Experience with stability evaluation for a surface hoar layer during winter 1995-96 at Rogers Pass, British Columbia, Canada

Jürg Schweizer[1], David Skjonsberg[2] and Bruce McMahon[2]
[1]Department of Civil Engineering, University of Calgary, 2500 University Drive NW, Calgary AB T2N 1N4, Canada
phone: +1 403 220 7479, fax: +1 403 282 7026, e-mail: jschweiz@acs.ucalgary.ca
[2]Avalanche Control, Mt. Revelstoke and Glacier National Parks, PO Box 350, Revelstoke BC V0E 2S0, Canada
phone: +1 604 837 7516, fax: +1 604 837 7536, e-mail: david_skjonsberg@pch.gc.ca

Keywords: snow crystals, snow strength, snow cover stability, avalanche forecasting, avalanche control

ABSTRACT
During January 1996 the stability evaluation for both the transportation corridor and the backcountry area depended on a buried surface hoar layer prominent throughout Glacier National Park, British Columbia, Canada. The little case study reviews some of the, we think, rather unusual behavior of this snowpack weakness. The most distinct feature of this situation was the spatial distribution of the surface hoar layer.

INTRODUCTION

The avalanche control section at Rogers Pass, British Columbia, Canada, is responsible for the avalanche safety within Glacier National Park. This involves the protection of the Trans Canada Highway (TCH) and the Canadian Pacific Railroad (CPR) mainline and the issue of an avalanche warning bulletin for backcountry users of the park. When avalanche conditions become critical the transportation corridor is closed and avalanches are released artificially by artillery fire.

Primary parameters for stability evaluation include upper elevation meteorological data (e.g. to assess snow transport by wind), index values from study plots (e.g. shear frame test results), stability tests from slopes (e.g. rutschblocks, hand charges) and avalanche activity (avalanche observation patrol).

The principle observation site is Mt. Fidelity 1905 m a.s.l. Traditional weather and snowpack observation in the study plot is supplemented by four automatic stations located in the control area that collect additional data that is transmitted by radio modem to the control centre at Rogers Pass 1300 m a.s.l. where another study plot is located.

THE AVALANCHE CYCLES DURING JANUARY 1996

During roughly the first two weeks of January 1996 a total of 207 cm of new snow was recorded at Mt. Fidelity (Fig. 1). Four major avalanche cycles occurred (Fig. 2). All began with natural activity and resulted in a control program. The snowpack weakness of concern was a buried surface hoar layer.

SURFACE HOAR GROWTH

The surface hoar crystals had formed towards the end of December 1995 during anticyclone weather conditions. A prominent temperature inversion (Fig. 3) due to nocturnal radiative cooling and primarily calm conditions, had favored crystal growth in the valleys, and in particular in an elevation band just below the top of the inversion layer where clouds (radiation or ground fog) had formed (Fig. 4). This feature of spatial distribution strongly influenced stability evaluation.

DISCUSSION

Of particular interest was the reactivity (sensitivity, response to dynamic loading) of the surface hoar layer, i.e. when and where avalanches actually occurred and/or were triggered. General experience suggests and measurements show that surface hoar layers can be snowpack weaknesses for weeks (Jamieson, 1995). However, this layer seemed to be critical only for a relatively short period of time.

