Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

CODE OF PRACTICE

Ground control for Western Australian mining operations

MIAC
MINING INDUSTRY ADVISORY COMMITTEE

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Foreword

Basis for code of practice

This code of practice is issued by the Department of Mines, Industry Regulation and Safety (the Department) and Mining Industry Advisory Committee (MIAC) under the *Mines Safety and Inspection Act 1994* (the Act).

A code of practice is a practical guide to achieving the standards of occupational safety and health required under legislation. It applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following a code of practice would achieve compliance with the duties in the legislation in relation to the subject matter of the code. However, like regulations, codes of practice deal with particular issues and do not cover all hazards or risks that may arise. Duty holders need to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates. However, compliance with the legislation may be achieved by following alternate methods, such as a technical or an industry standard, if it provides an equivalent or higher standard of occupational safety and health than the code.

Scope and application

This code of practice will assist those operating a mine to consider the geotechnical aspects for the safe design, construction, operation and closure of the mine workings for which they are responsible so they may meet their legislative obligations for occupational safety and health under the Act and the Mines Safety and Inspection Regulations 1995 (the regulations).

The code of practice is designed to outline the regulatory expectations for minimising workforce exposure to hazardous ground movements.

It focuses on the role of ground control management to ensure the application of sound geotechnical engineering practice. Ground control involves the implementation of formal systematic strategies throughout the life of a mine to manage hazardous ground movements.

The provisions of this code of practice apply to all mines (e.g. sand mines, rock quarries, open pits, underground) as defined in section 4(1) of the Act.

Who should use this code of practice?

You should use this code of practice if you have control of a mine (e.g. employer, Registered Manager, Quarry Manager, Underground Mine Manager), or have operational functions and responsibilities for ground control. You should also use this code if you design, manufacture or supply plant that can influence ground stability or be influenced by ground movement.

Safety and health representatives and workers who need to understand the risks associated with ground instability hazards may also find this code useful.

How to use this code of practice

The code of practice includes references to both mandatory and non-mandatory actions.

The words "must" or "requires" indicate that legal requirements exist, which must be complied with. The word "should" indicates a recommended course of action.

Contents

1 Introduction

1.1 Importance of ground control

From a safety perspective, hazardous ground movements resulting from ineffective or inadequate ground control can lead to injury or death due to the immediate effects of:

- unplanned and uncontrolled ground movement (e.g. falling rock, wall failure, rock ejection)
- falling from height (e.g. cave-in, edge failure)
- physical entrapment (e.g. collapse of a sand pile, subsidence of a backfilled stope in underground workings).

Ground instability and hazardous ground movements can directly affect:

- geotechnical infrastructure within the mining operation (e.g. underground excavations, pit walls, waste rock landforms, tailings storage facilities, ore stockpiles, foundations, structures to manage water storage and runoff)
- other infrastructure and important features outside the mining operation (e.g. public transport routes, pipelines, surface drainage systems).

1.2 Structure of code

This code of practice is written to accommodate diverse mining scenarios from small sandpits and quarries through to deep underground or large surface operations with extensive mine workings.

The code is structured to support a risk management approach to ground control through the development and maintenance of a ground control management plan (GCMP) and related safe systems of work (Chapter 2). The following elements are integral for effective ground control management:

- safe design incorporating a well-integrated geotechnical database, and design processes and concepts (Chapter 3)
- correct design implementation, and ongoing performance monitoring, review and updating of ground control strategies throughout the life of the mine (Chapter 4)
- communication, training and supervision relevant to mining tasks associated with ground control (Chapter 5).

Appendix 1 lists the legislative provisions that apply to ground control.

Appendix 2 provides a glossary of terms used in this code of practice.

Note: This code of practice is supported by the Department's Ground control management in Western Australian mining operations – guideline.

1.3 Responsibilities

Employers and managers of mines should appoint competent persons to assist them in carrying out the duties placed upon them, and develop management plans to limit or control the potential effects of identified ground instability hazards.

