

Highwall Hazard Awareness and Risk Assessment



Surface Ground Control
Aggregate Miner Safety Conference
April 10, 2018



Topics

- MSHA Standard
- Causes of Unstable Ground Conditions
- Terminology
- Types of Failures
- Unstable Ground Hazards
- Spoil piles & Stockpile



Ground Control Definition

- **When it is necessary to remove overburden to extract minerals, the methods used to maintain the stability of the earthen material left in place and how it is handled is addressed here as surface ground control.**

MSHA



- **30 CFR § 56.3130**

- **Wall, Bank, and Slope Stability**

- Mining methods shall be used that will maintain wall, bank and slope stability in places where persons work or travel in performing their assigned tasks. When benching is necessary , the width and height shall be based on the type of equipment used for cleaning of benches or for scaling of walls, banks, and slopes.

MSHA



- **30 CFR § 56.3131**

- **Pit or Quarry Wall Perimeter**

- In places where persons work or travel in performing their assigned tasks, loose or unconsolidated material shall be sloped to the angle of repose or stripped back 10 feet from the top of the pit or quarry wall. Other conditions at or near the perimeter of the pit or quarry wall which create a fall-of-material hazard to persons shall be corrected.

MSHA



- **30 CFR § 56.3200**

- **Correction of Hazardous Conditions (Scaling and Support)**

- Ground conditions that create a hazard to persons shall be taken down or supported before other work or travel is permitted in the affected area. Until corrective work is completed, the area shall be posted with a warning against entry and, when left unattended, a barrier shall be installed to impede unauthorized entry.

MSHA



- **30 CFR § 56.3401**

- **Examination of Ground Conditions**

- Persons experienced in examining and testing for loose ground shall be designated by the mine operator. Appropriate supervisors or other designated persons shall examine and, where applicable, test ground conditions in areas where work is to be performed, prior to work commencing, after blasting, and as ground conditions warrant during the work shift. Underground haulage ways and travel ways and surface area highwalls and banks adjoining travel ways shall be examined weekly or more often if changing ground conditions warrant.



What is MSHA looking for?

- Unstable ground conditions
- Equipment in unsafe operating condition
- Not using explosives properly (shooting hard, not decking, wrong delay patterns).
- Lack of information (training, maps).
- Unsafe work practices (highwall dumping, working near bad wall, activity between equipment and the wall/bank, undercutting).
- Clutter and Housekeeping on benches.
- Scaling shall be done from a safe location and in a safe manner.

Typical Highwall Profile

Bottom of Unconsolidated Material

[30 CFR § 56.3131](#) requires that where persons work or travel in performing their assigned tasks, loose or unconsolidated material is to be sloped to the angle of repose or stripped back for at least 10 feet from the top of the pit or quarry wall. It also requires correction of other conditions at or near the perimeter of the pit or quarry wall which create a fall-of-material hazard.

Over-Travel Berms

CFR 56.9300 requires these when there is a chance that a vehicle could overturn. They must be mid-axle high on the largest vehicle that will travel on the bench or roadway.

These berms will also catch loose rock that may fall off the highwall and are also used to limit access to the highwall.

Top Of The Pit

Safety Bench (Safety Berm)

The width of these benches is should be based on the geology, the highwall height, and 30 CFR 56.3130.

Highwalls

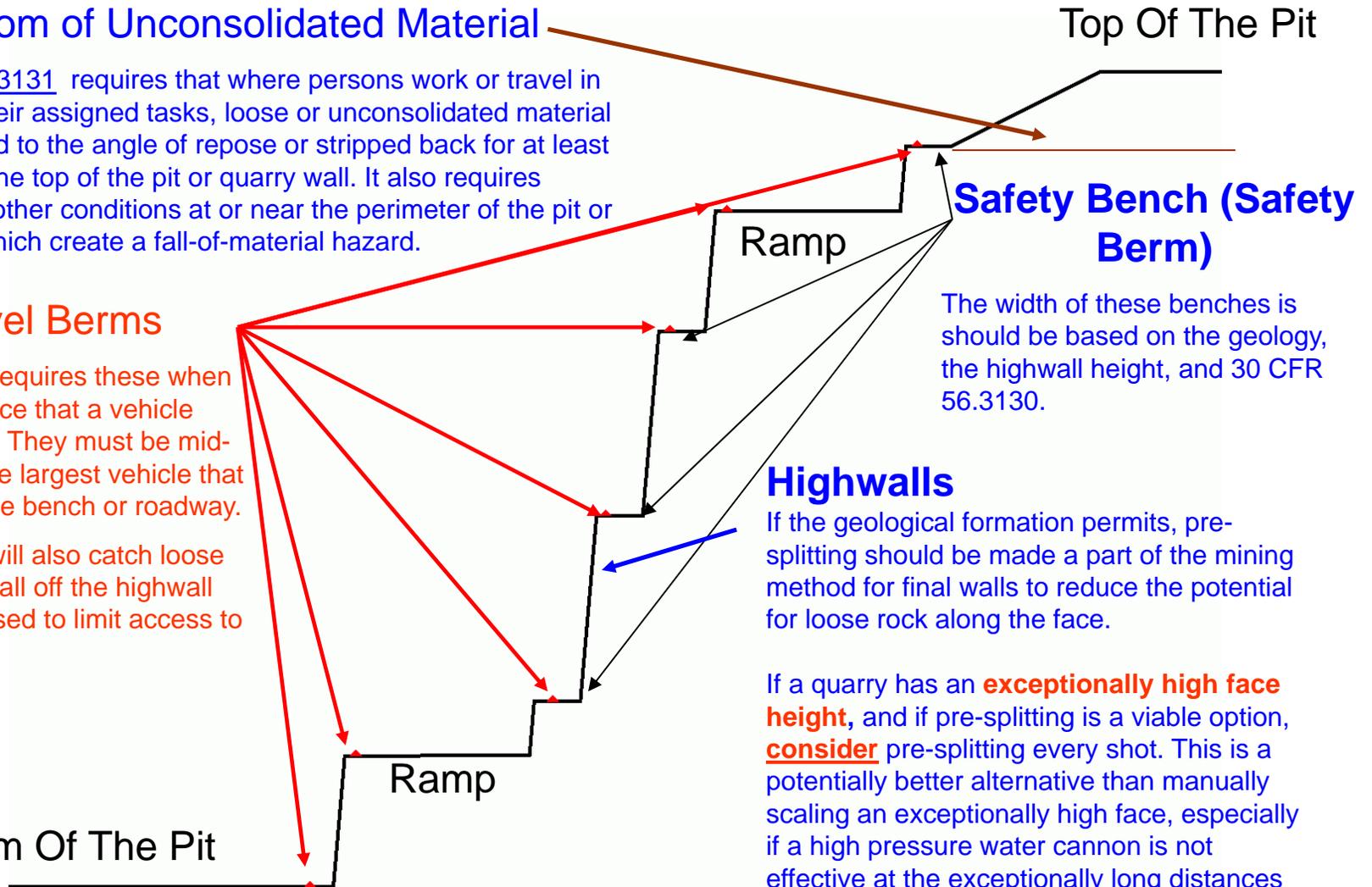
If the geological formation permits, pre-splitting should be made a part of the mining method for final walls to reduce the potential for loose rock along the face.

If a quarry has an **exceptionally high face height**, and if pre-splitting is a viable option, **consider** pre-splitting every shot. This is a potentially better alternative than manually scaling an exceptionally high face, especially if a high pressure water cannon is not effective at the exceptionally long distances the water must reach.

Bottom Of The Pit

Ramp

Ramp





Causes of Unstable Ground Conditions

- Joint sets (mud seams) in highwalls.
- Strata changes (including ground faults).
- Bedding Planes
- Effects of Water & Ice

Joint Sets

- Vertical cracks in strata (shale, sandstone, etc.) that tend to fill with sediment over millions of years (thus the term “mud seams”).
- Tend to occur at regular intervals.
- Result in fall of rock (can be major) in face of highwalls when toe weakens or when two intersecting joints develop a wedge (chimney) that can topple or slide out of the wall.
- This type of discontinuity can result in narrow ridge separation where hadr blasting occurs (cast blasting).

