Safety in Mines Research Advisory Committee

Final Project Report

Identify and Draft Outcomes-based Training Material in Strata Control for Underground Workers

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Executive summary

Assessments of accident records indicate the need for improved understanding and competence among underground production and service personnel with regard to strata control, and the associated risks, in gold and platinum mines. The underground personnel most directly affected by strata control risks, i.e. shift overseer level and lower, are categorised by the South African Qualifications Authority (SAQA) at job levels 1-4. Appropriate training courses and material are required in order to improve the competencies of employees with respect to the strata control risks to which they are exposed.

Rock engineering related training courses have to date been primarily aimed at rock engineering and senior mine personnel, however, such course material is inappropriate for the current objective. Course material of a simplified nature is required, which focuses on essential information about strata control risks and their amelioration. Training for SAQA levels 1-4 has traditionally focused on the "how" side of things, however it is believed that by also providing an understanding of the "why", such training can significantly reduce worker risk. The outcomes-based education and training (OBET) concept that is being implemented in South Africa by SAQA, and in the mining industry by the Mining Qualifications Authority (MQA), prescribes the framework and direction for the formulation of such relevant and competency-based training material. In this context, the understanding and application of the OBET methodology is required for the successful development of appropriate training material.

In order to formulate appropriate OBET course material, it was first necessary to determine which competencies are required by the underground personnel at SAQA levels 1-4 in relation to the strata control risks that they experience. These competencies were determined by interviewing a representative cross-section of industry, DME personnel and union/worker representatives. On the basis of an analysis of these competences, the identified strata control hazards were then drafted in OBET terminology and format for subsequent use by mine training departments, MQA, DME and unions.

In undertaking this study, input from all sources surveyed has indicated the importance of rock engineering training at these levels. Many individuals from all sectors interviewed have highlighted the potential impact of indicated training on safety. A strong degree of synergy was seen between union and industry representatives.

International input has indicated the efficacy of outcomes based training applied in mining in the United States and Australia albeit at a more advanced level. The outcomes based approach used by MQA/SAQA is seen as appropriate particularly in addressing the needs of the industry at this level.

Appropriate units of learning related to safety and rock engineering applicable to levels 1 to 4 have been drafted. These cover stope support, basic geology, tunnel support and elements within making safe procedures and in drilling of blast and support holes at levels 1 and 2. Similarly stope support, tunnel support, installing support, drilling and blasting and some topics in layouts, barring and geology are covered at levels 3 and 4. The more advanced levels build on competencies demonstrated at lower levels.

A great diversity of detail in training requirements has been indicated in the results of this study. In order to handle this diversity, information is treated in a matrix format, which indicates training requirements specific to the needs of the individual to be assessed. At this level, these would be specific to the mine, mineral, depth, mining method, reef and local conditions.

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Rock engineering related training courses have to date been primarily aimed at rock engineering and senior mine personnel, however, such course material is inappropriate for the current objective. Course material of a simplified nature is required, which focuses on essential information about strata control risks and their amelioration. Training for SAQA levels 1-4 has traditionally focused on the “how” side of things, however it is believed that by also providing an understanding of the “why”, such training can significantly reduce worker risk. The outcomes-based education and training concept (OBET) that is being implemented in South Africa by SAQA, and in the mining industry by the Mining Qualifications Authority (MQA), prescribes the framework and direction for the formulation of such relevant and competency-based training material. In this context, the understanding and application of the OBET methodology is required for the successful development of appropriate training material.

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2 Scope of work

In essence the project set out to define the knowledge and skills necessary to improve the competence of employees when dealing with strata control related risks in the underground environment. It must, however, be noted that training methods *per se* are excluded from the scope of the project.

The following aspects are involved:

- Specify competencies in outcomes-based education terminology (OBET).
- Identify strata control hazards and draft in OBET.
- In consultation with Mining Qualifications Authority (MQA) and South African Qualifications Authority (SAQA) use the abovementioned to form the basis for unit standard development in rock engineering levels 1 to 4.
- Detail documentation and findings in a clear and useful form.
- Present findings at a series of technology transfer workshops directed at the gold and platinum mines.

