Activities of the Japanese-Norwegian collaboration on snow avalanche research during the winters 1990/1991 and 1991/1992

581200-29 5 March, 1993

For the Norwegian Geotechnical Institute

Project manager: Frode Sandersen

Work also carried out by:

Steinar Bakkehøi
Krister Kristensen
Harald Norem
Koichi Nishimura

Norwegian Geotechnical Institute Sognsveien 72
Postal address: P.O. Box 3930 Ullevaal Hageby N-0806 Oslo
Telephone: +47 22 23 03 88
Telefax: +47 22 23 04 48
Telex: 19787 ngi n

048. Bra-Trykk AS

Summary

The report gives a brief summary of the activities carried out by the Japanese - Norwegian collaboration on snow avalanche reasearch during the winters of 1990/1991 and 1991/1992. The research was mainly carried out in the Ryggfonn experiment site and at NGI research station in Grasdalen, Stryn community, Møre og Romsdal county in Southern Norway.

The installation in Ryggfonn were extended by a wind sensor, a seismometer, an air pressure sensor and two video-cameras. During the first winter one artifically released wet snow avalanche was recorded. The avalanche had a volume of approximately 20.000 m^3 and a velocity of 25 m/s in the steep part of the path. During the second winter two avalanches were recorded: One dry naturally and one wet artificially released avalanche with volumes of 20 000 m^3 and 30.000 m^3, and maximum speeds of 30 m/s and 20 m/s respectively.

Snow cover studies were carried out to investigate differencies in the potential sliding layers of the snow pack in Japan and Norway. In addition, analysis to compare the Norwegian experience on full scale avalanches with the Japanese experience on model experiments were carried out.

CONTENTS:

1 INTRODUCTION

This report gives a brief summary of the activities carried out by the Japanese-Norwegian collaboration on snow avalanche research during the winters of 1990/1991 and 1991/1992.

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, 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 1990/1991.

During the periods March 3-25, 1991 and February 16 - March 28, 1992 nine 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:

N. Maeno	- Inst. of Low Temp. Science
K. Nishimura	- Inst. of Low Temp. Science
M. Nakagawa	- Tohoku Univ.
Y. Nohguchi	- Nat. Res. Cen. for Disaster Prevention, Nagaoka
T. Fukuzawa	- Inst. of Low Temp. Science
H. Iida	- The Board of Education in Kurobe city
K. Izumi	- Niigata University
K. Kawada	- Toyama University
R. Kimura	- Tokyo University
K. Lied	- NGI
H. Norem	- NGI
S. Bakkehøi	- NGI
K. Kristensen	- NGI
F. Sandersen	- NGI

2. THE RYGGFONN PROJECT

2.1 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 m 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 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 the dam a 10 m tubular 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.

048 Bra-Trykk AS

3. INSTRUMENTS SUPPLIED BY THE INSTITUTE OF LOW TEMPERATURE SCIENCE

All instruments supplied by the Institute of Low Temperature Science were installed in the Ryggfonn area in the periods of March, 1991, and October, 1992.

3.1 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.

3.2 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.

3.3 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.

3.4 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.

3.5 Impact pressure sensors

Two sensors were installed in the steel mast and the concrete structure respectively to measure internal velocity.

3.6 Optical sensors

Optical sensors were installed on the concrete structure to obtain the density variation as well as the internal velocity.

4. RECORDED AVALANCHES

The two winter seasons were mild with relatively high precipitation amounts. The snow cover was stable most of the time, due to the high temperatures and hence quick stabilization processes.

Three avalanches were recorded, of which one was naturally and two were artificially released. Normally 2-3 avalanches are recorded each winter.

During the first winter one artificially released wet snow avalanche was recorded with a volume of 20 000 m^3 and a velocity of 25 m/s in the steep part of the path. During the second winter two avalanches were recorded: One dry naturally and one wet artificially released avalanche with volumes of 20 000 and 30 000 m^3 and maximum velocities of 30 and 20 m/s respectively.

In addition many unsuccessful attempts to trigger avalanches by means of explosives were made.

The recordings and the characteristics of the avalanches are given in a separate year reports of the Ryggfonn-project.

5. STUDIES OF THE SLIDING LAYER IN THE SNOW COVER

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. Both Grasdalen and Japan has a maritime climate. A part of the study was also to compare this kind of snow pack with a more continental snow pack. Grasdalen is very close to the water divide in Southern Norway, with 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.

This part of the collaboration was accomplished during the first winter, and the results are planned to be presented by the Japanese.

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 OF THE HORIZONTAL HETEROGENITY OF THE 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 the snow cover in Grasdalen was observed by using a ramsonde which measures the strength of the different snowlayers. The results will be compared with similar investigations on Japanese snow covers, and the the climatic influence on the heterogeneousity of the snow pack will be evaluated.