Joint Sets



Strata Changes

- Strata changes require special blasting techniques (decking) and result in failures caused by the different effects of exposure on the different strata. Shale underlying sandstone will deteriorate causing loss of toe and allow the sandstone to move.

Strata Change



Bedding Planes

- Cracks (discontinuities) that lay nearly horizontal in strata but can have a pitching orientation that can result in shear plane failures. It is usually not possible to detect the pitch by looking at the face of the wall unless the pitch is “running” with the face of the wall.



Bedding Plane



10.13.2011 14:17
Bedding Plane



Effects of Water

- When the ground water table or saturated zone is above the discontinuity, the water in the joint acts outward in all directions resulting in a uplifting force on the rock or material. This lessens the resistance to sliding.



Effects of Water

- The second effect of water is found when you have a tension crack (or open joint) which can fill with water. In this case, a portion of the hydrostatic pressure acts to push the rock into the pit. This is compounded when that water is allowed to freeze (water expands when it freezes).
- When the deposited soil gets saturated with water, the additional weight tends to overcome the resistance (angle of repose) resulting in slides.

Water



- **Causes erosion of the pit perimeter and benches.**
- **Acts as a lubricant for slips and geological structures.**
- **Expands when frozen forcing separation of materials and strata.**
- **Causes compaction of material.**
- **Adds weight to already unstable material.**

Effects of Water



California floods, January
2005

Water Hazard or Highwall Hazard?



When is a boat necessary?



Where do we place the boat?





Effects of Ice

- During periods of freeze/thaw existing water in highwalls tend to form ice on the face. This adds additional weight to the highwall strata (also raises the level of water in the wall behind the ice) and presents an additional problem with the overhanging ice as it thaws and loosens up.
- Studies have shown that the greatest frequency of rock falls occur in fall and spring when you have a combination of more rainfall and the effects of freeze/thaw cycles – which both act to destabilize highwalls and banks by loosening and removing material.





Terminology (Types of Failures)

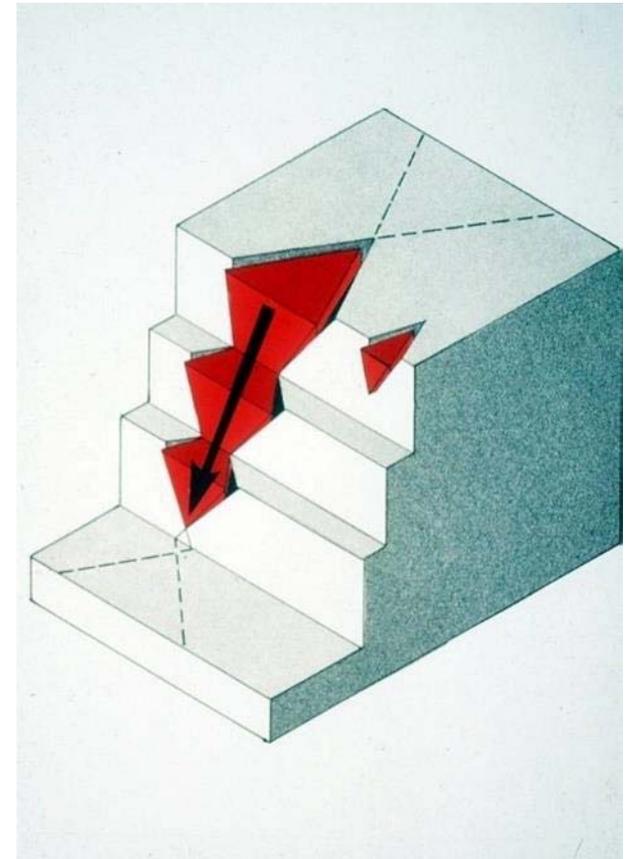
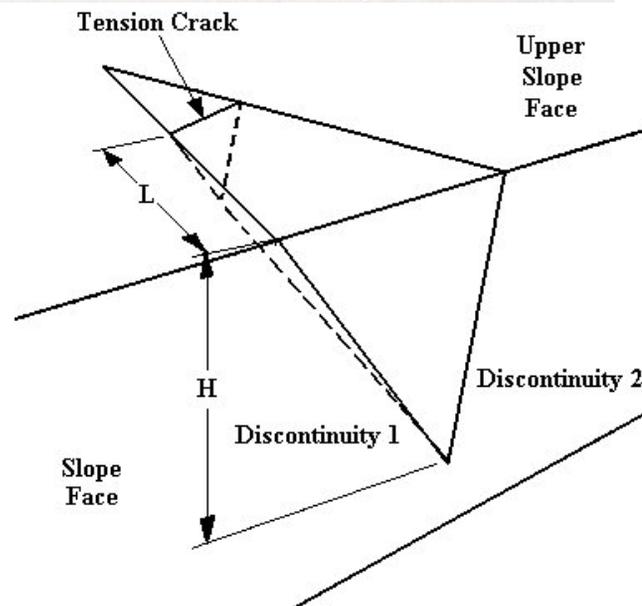
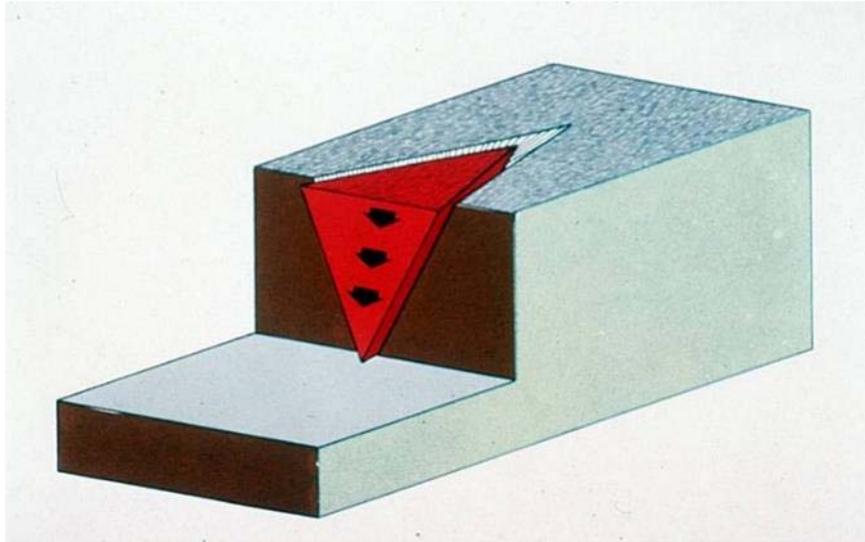
- Geologic Structures – 3 Types to Understand
 - Wedge Failure
 - Plane and Circular Failure
 - Toppling Failure



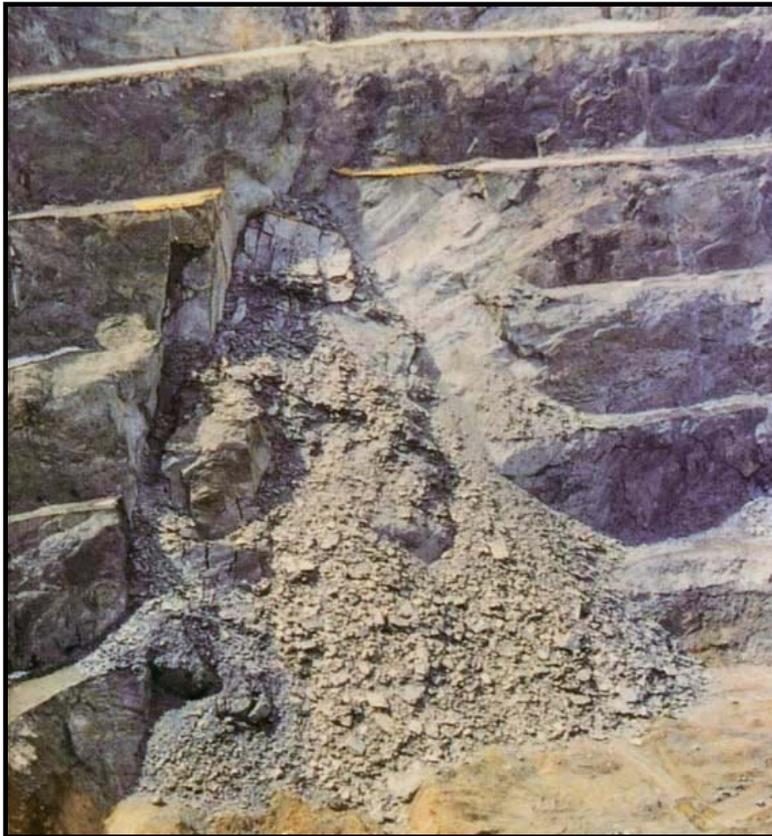
Rock Falls

- Rock Falls usually are a result of areas of weakness in rock formations. Several indicators that may signal a rock fall are as follows:
 - Fractured or broken rocks on the highwall.
 - Vertical displacement of rock layers.
 - Openings or cracks in rocks releasing water.

