Geohazards and risk: Rock mechanics assessments

by: Philip Cloues, Mining Engineer

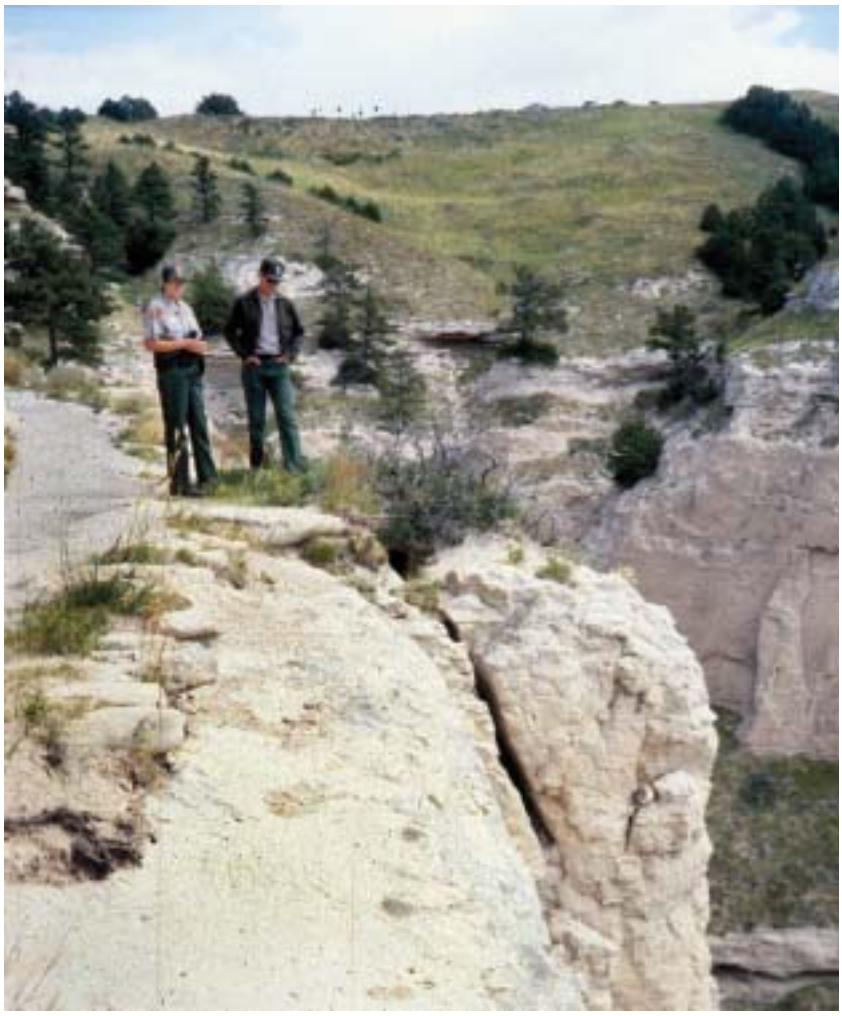
When a rock breaks loose, tumbles down a mountain slope or hillside, and comes to rest on a trail, a road, a building, or a person we ask ourselves the routine set of questions.

Why did it happen?

Will it happen again?

Could it have been prevented?

Occasionally, some alert person notices cracks or small rocks on a trail that indicate that a larger rockfall may be about to happen. If someone or something of value is in its path, then we call the problem rock a geohazard. Rockfalls are Mother Nature's way of using gravity to move rock features at high elevation to sea level. Gravity is assisted by water, freeze and thaw cycles, wind, rodents, roots, thermal changes, blasting, or seismic vibration from traffic or earthquakes. Rocks can become unstable if the slope is altered by construction for road or trail development, power line supports, canals, ditches, or building sites. Three key elements to rock stability are geology, geology, and geology. Rock type, fracture patterns, bedding planes, joints, inclination, geometry, specific gravity, strength, and many other factors can contribute to rock failure.



Trailside cracks at Scotts Bluff National Monument, Nebraska provide evidence of ongoing natural bluff retreat and potential rockfall areas.

When a potential rockfall threatens lives or physical assets, we have a problem. When these things are not threatened, we have erosion. Because of the random frequency of rockfalls, there is an element of risk or chance involved in the assessment of hazard analysis. Geologic processes of erosion may appear infrequent within our busy hectic schedules bounded by hours, days, and weeks. But geologic time is measured in millions of years and rockfalls that take place within a few years or decades are in fact a present day happening. Remember that gravity is always at work and its finished product is sand.

There are three possible solutions to geohazards involving rockfalls. Remove the hazard, remove the target, or engineer an artificial support for the problem rock. There is a forth alternative, no action, but this essentially relegates the target to an unknowing game of Russian Roulette. While appearing simple in concept, the access, size of potential rockfall, location, risk of triggering the fall by tampering with the problem, cost, surrounding geology, and other factors may complicate the remediation. Good planning should take into consideration the potential for rockfalls and avoid building facilities or structures within their path. Trails and roads should be constructed outside the fall zone if possible. Engineering solutions (e.g., rock bolts, cable anchors, concrete support, rerouting water runoff, energy absorbing cable nets, etc.) must be carefully analyzed, designed, constructed, monitored, and maintained to be effective.

Education is also a good tool to alert visitors and staff to the potential of rock falls. One can learn to spot hazard areas and avoid remaining at rest within the area (i.e., WATCH FOR FALLING ROCKS). People can become the early warning system to report rocks on the trail or road. An inspection can then determine if the small rocks are precursors to a larger event and a remedial action can be planned and implemented. Monitoring and good systematic record keeping can provide helpful information to long-term problems that appear to be random incidents but are in fact frequent and regular geologic incidents within the processes of erosion. Preventive maintenance and education can reduce the serious incidents, save lives, reduce injuries, and reduce costs. With geohazards, an ounce of prevention

can go a long way toward managing the problem rather than managing the destruction and clean-up action.

Parks can develop, through their loss management team, a contingency plan to respond to geohazard incidents. Education, monitoring, planning, and maintenance are tools to help manage a disaster before it happens. And, if an incident takes place, the preparedness should reduce the stress and facilitate the handling of the problem by better coordination of maintenance staff and equipment, rescue team, and local medical facilities. Planning prior to an incident in a period of calm makes handling an incident in the wake of stress and injuries a more manageable task and allows for a more professional response.

Rock mechanic engineering assessments of geohazards in 2001 took place at Harpers Ferry National Historic Park, Scotts Bluff National Monument, and Carlsbad Caverns National Park. Rock falls varied from a few tons to approximately 450 tons and potential rock fall included fractured rocks above roads, railroads, grass malls, surface trails, and underground trails. Rock types included sedimentary shale, mudstone, and limestone, as well as metamorphic schist and phyllite.

The Geologic Resources Division has expertise and contacts that can help in identifying potential problems and assisting with remedial recommendations and follow-up actions. In addition, *Management Policies 2001 (4.8.1.3 Geologic Hazards)* contains helpful information in dealing with such problems while considering the protection of natural processes. Each geologic hazard can be unique in its complexity but the policies will assist in a thorough analysis that should optimize the solution in a balanced manner. ◆