body wave is attenuated as it propagates through non-elastic rock
- Describe and explain how seismic waves and the energy of seismic waves causes damage in excavations
- Describe, explain and discuss the phenomena of reflection and refraction of seismic body waves
- Describe, explain and discuss how seismic wave reflection and refraction gives rise to and affects rockburst damage in excavations
- Describe, explain and discuss the objectives of seismic monitoring in mines
- Identify, describe, explain and discuss the features of seismic events that are used to locate the source of seismic events
- Identify, describe and explain the common methods used to locate seismic events
- Describe the simplifying assumptions commonly used in determining seismic event location
- Explain the difference between the terms hypo-centre and epi-centre used in describing the location of seismic events
- Distinguish between seismic source mechanism and seismic damage mechanism
- Define, describe, explain, discuss and contrast the following primary source parameters in terms of their physical meaning and the data required to determine them :

  Richter magnitude, Local magnitude, Moment magnitude
  Seismic energy, Seismic moment, Seismic displacement

- Define, describe, explain, discuss and contrast the following secondary source parameters, in terms of their physical meaning and the data required to determine them :

  Corner frequency, Source radius, Apparent volume,
  Stress drop, Energy index

- Describe and explain the common methods of seismic data analysis.

### 3.4.2 MINE SEISMOLOGY AND ROCKMASS STABILITY

#### 3.4.2.1 MINE SEISMOLOGY

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

- Describe, explain and discuss the characteristics of mine seismicity in terms of :

  Causes
  Location, Incidence, Magnitude, Time
  Effects

- Define, describe, explain and discuss the following terms :

  Rockburst, Strong ground motion, Peak particle velocity

- List, describe, explain and discuss the factors that determine the nature of seismicity in tabular hard-rock mining
- Describe, explain and discuss the relationship between mine layout and seismicity
- Describe, explain and discuss the relationship between depth and seismicity
- Describe, explain and discuss the relationship between rock types and seismicity
- Describe, explain and discuss the relationship between local geology and seismicity
- Describe, explain and discuss the relationship between regional geology and seismicity
- List, describe, explain and discuss the measures that may be applied to control seismicity
- Describe, explain and discuss measures to reduce the maximum magnitude of seismic events
- Describe, explain and discuss measures to reduce the frequency of seismic events
- Define, describe, explain, discuss and contrast the following secondary source parameters in terms of :

  their physical meaning :
  the data required to determine them :

  Source dimension, Apparent volume
  Static seismic stress drop, Dynamic seismic stress drop
  Energy index, Apparent stress
  Dominant frequency, Corner frequency

- Explain the difference between the following source parameters :

  Richter magnitude, Local magnitude, Moment magnitude

- State, describe and explain the main characteristics of the Brune Model
- Describe and explain how to obtain a fault plane solution from moment tensor analysis
- Describe and explain the following common methods of seismic data analysis :

  Gutenberg-Richter analysis

 

Magnitude-Frequency relationship
Energy-Moment relationship
Trend analysis
Time-of-day distribution
Instability analysis

Describe typical outputs of the above analyses

Describe, explain and discuss the relationships between :

Extent of stressed rock and Maximum potential seismic event magnitude
Volumetric closure and Seismic moment
Event magnitude and Damage caused by seismic events
Peak particle velocity and Damage caused by seismic events

- Describe, explain and discuss how peak particle velocity decreases with distance from a seismic event source
- Identify, describe and explain the basic steps that are involved in carrying out a rockburst site investigation
- Describe and explain the relevant factors to inspect and investigate at a rockburst site
- Describe and explain the relevant seismic source parameters to investigate
- Describe and explain the relevant aspects of seismic history to analyse
- Describe, explain, discuss and contrast the relationship between :

Rockburst damage and Seismic source characteristics
Rockburst damage and Excavation support characteristics

- Describe, explain and discuss the different types of seismic emission sources in tabular hard-rock mining
- Demonstrate familiarity with the guideline for the compilation of a code of practice to combat rock related accidents by being able to :

Define, describe and explain the term 'seismically active' as defined in the guideline
Describe and explain the methods of estimating seismic hazard in tabular hard-rock mines
Describe and explain the steps necessary to define emission sources in various ground control districts
Describe and explain the term 'reasonably practicable' in the context of seismic risk management
Describe and explain the various strategies to combat seismicity related risks
Describe and explain the various seismic energy emission control measures
Describe and explain the various rockburst damage control measures.

 

#### 3.4.2.2 ROCKMASS STABILITY

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 strategies assist in reducing rockburst hazards :
- Pre-conditioning, Backfilling, Stabilising pillars.

# 4 MINING LAYOUT STRATEGIES

## 4.1 HARD ROCK TABULAR MINING METHODS

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 fundamental mining and rock engineering principles associated with the following tabular, hard rock mining methods :

  Room and Pillar mining
  Scattered mining
  Longwall mining
  Sequential Grid mining
  Closely Spaced Dip Pillar mining

## 4.2 REGIONAL STABILITY STRATEGIES

### 4.2.1 PILLARS AS REGIONAL SUPPORT

#### 4.2.1.1 REGIONAL 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

 

- List, describe, explain and discuss the various design criteria that may be applied to the design of regional pillars
- Describe, explain and discuss the assumptions associated with these pillar design criteria
- Describe, explain and discuss the limitations associated with these pillar design criteria
- Design regional stability pillars for workings at shallow depths
- Design regional stability pillars for workings at intermediate depths
- Design regional stability pillars for workings at great depths
- Sketch, describe, explain and discuss the functions of stabilising pillars at depth
- Describe, explain and discuss the effect of stabilising pillars on energy release rate at depth
- Describe, explain and discuss the effect of stabilising pillars on excess shear stress at depth
- Apply empirical design criteria to design stabilising pillars for workings at depth
- Calculate the effect of regular stabilising pillars on energy release rates assuming elastic conditions.

