The Ryggfonn Avalanche Dynamics Project

Krister Kristensen and Jan Otto Larsen
Norwegian Geotechnical Institute
P.O. Box 236, N-6880 STRYN, Norway Phone: +47 5787 7370
Fax: +47 5787 7371, e-mail: KRISTER.KRISTENSEN@sprint-norway.sprint.com

EXTENDED ABSTRACT

A full scale avalanche dynamics experiment has been carried out for several years by the Norwegian Geotechnical Institute. The experiment site is the Ryggfonn avalanche path close to NGI's research station in Grasdalen, Western Norway.

Objective

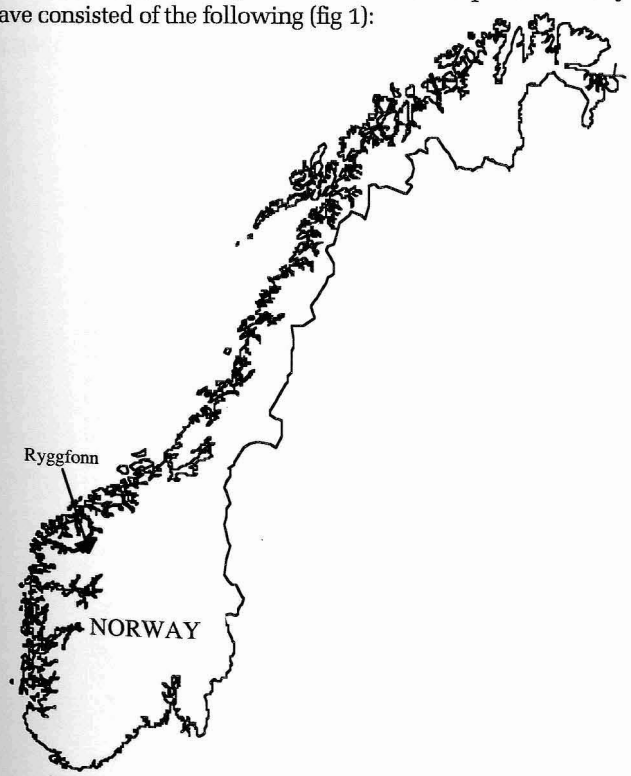
The Ryggfonn project is carried out to investigate the forces on fixed structures from avalanches of different types. In addition, the effect of a retaining dam in the avalanche path is observed. Data from the avalanches are also used in the development of avalanche dynamics models and for parametric studies. Today, the project is financed mainly by Statnett, a division of the Norwegian State Electricity Board and the Norwegian Geotechnical Institute.

Location

The experiment avalanche, Ryggfonn, is situated in Grasdalen, Western Norway. The avalanche usually starts from a north-facing cirque at around 1530 m a.s.l. and runs down a slightly channelled path into the valley floor below. The vertical drop from the starting zone to the runout area is approximately 900 m.

Experimental setup

The installations in the lower part of the avalanche path have varied from time to time, but for most of the experiments they have consisted of the following (fig 1):



- A 15 m high and 75 m wide retaining dam in the avalanche runout zone. On top of the dam is a 6.5 m high steel mast that is instrumented with strain gauges and sometimes an anemometer.
- Three load cells, each with an area of 0.72 m2, are mounted on a 4.5 m high concrete structure situated 230 m up-slope from the dam.
- A 10 m (from 1994: 8.5 m) high tubular steel tower situated 320 m up-slope from the dam. The tower consists of four sections, each having a diameter of 1335 mm and wall thickness of 15 mm.
- The tower is instrumented with strain gauges for measuring shear and moment strains at three sections, mechanical pressure indicators for every 0.5 m and a geophone for detecting the avalanches and triggering the recording system.
- Geophones placed on the ground or snow surface 50 and 100 m up-slope from the dam for the purpose of determining the velocities of passing avalanches.
- An instrument shelter near the runout area with recording equipment. The equipment converts the analogue signals to digital signals and records them on a digital tape recorder.

The avalanches studied are both natural and artificially released. In the case of natural avalanches, the recording system is started when the signal from a geophone on the uppermost construction (the steel tower) exceeds a preset triggering level.

Artificial avalanches are released by detonating up till five preplaced charges in the staring zone by means of a radio controlled detonating system. Typically, each charge consists of 75 to 100 kg of dynamite. Artificial avalanches are usually video-taped and photographed with at time-lapse camera. In some cases, filming is done from the opposite mountain ridge. Avalanche debris boundaries are mapped and the surfaces surveyed for volume calculations.

