Resources Regulator
Department of Regional NSW

Consolidated report

Ground or strata failure - underground coal mines - secondary extraction

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Executive summary

A crucial part of the NSW Resources Regulator's *Incident Prevention Strategy* involves targeted assessment and planned inspection programs for mines and petroleum sites. This is a focus on assessing an operation's control of critical risks through evaluating the effectiveness of control measures in the mine's safety management system.

The Regulator has developed a bowtie hazard management framework and standardised assessment checklist for each program plan. Under each program plan, the effectiveness of the safety management system at each mine site is assessed against a standard set of control supports and critical controls.

This report summarises the assessment findings from 20 mines in relation to assessments for the hazard of ground or strata failure with secondary extraction areas, conducted between March 2021 to June 2022.

The threats, consequence and critical controls assessed for the material unwanted event (ground or strata failure) are shown in Table 1.

Table 1: Threats, Consequences and Critical Controls for the Material Unwanted Event (Ground or strata failure – secondary extraction – underground coal mines)

THREAT/CONSEQUENCE		CRITICAL CONTROL
Threat	• Ground conditions	PC 1.4 – Manage void formation
Threat	• Ground conditions • Pillar overload • Seismic event	PC 1.6 – Ground support
Threat	• Ground conditions	PC1.7 – Ground support lifecycle management
Consequence	• Crush injuries • Impact injuries • Asphyxia	MC1.1 – Control access to unsupported ground

Legislative requirements and published guidance relating to the principal hazard of ground or strata failure is listed in Appendix A. Figure 1 presents safety compliance findings for each deidentified mine and critical control assessed for the material unwanted event of ground or strata failure. Explanatory notes on the assessment system are also listed in Appendix B.

Throughout the inspection program, there were several examples where sites could demonstrate they had well-established plans and procedures in place to control the principal hazard of ground or strata failure.

Improvement areas were also identified and discussed with the sites during the assessments for managing their strata failure hazards. This resulted in 23 notices (including notices of concern, improvement notices, and prohibition notices) being issued throughout the inspection program.

Key findings

Resource Regulator inspectors were able to share information from other mine sites of work that was being done well to manage the hazards associated with strata failure, as well as any incidents

that had occurred within the mining industry and what controls were applied to prevent a similar type of incident from reoccurring.

Some general findings from the inspection program are listed below, as well as some specific findings for each of the critical controls assessed.

General findings:

- Risk assessments were completed in consultation with workers as well as involving internal and external geological and geotechnical expertise at most sites.
- Where any incidents of strata failure occurred, various stakeholders were involved within the incident investigation as well as developing the necessary controls to prevent a similar type of incident from occurring.
- Ground or strata failure principal mining hazard management plans were current and defined the necessary controls.
- There were 5 roof falls in development roadways within the past 2 years, with an additional partial fall of material resulting in a serious injury to a mine worker. Four of the roof falls occurred within several weeks of the roadway being excavated and supported. Three of the falls were supported with primary support.

Critical control: PC1.4 – Manage void formation

- All mines reviewed had risk assessments and strata failure management plans that were current and in date.
- All mines had completed training in the roof and rib TARPs, and the subsequent response to changes in mine environments that would trigger actions. This was especially relevant to development operators and appointed development supervisors.
- All longwall mines had systems in place to monitor roof convergence and changes in longwall roof support leg pressures, both on the surface and from the face.
- All longwall mines had systems in place regarding windblast, but generally caving of the longwall occurred within 15 m of the face-line commencement, and cyclic loading was not a common occurrence.
- All longwall mines had procedures in place for face alignment and horizon control, with varying degrees of automation being used to operate the longwall.
- One mine using partial extraction, had a very robust mining plan in place with each pillar geologically and geotechnically mapped, secondary support installed as required, resulting in a comprehensive extraction plan, limiting uncontrolled void formation and a controlled caving of goaf areas.

Critical control: PC1.6 – Ground support

- Most sites conducted communication sessions to the workforce upon bolt up of a longwall panel, relocation to new mining areas, widening of roadways, authorities to mine, expected mining conditions and ground support requirements.
- Statutory reports included roof and rib support inspections and indicative signs of any geological anomalies or changes in conditions. The reports were communicated to supervisors and senior staff, including the geotechnical engineer and the technical resource manager.
- Most sites had a designated supervisor that completed the weekly/monthly monitoring device inspection, recording readings and assisting the geotechnical engineer with the secondary support plan, remedial work plan and completing the monthly strata report for the strata management team.

- Generally, the testing of the installed support (pull tests) was completed monthly/bi-monthly in each production unit, comprising drill rig torque testing, encapsulation and roof bolt pull tests - by the contracted support system provider.
- Depending on the mining system employed at the mine, and the rate of development, this could result in perhaps as little as 1% of installed bolts being checked to determine that there were no performance issues.
- Roof bolt encapsulation varied from fully encapsulated (at several mines) up to a 900 mm gap (at one mine), and all approved by independent geotechnical engineers. Testing of encapsulation varied from once/metre, several times per shift, out to the monthly/bi-monthly pull test. Results of encapsulation tests, when conducted, were included in the supervisor shift report.
- All sites completed refresher training for supervisory and mining personnel that included strata failure, TARPs for both roof and ribs, and knowledge of the authority to mine (ATM).