#### 4.2.1.2 STABILISING PILLARS

See Regional Pillars

#### 4.2.1.3 BRACKET 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 bracket pillars at depth
- Describe, explain and discuss the effect of bracket pillars on excess shear stress at depth
- List, describe, explain and discuss the various design criteria that may be applied to the design of bracket pillars
- Describe, explain and discuss the assumptions associated with these pillar design criteria
- Describe, explain and discuss the limitations associated with these pillar design criteria
- Design bracket pillars for workings at depth
- Explain the problems associated with designing adequate bracket pillars.

### 4.2.2 BACKFILL AS REGIONAL SUPPORT

 

#### 4.2.2.1 BACKFILL PERFORMANCE

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

- Sketch, describe, explain and discuss typical purposes of :
- Sketch, describe, explain and discuss typical applications of :
- Sketch, describe, explain and discuss typical selection criteria for :
- Sketch, describe, explain and discuss typical partical size distribution, for :
- Sketch, describe, explain and discuss typical stress-strain curves for :
- Sketch, describe, explain and discuss typical SG s for :
- Sketch, describe, explain and discuss typical drainage characteristics of :
- Sketch, describe, explain and discuss typical pumping characteristics of :
- Sketch, describe, explain and discuss typical stowing characteristics of :

  Classified tailings backfill
  Full plant tailings
  Paste fill
  Sand fill
  Aggregate fill

- Sketch, describe, explain and discuss the use and effects of cementitious binders with the above types of fill
- Specify performance criteria, backfill type and placement method to ensure successful backfilling on a mine.

#### 4.2.2.2 BACKFILL FOR ENERGY RELEASE RATE CONTROL

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

- Describe, explain and discuss the ability of backfill to reduce energy release rates
- Explain and discuss the effect of placement lag on the effectiveness of backfill as a means of reducing energy release rates
- Explain and discuss why it is not necessary to completely backfill the mined area to ensure a significant reduction in energy release rate
- Estimate and discuss the effect of backfill on ultimate energy release rates given backfill performance parameters and stope closure rates.

#### 4.2.2.3 BACKFILL FOR EXCESS SHEAR STRESS CONTROL

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

- Describe, explain and discuss how backfill affects the excess shear stress acting on geological features.

 

### 4.2.3 REGIONAL MINING 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 mining layout strategies to ensure regional stability of workings at shallow, intermediate and great depth
- Sketch, describe, explain and discuss stoping layouts to ensure regional stability of workings at shallow, intermediate and great depth
- Sketch, describe, explain and discuss stoping sequences to ensure regional stability of workings at shallow, intermediate and great depth
- Design stoping layouts and sequences to ensure the regional stability of workings at shallow, intermediate and great depth.

## 4.3 LOCAL STABILITY STRATEGIES

### 4.3.1 STOPING LAYOUTS AND SEQUENCES

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 layout of the following stoping methods:

  Bord and Pillar mining
  Scattered mining
  Longwall mining
  Sequential Grid mining

  Indicate the location of access tunnels, service excavations and rockpasses

- Sketch, describe, explain and discuss how the following orebody geometries and/or combinations of orebody geometries may be mined :

  Wide reefs, Multiple reefs
  Steep reefs, Flat reefs
  Shallow reefs, Deep reefs
  Erratically payable reefs

- Sketch, describe, explain and discuss how a longwall may be re-established beyond a large geological displacement
- Indicate appropriate development and stoping sequences for re-establishing a longwall beyond a large geological displacement
- Estimate relative mining rates for the various re-establishment methods.

 

## 4.4 SERVICE EXCAVATION LAYOUTS

### 4.4.1 TUNNEL LAYOUTS

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

- Describe, explain and discuss the rock engineering criteria used to determine the optimum size, shape and orientation of service tunnels
- Describe, explain and discuss the rock engineering criteria used to determine the optimum layout, positioning, orientation and spacing of service tunnels relative to :

    Static stope abutments
    Moving stope abutments
    Pillars of various shape, size and orientation
    Geological features of various types, orientation and history
    Other excavations

- Apply these criteria to design service tunnel layouts for :

    Tunnels of various purpose and life expectancy
    Various combinations of timing.

### 4.4.2 LARGE CHAMBER LAYOUTS

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

- Describe, explain and discuss the rock engineering criteria used to determine the optimum size, shape and orientation of large service chambers
- Describe, explain and discuss the rock engineering criteria used to determine the optimum excavation methodology and sequence for large service chambers
- Describe, explain and discuss the rock engineering criteria used to determine the optimum support methodology and sequence for large service chambers
- Describe, explain and discuss the rock engineering criteria used to determine the optimum layout, positioning, orientation and spacing of large chambers relative to :

    Static stope abutments
    Moving stope abutments
    Pillars of various shape, size and orientation
    Geological features of various types, orientation and history
    Other excavations

 

- Apply these criteria to design large service chamber layouts for :

    Chambers of various purpose and life expectancy
    Various combinations of timing.

