Workplace Safety North™

Best Practices for Assessing Ground Control Hazards in the Workplace

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Best Practices for Assessing Ground Control Hazards in the Workplace First publication

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Dedication

This Best Practices for Assessing Ground Control Hazards in the Workplace is dedicated to the memory of Trevor King. Trevor was a miner at an underground mine in Northern Ontario and enjoyed going to work every day, he loved his job. He died of a ground control related hazard after he was hit by a loose rock while loading explosives within a development round.

This illustrated quick reference booklet is developed for the awareness training of miners for assessing ground control hazards in the workplace in an effort to mitigate injuries related to fall of ground or other geotechnical risk. The intent of this document is for everyone who works underground to be trained on how to identify hazards pertaining to ground control. This booklet will help underground mine workers recognize the clues that a hazard could be developing and to become trained observers of the conditions around them as they work.

WSN ground Control Technical Advisory Committee
Membership as of March 2017

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Alun Price Jones (Vice-Chair)	Cementation
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Best Practices for Assessing Ground Control Hazards in the Workplace

1. Introduction

Falls of ground and rockbursts are recognized as the main causes of deaths and serious incidents in underground mines. The formal review of health and safety in the Ontario Mining Sector known as the Mining Health, Safety and Prevention Review (MHSPR) undertaken by the Ministry of Labour (MOL) throughout 2014 and in the early part of 2015 included eighteen recommendations and of these eighteen recommendations, two pertain to ground control. This booklet is intended as an illustrated quick reference for assessing ground control related hazards in the workplace. It is generic and very visual and contains information with photographs and illustrations that underground mine workers can refer to on what ground control issues to look for at the workplace.

The Workplace Safety North (WSN) and WSN's ground Control Technical Advisory Committee (GC TAC) thought that the topic is relevant and timely considering the recommendations of the MHSPR Review pertaining to ground control.

WSN recognizes that individual companies must develop health and safety policies and programs which apply to their workplaces and comply with appropriate legislation. The information contained in this reference material is distributed as a guide only to assist in developing those policies and programs.

Everyone who works underground must be trained on how to identify ground conditions. This booklet will help underground mine workers recognize the clues that a hazard could be developing. Become a trained observer of the conditions around you as you work.

2. Types of Ground Failures in Hard Rock Mines

The failure of a rock mass around an underground opening depends upon the in situ stress level and upon the characteristics of the rock mass. In underground openings excavated at relatively shallow depth and jointed rock masses, the most common types of failure are those involving wedges falling from the roof or sliding out of the sidewalls of the openings. **Figure 2.1** shows a simplified illustration of a wedge failure.

Underground openings excavated in deep, high stressed, massive with few joints, and jointed rock masses, failure progresses from brittle spalling and slabbing (in the case of massive rocks with few joints) to a more ductile type of failure (for heavily jointed rock masses). **Figure 2.2** gives a simplified description of the various types of failure which are commonly observed underground in deep, high stressed, massive with few joints, and jointed rock masses.

Rockbursts present hazards that are particular to hard rock mines. Factors that affect seismicity at a mine include rock characteristics, pre-mining stresses, the presence of geological structures, the amount of material extracted and mine sequencing. Figure 2.3 shows damage mechanisms caused by rockbursts. The depth of damage caused by bulking, ejection and shaking depends on rock stress levels, rock mass quality, excavation shape, support systems type, state of loading and remaining dynamic capacity, and the magnitude of the seismic event.

Figure 2.1 - simplified illustration of a wedge failure in underground openings excavated in shallow depth and jointed rock masses: (a) falling wedge from the back; (b) sliding wedge from the wall (*after Hoek et al., 1993*).

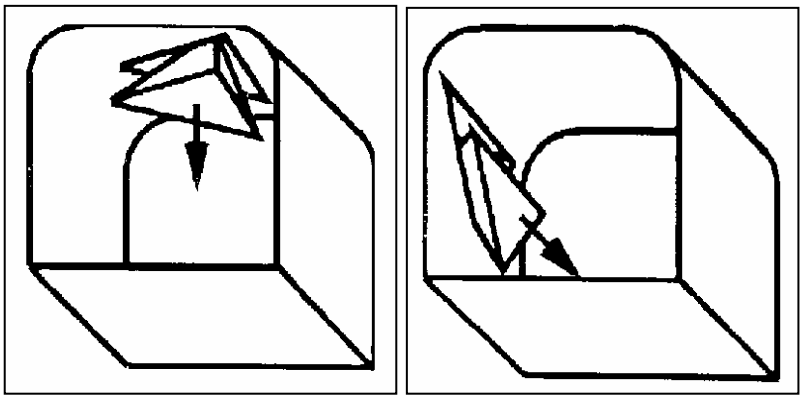


Figure 2.2 - simplified description of the various types of failure which are commonly observed in underground openings excavated in deep, high stressed, massive with few joints, and jointed rock masses (*WSN's Ground Support Manual*).

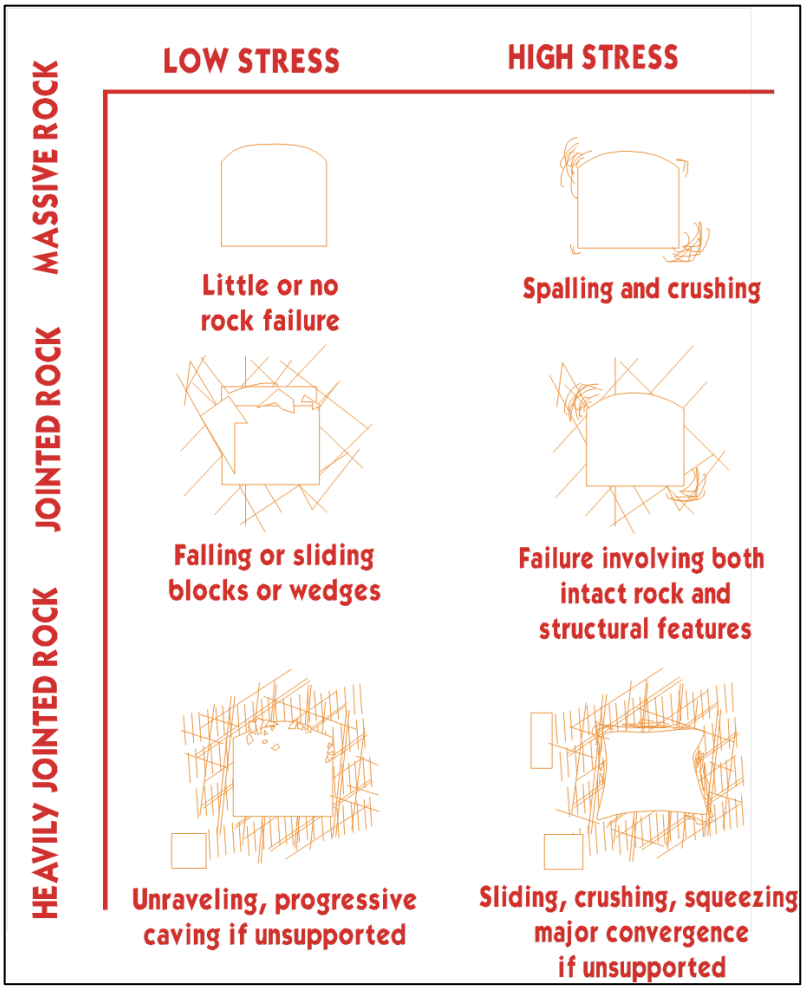
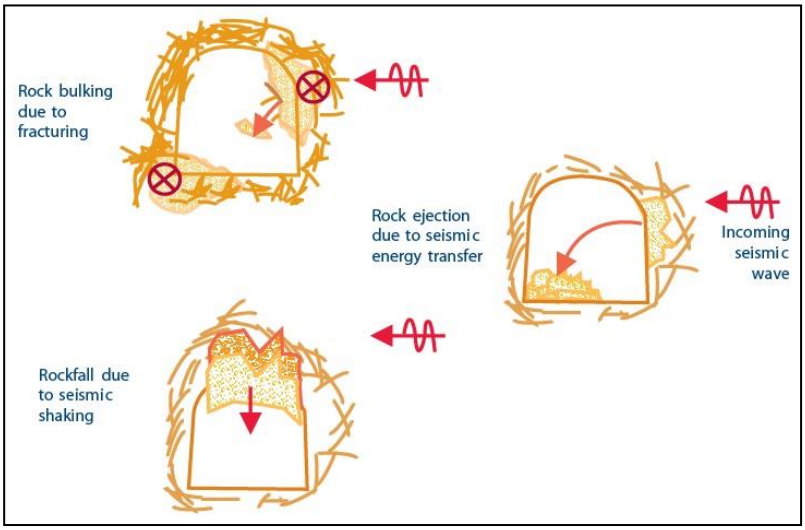


Figure 2.3 - rockburst damage mechanism (*after CAMIRO, 1995*).



