Highwall Management & Use of Drones

Refer to sign-in sheet for attendees (note: a separate meeting should be held with all absent employees).

1. **Overview**. Unexpected rock movement can cause injuries, endanger lives, and can potentially result in a mine catastrophe. Even relatively shallow quarries can experience devastating consequences from slope failure. Using drones can help monitor conditions.

   Exposure to cracks and seams are common to natural stone mining operations. Strict evaluation of the structural integrity of the stone deposit should be made before entering an area. The entire crew shares this responsibility (see something, say something). Auditing and team work combined with pre-shift workplace examinations are the tools that everyone needs to utilize in "following the cracks" to avoid the hazard of falling rock.

   What is a **highwall hazard**? A highwall hazard is created when anyone is exposed to a highwall with the potential for failure.

   A **highwall failure** is the unintended loss of material from a highwall.

2. Factors contributing to highwall failure:
   - Rock mass properties (strength, structure, etc.); highwall geometry (angles, heights, etc.); face orientation.
   - Precipitation (rain, snow) – Sudden changes in precipitation levels or water flow may also precede slope failures. Spring run-off from snow melt is one of the most obvious examples of increased water flow that may have adverse effects on slopes.
   - Ground water.
   - Freeze – Thaw Cycles. Winter months can bring drastic changes to the stability of highwalls due to freezing and thawing. Water accumulates in crevices of rocks and then freezes. The ice acts as a wedge to expand the crevice opening. The ice thaws and the cycle begins again which in turn compromises the stability of the highwall that can result in highwall failure.
   - Equipment vibrations and blasting.
   - Soil decomposition.
   - Burrowing animals, tree roots.
   - Wind.

3. **Who at risk?** Miners, contractors, anyone working near a highwall which has the potential for failure.

4. **Mitigation:** There are several methods used to reduce the hazards associated with slope failures:
   - Safe geotechnical designs;
   - Secondary supports or rock fall catchment systems;
   - Monitoring devices for adequate advance warning of impending failures including the use of EDM (electronic distance measurement) equipment;

- Monitoring the changes in crack width and direction of crack propagation is required to establish the extent of the unstable area. A simple method for monitoring cracks is to spray paint a well-defined line across the ends of a crack. New cracks or spread along existing cracks can be easily identified on subsequent inspections.
- Proper and sufficient scaling of loose/dangerous material from highwalls. At any surface operation, some instability can be expected – from minor bench raveling to massive slope failures.

Acknowledging that slope failures may occur and knowing what the warning signs are will contribute to the safety of the operation. Some of the more common warning signs of slope instability follow:

- **Tension cracks**: The formation of cracks at the top of a slope is an obvious sign of instability. Cracks form when slope material has moved toward the pit.
- **Vertical erosion:** Material that has moved down in a vertical or nearly vertical fashion. Both the material that has moved vertically and the remaining face may be unstable and should be monitored accordingly.
- **Abnormal water flows:** Sudden changes in precipitation levels or water flow may also precede slope failures. Use rainy days for early recognition and observation of potential hazards.
- **Bulges or creep:** Bulging material or "cattle tracks" appearing on a slope indicate creep or slow subsurface movement of the slope. Other indicators of creep can be determined by looking at vegetation in the area. While most mines do not have vegetation on the slope faces, movement of trees at the crest of a slope can be an indicator of instability.
- **Rubble at the toe:** Fresh rubble at the toe or on the pit floor is a very obvious indicator that instability has occurred.

5. General Rules for Working Safely

- Train all miners to recognize hazardous highwall conditions.
- Safely examine highwalls from as many perspectives as possible (bottom, sides, and top/crest). Look for signs of cracking and other geologic features that could lead to instability and secure or remove hazardous conditions.
- Conduct additional examinations as ground conditions warrant, especially during periods of changing weather conditions.
- Conduct examinations of the highwall before, during and after rain, freeze, or thaw events.
- Follow the approved ground control plan at all times to ensure the safe control of highwalls.
- Use mining methods that ensure highwall stability and safe working conditions and do not undermine the base of the highwall.
- Ensure that miners work, travel, and operate mining equipment at safe distances from the highwall.

