OBSERVATIONS OF SNOW AVALANCHES ON DYNAMIC INTERNAL STRUCTURES AT ALTA, UTAH

Osamu Abe*1, Tsutomu Nakamura*2, Yasuaki Nohguchi*2,
Rand Decker*3,Thor Femenias*3 and Daniel Howlett*4

*1 Shinjo Branch of Snow and Ice Studies, National Research Institute for Earth Science and Disaster Prevention(NIED)
Tokamachi, Shinjo-shi, Yamagata-ken, 996 Japan
Tel.+81-233-22-7550 Fax.+81-233-22-7554
*2 Nagaoka Institute of Snow and Ice Studies, NIED
Suyoshi, Nagaoka-shi, Niigata-ken, 940 Japan
*3 Department of Civil Engineering, University of Utah
Merrill Engineering Bldg., Salt Lake City, Utah 84112 USA
*4 Center for Snow Science at Alta
Post Office Box 8067, Alta, Utah 84092 USA

ABSTRACT

Observations of snow avalanches on dynamic internal structures were carried out at Alta, Utah as a Japan/U.S. joint research project. A pylon to measure the impact pressures of snow avalanches was installed beneath Mount Baldy in an avalanche path which releases frequency both naturally and artificially. The mean slope angle of the avalanche path is approximately in 37 degrees. Three pairs of pressure gauges of 1.2 cm in diameter and two load cells with a pressure plate of 12.0 cm in diameter were set up on the pylon. Each pressure gauge has a sufficient small contact area as compared with to a snow block contained in avalanches. The pairs of the pressure gauges were prepared to determine the internal velocities from the lag times of each two impact pressure waves. A data set with regard to the internal structures was obtained by the research project. Meteorological data were also obtained in the Alta ski area. The data is being analysised in the both countries.

INTRODUCTION

There are few data with regard to internal structures of snow avalanches(Schaerer,1973; Kawada et al.,1989; Nishimura et al.,1993). The internal structures of avalanches must affect the impact velocity and the runout distance. Recently, an impact pressure data set of the snow avalanches released naturally or artificially was obtained at Alta, Utah by a Japan-U.S. joint research project involving the National Research Institute for Earth Science and Disaster Prevention, the USDA Forest Service National Avalanche Center, the Department of Civil Engineering at the University of Utah and the Center for Snow Science at Alta.

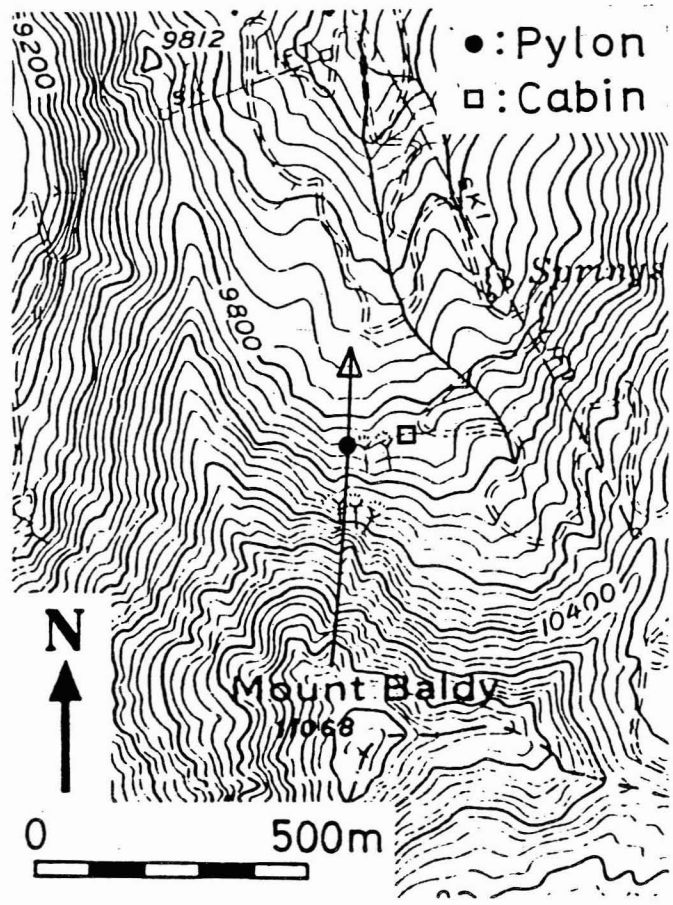


Fig.1 Topographical map around the observation site.