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.

NGI has concentrated their studies on the flow of the dense part of the avalanche close to the ground. In this model it is assumed 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.

A main scope of the Japanese-Norwegian collaboration on snow avalanche research was to exchange experience on avalanche dynamics, where Norway mainly has experience on full-scale experiments through the Ryggfonn-project, while Japan has carried out extensive model experiments. The results of the full-scale and the model experiments have been analysed based on the NGI-model for the dense part of avalanches. The analyses were presented at the Symposium of International Glaciological Society, held at Nigata, Japan, 1992, and indicates that the differences found between the full-scale and model experiments may be described by the model. The analysis give a valuable background for transferring model avalanche results to real avalanche conditions.

8. ARTICLES

As a result of the joint prosject two papers were presentated in the International Glaciolgical Symposium held in Japan 1992:

Norem, H., Nishimura, K., and Maeno, N. (1992):
Comparing model and full-scale experiments on snow avalanche dynamics.

Nishimura, K., Maeno, N., Sandersen, F., Kristensen, K., Norem, H. and Lied, K. (1992):
Observation of the dynamic structure of snow avalanches.

In addition papers concerning the differences in the snow pack properties in Norway and Japan are under preparation.

9. FURTHER COLLABORATION

The Japanese-Norwegian collaboration has shown that the most interesting topic for further collaboration in the field of snow science is within snow avalanche dynamics. The Institute of Low Temperature Science has installed the ultrasonic anemometer in Ryggfonn more permanently. Dr. K. Nishimura is planning to visit the Ryggfonn experimental site for three weeks in March 1994. He will bring along instruments to obtain data of velocity and density distribution. The experimental data from Ryggfonn will thus still be shared to exchange mutual interests how to evaluate the data.

ACKNOWLEDGEMENT

This Norwegian - Japanes collaboration has been made possible by financial support from the Japan Ministery of Education, Science and Culture and by the Royal Norwegian Council for Scientific and Industrial Research. We thank for their support and for all help received by our collegues.

Document check-list

NGI

Client/Project	Japanese-Norwegian collaboration on snow avalanche 1990-1992	○ NS-ISO 9001 ○ NS-ISO 9002 ○ NS-ISO 9003 ⊗ Own check Sign. FS
Contract ref.		
NGI project No.	581200	
Document title	Activities of the Japanese-Norwegian collaboration on snow avalanche research during the winters 1990/1991 and 1991/1992 by Steinar Bakkehøi, Harald Norem, Frode Sandersen, Krister Kristensen and Koichi Nishimura	Document No. 581200-25
Prepared by	Frode Sandersen	Date 1993-03-05

To be checked by Sign. FS	Type of check	Document		Revision 1		Revision 2	
		Accepted		Accepted		Accepted	
		Date	Sign.	Date	Sign.	Date	Sign
HN	General evaluation*	5/3-93	HN				
HN	Style	5/3-93	HN				
HN	Logical	5/3-93	HN				
HN	Technical - intelligence	5/3-93	HN				
	- extended						
	- interdisciplinary						
WUT	Layout						
FS	Final check	5.3.93	FS				
JGS	Copy quality	8/3-93	J.S.				

Comments:

Document approved for release Date 5/3-93 Sign. Frode Sandersen

* On the basis of an overall evaluation of the entire report, its content and form of presentation

048. Bra-Trykk AS

Referanseside - *Documentation page*

NGI

Rapportnummer / *Report No.* 581200-29	
Rapporttittel / *Report title* Activities of the Japanese-Norwegian collaboration of snow avalanche research during the winters 1990/1991 and 1991/1992. Final report. Oppdragsgiver / *Client*	**Distribusjon / *Distribution*** [ ] Fri / *Unlimited* [x] Begrenset / *Limited* [ ] Ingen / *None*
Prosjektleder / *Project Manager* Frode Sandersen Utarbeidet av / *Prepared by* Steinar Bakkehøi, Harald Norem, Frode Sandersen, Koichi Nishimura	Dato / *Date* 1993-03-05 Revisjon / *Revision* Sider / *Pages*
Emneord / *Keywords* Snow avalanche, research	

Geografiske opplysninger / *Geographical information*

Landområder / *Onshore* Land, fylke / *Country, County*: Sogn og Fjordane Kommune / *Municipality*: Stryn Sted / *Location*: Grasdalen Kartblad / *Map*: 1418 IV, 1318 I, 1219 II UTM-koordinater / *UTM-coordinates*	**Havområder / *Offshore*** Havområde / *Offshore area* Feltnavn / *Field name* Sted / *Location* Felt, blokknr. / *Field, Block No.*

048 Bra-Trykk AS