### 4.4.3 ROCKPASS LAYOUTS

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

- Describe, explain and discuss the causes of instability in rockpasses
- Describe, explain and discuss the effects of instability in rockpasses
- Describe, explain and discuss the options available to optimise rockpass layouts
- Describe, explain and discuss the options available for stabilising rockpasses
- Describe, explain and discuss the options available for supporting rockpasses
- Determine appropriate rockpass layout, orientation and support measures using rockmass and stress characterisation techniques
- Assess the suitability of rockpass layout, orientation and support measures for given sets of rockmass and structural conditions
- Assess the suitability of rockpass layout, orientation and support measures for given sets of field stress and induced stress conditions
- Describe, explain and discuss the rock engineering criteria used to determine the optimum size, shape and orientation of rockpasses
- Describe, explain and discuss the rock engineering criteria used to determine the optimum layout, positioning and spacing of rockpasses relative to :

    Static stope abutments
    Moving stope abutments
    Pillars of various shape, size and orientation
    Geological features of various types, orientation and history
    Other excavations

- Apply these criteria to design rockpass layouts for :

    Passes of various purpose and life expectancy
    Various combinations of timing

- Describe, explain and discuss the rock engineering criteria used to rehabilitate damaged rockpasses
- Estimate the rockpass life expectancy as a result of various support and rehabilitation measures.

### 4.4.4 SHAFT LAYOUTS

 

#### 4.4.4.1 SHAFT PROTECTION 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 rock engineering criteria used to design incline shaft protection pillars at shallow, intermediate and great depth
- Sketch, describe, explain and discuss the rock engineering criteria used to design vertical shaft protection pillars at shallow, intermediate and great depth
- Calculate stress, strain and tilt in vertical shafts using equations for circular shaft pillars in an elastic medium
- Apply the results from the above calculations to design appropriate shaft pillar dimensions
- Design shaft layouts for given depth, geology and rockmass conditions
- Explain the limitations that concrete linings and steelwork place on allowable movements in shafts.

#### 4.4.4.2 SHAFT PILLAR 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 preparatory work required prior to shaft pillar extraction at shallow, intermediate and great depth
- Describe, explain and discuss the extent and magnitude of stress changes to be expected around a shaft before, during and after shaft pillar extraction
- Describe, explain and discuss the extent and magnitude of movements to be expected in and around a shaft before, during and after shaft pillar extraction
- Describe, explain and discuss the extent and magnitude of seismicity to be expected around a shaft before, during and after shaft pillar extraction
- Sketch, describe, explain and discuss appropriate mining sequences for extracting a shaft pillar
- Sketch, describe, explain and discuss appropriate methods of support when extracting a shaft pillar
- Design appropriate shaft pillar extraction sequences for given shaft pillar layouts and rockmass data
- Design appropriate support for shaft pillar extraction workings for given shaft pillar layouts and rockmass data
- Design appropriate support and protection measures for associated shaft pillar excavations for given shaft pillar layouts and rockmass data.

#### 4.4.4.3 ALTERNATIVE SHAFT PROTECTION METHODS

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 geotechnical issues associated with the following alternative shaft protection methods at shallow, intermediate and great depth :

  Satellite Pillars
  Bracket Pillars
  Partial Extraction
  Shaft Reef Extraction
  Non-Intersection

- Sketch, describe, explain and discuss the functions of satellite shaft protection pillars
- Sketch, describe, explain and discuss the design of satellite shaft protection pillars
- Describe, explain and discuss the advantages and disadvantages of this approach
- Sketch, describe, explain and discuss the functions of shaft reef bracket pillars
- Sketch, describe, explain and discuss the design of shaft reef bracket pillars
- Describe, explain and discuss the advantages and disadvantages of this approach
- Sketch, describe, explain and discuss the purpose of partial shaft reef extraction
- Sketch, describe, explain and discuss the design of partial shaft reef extraction
- Describe, explain and discuss the advantages and disadvantages of this approach
- Sketch, describe, explain and discuss the effects of extracting the shaft reef at an early stage to avoid leaving a shaft protection pillar
- Describe, explain and discuss the advantages and disadvantages of this approach
- Sketch, describe, explain and discuss the precautions required to allow early extraction of the reef around shafts
- Sketch, describe, explain and discuss the adjustments required to the shaft to allow early extraction of the reef around a shaft
- Evaluate mining layouts, sequences, support and precautions necessary to allow early extraction of the reef around a shaft for given circumstances
- Sketch, describe, explain and discuss the precautions required to mine within shaft pillars transgressed by seismically active geological structures
- Sketch, describe, explain and discuss the siting of shafts entirely in the hangingwall or footwall so as not to intersect reef
- Describe, explain and discuss the advantages and disadvantages of this approach.

## 4.5 LAYOUT DESIGN CRITERIA

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

 

- Describe, explain and discuss the derivation and application of the following mine layout and support design criteria for shallow, intermediate and great depths :

  Average Pillar Stress
  Energy Release Rate
  Excess Shear Stress
  Rockwall Condition Factor.