3 Literature review

A literature review was conducted of prevailing strata control hazards in gold and platinum mines, local and international strata control training content and the methodology and terminology associated with outcomes-based training (Appendix B).

It is reported (Gürtunca, 1997) that rockbursts are most frequently assigned to a lack of suitable systems, facilities or equipment and rockfalls are ascribed to inadequate examination. These findings indicate a considerable lack of technology component in the case of rockbursts and lack of application and implementation in the case of rockfalls. The latter shortcoming, in particular, can be appropriately addressed by the implementation of suitable training. It is also noted that attention to the rockfall problem would also reduce accidents resulting from rockbursts.

The need is identified for training to instil appropriate job knowledge and to link that knowledge with its suitable application in the workplace (i.e. produce relevant skills or competencies). The OBET system provides a rigorous methodology for the formulation of training course material that directly relates to functional aspects of a trainee's job. The OBET goal of producing functional competencies in specific job related outputs has an obvious connection to the application of knowledge related to the work environment and is, therefore, a training approach which is relevant to the local mining industry. With this approach, the competencies that trainees must demonstrate are prescribed for each identified strata control risk/hazard and the training content necessary to produce these competencies is subsequently formulated.

Some published data exists regarding prevailing strata control hazards and causes of accidents. However, this does not reveal in sufficient detail the strata control issues for which mine personnel need to be trained for their respective mining environments. Also, very little published literature exists as to strata control training course content relevant to the South African gold and platinum mining industry. International material, e.g. Australia and USA, is generally not available in the public domain and is on a more advanced level than that considered in this project and has limited relevance to the local mining industry. Accessible Australian material (Western Australia, 1997) provides a systematic framework example, for barring and scaling, albeit at a more advanced level, and American material (McClain, 1998) provides guidelines for generating effective course material that is comparable to that required by OBET (see Appendix C).

There is, therefore, a need to survey the industry to determine the prevailing strata control risks and to categorise these according to their applicability to the industry as a whole or to specific sectors (e.g. mining districts or reef horizons) in the industry. The identified risks will in turn dictate the necessary workforce competencies and appropriate training course content ultimately translated to units of learning (or parts of units of learning) under the MQA/SAQA framework.

The main findings of the literature review are:

- A lack of perception of dangerous hangingwall conditions underground and a lack of application and implementation of procedures are the most significant causes of strata control related accidents and fatalities.

- There is a need to train mineworkers to evaluate hazardous conditions by teaching them an appropriate strategy (methodology) and by teaching them how to apply the strategy. Teaching a strategy without teaching its application will prove unsuccessful.

- International material is mostly at an advanced level with limited relevance to the local mining industry. Some available Australian material provides a systematic framework examples albeit at a more advanced level, and the USA material is similar to the Australian but the content is not in public domain.

- OBET is defined as "a learner-centred approach to education and training that is primarily characterized by a focus on results and outputs as opposed to inputs and syllabi or curriculum"(Mokhobo-Nomvete, 1999).

- OBET, with its focus on producing functional competencies in specific job related outputs, appears to offer a relevant methodology for achieving appropriate strata control training in the mining industry.

- A survey of the gold and platinum mining industry's prevailing strata control risks is required to identify necessary workforce strata control competencies.

4 Methodology

4.1 Introduction

Since OBET focuses on functional competencies, the first objective of the work is to identify the necessary competencies for safe work practices in strata control of workers up to shift overseer level (SAQA levels 1-4). This process is achieved by conducting questionnaire-based interviews and general review sessions with relevant personnel from industry and unions reflecting the geographical spread of the gold and platinum mining regions and distinct mining conditions.

The questionnaire and other responses are then consolidated (based on mining depth, mining method and mining district) in matrix format for interpretation purposes and the subsequently identified relevant strata control related training topics are written up as OBET unit standards. This assessment matrix also provides guidance in determining the applicability of individual unit standards to particular sectors of the gold and platinum mining industry.

4.2 Selection of contributors

Contributors to the study, both questionnaire and general review respondents, were selected to ensure adequate input from pertinent stakeholders, i.e. unions, DME, MQA and relevant mining personnel, e.g. rock engineers, training and safety personnel. In addition, contributors were selected to cover the spread of mining groups, districts, reefs and general diversity of conditions in the gold and platinum mining industries. A full list of the contributors is provided in Appendix D.