Wedge Failure



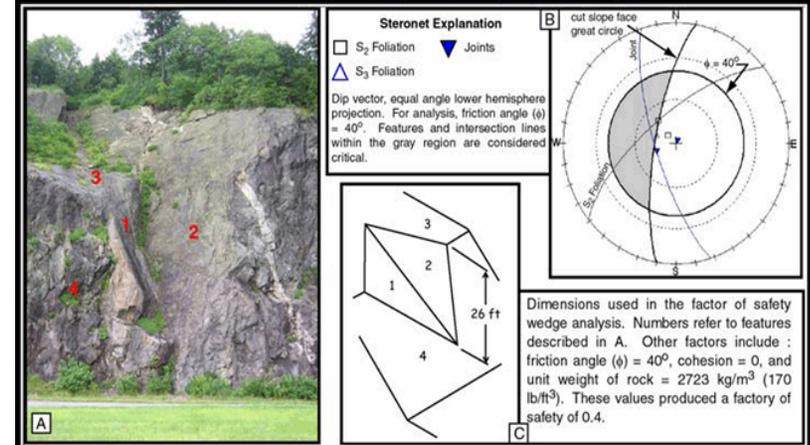
Wedge Failure



Past Rockslide (Wedge Failure)

Caney Fork Overlook

Blue Ridge Parkway MM 428

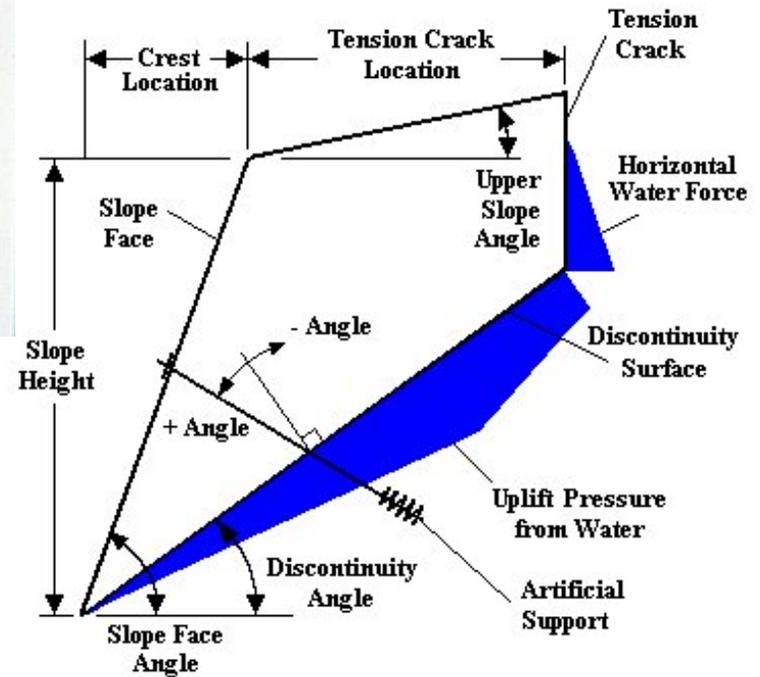
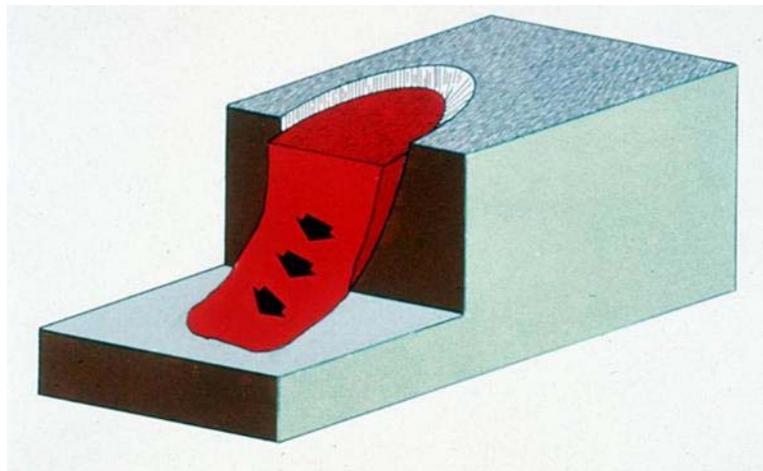
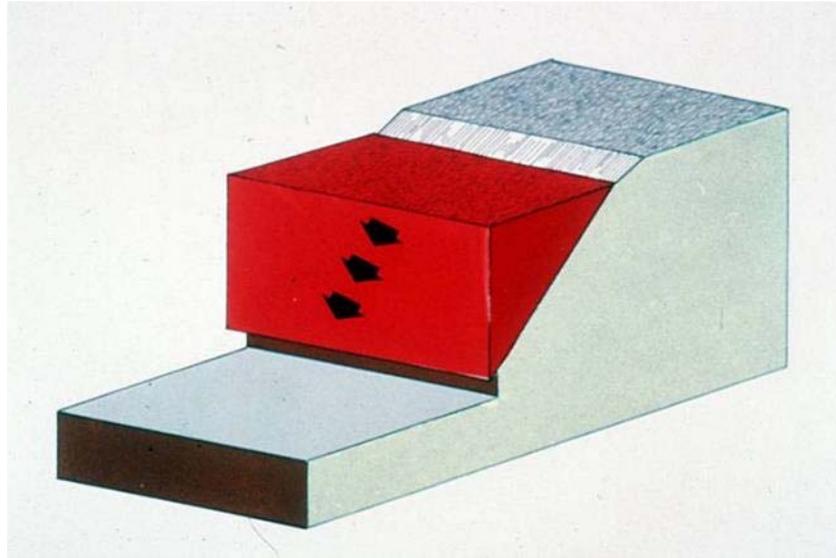




Plane Shear

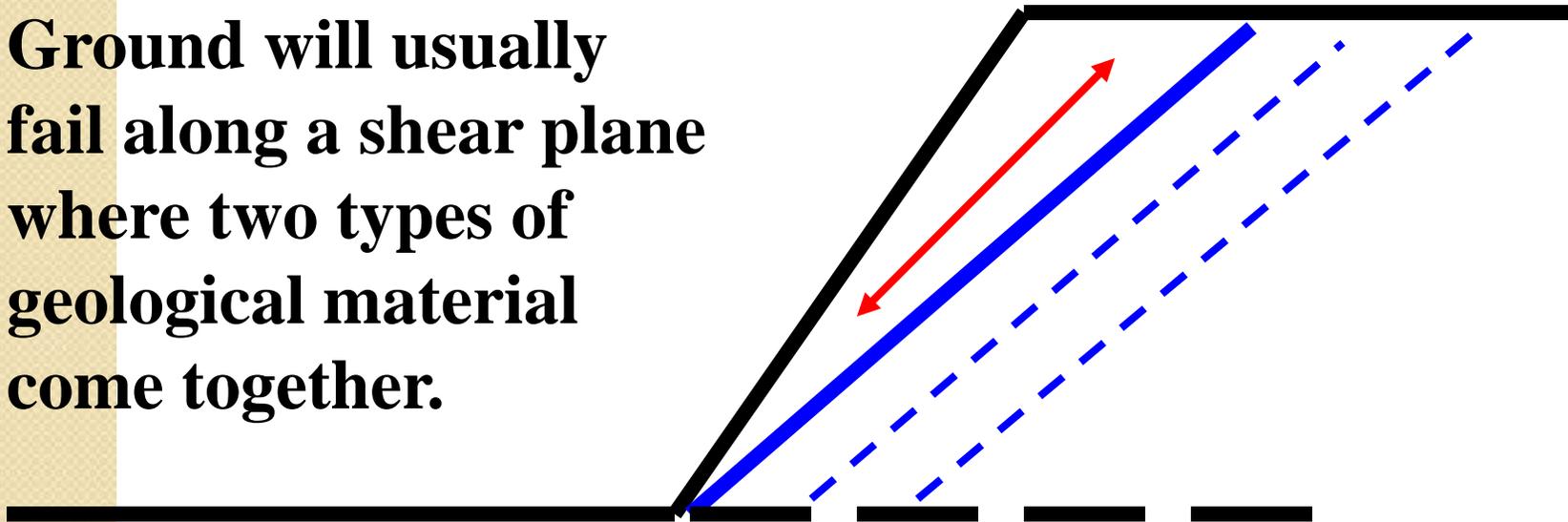
- A plane shear occurs in areas of rocks that have been displaced or fractured. A wedge shaped chunk of rock will break free when it occurs. Commonly caused during periods of freezing and thawing.

