Preliminary results at the Hijiori avalanche test site

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ABSTRACT: Hijiori is one of the heaviest snow areas in Japan. Recently to observe blowing snow and avalanches, an almost perfect place was found in this area. There are both a long flat plain along the main wind direction and a long edge with slopes. When strong winds blow with heavy snowfall, snow cornices are formed quickly at the edge. During last three winters nine avalanche events were recorded by a web camera, and five of them included collapse of the snow cornices. Thus we can observe avalanche occurrence, snow cornice formation and blowing snow at the same site.

KEYWORDS: avalanche test site, avalanche dynamics, snow cornice.

1 INTRODUCTION

The national road, R458 connecting to Hijiori is closed sometimes by avalanches. National Research Institute for Earth Science and Disaster Prevention (NIED) has prepared an avalanche information system on the web for typical slopes along the road to maintenance section (Nakai et al., 2012). NIED is also developing a real time hazard mapping system for avalanches, which needs fit parameters of the dynamic model to predict run-out zone. Recently to observe blowing snow and avalanches, an almost perfect place was found in this area.

2 REQUIREMENTS OF AVALANCHE TEST SITE

We have joined with domestic and international projects on avalanche dynamics. Various test sites used in the projects are located at Kurobe canyon in Hida Mountains (Japan; Kawada et al., 1989), Ryggfonn in Kjølen Mountains (Norway; Nishimura et al., 1993), Alta in Rocky Mountains (United State; Abe et al., 1995), and Gongnaisi in Tianshan Mountains (China; Qiu et al., 1997). From these experiences we conclude that avalanche test site should have three requirements as follows;

(1) Avalanches occur certainly on the slope.
(2) Meteorological and snow pit data should be prepared.
(3) Electric power supply and mobile phone should be equipped.

First one is most important to get data continuously. In Japan it is difficult to use explosive for triggering artificial avalanches, so we usually observe natural one, which constrains us to spend much effort without high-tech electronic devices. Meteorological data are used to investigate avalanche occurrence and snow profile, and snow pit data are useful to estimate the snow stability. Concerning the third, recently a buttery system with solar panels is popular for automatic weather station (AWS), and mobile phone can transfer the data to the station. Thus we are now in good situation.

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3 FEATURES OF HIJIORI TEST SITE

3.1 Topographical condition

The test site is located at the foot of Mt. Gassan, 40 km away from the Sea of Japan (Figure 1). There are both a 1.2 km long plain along the main wind direction and a 1 km wide edge with slopes at the leeward end of the plain (Figure 2). Large snow cornices are formed at the edge, and avalanches occur frequently on the slopes. Slope angle of release zone is about 40 degrees, and horizontal run-out distance of avalanches is about 200 m. Recently a data set of digital elevation map around the test site with a resolution of 1 m was prepared by scanning the infrared laser scanner on the ground (Figure 3).

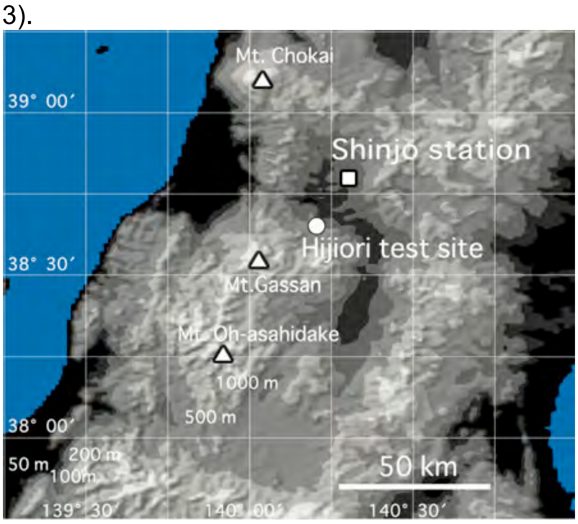

Figure 1. Location of the test site (○)

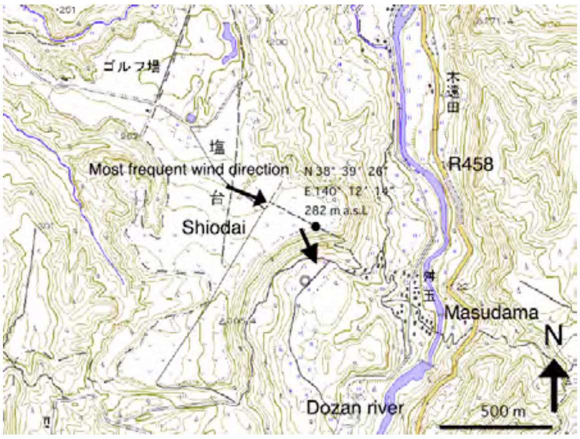

Figure 2. Topographical map around the test site. A short arrow on the slope means the main avalanche pass, a long arrow on the plain the most frequent wind direction. ●: AWS installed at the leeward end of the plain, ◎: Web camera at the bottom.