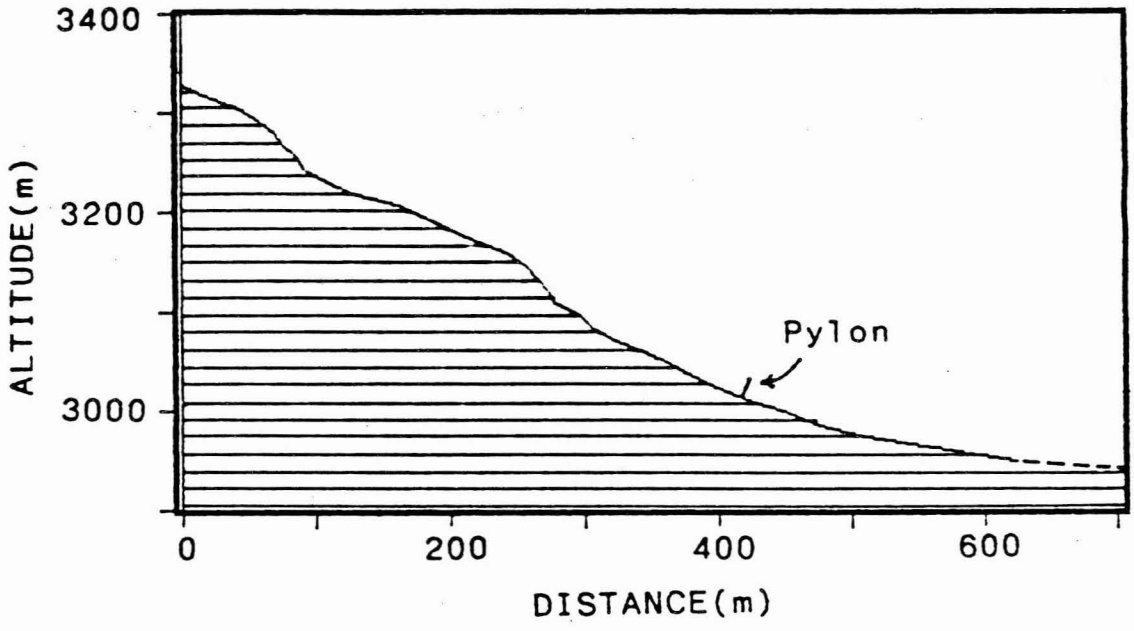


Fig.2 Slope profile on the avalanche path.

