REFERENCE NUMBER: DME 16/3/2/1 - A5

DEPARTMENT OF MINERALS AND ENERGY

Minerals and Energy for Development and prosperity

MINE HEALTH AND SAFETY INSPECTORATE

GUIDELINE FOR THE COMPILATION OF A MANDATORY CODE OF PRACTICE TO COMBAT ROCKMASS FAILURE ACCIDENTS IN MASSIVE MINING OPERATIONS

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Acting Chief Inspector of Mines

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DATE

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PART A: THE GUIDELINE

1. FOREWORD

1.1 The majority of accidents occurring at mines are as a result rockmass failures and roof falls, gravitationally induced. Over the last few years the fatality rate pertaining to rockmass failure-related accidents has reached a plateau and no real or meaningful improvement has been attained.

1.2 In an initiative to solve this problem, a tripartite task group was established under the auspices of the Mining Regulation Advisory Commitee (MRAC). The initial terms of reference of the task group were to investigate and identify root causes of rockmass failure related accidents. Current work practices and any compliance and/or non-compliance with regulations, standards, directives, guidelines and COPs, and their impact on root causes were scrutinised. Research conducted into solutions under the direction of the Safety in Mines Research Advisory Committee (SIMRAC) was also examined.

1.3 Subsequent to the investigation it was concluded that, as a matter of urgency, a guideline for the compilation of a mandatory COP to combat rockmass failure accidents in massive mine operations should be produced. Due to the complexity and variability of conditions at massive mines pertaining to the design, geometry and support requirements, rigid and prescriptive requirements would not be in the interests of rock related safety. An approach was adopted which allows for local expertise, experience and knowledge on the mines to be effectively utilised.

1.4 This guideline is a generic document and is not intended to address the rock related accident problems encountered on a particular mine.

2. THE LEGAL STATUS OF GUIDELINES AND COPs

2.1 In accordance with section 9(2) of the Mine Health and Safety Act, 29 of 1996(MHSA), an employer must prepare and implement a COP on any matter affecting the health and safety of employees and any other person who may be directly affected by the activities at the mine if the Chief Inspector of Mines requires it. In terms of section 9(3) of the MHSA, a COP must comply with the relevant guideline issued by the Chief Inspector of Mines.

2.2 Failure by the employer to prepare or implement a COP in compliance with this guideline is a breach of the MHSA. Any contravention of, or failure to comply with, a COP is not, in itself, a breach of the MHSA, except a contravention or failure by an employer that also constitutes a failure to prepare or implement the COP. Since the DME does not approve COPs, its focus is not to enforce them either. The focus of the DME is to ensure that employers provide healthy and safe working environments at mines, i.e. focusing on system failures and compliance with the MHSA, rather than enforcing compliance with the COP.

2.3 The fact that a contravention of, or failure to comply with the COP is not a breach of the MHSA, does not mean that such breaches will have no legal implications. As far the employer is concerned, there are numerous specific and general obligations on the employer in the MHSA, aimed at ensuring the health and safety of all employees and all persons who are not employees but who may be directly affected by the activities at the mine. Where any failure to comply with a COP also constitutes a breach of any of the employer's obligations under the MHSA, the employer could be liable to an administrative fine for such breach. An inspector could also issue various instructions to the employer and employees in terms of section 54 to protect the health or safety of persons at the mine. Failure by an employer to comply with such an instruction could render the employer liable to an administrative fine.

2.4 As far as employees are concerned, section 22 places a number of obligations on employees, including that they must take reasonable care to protect their own health and safety and the health and safety of other persons who may be affected by their conduct. Where a failure by an employee to comply with a COP would also constitute a breach of the employee's duties in terms of section 22 (or a breach of section 84, 86(1) or 88), the employee could be criminally charged for such breach. As is the case with employers, the inspectorate could issue instructions to employees in terms of section 54 and failure to comply with such an instruction constitutes a criminal offence.

2.5 Employers should deal with breaches by employees of the COP in terms of the mine's standard instructions and the employer's disciplinary procedures. This is not the responsibility of the State.

3. THE OBJECTIVE OF THIS GUIDELINE

The objective of this guideline is to enable the employer at every mine to compile a COP, which, if properly implemented and complied with, would reduce the number of rockmass failure accidents at the mine.

