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Critical role of risk management in ground engineering and opportunities for improvement

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ABSTRACT

Green mining is concerned with mining in a sustainable manner, such that the needs of the present are met without compromising future generations. The achievement of this objective depends on balancing social, environmental and economic objectives and has to have regard to both active mining operations and legacy issues associated with mine closure. Ground engineering has a critical role in achieving green mining objectives but its contribution is characterised by pervasive uncertainty. Uncertainty equates to risk. This means that ground engineering should be practiced within a risk management framework that aims to both prevent unwanted outcomes and to mitigate their consequences to an acceptable level. This keynote address presents the fundamentals of risk management and demonstrates its effectiveness by reference to improvements in the safety performance of the NSW coal sector over the past three decades. Nevertheless, ground control remains a mix of art and science, relying heavily on judgements which should be premised on knowledge, skill and experience (that is, competence). Risk management has now been enshrined in mining legislation and operating practice in Australia for over two decades. Notwithstanding this, near-hit and accident and incident investigations, commissions of inquiry and legal proceedings almost invariably identify deficiencies and opportunities for improvements necessary to achieve the objectives of sustainable mining. Three of the more important opportunities which have global application in relation to ground engineering are discussed. These relate to the vexing issue of defining competency in ground engineering; the criteria for undertaking rigorous risk assessment; and the need for ground engineers to become involved in mine rehabilitation and closure planning over the full life cycle of a mine, commencing at the prefeasibility stage.

1. Introduction

Green mining is concerned with mining in a sustainable manner, such that the needs of the present are met without compromising future generations. The achievement of this objective depends on balancing social, environmental and economic objectives and has to have regard to both active mining operations and legacy issues associated with mine closure. Ground engineering has a critical role in achieving green mining objectives but its contribution is characterised by pervasive uncertainty due to an incomplete knowledge of material properties, behaviour mechanisms, loading environments and the strength of rock structures.

The effect of this uncertainty on achieving objectives constitutes risk. This means that ground engineering should be practiced within a risk management framework that aims to both prevent unwanted outcomes and to mitigate their consequences to an acceptable level. To be successful, this process requires knowledge of fundamental scientific and engineering principles relevant to ground behaviour, knowledge of mining systems, practices and hazards, and an understanding of risk management principles, supported by appropriate experience and skill.

2. Risk management

Risk management refers to the architecture (principles, framework and processes) for managing risks effectively. The process comprises the systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analysing, evaluating, treating, monitoring and reviewing risk [1].

Fig. 1 summarises the fundamental steps involved in the risk management process. It commences with identifying hazards and then assessing associated likelihood and consequence in order to determine the risk presented by each hazard. Next, controls are devised to eliminate each hazard where possible, or otherwise to reduce the risk associated with it to an acceptable level. These

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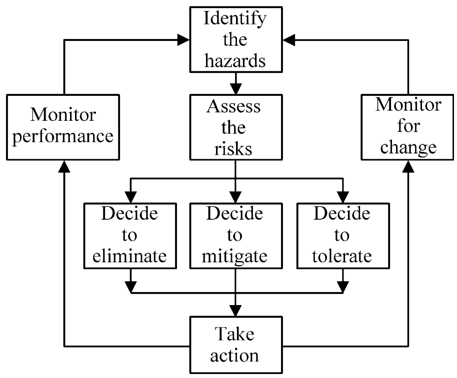

Fig. 1. Basic framework for managing risk (after [2]).

controls need to be risk assessed in their own right to confirm their likely effectiveness, to verify that they will not give rise to higher risks than those they are intended to address, and to determine residual risk levels. Then, having implemented the controls, it is essential that performance is monitored to verify the effectiveness of the risk assessment process. It is also essential that monitoring for change is undertaken to identify any deviations from the conditions and circumstances on which the risk management process was based and to intervene in a timely manner before a hazard materialises. Hence, the risk management framework equates to a continuous improvement process of plan-do-check-act.

Risk management has added significance for ground engineering in mining because "recovery measures" may also need to be pre-planned to minimise the consequences of any ground instability. A so-called "bow tie diagram", illustrated in Fig. 2, is a particularly useful risk management tool for analysing risk. It provides a powerful graphical representation of upstream threats and downstream consequences and facilitates the identification of preventative controls and, should the unwanted event still occur, contingencies for mitigating the consequences. Bow tie analysis finds extensive application in ground engineering in those jurisdictions operating under a risk management framework.

