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Mechanical vulnerability assessment of civil structures to snow avalanches.

D. Bertrand and M. Naaim

Cemagref - Snow avalanche engineering and torrent control research unit, Grenoble Regional Center, Domaine universitaire, 2 rue de la papeterie BP 76, F-38402 St Martin d'Hères cedex, Tel. +33 4 76 76 28 31

(name.surname@grenoble.cemagref.fr / Fax: +33 4 76 51 38 03)

The development of tourism, infrastructures and communication networks, and the rarefaction of the safe areas, make difficult to reconcile security, economic and social development. To protect inhabitants against the natural threats, new strategies for risk mitigation has to be adopted. Quantitative risk analysis, which expresses the risk as the product of the hazard (A) and the vulnerability of the element at risk (V), is the one of the main steps.

This communication deals with the assessment of physical vulnerability of civil engineering structures threatened by snow avalanches. The *vulnerability of a given element at risk* is defined by the damage level of the structure after the loading phase. It is expressed on a scale from 0 (no damage) to 1 (total destruction). Nowadays, the assessment of the structure vulnerability is still difficult even if the back-analysis of observed events, allows assessing the vulnerability of a structure damaged by a snow avalanche. However, only a few well documented events are available and the uncertainty of the obtained relations is very high.

The vulnerability depends on the mechanical properties of the material of the structure and its building technology. Moreover, the lack of knowledge concerning on how an avalanche impact damages a structure makes it difficult to know what is the effect of the pressure field applied on the structure. These latter points are explored in order to establish vulnerability relations between impact pressure and the strength of a structure.

For this purpose, numerical simulations of structures loaded by snow avalanches are

carried out in dynamic conditions with the computational software Flac^{3D}. In this first study, only concrete structures are considered. The pressure field developed by a snow loading is supposed to be representative of a type of avalanche (dense, aerosol or mixed). The calibration of the modelling is performed by comparing field observations and numerical results.

For a given type of avalanche and structure, the level of damage is assessed by the plastic zones developed during the loading. Thus, vulnerability relation between the avalanche magnitude and the structure strength capacity can be obtained. The main interest is that every kind of geometries can be simulated very quickly and many different pressure fields can be applied. Thus, vulnerability relations can be obtained easily.