Guideline for the Compilation of a Mandatory Code of Practice to Combat Rockfall Accidents in Collieries

1 FOREWORD

A significant number of accidents occurring in collieries are as a result of rockfalls. Over the last few years the fatality rate pertaining to rockfall accidents has reached a plateau and no real or meaningful improvement has been attained.

In an initiative to solve this problem, a tripartite task group was established under the auspices of the Mining Regulation Advisory Committee. The terms of reference of the task group were to investigate and identify root causes of rock related accidents. Current work practices and any compliance and/or non compliance with regulations, standards, directives, guidelines and codes of practice, and its impact on root causes were scrutinised. Research conducted into solutions under the direction of the Safety in Mines Research Advisory Committee was also examined.

Subsequent to the investigation it was concluded that, as a matter of urgency, a **guideline** for the compilation of codes of practice to combat rockfall accidents and **proposed regulations** supplementing the code of practice be drafted and presented to the Mining Regulation Advisory Committee. Due to the complexity and variability of conditions at mines pertaining to the design, geometry and support requirements, rigid and prescriptive guidelines would not be in the interests of rock related safety. An approach was adopted which allowed for local expertise, experience and knowledge on the mines to be effectively utilised. In addition, the positive contribution of tripartism to initiate a process to combat rock related accidents would be enhanced.

2 TASK GROUP MEMBERSHIP

This document has been prepared by the following appointed members of the MRAC Task Group on Rock-Related Safety:

MR B J ERASMUS (Facilitator) - State

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The following persons/organisations were also consulted :-

Mr A J Jager - Miningtek

Dr B J Madden - Miningtek

Mr D C Oldroyd - Ingwe

Dr J N v/d Merwe - SANGORM

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Sub-Committee on Rock Engineering - C.O.M

DRAFT

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3 APPOINTMENT OF CODE OF PRACTICE DRAFTING COMMITTEE

The manager must, after consultation with the Health and Safety Committee, appoint a committee responsible for drafting the Code of Practice.

The members of the Drafting Committee assisting the mine manager in drawing up the Code of Practice must be listed on the title page giving their full names and designation, as well as their professional qualifications and/or experience and affiliation. This committee must include a suitably qualified rock engineering practitioner.

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4 STATUS OF CODE OF PRACTICE AND RELATED DOCUMENTS

In accordance with Section 9(2) of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996), the Chief Inspector may require the manager to prepare and implement codes of practice. These codes of practice must comply with all applicable provisions in any guideline that the Chief Inspector has issued.

This mandatory Code of Practice is a legal document and non-compliance with the provisions thereof is an offence in terms of Section 91 (1) (c).

All managerial instructions, recommended procedures and standards on the relevant topics must comply with the Code of Practice and must be reviewed to establish compliance.

Such a mandatory Code of Practice and related documents must be used in accident inquiries to ascertain compliance.

The Code of Practice remains in force should the colliery change ownership or close temporarily.

5 ROCK ENGINEERING APPRAISAL OF CODE OF PRACTICE

The manager of the mine must ensure that the Code of Practice reflects accepted rock engineering practice. The Code of Practice must be technically appraised by an independent and experienced rock engineering consultant to prevent vital design aspects being overlooked and compromised. Where a Mining House employs a full time rock engineering consultant, he is considered as independent and thereby able to fulfill this role. See Appendix 4

6 REVISION OF CODE OF PRACTICE

The Code of Practice must be reviewed annually and updated to cater for technological developments, or more frequently should the risk assessment or other evidence show that particular hazards are not adequately addressed.

7 ACCESS TO CODE OF PRACTICE AND RELATED DOCUMENTS

The complete Code of Practice and related documents such as recommended procedures must be kept on file by the mine manager. Copies should also be kept by members of the Health and Safety Committee. A registered trade union with members at the mine, a health and safety committee or a health and safety representative at the mine, or, if there is no health and safety representative on the mine, an employee representing the employees on the mine, must be provided with a copy if they submit a written request to the mine manager. A register must be kept of those person/s institutions who have copies in order that they can be forwarded any updates .

A procedure must be instituted by mine management to ensure that all employees are fully conversant with those sections of the Code of Practice relevant to their respective areas of responsibilities.

Relevant extracts must be translated into such other language/s as determined through consultation between management and the Health and Safety Committee and/or the safety representatives, where technically practicable.

8 FORMAT OF CODE OF PRACTICE

The chapters should, where possible, follow the sequence laid out under the heading "Contents of the Code of Practice ". Numbering must be consistent to facilitate cross referencing. Each page must be numbered for easy reference. Wording must be unambiguous and concise.

Whenever possible, illustrations must be used to avoid long descriptions and/or explanations.

When reference has been made in the text to publications or reports, those sources must be included in a bibliography as an appendix.

Appendices 1-4 form part of this guideline.

Documents providing additional information to the Code of Practice must be included as appendices.

9 CRITICAL ASPECTS TO BE INCLUDED IN THE CODE OF PRACTICE

The following aspects are critical to the drafting of the Code of Practice and must be addressed when compiling it.