4. DEFINITIONS AND ACRONYMS

In this guideline for a COP or any amendment thereof, unless the context otherwise indicates: -

COP means Code of Practice;

DME means the Department of Minerals and Energy;

Geology means the scientific study of the earth, the rock of which it is composed and the changes which it has undergone or is undergoing;

Ground Control meanstheability to predict and influence the behaviour of rock in a mining environment, having due regard for the safety of the workforce and the required service ability and design life of the mine;

Ground Control Districts means 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;

Ground Control District Plan means a plan on good quality transparent draughting material of a thickness not less than 0,08 mm indicating to a scale of 1 in 2500 all applicable ground control districts of the mine;

Hazard means a source of, or exposure to, danger;

Massive Mine means any mine, excluding a surface (opencast) mine, where minerals are won underground from a non-tabular mineral deposit;

MHSA means Mine Health and Safety Act, 1996 (Act No. 29 of 1996);

MRAC means Mining Regulation Advisory Committee;

Permanent Support means support that, once installed, is not removed;

Pillar means rock left in situ during the mining process to support the local hanging wall, roof or to provide stability to the mine or portion thereof;

Primitive (virgin) Stress means the state of stress in a geological formation before the stress field is altered by mining operations;

Risk means the likelihood that occupational injury or harm to persons will occur;

Rock Engineering means the engineering application of rock mechanics;

Rockmass Failure (fall of ground) means a fall of any fragment or portion of rockmass;

Rockmass means the sum total of the rock as it exists in place, taking into account the intact rock material, groundwater, as well as joints, faults and other natural planes of weakness that can divide the rock into interlocking blocks of varying sizes and shapes;

PART B: AUTHOR'S GUIDE

1. The COP must, where possible, follow the sequence laid out in Part C "Format and Content of the COP." The pages as well as the chapters and sections must be numbered to facilitate cross-referencing. Wording must be unambiguous and concise.

2. It should be indicated in the COP and on each annex to the COP whether -

2.1 the Annex forms part of the COP and must be complied with or incorporated in the COP or whether aspects thereof must be complied with or incorporated in the COP; or

2.2 the Annex is merely attached as information for consideration in the preparation of the COP (i.e. compliance is discretionary).

3 When Annexes are used the numbering should be preceded by the letter allocated to that particular annex and the numbering should start at one (1) (e.g. 1, 2, 3, A1, A2, A3,...).

4 Whenever possible illustrations, tables, graphs and the like, should be used to avoid long descriptions and/or explanations.

5 When reference has been made in the text to publications or reports, references to these sources must be included in the text as footnotes or side notes as well as in a separate bibliography.

PART C: FORMAT AND CONTENT OF THE MANDATORY COP

1. **TITLE PAGE**

The COP should have a title page reflecting at least the following:

- The name of the mine;
- The heading of the COP (for example, Mandatory COP to Combat Rockmass Failure Accidents in Massive Mining Operations);
- A statement to the effect that the COP was drawn up in accordance with DME guideline, reference no. DME 16/3/2/1 - A5 issued by the Chief Inspector of Mines; and
- The mine's reference number for the COP.

2. **TABLE OF CONTENTS**

The COP must have a comprehensive table of contents.

3. **STATUS OF MANDATORY COP**

Under this heading the COP must contain statements to the effect that -

3.1 The mandatory COP was drawn up in accordance with DME guideline Reference Number DME 16/3/2/1 - A5 issued by the Chief Inspector of Mines;

3.2 This is a mandatory COP in terms of sections 9(2) and (3) of the MHSA;

3.3 The COP may be used in an accident investigation/inquiry to ascertain compliance and also to establish whether the COP is effective and fit for purpose;

3.4 The COP supersedes all previous relevant COPs; and

3.5 All managerial instructions or recommended procedures (voluntary COPs) and standards on the relevant topics must comply with the COP and must be reviewed to ensure compliance.

4. **MEMBERS OF DRAFTING COMMITTEE**

4.1 In terms of section 9(4) of the MHSA the employer must consult with the Health and Safety Committee on the preparation, implementation or revision of the COP.

4.2 It is recommended that the employer should, after consultation with the employees in terms of the MHSA, appoint a committee responsible for drafting the COP.

4.3 The COP must not be an overly technical rock engineering document and the participation of supervisory and employee level personnel when compiling the document is essential.

4.4 The members of the Drafting Committee assisting the employer in drawing up the COP must be listed giving their full names, designations, affiliations, professional qualifications and experience. This committee should include persons competent in rock engineering sufficient in number effectively to draft the COP.

5. GENERAL INFORMATION

Relevant information relating to the mine must be stated in this paragraph. The following minimum information must be provided -

5.1 Locality

A brief description and locality map 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.

