The 19th International Mining Congress and Fair of Turkey 1MCET2005 Lmir Turkey June 09 12 2005

3R - Rock Related Risk Management System for Mines

K S Koldaş
Omya Mining, Istanbul - Turkey

ABSTRACT Increasingly, raining regulatory bodies are requiring mine operators to base their health and safety assurance on the issue of risk assessment This is because it is now well recognised that risk assessment is an ideal process on which to build a pro active safety management system that can lead to dramatic improvement m safety and health performance A high incidence of rock related 'falls of ground' accidents prevail in many mines Although it is known but not yet applied in many mining industry in Turkey the risk assessment issue has been legalised and an inevitable part of mine management in many countries In this study, the author firstly described the concept of nsk management system and adopted into rock engineering principles in order to improve productivity and safety in mines

1. INTRODUCTION

It is true that mining is a risky business both in terms safety and economic point of views In order to mitigate the consequences and frequency of the risks in mining industry one should definitely consider in on risk assessment process On the other hand mining regulatory bodies in many developed countries are requiring mine operators to base their health and safety assurance on the use of risk assessment This is because it is now well recognised that risk assessment is an ideal process on which to build a pro active safety management system that can lead to dramatic improvements in safety and health performance

2. RISK ASSESSMENT CONCEPT

Risk assessment is a systematic examination of any activity, location or work process to identify risks to system success, understand the likelihood and potential and potential consequences the threat to success or hazards and review the current or planned approach to controlling the risk, adding new potential controls where required System success is defined by safety, health, production, environmental protection, community acceptance, security, or, m quality terms, optimal output with minimal waste

There are two distinct approaches to the assessment of risk quantitative and subjective Quantitative risk assessment has its origins in the high technology process industries, where it is used principally to assess risks associated with major accident hazards In quantitative risk assessment, numerical probabilities of risk are calculated using various sources of engineering data, and compared against a pre-set value of acceptance Rigorous and relatively complex formal hazard identification techniques, such as fault trees and event trees are used In subjective risk assessment, which is more commonly used within lower technology industries estimates of risk are based on subjective judgements of likelihood and severity The judgements of likelihood and severity are based on some form of subjective scales and often, less formal hazard identification techniques are employed

Whichever risk assessment technique is used, it is important to remember that the true purpose of introducing such a process is to improve health and safety In most cases, times consuming quantitative techniques are neither practical nor necessary to achieve this end result

3-ROCK RELATED RISK MANAGEMENT-3RM

One stated that *'the first principal duty of business is to survive and the guiding principles of* *business economic? is not the maximize of profit - it is the avoidance of loss'*

During the last few decades a great deal of effort has been Jevoted to the development of rock mechan ;> as applied to engineering The basic principles of the subject have been established and a variety o methods and tools specifically relevant to this fled of application have been developed

When we start to examine the safety statistics of many mines we obviously reckon that most of the accidents occur as a result *of falls of ground, lack of or inappropriate support units, lack of excavation & blasting design* as well as rock engineering knowledge etc The source mechanism of all these types of accidents are of course *rock related* Because we all mining engineers deal with rock and have moral obligations to safety of workforce we must adopt and develop some sort of rock engineering risk assessment techniques in order to combat rock-related hazards in mines

In mining, rock mechanics has become an important tool in planning the layout of open pit and underground mines, in the evaluation of support requirements, in the alleviation of mining hazards and in making various technical decisions Therefore rock-engineering professionals can make a major contribution to both safety and profitability of mines

The rock-related nsk management provides the basis for decision -making and enables management to create a safer environment The principal purpose of rock-related risk management system is as follows (DME, 1996)

» Identify and describe rock related hazards, which are likely to arise from the mining of each geotechmcal area identified
- Assess and prioritise the health and safety risks to which workers will be exposed and record findings
- Develop and implement reasonably practicable strategies to reduce and manage these risks, based on above risk assessment and accident analysis
- Record the significant hazards to cerate safer and long term establishment

We can develop three types of rock-related risk assessment techniques in mines, which are namely (SIMRAC, 1997)

/ *Base line Risk Assessment*

This will be done to identify major risk for future risk control such as analysis of historical data, accident reports, internet, information, sharing info between mines etc These studies need to be comprehensive, and may well lead to further, separate, more m-depth risk assessment studies