9.1 Strategies to combat rock-related accidents

The Code of Practice must detail the strategies employed to combat rockfall accidents. These strategies embody various principles, techniques and methodologies employed to combat the hazards peculiar to a particular orebody and include such aspects as layouts, mining sequence, support and monitoring procedure.

Where a strategy is not yet in place, the manager must provide a detailed time table for the preparation and subsequent implementation thereof.

Mine standards are derived from the strategies and are in essence not part of the code of practice *per se*. Mine standards may be changed by management after consultation with the mine's Health and Safety Committee provided these standards meet the requirements of the strategies prescribed in the Code of Practice.

9.2 Deviation from proposed Support Design Methodology

Where a support design methodology other than that described in this document is used, it must be scientifically shown to be equally effective to the methodology described in this document and must be properly motivated and documented. This methodology must be technically appraised by an independent and experienced rock engineering consultant.

9.3 Competency Criteria / Education and Training Syllabi

The critical competency criteria and education and training syllabi for all employees at the different levels in the organisation on issues covered by the Code of Practice, must be described.

9.4 Functions of Departments / Consultants

The functions of departments/consultants and responsibilities of persons in executing aspects of the strategies, must be included in the Code of Practice. Training for these responsibilities must be reflected in the training programme.

9.5 Implementation Plan

The mine manager must prepare an implementation plan that makes provision for issues such as structures, responsibilities of functionaries and programmes and schedules that will enable proper implementation and management of the Code of Practice.

9.6 Assuring compliance with the Code of Practice

The mine manager must ensure compliance with the Code of Practice and institute measures for monitoring compliance.

10 CONTENT OF A CODE OF PRACTICE

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10.1 Title Page

The title page of the Code of Practice must be brief, giving accurate information and all pertinent details about the collieries name, date of issue of the Code of Practice, membership of the Drafting Committee and (where applicable) any revision date.

As an example, the title page could have the following information:

ABC Colliery

Code of Practice to Combat Rockfall Accidents

December 1995 (revised December 1996 if applicable)

Reference No

Drafting Committee: Membership

Seams Mined

Number of Sections

Types of Mining

10.2 Origin

State whether the Code of Practice is compiled at the manager's discretion or mandatory in terms of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996).

State that the Code of Practice has been drawn up in accordance with Guideline

GME 7/4/118-AB2 issued by the Chief Inspector of Mines.

10.3 Status and Review

State that the Code of Practice is a legal document and that it is an offence for any person not to comply with the provisions of the Code of Practice. State that all managerial instructions, recommended procedures and standards on the relevant topics must comply with the Code of Practice and must be reviewed to establish compliance.

10.4 Members of Drafting Committee

The members of the Drafting Committee assisting the mine manager in drawing up the Code of Practice must be listed on the title page giving their full names and designation, as well as professional qualifications and/or experience and affiliation. This committee must include a suitably qualified rock engineering practitioner.

10.5 Terms and Definitions

A glossary of terms and definitions is given in Appendix 4 of this document and must be incorporated into the Code of Practice. Any other terms and definitions , or jargon of which the meaning is not absolutely clear, must be defined and added.

10.6 Geotechnical / Mine Environment

The following minimum information must be provided:

10.6.1 Locality Map

A locality map must be included to indicate the location of the mine in relation to towns, existing infrastructure and any other relevant features such as mines sharing a common boundary, dams, rivers and any other topographical features which could influence the strategies adopted.

10.6.2 Geological Setting

Geological structures, such as faults and dykes and stratigraphy, around individual seams must be described and any dangerous or difficult strata highlighted. A typical section must also be included. A detailed geological assessment may not be necessary but a map showing major geological features in relation to mining outlines and shafts must be included.

10.6.3 Coal Seams Mined

A general description of seams being mined including any relevant information such as average and range of mining depth, seam width / thickness, dip and strike must be given.

10.6.4 Regional Hydrology

The regional hydrology, such as the occurrence of any significant groundwater and/or any other relevant information, must be described.

10.6.5 Geotechnical Areas

Geotechnical areas based on known geological hazards, structures, jointing and changes in rock type and strength, or any other factor which may impact on mining, the regional support strategy or panel and roadway support strategies must be described and their location and extent depicted on a plan. The nature of the occurrence of significant pore water and any other local geological features, must be included here.

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10.7 Mine Rockfall Accident Analysis

The Code of Practice must contain a tabulation of the mine's five year history of rock-related casualties (fatals, reportables and disabling incidents) and non-casualty incidents (where available), categorised according to rockfalls per

1 000 employees at work for both surface and underground operations.

This information must be graphically represented depicting annual statistics to facilitate easy interpretation of the data and to highlight trends.

Accident report form 13, as required by the Mine Health and Safety Regulation 34.1 is formulated in a manner which facilitates identification of the root causes of fatal and reportable accidents. The information must be stored in the mine's data bank to facilitate analyses to identify as many root causes as possible.