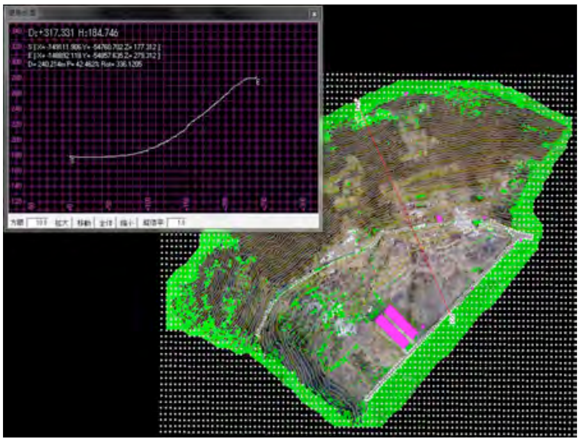

Figure 3. High resolution map with a 1 m grid. A slope profile along the red line in the map is also shown in the top.

3.2 Meteorological condition

Hijiori, where the maximum snow depth exceeds 3 m, is one of the heaviest snow areas in Japan. We installed an automatic weather station (AWS) near the edge of the plain in 2008 (switched to another AWS in 2010, Figure 4). Based on the observation, the mean air temperature in midwinter of January and February is about -3 ºC just below the melting point of snow. The mean wind speed in midwinter is about 3 m/s, however strong winds exceeding 10 m/s with heavy snowfall sometimes blow for several days. The most frequent wind direction is WNW, in which wind blows for long distance without any obstacle over the plain. Then when strong winds blow with heavy snowfall, a huge amount of snow particles are transported until the leeward end of the plain, and large snow cornices are formed at the edge.

Figure 4. Automatic weather station at the leeward end of the plain.

3.3 Snowfall conditions

We attempted continuous observation on snowfall at the bottom during two winters of 2007/08 and 2008/09. The maximum depth of daily fallen new snow was 0.57 m. We did not make observation on snow crystals here, however according to the observation at the Shinjo station (Shinjo Cryospheric Environment Laboratory) which is located 30 km from the test site, it was found that most of snow flakes include rimed crystal or graupellike snow, which are classified by Magono and Lee (1966). New snow may change to compacted snow for several days under the dry-metamorphism because of the temperature just below 0 ºC.

3.4 Equipment conditions

We installed a web camera at the bottom of the slopes in December 2010 (Figure 5). The web camera stores image data of one main frame every 1 sec and of three sub-frames every 10 min into a hard disk connecting with a mobile phone, then we can watch the slopes from remote areas (e.g. Shinjo station).

Figure 5. Web camera (left) records behavior of the slopes.

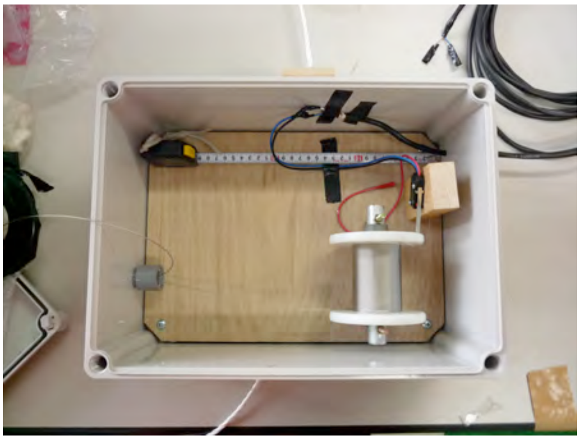

Figure 6. A simple glide meter installed at the top of the slope.

We have developed a simple and cheap glide meter (Figure 6), which make a pulse as snow glides 9 mm on the slope. A sled is set on the slope, and a steel wire is connected between the sled and the glide meter. The pulse signals produced by the glide meter are recorded on the ASW, which has two channels for pulse counter.

4 PRELIMINARY RESULTS AT HIJIORI TEST SITE

Various observations on avalanche, snow cornice and blowing snow have attempted in the test site. Preliminary results are shown as follows.

4.1 Occurrence of avalanches

From three-winter monitoring of avalanches by the web camera, we obtained 9 moving images of avalanche movement which were compiled from series of image data stored every 1 sec (Figure 7). All of them were natural release full depth avalanches; 5 included collapse of the snow cornices, 2 included another avalanche (no count in total) occurred immediately after them, and 2 occurred at the neighbor slope of another avalanche. Thus it was found that avalanche occurrence processes has a wide variety.

After the avalanche occurrence, we have made snow survey to determine the area and volume of debris, run-out distance, snow profiles both of debris and undisturbed snow at foot (Figure 8). These data will be important to simulate avalanche movement for fitting some parameters of the dynamic models.

