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Physical vulnerability assessment of masonry structures submitted to snow avalanches

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Today, risk analysis constitutes an efficient tool for the protection of people against natural threats. Usually, the risk is expressed as the conjunction between the vulnerability of the element at risk (V) and the natural hazard (A). The vulnerability is the degree of loss (from 0 to 1) of a given element within the threaten area. In this communication, the attention is focused on the derivation of vulnerability relations related to civil engineering structures. The methodology followed for the physical vulnerability assessment of unreinforced masonry structures exposed to snow avalanches is presented.

For estimating snow avalanche risk in residential areas, few vulnerability relations have been proposed. As a rule, field observations are used to build these latter relations. However, the most common problem when applying a purely empirical approach is the unavailability (sufficient and reliable) of data for several intensities. This is the reason why numerical simulations are used to describe the mechanical behavior of the structure and to assess it damage level after the loading. Then, the vulnerability of the structure is expressed from the damage level.

Masonry structures are made up of blocks connected together with mortar. Thus, the so-called *discrete element method* is particularly well adapted to carry out the structure modeling. The structure is described as an assembly of distinct blocks. The interactions between these blocks are controlled by cohesive contact models. This numerical approach makes it possible to simulate large displacements between blocks under

static or dynamic conditions. In order to simulate the avalanche loading, a pressure field is applied to the structure and is chosen to be representative of the avalanche type. Then, the damage of the structure is estimated by the number of broken joints. The latter allows the derivation of vulnerability relations linking the avalanche magnitude and the structure mechanical features.