The Code of Practice must clearly state who is responsible for the completion of accident report forms and the maintenance and interpretation of mine accident statistics.

10.8 Rock-Related Risk Management

The Mine Health and Safety Act requires the manager to identify the hazards, to assess the health and safety risk to which workers may be exposed while they are at work, record these findings and implement reasonably practicable measures to control the risk.

When dealing with the aspect of hazard identification and risk assessment, the risk control programme manager should use the Tripartite Risk Assessment Guidelines on the subject.

The manager is required here to identify and describe rock-related hazards which are likely to arise from the mining of each geotechnical area identified. This should include the potential hazard associated with the destruction of support pillars by fire. This information and that arising from the above accident analysis will enable the manager to develop strategies required in each of the following sections.

10.9 Strategies to reduce and manage rock-related risks

This section forms the principal element of the Code of Practice.

After the hazards associated with the mining of an orebody have been identified and the related risks prioritised, it is necessary to define the strategies to reduce and manage these risks.

The department or persons responsible for the execution of the particular strategies or portions thereof must be stated in all cases.

Mine standards are derived from the strategies. The Code of Practice specifies **what** is required whilst mine standards reflect implementation instructions or rules.

Where a strategy is not yet in place, the mine manager must provide a detailed time table for the preparation and subsequent implementation thereof.

10.9.1 Mining Method, Sequence and Overall Mine Stability.

The strategy for the overall stability of a mine must include measures to avoid failures that may injure employees or damage mine excavations or equipment. It must take into account the geotechnical environment and potential major rock related hazards identified in the risk assessment process. The overall mining method and sequencing to be followed to manage the risk involved must be described. Where more than one seam occurs in close proximity to each other, and where the mining of one or more seams can be expected to have an adverse effect and induce hazardous conditions on the other, the strategy adopted to manage this risk must be described.

Included in this strategy must be a detailed description of the use of ongoing rock engineering input in mine layout design and performance monitoring.

In the case of:

10.9.1.(a) Opencast and strip mining operations:

As part of the strategy for the design of pit slope angles, detailed studies of the geology, groundwater and geomechanical properties of the rockmass and discontinuities must be undertaken. The methodology and frequency of these investigations must be described.

It is recognised that in an open pit environment there are risks of failure on bench, stack and overall slopes, and a slope management programme must be described to reduce the impact of such failures on employees and mine equipment. Detailed strategies for an ongoing stability monitoring and geotechnical mapping programme, together with the development of a pit slope hazard plan, must be included in order to reduce risks.

A strategy to reduce the amount of damage behind the slope design line, and thereby reduce the risk of slope instability and potential for rockfalls from both bench and stacks within the pit, must be described, e.g. pit limit blasting.

Methods of "housekeeping" with respect to the dressing of loose material on the bench face and, in particular, the crest areas, to reduce the hazards in and around the mining area, must be described.

10.9.1(b) The influence of the mining activity on the surface environment:

The design methodology to avoid uncontrolled collapses of the mine or portion/s thereof, and the effects of the mining methods employed on surface structures and topography, must be described. Included here would be the methodology and criteria used for the design of in-panel and barrier pillars. The reasons for selecting a specific type of pillar must also be described.

10.9.1(c) The influence of mining activities on neighbouring mines:

Where the possibility exists of one mine’s activities influencing the activities of another mine, a method to ensure that the mines concerned exchange data concerning mining methods, regional support, mining sequence, common geological features, percentage extraction and the location, magnitude and nature of seismic events must be described. This section must also include the timing and overall sequencing for the removal of the boundary pillar where applicable.

10.9.2 Roof / Panel Design and Support

This strategy must accommodate the conditions expected from the geotechnical settings and the type of accident encountered. The strategy may vary for different parts of the same mine where the geotechnical environments differ. Reference must be made to the accident analysis for the identification of problem areas.

The layout must include the location and support of two separate accessways for each panel.

The design methodology for the roof support for bord and pillar workings as well as high extraction mining must be described. It must include specific matters related to the mining equipment used on the mine such as maximum bord widths for different types of continuous miners and shape of the excavations.

However, where a different methodology is used, it must be scientifically shown to be equally effective to the methodology described in Appendix 1 of this document. This methodology must be properly motivated and documented. This methodology must be technically appraised by an independent and experienced rock engineering

consultant.

When experimenting with a mining or support system that differs from that in the code of practice it must be subjected to a risk assessment and fully documented in a manner complying with this guideline.

10.9.3 Bord Intersection and Service Excavation Stability

A strategy must be adopted to ensure the safety of personnel working and/or travelling in roadways and must be detailed. Opening-up and resupporting procedures must also be included. Reference to Appendix 1 must be made when compiling the strategy for this section. Cross referencing with the mine standard is necessary.

10.9.4 Mine Access Protection

The strategy for the protection of shafts and/or other main entrances must be described.

This must include a summary of the rock engineering appraisal of the existing accessways' current stability, procedures employed to monitor ground movement in shafts and accessways, the steps taken to minimise the risk associated with such movements. Reports in this regard must be referenced.