Plane and Circular Failure

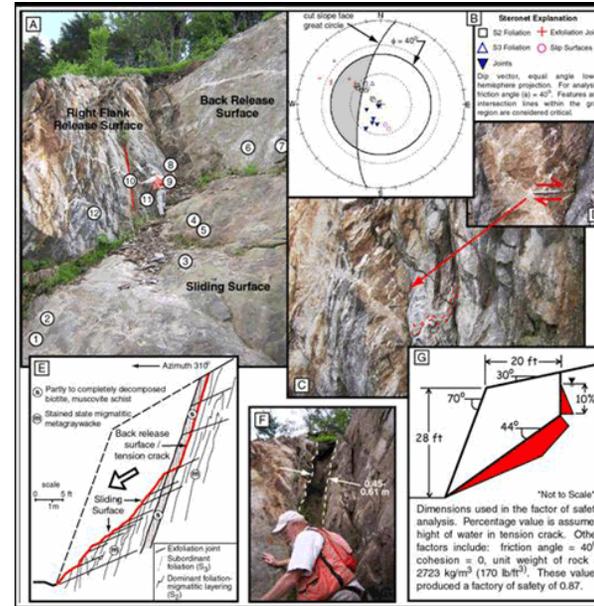


Plane Shear

Ground will usually fail along a shear plane where two types of geological material come together.



Plane and Circular Failure



**Past
Rockslide
(Plane Failure)
Blue Ridge
Parkway
Caney Fork
Overlook
MM 428**

Plane and Circular Failure

(Before)

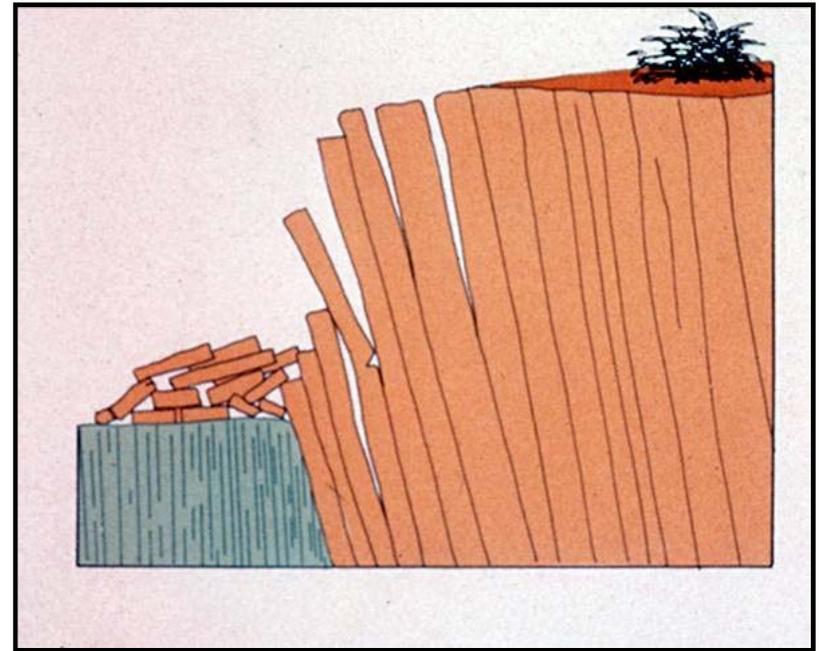
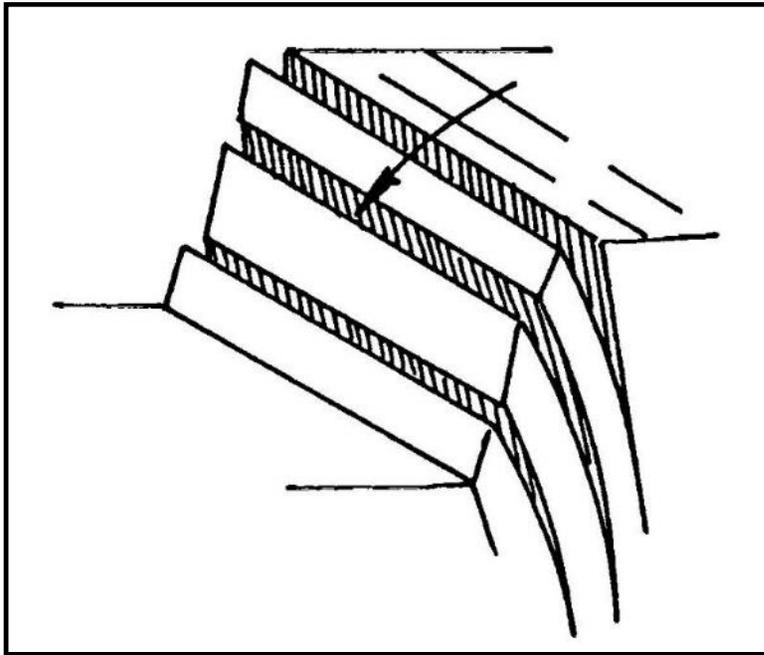


Plane and Circular Failure

(After)



Toppling Failure



Plane Failure



Wedge Failure



Plane Failure



Toppling Failure





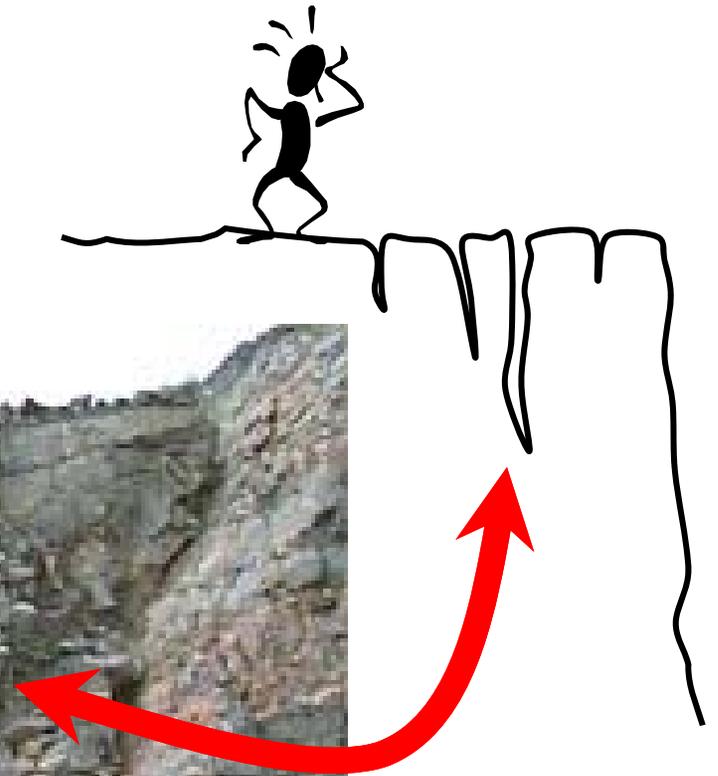
Unstable Ground Hazards

- **Overhangs**
- **Backbreak**
- **Cavities**
- **Sloping Crests**
- **Low Angle Slips**