5.2 Geological Setting

Geological structures, such as faults and dykes and stratigraphy, around individual orebodies must be described and any hazardous conditions highlighted. A typical geological section of the mine 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.

5.3 Mining environment

The mining environment describes major subdivisions of an orebody, which dictates specific fundamental extraction strategies and occurs on a regional scale thus crossing mine boundaries. Under this section the following information must be provided:

5.3.1 Orebodies mined: A general description of orebodies being mined, including any relevant information such as average and range of mining depth, extent in major directions, and the strike and plunge.

5.3.2 Regional Hydrology: The regional hydrology such as the rainfall pattern in quantity and seasonal variation, the existence and location of water (or mud) accumulations on surface, surface workings or in groundwater aquifers and/or any other relevant information must be described.

5.4 Ground Control Districts

5.4.1 The location and extent of ground control districts must clearly be described in the COP. The nature of the primitive stress field in which mining is to take place, as well as the occurrence of significant pore-water and any other local geological features, must be included here.

5.4.2 All ground control districts must be indicated on a ground control district plan, which should be kept in an office designated for that purpose by the employer.

5.4.3 It is possible that the ground control district in which service excavations and access tunnels are located may not correspond with those of extraction areas. If this should be the case, these ground control districts must be described and clearly indicated on the ground control district plan.

5.5 Mine Rockmass Failure Incident Analysis

5.5.1 The COP 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 and rock falls per 1000 employees at work for both surface and underground operations.

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

5.5.3 The COP must reflect the incident trend associated with the identified hazards. From this information the risk associated with each hazard can be established. These statistics should be normalised with respect to production tonnage in the different ground control districts.

6. TERMS AND DEFINITION

Any word, phrase or term of which the meaning is not absolutely clear or which will have a specific meaning assigned to it in the COP, must be clearly defined. Existing and/or known definitions should be used as far as possible. The drafting committee should avoid jargon and abbreviations that are not in common use or that have not been defined. The definitions section should also include acronyms and technical terms used.

7. RISK MANAGEMENT

7.1 Section 11 of the MHSA requires the employer to identify hazards, assess the health and safety risks to which employees may be exposed while they are at work and record the significant hazards identified and risk assessed. The COP must address how the significant risks identified in the risk assessment process must be dealt with, having regard to the requirement of section 11(2) and (3) that, as far as reasonably practicable, attempts should first be made to eliminate the risk, thereafter to control the risk at source, thereafter to minimize the risk and thereafter, insofar as the risk remains, to provide personal protective equipment and to institute a programme to monitor the risk.

7.2 To assist the employer with the hazard identification and risk assessment, all possible relevant information such as accident statistics, research reports, various geological, hydrological, seismological information and geotechnical parameters or rock excavation processes must be considered.

7.3 In addition to the periodic review required by section 11(4) of the MHSA, the COP should be reviewed and updated after every serious incident relating to the topic covered in the COP, or if significant changes are introduced to procedures, mining and ventilation layouts, mining methods, plant or equipment and material.

8. ASPECTS TO BE ADDRESSED IN THE MANDATORY COP

The COP must set out how the significant risks, identified and assessed in terms of the risk assessment process referred to in paragraph 7.1, will be addressed. Unless there is no significant risk associated with that aspect at the mine the COP must cover at least the aspects set out below.

8.1 **Overall Mine Stability**

8.1.1 In order to prevent catastrophic accidents or situations that give rise to a multitude of minor incidents or accidents to persons at the mine, the COP must set out a description of the strategy or strategies to ensure overall stability of the mine. These strategies should embody various principles, techniques and methodologies employed to reduce the risks of rockmass failures peculiar to particular ground control districts and include such aspects as mining layouts, mining sequence, support, excavation process, sequence for all large excavations, and procedures for monitoring the stability of rockmasses encountered in the workings. Where hazards/risks are related to specific ground control districts, these relationships must be clearly indicated;

8.1.2 In order to prevent persons from being injured by rock falls caused by the interaction between the underground mining operations and relevant pit slopes, where underground mining is overlain by an open pit, or where access to underground workings is through an open pit, the COP must set out a description of the strategy to deal with this risk;

8.1.3 In order to prevent persons from being injured by a possible mud rush from any open pit into the workings, the COP must set out a description of the strategies to avoid such an occurrence;

8.1.4 Where more than one orebody occurs in close proximity to another, and where the mining of one or more orebodies is expected to have an adverse effect and induce hazardous conditions on the other, the COP must set out a description of the strategy to be followed for the mining methods and sequencing.