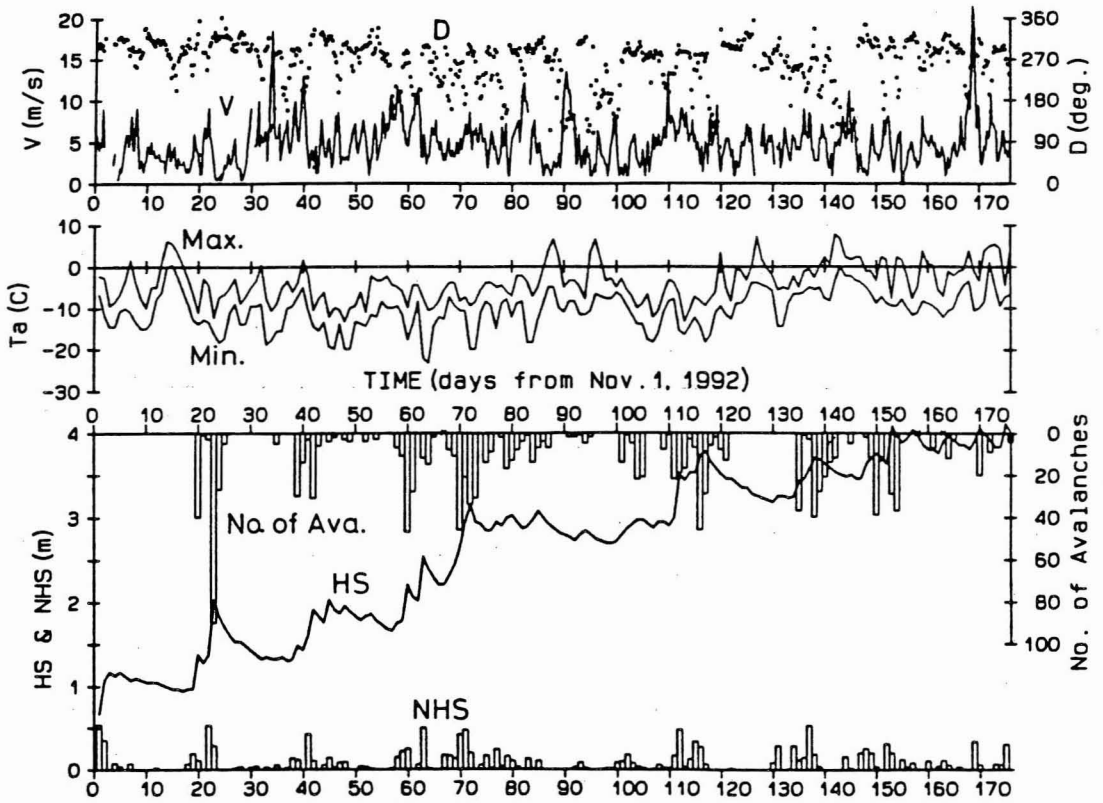
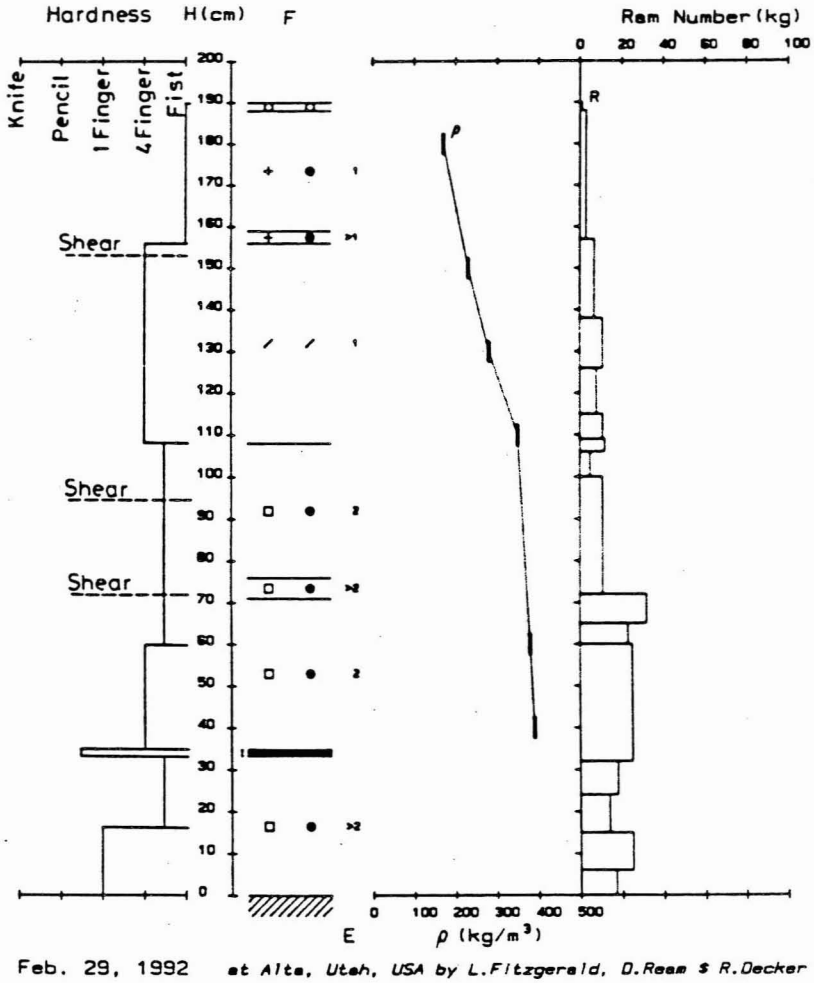


Fig.3 Daily variations of meteorological data.



Feb. 29, 1992 at Alta, Utah, USA by L.Fitzgerald, D.Ream & R.Decker

Fig.4 Result of the full depth snow pit observation.

LOCATION

The observation site is located in the Alta ski area, Utah. Fig.1 shows a topographical map including the observation site. The pylon facility was installed beneath Mount Baldy in an avalanche path which releases frequency both naturally and artificially as a result of Alta Ski Lift's operational control program. A cabin beside the pylon is used to keep the recording system. Elevation of the observation site is 3,000m high above mean sea level.