10.9.5 Special Areas.

A strategy must be described to identify and deal with an increased risk of rockfalls which may develop during the course of routine mining operations. Such areas shall be designated as "special areas" and require additional attention and precautions. In this strategy allowance must be made for management to make rapid modifications to support and procedures where such action is urgently required. Reference must be made to Appendix 2 of this document when compiling this section.

The strategy must describe the responsibility of rock engineering in designing the layout, mining sequence, support and monitoring of special areas. This strategy must clearly indicate where the management approved procedure, and any subsequent modifications for individual/specific areas, are to be located and to whom copies of these instructions are to be distributed.

10.9.6 Monitoring and Control.

Suitable monitoring strategies must be described which will ensure that the coal seam/s is/are safely exploited and that early warning of changing conditions is communicated to responsible persons. This monitoring can be done either visually or with the use of appropriate instruments, or using both, depending on the circumstances.

Procedures and the persons responsible for the examination of the safety of the working area, its reporting and control by all relevant categories of employees must be described. The appropriate procedures taken for rendering an area safe and to reduce risk must be specified. In addition, it must outline the controls and procedures to be followed and specify the responsibility for each identified hazard. The key points should be tabulated in accordance with the format shown rather than detailed descriptions. For example the following table contents serve to explain what is required for a particular hazard:-

Hazard	**Controls**	**Procedures, Rules or Standards**	**Responsible Person**
Fall of roof in panel	Early shift examination	Mine Standard No.	Team Leader
	Miner's follow-up examination	Mine Standard No.	Miner
	Midshift examination	Mine Standard No.	Team Members
	Barring before charging up	Mine Standard No.	Machine Operators
	Persons not to work in unsupported area	Procedure No.	Miner
	Persons not to enter panel prior to the installation of temporary support	Procedure No.	Miner
	Support installation	Procedure No.	Miner
	Support design	Procedure No.	Rock Engineering Practitioner
	Blast design	Procedure No.	Rock Engineering Practitioner

The table content must be made site specific. It must be expanded to include all relevant rock-related hazards, controls and procedures.

The mine manager must establish and maintain monitoring programmes and procedures to ensure that the code of practice is being properly implemented and maintained. These must be described in the Code of Practice.

The mine manager must appoint and empower persons who shall be responsible for assuring conformance with particular sections of the Code of Practice. Furthermore, he must institute measures for monitoring conformance. These procedures must be described in the Code of Practice.

A method to ensure that general conditions of the rockwalls in all working places are reported on a regular basis must be described. For example, when changes in conditions are observed, they must be recorded in the shift boss's logbook and communicated to those specified in the Code of Practice. Procedures for analysing the data to identify deteriorating conditions must be specified and described.

The role of the rock engineering department/consultant and the routine input by rock engineering personnel in the monitoring process must be described here.

With respect to the above, a suitably qualified rock engineering practitioner must conduct a regular review of every separate working place in the mine or section of the mine for which he is responsible. The frequency of the review of working places with different risk classifications must be specified in the Code of Practice. The review must describe all facts, trends and matters that may affect current or projected rock-related hazards in each working place as far as reasonably practicable. The review must be systematically and chronologically recorded and must include the practitioner's comments and recommendations for each working place and must be referred to at all planning meetings.

The frequency of visits to working places with different risk classifications by suitably trained personnel must be specified in the Code of Practice.

The procedure for monitoring the influence of mining on adjacent properties must be described.

10.9.7 Blast design and practice

The blasting strategy adopted to minimise blast induced damage must be described. This must include methods to ensure drilling accuracy, types of explosives and method of initiation. Due consideration must be given to conditions in different geotechnical areas.

10.9.8 Appendices to Code of Practice

Documents providing additional information to the Code of Practice should be included as appendices.

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APPENDIX 1

BORD AND PILLAR MINING DESIGN STRATEGY / ROADWAY SUPPORT STRATEGY / HIGH EXTRACTION PANEL DESIGN STRATEGY / SUBSIDENCE CONTROL

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1. Introduction

Separate sections in the Codes of Practice shall be drawn up for each geotechnical area that was defined under 10.6.5. For each area, strategies for the following shall be recorded.

(a) Bord and pillar mining pillar design;

(b) Roadway roof support strategy;

(c) Where applicable, high extraction panel and pillar design strategy;

(d) Where applicable, subsidence control measures;

(e) Communication of changes in ground conditions.

The dimensions of roof support, pillar sizes, etc. should be contained in the mine standards. The strategy statements in the Code of Practice should contain details of the methods which are to be used to determine those exact dimensions.

2. Design Methodology

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2.1 Bord and pillar mining pillar design

Pillars shall be designed to suitable safety factors using the Salamon and Munro (1976) formula or any other formula with proven applicability. Safety factors must be specified for the following :

(a) Main development;

(b) Secondary development; and

(c) Production panels.