# 5 MINING SUPPORT STRATEGIES

## 5.1 STOPING EXCAVATION SUPPORT STRATEGIES

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 various behaviour of rock around excavations at shallow, intermediate and great depth
- Describe, explain and discuss how this affects stope support requirements at shallow, intermediate and great depth
- Describe, explain and discuss the concept of geotechnical areas / ground control districts
- Describe, explain and discuss rockmass classification schemes for the determination of geotechnical areas / ground control districts
- Describe, explain and discuss the determination of geotechnical areas / ground control districts
- Describe, explain and discuss the application of the concept of geotechnical areas / ground control districts
- Sketch, describe, explain and discuss appropriate support strategies to control the hangingwall in narrow stopes under static conditions at shallow, intermediate and great depth
- Sketch, describe, explain and discuss appropriate support strategies to control the hangingwall in narrow stopes under seismic conditions at depth
- Sketch, describe, explain and discuss the special problems of supporting wide reef stopes at shallow, intermediate and great depths
- Describe, explain and discuss appropriate strategies to ensure stability under wide reef conditions
- Sketch, describe, explain and discuss the special problems of supporting multiple, closely spaced reef stopes at shallow, intermediate and great depths
- Describe, explain and discuss appropriate strategies to ensure stability under multiple, closely spaced reef conditions
- Sketch, describe, explain and discuss how gullies should be supported at shallow, intermediate and great depths
- Describe, explain and discuss appropriate support strategies to ensure gully stability in various layouts at shallow, intermediate and great depths

 

- Describe, explain and discuss the special problems of supporting gullies relative to various stope layout and fracture configurations at shallow, intermediate and great depths
- Determine the required support reaction for static conditions given typical fall of ground dimensions and loading conditions
- Determine the required support reaction for dynamic (rockburst) conditions given typical fall of ground dimensions and loading conditions
- Determine appropriate stope support strategies for given rockmass conditions, field stress regimes and geological circumstances.

## 5.2 SERVICE EXCAVATION SUPPORT STRATEGIES

### 5.2.1 TUNNEL SUPPORT STRATEGIES

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 various behaviour of rock around excavations at shallow, intermediate and great depth
- Describe, explain and discuss how this affects tunnel support requirements at shallow, intermediate and great depth
- Include in design deliberations the influences occasioned by the following considerations :

  Gravity loading environment, Seismic loading environment
  Rock characteristics, Rockmass characteristics, Geological structure
  Stress mechanisms, Stress cycle, Rate of stress change, Initial stress conditions
  Mining configuration, Mining cycle, Overstoping techniques, Destressing techniques
  Tunnelling configuration, Tunnelling cycle, Pre-development, Follow-behind development
  Support components, Support systems, Support appropriateness
  Implementation quality, Management effectiveness, Quality control

- Describe, explain and discuss the objectives of primary support in tunnels
- Describe, explain and discuss the objectives of secondary support in tunnels
- Describe, explain and discuss the objectives of tertiary support in tunnels
- Describe, explain and discuss the concept of integrated support in tunnels
- Describe, explain and discuss various support strategies for :

  Return Airways
  Haulages, Crosscuts
  Travellingways
  Winzes, Raises
  Tunnel intersections
  Tunnels traversing faults, Tunnels traversing dykes

 

Trackless mining declines in stopes

- Describe, explain and discuss the strategies to support tunnels under the following conditions :

  Low stress with joint controlled behaviour
  High stress where stress fractures dominate stability
  Changing stress cycles and environments over time
  Changing spatial stress environments
  Seismic and rockburst conditions

- Determine appropriate support strategies for tunnels for given layouts, rockmass conditions, stress regimes and geological circumstances.

### 5.2.2 SUPPORT STRATEGIES FOR SHAFTS AND LARGE EXCAVATIONS

#### 5.2.2.1 SUPPORT STRATEGIES FOR VERTICAL SHAFTS

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

- Determine appropriate support strategies for vertical shafts for given mining and shaft layouts, rockmass conditions, stress regimes and geological circumstances.

#### 5.2.2.2 SUPPORT STRATEGIES FOR INCLINED SHAFTS

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

- Determine appropriate support strategies for inclined shafts for given mining and shaft layouts, rockmass conditions, stress regimes and geological circumstances.

#### 5.2.2.3 SUPPORT STRATEGIES FOR ROCKPASSES

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

- Determine appropriate support strategies for rockpasses for given mining and shaft layouts, rockmass conditions, stress regimes and geological circumstances.

#### 5.2.2.4 SUPPORT STRATEGIES FOR LARGE CHAMBERS

 

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 various behaviour of rock around large excavations at shallow, intermediate and great depth
- Describe, explain and discuss how this affects large excavation support requirements at shallow, intermediate and great depth
- Describe, explain and discuss rockmass classification schemes for the determination of support strategies for large chambers
- Describe, explain and discuss the application of the rockwall condition factor methodology to design support for large excavations at depth
- Apply the rockwall condition factor (RCF) methodology to design support for large excavations at depth
- Apply the Wiseman methodology to design support for large excavations at depth
- Describe, explain and discuss the effects of excavation sequence on support installation
- Determine appropriate excavation sequences to facilitate support installation
- Describe, explain and discuss the effects of excavation sequence on support effectiveness
- Determine appropriate excavation sequences to facilitate support effectiveness
- Describe, explain and discuss the rules of thumb for determining the length and spacing of tendons in large excavations
- Apply these rules of thumb to the design of support in large excavations
- Describe, explain and discuss the effects of overstoping and understoping on the stability and support requirements of off-reef excavations
- Determine appropriate support strategies for large chambers for given mining and shaft layouts, rockmass conditions, stress regimes and geological circumstances.