4.3 Questionnaire design

One of the challenges of this project was to gather information of relevance from a potentially broad diversity of opinion pertaining to safety related strata control and rock mechanics training requirements suited to production staff at SAQA levels 1-4, i.e. up to shift overseer level. In order to properly address the requirement of this project, input was required from union representatives and workers, government representatives, industry representatives from rock engineering, safety and training, the Mine Qualifications Authority (MQA) and mine head office staff.

To achieve this objective, a questionnaire was drafted that was broadly based on the training section (Chapter 11) of the draft of "A Handbook on Rock Engineering Practice for Tabular Hardrock Mines" (SIMRAC, 1999). This basic information was modified and extended to capture specific information reflecting the diversity of the targeted audience.

Questions relating to the depth range of mining, the number and type of reefs being mined and the mining methods used were included, as this information would be used in the analysis of responses. A number of questions were included relating to actual training methods currently used and on items interviewees believed suitable for practical training. Space was allowed in each section for additional comments. A blank copy of the questionnaire is included in Appendix E. The questionnaire was split into two sections covering MQA/SAQA levels 1-2 and 3-4. Inherent in this is that all items necessary for learning at levels 1 and 2 are also necessary for levels 3 and 4, though the converse is not true.

Questionnaires were completed in an interview format as experience has indicated that this provides the most effective results. Individual and group interviews were undertaken. In several instances union representatives met as a group to consider the questionnaire. All responses and completed questionnaires have been kept confidential to encourage frank and open answers.

4.4 Completion of the questionnaire

Questionnaires were completed by means of interviews conducted with relevant contributors (Appendix D). Interviews with contributors representing levels 1-2, e.g.

union or worker safety representatives, were usually conducted as a small group and therefore a consensus answer was obtained for each question. Interviews covering levels 1-4 or 3-4 were conducted on a one-to-one basis with relevant contributors, e.g. training or rock engineering personnel.

Depending upon the interviewee, or group of interviewees, a questionnaire was completed for levels 1-2 or 1-4, or as a generic overview.

On completion of the questionnaire, the following additional questions were asked:

- Whether the interviewees felt that some additional training was required in any specific aspect (as incorporated in Appendix E).
- What they felt could be addressed through practical training and how it could be taught (Section 5.7).
- What additional aspects or comments they felt should be included that were not originally included in the questionnaire (as incorporated in Appendix E).

All responses were held to be confidential, i.e. no specific interviewee's name or the mine at which they were employed would be indicated.

4.5 Questionnaire assessment

Questionnaires were summarized in a matrix format in which, using original questionnaire topics, responses were captured under the categories of mining district, mining depth, mining method and other (Appendix F). Different classes of respondents were distinguished by a series of codes. This method of coding is used to facilitate interpretation and usage of the information by personnel developing training material for different environments, e.g. mining, geotechnical and mineral sector.

The meaning of the codes is as follows:

1 = The industry representative (i.e. training or rock engineering personnel) gave a positive response to this being a topic requiring training.

X = The industry representative (i.e. training or rock engineering personnel) gave a negative response to this being a topic requiring training.

2 = The union/worker representative gave a positive response to this being a topic requiring training.

Z = The union/worker representative gave a negative response to this being a topic requiring training.

3 = Additional topics (text in italic) which the industry representative felt should be included in the training program that were not included in the original questionnaire.

The degree of repetition of positive responses in any given cell of the matrix is indicative of the topic's importance and persistence in a particular sub-category.

The issues that can be handled through practical training were also identified and assessed. (Section 5.7)

5 Findings

5.1 Introduction

Findings are derived from analysis of the assessment matrix (section 4.5) and these are categorised, for the gold and platinum mining industry, as either generic findings, applicable across the wider industry, or sector specific findings, applicable to only specific districts, depths and mining methods.

Certain findings under each category were as anticipated. Others were, however, unexpected and these are highlighted for discussion.