The roles and responsibilities given to mine personnel and others by management will depend on their job requirements and their capacity to influence ground control, whether at the mine-wide or local scale:

- mine-wide (overall stability of the mine or large sections of it)
  - competent persons (e.g. mine designer, geotechnical personnel) formulate and apply the ground control strategies through safe design
  - the general workforce typically has limited input into the design process
- local (immediate work area)
  - the general workforce implements the ground control strategies relevant to their tasks during their daily activities (e.g. ground support installation, scaling, drill-and-blast quality control, supervision)
  - other competent persons (e.g. geotechnical personnel, supervisor, supplier) may be assigned responsibilities to manage exposure to ground instability hazards.

The responsibilities of geotechnical personnel include:

- developing and maintaining the mine's geotechnical database or model
- developing and maintaining the mine's GCMP
- provide geotechnical input into the design, planning and implementation processes
- verifying ground control measures meets design specifications and tolerances
- auditing and reviewing the ground control strategies
- assisting with training personnel undertaking specific ground control roles
- recommending geotechnical changes where improvements to ground control management are required.

1.4 Incident reporting

There is a legislative requirement to report significant incidents involving ground movements to the Department as per section 78 of the MSIA. Mine operators are required to provide information regarding the nature of the incident, the direct and potential impact on mining operations, and the measures to be taken to prevent a recurrence. Relevant photographs should be provided when reporting the incident.

2 Ground control management

Effective ground control starts with identifying the potential for ground instability and hazardous ground movements, assessing the risks associated with those movements, and then implementing control measures and checking their adequacy. The results of the risk assessment are recorded in a hazard and risk register.

Risks to worker safety need to be managed. This is best achieved by implementing control measures through the hierarchy of controls. Higher order control measures eliminate or reduce the risk of exposure to the hazards more effectively than lower order controls — the provision of personal protective equipment (PPE) is generally insufficient to mitigate serious incidents (e.g. rock falls). Ground control, which comprises engineering and administrative measures, is one of the most effective tools to reduce risk.

The key elements for a risk-based approach to ground control management are shown in Figure 1. These elements, including assigned roles and responsibilities, should be captured in a GCMP.

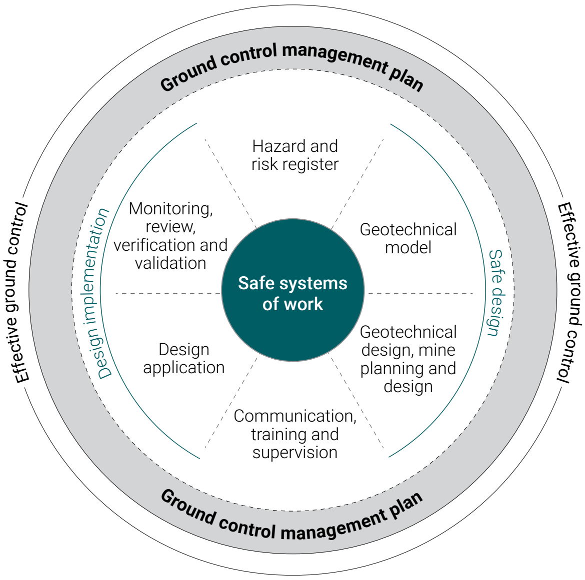

Figure 1 Key elements to consider for effective ground control management

The GCMP should be a single, overarching, easily accessible and easy-to-follow document developed and maintained by competent persons. The level of detail required within the plan should be appropriate for the scale and complexity of the operation, and potential consequences of ineffective or inadequate ground control. For example, a deep, geologically complex underground mine would require a more detailed GCMP than that for a shallow, remote sand pit – it would not be necessary to establish blasting procedures nor conduct regular mapping of geological structure in sand pits with homogenous materials.

The hazard and risk register is the foundation for the safe design (geotechnical model, geotechnical design) and implementation (design application, monitoring, verification, validation) processes involved in ground control management. The register should be reviewed and updated throughout the life of the mine as operations expand or the risk profile changes.