3. Why Ground Problems Occur

There are both natural and man-made factors that cause ground problems. Over millions of years of geological history, natural cracks called “joints” have formed in rock. As soon as we put an opening into a rock mass, we change the stresses in the rock. Now, time and gravity start to work. Blocks of rock separate along their joints and “relax” toward the opening. Geological formations like dykes, faults and shear zones may increase the risk of rock movement. Mining activities can also lead to blast- or stress-induced fracturing.

The risk of ground problems may be affected by:

- any natural geological formations present’
- rock types
- selection of mining method (including blasting, ground support)
- the depth of the mine
- the size, shape, location and orientation of the mine opening
- the proximity to other openings
- time between blasting and installation of ground support
- time between mining and backfilling
- damage caused by poor blasting practices
- damage caused by equipment
- movement of water and changes to water flow
- presence of methane in some mines

4. Danger Zones

Because of the way the rock mass behaves when we start drilling or digging into it, there are some areas that are more likely to develop problems. Be particularly alert to ground problems in these areas:

- where stope openings meet blocks formed from faults
- intersections of drifts and crosscuts
- brows of connecting openings or diminishing pillars
- where ground support is being installed after blasting
- where openings change direction
- where openings pass through changing rock types

5. Signs of Possible Ground and Support Problems

Ground falls and rockbursts happen because of geological structures and stresses in the rock, and improper ground support installation issues. There are signs which may indicate when the stress around or adjacent to an opening is increasing or decreasing. Every time you go into a heading, ask yourself “is there a risk of instability in this area?” Knowing what to look for can help you spot potential problems before they become dangerous. Most often, what you’re looking for is change – a change from what’s normal, or what you saw last time you were in this

area. You'll need a good light to see conditions clearly - take a second to check your cap lamp every day. When you are doing your initial inspection of your travelways and workplaces, look to see whether the ground support was installed correctly.

5.1 Things to check

When entering a heading:

- deformation of heading
- intersecting structures which may form wedges or blocks
- sagging of back in sedimentary rock
- bagging or gaps in screen
- corroded screen or bolts
- change in shape of drill holes or off setting of drill holes
- deterioration or change in shape of pillars (such as hourglass shape with fracturing and plate-like pieces)
- opening of existing cracks or fresh cracks in rock
- cracks in shotcrete
- change in water flow or rock moisture
- excessive amount of loose rock
- plate-like pieces or flakes of rock
- fresh dust on floor
- bending of rock bolt plates
- rings come off, or closed slot on friction stabilizers
- bolt heads popped off
- high torque readings on mechanical bolts
- crushing or splintering of timbers
- splayed (unraveled) ends on cable bolts
- high loads on cable bolts

From monitoring devices:

- seismic visualizer for a mine-wide seismic monitoring system (if available) will provide the time, location and magnitude of recent events
- readings from ground movement monitors (GMM), and other instruments that measure ground activity, displacement or the load on support elements
- driving layouts which would include geology such as the locations of faults and slips

5.2 What can be heard

- drummy sound when a mechanical bolt is tapped (indicates no load)
- ringing sound when a bolt is taking weight
- more, or less, rock noise (such as snapping or cracking)
- drummy or hollow sound (rather than a solid sound) when rock pieces are struck with a scaling bar during the check scaling process
- bumps or other sounds of rock failure, including falls of ground within stopes

5.3 What can be experienced

- longer scaling time required
- change in colour of drill water or cuttings
- change in penetration rate
- steel jumping ahead
- loss of drill water

6. What Should be Done

- Before going underground, check the ground control board, log book, or other notification system (if available) for information and updates.
- Check the driving layout or other engineering documents (production drill books, etc.) specific to the workplace for pertinent structural geology, proximity to other openings and other ground control information.
- Check work area as you enter, looking for signs of change.
- Check scale using the safe scaling procedures outlined on the following page.
- When working, stay alert to changes in conditions.
- Know how to recognize ground control related hazards in the workplace so that proper controls can be introduced.
- Report any changes in rock conditions to your supervisor. The company should have a procedure for communicating ground control information.
- Use proper drilling and blasting techniques.
- Install ground support according to company's procedures. Refer to the driving layout specific to the workplace.
- If in doubt about the need for additional ground support, check with supervisor.
- Trust your instincts and follow company procedures for dealing with ground hazards.
- If not sure an area is safe, leave. Barricade the area so no one else can enter, and report the problem to supervision immediately.

7. Recognizing Ground Control Hazards or Changing Ground Conditions and Action Response Plan

The degree of an appropriate response is dependent on the status and current extent of suspected hazardous conditions. Action responses can be categorized in 3 levels depending on the ground condition:

Level I: For little rock failure or bulking
Level II: For minor failure or bulking, spalling, falling, sliding blocks or wedges, crushing, failure involving both intact rock and structural features
Level III: For major failure or bulking, unravelling, sliding, crushing, spalling, caving, squeezing, convergence

Note that the action response plans provided here only serve as a guide. Individual companies must develop health and safety policies and programs which apply to their workplaces and comply with appropriate legislation. The information contained in this reference material is distributed as a guide only to assist in developing those policies and programs.

7.1 Things to check

Deformation (bulking) in heading

Action response plan:

Level I: (minor deformation or bulking)

- Perform pre-shift and on-shift examination.
- Scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout, rehabilitation plan, or other documentation.

Level II: (major deformation or bulking with moderate rock failure, spalling, or falling)

- Retreat from area if necessary.
- Barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major deformation or bulking with major rock failure, spalling, or falling)

- Retreat and barricade off area at safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.
- The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision.
- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.

Intersecting structural features, such as bedding planes and joints, which separate the rock mass into discrete but interlocked pieces forming a wedge, that can fall or slide from the surface if the bounding planes are continuous or rock bridges along the discontinuities are broken

Action response plan:

Level I: (about 0.5 - 2 m spacing of discontinuities, little [about < 1 mm] or no separation of joints with slightly rough surfaces, unweathered to slightly weathered surface, dry)

- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout.

Level II: (about 0.25 - 0.5 m spacing of joints with minor separation [about > 1 mm to < 3 mm] with slightly rough surfaces, moderately weathered surface, damp to slightly wet)

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (about 0.05 - 0.25 m spacing of joints with major and continuous separation [about > 3 mm], slickensided with infilling (gouge), highly weathered surface, wet to dripping)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.

Intersecting structural features, such as bedding planes and joints (continued) ▪ Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel. ▪ The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision. ▪ For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.	

Wedge structures - intersecting structural features, such as faults and joints forming a wedge, which can fall or slide from the surface if the bounding planes are continuous or rock bridges along the discontinuities are broken

Action response plan:

Level I: (minor [about < 1 mm] or no separation of fault with slightly rough surfaces, unweathered to slightly weathered surface, dry, driving with dip 20° - 90° when fault is perpendicular to the tunnel axis, fault strike parallel to the tunnel axis and dipping 0° - 45°)

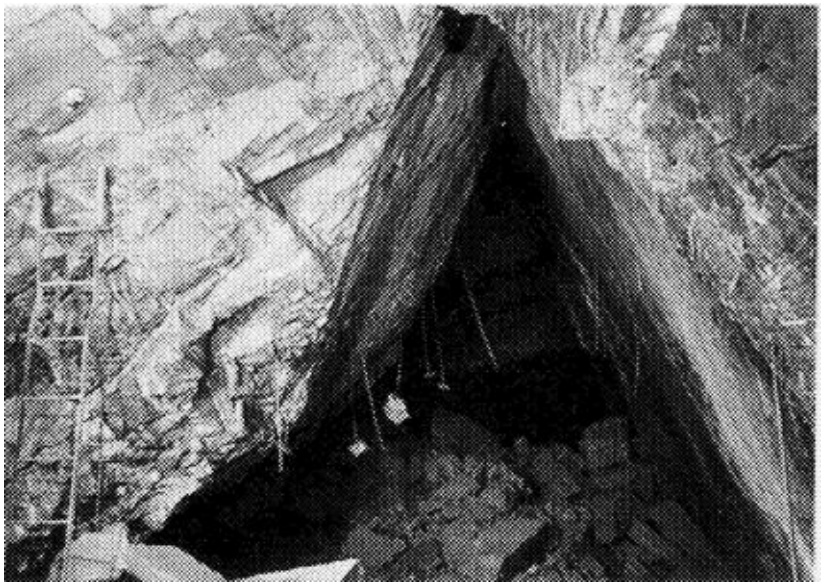
- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout, rehabilitation plan, or other documentation.