5.2 Generic findings

Based on the questionnaire analysis, some significant generally applicable training requirements have been identified at different levels. These items are marked as generic on the questionnaire assessment in Appendix F. By generic, is meant items that apply to both gold and platinum mines, at all depths, in all regions, for all different mining methods and that there is general agreement from DME, union and industry contributors surveyed. An ordered list of generic topics follows:

Underground Workers (SAQA Levels 1 & 2)

Basic geology and rock structures

Understanding that rock is not continuous

- joints
- faults and dykes

Discontinuities may be filled with weak material or water

Dangers of discontinuities intersecting - key blocks

Force of gravity, examination & making-safe procedures

Potential hazards associated with barring operation and whether to bar/support or blast

Support - Stopes

The function of local support:

- to hold key blocks in position
- prevent unravelling of the hangingwall rocks

Good support installation practice:

- Influence of support spacing on stability
- Importance of installing support close to face
- Importance of overlap of timber units in packs
- Perpendicularity of support to stope floor/roof

Actual stope support units used on the mine

The need for and the dangers of removing support. (remote release/ blast, etc) (install alternative timeously)

Removing temporary support - proper procedures

Brows – support, negotiating and undercutting

Support - Tunnels

The purpose of tunnel support (active vs. passive)

Types of tunnel support, e.g. splitsets, grouted tendons,…

The importance of properly installed temporary poles and mechanical props in development ends

Shotcrete support:

- the importance of quality of grouting
- potential consequences of poorly installed units

Support standards and practices on the mine

Drilling of blast and support holes

Direction and position

Position & orientation of drillholes w.r.t. joints & disc.

Hazards of drilling shot holes off-line

Underground Workers (SAQA Levels 3 & 4)

Support - Stope and gully

Stress-strain curves of different support type? (force/deformation)

Where and why different support types should be used

Support resistance , what is it and what makes it change?

Matching support to conditions

Support where conditions have deteriorated or are deteriorating

Brows – support, negotiating and undercutting

Support - Tunnels

Full column grouting with grout types: OPC, resins, accelerators

Installation procedure

Support removal in tunnel rehabilitation

Support removal in development ends

Installing support

Pre-stressing (packs and tendons)

Effect of height to width ratio on support performance: if excessive this results in blast out, buckle etc.

Importance of installing support close to the face

Consequence of blasting if support installation is sub-standard

Drilling and blasting

Importance and advantages of consistent hole burden

Effects of over charging / incorrect burden

Direction of drilling to minimise host rock damage

Fracturing around blast holes

Drilling patterns - stoping

Barring

Dangers of unravelling of the rockmass during barring

Barring vs supporting

Layouts – Headings and gullies

Fracturing around tunnels and stopes (fracture intensity and orientation)

Importance of up to date sidings of correct depth

Difficulties and dangers with low angled fractures

5.3 Sector specific findings

Based on the questionnaire analysis, some significant environment specific training requirements have been identified at different levels. By sector specific, is meant items that apply to one or more specific circumstance such as: depth range, region or mining method and that there is general agreement from DME, union and industry contributors surveyed. An ordered list of sector specific topics follows:

Underground Workers (SAQA Levels 1 & 2)

Basic geology and rock structures

Mining-induced fractures

Identify weak and problematic rock types

Identify unstable/dangerous blocks

Force of gravity, examination & making-safe procedures

The likely consequences of being hit by a falling object

Recognition of hazardous conditions. Bar or support or blast

Position from which barring should be undertaken

Appropriate barring tools with protective equipment

Support - Stopes

Gully support

Support - Tunnels

Support appropriate for different areas & conditions

Common types of support failure and defects

- pinning mesh into hollows in a tunnel profile
- tensioning of lacing

Underground Workers (SAQA Levels 3 & 4)

Support - Stope and gully

Stress-strain curves of different support types (Force/deformation)

Hydraulic prop performance vs pre-stressed yielding elongates

Gully support: packs/gully sidewall

Gully support: tendons/hangingwall

Backfill technology, placement, effects on strata control

ERR

Support - Tunnels

End-anchored tendons

Pre-stressed tendons

Mesh and lacing

Installing support

Understanding of the zone of influence

Impact of too large a support spacing or missing units

Assess conditions w.r.t. standards

Drilling and blasting

Different explosive types used on the mine

Drilling patterns - Development

Barring

Ability of rocks to rotate if peeling away from a surface.

