



S A F E T Y B U L L E T I N

GROUND SUPPORT IN UNDERGROUND MINES

The inspectorate has had a long standing concern with the methods and procedures in use in the underground sector of the industry for designing and implementing ground control programmes. There is no doubt that accidents from falls of ground form a substantial proportion of those experienced in this industry sector. In Western Australia, ***approximately 25% of all underground injuries occur as a direct result of rock falls.*** A study of fatalities in the WA mining industry which was carried out by the inspectorate revealed that over the study period (1980 - 1991) ***20 of the 55 underground fatalities resulted from rock falls (36%).*** This was the largest single cause of death in underground accidents. In subsequent years, a similar trend has emerged:

1991/92	2 of a total of 3 underground fatalities resulting from rock falls (67%)
1992/93	1 of a total of 2 underground fatalities resulting from rock falls (50%)
1993/94	1 of a total of 3 underground fatalities resulting from rock falls (33%)
1994/95	1 of a total of 3 underground fatalities resulting from rock falls (33%)

Even without this statistical confirmation, it is (and has been, over centuries of experience) readily apparent to all who work in the underground mining industry that rock falls are a major hazard in that industry.

Section 9 of the Mines Safety and Inspection Act 1995 casts a clear duty on employers to have in place some means of preventing employees from being exposed to the very evident risk of rock falls in the workplace. Similarly, Section 13 of the Act casts a duty on all managers and principal employers to eliminate or control those risks in entry and exit to the mine.

Further, more specific (though not exhaustive) guidance on what is required in respect of underground mines may be obtained from Regulation 10.28 of the Mines Safety and Inspection Regulations 1996, which is reproduced below in its entirety:

Geotechnical considerations

10.28. (1) The principal employer at, and the manager of, an underground mine must ensure that geotechnical aspects are adequately considered in relation to the design, operation and abandonment of the mine.

Penalty: See regulation 17.1.

(2) The principal employer at, and the manager of, an underground mine must ensure that the following things are done in relation to workplaces, travelways and installations underground in the mine -

- (a) *due consideration is given to local geological structure and its influence on rock stability;*
- (b) *rock damage at the excavation perimeter due to blasting is minimised by careful drilling and charging;*
- (c) *due consideration is given to the size and geometry of openings;*
- (d) *appropriate equipment and procedures are used for scaling;*
- (e) *appropriate measures are taken to ensure the proper design, installation and quality control of rock support and reinforcement; and*
- (f) *the installation of ground support is timed to take into account rock conditions.*

Penalty: See regulation 17.1.

(3) The principal employer at, and the manager of, an underground mine must ensure that the following things are done in relation to all development openings and stoping systems underground in the mine -

- (a) *geotechnical data (including monitoring of openings when appropriate) is systematically collected, analysed and interpreted;*
- (b) *appropriate stope and pillar dimensions are determined;*
- (c) *rationale for sequencing stope extraction and filling (if appropriate) is determined;*
- (d) *there is adequate design, control and monitoring of production blasts; and*
- (e) *rock support and reinforcement are adequately designed and installed.*

Penalty: See regulation 17.1.

The inspectorate has conducted a survey to gather data on ground support and rock reinforcement design methods, selection criteria, usage levels, installation procedures and quality control issues. The basis of the survey was the calendar year 1994. Specific information relating to the survey items was requested from both underground mine managers and ground support and rock reinforcement suppliers.

It is disappointing to report that, with one exception, very little information was forthcoming from suppliers. Of a total of 59 underground mines operating within the period covered by the survey, 18 responses (31%) were received. It is believed that this rate of reply, while not what might have been reasonably expected in response to requests for information on a subject of such importance to the industry as a whole, is sufficient for valid conclusions to be drawn.

