NEW EXPERIMENTS WITH METHODS FOR AVALANCHE RELEASE

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Abstract

This contribution is based on a paper presented to the Symposium on Applied Glaciology, International Glaciological Society, Cambridge, England, 1976. The paper can be found in the Proceedings of that symposium.

The method of artificial avalanche release most widely used today is the initiation of snow slab fracturing by high explosives. Such explosives, delivered to the avalanche release zone by hand or as artillery projectiles, provide a powerful disruptive force which can cause avalanche release in an unstable, stressed snow cover. Currently, the rising demand for avalanche control activities to protect ski resorts, highways and railways by artificial release is coming into conflict with the safety and regulatory problems of storing and handling explosives and, especially in the U.S.A., the declining availability of surplus military weapons and ammunition which have been widely used for this purpose. To provide alternatives to high explosives, a research programme is now under way to design and field-test other methods of artificially releasing avalanches. Innovative methods to prevent formation of unstable snow slabs are also being considered. Replacements for artillery and explosives are not expected to be found for all cases, but very possibly they can be developed for many of the smaller and more active avalanche paths which require a major part of the control activities.

Two new methods of initiating avalanche release have now been proven effective. Both make use of a basic characteristic of snow slabs, the differential creep and glide leading to the storage of elastic strain energy in snow. The subsequent propagation of fracturing, sometimes extensive, is often accompanied by avalanche release. These methods depend, as does the use of explosives, on providing a means to initiate such fracturing in snow.

1. Gas Exploder System. Canisters buried in the ground (several configurations have been tested) permit the repeated discharge of a detonating gas mixture upward into the snow cover. Several canisters can be fired simultaneously along a normal avalanche fracture line. A control system meters the gases (oxygen and acetylene) through a hose to the canisters and provides an electric spark for firing. Gas cylinders,

regulating valves and the control system are installed adjacent to the avalanche release zone, with operation initiated remotely by radio or land line signals. A typical installation stores enough gas for 30 to 50 firings, adequate for an entire winter's control operation. This system is effective and reliable for avalanche release in climates with cold, shallow snow covers. So far, it has proven less effective in deep, heavy snows of a maritime climate, where larger levels of explosive energy are required at the base of the snow cover.

2. Air Bag Inflation. Relatively small pressures (40 kN/m^2) are required to lift the snow of even a deep alpine snow cover, while larger but still modest pressures (100-200 kN/m^2) can break the rigid beam of even the strongest snow slab. Large, strong, inflatable air bags (1.3 m × 2.8 m and up) are readily available commercially as cargo dunnage bags. These have been tested for snow avalanche and cornice release by installing them on the ground surface prior to winter snow accumulation and then inflating them from time to time during the winter. They are highly effective at disrupting the snow cover, initiating fracturing and displacing cornices. Current tests include several configurations of bag deployment and several inflation methods such as direct air line from a heavy compressor (highway), local high-pressure air cylinders and small local compressors operated by remote control. This relatively low-cost system offers considerable promise for practical avalanche control.

Mechanical vibrations and sound energy are also being investigated as a means of releasing avalanches. Sufficiently high-energy motions (e.g., ground motions from earthquakes) are known to be effective avalanche triggers, but uncertainty exists about the efficacy of practically useful energy levels, owing to the very high absorptivity of snow for sound energy. The theoretical ideal would be to induce standing waves (mechanical resonance) in bounded slabs from a small-amplitude source of the proper frequency. Current basic investigations into sound propagation in snow have failed so far to support this ideal or even identify the natural resonant frequencies. Additional investigations are under way supplemented by empirical field tests of energetic vibrators (compressed air tools) located in avalanche release zones.

Modification of the snow-earth interface to inhibit creep and glide of the snow cover (supporting structures) is a well-established means of avalanche prevention. The converse principle, enhancement of creep and glide to encourage frequent small avalanches at the expense of large ones, is now being investigated. Preliminary tests have shown that plastic membranes placed on the ground surface in avalanche release zones enhance glide to the point where a persistent snow cover cannot be sustained on the mountainside. A number of practical problems exist with this approach, especially with anchoring the membrane against high wind, but it shows considerable promise for management of avalanche occurrence in selected areas. Field tests are continuing.

For further details on these new methods of avalanche control, interested readers may consult the following references:

References

LaChapelle, E.R. et al., 1975. Alternate methods of avalanche control. Washington State Highway Department Research Programme Report 19.1, Olympia, 158p.

LaChapelle, E.R. et al. 1976. Alternate methods of avalanche control, Phase II. Washington State Highway Department Research Programme Report 19.2, Olympia, 95p.

Discussion

THYER: Could the "interface sheets" be used for cornice control?

LACHAPELLE: We have not yet experimented with that particular idea but the technique has wide application. Cold snow does not adhere to polyethylene. People with mountain cabins cover their roofs with polyethylene sheets to avoid shovelling.

EIGENMANN: Did you find that temperature affected the efficiency of the "interface sheets"?

LACHAPELLE: Snow appears to slide off the sheets at all temperatures. However, there may be some adhesion after thawing and refreezing. Once installed, an "interface sheet" seems to work well, although it is not easy to keep the sheets fastened in strong winds.

KUCERA: Have you considered trying to support your interface sheets against wind with polyethylene mesh, the type used for erosion control fabrics and cargo nets?

LACHAPELLE: No, but we would be interested in learning more about this mesh and running some tests.

EIGENMANN: Have you compared costs of your "airbag" equipment with conventional explosives?

LACHAPELLE: This project is still in the research stage and we have not made a commercial cost study. Initial installation costs are relatively high. However, in the long run, such equipment could compete economically with the cost of artillery rounds. Airbags cost $200 per unit, but in contrast to artillery rounds, they are reusable.

GEISLER: Can you clarify your remark about the efficiency of an explosive charge detonated above the snow compared to a charge detonated in the snow?

LACHAPELLE: Tests made by Gubler in Switzerland indicate that a charge detonated above the snow is more efficient than a charge detonated within the snow. The air-blast spreads the energy out more efficiently, and with respect to slab avalanches, would give a better chance of hitting islands of weakness. In Austria, recent experience in firing charges above the snow have shown that the efficiency increases by a considerable percentage; in one series of experiments from 30% to 90%. Earlier, we discussed with the Army the possibility of using proximity fuses in our artillery rounds, but were advised that these rounds could be quite hazardous.

KOEDT: What is the optimum height above the snow for detonating explosives?

LACHAPELLE: Approximately 2 m.

WILSON: Would air-blast be more effective for soft slabs than deep slabs?

LACHAPELLE: Probably more effective for soft slabs, but we need more data.

ANDERSON: What types of explosives were used in Gubler's experiments?

LACHAPELLE: He used explosives with a wide variety of speeds, and confirmed that high-speed explosives are more efficient. This is something that we have suspected for some time.

HAMRE: With respect to shot placement, we have found that, in some cases, a shot placed low on a slope, in the compression or Stauchwall region, is more effective than a high shot placed in the tension or crown region.

STETHEM: At Whistler Mountain, we have also had good luck aiming into the compression zone of the slab.

PERLA: I think all of us can relate an experience where a low shot released a sizeable slab. Sometimes, it appears that the spectacular crown fracture is the last place where the slab fails, hinting, for that particular case, that shear fracture propagated upslope from the Stauchwall failure. At present, there is a definite preference among field-men to fire into the crowns. However, the optimum target location (crown, centre, or Stauchwall) is a topic of controversy that requires further study.