Layouts – Headings and gullies

Holing/trenching/approaching geological features

Geology

Hard and soft rocks

Rock failure – types & causes

Slip on discontinuities

Need to recognise/report changing ground conditions

Pillars

Safety factors

Influence of width to height ratio on strength and behaviour

Cutting of pillars; Fracturing around pillars

Planned dimensions and the need for pillars to be accurately cut

Pillar behaviour – Non-yield, crush, and yield pillars

Problems:

- if spans are too great
- if planned pillar positions are changed

Stress

Increase with depth

Horizontal stresses

Fracturing, deformation and failure

5.4 Unexpected or anomalous questionnaire results

In assessing questionnaire responses a number of findings were not as expected or are believed to be somewhat anomalous. These responses are listed here, with some discussion as deemed necessary.

Underground Workers (SAQA Levels 1 & 2)

Basic geology and rock structures

Sedimentary layers A number of respondents from both the union and industry indicated that sedimentary layers were not important. This should be contrasted with a comment from the Klerksdorp area that bed separation is a problem.

Mining-induced fractures Almost all respondents from shallow mining areas indicated this as something to be taught, in spite of their being little or no such fracturing at their mines.

Force of gravity, examination & making-safe procedures

The likely consequences of being hit by a falling object, Recognition of hazardous conditions, Appropriate barring tools, Potential hazards associated with barring operation Several respondents from both the union and industry indicated that all the above listed topics were not needed. This response is surprising, especially given the number of accidents annually associated with this operation. Some union people felt that this was already adequately taught.

Support - Stopes

Support appropriate for different areas & conditions, support for special areas Several respondents felt this should not be taught at this level.

Gully support Quite a number of union respondents across all sectors in the survey believed that gully support need not be taught. An evaluation of fall of ground accidents, however, indicates the gully area to be one of the highest risk areas.

Support - Tunnels

For both *Support appropriate for different areas & conditions,* and *Common types of support failure and defects* a number of respondents from both the union and industry indicated that all the above listed topics were not needed. The latter is particularly surprising given that workers at level 1 and 2 are probably in the best position to assess defective support units during installation.

Also surprising in that *pinning mesh in hollows in the tunnel profile* and *tensioning of lacing* are not indicated as necessary by union members in areas prone to rockbursting.

Underground Workers (SAQA Levels 3 & 4)

Support - Stope and gully

Gully support Quite surprising one industry representative believed that gully supporting need not be taught. An evaluation of fall of ground accidents, however, indicates the gully area to be one of the highest risk areas.

Installing support

It would have been expected that all at this level should be taught to *compare support against standard* - so it is surprising that one industry respondent felt this to be unnecessary at this level. Similarly for the *Impact of too large a support spacing or missing units*.

Drilling and blasting

Drilling patterns - Stoping are indicated as to be taught, so it is surprising that *Development and special excavations* drilling patterns are not indicated to be taught.

Layouts – Headings and gullies

Holing/trenching/approaching geological features is acknowledged as a high risk activity, so it is surprising that not all respondents indicate this to be taught.

Hazardous layouts commonly occurring in your mine and *High risk areas and suitable support* are both not universally indicated as to be taught, which is surprising, especially the former item. One would expect level 3 and 4 staff to need to be familiar with both these.

Geology

Need to recognise/report changing ground conditions can provide information early so as to timeously take corrective action as necessary. It is felt that these people are in the best position to provide this early warning.

Pillars

It is surprising that there is a general lack of indication of the need to teach about pillars. This is particularly surprising at shallow and intermediate depth mines where in-stope pillars are used. There are significant hazards associated with leaving pillars that are too small or too large and also with leaving out pillars. As depth increases, it would seem to be important to understand the behaviour of remnant pillars and the role of stability and bracket pillars.

Stress

Also surprising is that few saw the need to teach about stress. The role of horizontal stress at shallow depth as well as the potential deleterious effects of high stress at depth - failure & bursting should be considered for inclusion at this level.

5.5 Additional topics

During the questionnaire-based interviews and general review sessions a record was made of any relevant additional topics for strata control training suggested by contributors. These additional topics are shown in italics in Appendix F and reflected in the matrix by a code 3.

