PASSIVE DEFENCE STRUCTURES AGAINST DENSE SNOW AVALANCHES EXPERIMENTAL ANALYSIS

Paolo Scotton[1], Stefano De Toni[2] , Francesca Moro[3]

In Alpine regions snow avalanches are a severe threat for human settlements, activities, infrastructures. The only countermeasure against snow powder avalanches is to prevent the initiation of the motion by means of active structures, built in the detachment area, and through the artificial trigger of avalanches. Besides, passive structures along the path and in the run-out zone can be very effective in deviating, slowing down, or stopping dense snow avalanches. The design of passive structure is based mostly on the experience of the technicians, because objective design criteria are absent. At the Hydraulic Laboratory of the Faculty of Engineering of the University of Trento an experimental campaign has been carried out in order to analyse the behaviour of some type of structures against granular avalanches.

THE EXPERIMENTAL SET-UP

The experimental apparatus is made up of two inclined planes in forex, with adjustable slope, connected by a narrow flexible strip. A rectangular double slope chute, *20 cm* wide, with transparent sides in perspex, is mounted on the upstream plane, ending about *20 cm* above the change of slope. The granular flow is simulated by releasing a given amount of granular material down the rectangular chute from a reservoir. The granular material is zeolite, a synthetic resin, with roughly spherical grains having a mean diameter of *1 mm*. The motion spreads out of the chute and then stops on the unconfined downstream surface with gentle slope, fixed at 7°. Some conical or wedge-shaped elements, located at the lower end of the chute, slow down the motion.
Different experiments were carried out varying the upper plane slope (*24°*, *27°* and *30°*), the mass of zeolite (*3* and *7 kg*) and using 1 or 3 slowing down elements. In the case of three elements, these were distributed at the vertices of an isosceles triangle, symmetrical with respect to the axis of the chute. The angle θ at the upper vertex was modulated to verify the efficiency of the apparatus with different geometrical arrangements (see in Fig. 1 the final deposits for three different configurations of the slowing down system).

[1] Ass. Prof., Department of Geosciences, University of Padua, Via Giotto 1, 35137 Padova, ITALY (tel: +39-049-827-1865; fax: +39-049-827-2070; e-mail: paolo.scotton@unipd.it).
[2] PhD, Department of Civil and Environmental Engineering, University of Trento, Via Mesiano 77, 38100 Povo (TN), ITALY (Tel.: +39-0461-882603; Fax: +39-0461-882672; email: stefano.detoni@ing.unitn.it).
[3] PhD student, Department of Geosciences, University of Padova, Via Giotto 1, 35137 Padova, ITALY (tel: +39-049-827-2050; fax: +39-049-827-2070; e-mail: francesca.moro@unipd.it).

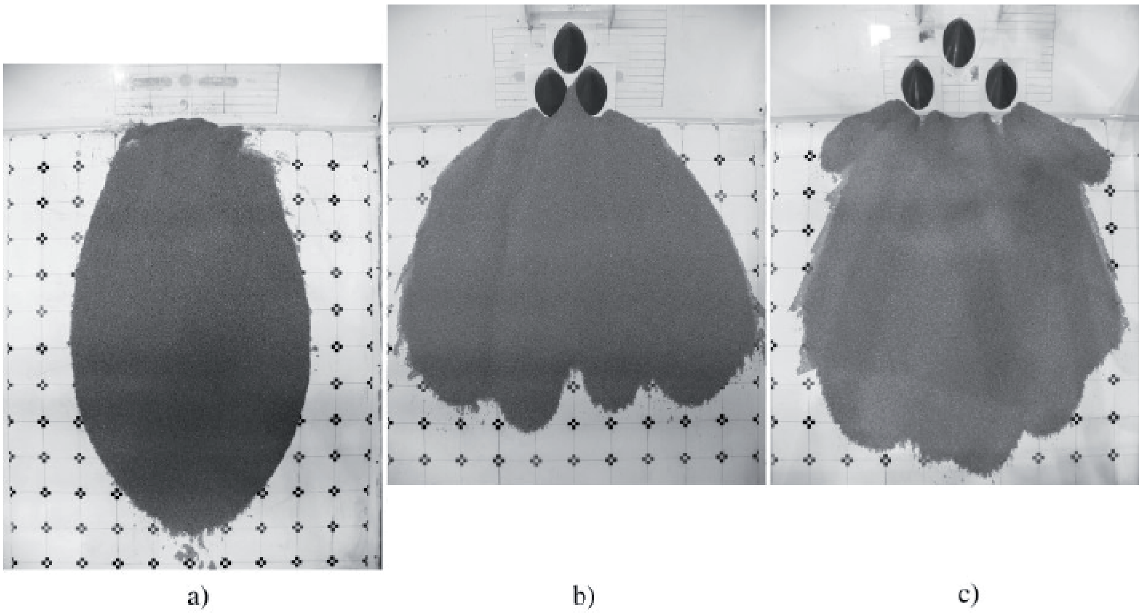

Fig. 1: The final deposit of the granular material for three different arrangements of the conical elements: a) without elements; b) 3 elements with θ=26°; c) θ=45°. The upper plane is inclined at 30°, the mass is of 7 kg

EXPERIMENTAL RESULTS

The experimental analysis provided important informations on how these types of structures work, confirming and improving the knowledges acquired with previous experimental campaigns. The behaviour of three non-dimensional parameters has been investigated: the non-dimensional impact force $F/\rho v^2 A$ (where F is the force, ρ is the density of the granular material, v is the velocity and A the projected impact surface); the longitudinal efficiency $(d_{a\ max}-d_a)/d_{a\ max}$ (being d_a and $d_{a\ max}$ the run-out distances, with and without slowing down elements); the transversal efficiency $(L_{a\ max}-L_a)/L_{a\ max}$ (being L_a and $L_{a\ max}$ the maximum widths of the deposit, with and without slowing down elements).

In the case of one only element with conical shape, the non-dimensional impact force has values varying in a fixed range, independently of the type of experiment, while in the case of one wedge-shaped element, it depends on the ratio between the flowing depth and the height of the element.

When three elements interfere with the motion, the maximum non-dimensional impact force against the lower elements is caught when the angle θ is *30°*. Accordingly the maximum efficiencies are obtained with θ included between *26°* and *30°*.

The wedge-shaped elements proved themselves more effective than conical elements, offering a greater resistance to the motion.

Keywords: passive defence structures, dense snow avalanches, granular flows.