## 5.3 SUPPORT DESIGN CRITERIA

### 5.3.1 STOPE SUPPORT DESIGN CRITERIA

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

- Describe, explain and discuss stope support requirements in terms of :

  Initial stiffness, Yieldability
  Areal coverage, Area of influence, Beam reinforcement, Suspension
  Support resistance, Energy absorption

- Describe, explain and discuss how support resistance varies for static and dynamic conditions
- Calculate required support resistances for static conditions
- Calculate required support resistances for dynamic (rockburst) conditions

 

- Calculate support loads for support systems made up of various units
- Calculate energy absorption for support systems made up of various units
- Calculate required support resistances and energy absorption for complete mining cycles to ensure minima are always achieved throughout the cycle
- Consider the effects of variability of support unit quality
- Consider the effects of variability of support unit installation.

### 5.3.2 TUNNEL, CHAMBER AND SHAFT SUPPORT DESIGN CRITERIA

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

- Describe, explain and discuss excavation support and rockwall reinforcement requirements in terms of :

  Initial stiffness, Yieldability
  Unit length, Areal coverage, Area of influence, Beam reinforcement, Suspension
  Support resistance, Energy absorption

- Describe, explain and discuss how support resistance varies for static and dynamic conditions
- Calculate required support resistances for static conditions
- Calculate required support resistances for dynamic (rockburst) conditions
- Calculate support loads for support systems made up of various units
- Calculate energy absorption for support systems made up of various units
- Consider the effects of variability of support unit quality
- Consider the effects of variability of support unit installation.

## 5.4 SUPPORT UNIT AND SUPPORT SYSTEM TYPES AND CHARACTERISTICS

### 5.4.1 PILLARS AS STOPE SUPPORT

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 meaning, application and behavioural characteristics of :

  Rigid pillars, Yield pillars, Crush pillars

- Describe, explain and discuss the factors that should be taken into consideration when designing a pillar support system
- Describe, explain, discuss and account for the limitations in determining the strength of hard rock pillars

- Describe, explain and apply empirical formulae to derive the strength of hard rock pillars
- Sketch, describe, explain and discuss the role of loading system stiffness in the stability of pillar systems once pillars have exceeded their peak strength
- Describe, explain and discuss the mechanism of foundation failure of pillars
- Describe, explain and discuss the factors that affect foundation failure of pillars
- Design in-stope pillar support layouts for :

  Breast mining, Up-dip mining.

### 5.4.2 BACKFILL AS STOPE SUPPORT

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 main types of backfill used in tabular, hard rock mining support
- Sketch, describe, explain and discuss the preparation, reticulation and placement of the main types of backfill used in mining support
- Sketch, describe, explain and discuss the applications of the main types of backfill used in mining support
- Sketch, describe, explain and discuss the important backfill material characteristics that affect performance
- Sketch, describe, explain and discuss the important backfill placement characteristics that affect performance
- Describe, explain and discuss the backfill characteristics required for filling flat-dipping narrow tabular stopes at depth
- Describe which backfill types are suitable for filling flat-dipping narrow tabular stopes at depth
- Describe, explain and discuss the backfill characteristics required for filling shallow wide-reef tabular stopes
- Describe which backfill types are suitable for filling shallow wide-reef tabular stopes
- Describe, explain and discuss how backfill assists in improving the stability of rockwalls at the face
- Describe, explain and discuss how backfilling fits into the mining cycle
- Calculate the support resistance of backfill given the backfill performance characteristics and the stope closure rate
- Evaluate potential benefits of backfilling for given rockmass conditions and mining situations
- Determine appropriate backfill types for given rockmass conditions and mining situations
- Determine appropriate placement procedures for given rockmass conditions and mining situations.

 

### 5.4.3 PACK AND ELONGATE SUPPORT IN STOPES

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

- Describe, explain and discuss the stress-strain behaviour of timber :

  When compressed parallel to the grain
  When compressed perpendicular to the grain

- Describe, explain and discuss the effect of loading rate on the stress-strain behaviour of timber
- Describe, explain and discuss the effect of moisture content on the stress-strain behaviour of timber
- Describe, explain and discuss the effect of construction and installation on the stress-strain behaviour of timber
- Sketch, describe, explain and discuss typical load-deformation characteristics of the following support units :

  Mine poles, Profile props, Pipe-sticks
  Mechanical face props, Rapid-yielding hydraulic props
  Cluster sticks
  Other commonly available elongate support units
  Timber packs, Timber-Cement (Composite) packs
  Cement-based packs

- Describe, explain and discuss prestressing devices and systems in terms of :

  Their effects on the above support types
  Their limitations

- Sketch, describe, explain and discuss the principles of operation of rapid yielding hydraulic props
- Evaluate the various types of support units in terms of given mining environments, rockmass conditions and stress regimes
- Determine the support resistance of support units and support systems at various distances from the face for various support layouts
- Determine appropriate support designs for given mining environments, rockmass conditions and stress regimes.

