Lautaret avalanche test site: outcomes from the 11th april 2012 event

Xavier Ravanat, Hervé Bellot, Frédéric Ousset, Emmanuel Thibert, Mohamed Naaim

LAUTARET AVALANCHE TEST SITE : OUTCOMES FROM THE 11th APRIL 2012 EVENT

Xavier Ravanat, Hervé Bellot, Frederic Ousset, Emmanuel Thibert and Mohamed Naaim
Irstea, 2 rue de la Papeterie, BP 76, 38402 Saint Martin d'Hères France

ABSTRACT: The Lautaret full-scale avalanche test site has been used by Cemagref-Irstea since the early 70's. The first studies were dedicated to avalanche released systems. Later, experiments focused on avalanche dynamics and avalanche impact pressures both in relation with the fundamental knowledge of snow flow rheology and the engineering of defense structures and avalanche hazard zoning. Recent instrumentation developments now provide rich-documented in situ measurements of avalanche flow. 20 cm-resolution vertical profiles of pressure and velocity get inside into the internal structure of snow flows with a time sampling rate of 3 kHz. In complement to this Eulerian measurement, the Lagrangian velocity of the avalanche front is measured along the track by digital high-speed stereo-photogrammetry. This remote sensing system also provides the initial surface and volume conditions in the starting zone. These measurements are associated to a 2d shallow water avalanche dynamics model to retrieve best possible rheological parameters (i.e. basal friction law) to be fitted on each avalanche event.

KEYWORDS: snow, avalanche, experimental test-site, propagation model

1. INTRODUCTION

Each year hundreds of avalanches present serious risks in the French mountains for humans and constructions (including roads, bridges etc). From the point of view of fluid mechanics the flow of avalanches is a most complex phenomenon. One of the principal tasks of the research unit ETNA of the French institution Irstea is to conceive and construct tools which may be applied to the reduction of natural hazards related to avalanches.
At the full-scale installation at the Lautaret pass, the avalanches are triggered artificially and are studied using instruments in the avalanche path. In particular the flow dynamics and the impact on constructions are studied in detail.

2. THE AVALANCHE SITE OF THE LAUTARET PASS

corresponding author address: X. RAVANAT, ETNA (Irstea), BP76, 2 rue de la papeterie, 38402 Saint Martin d'Hères FRANCE. ; xavier.ravanat@irstea.fr

2.1 *The site*

This site is used by the Irstea (former Cemagref) since 1972. It is located on the Chaillol mountain between the Lautaret pass and the Galibier pass. The initial goal of this site was the study of snow avalanche dynamics and artificial release technology. It was chosen because it is close to Grenoble (90km) and the Grenoble-Briançon road is open all year long despite the pass elevation of 2068 m. Heavy snowfalls and severe storms can occur there and the site offers seven avalanche paths.

The starting altitudes vary between 2300 and 2600 m. The run-out zones are around 2100 m. The slopes of the flowing areas vary between 30° and 40°. The released avalanche volumes vary between 1000 and 10000 m^3. The covered distances are between 300 and 800 m. Various avalanche types are observed: wet-snow avalanches, dry dense-snow avalanches and mixed avalanches. The involved snow is often new snow deposit under the crest. The snow height in the starting area varies between 0,50 and 2 m. The maximum observed velocities varies between 20 and 40 m/s. Today 3 paths are used, all crossing the Galibier road (Fig. 1).

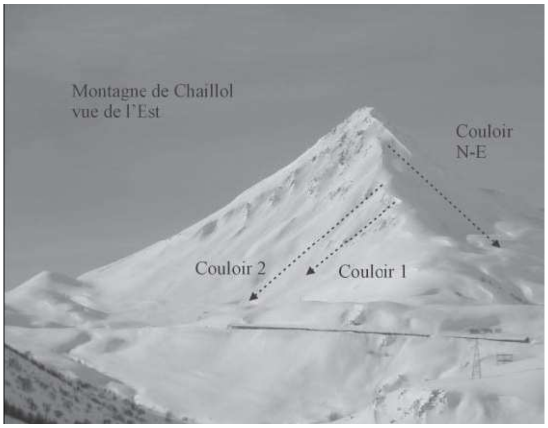

Figure 1: Avalanche Lautaret site

2.2 *The triggering*

After the first Catex (bomb-tram) used in France was tested here, path n°1 is currently released by manual explosive (Fig. 2) with electric starting, and path n°2 is released with a Gazex remote system (gas explosive tube). The North-East path is released with an Avalhex (gas explosive balloon), a new system developed and tested by Irstea and CEA in Lautaret site.

2.3 *The Avalanche path n°1*

Its length is 500 m with an average slope angle of 36° that reaches 40° in the starting zone. An instrumented structure is set up to measure avalanche impact pressure. It consists of a one square-meter plate supported by a 3.5 m high steel cantilever, facing the avalanche, and fixed in a strong concrete foundation (Fig. 3). The plate can be moved along the beam to be located exactly at the surface of the initial snow-cover prior to avalanche release. It represents a large obstacle in comparison to the flow height and therefore integrates the effects of flow heterogeneities. Strains are measured at the bottom of the beam with precision strain gages placed in the maximum bending moment area. Sampling rate for data acquisition is set at 3000 Hz to record dynamic effects. Signals are filtered with a cut-off frequency of 1000 Hz to ensure a bandwidth without aliasing. This system has provided new results in avalanche impact pressure quantification (Berthet-Rambaud et al., 2008; Thibert et al., 2008; Baroudi and Thibert, 2009).

Figure 2: Avalanche artificially released on the 15 February 2007 in path n°1.