2 Issue Based Ri sk A sse ssment

As circumstances and needs arise, separate risk assessment studies will be conducted when, for example a new support is introduced into the mine, after an accident or near miss incident, new knowledge comes into to light and information is received which may influence the level of risk to employees at the mine etc The suppliers m mines must ensure, as far as reasonably practicable, that the article is safe and without risk to health ad safety when used properly

3 Continues Risk Assessment

This is the most important for all of risk assessment, which will take place continuously, as an integral part of day-to-day management of the mine This will mainly be used by the front line supervisors in the mine, for example checklists, audits, planned task observations, daily workplace inspection etc

The baseline risk profile for rock engineering is presented in Table 1, followed by the risk-ranking scheme used for this overview This profile will help define the objectives of the mine's rock-engmeenng department, against which achievement targets will be set and reviewed It also highlights the rock related safety issues that need to be addressed by other departments m the future

After a baseline risk profile has been established highest priority risk areas are addressed in more detailed risk assessment The method, which has been used widely in mines, is the *WRAC (Workplace Risk Assessment and Control)* technique, Table 2 Using this technique, assessment can be done by a group or vertical slice of people from the workplace ranging from the person undertaking a given task to a higher level supervisor and is facilitated by personnel from rock Engineering Department

Hazards are identified by considering each step m the completion of a task and ranking the risk according to the *probability* of an incident happening and the likely *consequence*, as indicated by the risk ranking matrix illustrated in Table 1

Table 1.Risk Matrix-f (CxP)

	PROBABILITY				
CONS.	**A**	**B**	**C**	**D**	**E**
Fatality-1					11
Serious Injury-2			8	12	16
Disabling Case-3		9	13	17	20
First Aid Case-4	10	14	18	21	23
No Injury-5	15	19	22	24	25

PROBABILITIES: This is normally a compound of two separate factors. Firstly, exposure, which is an analysis of how often and for how long the employees involved, is exposed to the hazard. Secondly, it includes an analysis of **probability,** that is the chance that a person or persons will be harmed during the exposure period. Common- (Daily)-A, Likely- (Weekly)-B, Happens- (Monthly)-C, Unlikely- (Yearly)-D, Rarely (1-3 years)-E

CONSEQUENCES: Here, the degree of harm from the identified hazard is assessed in terms of the potential severity of the injuries or ill health and/or the number of people potentially affected. (Fatality-1, Serious injury-2, First aid case-3, No injury-4)

A risk ranking of 1 is the most serious and 25 the least serious. Thus all rankings from 1 to7 are critical and require urgent consideration, rankings 8 and 15 are serious and 16 to 25 are of lesser severity and should be addressed only when the more serious risks have been eliminated or controlled.

3.1 Risk **Control** Measures

The risk assessment team should consider the following strategies and make recommendations to the manager:

Elimination

This can be done by either removing the hazard from the working environment, or by working in a different area.

Control the Risk at Source

This strategy may involve limiting access to the hazardous area, or by guarding against the hazard, or by operating from a remote distance.

Minimise the Risk

This strategy involves aspects such as hazard awareness training programmes to ensure that workers keep away from the hazardous areas and the use of safety devices.

High frequency and high consequence hazards are the highest priority. Those with a low frequency and low consequence are low priority and those with both high frequenc; and low consequence, or high consequence aid low frequency are considered as medium priority.

Personal Protective Equipment and Monitoring of the Risks

This approach should be the last resort to risk control.

Table 2. Example of risk assessment using the WRAC techniques in mines

Step	Hazard	P	C	R	System	RP
Application of standards	Unsafe support working areas	-	-	-	Codes of Practice	ME

When the current system fails or is insufficient then *recommended action* needs to be developed in order to eliminate risk.

3.2 Reporting and Recording of significant risks

All risk assessment exercises should be recorded by the rock engineer professional and must be easily accessible to all concerned. However, the documentation system should not detract from the major purpose of risk assessment and that is to improve the management of risks, thereby ensuring the health and safety of employees. The following aspects should be reported on:

* The major hazards identified.
- A review of the existing safety measures and the extents to which they work in controlling risks.
- Those who may be affected by the major hazards.