### 5.4.4 SUPPORT AND REINFORCEMENT OF TUNNELS

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

- Apply the various rockmass classification systems to select appropriate support for tunnels in shallow, intermediate and deep mines

 

- Apply the rockwall condition factor (RCF) to select appropriate support for tunnels at depth
- Apply other appropriate criteria to select appropriate support for tunnels at depth
- Describe and discuss the following rockwall support types :

  Mechanically anchored bolts, Cable bolts, Friction bolts
  Cement grouted bolts, Resin bonded bolts
  Full-column grouted/bonded bolts
  Yielding bolts (cone bolts)
  Multiple rod bolts, Multiple strand cable anchors
  Prestressed tendons
  Steel arches, Massive concrete linings
  Shotcrete, Gunite, Thin sprayed linings
  Wire mesh, Rope lacing, Tendon straps

- Characterise the following aspects of the above units :

  their principles of operation
  their technical specifications
  their load-deformation characteristics
  the methods of ensuring support unit quality
  their installation/application procedures
  the methods of ensuring their installed quality

- Design and evaluate the use of appropriate support units, support systems, support patterns and installation procedures for given rockmass conditions, stress regimes and mining layouts.

# 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 in terms of :

  Type of test procedure relevant to data requirements (UCS, TCS, UTS, etc)
  Sample gathering, Sample description, Sample labeling, Sample preparation, Sample quality
  Test methods and procedures to obtain required data
  Data collection, Data classification, Failure modes
  Interpret and incorporate test results in analysis and design
  Account for the limitations of laboratory tests results relative to mine design requirements.

 

## 6.2 MONITORING

### 6.2.1 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.

### 6.2.2 SEISMIC MONITORING 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 differences between geophones and accelerometers
- Describe, explain and discuss typical applications of geophones
- Describe, explain and discuss typical applications of accelerometers
- Describe, explain and discuss the functions and physical attributes of the following components of a seismic system :

  Seismometer, Amplifier
  Analogue to Digital Converter
  Trigger Unit, Storage Unit

- Describe, discuss and explain how to determine objectives for a seismic monitoring system in tabular hard-rock mines
- Explain and discuss key performance criteria for seismic networks
- Explain and discuss the evaluation of historic seismicity for network design
- Explain and discuss the requirements of spatial seismic coverage
- Explain and discuss methods to quantify required seismic sensitivity and location accuracy
- Explain and discuss the needs of various stakeholders for seismic information with respect to monitoring objectives
- Describe, discuss and explain the role of seismic sensitivity and location accuracy modelling in network design
- Describe, discuss and explain how to derive a compromise between ideal network layout and the following constraints :

  Accessibility constraints
  Budgetary constraints

 

- Describe, discuss and explain the factors that need to be considered in placing seismometers
- Explain and discuss how seismometer placement could affect the event location accuracy of a seismic system
- Explain and discuss how seismometer placement could affect the sensitivity of a seismic system
- Describe, discuss and explain relevant procedures to ensure that seismic monitoring information is distributed effectively to stakeholders
- Describe, discuss and explain methods of quality assurance in seismic system management
- Describe and discuss relevant aspects of seismic system audits
- Describe and discuss methods to assess stakeholder needs
- Describe and discuss methods to identify possible shortfalls between seismic monitoring objectives and seismic system performance
- Describe, discuss and explain the predictability of seismicity
- Describe, discuss and explain the predictability of rockbursts
- Describe, discuss and contrast the various seismic magnitude scales
- Describe and discuss the use of seismic data in pro-active and re-active mine design
- Describe and discuss the main seismic parameters used in analysis and interpretation
- Describe and discuss how seismic data and parameter relations are interpreted.

### 6.2.3 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 various subsidence models
- Sketch, describe, explain and discuss various subsidence modelling procedures
- Sketch, describe, explain and discuss various subsidence monitoring procedures.

## 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 differences between physical, empirical and numerical models
- Describe, explain and discuss the limitations of physical, empirical and numerical models

 

- Describe, explain and discuss the selection of appropriate models and 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
- Describe, explain and discuss the difference between relative and absolute results from numerical models
- Describe, explain and discuss the appropriate use of relative and absolute results from numerical models
- Describe and explain the relevance of calibration, correlation and back analysis in interpreting absolute results from numerical models
- Describe and explain the relevance of calibration, correlation and back analysis in interpreting relative results from numerical models.

## 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 HARD 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 geotechnical aspects associated with various non-explosive rock breaking procedures that include :

  Expanding grout techniques
  Block sawing
  Reef cutting, Reef boring
  Tunnel boring, Raise boring

- Describe, explain and discuss the methodologies and applications of these techniques
- List and discuss the advantages and disadvantages of these techniques.

## 7.2 DRILLING TECHNIQUES

 

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 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
- Describe, explain and discuss the optimum explosive types and their properties for use 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
- Describe, explain and discuss the optimum explosive types and their properties for use in the above rounds
- Sketch, describe, explain and discuss blast hole layouts in stopes
- Describe, explain and discuss the direction of drilling of blast holes in stopes
- Describe, explain and discuss the sequence of initiation of blast holes in stopes
- Describe, explain and discuss the optimum explosive types and their properties for use in the above rounds
- Describe, explain and discuss the importance of blast-hole drilling accuracy in the following applications:
- Shaft sinking, Chamber excavation, Orepass excavation, Tunnel development, Stope advance
- Cushion blasting, Smooth blasting.

## 7.3 BLASTING PRACTICES

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 chemical reactions associated with various explosives used in mining
- Sketch, describe, explain and discuss the physical manifestations associated with various explosives used in mining
- Sketch, describe, explain and discuss the basic differences between explosives used in mining
- 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 stopes making use of knowledge of explosives
- Evaluate and determine appropriate blasting rounds to suit given conditions in stopes
- Evaluate and determine appropriate explosive types to suit given conditions in stopes.