The principal conclusions of the analysis of the survey are as follows:

- 67% of mines indicated that they were not using any of the recognised ground support and rock reinforcement design methods.
- 33% of mines were apparently making at least some use of rock-mass classification and/or block analysis techniques.
- The three practical issues assigned most importance when selecting the type of ground support or reinforcement to be used were:

- equipment availability
 - local mine experience
 - excavation dimensions
- The three practical issues assigned least importance when selecting the type of ground support or reinforcement to be used were:
 - ground water
 - Australian mining experience
 - cost
 - 65% of all ground support and reinforcement units installed were friction rock stabilisers of the split tube type.
 - Galvanised friction rock stabilisers were three times more widely used than the black steel type.
 - 56% of mines reported that they did not conduct any load testing whatsoever of ground support and reinforcement.
 - Only 0.3% of the total number of ground support and reinforcement units installed were load tested. One single mine accounted for 60% of all load tests carried out.
 - Only 22% of mines appear to have formal written installation procedures of some kind to govern the use of ground support and reinforcement.
 - Only 6% of mines appear to have formal written quality control and testing procedures for ground support and reinforcement.
 - The industry's total rate of ground support and reinforcement installation is estimated to be 1.1 million units per annum.

The results of the survey do not indicate an adequate level of awareness of and compliance with the law, particularly with the employers' and managers' duty of care to employees and others and the specific requirements of Regulations 10.28 (2)(a) and (e) and 10.28 (3)(a) and (e).

The lack of formal and systematic design in ground control is little short of an indictment of the engineering competence and performance of the industry. The survey results confirm the view of the inspectorate that ground control is commonly held to be the province of the miner on the job or, at best, of the first-line supervisor, rather than the engineer or manager and that ground control design is carried out (if at all) in an ad hoc fashion. (This issue was drawn to the attention of the industry in the 1990 Report on the Inquiry into Safety in Underground Gold Mines). The reality is that even the most experienced face employee, while entitled to be consulted and to provide the benefit of his practical experience and local knowledge, does not have and should not be expected to have the ability to make often critical judgements on the design of ground control systems and the appropriateness or otherwise of particular types of support.

It is apparent that the use of the split-tube type of friction rock stabiliser predominates whether or not such reinforcement is appropriate under particular circumstances. In brief it remains a matter of operating convenience. This, coupled with the woeful inadequacy of quality control measures is of great concern to the inspectorate and should be of even greater concern to employers and managers who carry the statutory duty to ensure adequate ground control measures are implemented.

What emerges from the survey is a picture of an industry where inadequate information on ground conditions, structure and stress regimes is masked by the delegation of important decisions on support and reinforcement to unqualified (and variously "experienced") employees. This is compounded by inadequate quality control and may result in a situation where management may be unaware that at least some of the time, resources and funds expended on ground support are entirely wasted and have no significant effect on the overall safety of an operation.

A separate, but related issue, also covered by Regulation 10.28, is that of the use of appropriate drilling and blasting techniques to control and limit rock damage at the excavation perimeter, particularly in development and in entry-method stoping operations. While not covered by the survey detailed above, it is the experience of the inspectorate that insufficient attention is being paid to this important issue in the development and everyday operation of Western Australian mines.

There is a tendency to continue the use of patently unsuitable drilling patterns and explosives combinations, or to leave important decisions on these matters to the miner on the job and then to proclaim reliance on his "experience" in these matters as a prime determinant of the methods employed.

These are important management decisions which may well have a major effect on both the short-term and the long-term safety of the operation and responsibility for them cannot be delegated to the workforce. Consultation with the miner is important, but the decision and its consequences (and the responsibility for enforcing the appropriate standards where the miner is recalcitrant) are, and remain, management functions which cannot be delegated.

Employers and managers are therefore strongly enjoined to conduct a critical review of their own operations with a view to establishing that their geological and geotechnical databases are adequate to ensure valid input to the ground support design process, that this process is professionally carried out using recognised and demonstrably successful techniques and that quality control and testing on the job are adequate to ensure that design capacities of the rock reinforcement systems employed are attained in practice. Anything short of this will leave them exposed to the consequences (including the legal consequences under both the civil and the criminal law) of their failure to act in a responsible fashion.

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