Overhang



Backbreak



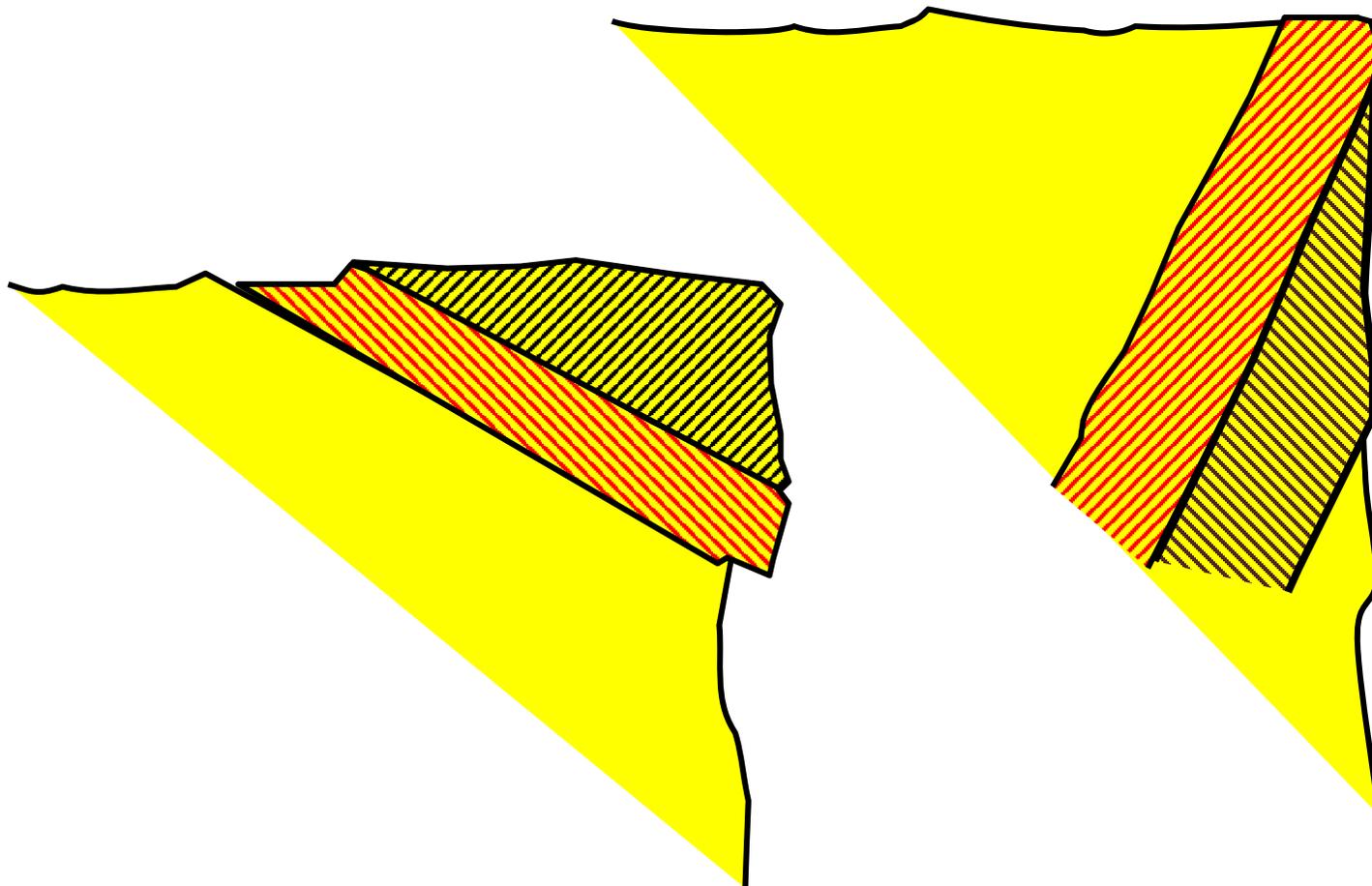
Cavities



Sloping Crest



Slips & Faults





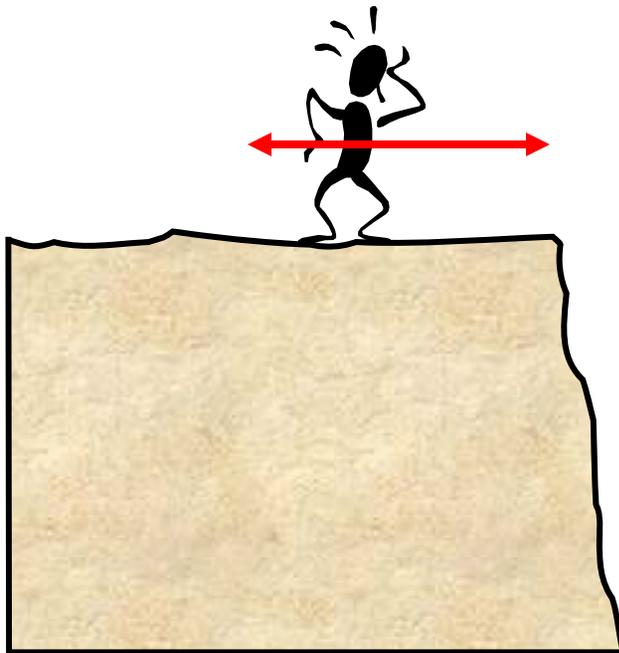
Working at the Top of Wall

- Additional weight added at the top of a highwall changes safety factor for the wall. This weight can come from operating equipment or depositing spoil, cleanings, or minerals. Working equipment also cause vibration in the underlying strata.

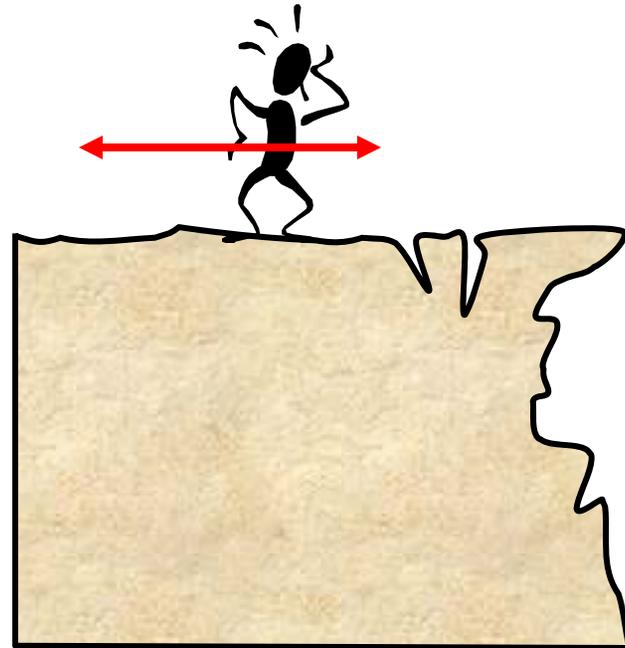
Working Close to Crest

The Fall Hazard Zone

- **6 Feet or Less From Stable Crest**



- **6 Feet or Less From Unstable Ground or Footing**





Highwall Stability

- Benching increase the safety factor of a highwall by providing additional material near the base of a wall.
- Exposure increases the likelihood of deteriorating material falling out of the wall. If a wall is exposed for long periods, providing benches will keep this material out of the pit where workers are located. Benches should be made wide enough to facilitate cleaning if sloughing material will fill the benches before work is completed in the area.



Highwall Stability

- Pre-splitting makes a wall shoot cleaner and reduces the chance of loose material falling out of the wall. Pre-split should be shot prior to a production shot and the closer the hole spacing and smaller diameter the holes, the better the results if the holes are loaded correctly with explosives.



Nat Pre-Split

Pre-Split

Scaling



- **When performing scaling operations the miner shall be:**
 - **Located where he/she will not be exposed to injury from falling material or provided with protection from falling material.**
- **If the miner is performing scaling utilizing mobile equipment the travel area should be inspected for stability by qualified personnel. If the area is confined, and scaling needs to take place in close proximity to edges of roadways or benches, spotters should be used to assist the equipment operator in location and placement of their vehicle.**



Installing Barriers

To prevent access to “idled walls,” catch basins or berms will be constructed and warning signs will be installed. Idled walls are defined as walls that will not be mined according to the current mine plan.