8.1.5 In order to prevent persons from being injured by rock falls due to support failures, the COP must set out a description of the strategies to ensure correct selection criteria, design and installation methodology, use and maintenance of the support systems and methods;

8.1.6 In order to prevent uncontrolled collapses of the mine or portion/s thereof, and to prevent any detrimental effects of the mining methods employed on surface structures and topography, the COP must set out a description of the design methodology to be applied to prevent such occurrence;

8.1.7 In order to ensure overall mine stability and prevent catastrophic accidents or situations due to seismicity, the COP must set out a description of how processed seismic data is to be used in the mine design methodology and operating procedures.

8.2 **Protection of Mine Accesses/Exits**

In order to prevent employees from being trapped underground, the COP must set out a description of the strategies for the protection of the access/exit ways of the mine (e.g. shafts and/or other main entrances/exits), covering at least the following-

- a summary of the rock-engineering appraisal of the current stability of mine access/exit access ways;
- measures to monitor ground movement;
- measures to protect employees against the risks associated with instability of access / exit ways; and
- measures to minimise the risk associated with ground movements caused by the extraction of shaft pillars.

8.3. **Stability of Tunnel and Service Excavations**

In order to prevent employees from being injured by a rockmass failure in any tunnel or service excavations of the mine, the COP must set out a description of the strategies to ensure stability of such tunnels and service excavations arising from the following-

- Damage to the walls of excavations, resulting from rock breakingprocesses (explosives);
- Poor rock conditions due to geological features;
- High or changing stress conditions;
- Proximity to other workings;
- Excavation process and mining sequence for all large excavations.

ANNEX 1 sets out guidelines for tunnel and surface excavation support strategy and is appended for information purposes only.

8.4 **Orebody Extraction**

In order to prevent persons from being injured as a result of any rockmass failure arising from the orebody extraction processes, the COP must set out a description of the strategies to identify and address the relevant risks, including at least the following-

- Loose rock arising from changes in the prevailing stress regime, rock breaking practices (explosives), face or draw point support, draw point control, undercutting and pillar cutting; prevailing geotechnical conditions (regime);
- Extraction design methodology and the effect thereof on surrounding excavations due to changing stress conditions.
- Selection criteria for the most appropriate stope- and draw point support design requirements (e.g. energy absorption capability, yieldability, and areal coverage);
- Effects of drawn caved rock and secondary blasting on draw point tunnels (if applicable); and
- Air blast occurring because of factors such as mining near surface, major flat dipping structures in the hanging wall and the rate of undercutting.

8.5. **Special Areas**

In order to prevent injury to persons in the working place where an increase in the risk of rockmass failures may develop during the course of routine mining operations, the COP must set out a description of the strategies for identifying such areas and addressing the increased risks, covering at least the following:

- The designation and classification of such areas as "Special Areas";
- Additional/special attention or precautionary measures for these areas;

- Measures to effect rapid modifications to processes and/or procedures should they require urgent review;

- The role and responsibility of a competent person in the identification of such special areas.

ANNEX 2 sets out guidelines for strategies for special areas and is appended for information purposes only.

8.6. **Rock-Breaking**

In order to prevent persons from being injured as a result of excavation walls failing due to blasting operations, the COP must set out a description of the rock-breaking strategies aimed at ensuring the integrity and stability of the excavation walls, covering at least the following-

- Type of explosives and accessories to be used;

- Drilling patterns and accuracy of drill holes;

- Selection and application of explosives and accessories to the conditions prevailing in different ground control districts;

- Method and sequence of initiation of explosive charges.

8.7 **The Impact of Mining Activities on Neighbouring Mines**

Where the massive mining operations at a mine might have a significant detrimental impact on the rockmass stability of any adjacent mine, the COP must set out a description of measures that will ensure that affected mines exchange relevant information, covering at least the following-

- Rock excavation processes, methodology, techniques, sequence, excavation speed, etc;

- Regional support;

- Prevailing common geological features/regime;

- Percentage extraction of mineral resources/reserves; and

- The timing and overall sequencing for the removal of the boundary pillar separating adjacent mines.

8.8 **Integrated Mine Process Design and Planning**

In order to ensure that persons are not injured by a rockmass failure caused by any mining operations at the mine, the COP must set out measures to ensure integration of the management of rock related risks into the overall mine planning process, and this should include the role of relevant individuals, the recording and archiving of major decisions and the execution procedure.