Level II: (moderate separation [about 1 mm] of fault with slightly rough surfaces, moderately weathered surface, damp to slightly wet, driving against dip 45° - 90° when fault is perpendicular to the tunnel axis, fault strike parallel to the tunnel axis and dipping 45° - 60°).

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major fault separation [about > 1 mm] with slickensided with infilling (gouge), highly weathered surface, wet to dripping, driving against dip 20° - 45° when fault is perpendicular to the tunnel axis, fault strike parallel to the tunnel wall axis and dipping 60° - 90°, fault strike parallel to the tunnel back axis and dipping 0° - 20°)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.



Wedge structures (continued)

- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.
- The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision.
- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.

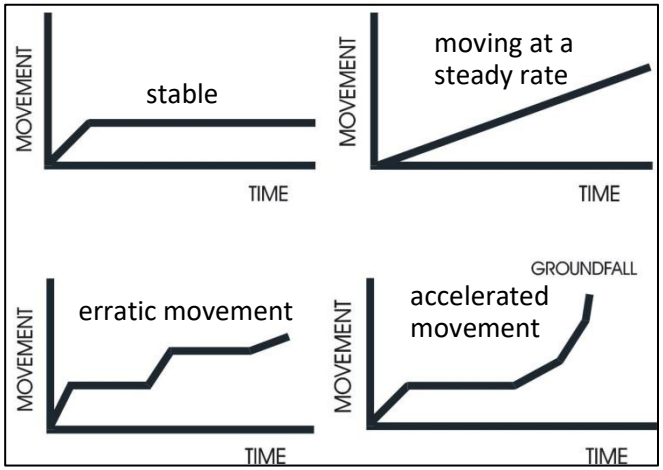
Note that wedge structure separation may be observed visually or may be tracked using appropriate ground movement instrumentation such as single point anchor ground movement monitors (GMMs), multiple point borehole extensometers (MPBX) or SMART cables. Ground movement instrumentations are installed to track movement and confirm if wedge is stable, moving at a steady rate or accelerating.

Action response plans follow the same criteria mentioned above and varies depending on the interpretation of instrument monitoring data:

Level I action response plan may apply if ground movement versus time indicates stable or moving at a steady rate.

Level 2 action response plan may apply if ground movement versus time indicates erratic movement; and

Level 3 action response plan may apply if ground movement versus time indicates accelerated movement.



Movement versus time interpretation of instrumentation monitoring data.

Bagging in screens, excessive amount of loose rock

Action response plan:

Level I: (minor bagging of screen)

- Perform pre-shift and on-shift examination.
- Check scale to remove pieces of rock smaller than the mean opening of the screen.
- Check extent of bagging and integrity of screen.
- Stay clear of these areas and perform de-bagging if necessary.

Level II: (moderate bagging with undamaged screen)

- Stay clear and retreat from area if necessary.
- Inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel. The group will provide recommendations for de-bagging action and ground support based on ground conditions.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major bagging with damaged screen)

- Retreat and barricade off area at safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide recommendations for de-bagging action and ground support based on ground conditions.
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.
- The workplace will only be reverted to *Level I* when the de-bagging activity and ground support recommendations have been implemented and completion has been signed-off by supervision.

Bagging in screens, excessive amount of loose rock (continued)

- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.

Deterioration or change in shape of pillars (such as hourglass shape with fracturing and plate-like pieces, failed rib pillar, etc.)

Action response plan:

Level I: (minor fracture development with little or no rock failure)

- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout.

Level II: (moderate fracture development with minor spalling or rock failure)

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major fracture development with progressive spalling or unravelling)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.
- The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision.
- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.

Deterioration or change in shape of pillars (such as hourglass shape with fracturing and plate-like pieces, failed rib pillar, etc.) (Continued)	 

Opening of existing cracks or fresh cracks in stopes

Action response plan:

Level I: (minor separation [about < 1 mm] of fresh or existing cracks)

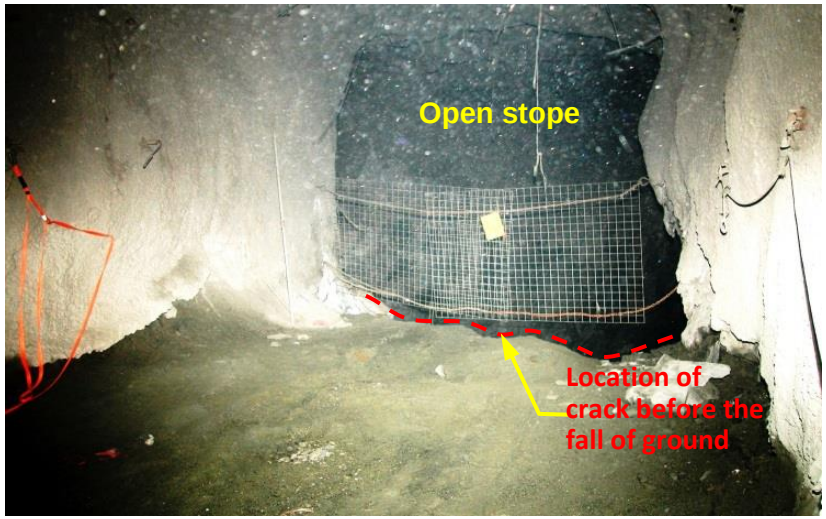
- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout.

Level II: (moderate separation [about 1 mm] of fresh or existing cracks, damp to slightly wet, no slickenside movement)

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major separation [about > 1 mm] with slickenside movement, wet to dripping)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions or recommend alternate plans such as:
  - Work external to stope;
  - Abandon area and install permanent barricade;
  - Backfill void; and
  - Ohers
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.



▪ The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision. ▪ For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.	

Opening of existing cracks or fresh cracks in drifts and other headings

Action response plan:

Level I: (minor separation [about < 1 mm] of fresh or existing cracks)

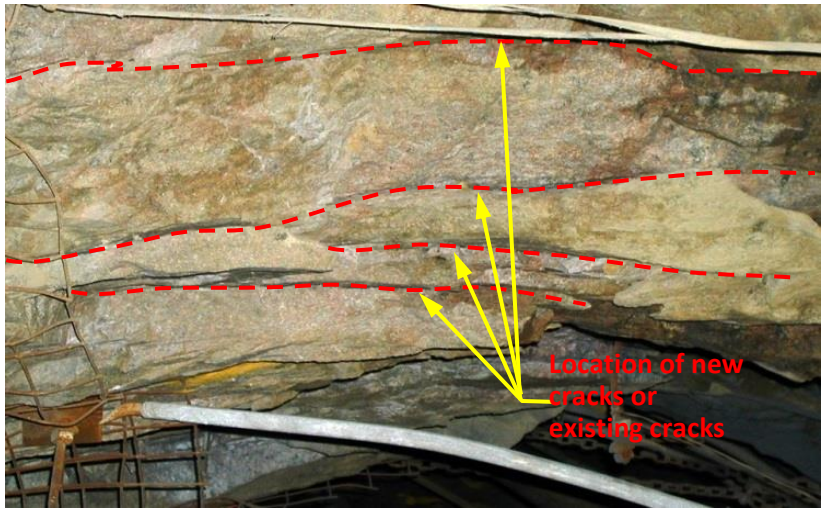
- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout.