In all cases cognisance shall be taken of any structures which exist or could be reasonably foreseen to be created on or in the overlying surface and such structures shall be protected by designing pillars to the appropriate safety factors. Where the coal strength is known to be different from the average value of 7,2 MPa which was derived by Salamon and Munro (1967), the locally applicable value shall be used.

Deviations from the Salamon and Munro (1967) formula must be approved by the Chief Inspector.

2.2 <u>Roadway roof support design methodology</u>

Coal mining roofs can be broadly classified into three main types :

2.2.1 No systematic support required (i.e. massive sandstone roof):

Strong roof requiring no systematic support shall be investigated for changes in lithology at monthly intervals and the strategy adapted where necessary.

2.2.2 Suspension type (i.e. relatively thin layer of weak material overlain by stronger layer):

Suspension type roofs shall be supported by means of a suitable support system designed by a suitably qualified rock engineering practitioner. The design shall be based on the weight of the weak material, multiplied by a suitable safety factor, balanced by the load bearing capacity of the support system. The load bearing capacity of the system shall be determined by tests.

Attention must be given to potential failures between support components, the support of discontinuities and the pre-support protection measures (i.e. maximum drivage distance before support is installed, temporary supports, canopy protection and the time delay before installing support).

2.2.3 Beam creation type (i.e. thick layer of weak material like shale, mudstone or other laminated material)

Where a thick, weak roof occurs, an artificial beam shall be created by placing roof support in such a way that the shear stresses in the roof are countered. Alternatively, prop support or long anchors to provide sufficient suspension resistance shall be provided. This support shall be designed by a qualified rock engineering practitioner/consultant.

Attention shall also be given to inter support element failures, the support of discontinuities and the pre-support protection measures (i.e. maximum drivage distance before support is installed, temporary supports, canopy protection and the time delay before installing support).

2.2.4 Generic roof support requirements:

(i) *Discontinuities:*

Joints, slips and other geological discontinuities should receive priority attention. An effective, scientifically motivated, discontinuity support system or systems shall be included, beginning at the identification of the hazard and covering all steps up to the final safe situation.

(ii) *Road width:*

The maximum tolerable road width is an integral part of roof support, be it a massive, strong roof or a thick, weak material. Roof stability is inversely proportional to the square of road width.

In the absence of historical data, the maximum road width shall be calculated with standard beam theory, taking account of the thickness of roof layers, the loading of the beam and the tensile strength of the roof material.

(iii) *Burnt coal:*

Special support making provision for extended area cover (i.e. wiremesh, shotcrete, etc.) shall be called for in burnt coal areas. The maximum pre-support drivage distance in burnt coal shall be included in the strategy.

(iv) *Ribside support:*

Where ribside spalling could pose a hazard (due to depth, mining height, weak or burnt coal, etc.) a suitable ribside support strategy shall be part of the roof support strategy.

(v) *Water and gas pressure*

In cases where gas or water pressure could pose a hazard, suitable measures such as pressure relieving holes or additional support shall be included in the roof support strategy.

(vi) All materials used for roof support must be subjected to quality control testing according to laid down procedures.

(vii) A procedure to determine changes in roof condition shall be specified.

2.3 <u>High extraction panel and pillar design strategy</u>

The strata control of high extraction coal mining is dominated by the behaviour of the overburden strata and pillars. Panel width should be designed to ensure that the overburden either fails or remains intact, and then pillars should be designed to cater for the predicted stress levels.

For instance, if it is decided to mine in such a manner that a dolerite sill in the overburden remains intact, then higher stress levels will develop on stooping pillars and this increased stress must be taken into account when sizing the pillars. The same is true for inter panel pillars and chain pillars in longwalling.

The decision, on whether to allow the overburden to fail or not, should be based on the following considerations :

- underground stress conditions
- surface control
- groundwater control, i.e. water influx into the mine and

environmental considerations.

In the case of stooping, the strategy shall include the considerations on which the direction of pillar extraction is to be done (i.e. from high to lower stress side of the panel or based on the trends of geological discontinuities) and the method of extracting a pillar as well as the stooping support (i.e. roofbolt or timber breaker lines).

The panel and pillar design for high extraction mining should be done by a suitably qualified rock engineering practitioner. In the case where existing panels are considered for stooping, a suitably qualified rock engineering practitioner must carry out an investigation.

2.4 __Subsidence control:__

In the case of high extraction mining or any other mining method which could lead to subsidence of the surface, the strategy should include the handling of subsidence effects. This will require a survey of the surface use, be it agricultural or whether there are artificial structures. Consideration must also be given to the consequences of rapid drainage of flooded areas.

The nature and magnitude of the subsidence must be predicted, followed by a prediction of the effects of the subsidence. This could include ponding, drying up of boreholes or cosmetic, architectural or structural damage to artificial structures.

The strategy should include a method of handling these effects, for instance mitigation of ponds, compensation for crop losses, repair, replacement or abandonment of structures.

