MEASUREMENT OF SNOW HARDNESS IN SNOW PITS USING A RESISTOMETER

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EXTENDED ABSTRACT

Measurements of snow hardness in snow pits are commonly made using the hand test, whereby objects of different areas are pushed into the snow pit wall to obtain a relative measure of the hardness of various layers (Colbeck, et al., 1990). Results from the hand hardness test vary between observers, making a comparison of snow pits dug by different observers (with different levels of experience) over a large area difficult. Additionally, graphic representations of these data may not accurately reflect the hardness relationship between various layers. Although a more quantitative and consistent measure of snow hardness can be derived from the Swiss Rammsonde, rammsonde measurements are time consuming, the rammsonde is heavy, and rammsondes are not widely used by operational avalanche professionals in the United States. It would be beneficial to develop a methodology for hardness measurements combining the quickness and portability of the hand test with the consistency and accurate graphical representations provided by the rammsonde.

In this study a "resistometer" used in the 1960's for avalanche investigations (Bradley, 1966) was modified to allow the measurement of the hardness of various snowpack layers. The resistometer, which is easily portable, consists of a 4 cm^2 plate which is attached to an encased spring and a 0.01 mm displacement gauge with a maximum hand. Similar to the hand test, the plate is pushed into the snow layer of interest on the snow pit wall, and a reading of the displacement is taken. Five to eight readings were taken for each layer, and a mean value was calculated. The device is calibrated such that a displacement of 0.01 mm is equal to a force of 2 gm/cm^2, which can be easily converted into Pascals. Resistometer data were plotted side by side with hand hardness data so a comparison of the tests could be made.

Problems associated with refining the instrument this past season included a broken displacement gauge which had to be replaced, missing critical screws and other assorted difficulties. Waiting for replacement parts hampered data collection efforts, precluding the collection of sufficient data before the snowpack went isothermal for reliable statistical tests for this season. However, initial results with the resistometer are promising.

The resistometer was easily portable, with a weight similar to a 35 mm camera. Additionally, it was simple to use; measurements for a snow pit typically took less than 5 minutes. A comparison of the resistometer with the hand hardness test showed that both tests demonstrated the relative strengths between layers (Figure 1). However, only the resistometer was able to reveal the actual hardness relationships between the layers. Comparisons between workers demonstrated that the resistometer could be used by different people to obtain similar results, but insufficient data were collected to calculate a statistical relationship.

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Additionally, the resistometer, with its increased sensitivity and small plate size, was better able to pick up subtle weaknesses and strengths within the snowpack. In Figure 1 a delicate layer of surface hoar at 85 cm was identified with the resistometer which was not measurable with the hand test. The snow pit profile for the resistometer at this site was much better able to describe the intricacies of the snowpack. Identification and quantification of this particular layer was important, since this surface hoar formed the weak layer for several avalanches in southwest Montana during February, including two which resulted in fatalities.

Initial work with the resistometer indicates that it has the potential to be a portable and reliable instrument for the measurement of consistent snow hardness data. It also may help to measure small and/or extremely weak layers that are not adequately measured with the hand hardness test. Now that the instrument is fully operational, work next winter is planned to quantify the relationship between resistometer measurements and hand hardnesses, and to try to establish strength thresholds which may be important for snowpack stability. Other work will quantify the consistency of measurements taken by different individuals.