5.6 Quotable quotes

Several contributors made notable comments. These are:

"Much emphasis on support standards, especially the reason for a particular spacing, and what it is designed to do."

"It is important to explain the pros and cons of columnar versus pack support."

"There is a major lack of communication between workers and management. People are not being told the reason for doing things, they are just being ordered."

"Most times, the face is not being watered down before the commencement of the work and this results in dust that makes it difficult to identify the dangerous situations."

"The senior staff (management) do not respect those on a lower level."

"Working hours must be known."

"The workers are not aware of the important aspects such as mine standards."

"The workers push production to achieve the bonus payment, sometimes compromising safety. This practice, in turn results in a lot of accidents and even fatalities."

"We suggest the use of underground training centres so that workers can practice what they learn in the proper working environment."

"A level 3-4 person should know about short/medium term planning e.g. 6 month plan, face shape, interaction with other longwalls etc. He must be able to read a plan and know the aspects like, finding strike/dip elevations etc. He should also know about excavation spacings, size, shape, relation to rock types, other excavations etc."

"Use results of MINSIM modelling to show the influence of stress etc."

5.7 Items amenable to practical training

In response to questions regarding the way in which various topics were or should be taught it became apparent that the topics listed in Table 5.1 were amenable to the various means of what could be termed as practical training.

Although these topics were captured during the interview sessions with contributors, it should be noted that training methods *per se* are excluded from the scope of this project.

Table 5.1 Topics amenable to practical training

Topic	Practical Training Method (in addition to theory)
Basic geology (joints, fractures, bedding, faults, dykes, infillings key blocks, weak rocks)	Models On job training Barring underground Artificial stope
The force of gravity, examination and making safe procedures (rockfall hazard, bar or support, position when barring, hazards when barring)	Models On the job training Barring underground Artificial stope
Support-stopes	Models On job training Artificial stope

6 Drafting material in OBET units

6.1 Introduction

In undertaking the assessment of the survey results, and in subsequent interaction with MQA, industry and union people concerned, units for training at the different levels were selected. The primary criteria for these selections were, however the consolidated responses to the questionnaire from respondents.

In this assessment at level 1 and 2, if more than two respondents felt something should not be included for training at a particular level, then this item has been considered further to evaluate the merits of inclusion. If the negative responses covered input from both union and industry the point would be excluded. If, however, the negative responses were both from the same source, then the decision was based on further consideration of the background to the responses. Such items have been flagged as anomalous or unexpected responses and are discussed in Section 5.4. A similar process was followed for level 3 and 4; only a single negative response indicated possible non-inclusion, given the smaller survey sample.

Additional OBET material of relevance is also included in Appendices A, B and G.

6.2 OBET concept and structure

OBET is defined as "a learner-centred approach to education and training that is primarily characterized by a focus on results and outputs as opposed to inputs and syllabi or curriculum" (Mokhobo-Nomvete, 1999).

The implementation of OBET is overseen by the South African Qualifications Authority (SAQA), which is a statutory body established under the South African Qualifications Authority Act, 1995 (RSA, 1995). SAQA Regulations (RSA, 1998a and RSA, 1998b) provide further detail and prescribe the specific format and structure of OBET implementation. One such specified, and fundamental, component of OBET is the *unit standard,* which is defined by SAQA as "registered statements of desired education and training outcomes and their associated assessment criteria together with administrative and other information as specified in the regulations".

The purpose of a unit standard is to serve as:

a) an assessor document,

b) a learner's guide, and

c) a trainer's guide for preparing training material.

Unit standards must, therefore, contain clearly defined learning outcomes associated with clearly defined criteria in order to ensure that standards are adhered to (Olivier, 1999). The formulation of correctly structured unit standards is achieved by adherence to the format laid down by SAQA Regulations (see Appendix G).

Various OBET specific terms are used in unit standards, e.g. specific outcomes, assessment criteria and range statement, and these are defined in Appendix A.

6.3 Unit standards selection

The selection of unit standards was based on the questionnaire structure and responses thereto, which loosely follows the structure of the training requirements of the industry handbook.