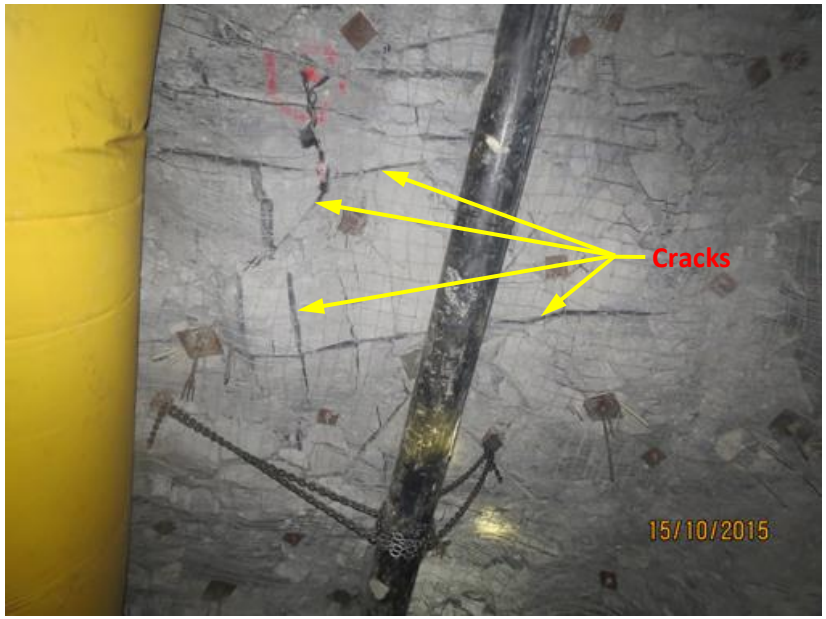
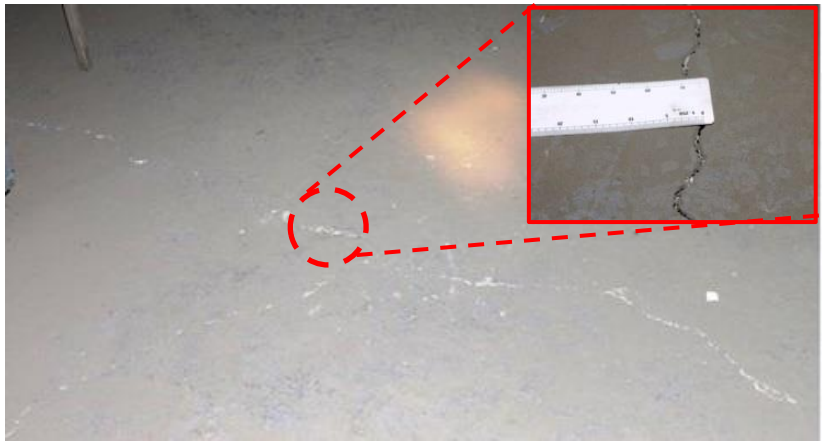
Level II: (moderate separation [about 1 - 3 mm] of fresh or existing cracks, damp to slightly wet, no slickenside movement)

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major separation [about > 3 mm] with slickenside movement, wet to dripping)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.
- The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision.
- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.



Opening of existing cracks or fresh cracks in drifts and other headings (Continued)	 

Cracks in shotcrete

Action response plan:

Level I: (minor separation [about 3 - 5 mm] of fresh or existing cracks)

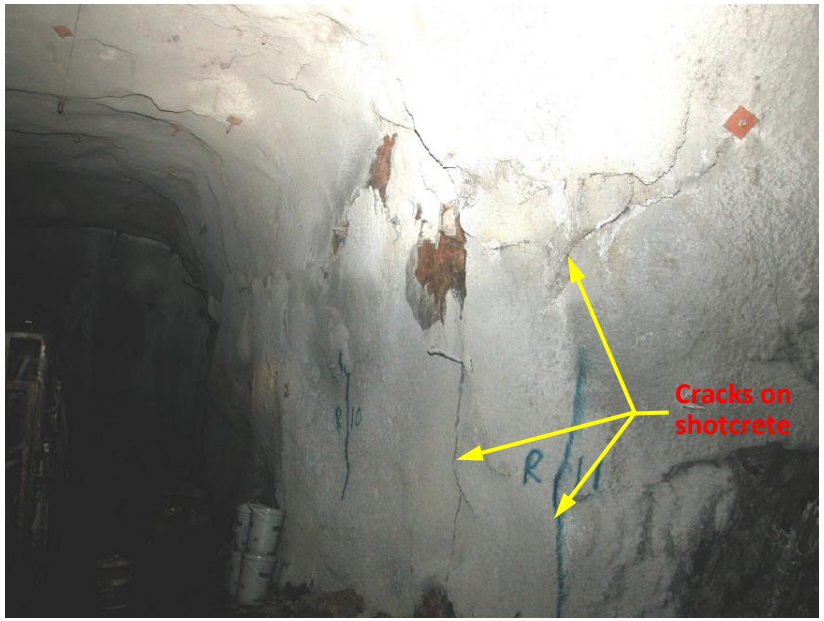
- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout.

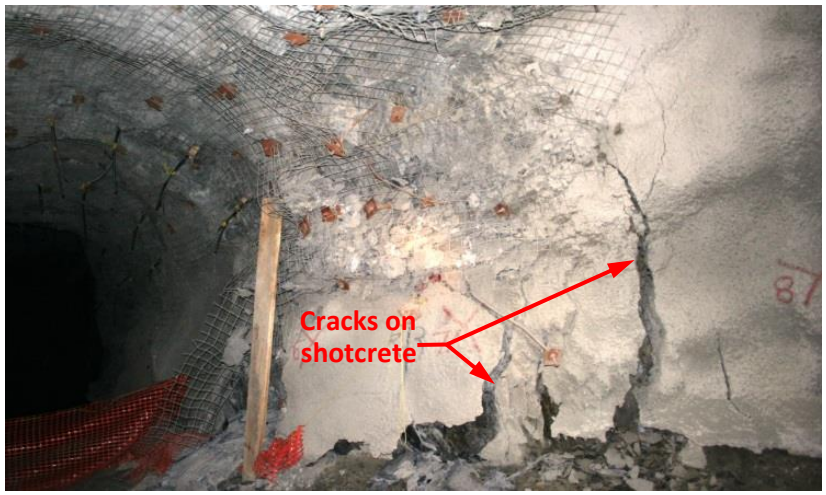
Level II: (moderate separation [about > 5 - 10 mm] of fresh or existing cracks, with minor bulking, spalling)

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
  - Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major separation [about > 10 mm] with major bulking and spalling of shotcrete)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.
- The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision.
- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.





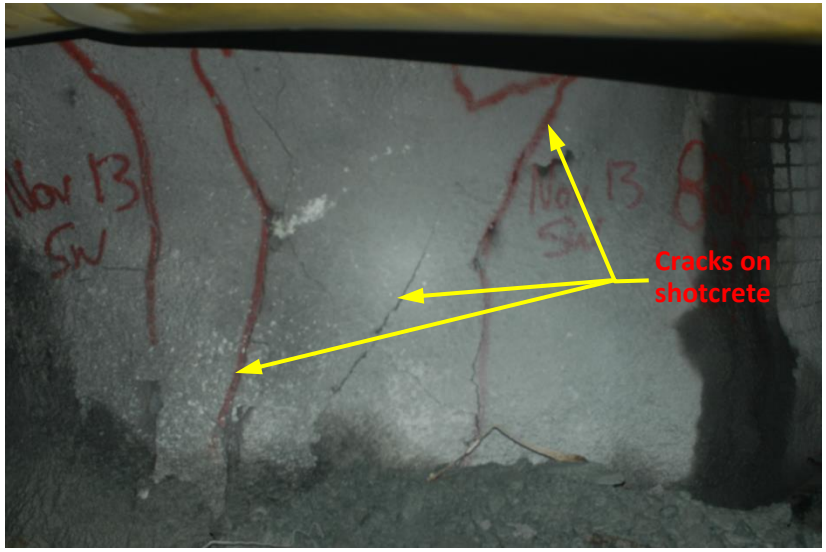
Cracks in shotcrete (Continued)	

Plate-like pieces or flakes of rock - stress fracturing

Action response plan:

Level I: (minor spalling and crushing)

- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout.

