GENERATION CONDITION OF THE FULL-DEPTH AVALANCHE OUT OF THE DATA OF OCCURRENCE FOR FIVE CONSECUTIVE YEARS AT SHIBAHARA , NIIGATA PREFECTURE OF JAPAN

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ABSTRACT: It is well known that a full-depth avalanche of wet snow occurs when, among others, air temperature rises. However, the exact condition of the generation of a full-depth avalanche appears to be difficult to formulate probably because it strongly depends on the ground surface condition which is difficult to be generalized. It seems that accumulation of field data related to the occurrence of a full-depth avalanche is necessary to advance our knowledge on this matter.
In Shibahara, Niigata Prefecture of Japan, a full-depth avalanche is observed to have occurred on the same slope for five consecutive years offering a rare opportunity to study the generating condition. Details of all these occurrences and the meteorological data are collected and carefully studied for the process leading to the avalanche generation. It is then observed that the avalanche occurs under the large snow depth and after the temperature rise up to around 10 degrees Celsius.
This effort produced a plot of snow depth against 3-day consecutive positive temperatures suggesting a possible criterion for generation of the full-depth avalanche on this slope. The data of the non-occurrence gave the snow depth minimum value.
dependent. However, the method should be beneficiary to the study at another area.

KEYWORDS: Full-depth avalanche, wet snow, Generation condition of avalanche

1. INTRODUCTION

It is well known that a full-depth avalanche of wet snow occurs when, among others, air temperature rises. However, the exact condition of the generation of a full-depth avalanche appears to be difficult to formulate probably because it strongly depends on the ground surface condition which is difficult to be generalized. It seems that accumulation of field data related to the occurrence of a full-depth avalanche is necessary to advance our knowledge on this matter.

In Shibahara, Niigata Prefecture of Japan, a full-depth avalanche is observed to have occurred on the same slope for five consecutive years offering a rare opportunity to study the generating condition. Details of all these occurrences and the meteorological data are collected and carefully studied for the process leading to the avalanche generation. It is then observed that the avalanche occurs under the large snow depth and after the temperature rise up to around 10 degrees Celsius. This effort produced a plot of snow depth against 3-day consecutive positive temperatures suggesting a possible criterion for generation of the full-depth avalanche on this slope. The data of the non-occurrence gave the snow depth minimum value.

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2. AVALANCHE SLOPE

The avalanche slope concerned is located at Shibahara area of Yuzawa town, Niigata Prefecture, Japan. The slope is at the hilly area along the national highway Route 17 as shown in Fig. 1. Fig. 1 shows the avalanche paths for five consecutive years indicating that they started at almost same area, around the ridge of the slope. This avalanche starting zone is at the elevation of 720m, with the slope inclination of about 40 degrees. Vegetation cover of this slope mostly includes low bush with diameter of 3 to 10cm and they are not enough to resist the gliding of the snow layer of heavy wet snow.

General description of the avalanche observed for five years is given in Table 1 This table shows that all events occurred in the late winter or early spring and run-out-distances are, fortunately, short enough to reach the Route 17, although the emergency measure was taken by building the snow-bank after the initial occurrence.

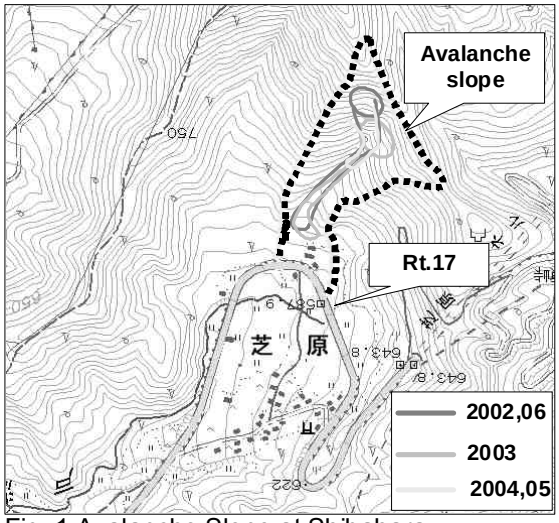

Fig. 1 Avalanche Slope at Shibahara

3. DESCRIPTION OF THE OBSERVED AVALNCHE

3.1 Year 2002,2003,2004

In all these years, cracks were observed in the slope about one week before the avalanche occurrence.