The Australian mining industry began to adopt a risk management approach to health and safety in the mid-1980s and to support it with a range of research and development initiatives and guidance material. The identification of hazards and the need to then reduce risk associated with these hazards to acceptable levels has been a major driver of innovation. Many of the ground engineering controls that are taken for granted today were either not available in the 1980s or in a very early stage of development.

The benefits of a risk management approach supported by technological innovation are reflected in trends in the safety performance of the NSW coal sector, Figs. 3 and 4. Since the early 1980s, the sector has experienced a 15-fold decrease in fatalities, with a number of fatality free years, and a 10-fold decrease in lost time injuries per one million employee hours worked, or loss time injury frequency rate (LTIFR) (Fig. 3). Improvements have been particularly pronounced in ground control, with ground instability related incidents accounting for only four fatalities in the 15 years to 2016 and only 2% of all injury compensation claims as at 2007 (Fig. 4), down from 16% in 1995 (later comparisons are restricted by changes in data recording).

3. Risk management in ground engineering

Risk is present throughout the whole life cycle of a mining operation, from prefeasibility assessment through to mine rehabilitation and closure. It has implications for occupational/workplace health and safety (OHS/WHS), the environment, community, government relations, litigation, business performance, corporate reputation and industry reputation. Experience, such as the failure of the tailings dam at Samarco Mine in Brazil in November 2015, has demonstrated that all of these risks can materialise with devastating consequences when disasters occur, contrary to the objectives of green, sustainable mining. Hence, it is not uncommon for organisations to have 'enterprise wide' risk management policies, standards and procedures, with workplace health and safety assuming the highest priority.

As ground control is a core risk in mining, it now features strongly in enterprise risk management within many major mining companies and in legislation and mine approval conditions. At the highest level, it is encapsulated in an overarching requirement of OHS/WHS legislation for an employer not to expose an employee to an unacceptable level of risk in the workplace. The standard to be achieved in this regard varies with community expectations which, in turn, vary from culture to culture, country to country and over time. Risk assessment in ground engineering has evolved from the concept that risk should be reduced to a level that is "as low as reasonably practicable" (ALARP). Since 2011, some legal jurisdictions have required risk to be reduced to "so far as is reasonably practicable" (SFAIRP), which is a more onerous standard as discussed by Robinson [3].

Some of the more important reasons for risk being associated with ground engineering throughout the life cycle of a mine are

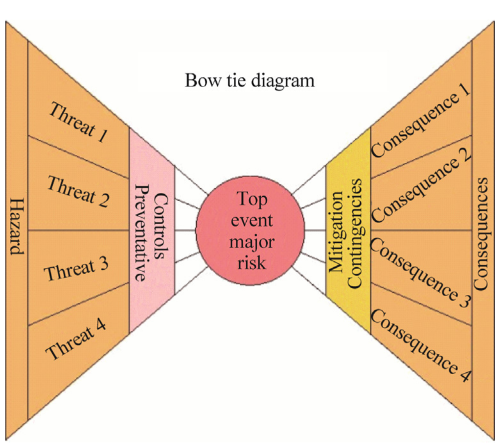

Fig. 2. Concept of a bow tie diagram' for analysing risk.

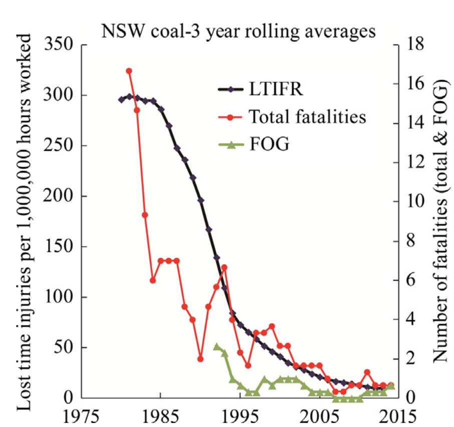

Fig. 3. Trends in safety performance measures for the NSW coal mining sector, expressed as three year rolling averages (plots based on data compiled by the Joint Coal Board and by Coal Services Pty Limited).

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