DEEP SLAB INSTABILITY

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Abstract[1]

Deep slab releases continue to claim victims. The best documented of these releases occur in ski area and highway situations where the deep instability is often anticipated by avalanche workers who must attempt to control the suspect avalanche slopes. The majority of deep slab (climax) avalanches involve a layer of temperature gradient snow and/or other major discontinuities within the snowpack.

The explosive test remains our single best method of testing for instability, but the test provided by explosives cannot be considered conclusive under all weather and snow conditions.

The questions, then, are: When can the explosive test be relied on? When is the test suspect? Beyond the basic explosive test, what additional test or control measures are in order, and when should these be implemented?

The above are discussed in technical but non-scientific terms. Practical solutions are offered.

Discussion

LACHAPELLE: Norm Wilson should be congratulated for raising the important question of charge-size. Allow me to give some history of charge-size in North America. When Atwater and I first experimented with explosives at Alta, we used charge-sizes of 8 kg of tetrytol - an explosive about 20% more powerful than TNT. We had quite an audience of skiers watching us from the porch of the Alta Lodge. These skiers were anxious to get back on the slopes, and we had to produce an avalanche to justify the closure. With a big explosive charge we usually produced the necessary avalanche. As the lifts expanded in Little Cottonwood Canyon, the avalanche problem became more complex, and we found it necessary to control more paths. Given constraints of manpower, time, and money, the only practical solution was to reduce the size of the explosive - from 8 kg to 4 kg,

[1] Full-length version of paper available by writing directly to the author.

to 2 kg, and, finally, to what is now standard, 1 kg. We experimented with smaller charges and convinced ourselves that it would not be wise to use less than 1 kg. However, my recommendation is, that if you have any doubt, use a large charge.

HOTCHKISS: I wonder, Dr. LaChapelle, in the days when you and Atwater did control if you really had a sufficiently large sample size to draw definite conclusions about the effect of explosive size, especially about the post control release problem?

LACHAPELLE: You have a good point. We were not throwing the thousands of charges as is common today in some of the more complex areas.

SIMMS: I hate to open up a "can of worms," but the combined control programmes at Jackson and Snowbird use about 10,000 hand-charges each season. The majority of our charges are 1 kg, but we often use ½ kg for surface instability. It is not clear to us that 1 kg represents an absolute minimum.

FUHRMANN: Continuing with this "can of worms"; in a ski area, perhaps 1 kg is practical for day-to-day operations where slopes are constantly monitored and under control, but for helicopter control we often arrive after slopes have started to stabilize. We cannot leave the snow hanging over the road to release spontaneously at the start of the next storm. We have had very good success using large charges from 5 kg to 40 kg.

FITZGERALD: One should not rely too heavily on explosives, regardless of amount. Slopes have been saturated with explosives, only to release accidentally at a later time. Adjusting the explosive amount is not a substitute for proper timing of control, correct target selection, or for making a proper evaluation of conditions and taking necessary precautions.

WILLIAMS: Selection of an appropriate charge-size for given conditions is still a research topic. It is difficult to decide on the question until we find better methods for measuring changes in the slope stability caused by the explosive blast. Perhaps recent work with acoustic emissions, geophones, and accelerometers will provide the much-needed clues. For now, the question is quite open.

WILSON: I agree with much of what has been said, but unless we set some standard, ski areas may be tempted to use smaller and smaller charges to save money, until an increased number of accidents makes it clear that explosive sizes are too small.

NEWCOMB: I hope no one objects if we move on to another question. Why does a rise in temperature reduce stability?

BRADLEY: Snow becomes very weak as it approaches the melt point (0°C). This is quite evident in the spring.

PERLA: A temperature rise during a storm could produce an inverted density profile, with a heavy dense slab resting on a loose sliding layer. A temperature rise may also correlate with an increase in precipitation intensity during a storm.

WILSON: In my paper, I was not referring to spring conditions, or to a temperature rise during a storm, but to a sudden rise in temperature on a clear winter day, when the snowpack temperatures are below 0°C.

MCCLUNG: The near-surface snow layers will deform more rapidly at warmer temperatures.

NEWCOMB: But how does one explain deep slab instability with this mechanism? Snow is a good insulator, and conducts heat slowly. Perhaps a sudden temperature rise affects the surface, but what does this have to do with deep slab instability?

WILLIAMS: Also, Norm Wilson mentioned that a sudden drop in temperature may also decrease stability.

WILSON: I reluctantly included that remark in my presentation. However, a number of the people I work with believe that any sudden temperature change, rise or fall, decreases stability.

WAKABAYASHI: A temperature change, rise or fall, could lead to changes in surface tensions, and differential contractions or expansions.

LEV: At Alta, we have also been concerned about all sudden changes in the stress state of the snowpack. Snow Ranger, Bingt Sandhal, is presently measuring the effects of barometric pressure changes as well as temperature changes. One must keep in mind that the snowpack fails due to stress changes that are quite low ($\sim$ 10 mb).

ARMSTRONG: Granted, that sudden air temperature changes affect the snow surface, but, as Rod Newcomb previously noted, snow is a poor conductor of heat. Therefore, how is a rapid change in air temperature transmitted to any significant depth?

LACHAPELLE: Indeed, heat is conducted slowly, but mechanical disturbances (fracture, stress waves) propagate quickly. If the temperature change leads to a mechanical change at the surface, then perhaps it is the mechanical disturbance that propagates to depth.

WILSON: I hope I did not leave the impression that sudden temperature change is the most important variable in deep slab instability. It may only be the "straw that broke the camel's back."