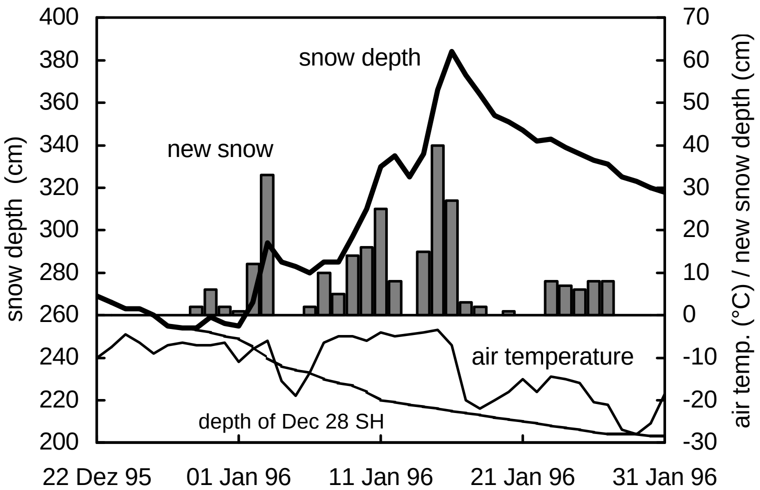

Figure 1: Wheather and snowpack development at Mt. Fidelity 1905 m a.s.l.

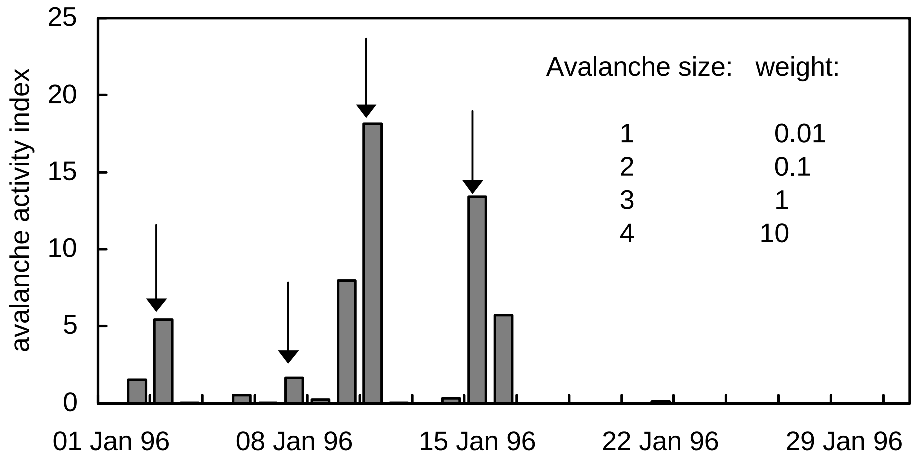

Figure 2: Natural avalanche activity along the transportation corridor through Glacier National Park. The avalanche activity index is the sum of all natural avalanches considering avalanche size by a weighting factor (approximately related to the volume).

Initially, artillery avalanche control was unsuccessful in initiating release of this weakness due to the spatial distribution of the surface hoar layer, and to the slab properties that were not favourable for failure initiation (Schweizer et al., 1995). Finally, during the avalanche cycle of January 10-11, 1996, avalanches from the high elevation starting zones running on a new snow instability, triggered the surface hoar layer in most avalanche paths resulting in the release of large masses of snow.

Skier triggering was unlikely until about 5 January 1996. Most involvements were reported around 8 January 1996 after additional snow fall, and in particular, after warming quickly changed the slab properties. After the last storm on 15 January 1996, skier triggering quickly became unlikely due to depth of the weak layer. Substantial cooling may also have contributed to stabilization.

The case study suggests that monitoring snowpack weaknesses is an essential part of successful stability evaluation. Jamieson (1995) showed in detail that the skier stability index is a better predictor for skier triggered slabs than common meteorological observations. Consistent and continuous shear frame measurements in a representative study plot on new (storm) and old (persistent) snow instabilities is a good method to monitor the strength of weak layers. As slab properties are important to assess failure propensity, these measurements should be complemented with stability tests on nearby slopes.

