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Small-scale laboratory experiments on debris flow countermeasures

Paolo Salandin and Stefano Lanzoni
Civil, Environmental and Architectural Engineering, University of Padova, Italy (paolo.salandin@unipd.it)

The complex physics that dominate debris flow phenomena put severe limits in the correct reproduction of such events through both numerical models and laboratory experiments (Iverson, 1997). These limitations, in turn, make the definition and testing of effective countermeasures problematic.

Even though the scaling from the model to the prototype is affected by a great uncertainty, physical models give the possibility to test and compare quickly different solutions, thus providing useful information for a preliminary design of the real world structures.

Here, the results of a series of small-scale laboratory experiments are analyzed to evaluate the performances of open-type Sabo dams made of steel pipes (Mizuyama, 2008) in counteracting stony debris flow surges (Lanzoni et al., 2017).

The study has been carried out at the Laboratory of Hydraulics and Hydraulic Works of the University of Padova. The experimental apparatus consists of a sloped flume 3 m long, 0.3 m wide and 0.3 m deep, with a PVC secondary bottom that leaves 9 cm height free space to insert the measurement devices. A model of steel piped slit Sabo dam has been located at a downstream section of the flume. The slope angles investigated in the tests are 17° and 19°.

The dam model is realized to choose among different arrangements of the debris breaker structure. In particular, it consisted of aluminum logs, each with a 12 cm height, a 2 cm diameter, and a central angle of 50°. The array of breakers used in the various tests were 4, 5 and 6.

The sediment chosen for the experiments consisted of medium to fine gravel material (d_{90}=9.5, d_{50}=6.6, d_{10}=4.8 mm), with no content of fines.

A 10 cm thick layer of material was placed on the secondary bottom of the flume and preliminarily saturated with a suitable water discharge. Debris flows were subsequently generated by releasing a preset water discharge over the erodible bed. A system of sensors allowed to record the levels of the flowing sediment-water mixture in different positions, as well as the saturation and triggering water discharges.

A first series of experiments were devoted to assess the overall behavior of the debris surge in terms of surface levels as a function of different openings between the elements (trestles) that constitute the functional part of the structure. A second series of experiments were carried out to assess the performance of a bottom drainage screen placed immediately upstream of the open dam for the same configurations analyzed in the first series of tests.

Tests on each configuration were repeated several times with the same initial and boundary conditions to evaluate the probability of clogging and the ability of the structure to stop the debris flow. The experimental results so far analyzed suggest that the considered dam works properly even for opening between the elements larger than those reported in literature. The insertion of a bottom drainage screen just upstream of the steel piped slit Sabo dam enhances the effectiveness of the investigated debris flow countermeasure.