3.3 Preventative and Protective Measures

If possible, risks should be eliminated. If this is not possible, and then they should either be mitigated/controlled or minimised or, if none of these is possible, then personal protection should be provided. In deciding upon the types of preventative and protective measures that need to be provided, the following principles should be considered by the manager

- It is always best, if possible, to avoid a risk altogether. This can be done by using a different approach, substance or method of work.

- Combat risks at source rather than by adopting secondary measures.
- Where' -r possible, work should be adapted to the ' .dividual rather than the individual adapted to the work.
- Make use of technological and technical progress when treating risks.
- Collective protection measures should be given priority.
- Protection provided should be backed up with adequate training and supervision.
- Measures to avoid, prevent and reduce risks need to be an accepted part of the approach and attitudes at all levels of the organisation.

3.4 Other methods of hazard identification

A number of hazard identification methods exist, most of which are implicit in the methods in section 3.

A number of methods are based on prior experience. These include (Koldaş, K.S, 1998): -

1. Accident analysis, major incident reviews and near miss analysis from which commonalties can be identified.
2. Members of the team may have been involved with investigations or have read accounts of incidents and, from personal experience and memory, are able to list factors.
3. Codes of practice, standards and working procedures are generally designed to prevent losses and their analysis can uncover expected hazards and incidents.
4. Safety and loss control audits may explicitly identify hazards ad incidents arising therefrom.
5. From imagination techniques such as brainstorming, scenarios are developed in which previously un-encountered incidents are created within a specific hazardous environment.
6. *'Cause-consequences'* methods rely on a systematic analysis of a given scenario such as a *'fault tree', 'event tree',* 'failure mode-effect and critically analysis (FMECA), the hazard and operability study (HAZOP).

3.5 Rock engineering, hazard identification in strategic planning

The objectives of any strategic planing process are twofold; the first is to identify a suitable strategy to meet the requirements of the particular problem. The second is to provide broad guidelines for detailed design work based on the chosen strategy.

Rock engineering input to strategic planing occurs in four main phases: -

1. Assisting in defining the requirements of the particular project.
2. Gathering relevant geotechnical information on conditions that will prevail
3. Assisting in generating alternative scenarios to meet the requirements defined in section 3.2
4. Assisting in selection of suitable scenario

An example of rock engineering input and hazard identification applied to strategic planning is such as shaft pillar, support design or remnant extraction.

3.6 Rock engineering and hazard identification process in operational planning and design

There are three main objectives of operational planning and design. Based on the information generated when defining the preferred strategy, the first objectives are to identify, in detail, hazards present and the incidents that could arise from them. The second objective is to identify methods of preventing or ameliorating the effects of those hazards and to incorporate those methods into the detailed design. The third objective is to provide guidelines for practice, procedures and specifications to control work during the operational phase.

The duties of the rock engineering service are to:

- review design and planning of new areas;
- review abnormal ground conditions and make proactive recommendations;
- review designated special areas and advice on requirements;
- participate in regular interdisciplinary mine planning and design meetings;
- initiate and implement monitoring, recording and reporting procedure;
- assist management with training in rock engineering aspects;
- assist management with investigation of serious rock related incidents;
- assist management with risk assessment of rock related issues;
- assist management with compiling and updating of the Code of Practice and

- assist management with the compiling and updating of Mine Standards.

3.7 Review **and** Revision

Risk assessment is a continuous process and as work changes, the hazards and risks may change and therefore the risk assessment process must also change. Risk assessments should be reviewed or modified when an accident occurs, or if more is learnt about certain hazards in the workplace. Thus, after an accident, the safety officer should select a risk assessment team and revisit the previous risk assessment to see:

- whether the accident which has occurred was predicted;
- whether it was decided to prevent that accident;
- if so, why the preventative measures did not work;
- if the accident was not predicted, whether it is necessary to revise the risk assessment process or not;
- if the accident was predicted but it was decided to tolerate the risk, whether the decision was valid;
- why the accident occurred, and what should be done to prevent similar accidents occurring, as far as is reasonably practicable.

It is appreciated that the service provides maximum benefit if it is proactive and identifies potential hazardous conditions before they occur and create dangerous situations.

