INTERNAL REPORT

ACTIVITIES OF THE JAPANESE-NORWEGIAN COLLABORATION ON SNOW AVALANCHE RESEARCH, MARCH 1991

by

Harald Norem
Koichi Nishimura
Steinar Bakkehøi

581200-23 August, 1991

Norges
Geotekniske
Institutt
Norwegian
Geotechnical
Institute

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S U M M A R Y

The report gives a brief summary of the activities carried out by the Japanese - Norwegian collaboration on snow avalanche reasearch during the winter of 1990/19991. The research was mainly carried out in the Ryggfonn experiment site and at NGI research station in Grasdalen in Ryggfonn.

The installation in Ryggfonn were extended by a wind sensor, a seismometer, an air pressure sensor and two video-cameras. One artifically released wet snow avalanche was recorded. The avalanche had a volume of approximately 20.000m^3 and a velocity of 25 m/s in the steep part of the path.

Snow cover studies were carried out to investigate if there were differencies in the potential sliding layers of the snow pack in Japan and Norway. In addition, theories of the dynamics of granular materials developed in Norway and Japan were compared.

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Postal Address: P.O.Box 40 Tåsen N-0801 Oslo 8 Norway
Street Address: Sognsveien 72 Oslo
Telephone: National (02) 23 03 88 International +47 2 23 03 88
Telefax: National (02) 23 04 48 International +47 2 23 04 48
Telex: 19787 ngi n
Postal Giro Account No.: 0814 5160643
Bankers: Den norske Bank Account No.: 5096.05.01281

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1. INTRODUCTION

This report gives a brief summary of the activities carried out by the Japanese-Norwegian collaboration on snow avalanche research during the winter 1990/1991.

The collaboration was initiated during the International Symposium on Glacier and Avalanche Research organized by the International Glaciological Society in Lom, Norway, 1988. In February 1990, the Japanese scientist, K. Fujisawa from Public Works Institute, Tsukuba City, visited NGI, and in March 1990 J.O. Larsen, NGI, visited several research institutes in Japan.

The Institute of Low Temperature Science, Hokkaido University, Sapporo, presented in February 1990 a project proposal to collaborate on research in snow avalanche dynamics. The project included participating in the full-scale project in Ryggfonn, Grasdalen, run by NGI, participating in model experiments at the Institute in Sapporo, and exchange of theories. Prof. N. Maeno and Dr. K. Nishimura visited Norway in October to plan for the activities in the winter 90/91.

During the period March 3-25, four scientists from Japan visited Norway. They took part in the Ryggfonn project and carried out separate studies of the snow cover and the snow crystals in the region of the NGI research station Fonnbu. The participants of the collaborative research group were:

K. Nishimura - Inst. of Low Temp. Science
M. Nakagawe - Faculty of Eng. Tohoku Univ.
Y. Nohguchi - Nat. Res. Cen. for Disaster Prevention, Nagaoka
T. Fukuzawa - Inst. of Low Temp. Science
K. Lied - NGI
H. Norem - NGI
S. Bakkehøi - NGI
K. Kristensen - NGI

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2. THE RYGGFONN PROJECT

Installations and instrumentation

The Ryggfonn project is a full scale experiment carried out to investigate impact forces of avalanches on structures and the effects of a retaining dam in the avalanche path. The experimental site is close to NGI's research station, Fonnbu, in Grasdalen, Western Norway.

The avalanche in Ryggfonn starts at 1530 a.s.l. and the vertical drop is 910 m. The volume and maximum speed of the avalanches vary within 10.000 - 100.000 m^3 and 30-60 m/s respectively.

The experimental set-up consists of (fig. 1):

- A 15 m high and 75 m wide retaining dam in the avalanche runout zone. On top of the dam is one 6.5 m high steel mast which is instrumented with strain gauges, and one 1.0 m high mast which has a load cell.

- 230 m upslope from the dam, a 4.5 m high concrete structure with three load cells, each 0.72 m^2 in area, has been constructed.

- 320 m upslope from the dam a 10 m tubaler tower has been erected. The tower is instrumented with strain gauges to record shear forces and moments in three sections. Mechanical pressure indicators are also mounted on front of the tower for every 0.5 m.

- 50 and 100 m upslope from the dam, two vertical geophones are sensing the vibrations from the passing avalanche.

- The analogue signals are digitized and recorded on a magnetic tape recorder in Pulse-Code-Modulation (PCM) format.

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3. INSTRUMENTS SUPPLIED BY INSTITUTE OF LOW TEMPERATURE SCIENCE

Wind sensor

A wind sensor was mounted on top of the mast on top of the dam, Fig. 2. The wind sensor has no moving parts and record the wind speed in three directions. The main characteristics of the sensor is given in Appendix 1.

The main scope of the sensor is to study the wind condition within the snow cloud, and especially if there exists internal velocities well above the frontal speed of the avalanche. The output signal of the wind sensor makes it also possible to evaluate the turbulence within the snow cloud.

The analysed data may be important to estimate the impact pressure on constructions and to evaluate the capacity of the snow cloud to transport snow particles in suspension.

Seismometer

A seismometer was installed in a tube located into the top of the dam. The seismometer data will give the magnitude of ground vibrations, and thus detect the time of the avalanche and the influence of the avalanche flow to the ground.

Air pressure sensor

An air pressure sensor was installed on the top of the dam. The sensor records the air pressure variations when the avalanche passes the dam. Both the increase in the air pressure and especially if there is a substantial reduction in the air pressure, are important to evaluate the hazard of being caught by the snow cloud.

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Video-cameras

Two video-cameras were installed to film the movement of the slides. One camera has a fixed position in front of the avalanche path, and the signals of the camera are transmitted by a 500 m cable to the instrument hut.