Safe systems of work are essential to ensure compliance with the safe design intent and manage work aspects that can affect or be affected by ground control. Before mining commences, a competent person should develop and formally document the safe systems of work to be adopted.

Effective ground control management also requires appropriate communication, training and supervision systems.

The safe systems of work documents (e.g. safe work procedures, standard operating procedures, training requirements) should be included or referenced in the ground control management plan.

The plan and any document related to ground control should be reviewed regularly, and specifically:

- to address issues identified during validations
- following an incident
- when there is a planned or anticipated change in the ground control risk profile (e.g. ground conditions, operating practices, mine design).

Note: For further information on ground control management, refer to the Department's Ground control management at Western Australian mining operations – guideline.

3 Safe design

3.1 Geotechnical model

The validity of the mine design and associated ground control strategies largely depends on having data of sufficient quantity and quality for the geotechnical model to support the design process.

The level of detail in the geotechnical model needs to be appropriate for the:

- complexity of geological characteristics and engineering properties of the rock mass that may influence the stability of the mine
- level of risk for each area of the mine
- critical stages of mine development.

The geotechnical model should include the engineering properties of all materials and geological structures that can be influenced by the design or have an influence on the design.

The geotechnical model can be represented as different domains with similar characteristics and potentially similar ground behaviour. These domains will assist in establishing the safe design for all areas to be mined.

A competent person with considerable engineering and relevant mining experience should determine the levels and methods of geotechnical investigation required to develop the geotechnical model. The model should be updated as mining progresses and more data is collected.

3.2 Geotechnical design

Design approach

The geotechnical hazards associated with mining operations vary widely across Western Australia. The strategies used to manage the risks associated with these hazards should be carefully selected, justified and documented.

Safe design and mine planning processes should be applied throughout the life of the mine. Designs should be prepared, reviewed and revised by a competent person (e.g. geotechnical and other engineering, geological and surveying staff).

Design methods

Safe geotechnical design methods include:

- empirical methods
- kinematic methods
- analytical, deterministic or limit equilibrium methods, which use geotechnical parameters derived from either laboratory testing or back analysis of existing failures
- numerical modelling
- physical modelling (rarely used).

Safe mine design necessitates a good understanding of the risks and limitations associated with the use of any particular design method, and the circumstances under which the method can be applied.

An appropriate combination of design methods should be used to minimise risk and determine the optimal safe design of geotechnical infrastructure.

Sensitivity analyses should be conducted to determine the potential range of effects for critical engineering properties used for the safe design of geotechnical infrastructure and the various geotechnical design techniques used. Design elements that have significant impacts on safe design require higher levels of confidence in the knowledge of the input data and outcome.

Design acceptance

Design acceptance criteria (e.g. factor of safety, acceptable residual risk) vary for each design method and are influenced by factors such as:

- type of ground movement expected
- degree of inherent uncertainty regarding the characteristics of the ground
- degree of suitability of the design method with respect to the geotechnical infrastructure and potential ground movements
- design life of the excavation (e.g. required “stand-up time” and likelihood of exposure to large-scale events such as earthquakes and floods)
- potential consequences of hazardous ground movements.

In general, any simplification of the overall geotechnical environment by the design method used, or uncertainty in the geotechnical model, should have a higher degree of conservatism for the design acceptance criteria (e.g. higher factor of safety).

The basis for adopting any design method and design acceptance criteria needs to be formally justified and documented, which includes listing all assumptions made. For example, geotechnical infrastructure at mines with complex geology or located near public infrastructure should have more sophisticated design models that are based on adequate representative data for the geotechnical environment.

4 Design implementation

4.1 Design application

Effective ground control not only relies on establishing safe design principles but also their application and implementation through safe systems of work.