SLOPE PROFILE

The avalanche path, "Tombstone" called the chute beneath Mount Baldy was selected as mentioned above. The slope profile of the avalanche path is shown in Fig.2. Average slope angle is 37 degrees approximately and an angle at the pylon site is 23.5 degrees. In the slope, a big avalanche passes the pylon site, but a small one stops around there. In fact the pylon was buried from debris of the small avalanches.

WEATHER CONDITION

Typical weather conditions in winter at Alta are low temperature and heavy snow fall. Fig.3 shows an example of daily variations of wind speed ,wind direction, maximum and minimum air temperatures,snow depth and newly fallen snow depth, and number of the avalanches occurred naturally and artificially in Alta for 1992/93 winter. The meteorological data were obtained in the base of the Alta ski area. The most frequency wind direction is north-west, and mean wind speed is 5 m/s approximately.

Fig.4 shows an example of results of full depth snow pit observation in the end of February, 1992. There are many dry snow layers formed by non-melting metamorphism as shown in this figure.

PYLON FACILITY

The avalanche impact pylon facility was designed by Japanese side, and was installed by U.S. side. For the design of the footing of the pylon under the avalanche forces sufficient investigations were carried out by Clayton A. et al.(1992). Six pressure gauges of 1.2 cm in diameter and two load cells with a pressure plate of 12.0 cm in diameter were set up on the pylon(Fig.5). An acceleration meter to detect the vibration caused from the avalanches was also set up on the pylon. Schaerer P.A.(1973) investigated that the snow avalanche consists of snow blocks of many kinds of size. The pressure gauges on the pylon have a sufficient small contact area as compared with to the snow block contained in avalanches.

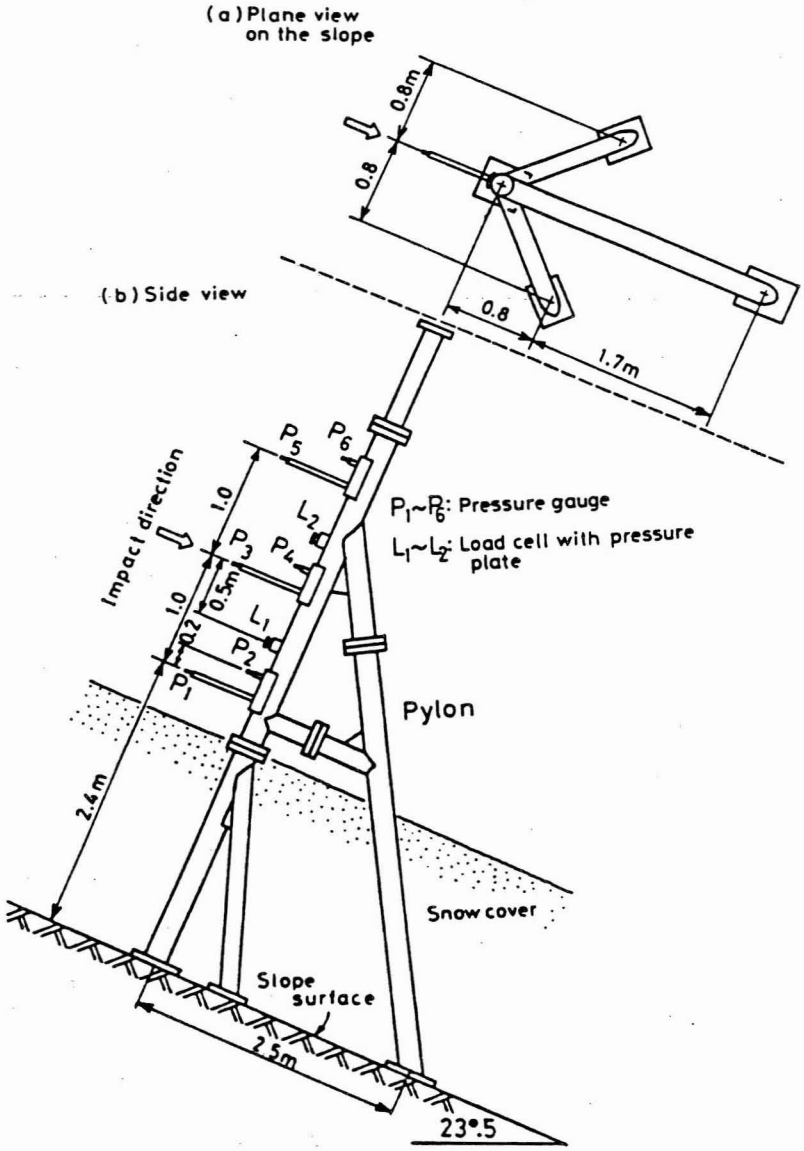


Fig.5 Pylon facility installed at Alta.