For the Year 2002 case, the avalanche occurred with the generating zone volume of 1800chbic meters as shown in Fig. 2.1

For the Year 2003 case, cracks were found on the slope about one week prior to the avalanche occurrence. The generating zone is a little below that of other years in this case Fig. 2.2 shows the generating zone.

For the Year 2004 case, cracks were found on the slope about two weeks in advance and the avalanche was observed to occur in three times this year with the smallest amount of debris deposited among the five cases as shown in Fig. 2.3.

Table 1 General Description of the five cases

Avalanche generating time				Run out distance (m)	Snow depth (cm)
Year	Mo.	Day	Time		
2002	2	22	15:00	400	270
2003	3	25	15:00	450	270
2004	3	12	6:00	200	250
			8:40	250	
			9:30	250	
2005	4	14	16:00	200	180
2006	2	24	(Night)	450	336

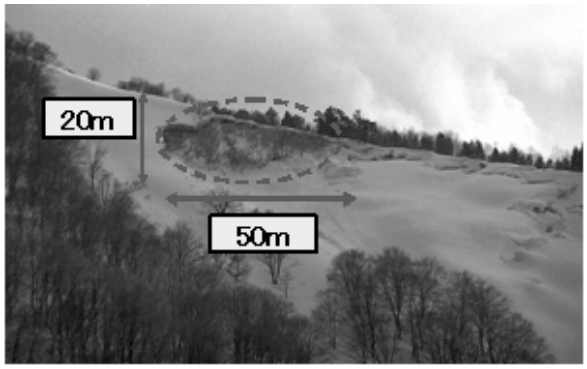

Fig.2.1 Starting Zone of 2002 Avalanche

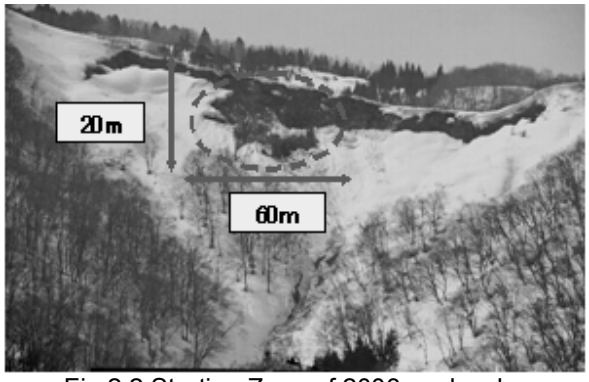

Fig.2.2 Starting Zone of 2003 avalanche

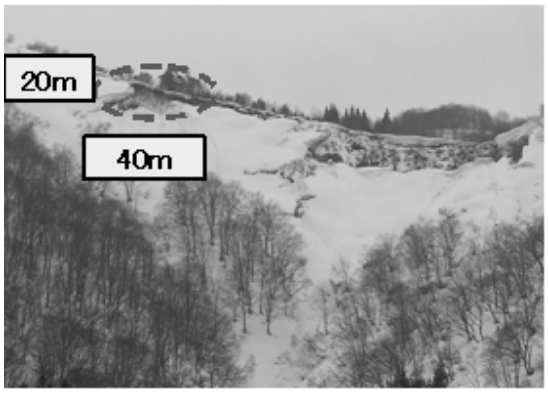

Fig.2.3 Starting Zone of 2004 Avalanche

3.2 Year 2005

This year, cracks were found on the slope as early as May 15, but the avalanche occurred almost one month later, April 14.

The particular feature of this year is such that the avalanchem after generation, is soon divided into two branches and then merged again. This motion is depicted in Fig. 2.4. The avalanche energy was apparently damped due to this motion and the run-out- distance and induced volume were both small.

3.3 Year 2006

This year saw unusual heavy snow and the slope exhibited cracks early in February to generate the avalanche on February 24. Fig. 2.5 shows the starting zone and it indicates the generating volume of about 1,200 cubic meters. This amount is compared the estimated volume of the debris of 4,000cubic meters to show how large the induced snow alongthe valley was large.