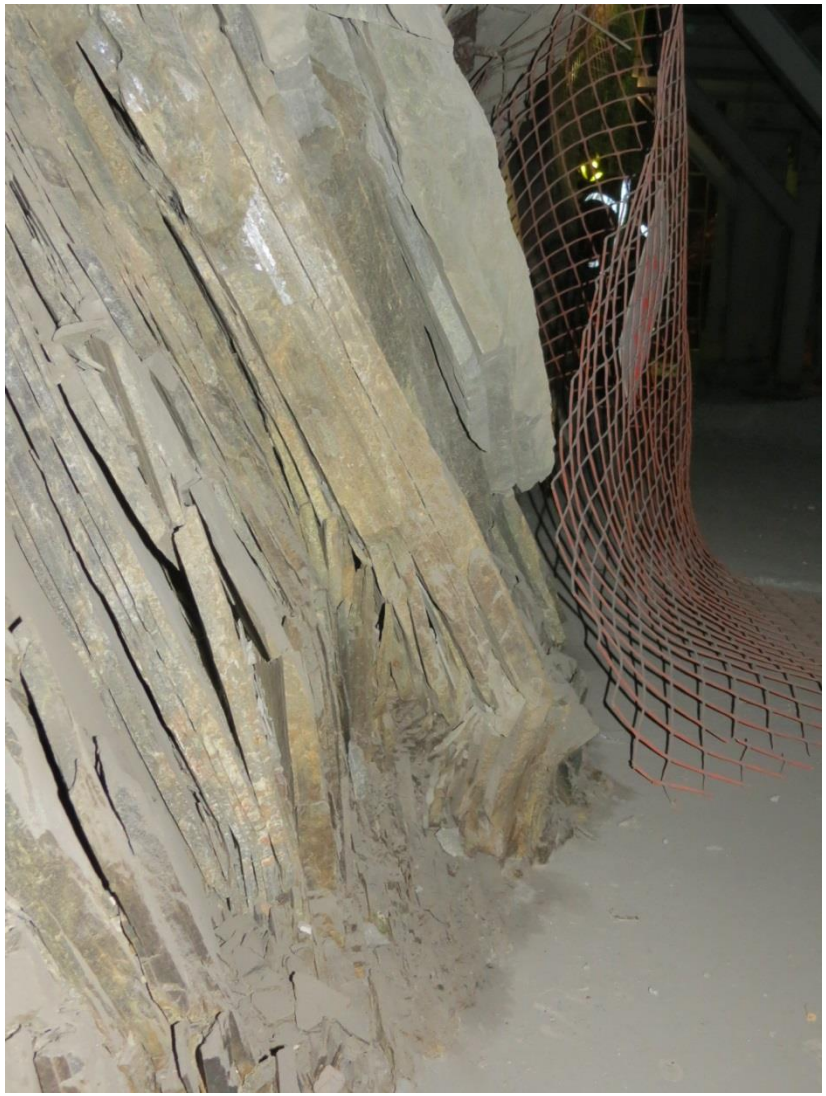
Level II: (moderate failure involving both intact and structural features, i.e. joints, fault, etc.)

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major sliding, crushing, squeezing, major convergence if unsupported)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.
- The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision.
- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.

Plate-like pieces or flakes of rock - stress fracturing (continued)	 

Plate-like pieces or flakes of rock - stress fracturing (continued)	

Signs of loading on ground support - damaged shotcrete post, bent timber post or cap, crushed timber post

Action response plan:

Level I: (minor cracks showing on shotcrete pillar, minor bending of timber post or cap, minor crushing of wooden wedge)

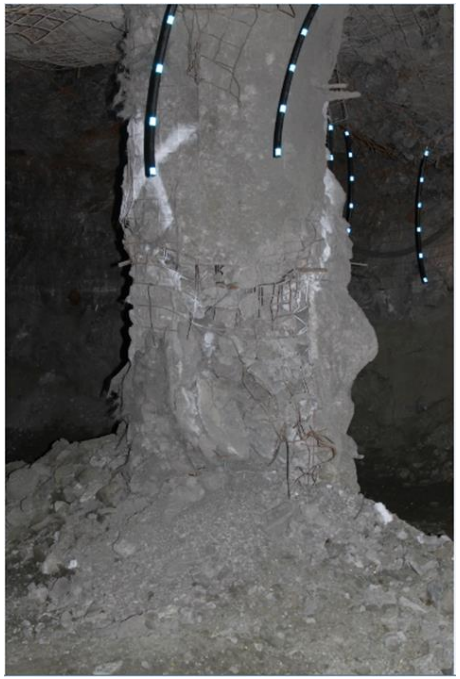
- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout.

Level II: (moderate spalling or failure of shotcrete post, moderate bending of timber post or cap, moderate crushing of wooden wedge)

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major spalling or failure of shotcrete post; exposed and bent reinforcing elements, major bending, squeezing of timber support, major convergence)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.
- The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision.



Signs of loading on ground support - damaged shotcrete post, bent timber post or cap, crushed timber post (continued)

- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.

Signs of loading on ground support – ringing sound on bolt head when tapped by crescent, bent bolt plate, stripped, unraveled, pigtailed and ruptured cable bolt, failed bolt head

Action response plan:

Level I: (ringing sound of ground support when tapped with crescent tool, few minor bending of plate)

- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout.

Level II: (several major bending of bolt plates, stripped and unraveling of cable bolt)

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (failed bolt plate and head, pigtailed and ruptured cable bolt)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
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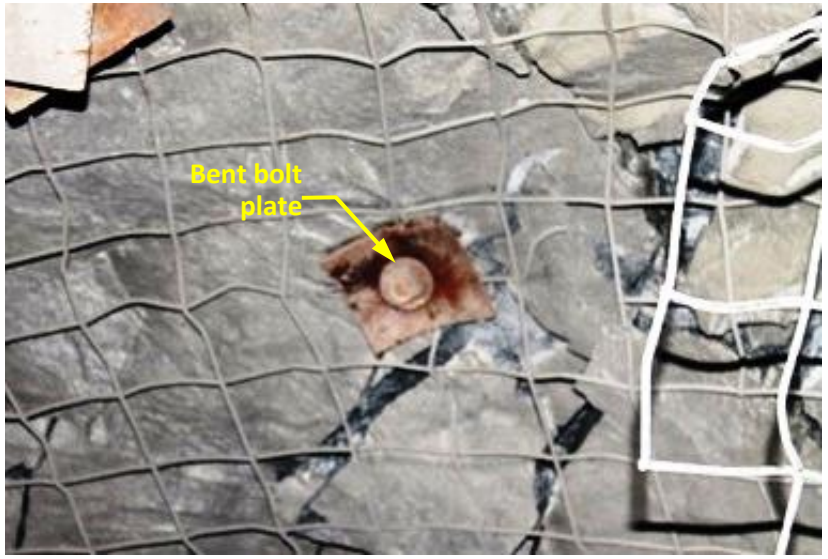
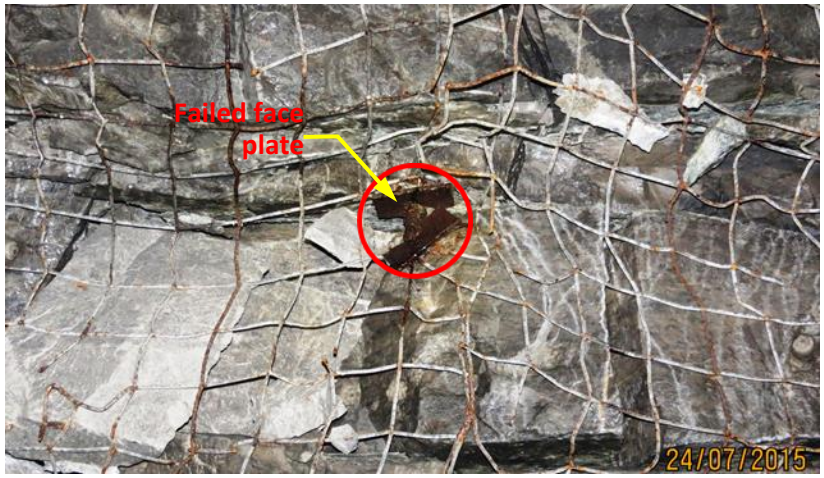
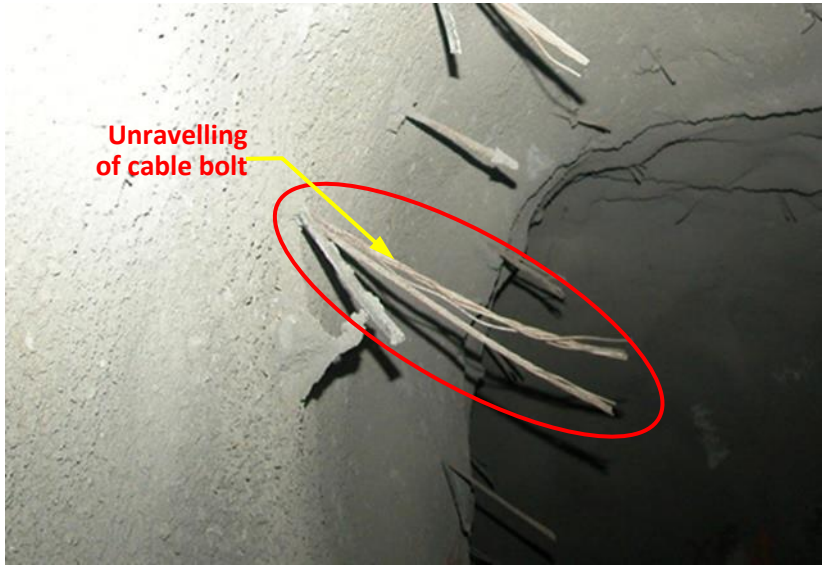


Signs of loading on ground support (continued)

- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.