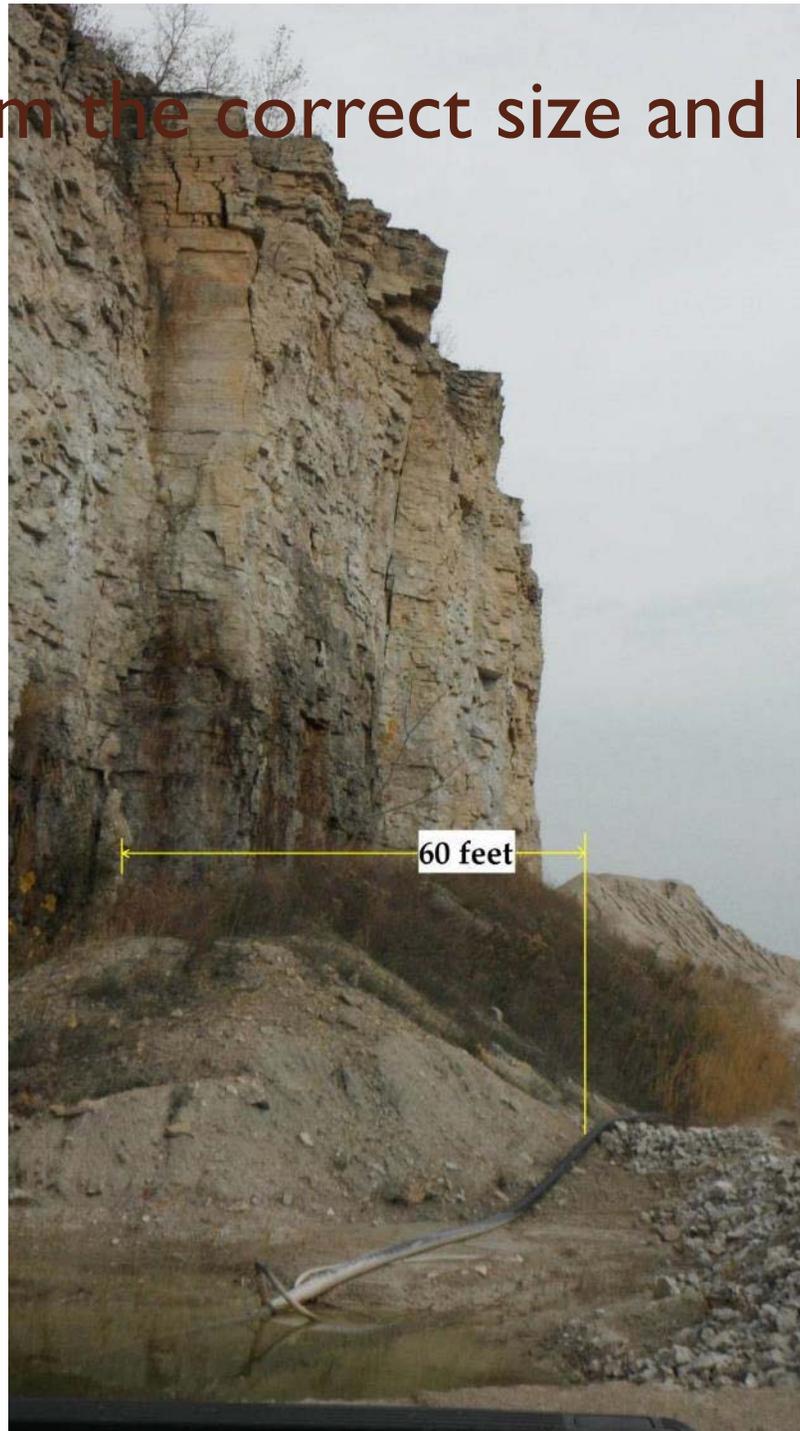
Is the berm the correct size and location?



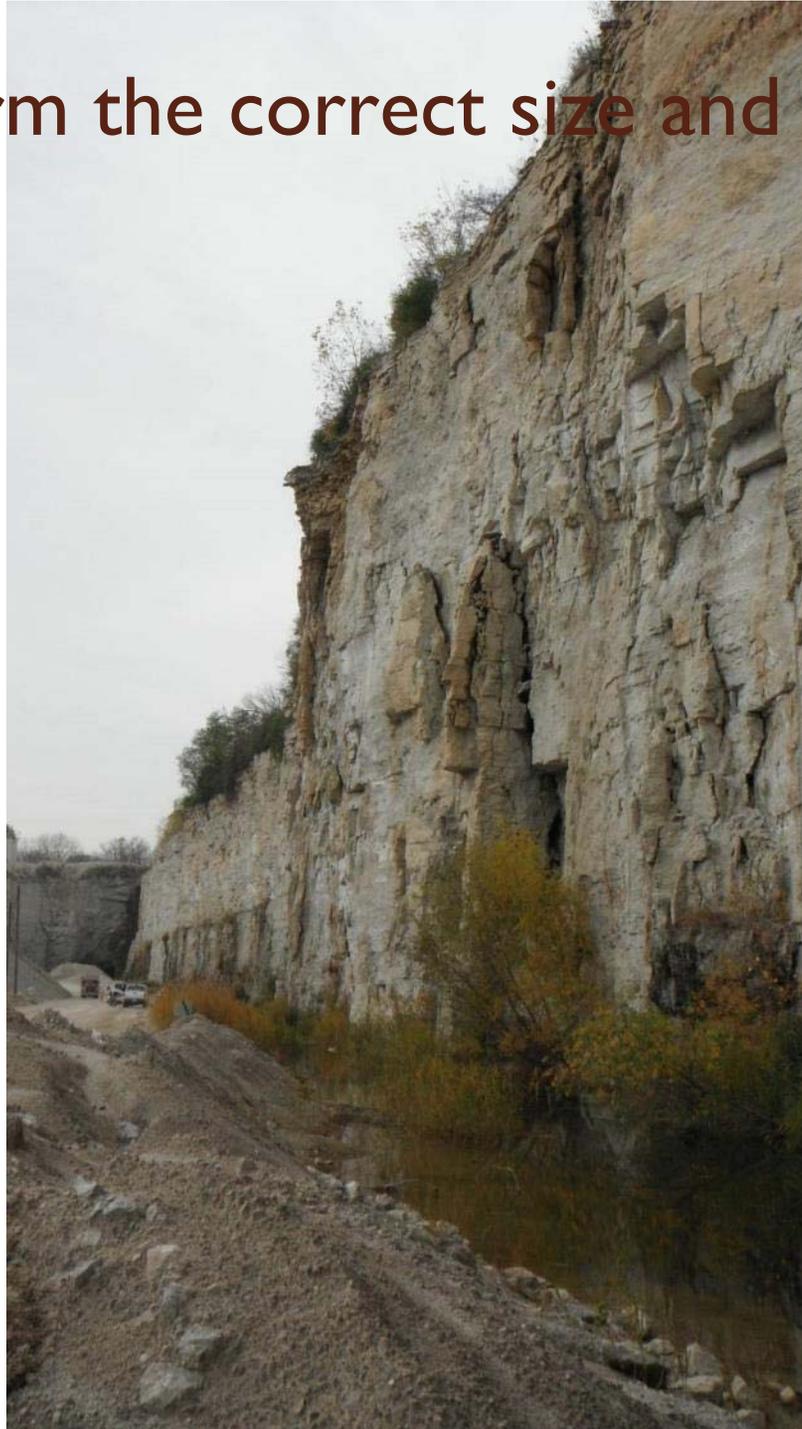
Is the berm the correct size and location?



Is the berm the correct size and location?



Is the berm the correct size and location?



HIGHWALLS

A photograph showing the wreckage of a 1-ton truck that has crashed into a rocky embankment. The truck's metal body is crushed and twisted, with debris scattered across the ground. A large, light-colored rock is prominent in the center of the scene, partially obscuring the wreckage. The surrounding area is filled with smaller rocks and debris, indicating a steep and hazardous slope.