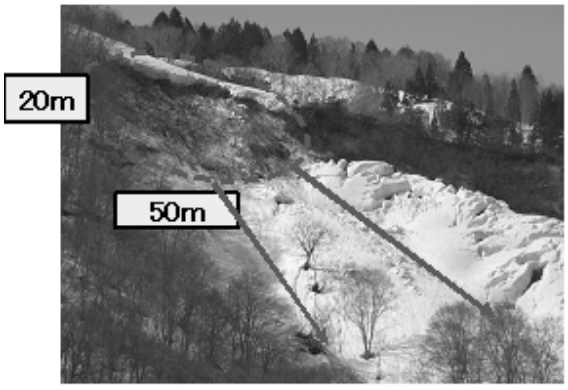

Fig.2.4 Starting Zone of 2005 Avalanche

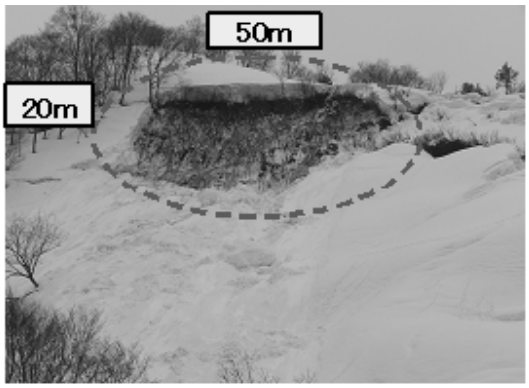

Fig.2.5 Starting Zone of 2006 avalanche

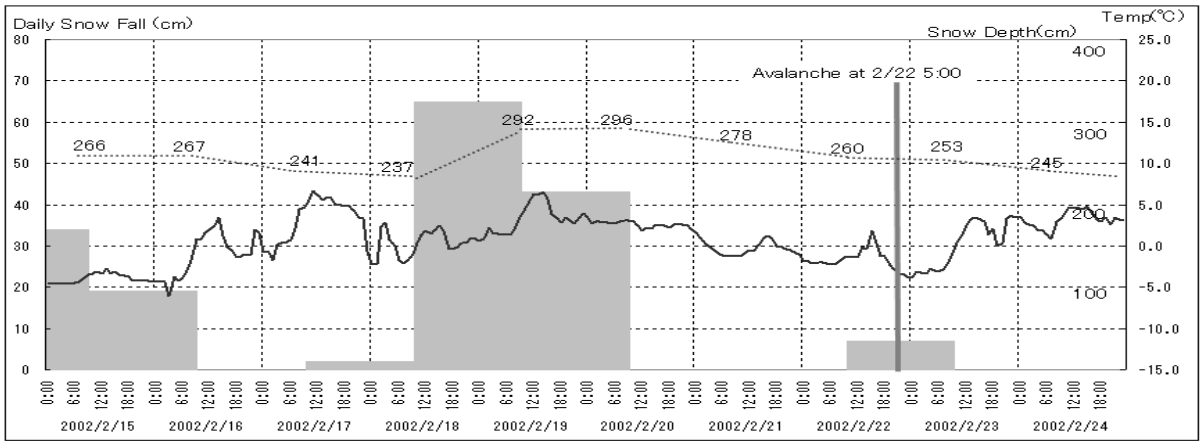

Fig. 3.1 Meteorological Data of 2002

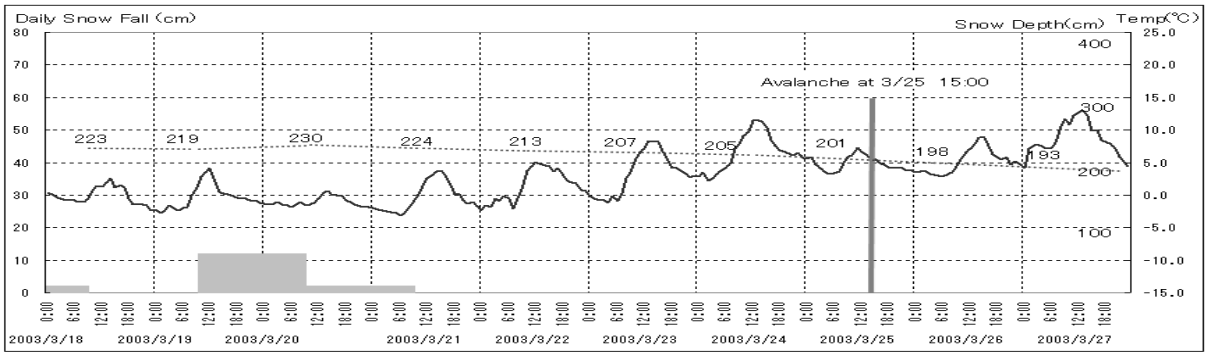

Fig. 3.2 Meteorological Data of 2003

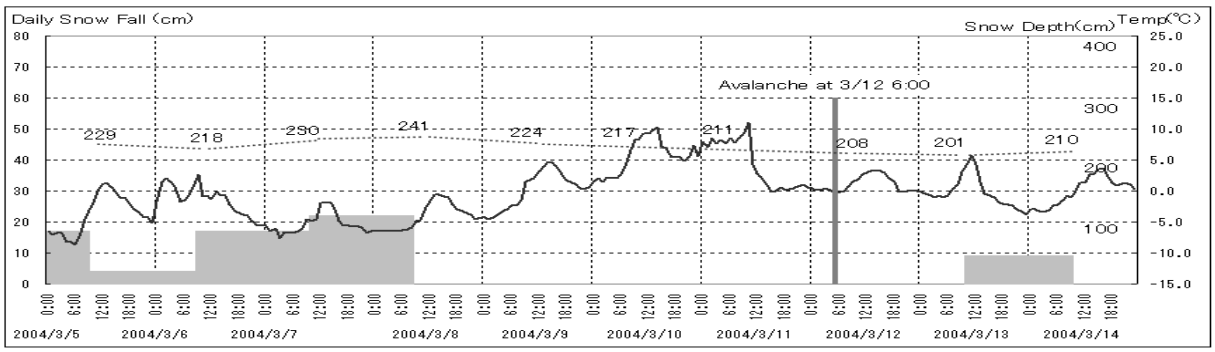

Fig. 3.3 Meteorological Data of 2004

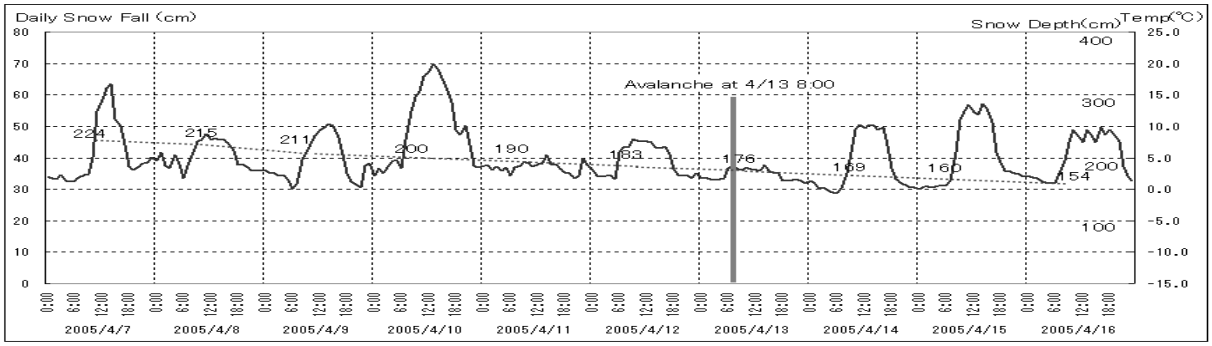

Fig. 3.4 Meteorological Data of 2005

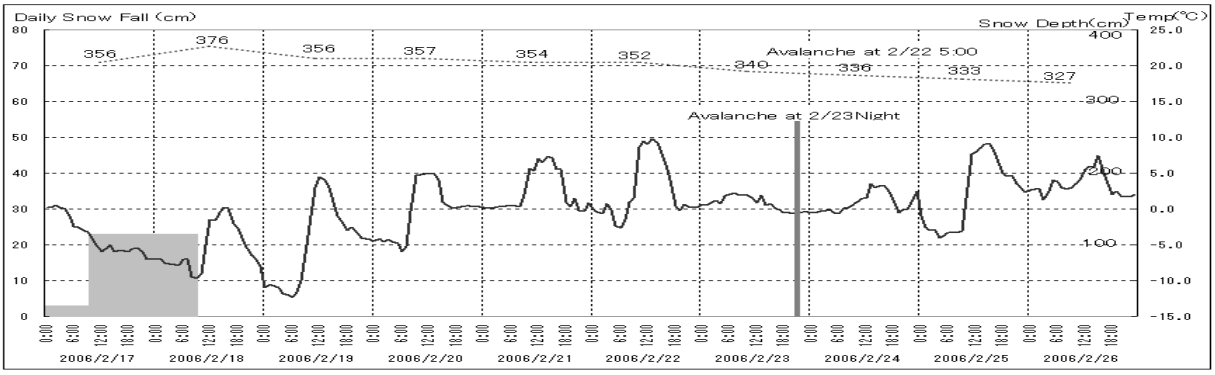

Fig. 3.5 Meteorological Data of 2006

4. METEOROLOGICAL DATA

The meteorological data including snow depth have been measured and archived by the Nagaoka Highway Office, Ministry of Construction of Japan, at several strategic locations along Route 17. In this study, the data of ,the nearby Mitsumata meteorological station with elevation of 533m and about 3km away from the Shibahara area was collected for a period of one week in advance of the avalanche occurrence. The collected data include air temperature, snow depth and daily snowfall.

Fig. 3.1 is the data for 2002 indicating that air temperature stayed slightly over freezing for six days prior to avalanche day and there was a large snowfall 3 to 4 days prior to the avalanche day. Snow depth this year is large but this large snowfall appears to cause both melting and settling of snow to induce, at least in part, an avalanche.