The subsidence prediction must include prediction of surface strains and tilts and be done using proven and established methods, either developed in a specific mining region or one of the more general methods like those of Schümann or van der Merwe.

3. References

Salamon, MDG and Oravecz, KI (1976). Rock Mechanics in Coal Mining. Chamber of Mines of South Africa.

Salamon, MDG and Munro, AH (1967). A study of the strength of coal pillars. J.S. Afr. Inst. Min. Metall. September 1967.

Van der Merwe, JN (1992). Subsidence caused by high extraction coal mining in the Sasolburg and Secunda areas : prediction thereof and the mitigation of its effects. Ph D thesis, University of the Witwatersrand.

Van der Merwe, JN (1996). Practical Coal Mining Strata Control. Sasol Mining (Pty) Ltd.

Schümann, EHR (1993). Investigations Into The Development Of Subsidence At South African Coal Mines.

Madden, B J (1991), Re-evaluation of Coal Pillar Design. J.S. Afr. Inst. Min. Metall.

APPENDIX 2

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COAL MINES: STRATEGIES FOR SPECIAL AREAS

1. Description of Special Areas

Any area which will require more stringent support than the normal support used on the mine, such as major burnt coal areas, major dykes, multiple fault zones, etc., shall be designated as a Special Area. This designation allows management to make rapid modifications where it is required. The procedure for making the changes must be stated in the strategy.

1.1. Special areas declaration procedure

A procedure must be established which provides for:

(a) the identification of a special area;

(b) the written notification to relevant personnel;

(c) the acknowledgement of receipt by personnel;

(d) the work place entry procedure;

(e) the type and spacing of support to be used; and

(f) a separate file for each working place classified as a special area containing all relevant information regarding the classification, declaration procedure, and monitoring of that area.

To ensure the smooth operation of the entire procedure, the mine manager shall appoint a Special Area Officer in writing. The duties must be specified in the letter of appointment.

1.2 Special Areas Committee

In order to review progress and co-ordinate general mine policy regarding the mining of special areas, a Special Areas Committee should be convened and meet at intervals not exceeding three months.

The Committee shall comprise Senior Mine Management, a suitably qualified rock engineering practitioner/consultant and a representative from the Health and Safety Committee.

1.3 Functions of the Special Areas Committee

The Code of Practice shall specify the functions of the Special Areas Committee.

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APPENDIX 3

THE FUNCTION OF A ROCK ENGINEERING SERVICE

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1. Introduction

An efficient rock engineering service is required in a mining operation to apply rock mechanics and strata control principles for the safe and economic design of mine workings.

The level of service required is related to the risk profile of the colliery

Maximum benefit is derived from a rock engineering department/consultant when it acts proactively, identifying potentially dangerous situations and taking or recommending remedial action before persons are injured or workings damaged.

To achieve this it is advisable that such a service be closely associated with mining operations by operating as follows:

- Participate in planning activities in order to identify and advise management on potentially dangerous or damaging situations created by, or likely to be created by mining operations.
- Design and assist in implementing systems, procedures and techniques which will reduce or eliminate rockfall hazards.
- Initiate and implement monitoring, recording and reporting systems and procedures

which ensure that relevant information is timeously provided to the correct people in planning and operating functions.

- Ensure mining systems are employed which will provide conditions conforming to those required by relevant authorities with regard to surface structures.
- Assist with training of all levels of mine personnel in rock engineering aspects relevant to their occupations.

For a department to operate in this manner, it must be adequately equipped and staffed with properly qualified and experienced personnel closely associated with, but managed independently of the production department.

When operating correctly, the department must fulfil a number of functions.

The actual priority and volume of work involved in executing these functions will depend on the nature and size of the mining operation.

2 <u>The Planning and Design Function</u>

2.1 Select the most suitable mining techniques and regional support for particular deposits by applying rock engineering analysis to ensure that the desired levels of stability will be maintained throughout the required period of operation.

2.2 Develop strategies for the code of practice after consultation with the mine's Health and Safety Committee.

2.3 Design all protection, control and support pillars on the mine.

2.4 Design all service excavations to ensure stability throughout the excavation's active life.

2.5 Approve plans for mining sequences to ensure that:-

- the factors affecting the stability of all excavations are taken into account;

- support systems to accommodate current and anticipated rock conditions are incorporated.

2.6 In bord and pillar workings:-

- select bord width based on sound rock engineering principles and design bord support systems;

- check (by a suitably qualified rock engineering practitioner) the application of standard design techniques for correctness.

- approve the design of pillar extraction operations taking rock engineering principles into account.

2.7 The responsible rock engineering practitioner/consultant to provide input into mine planning or review meetings to ensure that the desired sequencing is adhered to and to answer any queries. Where significant departures from the planned layout occur, the rock engineering practitioner/consultant must ensure that variations do not create a hazardous situation. Where necessary, he must indicate what steps are to be taken to rectify the situation.