Figure 3: Instrumented structure set up in path n°1. The 1 m^2 plate can be moved along the beam to be located exactly at the surface of the snow-cover.

2.4 *The Avalanche path n°2*

A little bit longer than the n°1 but with similar slope angles, path n°2 is dedicated to the study of flow dynamics (Fig. 4). To this end a sensor support (a steel tripod) is equipped with sensors able to measure the flow velocity of the avalanche and the pressure each 20 cm over a vertical height of 3.5 m. The pressure sensors are commercially constructed and are set up on a mast facing the flow. The velocity sensors, developed in our laboratory, are located on arms attached on the left side of the mast (Fig 5). An accelerometer measures the vibration of the tripod to check the boundary conditions of the pressure sensors. Electronic signals are conveyed to the measurement bunker situated between the two avalanches paths. Preliminary results will be shortly published.

Figure 4: Avalanche artificially released on the 27 February 2007 in path n°2.

Figure 5: Pressure (right) and velocity (left) sensors set up on the tripod at path n°2.

3. A TYPICAL DAY OF TRIGGERING

3.1 *The staff and its missions*

One of the main problem to organize a triggering operation is that you need to gather very quickly (a day ahead) a staff of, at least, 8 people. They each have a very specific job: bombers, a gazex operator, a stereo-photogrammetry manipulator, data recording persons and 2 persons as look-out for the public likely to be on site.

3.2 *The legal obligation*

Any triggering operation in France needs to be framed by an official document called PIDA (*Plan d'Intervention pour le Déclenchement des Avalanches*), i.e. a legal procedure for the triggering of avalanches. It is an obligation and it solves three essential questions:

-Where? The location, how to get there, the forbidden zone where nobody is allowed to be (avalanche path) and the zone where the public is forbidden to be.

-Who? You have to fill in the name of the chief of the triggering, of the technical manager of the PIDA, and of the staff which are taking part in the triggering.

-How? Description of the different methods that will be used on the site and their applications.

3.3 *The timing*

All the operators leave from the Irstea center near Grenoble which is a 2h drive from the site of Lautaret.

The bombers leave first in order to get the dynamite from the Serre-chevalier Valley ski resort.

Everybody meets at the Lautaret pass and the staff equips itself with beacon, probe, shovel, ABS backpack and VHF radio and they reach the place where they need to be.

Particularly bombers and data recording persons, who progress in the dangerous zone, have to follow the PIDA instructions.

When the team is ready, the chief of the triggering (who, in this case, is also the ski-patrol manager of the Serre-chevalier Valley ski resort) arrives on the site.

The exposed portion of the main road is then forbidden to the public and the 2 couloirs can be triggered one after the other.

Then the snow profile of the starting zone has to be recorded, and also the snow density sample and topography in the deposit zone.

4. THE 11th APRIL 2012 EVENT

4.1 *The avalanche path n°1*

On this particular day, we discovered a natural deposit around the instrumented structure made of very dense snow packs (too hard to be gouged for a density sample), with huge blocks (≥ 6 m^3).

Figure 6: snow blocks around the measured structure.

This day we discovered that the steel beam was totally twisted by the impact and the measuring was impossible.

Figure 7: the steel beam twisted.

Figure 8: one of the sensor completely eccentric

4.2 _The path n°2_

The triggering of this path was normal. The break measured around 40cm and was made of recognizable particle (/\) with a density of 120 kg/m^3.

The flow of the avalanche was small, nevertheless it hit the sensor support. It was made of multitude of small balls, around 20 cm in size, which stopped quickly after reaching the sensor support.

Figure 9: a balls field in the surface of the deposit.

In the deposit, the density ranged from 200 to 280 kg/m^3 in the lower part, whereas the balls themselves had values of 300 to 400 kg/m^3.

5. HOW TO USE SOME OF THESE RESULTS

Figure 10 : the 11th April 2012 avalanche.

For example, collected field data can be used for a better understanding of the impact force stemming from snow avalanches (Thibert et al., 2008; Baroudi and Thibert 2009). These data are also very relevant and helpful for numerical modeling calibration. Preliminary simulations of the 11th april event have been already carried out with the Irstea avalanche numerical model based on depth-averaged equations including a Voelmy rheology and an erosion/deposit model (Naaim et al., 2003; 2004)

Figure 11: the simulation of the 11th April 2012 avalanche.

6. CONCLUSION

This paper shows that, despite there are problems encountered during the work on the experimental site due to full-scale reality, the obtained results are precious because they are, for instance, helpful to understand avalanche impact force and to validate the numerical models which are a growing part of our research.

7. REFERENCES

Baroudi, D.,Thibert, E., 2009. An instrumented structure to measure avalanche impact pressure : Error analysis from Monte Carlo simulations. *Cold region science and technology* 59, p 242-250.

Berthet-Rambaud P., Baroudi D., A. Limam, E. Thibert, Taillandier J.-M., 2008. Characterization of avalanche loading on impacted structures: a new approach based on inverses analysis. J. Glaciology, 54(185), 324-332.

Naaim, M., Naaim-Bouvet F., Faug T., Bouchet, A. 2004.Dense snow avalanche modeling : flow, erosion, deposition and obstacle effects. *Cold region science and technology* 39: 193-204.

Naaim, M.,Faug, T.,Naaim-Bouvet, F., 2003. Dry granular flow modelling including erosion and deposition, *Surveys in geophysics,*n° 24 (5-6), p. 569-585.

Thibert, E., D. Baroudi, A. Limam, P. Berthet-Rambaud, 2008. Avalanche impact pressure on an instrumented structure. *Cold Regions Science and Technology.* doi: 10.1016/j. cold regions .2008.01.005.