The data for 2003 as shown in Fig. 3.2 indicates that the temperature gradually rose to above zero on four days prior to the avalanche and hit 10degrees in Celsius one day before the avalanche. The high temperature inducing snow melting apparently is the cause of this year's avalanche.

The data for 2004 given in Fig. 3.3 shows above zero temperature all day for one and two days in advance with the daily high hitting higher than 10degrees Celsius. This high temperature apparently caused the avalanche.

The data of 2005 given in Fig. 3.4 seems a little unusual, in that snow depth is not so large and the air temperature stays slightly above zero for two days in advance. Looking further at the air temperature data, hits one with an extraordinarily high temperature of 20degrees in Celsius 3 days in advance, which could be a reason to accelerate snow melting to induce an avalanche.

The data of 2006 given in Fig. 3.5 shows unusually large snow depth of this year and the air temperature data indicates that the avalanche was induced as the air temperature stayed above zero for three days in succession.

5. GENERATING CONDITION OF THE AVALANCHE

A close examination of the meteorological data suggests that full-depth avalanche at Shibahara is likely to occur when the snow depth is large and sometime after the air temperature reaches above zero. It is then conjectured that the generation of the fll-depth avalanche at Shibahara is controlled by two parameters: snow and accumulated aove-zero temperature for three days preceding the questioned day. Fig. 4 is such a plot showing the change of the two parameters as the avalanche day approaches for each year. Fig. 4 suggests that at which the full-depth avalanche occurs lies at the top, right area of the graph. And the delineating line for the generation of the avalanche can tentatively, although the data is still scarce, be drawn as shown in Fig. 4.

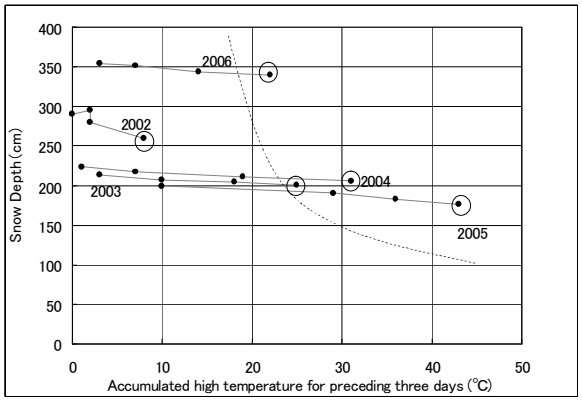

Fig.4 Criterion for the generation of the full-depth avalanche

6. Conclusions

A rare example of five-year consecutive occurrence of full-depth avalanche At the same slope is reported. Avalanche generally is started at almost the same location. Detailed description of the avalanche is given and the meteorological data is collected and the process leading to occurrence of avalanche is discussed. From these study, two parameters to be critical to generation of the full-depth avalanche at this location are conjectured. They are snow depth and accumulated high temperature for preceding three days. Plot of these two parameters suggest existence of the region at which the full-depth avalanche is likely to occur.

It is known that occurrence of full-depth avalanche is quite site-dependent and the generation condition reached in this study may not apply to other areas. However, the process to obtain the generation condition in this study should be meritorious to the other area.