At levels 1 and 2 there is almost universal indication that stope support, basic geology and tunnel support be included as units. Although the responses were less unanimous, a number of elements within making safe procedures and in drilling of blast and support holes were strongly indicated for inclusion. This was done. Interestingly, a number of union representatives felt that aspects of barring and making safe were not needed to be taught. Further consideration in this regard indicated this response to be based on the feeling that their members were all trained in this, in any case. These units have been written and are included in appendix H.

At levels 3 and 4 responses again strongly indicated the inclusion of stope support, tunnel support, installing support and drilling and blasting as units at an appropriately more comprehensive level. Strong support was indicated for some topics in layouts, barring and geology so these are included again as smaller units. Somewhat surprising was that almost no indication of the need for training in the effect pillars or of the influence of stress were received, even from mines where these topics are significant. These units have been written and are in Appendix I.

At all levels there were significant items excluded from the above indicated units. To ensure the findings are as comprehensive as possible, these have therefor been included as other items at both levels and should be included as an important safety item in broader units being developed.

6.4 Unit standard description

<u>Level 1 & 2</u>

stope support

Primary information that is included in this unit is that workers understand the function of local support and good support installation practice based around the actual support units used on the mine. In this regard, the need for support to keep blocks in place is emphasised, as is the need for adhering to standards as far as support spacing and position, as well as what comprises a properly installed support unit. The practice of replacing temporary support with permanent support is seen as important, as is undercutting a brow.

basic geology

There is a need to understand that rock is not continuous but is instead broken up by joints, faults, dykes and fractures. The focus of geology at this level is to assist workers to identify geological hazards as far as they impact support requirements and the formation of unstable blocks.

tunnel support

The emphasis in this section on tunnel support is on understanding mine tunnel support standards as applicable on their mine. Along with this are procedures to ensure proper support installation practices. The need for properly installed temporary support in tunnel development is also indicated.

making safe procedures

In this area, emphasis is on recognising hazardous conditions, and on then taking the right corrective action using appropriate tools, and from the correct position. An understanding of the hazards associated with this operation is important, especially given the high accident rates during this operation.

drilling of blast and support holes

Although this unit is significantly smaller than the areas described above, the drilling of blast and support holes is indicated as important as far as position, spacing and orientation. In addition, the hazards associated with drilling off-line are important, particularly on some reefs.

Level 3 & 4

It should be noted that requirements listed here are in addition to those indicated at level 1 and 2.

stope support

The importance of matching support used for different areas (e.g. stope face, back area & gully) and different requirements (e.g. undercutting a brow). This necessitates an understanding of support resistance offered by different support types. An understanding of how to recognise deteriorating conditions and to match a support system to address the changing conditions is required.

tunnel support

Emphasis here is on understanding and correctly using support based on different mechanisms and appropriate support procedures to match these differences. These include end-anchored, pre-stressed units, full column grouted units and some understanding of different grouts (e.g. OPC, resin). The hazards associated with support removal is also seen as important.

installing support

Although related to the above, great emphasis was placed on understanding the importance of support being installed close to the face. The need to pre-stress support units particularly if these are subject to blast forces, and the consequences of poor installation are important. The need to use meshing and lacing in some areas, and important principles related to these are included.

drilling and blasting

Much emphasis has been placed on proper blast practice. In particular the use of proper hole spacing, direction, patterns and burdens. The effects of poor blast practice on stability and the influence on support performance are indicated.

7 Application of findings

7.1 Introduction

The findings of this project are of use to personnel involved in mine training, MQA ans SAQA, unions and the DME.

Personnel in each of these categories of activity will have differing uses for these findings and it is pertinent to describe what this anticipated usage is for each category.

7.2 Mine training usage

It is envisaged that mine training personnel can use the matrix of training topics in Appendix F:

- as a checklist to ensure comprehensiveness of current training material
- as a check on what safety related rock engineering training is indicated at a particular level

- as a guide where the focus on results/outputs should be for new training courses
- as an indication of what would need to be trained in a particular mining setting (region, depth, mining method).