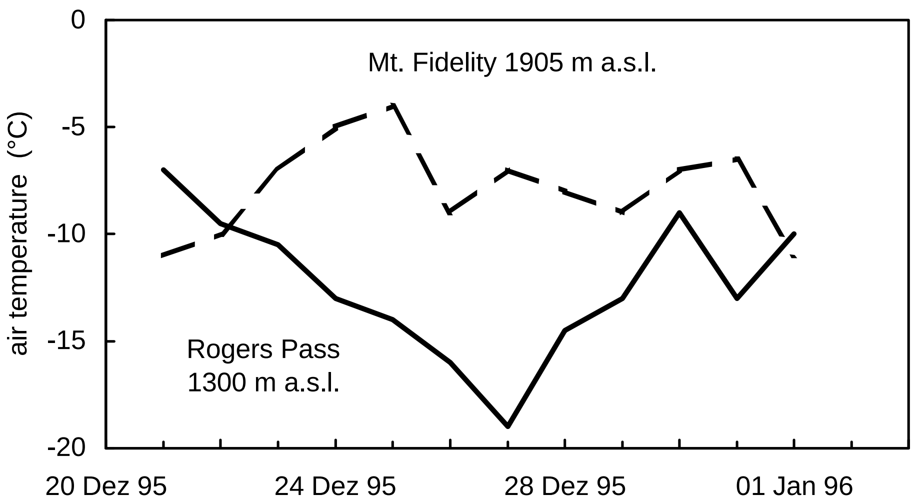

Figure 3: Air temperature (at 07:00) at Rogers Pass 1300 m a.s.l. and Mt. Fidelity 1905 m a.s.l. during the second half of December 1995 showing the strong atmospheric inversion.

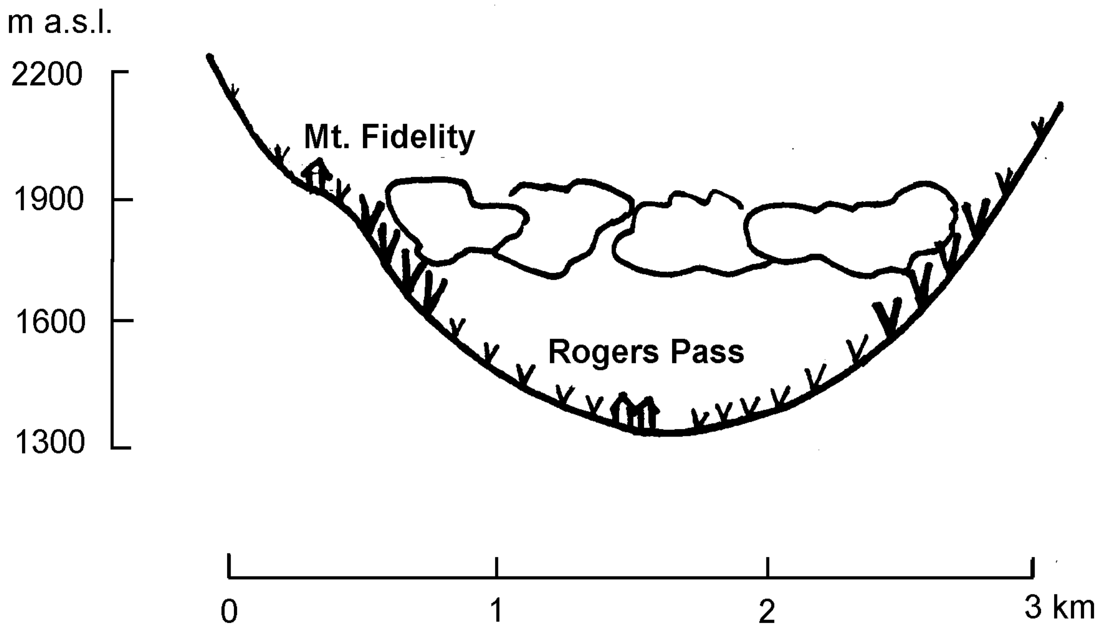

Figure 4: Schematic showing spatial distribution of surface hoar in a valley cross section.

References

Jamieson, J.B. 1995. Avalanche prediction for persistent snow slabs. Ph.D. Thesis. University of Calgary, Alberta, Canada, 258 pp.

Schweizer, J., Camponovo, C., Fierz, C. and Föhn, P.M.B. 1995. Skier triggered slab avalanche release - some practical implications. In: Proc. Int. Symposium: Sciences and mountain - The contribution of scientific research to snow, ice and avalanche safety, ANENA, Chamonix, France, May 30-June 3, 1995, 309-316.