Signs of loading on ground support (continued)	 

Signs of deformation of openings and drill holes or crushing of drilled holes - stress loading

Action response plan:

Level I: (minor bulking)

- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout.

Level II: (moderate bulking and failure involving both intact and structural features, i.e. joints, fault, etc.)

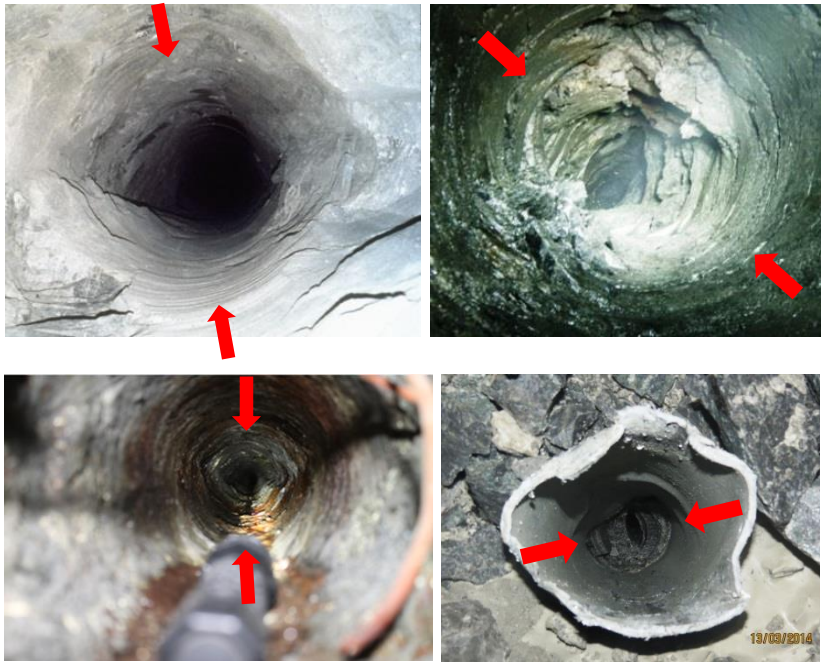
- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major bulking, crushing, squeezing, major convergence even if supported)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
- Work will only commence when the ground support recommendation is made, signed off by the supervisor and communicated to personnel.
- The workplace will only be reverted to *Level I* when the ground support recommendations have been implemented and completion has been signed-off by supervision.

Signs of deformation of openings and drill holes or crushing of drilled holes - stress loading (continued)

- For a workplace that cannot be secured or made safe, the area should be permanently abandoned and barricaded to avoid inadvertent entry.

Signs of deformation of openings and drill holes or crushing of drilled holes - stress loading (continued)	

Signs of stress loading in the rock mass

Action response plan:

Level I: (minor bulking)

- Perform pre-shift and on-shift inspection, and scale and check scale.
- Install all ground supports required by the minimum standard or as instructed in the driving layout. warping

Level II: (moderate bulking and failure involving both intact and structural features, i.e. joints, fault, etc.)

- Retreat from area if necessary, barricade off area at safe location and inform mine supervisor.
- Perform joint workplace inspection with supervisor.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
  - If uncertain, supervisor must report to general foreman, shift superintendent or ground control personnel.
- Once recommendations are provided and complied with, and condition under control, the workplace can be reverted back to *Level I*.

Level III: (major bulking, crushing, squeezing, major convergence even if supported)

- Retreat and barricade off area at a safe location, and report condition to mine supervisor, general foreman, shift superintendent or ground control personnel.
- Communicate workplace condition and actions in the ground control logbook or per other accepted notification procedures.
- Request inspection of the area by mine supervisor, general foreman, shift superintendent and ground control personnel. The group will provide ground support recommendations based on ground conditions.
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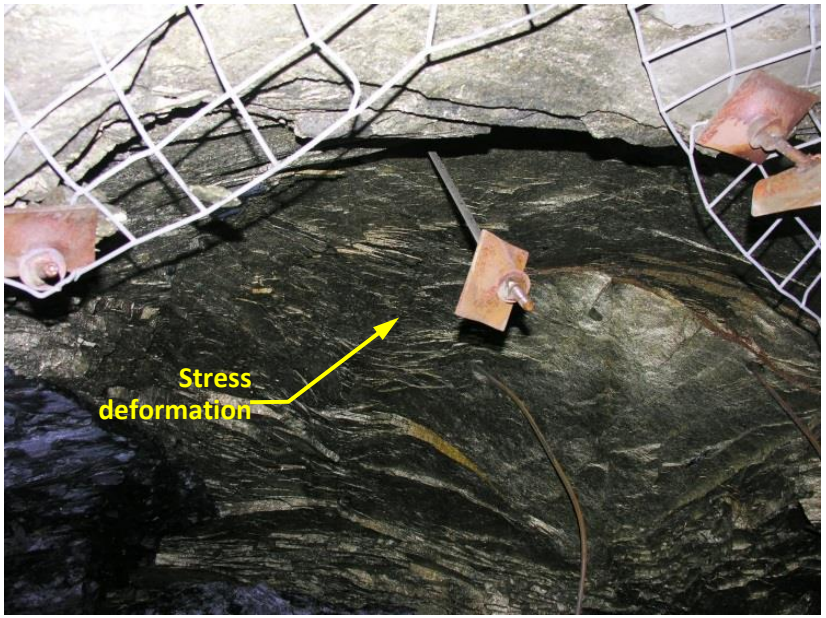
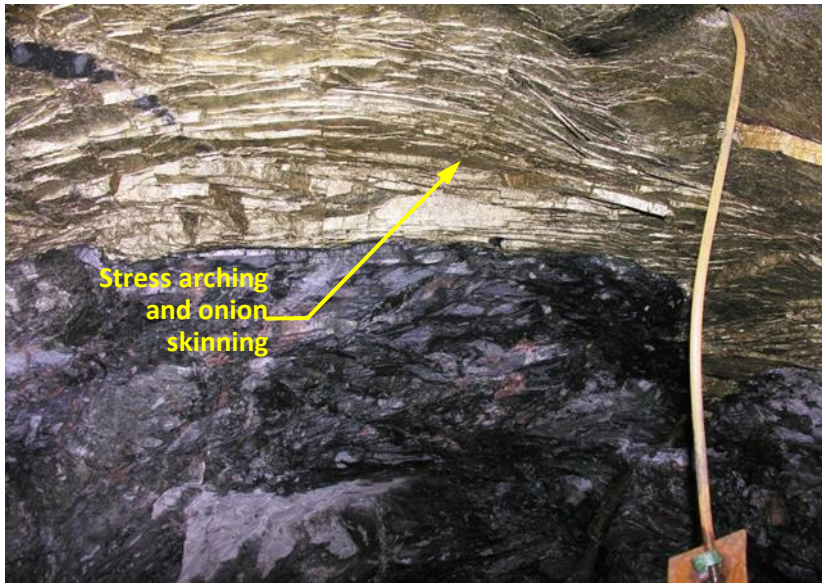
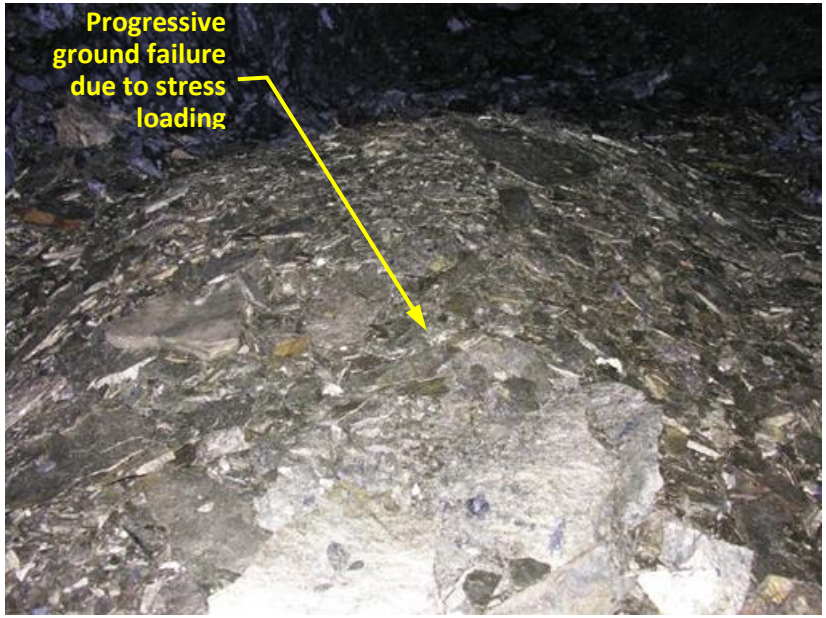