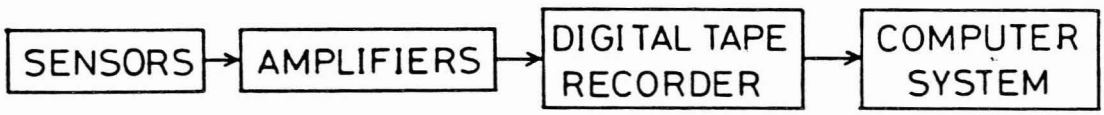


Fig.6 Measuring system.

MEASURING SYSTEM

Each sensor used in the measuring system has a high frequency responses over 5 kHz. The sensors have a paformance to detect a small size of the snow blocks. If an avalanche of 20 m/s in velocity passes the sensors, the minimum size of which the snow block can be detected, is caluculated easely to 0.004m(20m/s x 1/5000s). This size is sufficient small to detect the small snow blocks. Signals of the sensors were passed amplifiers and were recorded on a digital tape recorder(Sony magnescale Co. Ltd.) as shown in Fig.6. The recorder contains an auto trigger mode which starts to record the wave signals after one of the signals exceeds a level without miss before the start time because of transient memories. However, sometime a manual mode was used also for easy operation. After the record the data were trancformed to an Unix computer system.

INTERIM RESULTS

Many efforts were carried out to obtain the avalanche data. The wave data are being analysed with the Unix computer system, however an example of raw data obtained at 17 March, 1993 are shown in Fig.7. As mentioned above the pylon was burried by debris at the end of winter, so that the wave data only upper pressure gauges were recorded here. Fig.8 shows an avalanche attacking the pylon on the beginning of the winter 1993/94.

From wave analysis of the impact pressures, velocity and size distribution of snow blocks will be calculated. Also snow densities will be estimated from both the impact pressures and velocities. The results will be compared with those of the avalanches in Kurobe Canyon, Japan and others.

CONCLUSION

A pylon facility and measuring system to obtain dynamic data with regard to internal structures of snow avalanches was installed in a avalanche path at Alta, Utah. By the avalanche site installed at Alta the impact pressure waves can be taken constantly because of the high frequency of artificially released avalanches. This project continues even now by the efforts of both Japan and U.S. sides.

ACKNOWLEDGMENTS

The authors wish to express their thanks to Mr. Doug Abromeit and Mr. David Ream of the USDA forest service for their helpful collaboration, Alta Ski Lifts Company for their grateful backups.

