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Experimental analysis of the impact process of saturated granular mixtures against obstacles

A. Di Paolo (1), P. Ghilardi (2), M. Pagliardi (2), B. Zanuttigh (1)

(1) DISTART Idraulica, Università di Bologna, (2) Dipartimento di Ingegneria Idraulica e Ambientale, Università di Pavia

Debris flows exert enormous impact forces on obstacles in their path, such as bridge piles, defensive walls and buildings. The estimation of the range of these forces is necessary for planning defensive structures. As field monitoring and measurements in mountain areas are generally difficult and expensive, experiments are needed to improve the knowledge of debris forces and thus the design of defence works. The purposes of this work were to experimentally analyse impact process of debris flows on structures and to compare maximum forces obtained in the experiments with available analytical formulas. Small-scale dynamically similar model tests were carried out at the Hydraulic Laboratory of the University of Pavia in a 4.80 m long, 0.10 m wide inclined chute by releasing a fixed volume of water saturated granular mixtures that eventually impacted on PVC obstacles of different shape reproducing check-dams, filter-dams and isolated buildings. In the literature, the modelling of impact processes has been focused on binary mixtures flowing against dams with height equal or higher than flow depth. For this work, the mixtures were prepared to represent two typical field conditions. The first mixture was characterised by a widely ranging grain size similar to the one usually employed in the preparation of concrete; the second mixture was characterized by a greater porosity and by a prevailing coarser fraction. The average impact force on the obstacles was measured with a load cell fixed to the chute with a oscillating lever system; two laser level transducers were used to measure flow depth, video-recordings at the chute side with a high speed digital camera allowed a qualitative analysis of the surges front composition, of the single particles movement and of the evolving in time of the flow profile. For obstacles as wide as the chute it was observed that the impact induces a reflected bore travelling upstream for variable distances. Moreover, because of the dissipation of the pore pressure during the impact

on obstacle, the flow was deviated to form a vertical jet. Effects of mixture composition, obstacle size, shape and orientation - with respect to mean flow direction - on force values and deposit extension were examined. Experimental results do not show a particular relevance of grain size composition, whereas obstacle orientation and size clearly influence the maximum force. Only check-dams whose height is around twice the front depth can significantly reduce the kinetic energy and retain the flowing material. All the analytical expressions overestimate the measured force, probably because no-one of the tests produced the total reflection assumed in the formulas.