The other camera is used close to the instrument hut and is operated manually.

4. ARTIFICIAL RELEASE OF AVALANCHES

All instruments were installed in the Ryggfonn area in the period of March 7-11.

The first attempt to release an avalanche was made on March 15. The last 3 days in advance, there had been approx. 30 mm of precipitation. The temperature at Fonnbu was below 0°C, and the snow was dry in the whole avalanche path.

Detonation of 100 kg dynamite released a small avalanche. The avalanche entrained, however, very little snow in the avalanche path, and died out at the 1100 m level, and never arrived to the construction area.

On March 20 a new attempt to release an avalanche was made. Since the first attempt, there had been 15 mm of precipitation and very high temperatures, 12°C in maximum at the Research station. The snow in the starting zone had thus changed from dry snow to wet snow within less than one week.

The detonation of 100 kg explosives released an avalanche with the gliding layer within the remaining snow from the winter 89/90. The released avalanche was a moderate sized avalanche, approx. 20.000 m^3, having an average velocity of 25 m/s and a runout-distance to the front of the dam.

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The flow of the avalanche was both filmed by video-cameras and photographed. There are recordings from all impact sensors. The snow cloud had, however, a run-out distance not far enough to reach the sensors on top of the dam.

The recordings and the characteristics of the avalanche will be given in a separate year report of the Ryggfonn-project.

5. SNOW COVER STUDIES

Norway is mostly situated between 60° and 70° north while Japan is situated between 30° and 45° north. This causes great differences in the sunshine radiation in the winter season, in Grasdalen (62°N) at mid winter, the maximum sun elevation above horizon is 4,5° while at Sapporo (43°N) it is 23,5°.

The main topic with the snow cover investigation was to find out if there were differences in the potential sliding layers of the snow pack in Japan and Norway. While Grasdalen has a maritime climate, a part of the study was also to compare the snow pack with a more continental snow pack. Grasdalen is very close to the water divide in Southern Norway, and it is easy access to areas with more continental climate at Grotli only 20 km eastward.

In the period of the investigation, the temperature were above 0°C almost all the time at the research station. It was therefore necessary to take snow samples 200 m above the station and bring them in an insulated box back to the cold lab. The procedure was to dig a pit, classify the snow layers and measure temperature and density each 10 centimeter. Thereafter snow samples with potential sliding layers were dug out and put into the insulated box. The temperature in the cold lab were approx. -20°C, and the samples were investigated in microscope under these conditions.

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Samples from Grotli were also brought over to the cold lab and investigated. A report of the investigations and the preliminary results will be presented, and the research will continue next winter.

The Japanese group brought an automatic snow height sensor based on optical fibres. The measurements were given on a digital display, and a linear voltage output made it possible to connect the sensor to the automatic snow and weather registrating data equipment in Grasdalen.

The sensor has been working excellent since it was installed, and the resolution is one centimeter in a range of three meter.

6. STUDIES ON HORIZONTAL HETEROGENITY OF SNOW COVER

Any snow cover, in general, suffers a lot of horizontally heterogeneous fluctuations; for example, accumulation and erosion of snow by wind, occurrence of water drainage channel due to snow melting or rain fall, and so on. As a result, the snow cover becomes horizontally heterogeneous, even though snow falls homogeneously.

The horizontally heterogeneity of snow cover in Norway was observed by using ramsonde to compare it with that in Japan. A tube of ramsonde of a guide rod for hammer was penetrated into snow cover from its surface with some blows of hammer at intervals of 10 or 2 cam along some measuring lines 10-100 m in total length, and then the variation of the penetraion depth was obtained due to horizontal heterogeneity of snow cover. The results is now analyxzing from a viewpoint of *Fractal*.

7. THEORETICAL COLLABORATION ON THE DYNAMICS OF GRANULAR MATERIALS

Both the Japanese and the Norwegian group has carried out theoretical studies on the flow of snow avalanches and on the dynamics of granular materials.

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NGI has concentrated their studies on the flow of the dense part of the avalanche close to the ground. Their model assumes that the density within the flowing mass is constant and that the particles are in close contact to each other.

An interesting feature of this model is that above a certain velocity and inclination of the avalanche path, the model indicates that the particles no longer can be in close contact to each other. This physical process has also been shown experimentally in chute experiments.

The Nakagawa model is based on the assumption that there exists a free distance between the flowing particles and the binary collisions are the dominating mechanism for momentum transfer. The developed equations makes it then possible to calculate the shear and normal stresses dependent on the volumetric density and the velocity gradient.

A preliminary investigation indicate that it is possible to combine these two models to cover a wider range of velocities and steepnesses. This may also explain the reduced density that some times has been observed for certain types of avalanches.

The Japanese-Norwegian group plans to make a publication on these ideas. The results of such a publication will have importance for estimating avalanche impacts on constructions and how to combine the results of the Norwegian full-scale experiments and the Japanese model experiments.

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A P P E N D I X 1

ULTRASONIC ANEMOMETER

Specifications

Measuring Mode:
- Time-shearing sonic pulse method processing mode
- Two horizontal and 1 vertical components to be vector-synthesized electrically

Range:
- Wind velocity 0-60 m/s
- Wind direction 0-540 deg. (0-360 deg., 180-540 deg. automatic shifting)

Accuracy:
- Wind velocity: 4 % or 0.2 m/s
- Wind direction: 5 deg.

Responding time:
- 0.05 sec (both wind direction and velocity)

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Sted / *Location*	Feltnavn / *Field name*
	Sted / *Location*
Kartblad / *Map*	
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