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# Estimation of Vulnerability Functions for Debris Flows Using Different Intensity Parameters

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In landslide risk research, the majority of past studies have focused on hazard analysis, with only few targeting the concept of vulnerability. When debris flows are considered, there is no consensus or even modest agreement on a generalized methodology to estimate physical vulnerability of the affected buildings. Very few quantitative relationships have been proposed between intensities and vulnerability values. More importantly, in most of the existing relationships, information on process intensity is often missing or only described semi-quantitatively. However, robust assessment of vulnerabilities along with the associated uncertainties is of utmost importance from a quantitative risk analysis point of view.

On the morning of 13th July 2008, after more than two days of intense rainfall, several debris and mud flows were released in the central part of Valtellina, an Italian alpine valley in Lombardy Region. One of the largest muddy-debris flows occurred in Selvetta, a fraction of Colorina municipality. The result was the complete destruction of two buildings, and damage at varying severity levels to eight others. The authors had the chance to gather detailed information about the event, by conducting extensive field work and interviews with local inhabitants, civil protection teams, and officials. In addition to the data gathered from the field studies, the main characteristics of the debris flow have been estimated using numerical and empirical approaches.

The extensive data obtained from Selvetta event gave an opportunity to develop three separate empirical vulnerability curves, which are functions of deposition height, debris flow velocity, and pressure, respectively. Deposition heights were directly obtained from field surveys, whereas the velocity and pressure values were back-calculated using the finite difference program FLO2D. The vulnerability was defined as the ratio between the monetary loss and the reconstruction value. The monetary losses were obtained from official RASDA documents, which were compiled for claim purposes. For each building, the approximate reconstruction value was calculated according to the building type and size, using the official data given in the Housing Prices Index prepared by the Engineers and Architects of Milan.

The resulting vulnerability curves were compared to those in the literature, and among themselves. Specific recommendations were given regarding the most suitable parameter to be used for characterizing the intensity of debris flows within the context of physical vulnerability.