

# Slope stability in opencast mines and quarries



Health and Safety in NZ extractives

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# 1 Introduction

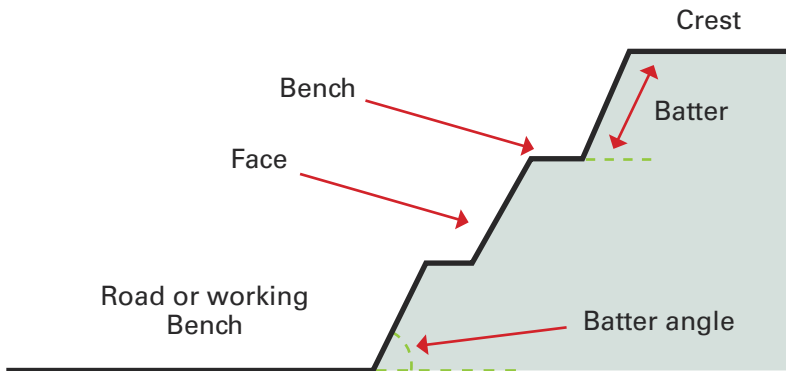
Working near faces can be hazardous due to rockfalls and slope failures.

The best control for protecting people working near faces is a quarry/ mine plan or design that has considered your site's particular geological and geotechnical characteristics. Planning for excavations requires a good understanding of ground conditions and identification of ways to avoid potential ground failure. As quarries and opencast mines develop over time, they usually get deeper and the overall slope angle becomes steeper which can increase the risk of rockfalls.

Regular inspections of faces, haul roads and working benches will identify small scale rockfalls and failures that may indicate larger scale ground instability.

The intent of this booklet is to provide you with ways to recognise and manage potential rockfall hazards. All workers need to be able to recognise potential hazards and act accordingly. If in doubt about the stability of a face, barricade the area and seek technical assistance.

# 2 Terminology



## Types of slope/ground failure

When mine/quarry faces are exposed, relaxation of the rock occurs which may lead to loose material falling or rolling from the face.

The likelihood of rockfalls and slope/batter instability increases when there is weak rock, bedding, joints, structures, blast damage, vehicle vibrations, crest loss, adverse weather (rainfall, wind) or inadequate design.

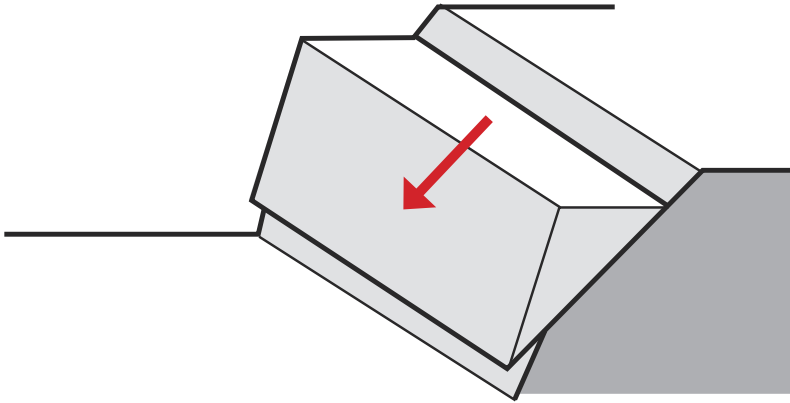
Consider all those tasks where workers may be exposed to the hazards of ground instability, for example digging/excavating, grading, water cart, drilling, loading shots, unplanned service of equipment, surveying, sampling, installing/moving pumps.

The following failures can occur in a mine or quarry:

- Planar failure
- Wedge failure
- Toppling failure
- Circular failure.

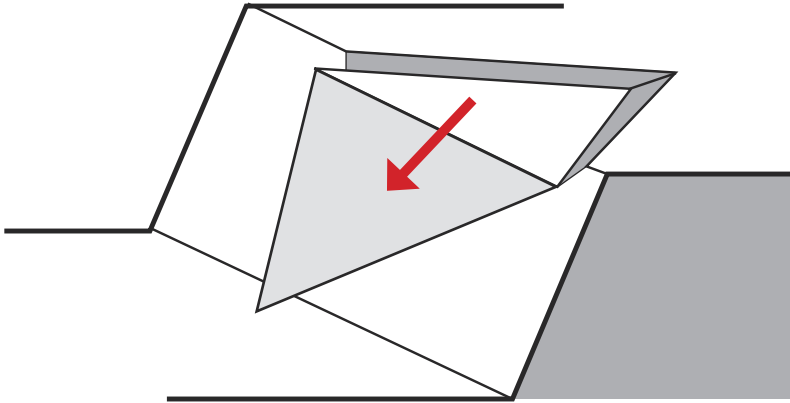
## Planar failure

A planar failure occurs along a surface where a block moves downwards along a surface.



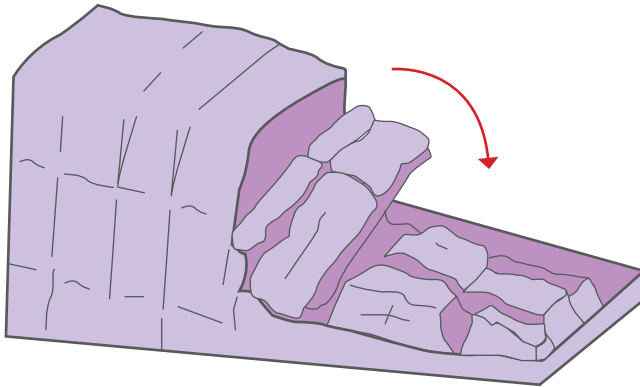
## Wedge failure

A wedge forms when two intersecting surfaces (such as bedding, faults, joints) meet and the block moves downwards.