At first, we were going to take a picture of slab avalanche, however no slab avalanche have been observed during the three winters. Slab avalanches usually occur under the condition with a weak layer buried into the snowpack (Perla, 1977). It is not sure yet whether weak layer could not be formed under the extremely

Figure 7. Example image of full depth avalanches

Figure 8. A snow survey one day after the incident.

snowfalls or three winter monitoring is too short for detecting this type of avalanche.

4.2 Formation of snow cornices

As mentioned above, snow cornices sometimes affect the avalanche occurrence. To monitor snow cornice formation, we have installed an interval camera at the edge, and two series of image data with 30 min interval were obtained during Jan.6 to Apr.1, 2012, and Nov.11 to Jan.10, 2013. Figure 9 shows quick increase of a snow cornice, which expands 1.6 m during 24 hours. Sometimes we have measured distribution of snow on the slope using an infrared laser rangefinder with a theodolite. Results obtained by this method, shows that the deposit area is limited just beside the edge. It means that most snow particles deposit at the edge to form the snow cornice.

5 CONCLUSIONS

Hijiori avalanche test site has no big slopes, but full depth snow avalanches occur frequently, and we can make a snow survey easily by short access of 45 min driving from the Shinjo station.

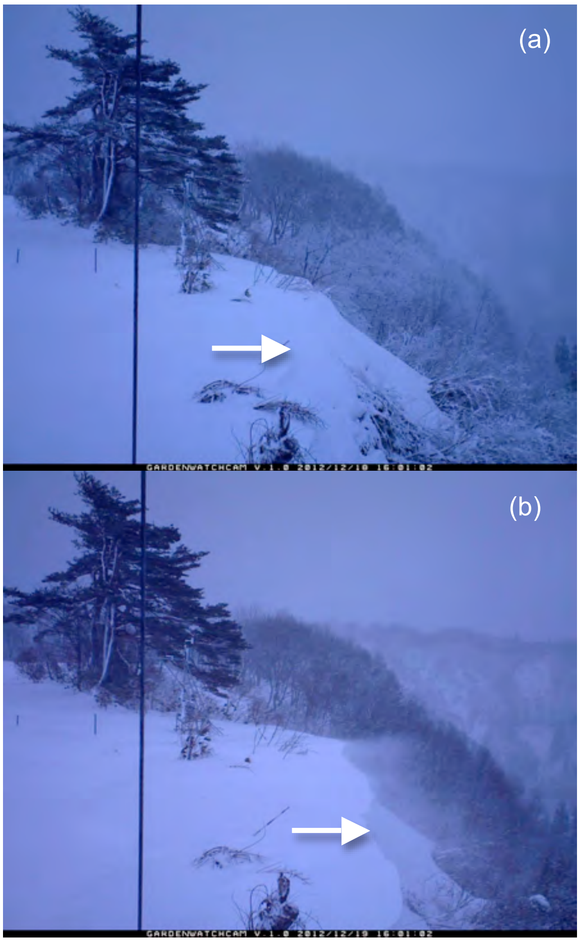

Figure 9. An example of snow cornice forming at the edge. (a) 16:01 Dec.18, 2012 in local time, (b) 24 hours later from (a).

Sometimes strong winds with heavy snowfall blow for several days, after this event, large snow cornices are formed at the edge, which affect avalanche occurrence. It is the advantage for the test site that we can observe avalanche occurrence, snow cornice formation and blowing snow under the temperature of just below 0 °C at the same site.

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7 REFERENCES

Abe, O., Nakamura, T., Nohguchi, Y., Decker, R., Femenias, T., and Howlett, D., 1995. Observations of snow avalanches on dynamic internal structures at Alta, Utah, Proc. ISSW'94, 385-392.

Kawada, K., Nishimura, K. and Maeno, N., 1989. Experimental studies on a powder-snow avalanche. Annals of Glaciology, Vol. 13, 129-134.

Magono, C. and Lee, C.W., 1966. Meteorological classification of natural snow crystals. Journal of the Faculty of Science, Hokkaido University, Sapporo, Japan, Series VII, Geophysics, 2(4), 321-335.

Nakai, S., Sato, T., Sato, A., Hirashima, H., Nemoto, M., Motoyoshi, H., Iwamoto, K., Misumi, R., Kamiishi, I., Kobayashi, T., Kosugi, K.,Yamaguchi, S., Abe, O. and Ishizaka, M., 2012. A Snow Disaster Forecasting System (SDFS) constructed from field observations and laboratory experiments. Cold Regions Science and Technology, 70, 53–61.

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.

Perla, R., 1977. Slab avalanche measurements. Canadian Geotechnical Journal, 14, 206-213.

Qiu, J., Xu, J., Jiang, F., Abe, O., Sato, A., Nohguchi, Y., and Nakamura, T., 1997. Study of avalanches in the Tianshan Mountains, Xinjiang, China. Snow Engineering -Recent Advances-, A.A. Balkema, Rotterdam, 85-90.