The application of the geotechnical design should be within the tolerance limits defined by the design intent and assumptions. This includes:

- excavation techniques (e.g. drill and blast) that comply with design intent
- ground support selection, installation and quality control in accordance with design standards and procedures
- use of equipment that is fit for purpose and maintained to the original equipment manufacturer's (OEM's) specifications
- backfilling in accordance with design intent
- sequence and rate of extraction, ground support installation and, if applicable, back filling
- scaling and maintenance of excavations in accordance with design standards and procedures
- appropriately trained personnel assessed as competent
- provision of adequate information, instructions, training and supervision.

4.2 Monitoring

The results of monitoring for changes in ground conditions and behaviour are used:

- for verification and validation of design procedures and assumptions
- as a warning tool to determine whether the specified tolerance limits are being approached or have been exceeded.

Timely warnings are important to trigger corrective measures, including the withdrawal of personnel if necessary.

Whether by instrumentation or observation, the monitoring system should be appropriate for detecting, measuring and recording the expected types of changes in ground conditions and behaviour. Instrumented systems should be designed to meet analytical requirements and address limitations in monitoring methods (e.g. power supply, exposure to blast damage, measurement accuracy, competency of personnel) and requirements for site access.

4.3 Review, verification and validation

Over the life of the mine, a competent person should regularly check performance to verify that ground control is functioning as intended and the geotechnical design remains valid. The learnings from failures as well as results of monitoring, inspections and audits form part of this review process.

Matters to be considered for review include:

- the geotechnical model (e.g. validity, degree of representation)
- mine planning and design processes
- operational issues relevant to ground control
- drill and blast effects
- rock support and reinforcement effectiveness
- quality assurance and quality control
- design confirmation and back analysis
- ground control monitoring and response
- training and competency.

A competent person should maintain records of monitoring results, geotechnical workplace inspections, audits, geotechnical incidents and investigations, including any actions taken or recommended to remediate unsafe areas and details of how they were addressed or implemented. A competent person should also update the geotechnical model and design as required.

5 Communication, training and supervision

5.1 Introduction

The provision of information, instruction, training and supervision is an essential component of any safe system of work.

The level of risk associated with ineffective or inadequate ground control substantially increases if:

- ground control hazards in workplaces are not identified
- ground conditions and ground control requirements are not well understood
- ground control measures are not implemented appropriately.

5.2 Communication

Many parties contribute to effective ground control. Responsibilities may overlap and, consequently, effective consultation and communication systems are important.

The communication strategy relevant to ground control should include the provision of information and instructions, such as:

- mine design and planning protocols
- the use of risk assessment tools, such as job safety or hazard analyses (JSAs or JHAs)
- policies, procedures and standards, such as standard operating procedures (SOPs) and safe work procedures
- requirements and specifications for ground support installation and ground monitoring (e.g. instrumentation, visual and aural observations)
- manuals and operating instructions provided by OEMs
- applicable legislation, Australian and industry standards, and other guidance material
- trigger action response plans (TARPs) for managing ground movements beyond the site's specified tolerance limits
- emergency response plan.

Effective change management processes should be implemented whenever there are variations in ground conditions, systems of work, or plant and equipment, or new designs or mining methods are introduced. This includes consultation with affected personnel, retraining as necessary, and a reassessment of competency.

5.3 Training

All personnel should understand the effect their activities may have on ground control in the mine. Workers who could be exposed to ground control hazards should be able to identify and respond appropriately to hazardous ground conditions.

Personnel must be competent in the tasks they are assigned. This means they have the knowledge and skills necessary to perform the task safely and correctly. Competency is gained through training and experience.

The level of ground control training, supervision and mentoring provided should be appropriate to the assigned roles and responsibilities.

Training systems (including refresher training) should consider the level of potential exposure to hazardous ground movements and complexity of tasks undertaken. The training should provide information on:

- identification of ground control hazards
- the ground control risk management process
- the safe system of work, including task-specific safe work methods.

Assessment of competency should be evidence-based.

Personnel should be retrained and their competencies reassessed whenever systems of work change, new systems of work are introduced (e.g. as a result of a change in ground conditions), or plant and equipment are introduced that may change the risk profile.

Training in ground control should be delivered by personnel competent in the subject matter being covered.

