SURFACE TENSION OF SNOW SLOPES AND AVALANCHE CONTROL

R. Wakabayashi

Abstract[1]

It is known that snow metamorphism is initially driven by the tendency of individual snow grains toward minimum surface area (Kuroiwa, 1976). Dendritic arms and other surface protrusions disappear as material is transferred by diffusion to either free crystal faces or to bonds between crystals. This type of metamorphism produces a volumetric contraction of the layer (Kojima, 1967; Nakamura and Kenmotsu, 1971). The contraction may be apparent in laboratory uniaxial tests. For example, Shinojima (1967) performed slow uniaxial tests on snow in compression and tension. He found that Poisson's ratio (ratio of lateral deformation to axial deformation) was approximately zero in compressive tests, and approximately 0.5 in tension tests. This behaviour can be explained by assuming that snow contraction is significant when samples are loaded at slow rates.

Contraction will cause added stress or surface tension in amounts that depend on geometry and boundary conditions. Some of the effects of surface tension are manifested by snow pressures against trees or posts (Takahashi, 1968). With respect to slab avalanche development, the critical stress field may be a result of contractions that occur at localized regions of the slope. The resulting surface tensions may cause fracturing and, hence, slab avalanche release. In studies of snow slope deformation (Nakamata, 1962; Sato and Ishikawa, 1971), it was found that the rate of contraction increased prior to the formation of cracks. Of course, it should be understood that contraction is not the sole cause of slab avalanche release, and that avalanche instability correlates statistically with such factors as rate of snowfall and wind (Bojo et al., 1973).

The author has developed a new method for measuring snow slope contraction. Using a portable frame, a set of three small holes (diameter 4 cm, depth 5 cm) are made on the snow surface in the configuration of an equilateral triangle (vertices spaced 80 cm apart). A coloured ping-pong ball is placed in each hole. From 20 to 50 of these triangular references are laid out on the test slope. After a certain number of days, the positions of the ping-pong balls are

---

[1] Full-length paper available on request from author.

monitored. Records are also kept of the inclination of the planes of the equilateral triangles. Strain-rates, as measured by the sides of the equilateral triangles, were generally found to be in the range of $\pm 10^{-3}$/day, and occasionally as high as 10^{-2}/day. It was interesting that the extreme values were observed at directions oblique to the fall line, indicating that flow patterns have distinct sideward components.

It may be possible to stabilize snow slopes by altering the surface tension field. Some promising experiments based on arranging logs on slopes in order to produce concavities are described by Wakabayashi, Yoshida, and Omori (1976).

References

Bojo, T. et al., 1973. Ippan kokudô 112-gôsen nadare chôsa hôkokusho (Report of Avalanche on National Route 112). Kokusaikôgyô Co. Ltd., Tokyo, Unpubl. Report 109 p.*

Kojima, K. 1967. Densification of seasonal snow cover. Physics of Snow and Ice, Institute of Low Temperature Science, Sapporo. pp. 929-952.

Kuroiwa, D. 1976. Bunsankei tositeno yuki no kôzô to rikigaku (Structure and mechanics of snow as a dispersed system.) Kishô-kenkyû-note Meteo. Soc. Japan, No. 128, pp. 231-251.*

Nakamata, S. 1962. Shamen setsuatsu (Pressure of a sloping snow cover). Railway Technical Research Report, No. 322, 56 p.*

Nakamura, T. and Kenmotsu, K. 1971. Sitsujun sekisetsu no assyuku nensei keisû no sokutei (The measurement of compactive viscosity factor of wet snow-pack). Short Report Japanese Soc. Snow and Ice, Showa 46, p. 43.*

Sato, S. and Ishikawa, M. 1971. Sekisetsu no idô to idôatsu ni oyobosu kaya no eikyô (Effect of grass cover on displacement and pressure of sloping snow-pack). Report Tôhoku-branch Japanese Forestry Society, No. 22, pp. 90-93.*

Shinojima, K. 1967. Study on the visco-elastic deformation of deposited snow. Physics of Snow and Ice, Institute of Low Temperature Science, Sapporo, pp. 875-907.

*In Japanese

Takahashi, K., Kataoka, K. and Sato, S. 1968. Ryûboku ni kuwawaru setsuatsu I (Pressure of snow cover acting on trees, 1st report). Bull. Government Forest Exp. Station, No. 210, pp. 155-174.**

Wakabayashi, R., Yoshida, T. and Omori, T. 1976. Hokkaidô-Daigaku Hiyamachihô-ensyûrin no nadare jôshûchi ni okeru shinrin zôsei shiken. (Test Afforestation on the avalanche hazard slope of Hiyama Experimental Forest of Hokkaido University.) Ensyrûin Gyômushiryô Hokkaido Univ., No. 16.*

*In Japanese

**In Japanese with English Summary.