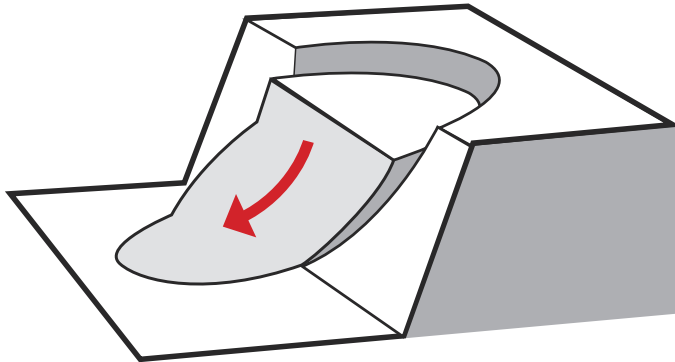
## Toppling failure

A toppling failure occurs as a result of vertical structures moving out and down due to lack of confinement.



## Circular failure

A circular failure occurs when a mass of material moves in a downward direction leaving a circular shaped scour. It most often occurs in weak material when ground conditions become saturated.





# 3 Controls for ground failures

Once a potential failure has been identified, barricade off the area and seek technical assistance. Small scale rockfalls may indicate larger scale ground instability.

The following controls should be considered:

- Decrease bench heights and overall slope height and angle
- Increase catch bench width and height
- Remove overhangs and other face hazards by blasting, scaling or cleaning faces
- Use appropriate type and size of equipment
- Place an adequate catch bund near the toe
- Create an adequate stand-off distance/exclusion zone near the toe
- Stabilise the toe by placing material against the face (buttressing)
- Establish procedures for safe entry to the pit following weather events or blasting.

You should also consider the following good practices:

- Good surface drainage away from the crest
- Safe blasting practices and blast damage minimisation
- Operational procedures such as positioning the excavator cab away from the face
- Regular monitoring of faces and benches for signs of instability.

## Catch bunds

A catch bund is an important control to minimise exposure of quarry workers to ground failure hazards and contain rockfalls. The dimensions and position of the catch bund will depend on the size of the potential slope failure or rockfall.



## Exclusion zones

An exclusion zone is an effective way to separate workers from rockfall hazards. When determining an appropriate distance to position the exclusion zone from the face, consider loose rocks, cracks, water running from the face, back break from blasting, overhang, and factors such as vehicle vibration, rainfall, and blasting.

The exclusion zone should be demarcated by bunding or some other form of delineation.

No work should be conducted, or vehicles parked, within exclusion zones.



# 4 Design of benches and faces

Excavations, benches, and ponds should be properly designed, with:

- stable slope angles
- adequate benches
- bench widths at least half the face height, and not less than 3.5 m
- face heights suitable for the site conditions and excavation method
- faces that do not exceed the reach of the excavator
- faces scaled to control the risk of rockfalls
- faces, at quarries, and working benches in alluvial mines, that have not been undermined.



All quarries and alluvials must obtain geotechnical advice from a competent person about any high-risk working face at the operation; and take that advice into account when developing, documenting, implementing, and maintaining the health and safety management system for the operation.

High-risk working faces are defined in the Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations as:

- A working face more than 15 metres high; or
- poses a significant risk to workers as a result of the height of the working face, or the ground type at the base of the working face, or the angle of the working face's slope, or the strength, composition or geological structure of the working face, or the presence of water on or around the working face; or
- is part of an excavation that, at its deepest, is more than 30 metres below the surrounding ground level.

# 5 Monitoring for slope instability

You need to monitor any changes in the condition of benches and faces identifying such things as rocks on berms, roads and the floor, cracks in faces, crest loss and changes in water flow.

Regular workplace inspections should be conducted and recorded so that potential “hot spots” of wall movement can be identified (refer Appendix 1 - Inspection checklist).

Extensometers are a useful means of measuring movement in cracks that appear on a bench. In its simplest form, this consists of pegs installed either side of the crack with the distance between the pegs measured at regular intervals to detect movement.



# Appendix 1

## Inspection Checklist

Feature	Location	Ok Y/N	Comment
<b>Batters/Walls</b>			
Constructed to design angle			
Face spalling or fretting			
Cracks/over hangs			
Toes maintained			
Water seepage			
Access ramp away from face			
Ramp bunded			
Blast damage			

<b>Berms/Benches</b>			
Design width achieved			
Crest loss			
Signs of instability			
Drainage adequate			

<b>Pit surrounds</b>			
Drainage away from pit			
Surface water ponding			
Windrows adequate			
Surface settlement or subsidence			
No environmental damage			

Feature	Location	Ok Y/N	Comment
<b>Road conditions</b>			
Wide enough for vehicles			
Adequate passing areas			
Drainage adequate			
Roads in good condition			

<b>Signage</b>			
Access to site adequately sign posted			
Open pit hazard identified			
Exclusion zones			

<b>Windrows/Catch bunds</b>			
Catch berms installed			
Adequate height for rockfall			

Person Inspecting \_\_\_\_\_

Signature \_\_\_\_\_

Date \_\_\_\_\_



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