3 Routine Monitoring and Special Investigations

3.1 Regularly monitor pillar performance to ensure that they conform to design requirements.

3.2 Visit production and service workings regularly to detect abnormal conditions and departures from planned layout.

3.3 Regularly inspect important chambers during the excavation, to ensure adherence to the designed excavation sequence and support standard and sequence.

3.4 Regularly monitor the performance of support systems in important excavations.

3.5 Where a danger of instability exists in shafts regularly monitor displacements and, in particular, fault plane intersections.

3.6 Investigate unusual ground conditions, report findings and recommend remedial action.

3.7 Investigate all rock-related fatal accidents and complete rock engineering aspects of the official accident report.

3.8 Inspect all large or serious falls of ground and submit a report.

3.9 Give input on risk assessment matters pertaining to rock related issues.

4 Research And Technology Transfer

Staff must remain aware of new technological developments and actively pursue the introduction of those that can be gainfully employed on the mine.

4.1 Investigate, on an on-going basis, the possibility of improving existing support systems.

4.2 Update mine’s codes of practice and related mine standards in consultation with the mine’s Health and Safety Committee.

5 Quality Control

5.1 Supervise routine quality control tests to ensure support elements provide the required performance characteristics for the loading conditions expected.

6 Training / Examinations

6.1 Assist with the training of underground personnel in strata control applicable to their mines, with particular emphasis on the identification of dangerous ground conditions.

6.2 Instruct training officials in aspects of strata control.

APPENDIX 4

GLOSSARY OF TERMS AND DEFINITIONS

Accelerometer: A seismometer which measures ground acceleration.

Adit: A horizontal opening, started from a hillside, to reach an orebody.

Bord: Roadway driven in orebody or seam.

Back: This is the orebody between a level and the surface,

or between two levels.

Burden : Distance between an explosive charge and the free

surface in the direction of throw.

Compressive stress: Normal stress tending to shorten the body in the

direction in which it acts.

Controlled blasting: All forms of blasting designed to preserve the integrity

of the remaining rocks (e.g. smooth blasting, pre-splitting, post- splitting).

Convergence: Reduction of the distance between two basically parallel

surfaces (usually the hangingwall and the footwall)

Creep: Time-dependent deformation.

Cross-cut: A horizontal opening, like a tunnel, that cuts the rock

formation at an angle to the strike in order to reach an orebody.

Decoupling: Ratio of the radius of a blasthole to the radius of the charge; this causes a reduction in the amplitude of the

strain wave by increasing the space between the charge

and the blasthole wall.

Deformation: A change in shape or size of a solid body.

Dilatancy: The property of volume increase under loading

Dip: Angle at which a stratum or other planar feature is

inclined from the horizontal

Discontinuity surface: Any surface across which some property of a

rockmass is discontinuous (e.g. bedding planes,

fractures).

Drive: A horizontal opening, like a tunnel, lying in or

near the orebody, parallel to the strike.

Elasticity: Property of a material whereby it returns to its

original form or condition after an applied force

is removed.

Footwall/floor: Mass of rock beneath a discontinuity surface (in

tabular mining, the rock below the reef plane).

Gate Road: Roadway at either end of a longwall or shortwall.

Geophone: A seismometer that measures ground velocity.

Geotechnical area: A portion of a mine where similar geological conditions exist which give rise to a unique set of identifiable rock-related hazards for which a common set of strategies can be employed to minimise the risk resulting from mining.

Force: An action that tries to move an object from a

stationery position, or to change its rate of

movement or its direction of movement.

Gully: An excavation cut in the immediate footwall or

hangingwall of the reef for the purpose of enabling the removal of rock from the face or providing

access to the face for men or material.

Hangingwall/roof: Mass of rock above a discontinuity surface (in

tabular mining, the rock above the reef plane).

Hypocentre: Location in 3 dimensions of the source of a

seismic event. Also know as the focus (or source

location).

Inelastic deformation: The portion of deformation under stress that is

not annulled by the removal of the stress.

Level: All openings at a horizon from which the orebody

is opened up and mining is started.

Magnitude (seismic): Measure of the size of a seismic event. May en-

compass energy, moment or both in its calculation.

Metalliferous mine: Includes all mines that are not diamond or

coal mines.

Normal force: Force directed normal (perpendicular) to the

surface element across which it acts.

Normal stress: Component of stress normal to the plane on

which it acts.

Overbreak: The quantity of rock that is removed beyond the

planned perimeter of the final excavation.

Peak particle velocity: Maximum velocity of the rockmass measured

directly at a geophone or calculated from ground

motion relations.

Permanent support: Support that once installed is not removed.

Pillar: Rock left in situ during the mining process to

support the local hangingwall, roof or to provide

stability to the mine or portion thereof.

Plasticity: State in which material continues to deform

indefinitely whilst sustaining a constant stress.

Poisson’s ratio: Ratio of shortening in the transverse direction

to elongation in the direction of an applied force

in a body under tension below the proportional

limit.

Primitive (virgin) State of stress in a geological formation before it

stress: is disturbed by man-made operations.