REFERENCES

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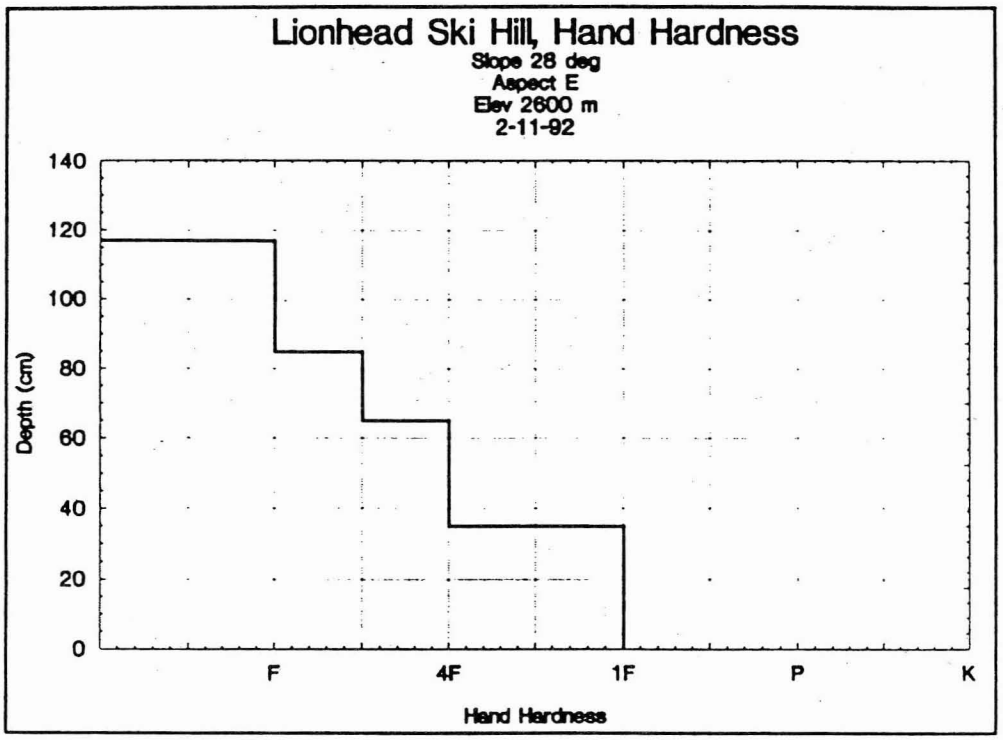

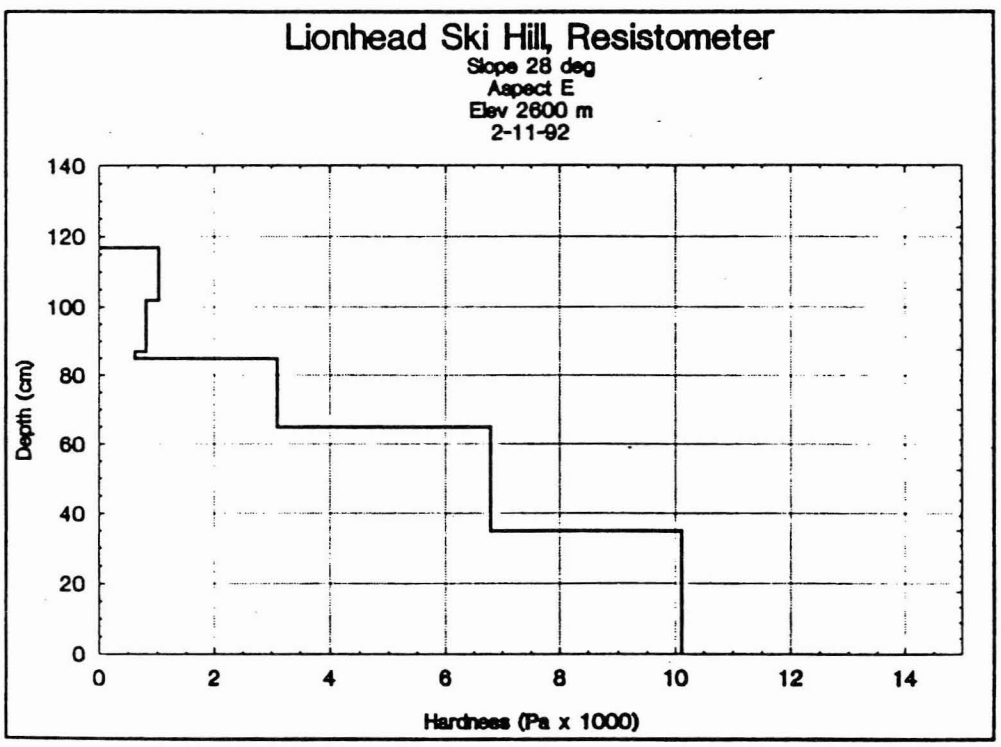

FIGURE 1: A comparison of hand hardness and resistometer profiles for a snow pit shows that the resistometer profile is better able to identify and quantify layers within the snowpack. The thin weak layer identified with the resistometer at 85 cm was a fragile layer of surface hoar.