Critical control: PC1.7 – Ground support lifecycle management

- All sites conducted communication sessions to the workforce regarding reporting damaged rib and roof support, as well as hazard identification and safety issues.
- Statutory inspections of all accessible roadways were completed by officials and reported on the statutory report sheets, with issues/concerns then escalated to senior officials and geotechnical staff. Generally, remedial work was actioned through the work order system, with the work prioritised by the geotechnical engineer.
- Most sites had a designated secondary support crew, especially longwall mines, that installed secondary support and completed any remedial work that was identified, in a timely manner.
- In some cases, there were several thousand monitoring devices in use, with the reading of the devices based on history and rate of change.
- Some mines had a computer-based system that monitored change continuously.

Critical control: MC1.1 – Control access to unsupported ground

- All sites identified unsupported ground and in general terms, it is an integral component of all the mining companies' golden/cardinal rules.
- Barriers were in place indicating unsupported roof, which usually consisted of no-road tape and tag, cross-sticks or fenced off areas. However, some sites (mines operating first workings or herringbone mining systems) did not have adequate hard barriers in place, preventing workers from inadvertently approaching unsupported runouts.
- One site installed a reflective dropper at the last bolt of a supported roadway when mining a free cut in the herringbone mining system such that the shuttle car driver, and all face operators knew exactly where the unsupported roof was located.
- The replacement of shearer picks in both the maingate and tailgate, accessing the tailgate for statutory inspections, and accessing the crusher/bsl areas for maintenance are locations that should be reviewed by mine operators and supervisors, regarding work inspections and procedures.
- Holing into the gate-ends by the shearer was not always at the required horizon, and as such, the integrity of the mesh and bolts could be compromised.

Recommendations

The planned inspection program identified varying levels of control implementation and effectiveness across all the sites assessed. This highlighted several practices that could be improved to assist in protecting the health and safety of workers when exposed to this hazard. Based on the assessments completed, the recommendations are as follows:

Critical control: PC1.4 – Manage void formation

- Mine operators should engage an external geotechnical engineer when completing strata failure risk assessments and complete a comprehensive evaluation of ground stress, geological anomalies, and stratigraphic columns, to determine changes in the mining environment/conditions.
- Where any roadway is driven such that the roadway exceeds 5.5m, there must be a HRA in place. Mining supervisors must check that operators are mining to the required support plans, from roadway width, intersection width and breakaway commencement.

Critical control: PC1.6 – Ground support

- Mine operators should train and communicate to all workers, the controls developed from their strata failure risk assessment, primarily through a thorough understanding of roof and rib TARP's, and an awareness of physical changes in mining conditions.
- Mine operators should review their primary (Green TARP) bolt density pattern, regarding bolt length, bolt position and resin encapsulation to ensure that there is a factor of safety built into the support design. The roof failures that the industry has experienced, were directly related to issues associated with bolt position and encapsulation.
- Mine operators should consider roof TARP's that include encapsulation checks on installed bolts, and a rate (mm/week or month) of movement on monitoring devices, especially as panels transition from production district to out bye district, noting that the inspection regime changes from once/shift to weekly.

Critical control: PC1.7 – Ground support lifecycle management

- Mine operators should review their procedures for testing if the installed monitoring device is working, considering that several mines have high salinity water present, and some mines install grouted secondary support, which could render the device ineffective.
- Geotechnical personnel, supervisors, and deputies must thoroughly inspect work areas for strata/geological hazards, report issues and rectify damaged support in a timely manner.
- Damaged or missing support, resulting from vehicle movements should be rectified in a timely manner. Longwall move equipment, vehicles passing other vehicles close to rib-lines, development service extensions, and access into longwall tailgate panels are areas requiring regular remedial support.

Critical control: MC1.1 – Control access to unsupported ground

- Sites should identify unsupported areas to workers by means of the affected area barricaded (physical barrier) or illuminated by a reflective dropper, to prevent inadvertent access.

Mine operators should review their procedures for maintenance activities on longwall faces for breakdown situations, repicking the shearer, and activities involving mesh installation/relocations, such that operators are aware of the hazards associated with the longwall strata and any subsequent goaf or unsupported areas.

Findings by mine

Figure 1 presents aggregate assessment findings by threat/consequence and critical control, providing a summary view of the status of each mine's hazard management processes. Importantly, the system recognises the value of fully implemented and documented controls by awarding an

additional point if both elements were assessed as present. More details explaining the assessment system are at Appendix B.