5.4 Supervision

Supervision is integral to the effective implementation of the ground control strategies by:

- ensuring technical and mining work is carried out in accordance with the safe systems of work and the operation's policies
- assigning workers who are trained and competent for the task to be undertaken
- assuring quality control requirements that may affect ground control are achieved
- inspecting and monitoring ground conditions
- reporting and addressing hazards
- escalating any issues according to the site's procedures.

Supervisory roles (e.g. manager, frontline supervisor, leading hand) and responsibilities should be specified in the ground control management plan.

Appendix 1 Legislative provisions

The sections of the *Mines Safety and Inspection Act 1994* and parts of the Mines Safety and Inspection Regulations 1995 that are applicable to this code of practice are listed below.

Mines Safety and Inspection Act 1994

Section 9	Employers, duties of
Section 10	Employees, duties of
Section 13	Principal employers and managers, duties of

Mines Safety and Inspection Regulations 1995

Part 4 General safety requirements

r. 4.11	Flood protection
r. 4.13	Induction and training of employees

Part 10 Specific requirements for underground mines

r. 10.5(2)	Persons working alone
r. 10.10	Means of entry and exit
r. 10.11	Stope to have 2 travelling ways
r. 10.12	Workers to be withdrawn if danger exists
r. 10.13	Excavations to be kept safe
r. 10.18	Approaching dangerous water
r. 10.19	Dams and plugs
r. 10.20(8)	Winze sinking operations *Note: deals with winze-related hazards.*
r. 10.23	Travelling ways to be made safe
r. 10.27	Procedures when workings are approaching each other
r. 10.28	Geotechnical considerations
r. 10.34	Shrinkage stoping or development

Part 12 Shaft sinking

r. 12.3	New shaft sinking operations *Note: indirectly deals with ground control issues while sinking shaft.*

Part 13 Surface mining operations

r. 13.5	Dumping precautions
r. 13.7(1)	Bench widths and open pit roads
r. 13.8	Geotechnical considerations
r. 13.9	Precautions in working faces and benches
r. 13.12(4)	Stockpile safety precautions
r. 13.14	Sand pits
r. 13.15	Mine boundaries

Note: The only authorised versions of the Mines Safety and Inspection Act 1994 and regulations are those available from the Parliamentary Counsel's Office, Department of Justice (www.legislation.wa.gov.au), the official publisher of Western Australian legislation and statutory information.

Appendix 2 Glossary

For the purposes of this document, the following terms are defined.

Competent person. Under section 4(1) of the Act, a competent person is a person appointed or designated by the employer to perform specified duties for which that person is qualified to perform through knowledge, training and experience. It is the duty of the principal employer to determine the level of competency required for each role or task.

Geological structure. Includes the folds, joints, faults, foliation, schistosity, bedding planes and other planes of weakness (defects) in rock or soil.

Geotechnical engineering. The application of engineering geology, hydrogeology, soil mechanics, rock mechanics and mining seismology to the practical solution of ground instability challenges.

Geotechnical infrastructure. Includes underground or surface excavations, embankments, waste dumps and stockpiles relating to mining operations.

Ground. Earthen material in all its possible forms, ranging from unoxidised, high-strength rock material to extremely weathered, low strength, essentially soil-like material, including evaporites. The term includes both consolidated and unconsolidated broken or loose material and all (back) fill materials, both cemented and stabilised in any way, and uncemented.

Ground control. The ability to forecast and influence the behaviour of ground in a mining environment. Having due regard for the safety of the workforce, and the required serviceability and design life of the mine openings or voids.

Surface mine. An engineering structure that, from a ground control perspective, comprises various forms of mine voids, waste storage, stockpiles and embankments. For the purposes of this code of practice, surface mines include open-cuts, open-pits, strip-mines, terraced mines, sand pits, borrow pits and quarries. These terms may be used interchangeably, depending on the application.

Underground mine. An engineering structure that, from a ground control perspective, comprises mine voids (both filled and unfilled), and pillars and abutments of various dimensions and orientations.

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