Remains of 1 ton
truck accident on
October 28, 2011

Fatality #23 – December 7, 2011

Fall of Highwall – Surface Mine – Virginia

Fairbanks Coal Company Inc – Fairbanks No. 4



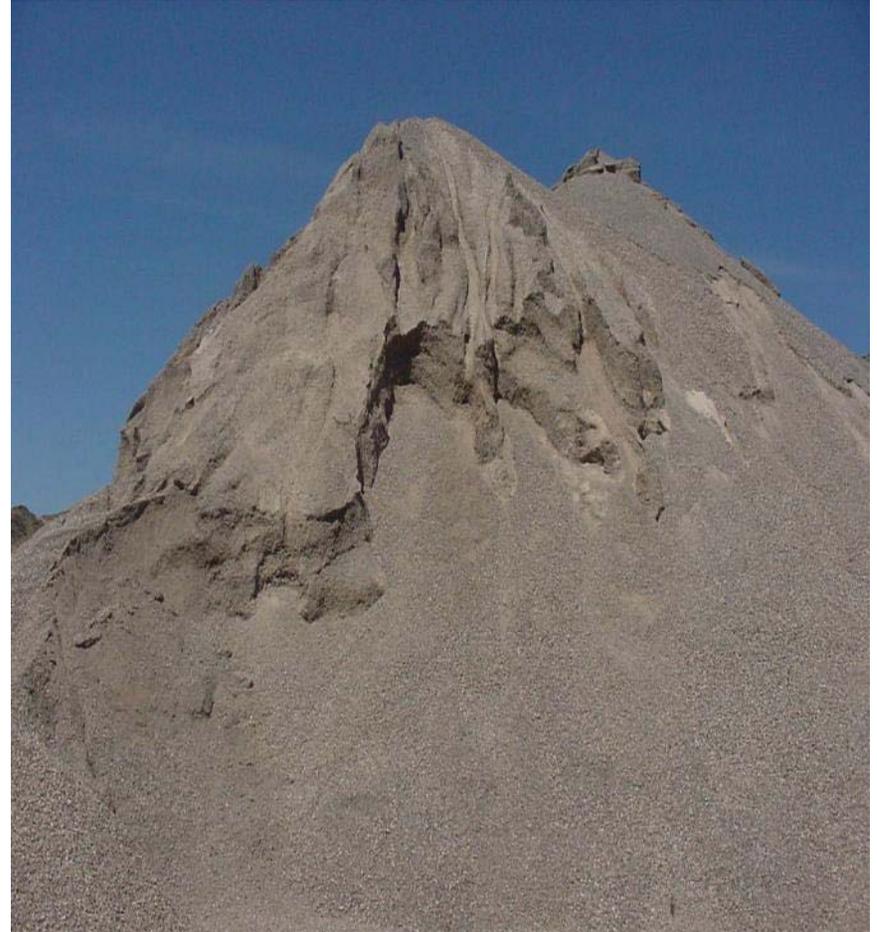
COAL MINE FATALITY - On Wednesday, December 7, 2011, at approximately 7:30 a.m., a 49-year-old excavator operator, with 20 years of mining experience, was fatally injured when a highwall he was working near collapsed. The excavator was being used to load rock trucks. The operator's cab was positioned on the highwall side when the accident occurred.



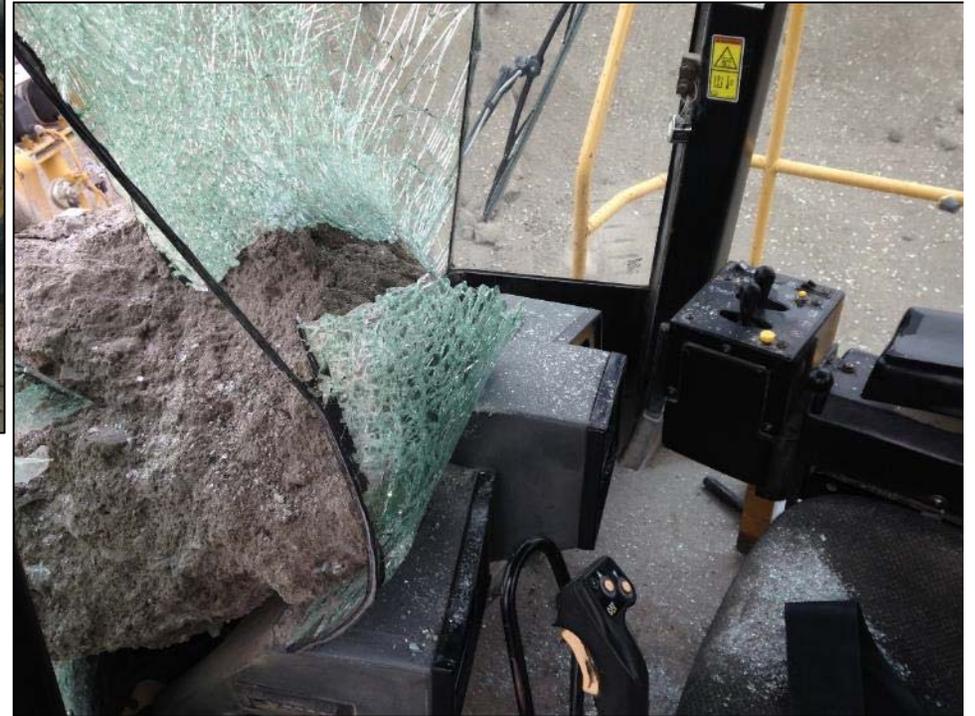
Spoil Banks & Stockpiles

Stockpiles & Banks

- **Slope to an angle of repose**
- **Always remove material from the area of the toe first, dressing the highwalls and banks as you go**
- **Be careful of overhang, if present remove**
- **Never drive or operate near the edges of the banks or highwalls due to the potential for bridged materials and slope failures**



Ground Control at Stockpiles





Dumpsites

- **Sloped to an angle of repose.**
- **Surface travel area maintained for vehicle travel.**
- **Dump edge bermed to mid-axle height of the largest vehicle operating. Berms should be of adequate construction.**
- **If wet conditions are present and there is any possibility of slumping at the edge of the dump, have haulage vehicles dump short and use dozers to push off.**
- **If visibility is limited, utilize truck spotters when backing to the edge. If unavailable, dump short.**
- **Lift dump bed slowly to transfer your center of gravity slowly. If you are moving wet or blocky material the sudden or rapid lifting of the dump bed could cause load stability problems as well as vehicle stability problems.**



What's wrong with this picture?

Stockpiling Safety

What is the proper way of stockpiling with haul trucks?

- Do not back directly to edge of pile. Keep one truck length away.
- Back perpendicular to the edge, NOT at an angle.
- Always use a dozer or loader, preferably a dozer, to push material over the edge. The dozer should always use a second pile to bump the material over the edge and ensure that a berm is always present.

Why should you not loadout where dumping is ongoing above?