8.9 Support Design Methodology

In order to prevent rockmass failures or rockbursts endangering the safety of persons, the support design methodologies to be used must be properly motivated and documented in the COP.

ANNEX 1 sets out guidelines for tunnel and surface excavation support strategy and is appended for information purposes only.

8.10 Rock Engineering Support Service

In order to ensure overall mine stability, appropriate rock engineering input must be included when the mine's COP is compiled and reviewed.

ANNEX 3 attached hereto sets out those aspects on which a person competent in rock engineering should provide input and is attached for information only.

8.11 Other aspects to be addressed in the COP

The COP must require that where any experimentation with rock excavations or support systems that differ substantially from that contained in the COP is carried out, full documentation regarding such experimentation must be kept at the mine, including records of related risk assessments and motivations for the experimentations.

PART D: IMPLEMENTATION OF THE COP

1. **Implementation Plan**

The employer must prepare an implementation plan for its COP that makes provision for issues such as organisational structures, responsibilities of functionaries and programmes and schedules for the COP that will enable proper implementation of the COP. (A summary of, and a reference to, a comprehensive implementation plan may be included.)

Information may be graphically represented to facilitate easy interpretation of the data and to highlight trends for the purpose of risk assessment.

2. **Compliance with COP**

The employer must institute measures for monitoring and ensuring compliance with the COP.

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3. **Access to the COP and related documents**

The employer must ensure that a complete COP and related documents are kept readily available at the mine for examination by any affected person.

A registered trade union with members at the mine or where there is no such union, a health and safety representative on the mine, or if there is no health and safety representative, an employee representing the employees on the mine, must be provided with a copy on written request to the manager. A register must be kept of such persons or institutions with copies to facilitate updating of such copies.

The employer must ensure that all employees are fully conversant with those sections of the COP relevant to their respective areas of responsibility.

ANNEX 1

TUNNEL AND SERVICE EXCAVATION SUPPORT STRATEGY AND DESIGN GUIDELINES
(For information only)

1. Support Strategy

1.1 General

A procedure should be established and described to ensure that the potential rock conditions for all tunnels are assessed for their effective working life. Support systems must be designed, selected, used, installed maintained and removed taking cognisance of the various rock conditions that may prevail.

Where conditions in the tunnel are expected to deteriorate as a result of a changing stress field or weathering, the techniques used in identifying the location of such deterioration should be described. Upon identification, the design and implementation of secondary support must be specified.

Particular attention should be given to the support of the area in the vicinity of the working face. In this regard, the timing of the installation/removal of temporary and primary support is important and, together with examination and making safe procedures, must be specifically dealt with.

When poor ground conditions are encountered in the working face area, the strategy to be adopted to deal with these conditions, such as the alteration of tunnel shape, smooth wall blasting and areal support, must be described.

The strategy should describe a separate support strategy for wide tunnels (e.g. breakaways) and, where existing tunnels have to be widened, the sequence of mining and additional support installation must be stipulated. In addition where excavation interaction is anticipated this must be considered in the support strategy.

The strategy must describe how the problem of corrosion of support elements is managed in excavations with a medium or long term operating life.

1.2 Support Installation

The majority of rock reinforcing tendons installed on mines is grouted in place and the effectiveness of these tendons is reliant on good quality grouting.

Ever since the introduction of these tendons, the quality of grouting has been of considerable concern. The quality of grouting cannot be evaluated visually and no instrument is currently available that can measure the effectiveness of the grouting. The "pull test" which is often used is destructive, slow and cumbersome and only identifies very poorly grouted tendons. It is therefore necessary that the problem be addressed at source to ensure that the best quality grouting possible is achieved.

Methods must be established and described to achieve consistently good quality grouting, including the training of support crews in tendon grouting and quality control.

Where ungrouted tendons are used, procedures must be described to ensure that the tension in the tendons is maintained and kept up to standard while the excavation is in use.

All materials used for support must be subjected to quality control testing according to laid down procedures. For purposes of ensuring quality, the testing of the materials must be done at an institution accredited by the South African Government endorsed National Accreditation Body (SANAS).

If friction anchored tendons are used, then the capacity of anchorage beyond the depth of instability must be capable of supporting the potentially unstable rock mass.

Over and above the standard (systematic) support for all excavations the support of key blocks must be attended to separately and the code must specify the procedure for handling (support or bar down) key blocks.