Despite the gold and platinum deposits both being tabular, there is significant diversity including:

- variability of depth,
- composition of reef and surrounding stratigraphy,
- geological disturbance,
- geotechnical variability,
- support practice,
- layout configuration.

As one would anticipate, this diversity needs to be accommodated in the design of training material at different levels. The matrix approach taken, while complex on the surface, is believed the simplest and most concise way to reflect this diversity. Several examples illustrating the use of this matrix have been completed and are included in Appendix J**.**

7.3 MQA/SAQA usage

The MQA/SAQA are currently drafting unit standards or units of learning for general rock engineering covering all minerals and mining methods and applicable at all levels from 1 through 8. It is believed essential that these units adequately address rock mechanics and strata control topics that could have a bearing on safety.

In carrying out this project it has become apparent that these safety related items vary considerably with level, mining depth and other factors that make the setting of adequate and comprehensive assessment criteria difficult. For this reason, the findings of this project have been drafted in the form of stand alone units of learning (see Appendices H and I). These units need to be used in conjunction with the assessment matrix (see Appendix F) to ensure that both the range and scope of the assessment is appropriate to the level being assessed, that it is comprehensive and that it is relevant to the local conditions of the individual being assessed.

It is envisaged that these safety related units can either be used as is in the MQA suite of units or that they could be incorporated into more general units of learning, to ensure adequate attention to safety aspects of rock engineering units at these levels.

7.4 Unions

It is envisaged that the unions will use these findings to:

- obtain general background information and knowledge about strata control issues
- interact more meaningfully and effectively with mine management
- be more involved and pro-active in addressing training requirements and shortcomings
- create improved hazard awareness and safety in underground working places

7.5 DME

The Mine Health and Safety Act, 1996 (RSA, 1996) states that employees must be trained in such a way as to enable them to perform their work safely and without risk to health. Furthermore they must be trained to recognise and deal with every risk. The DME will, therefore, use these findings to increase their awareness of risks in the industry and to assist in assessing industry's compliance with the Mine Health and Safety Act.

The findings of this report can be referred to and used by the DME when reviewing the critical competency criteria and education and training syllabi proposed by the industry in response to Section 9 of the "Guideline for the Compilation of a Mandatory Code of Practice to Combat Rockfall and Rockburst Accidents in Metalliferous Mines and Mines other than Coal".

The findings of the report can also be used as background knowledge during accident investigations and when auditing or reviewing the content and implementation of Codes of Practice.

8 Technology transfer

The findings of this work will be presented at three technology transfer workshops. The venues were chosen to facilitate attendance from the three major gold mining districts and the platinum mines and, therefore, will be held on three consecutive days at Welkom, Rustenburg and the West Wits region. The programme for the workshops will include the following:

- Objective
- Methodology
- MQA's involvement
- General findings
- Detailed examples to illustrate how information can be used
- Conclusions and recommendations

Mine managers, rock engineers, senior training personnel, senior safety officers, safety representatives, regional union representatives and appropriate personnel from the Department of Minerals and Energy have been invited to attend.

Useful comments and suggestions arising from these workshops will subsequently be documented as an addendum to this final report.

9 Conclusions

In undertaking this study, input from all sources surveyed has indicated the importance of rock engineering training at these levels. Many individuals from all sectors interviewed have highlighted the potential impact of indicated training on safety. A strong degree of synergy was seen between union and industry representatives.

International input has indicated the efficacy of outcomes based training applied in mining in the United States and Australia albeit at a more advanced level. The outcomes based approach used by MQA/SAQA is seen as appropriate particularly in addressing the needs of the industry at this level.

Appropriate units of learning related to safety and rock engineering applicable to levels 1 to 4 have been drafted. These cover stope support, basic geology, tunnel support and elements within making safe procedures and in drilling of blast and support holes at levels 1 & 2. Similarly stope support, tunnel support, installing support, drilling and blasting and some topics in layouts, barring and geology are covered at levels 3 and 4. The more advanced levels build on competencies demonstrated at previous levels.

A great diversity of detail in training requirements has been indicated in results of this study. In order to handle this diversity, information is treated in a matrix format, which indicates training requirements specific to the needs of the individual to be assessed. At this level, these would be specific to the mine, mineral, depth, mining method, reef and local conditions.

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