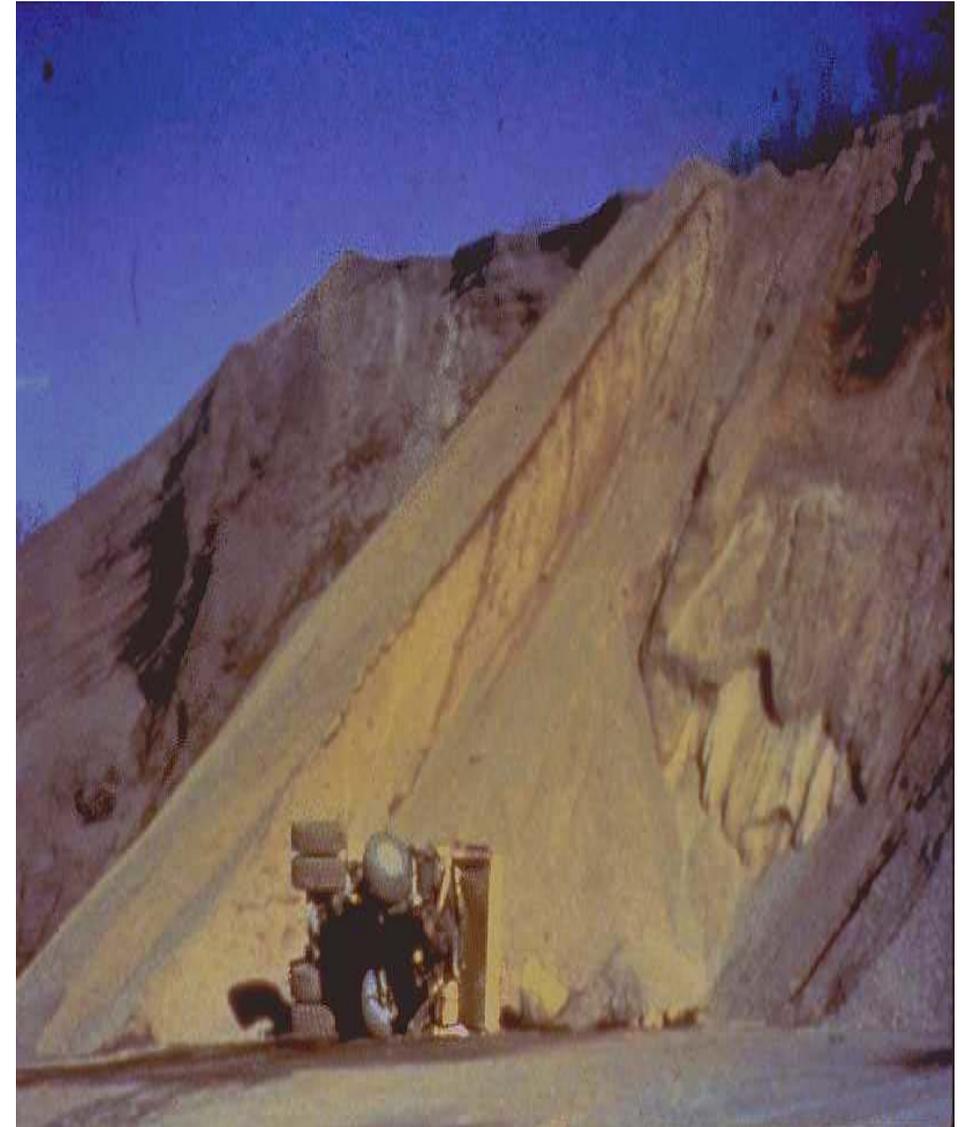
This is Why!



COURTESY PHOTO

Truck accident

The Lenoir Rescue Squad reported that Ray Triplett of Ferguson was injured Tuesday afternoon when his dump truck rolled over backwards onto another one. The incident occurred at the rock quarry on Bradford Mountain Road. Ferguson sustained injuries to an arm and leg, stated Chief Tony Lamberth of the rescue squad.



Customer and Employee Safety Around Stockpiles

- Keep piles “de-energized”. In other words, keep them at their natural angle of repose.



Is this at the natural angle of repose?

There is a great deal of potential energy stored in this pile.



Customers must be made aware of stockpile hazards and not be allowed outside their trucks next to the stockpiles.



Customer and Employee Safety Around Stockpiles

- Many times our job duties require us to drive up on stockpiles. Before driving up on a stockpile, what is the first thing we should do?

Communicate !

We need to communicate with the dozer/loader/stockpile truck operator by radio or visual or both.

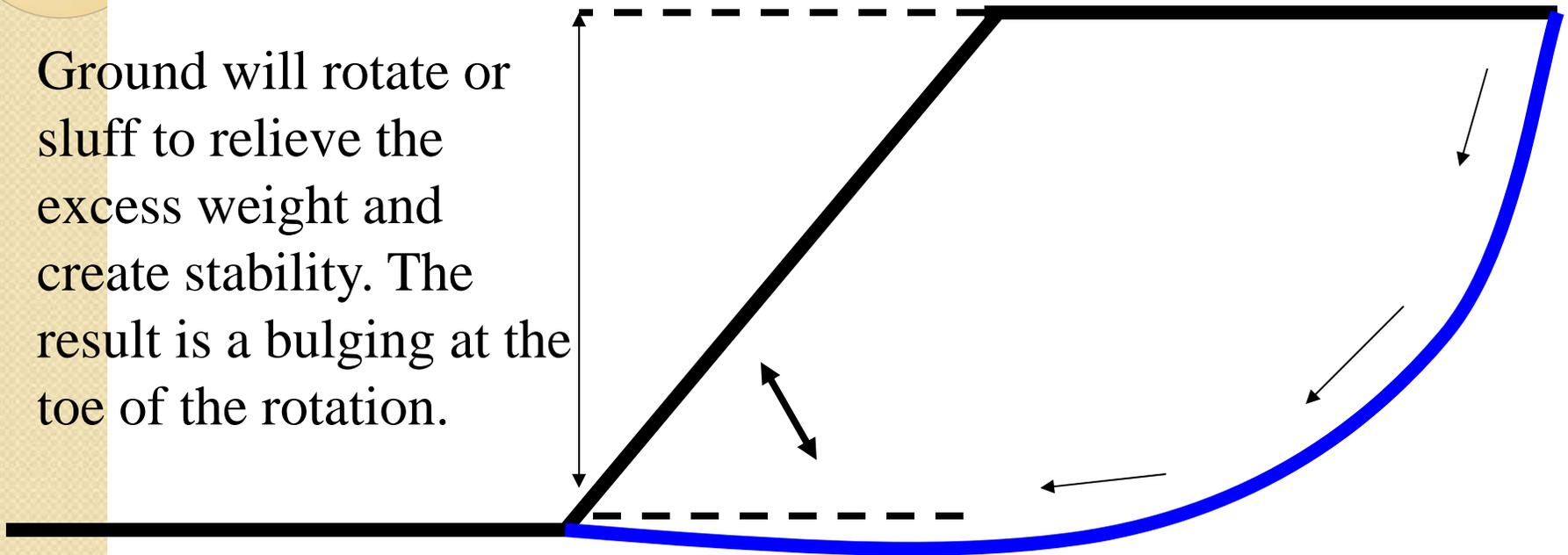


Rotational Slope Failure

- This will occur when similar size material is piled up. When the failure occurs, a bowl shape pattern of earth breaks loose. Influencing factors include:
 - Heavy rocks piled on top of lighter soil in the spoil bank. If the weight gets to be too great on top of the pile, the bottom material on the slope will slip out.
 - Material piled at a steeper than normal angle.
 - Wet rainy weather could add pressure to weaker layers and cause failures.

Rotational Shear

Ground will rotate or sluff to relieve the excess weight and create stability. The result is a bulging at the toe of the rotation.



Rotational Shear

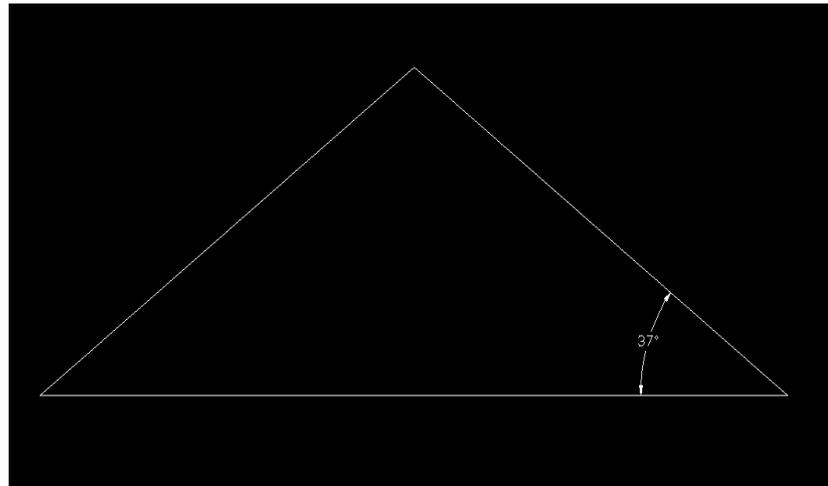






Hazards at Stockpiles

- Angle of Repose
 - The angle at which a slope is stable
 - Roughly 37 degrees
 - When a stockpile bank is frozen or compacted it may not immediately slough off.





Hazards at Stockpiles

- What can I do?
 - Keep Customer trucks a safe distance away so that if material breaks free there is no pinch point hazard.
 - Try not to undercut pile.
 - Work the entire face of the pile evenly.
 - Use loader bucket to back drag pile try to help to break the slope free.

What if I can't break the overhanging material free?