- Operate mobile equipment perpendicular to the highwall or with the operator's cab positioned away from the highwall.
- Use proper blasting techniques for forming highwalls and thoroughly examine the highwall after each blasting operation.
- Scale down loose hazardous material.
- Do not work under loose material for any reason.
- Pay special attention when working in the corners of box cuts.
- Increase the number of benches at each highwall to catch falling material.
- Keep equipment operators informed of changing highwall conditions.
- Maintain safe access to the top of highwalls so thorough examinations can be conducted. If found to be unsafe, then immediately remove all personnel exposed to hazardous ground conditions, barricade and post signs to prevent entry, and promptly correct unsafe conditions.
- Use mining methods that ensure highwall and bank stability and safe working conditions. Avoid undercutting and/or over steepening of the highwall or bank slope.
- Observe and evaluate pit, highwall, slope, and bank conditions prior to beginning work and throughout the shift to ensure safety. Be especially vigilant for these conditions as weather conditions change.
- Never place yourself between a highwall or stockpile and machinery. If a wall fails you will have a lesser chance of survival because if a machine is blocking your escape.
- Always run machines facing the highwall. This allows you to watch for indications that the highwall is about to fail as you are completing your duties.
- Finally, never turn your back on the highwall. You need to be able to watch the wall at all times for increases in falling material that may indicate a failure.

6. **Using Drones.** Unmanned aerial vehicles (UAVs), often called drones, are increasingly used to monitor quarry conditions for safety and other commercial purposes.

   Drones can be used to inspect highwalls, monitor cracks, and identify crests and toes. Drones can be used to examine power lines, traffic flows, and many other aspects of an operation. They can provide additional aerial safety checks in advance of blasting and documenting blast sequencing.

   If you have a small drone that is less than 55 pounds, you can fly for work or business by following FAA's Part 107 guidelines. According to the FAA, the purpose of these guidelines is to limit two sources of risk related to the use of drones: drones colliding with other flying objects and drones falling and injuring people or property on the ground. Make sure you understand what is - and is not - allowed under Part 107 rules.

7. **Highlights of the rule - Operating Requirements.**
   When you are manipulating the controls of a drone, always avoid manned aircraft and never operate in a careless or reckless manner. You must keep your drone within sight. Alternatively, if you use First Person View or similar technology, you must have a visual observer always keep your aircraft within unaided sight (i.e., no binoculars). Neither you nor

a visual observer can be responsible for more than one unmanned aircraft operation at a time.

Drones can be flown during daylight (30 minutes before official sunrise to 30 minutes after official sunset, local time) or in twilight with appropriate anti-collision lighting. Minimum weather visibility is three miles from your control station. The maximum allowable altitude is 400 feet above the ground, higher if the drone remains within 400 feet of a structure. Maximum speed is 100 mph (87 knots).

Currently, drones cannot be flown over anyone not directly participating in the operation, or under a covered structure, or inside a covered stationary vehicle. No operations from a moving vehicle are allowed unless you are flying over a sparsely populated area.

You can carry an external load if it is securely attached and does not adversely affect the flight characteristics or controllability of the aircraft.

You can request a waiver of most restrictions if you can show your operation will provide a level of safety at least equivalent to the restriction from which you want the waiver.

8. Drone Safety.

While there are many benefits to using UAVs in the quarry, the potential risks must be carefully studied. The presence of a drone flying close to a human worker can create new hazards at a quarry. Safety professionals need to be aware of these new hazards, assess the risks arising from them, and apply controls to reduce the risks. Adequate training of operators is essential to ensure the safe operation of the UAV.

There has been little published about the safety and health risks associated with the public or commercial use of UAVs. Unstable flying conditions, operator errors, and faulty equipment may represent potential hazards to nearby workers from the commercial use of drones. Adding to the uncertainty about the hazards to workers from the emerging use of UAVs in construction and other industries: the arrival of autonomous or semi-autonomous UAVs may introduce new hazards arising from the absence of human control.

Conclusion: It is important to develop hazard identification, risk characterization and mitigation approaches to ensure the safe operation of drones as their use promises significant benefits for industry.

9. Discussion:

- Discuss the geologic features existing in our quarry that might lead to wall instability.
- Has anyone worked with drones or seen them used? What are the risks/hazards as you see them?

10. Recap & Review.

- Review the factors listed in item 2 above as they relate to your work area.
- Review recent incidents and injuries relating to highwall failure.

11. Reminder. Safety is the responsibility of both management and employees!
Next Safety Meeting is scheduled for _____ and the topic will be _____.

Take Exam/ Review Results

Quarry Toolbox Acknowledgement
We would like to thank the National Building Granite Quarries Association (NBGQA) for their cooperation and assistance developing this safety resource. We are grateful for their commitment to the safety and health to the people of the dimension stone industry.

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