Figure 1: Assessment findings for the planned inspection program – Ground or strata failure – underground coal mines secondary extraction

Mine	Threat			Consequence
	1. Ground conditions	1. Ground conditions 3. Pillar Overload 4. Seismic event	1. Ground conditions	1. Crush injuries 2. Impact injuries 3. Asphyxia
	PC1.4	PC1.6	PC1.7	MC1.1
	Manage void formation	Ground support	Ground support lifecycle management	Control access to unsupported ground
Mine A				
Mine B				
Mine C				
Mine D				
Mine E				
Mine F				
Mine G				
Mine H				
Mine I				
Mine J				
Mine K				
Mine L				
Mine M				
Mine N				
Mine O				
Mine P				
Mine Q				
Mine R				
Mine S				
Mine T				

Green (=100%)
Yellow (>= 80% and <100%)
Orange (>= 65% and <80%)
Red (<65%)

Notices issued

Of the 20 sites assessed under the inspection program, 9 separate mines were given notices relating to the principal hazard of ground or strata failure, while some mines were given notices in relation to other matters. For the purposes of this report, contraventions related to other matters were removed from the analysis. The notices issued for ground or strata failure were examined in detail and Table 2 below lists the notices issued by type and details.

Table 2: Notices issued for the planned inspection program – Ground or strata failure – underground coal mines - secondary extraction

NOTICE TYPE	TOTAL ISSUED	NUMBER OF MINES
s.195 prohibition notice	1	1
s.191 improvement notice	12	8
s.23 notice of concerns	10	8
Total	**23**	**9**

Of the combined 23 notices issued, there were some common themes that were apparent throughout the program plan. Table 3 summarises the type of contraventions. These themes can be related to the critical controls outlined earlier and identify some trends that are of concern.

Table 3: Notices issued - prevalence of categories of concern

IDENTIFIED CONCERN CATEGORY
Mine operators should review their procedures for testing if the installed monitoring device is working.
Mine operators should review their primary bolt density pattern to ensure that there is a factor of safety built into the support design.
Mine operators should consider roof TARP's that include encapsulation checks on installed bolts.
Holing into the gate-ends by the shearer is not always at the required horizon, and as such, the integrity of the mesh and bolts can be compromised.
Rectify damaged support in a timely manner.

Further information

For more information on safety assessment programs, the findings outlined in this report, or other mine safety information, please contact the NSW Resources Regulator:

CONTACT TYPE	CONTACT DETAILS
Email	cau@regional.nsw.gov.au
Incident reporting	To report an incident or injury call 1300 814 609 or log in to the Regulator Portal
Website	www.resourcesregulator.nsw.gov.au
Address	NSW Resources Regulator 516 High Street Maitland NSW 2320

Appendix A. Legislative requirements and published guidance relating to the principal hazard ground or strata failure

The following is a list of certain legislative requirements for the management of ground or strata failure risks referred to in this report, as provided by the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 and Work Health and Safety Regulation 2017.

- Work Health and Safety (Mines and Petroleum Sites) Regulation 2022
- Schedule 1 (1) Ground or strata failure
- Safety Alert SA20-01 Roof fall buries a continuous miner
- Safety Bulletin SB22-02 Strata failures increase in underground coal mines across the state
- Safety Bulletin SB18-12 Rib failures in underground coal mines

Appendix B. Assessment system explained

The NSW Resources Regulator uses a bowtie framework to proactively assess how mine sites manage their principal hazards. Bowties are a widely used risk management tool that integrates preventative and mitigating controls onto threat lines that relate to a material unwanted event.

As part of program planning, controls were categorised by the NSW Resources Regulator's mine safety inspectorate in accordance with the ICMM handbook. Only controls deemed critical[1] are assessed under a planned inspection program. For a control to be assessed as effective, each of its control supports must be in place and operational.

Assessment findings results calculation

During the program, each control support assessed at each mine was rated and the findings recorded. Points were awarded depending on whether there was evidence that the control support had been documented and / or implemented. Importantly, the system recognises the value of fully implemented and documented controls by allocating four points if both these elements were present.

For finding outcomes, points were awarded for each control support identified within a critical control. An overall assessment result for the critical control was then calculated as a proportion of the maximum possible points for that critical control. For example, if a critical control comprises 10 control supports and five were assessed as fully implemented ('documented and implemented') and five were found to be 'not documented and not implemented' then the overall assessment result for that critical control would be 50%.

Table 3: Finding outcome and points

FINDING OUTCOME	POINTS
Documented and implemented	4
Implemented but not documented	2
Documented but not implemented	1
Not documented and not implemented	0

Critical control calculations also took into account instances where control supports were not applicable to the mine being assessed or when control supports were not able to be assessed during a site visit.

The overall assessment result for each critical control has been assigned a colour based on the assessment bands presented in the table below. The colour band results are then used to identify industry focus areas requiring improvement.

Table 4: Assessment results and colour code

CRITERIA	COLOUR
An assessment result of 100% of possible points	Green
An assessment result of ≥ 80% but < 100% of possible points	Yellow
An assessment result of ≥ 65% but < 80% of possible points	Orange
An assessment result of < 65% of possible points	Red

[1] Critical Control Management Implementation Guide, International Council on Mining and Metals (ICMM), 2015.