Rock engineering input to operational planing and design occurs in four main areas: -

1. Gathering detailed relevant geotechnical information relating to conditions that are likely to prevail; Table 3.

The geotechnical data, which should be collected, and recommended methods of collecting the data. Site investigations, geotechnical logging of borehole core, mapping of joints, rock mass classification mapping including recording of joint properties, and requirements for laboratory testing of rock samples are dealt with (SIMRAC, 1999).

- study of available geological plans and similar material;
- remote sensing (satellite imagery);
- aerial photograph interpretation;
- specific field mapping;
- targeted exploration drilling, including specific geotechnical drilling, all based on the information obtained from the above investigations;
- evaluation and prediction of geological influences:
- structural;
- in situ and induced stresses;
- groundwater;
- quality and durability of the rock and rock mass;
- control investigations during production, to identify conditions different from those on which the design was based.

2. Assisting in preparation of detailed micro layouts;
3. Assisting in generating macro sequences ad schedules;
4. Assisting in preparing codes of practice, operating procedures and specifications.

3.S The rock engineering and hazard identification processes **during operations**

During this phase there will be three main objectives of the hazard identification exercise: -

1. To generate awareness of hazard and their associated incidents amongst the workforce;
2. To monitor the effects of hazards in working places in order to allow timely intervention;
3. To provide information that will facilitate review and revision of practices, procedures and specifications.

Rock engineering input during operations consists largely of monitoring and observing conditions. It occurs in three main areas: -

1. To ensure that designs and methods for strata control are implemented correctly and are working effectively;
2. To identify any short, medium or longer term changes in geotechnical conditions which may demand modifications to procedures, practices or specifications and recommend appropriate action to deal with those changes;
3. To ensure that micro layouts are maintained and, if not, that the potential effects of deviations therefrom are

identified and appropriate action is implemented

Table 3 Example- Rock-related hazards associated with development in different rock types, (Koldaş, KS GCMP,2001)

ROCK TYPE	STRATEGIES
Hematitle Quartz Breccia	Hazard levels are increased for all rock types where tunnels and decline are developed or mined through faults and dykes due to presence of ground disturbed by jointing or smaller scale fracturing on the margin of these discontinuities Increase support density in all areas
Hydrothermal Breccia composed predominantly of andésite in a siliceous to silica clay matrix	Hazard levels are increased for all rock types where RQD values between 25 50% Steelarch units m conjunction with 2,4m grouted swellex + 50mm fibrecrete with wire mesh to be applied where poor ground and self mining conditions are intersected

3.9 Numerical Modelling

Numerical modeling provides excellent useful tools for assessing rock-related risks m mines Numerical modeling m rock engineering, as with almost computational analyses m traditional engineering disciplines, is based upon the assumption that the problem is well defined In realty this means that numerical modeling must be used to test proposed design specifications against well-established predefined criteria

4. CONCLUSION

Rock related risk management technique plays an ever increasing role in ensuring the safety and heath standard of mining operations The introduction of rock related risk assessment in mining industry presents a real opportunity to change and improve safety and health performance To do this successfully, it is vital that there is real commitment to change, to ensure that the process does not turn into yet another 'back protecting' paper exercise Rock related risk assessment requires a well-planned management system and rock-engineering professionals to ensure that improvements are implemented and to encourage widespread stakeholder participation

The mining industry throughout the world particularly in Turkey needs to improve its safety and health performance and it is therefore risk management process is an ideal opportunity to change the old culture

REFERENCES

DME, 1996 *Guideline for Compilation of a mandatory Code of Practice to Combat rockfall and Rockburst Accidents in South Africa,* Publication Ref No GME 7/4/118-AB2

Koldaş, K S 1998 Proposed Risk management Regulations for MRAC, *Department of Minerals and Energy Affairs of South Afuca*

Koldaş, K S 2001 GCMP *Rock Related Risk Assesemnt Studies in Newmont Ovacık Gold Mine*

SIMRAC, 1997 Practical guide to the risk assessment process, *Tupartite Woiking Group on risk Assessment*

SIMRAC, 1999 A Handbook on Rock Engineering Practice for Tabular Hard Rock Mines, Vol 1, pp 12-8