Principal stress Stress (or strain) normal to one of three mutually

(or strain): perpendicular planes on which the shear stress

(or strain) at the point in the body is zero.

P-Wave: Primary or compressive wave emanating from the

source of a seismic event. Consists of a train of

compressions and dilations (like a spring). Moves

at approximately 6 000 m/s through quartzites.

Rock A Professional Engineer or a Professional Natural Scientist Engineering specialising in Rock Engineering and practising, or a graduate Consultant: possessing the Chamber of Mines Certificate in Advanced Rock Engineering who has sufficient experience of rock engineering practice in the mining industry that he is able to advise management on strategic decisions that affect the industry and has sufficient theoretical knowledge to be able to understand and implement new research findings within the industry.

Radiated seismic Total elastic energy radiated from a seismic source.

energy: Describes the potential for damage to man-made

structures better than seismic moment, and is

based on the velocity of ground motion.

Raise: Any tunnel having an inclination (above horizontal in the direction of the working of more than 5

degrees (but not included under the definition of a

shaft).

Reef: A vein, bed or deposit (other than a surface alluvial

deposit) that contains minerals, except in the case of

coal or diamondiferous formations.

Regular review: Assessment of the conditions of an area through discussions, plan critique, planning meetings and / or underground visits.

Rock: Any naturally formed aggregate of mineral matter

occurring in large masses or fragments.

Rockburst: Seismic event that causes damage to underground

workings.

Rockfall Fall of a rock fragment or a portion of fractured rock

(fall of ground): mass without the simultaneous occurrence of a seismic

event.

Rockmass: Rock as it occurs in situ, including its discontinuities.

Rockmass instability: A softening within a critical volume of rock indicated

by accelerating deformation and a drop in stress.

Suitably qualified A person who is at least in possession of the Chamber of

rock engineering Mines Certificate in Rock Mechanics. (Coal).

practitioner:

Suitably trained A person trained in relevant rock engineering / strata

personnel: control competencies.

Seismometer: A device (transducer) that converts ground motion

into an electric signal.

Seismic event: Transient earth motion caused by a sudden release of the strain energy stored in the rock.

Seismic moment Measure of the strength of an earthquake or of a (scalar): seismic event and an indication of the amount of deformation (displacement) at a seismic source.

Seismic moment Describes completely the equivalent forces acting (tensor): at a seismic source and is equivalent to the total seismic moment integrated over the source volume of a seismic event.

Seismic strain: Sum of all moment tensors of all events within a given volume of the rockmass.

Seismic strain rate: Seismic strain over a specified period of time.

Seismic stress: Seismic energy radiated by all events recorded within a volume during a specified period of time.

Shaft: Any tunnel having a cross sectional dimension of 3,7 m or over and

(i) having an inclination to the horizontal of 15 degrees or over, or

(ii) having an inclination to the horizontal of less than 15 degrees but more than 10 degrees where the speed of traction exceeds 2 m/s.

Spalling: Longitudinal splitting in uniaxial compression, or the breaking-off of plate-like pieces from a free rock surface.

Special areas: During the course of routine mining an increased risk of rockfalls or rockbursts may develop. Such areas requiring additional attention and precautions must be designated special areas.

Spitting: Violent ejection of splinters of rock from the surface of an excavation.

Stiffness: Ratio of force versus displacement.

Stope: An underground excavation made in removal of any ground or mineral, other than coal, but does not apply to excavations made for engine rooms and pump chambers or for development purposes such as shafts, drives, winzes and raises.

Strain burst: Rockburst at the lower end of the spectrum of violent events occurring essentially at the surface of an excavation.

Strength: The maximum stress that a material can resist without failing for any given loading regime.

Stress: Force acting across a surface element divided by the area of the element.

Strike: Direction of the azimuth of a horizontal line in the plane of an inclined stratum (or other planar feature) within a rockmass.

Subsidence: Downward movement of the overburden (soil and/or rock) lying above an underground excavation or adjoining a surface excavation.

Support: A structure or a structural feature built into or around an underground excavation to maintain its stability.

S-Wave: Secondary or shear wave emanated from the source

or a seismic event. Consists of elastic vibrations perpendicular to the direction of travel. Moves at

approximately 3 650 m/s through quartzites.

Swelling: Constitutive mineralogical nature of the rock by which

water is absorbed, causing a measurable increase in

volume; swelling can exert very large time-dependent

forces on rock or support systems and reduce the size

of excavations.

Tangent modulus: Slope of the tangent to the curve of stress versus strain

at a given stress value (generally a stress equal to half

the compressive strength).

Temporary support: Support which will be removed.

Tensile stress: Normal stress tending to lengthen a body along the

direction in which it acts.

Thickness: Perpendicular distance between bounding surfaces

(e.g. bedding planes).

Transverse (shear) Wave in which the displacement at each point of the

wave: medium is parallel to the wavefront.

Weathering: Process of disintegration and decomposition as a consequence of exposure to the atmosphere, to chemical action, and to the action of frost, water and heat. Working place: The place where mine workers normally work or travel.