1.3 Rehabilitation

Rehabilitation and re-supporting of tunnels are carried out frequently on many mines. The conditions under which this work is carried out are often dangerous. A specific procedure must be adopted for each situation.

1.4 Large Excavations

The methodology to be followed in designing these excavations and the implementation thereof must be stated. Designs must take into account the stress field and any changes therein, available techniques such as rock mass classification, numerical modelling, seismic data analysis, support design criteria and the influence that the size of the excavation and blasting technique have on the stability of excavations.The long-term rock mass monitoring programme must be described.

At depths where stress fracturing will occur during excavation cutting, the support sequence and blasting technique employed must take into account the orientation and extent of the stress fracturing at the various stages and sequential deformation of the rock mass to ensure stability throughout the excavating process. The procedures to be followed must be in the form of a reference report from the rock engineering department/consultant.

2. **Design Guidelines**

2.1 General

To design an appropriate support system, it is first necessary to define the functions required of it. The strategy must define the functions of the different support systems used on a specific mine.

In shallow excavations or in excavations developed in stress relieved ground, the function of support is merely to pin individual potentially loose blocks, generally defined by geological discontinuities, to the competent rock mass.

In cases of weak, friable rock or rock which is likely to deteriorate by weathering, the support must hold in place all the friable material by supplying maximum area support as early as possible.

In deep mine tunnels where highly fractured rock is encountered, the support must

reinforce the annulus of fractured rock by the installation of tendons to assist the rock to support itself. In such cases, tendons need to be installed in a regular pattern to generate frictional forces between rock slabs. In cases of intense fracturing, tendon interaction will be limited and areal support must also be provided to prevent fallout and control the deformation of the rock slabs between tendons.

It is necessary to determine the force-deformation characteristics of the support elements comprising the support system, both under quasi-static and dynamic loading conditions. A record of the force-deformation characteristics of the different support elements used on the mine must be kept.

In broad terms, the design process must involve the following :-

Determine or assess the rock mass environment for which the support is to be designed, e.g. the rock mass will be controlled by the geotechnical structure in a low stress environment and stress controlled failure in a high stress environment.

Determine or assess the probable volume of rock to be supported or reinforced in all the rock walls as well as the expected deformation of the rock mass.

Determine or assess the estimated structure of the rock mass.

Establish criteria for the selection of all the support elements that constitute the support system, so as to cope with the anticipated rock mass structure (fractured/discontinuous) and deformation loading conditions (quasi-static or dynamic). The key characteristics, which govern their suitability for different environments are strength, initial stiffness, yieldability, energy absorption capacity, length of tendons, area coverage compatibility with other support elements and extent of interaction in order to integrate them into an effective system.

2.2 Control of Rock Falls

The strategy must stipulate the extent of areal coverage and support resistance required to control the rock fall problem.

The support resistance requirements must be calculated with reference to potential fallout thickness as determined from analyses of accidents.

2.3 Reduction of Rock Burst Damage

In service excavations likely to be affected by seismic events, the support system must be capable of absorbing kinetic energy.

Approximately half of the incidents classified as rock bursts are not severe, catastrophic events, but rather the dislodging of blocks of rock in a state of unstable equilibrium. Peak ground velocities experienced in these types of rock bursts are of the order of a few cm/s. For the control of this type of damage, conventional rock tendon and mesh support will suffice.

Where peak ground velocities start exceeding 1 m/s, significant kinetic energy and momentum are imparted to the rock, resulting in potentially large displacements. Under these circumstances, a yielding support system is required.

Using block ejection thickness determined from analyses of the anticipated depth of

instability, it is possible to calculate a minimum energy absorption requirement per square meter of rockwall.

The energy absorption criterion for the components of the support system in the hanging wall is:

$$Ehw = \tfrac{1}{2}mv^2 + mgh$$

Under dynamic loading conditions suitable attention should be given to shear deformation.

The energy adsorption criterion for the components of the support system in the side walls is:

$$Esw = \tfrac{1}{2}mv^2$$

Where:
- E = energy absorption
- m = mass of ejected rock
- v = peak ground velocity
- h = deformation limit of support
- g = 9,81 m/s²

In the absence of mine specific data for rock ejection thickness and peak ground velocity, current industry data must be used.

Recent work has given an improved understanding of the interaction of the reinforcement and support system within a discontinuous rock mass structure. This new understanding should be considered in the design of support systems in the deep level mining environment. (Please refer to SIMGAP Project Report GAP 335 Copy available from SIM PROSS at the Mine Health and Safety Council Office in Braamfontein, Johannesburg).