Signs of stress loading in the rock mass (continued)



Signs of stress loading in the rock mass (continued)	

Incidents Related to Fall of Ground and Rockburst

2000 - A worker was fatally injured while performing his duties as a longhole driller, in the presence of a supervisor. A rockburst occurred, which violently displaced 20 tons of rock burying both the worker and the supervisor. The supervisor survived but the worker was fatally injured.

2002 - A worker was manually operating a scoop tram while mucking in an open stope. While doing so, the worker was struck by a large piece of rock that fell from the wall of the stope causing the fatal injury. The worker was working alone at the time of the incident. The supervisor found the worker deceased in the scoop tram, with the engine still running, completely within the stops. Besides the worker's body was a large piece of loose.

2007 - A worker was fatally injured when struck by a massive slab of rock that fell from the back of a raise while working on a raise climber (Alimak raise climber). The fatally injured worker was a supervisor but on that day, the worker was working as a regular miner replacing one of the workers who did not report for work. The worker was drilling holes for a development round in the raise when the fall of ground occurred, causing the fatal injury. The ground was not supported with the appropriate ground support standard prior to the worker drilling the development round.

2012 - A worker was operating an ANFO loader to load explosives into the holes of a development round when a 14-ton piece of rock broke from the heading and struck the worker. The worker, who was working alone at the time, was fatally injured as a result of the incident.

2012 - A crew, consisting of two workers, was reloading misfired holes from a previous development round when one of the workers was struck by a piece of loose that broke from the face. Prior to the incident, the crew had cleaned the undetonated holes on the face, scaled and sounded the rock face, before reloading the holes with explosives. The fall of ground happened when the crew was about to reload explosives to approximately four holes left at the bottom (lifter holes). The incident rendered the worker unconscious and was taken to the hospital but died.

2014 - Two workers were struck by a fall of material believed to be shotcrete and rock, following a seismic event.

2014 - A worker was fatally injured outside the scoop tram he was operating when was struck by a piece of broken ore. The worker was mucking ore from a stope when found lifeless in a location ahead of the ‘safe limit line’ of the draw point. It was not known why the worker was ahead of the safety limit line outside the cab of the scoop tram, with the bucket full of rock. The scoop tram engine was still running with lights on and the operator cab door was open.

The Occupational Health and Safety Act and Regulations for Mines and Mining Plants (Regulation 854 Pertaining to Ground Control)

The Occupational Health and Safety Act

53. If an accident, premature or unexpected explosion, fire, flood or inrush of water, failure of any equipment, machine, device, article or thing, cave-in, subsidence, rockburst, or other prescribed incident occurs at a project site, mine or mining plant, the constructor of the project or the owner of the mine or mining plant shall, within two days after the occurrence, give notice in writing with the prescribed information and particulars,

(a) to the committee, health and safety representative and trade union, if any; and

(b) to a Director, unless a report under section 51 or a notice under section 52 has already been given to a Director. 2011, c. 1, Sched. 7, s. 2 (8).

Regulation 854 - Mines and Mining Plants (Sections Pertaining to Ground Control)

5.1 (1) An employer shall conduct a risk assessment of the workplace for the purpose of identifying, assessing and managing hazards, and potential hazards, that may expose a worker to injury or illness. O. Reg. 167/16, s. 3.

(2) A risk assessment must take into consideration the nature of the workplace, the type of work, the conditions of work at that workplace and the conditions of work common at similar workplaces. O. Reg. 167/16, s. 3.

(3) The results of an assessment must be provided, in writing, to the joint health and safety committee or the health and safety representative, if any. O. Reg. 167/16, s. 3.

(4) If no joint health and safety committee or health and safety representative is required at the workplace, the results of an assessment must be communicated to workers at the workplace and provided, in writing, to any worker at the workplace who requests them. O. Reg. 167/16, s. 3.

(5) The requirement in subsection (1) to conduct a risk assessment is in addition to any specific assessments required by the Act or any Regulation made under it. O. Reg. 167/16, s. 3.

5.2 (1) An employer shall, in consultation with the joint health and safety committee or the health and safety representative, if any, develop and maintain measures to eliminate, where practicable, or to control, where the elimination is impracticable, the hazards, and potential hazards, identified in a risk assessment conducted under subsection 5.1 (1). O. Reg. 167/16, s. 3.

(2) The measures referred to in subsection (1) shall be put in writing and shall include each of the following, as applicable and reasonable in the circumstances:

1. Substitution or reduction of a material, thing or process.
2. Engineering controls.
3. Work practices.
4. Industrial hygiene practices.
5. Administrative controls.
6. Personal protective equipment. O. Reg. 167/16, s. 3.

(3) Personal protective equipment shall only be used as a measure if the measures referred to in paragraphs 1 to 5 of subsection (2) are not obtainable, are impracticable or do not eliminate or fully control hazards and potential hazards. O. Reg. 167/16, s. 3.

5.3 (1) The risk assessment required by section 5.1 must be reviewed as often as necessary and at least annually. O. Reg. 167/16, s. 3.

(2) When conducting the review, the employer shall ensure that,

(a) new hazards or new potential hazards are assessed;

(b) existing hazards or potential hazards that have changed are re-assessed; and

(c) the measures required by section 5.2 continue to effectively protect the health and safety of workers. O. Reg. 167/16, s. 3.

(3) Subsections 5.1 (3) and (4) and section 5.2 apply with necessary modifications in respect of any new hazards and potential hazards and any existing hazards or potential hazards that have changed. O. Reg. 167/16, s. 3.

6. (1) The owner of a surface mine producing metallic ore or of an underground mine shall prepare and maintain a mine design assessing the ground stability of the active and proposed workings of the mine. R.R.O. 1990, Reg. 854, s. 6 (1).

(2) The mine design shall consist of drawings, plans, specifications or procedures to be used and shall be prepared under the direction of a competent person. O. Reg. 571/92, s. 3.

(2.1) The mine design shall be based upon sound geotechnical engineering practices and shall,

(a) describe the geology of the mine;

(b) outline the geometry of existing and proposed excavations;

(c) describe previous occurrences of ground instability;

(d) describe the mining method including stope sequencing and blasting methods;

(e) specify the ground support system; and

(f) describe measures planned and used to assess potential ground instability such as instrumentation and computer modelling. O. Reg. 571/92, s. 3; O. Reg. 60/94, s. 2.

(3) The mine design shall be assessed and updated at least annually and also before any alteration is made to the mine that may significantly affect the ground stability of the mine. R.R.O. 1990, Reg. 854, s. 6 (3).

(4) The mine design shall be kept readily available at the mine site for review by an inspector and by the joint health and safety committee or health and safety representative, if any. O. Reg. 272/97, s. 3.

(5) REVOKED: O. Reg. 272/97, s. 3.

6.1 (1) In an underground mine, the geometry of an existing excavation that does not have ground support shall not be altered unless,

(a) the owner of the mine arranges for a professional engineer to prepare, in accordance with sound geotechnical engineering practices, a written report on the proposed alteration; and

(b) the report states that the safety of workers will not be endangered by the proposed alteration. O. Reg. 31/04, s. 2.