## 8 SURFACE EFFECTS

### 8.1 SUBSIDENCE ENGINEERING

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 geotechnical aspects associated with subsidence of rock to surface above shallow tabular hard rock workings.

### 8.2 SURFACE PROTECTION

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 protection of the surface subject to subsidence above shallow tabular hard rock workings
- Design various appropriate pillars for the protection of the surface subject to subsidence above shallow tabular hard rock workings.

 

## 9 MINING STRATEGIES IN DIFFICULT CIRCUMSTANCES

### 9.1 SPECIAL AREAS

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 determining hazards and the level of risk associated with mining excavations
- Describe, explain and discuss the methods of determining hazards and the level of risk associated with mining layouts
- Describe, explain and discuss the reasons and motivation for implementing special area procedures on mines
- Describe, explain and discuss the procedures associated with assessing and declaring special areas on mines
- Describe, explain and discuss the procedures associated with implementing and managing special areas on mines
- Describe, explain and discuss the measures and precautions to be applied in special areas in terms of :

  Continuous risk assessment, Operational planning
  Access control, Mining methods, Support methods

- Describe, explain and discuss the additional mining and support precautions to be taken in the following situations :

  Mining in remnant areas
  Mining adjacent to geological features
  Mining through geological features
  Workings that are about to be stopped
  Workings that are to be re-opened after standing for some time
  Workings that are to be re-opened after a collapse.

### 9.2 PRE-CONDITIONING

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

- Sketch, describe, explain and discuss how pre-conditioning is applied to relieve high-stress conditions in stopes at depth
- Sketch, describe, explain and discuss how pre-conditioning is applied to relieve high-stress conditions in tunnels at depth
- Describe, explain and discuss the theoretical basis for pre-conditioning with reference to :

 

Rock strength, Rockmass strength, Stress regime, Rock fracturing, Seismic environment

- Typical applications where pre-conditioning is required or indicated.

**REFERENCES**

## 1 GEOTECHNICAL CHARACTERISTICS

### 9.3 GEOLOGY

#### 9.3.1 GEOLOGICAL SEQUENCES

Lurie J 1987 South African Geology for Mining, Metallurgical, Hydrological and Civil Engineering
Lexicon Publishers Jhb Chapter 9
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines
SIMRAC Jhb Chapter 1

#### 9.3.2 GEOLOGICAL STRUCTURES

Lurie J 1987 South African Geology for Mining, Metallurgical, Hydrological and Civil Engineering
Lexicon Publishers Jhb Chapter 6
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines
SIMRAC Jhb Chapter 1

### 9.4 ROCK STRENGTH

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 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

### 1.3 ROCKMASS CHARACTERISTICS

#### 1.3.1 GEOTECHNICAL ROCKMASS CLASSIFICATION

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
Stacey TR 2001 Best Practice Rock Engineering Handbook for 'Other' Mines SIMRAC Jhb Chapter 2

## 10 ROCK AND ROCKMASS BEHAVIOUR

### 10.1 ROCKMASS BEHAVIOUR AROUND TABULAR EXCAVATIONS

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6
Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 8
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapter 3, 4, 5
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 7, 8, 9

### 10.2 ROCKMASS BEHAVIOUR AROUND ACCESS AND SERVICE TUNNELS

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 8
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapter 3, 4, 5
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 7, 8, 9

### 10.3 ROCKMASS BEHAVIOUR AROUND SERVICE EXCAVATIONS AND SHAFTS

Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapter 3, 4, 5
Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 8
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 7, 8, 9

### 10.4 MINE SEISMICITY

 

10.4.1 PRINCIPLES OF SEISMICITY

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 5

2.4.2 MINE SEISMOLOGY AND ROCKMASS STABILITY

10.4.1.1 MINE SEISMOLOGY

Chief Inspector of Mines Latest Guideline for the Compilation of a Madatory Code of Practice to Combat Rock Fall and Rock Burst Accidents in Tabular Metalliferous Mines - Ref.No. DME 16/3/2/1-A3 DME
Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 9
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6
Mendecki AJ (ed) 1997 Seismic Monitoring in Mines Chapman & Hall London Chapters 1, 2, 5, 7, 8

10.4.1.2 ROCKMASS STABILITY

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 8
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6
Mendecki AJ (ed) 1997 Seismic Monitoring in Mines Chapman & Hall London Chapters 10, 11

## 11 MINING LAYOUT STRATEGIES

### 11.1 HARDROCK TABULAR MINING METHODS

Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 12, 13, 15

### 11.2 REGIONAL STABILITY STRATEGIES

### 11.2.1 PILLARS AS REGIONAL SUPPORT

#### 11.2.1.1 REGIONAL PILLARS

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 13

#### 11.2.1.2 STABILISING PILLARS

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6

#### 11.2.1.3 BRACKET PILLARS

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6

### 11.2.2 BACKFILL AS REGIONAL SUPPORT

#### 11.2.2.1 BACKFILL PERFORMANCE

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapters 6, 7
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 14
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapter 11

#### 11.2.2.2 BACKFILL FOR ENERGY RELEASE RATE CONTROL

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapters 6, 7

#### 11.2.2.3 BACKFILL FOR EXCESS SHEAR STRESS CONTROL

 