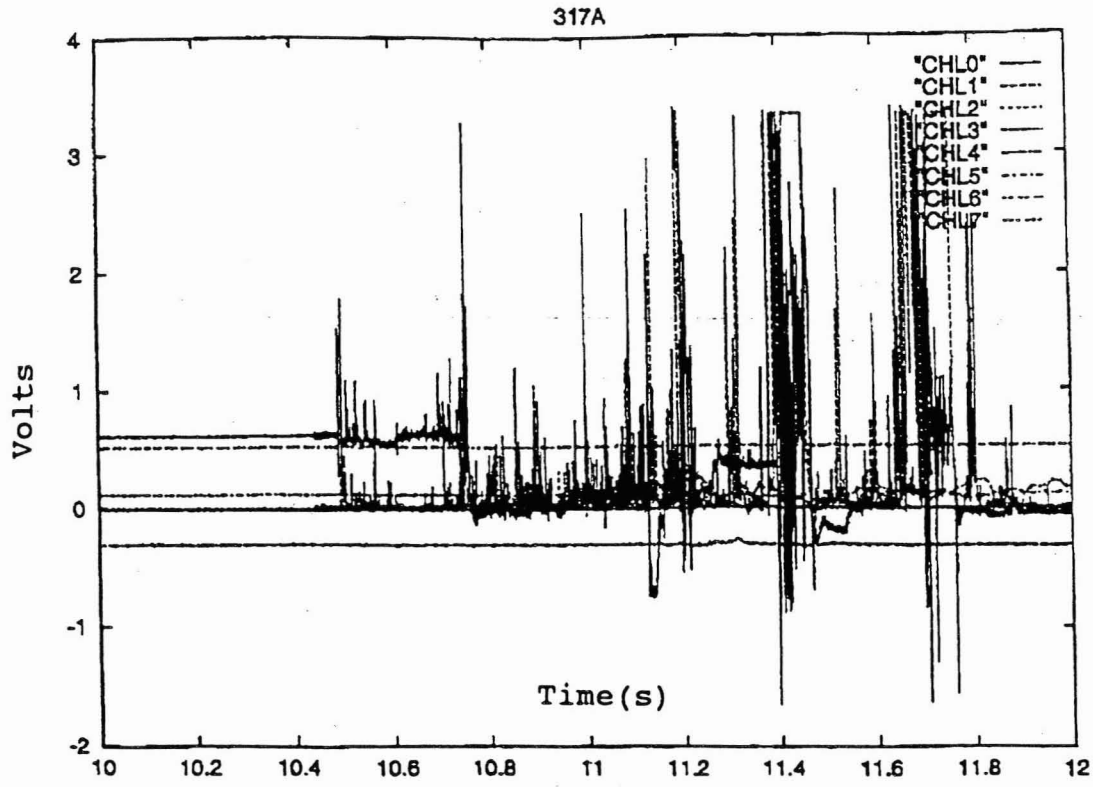


Fig.7 An example of the raw data of the impact pressures.

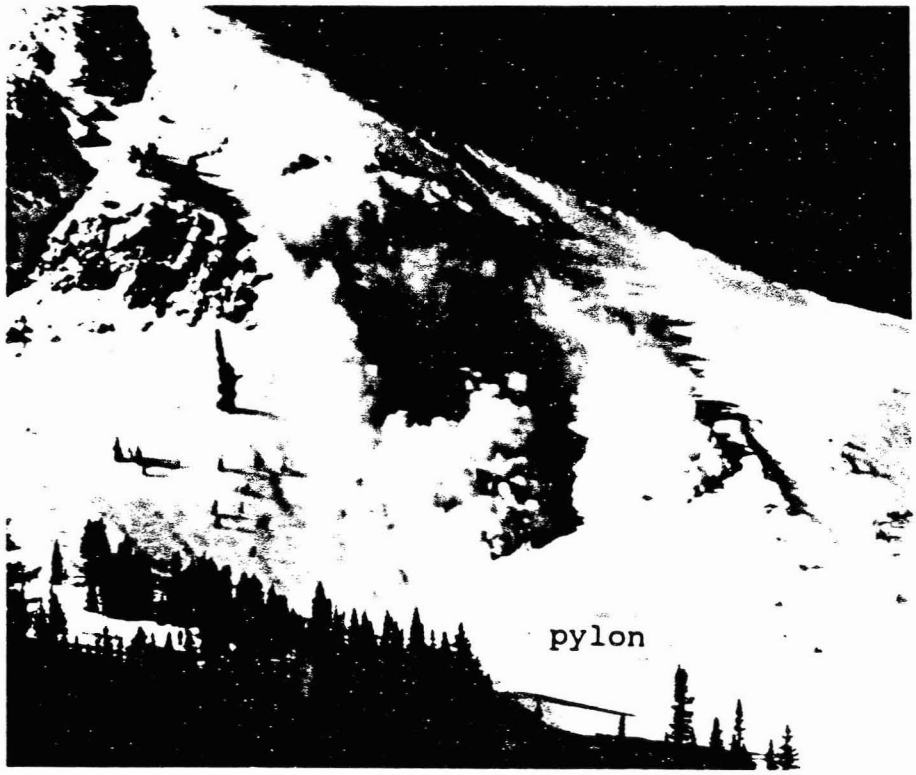


Fig.8 An avalanche attacking the pylon.
(photo by Gus Gilman)

REFERENCES

Clayton A.,Decker R.,Rechardson C. and Abe O.,1992: Installation Design of the Avalanche Impact Pylon Facility; Alta, Utah. Proc. ISSW'92, 182-190.

Kawada K.,Nishimura K. and Maeno N.,1989: Experimental Studies on a Powder-Snow Avalanche. Annals of Glaciology, 13, 129-133.

Nishimura K.,Maeno N.,Sandersen F.,Kristensen K.,Norem H. and Lied K.,1993: Observations of the Dynamic Structure of Snow Avalanches. Annals of Glaciology, 18, 313-316.

Schaerer P.A., 1973: Observation of Avalanche Impact Pressures, Advances in North American Technology, 1972 Symposium, USDA For. Serv. Gen. Tech. Rep. RM-3, 51-54.