RESULTS

The volumes of the 27 avalanches reaching the runout area have ranged from between 5000 to 470000 m3. The highest velocity recorded is 60 m/s and the highest recorded pressure on the load cells is 540 kPa. With respect to the effect of dam, the results show that in the cases of wet snow avalanches with volumes not exceeding the storage volume, the avalanches are stopped by the dam. The storage volume in the runout area upslope from the dam is approximately 70000 m3, consequently many avalanches have overrun the dam. For the dry snow avalanches the dam appears to have an effect in reducing the amount of debris on the leeward side of the dam, but there seems to be no significant effect with respect to runout length. For the fast moving powder avalanches the dam has hardly any stopping effect at all.

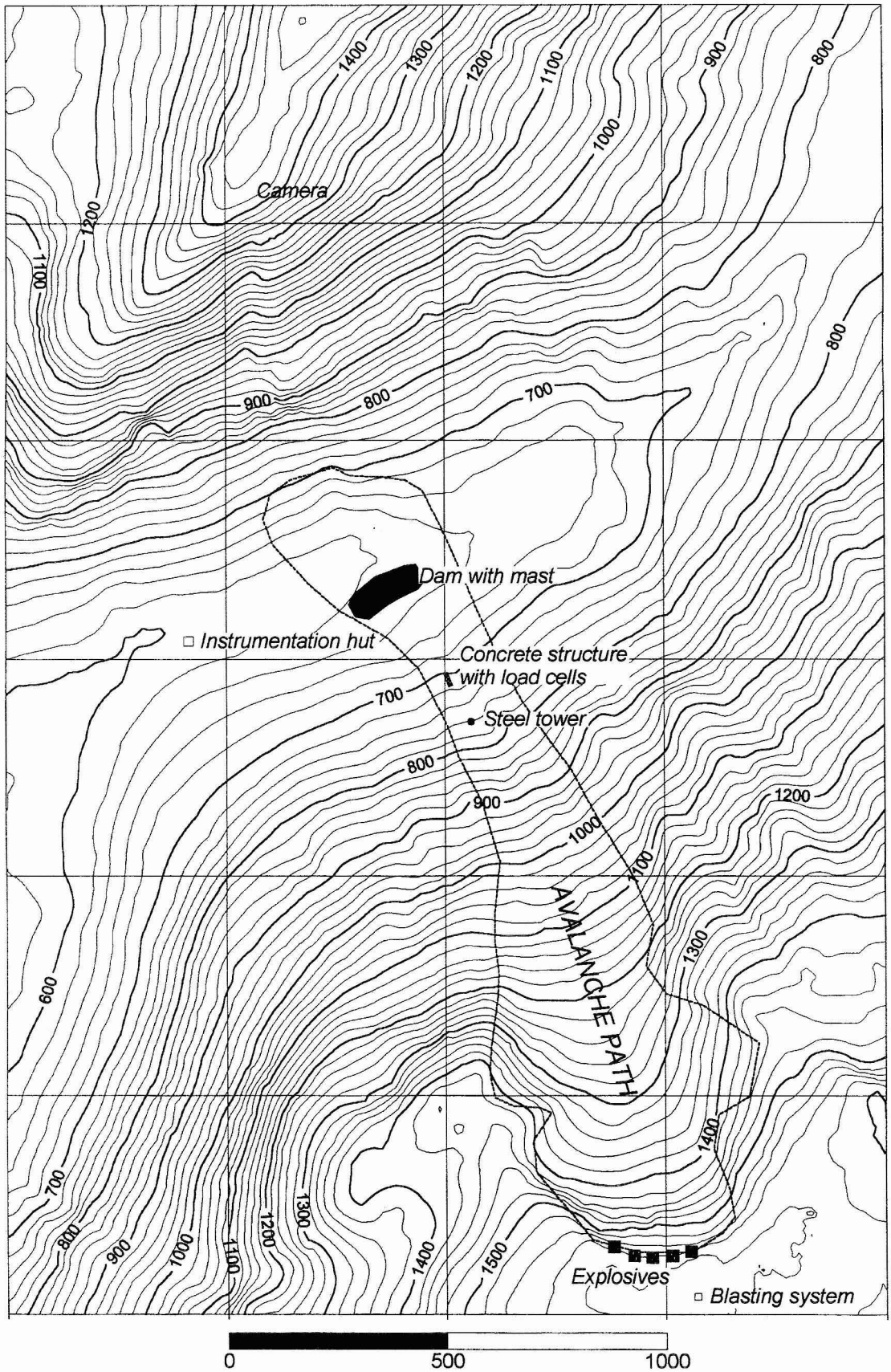


Figure 1: Map of the experiment site