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapters 6, 7

### 11.2.3 REGIONAL MINING LAYOUTS

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6
Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 2
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 7, 8, 9

## 11.3 LOCAL STABILITY STRATEGIES

### 11.3.1 STOPING LAYOUTS AND SEQUENCES

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 3
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 7, 8, 9
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapters 5, 6

## 11.4 SERVICE EXCAVATION LAYOUTS

### 11.4.1 TUNNEL LAYOUTS

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 5
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 7, 8, 9
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapters 4, 9

### 11.4.2 LARGE CHAMBER LAYOUTS

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

 

Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining
Chapman & Hall New York Chapters 7, 8, 9
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb
Chapter 9

### 11.4.3 ROCKPASS LAYOUTS

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock
Mines SIMRAC Jhb Chapter 7
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining
Chapman & Hall New York Chapters 7, 8, 9

### 11.4.4 SHAFT LAYOUTS

#### 11.4.4.1 SHAFT PROTECTION PILLARS

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock
Mines SIMRAC Jhb Chapter 7
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb
Chapter 10

#### 11.4.4.2 SHAFT PILLAR EXTRACTION

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock
Mines SIMRAC Jhb Chapter 7
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb
Chapter 10

#### 11.4.4.3 ALTERNATIVE SHAFT PROTECTION METHODS

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock
Mines SIMRAC Jhb Chapter 7
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb
Chapter 10

## 11.5 LAYOUT DESIGN CRITERIA

 

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 7, 8, 9
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapters 9, 12

# 12 MINING SUPPORT STRATEGIES

## 12.1 STOPING EXCAVATION SUPPORT STRATEGIES

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 4
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 7
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapters 7, 8
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 13, 14

## 12.2 SERVICE EXCAVATION SUPPORT STRATEGIES

### 12.2.1 TUNNEL SUPPORT STRATEGIES

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 7
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapters 4, 9
Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapters 7, 8, 9
Laas JJ 2004 Deep and High Stress Mining Jhb

### 12.2.2 SUPPORT STRATEGIES FOR SHAFTS AND LARGE EXCAVATIONS

#### 12.2.2.1 SUPPORT STRATEGIES FOR VERTICAL SHAFTS

 

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

12.2.2.2 SUPPORT STRATEGIES FOR INCLINED SHAFTS

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

12.2.2.3 SUPPORT STRATEGIES FOR ROCKPASSES

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

12.2.2.4 SUPPORT STRATEGIES FOR LARGE CHAMBERS

## 12.3 SUPPORT DESIGN CRITERIA

### 12.3.1 STOPE SUPPORT DESIGN CRITERIA

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 7
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 7
Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapters 7, 8

### 12.3.2 TUNNEL, CHAMBER AND SHAFT SUPPORT DESIGN CRITERIA

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 7
Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 7

## 12.4 SUPPORT UNIT AND SUPPORT SYSTEM TYPES AND CHARACTERISTICS

 

4.4.1 PILLARS AS STOPE SUPPORT

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

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 4

Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapter 8

Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 13

12.4.1 BACKFILL AS STOPE SUPPORT

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

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 4

Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapter 11

Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 14

12.4.2 PACK AND ELONGATE SUPPORT IN STOPES

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 4

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

Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapter 7

12.4.3 SUPPORT AND REINFORCEMENT OF TUNNELS

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 6

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

Budavari S (ed) 1986 Rock Mechanics in Mining Practice SAIMM Jhb Chapter 4

## 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 IN-SITU STRESS MEASUREMENT AND MONITORING

### 13.2.2 SEISMIC MONITORING SYSTEMS

Ryder JA & Jager AJ 2002 Rock Mechanics for Tabular Hard Rock Mines SIMRAC Jhb Chapter 5
Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 9
Oakland JJ 2003 Total Quality Management Butterworth/Heinemann Amsterdam Chapters 1-3, 17

### 13.2.3 SUBSIDENCE MONITORING

van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 5

## 13.3 MODELLING

### 13.3.1 NUMERICAL MODELLING

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 HARD ROCK

14.1 CUTTING TECHNIQUES

14.2 DRILLING TECHNIQUES

14.3 BLASTING PRACTICES

Brady BHG & Brown ET 1993 Rock Mechanics for Underground Mining Chapman & Hall New York Chapter 17
Local References ??
AEL Blasting News ??

## 15 SURFACE EFFECTS

15.1 SUBSIDENCE ENGINEERING

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
van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 3, 5
vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb
Stacey TR & Swart AH 2001 Practical Rock Engineering Practice for Shallow and Opencast Mines SIMRAC Jhb Chapter 4

15.2 SURFACE PROTECTION

van der Merwe JN 1995 Practical Coal Mining Strata Control Sasol Coal Division Jhb Chapter 3, 5

 

vd Merwe JN & Madden BJ 2002 Rock Engineering for Underground Coal Mines SAIMM Special Publication Series No.7 Jhb
Stacey TR & Swart AH 2001 Practical Rock Engineering Practice for Shallow and Opencast Mines SIMRAC Jhb Chapter 4

## 16 MINING STRATEGIES IN DIFFICULT CIRCUMSTANCES

### 16.1 SPECIAL AREAS

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 3
Simrac Reference ??

### 16.2 PRE-CONDITIONING

Jager AJ & Ryder JA 1999 Rock Engineering Practice for Tabular Hard Rock Mines SIMRAC Jhb Chapter 8

 