(2) In an underground mine, a new excavation that is planned to have no ground support shall not be made unless,

(a) the owner of the mine arranges for a professional engineer to prepare, in accordance with sound geotechnical engineering practices, a written report on the proposed excavation; and

(b) the report states that the safety of workers will not be endangered by the proposed excavation. O. Reg. 31/04, s. 2.

(3) The owner of the mine shall ensure that copies of reports prepared under subsections (1) and (2) are,

(a) kept readily available at the mine site; and

(b) given to the joint health and safety committee or health and safety representative, if any, and to any trade union representing workers at the workplace. O. Reg. 31/04, s. 2.

19. (1) Subject to subsection (2), a pillar sixty metres thick shall be established on either side of a party boundary between adjoining underground mining properties. R.R.O. 1990, Reg. 854, s. 19 (1).

(2) Except for exploration headings and diamond drilling, before the pillar is mined, drawings, plans, specifications, mining methods and procedures for the mining of the pillar shall be prepared or checked by a professional engineer in accordance with good engineering practice, filed with the owners of adjoining mining properties and kept readily available at each mine site. O. Reg. 272/97, s. 7.

(3) The drawings, plans, specifications, mining methods and procedures to be filed shall be maintained and kept up to date in accordance with subsection 29 (2) of the Act. R.R.O. 1990, Reg. 854, s. 19 (3).

(4) The pillar dimensions and mining methods and procedures shall,

(a) provide ground support to control rockbursting, ground falls or pillar failures; and

(b) withstand inrush of water or waterbearing materials across the party boundary. R.R.O. 1990, Reg. 854, s. 19 (4).

(5) Subject to subsections (2), (3) and (4), the party boundary pillar may be mined if the owners of the adjoining mines agree. O. Reg. 272/97, s. 7.

21. (1) The written report required by section 51 of the Act shall include,

(a) the name and address of the employer;

(b) the nature and the circumstances of the occurrence and the bodily injury sustained;

(c) a description of the machinery or equipment involved;

(d) the time and place of the occurrence;

(e) the name and address of the person who was killed or critically injured;

(f) the names and addresses of all witnesses to the occurrence and of all supervisors and workers who were involved; and

(g) the name and address of the physician or surgeon, if any, by whom the person was or is being attended for the injury. R.R.O. 1990, Reg. 854, s. 21 (1).

(2) For the purposes of section 52 of the Act, notice of,

(a) an accident, explosion or fire which disables a worker from performing his or her usual work; or

(b) an occupational illness,

shall include,

(c) the name, address and type of business of the employer;

(d) the nature and the circumstances of the occurrence and the bodily injury or illness sustained;

(e) a description of the machinery or equipment involved;

(f) the time and place of the occurrence;

(g) the name and address of the person suffering the injury or illness;

(h) the names and addresses of all witnesses to the occurrence;

(i) the name and address of the physician or surgeon, if any, by whom the person was or is being attended for the injury or illness; and

(j) the steps taken to prevent a recurrence. R.R.O. 1990, Reg. 854, s. 21 (2).

(3) A record of an accident, explosion or fire causing injury requiring medical attention but not disabling a worker from performing his or her usual work shall be kept in the permanent records of the employer and include particulars of,

(a) the nature and the circumstances of the occurrence and the injury sustained;

(b) the time and place of the occurrence; and

(c) the name and address of the injured person. R.R.O. 1990, Reg. 854, s. 21 (3).

(4) A record kept as prescribed by subsection (3) for the inspection of an inspector shall be notice to the Director. R.R.O. 1990, Reg. 854, s. 21 (4).

(5) In addition to the occurrences referred to in section 53 of the Act, a notice in writing shall be given where,

(a) a failure occurs in or to a hoist, sheave, hoisting rope, shaft conveyance, shaft timbering or shaft lining;

(b) flammable gas is present in a workplace in an underground mine;
(c) spontaneous heating with evolution of gas occurs in a workplace;
(d) a major failure or major damage occurs or is caused to electrical equipment, standard gauge railroad equipment, a crane or a motor vehicle underground;
(e) a rockburst occurs causing damage to equipment or the displacement of more than five tonnes of material;
(f) an uncontrolled fall of ground occurs causing damage to equipment or the displacement of more than fifty tonnes of material;
(g) a fuse, a detonator or an explosive is found to be defective;
(h) a structural failure occurs in any matter or thing for which a design by a professional engineer is prescribed by this Regulation; or
(i) an unexpected and uncontrolled run of material, water or slimes in excess of one cubic metre occurs that could have endangered a worker. R.R.O. 1990, Reg. 854, s. 21 (5); O. Reg. 60/94, s. 3; O. Reg. 34/14, s. 2.

65. (1) An employer in an underground mine, in consultation with the joint health and safety committee, if any, for the mine, shall develop a written program to provide for the timely communication of information between workers and supervisors in the mine respecting ground stability, ground movement, falls of ground, ground monitoring equipment and emergencies. R.R.O. 1990, Reg. 854, s. 65 (1).

(2) The communications program shall set out,

(a) means and procedures for communicating information;

(b) the kind of information to be communicated; and

(c) the actions to be taken by supervisors and workers with respect to information that is communicated to them. R.R.O. 1990, Reg. 854, s. 65 (2).

67. (1) An employer shall prepare written procedures to be used at an underground mine concerning,

(a) activities relating to the installation of ground support at the mine; and

(b) activities that require a worker to be exposed to unsupported ground before the ground support is installed. O. Reg. 571/92, s. 7.

(2) The procedures shall state the methods for undertaking the activities and for preventing workers' exposure to unsafe ground conditions. O. Reg. 571/92, s. 7.

(3) The employer shall consult with the joint health and safety committee or, if no committee exists, with the health and safety representative in preparing the procedures. O. Reg. 571/92, s. 7.

67.1 During scaling procedures in a workplace in an underground mine, no other work shall be carried on that hinders the scaling procedures. O. Reg. 571/92, s. 7.

69. (1) Illumination shall be provided in an underground mine adequate for a worker to visually assess ground conditions at the worker's workplace. R.R.O. 1990, Reg. 854, s. 69 (1).

(2) Where a cap lamp is used to provide the illumination as required by subsection (1), it shall be capable of providing a peak illuminance of at least 1500 lux at 1.2 metres from the light source. R.R.O. 1990, Reg. 854, s. 69 (2).

(3) An employer in an underground mine who supplies cap lamps to workers shall develop a procedure for assessing and maintaining cap lamps and a copy of the procedure shall be available at the mine site for review by the joint health and safety committee or health and safety representative, if any, for the mine. R.R.O. 1990, Reg. 854, s. 69 (3); O. Reg. 272/97, s. 12.

(4) A record of cap lamp maintenance test results shall be kept. R.R.O. 1990, Reg. 854, s. 69 (4).

(5) Despite subsection (2), if the ground to be assessed is at a distance that is greater than the effective range of a cap lamp, the employer shall supply, and the worker shall use, auxiliary lighting that will provide the illumination required by subsection (1). R.R.O. 1990, Reg. 854, s. 69 (5).

72. (1) In the event of an occurrence listed in subsection (2) at an underground mine, a record of that occurrence shall be kept in writing and shall provide the following:

1. The time, location and extent of the occurrence.
2. A description of any injuries caused to workers.
3. Any other relevant information, including the records of any monitoring instruments or devices before the occurrence. O. Reg. 167/16, s. 8.

(2) For the purposes of subsection (1), the following are considered occurrences:

1. A rockburst.
2. An uncontrolled fall of ground.
3. A seismic event that is of a magnitude that is likely to cause significant rock mass damage or may compromise the effectiveness of the ground support system.
4. A seismic event that occurs in or near an active area of a mine that is of a magnitude that may cause ground instability. O. Reg. 167/16, s. 8.

73. (1) An employer shall develop a quality control program for work in an underground mine to ensure that the ground support systems that are specified in the mine design are properly installed and remain effective while in use. O. Reg. 571/92, s. 8.

(2) The employer shall maintain a record of the tests that are required under the quality control program. O. Reg. 571/92, s. 8.

(3) If requested, the employer shall provide a copy of the quality control program and of the record of tests under the program to the joint health and safety committee or, if no committee exists, to the health and safety representative. O. Reg. 571/92, s. 8.

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