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Laboratory scale modelling of debris flows

Hervé Vicari, Ashenafi Yifru, Vikas Thakur, and Steinar Nordal
NTNU, Civil and Environmental Engineering, Trondheim, Norway (herve.vicari@ntnu.no)

In mountainous areas, debris flows are endangering human lives and infrastructures. A correct understanding of their behaviour is fundamental to predict their dynamics and runout and to design successfully countermeasures. However, few field observations are available in literature due to the difficulty to predict the phenomenon and to instrument the slope. Physical modelling is therefore an efficient way to catch the relevant dynamical processes; to study the influence of initial and boundary conditions on the flow behaviour and to evaluate the interaction of the debris flow with some mitigation structures.

The flume model used in this study has a 0.3 m wide, 6 m long runout channel and a 2.4 m wide, 4 m long deposition area. The slope of the channel is 17°, while the slope of the deposition zone is 2°. The material (mean diameter: δ_{50}=0.88 mm, coefficient of uniformity: C_u =42 and with varying solid concentrations) is released from a mixing cylinder. The model is equipped with three flow height sensors in the channel and one in the deposition zone. Four cameras are placed to observe in detail the flow behaviour and to calculate the flow velocity. In some tests, the impact force on a rectangular pillar placed at the end of the channel was measured.

Sediment concentration is changed between 50%, 55% and 60% and release volume between 25 L, 30 L and 35 L. An increase of sediment concentration decreases the runout distance and the flow velocity. Release volume increases the flow height.

High values of Froude number are found (between 4 and 8), compared to large-scale debris flows (below 3). This corresponds to a thin and fast flow, characterized by high Savage and Bagnold numbers: collisional processes are dominant in these tests.

The impact pressure was calculated and it shows an optimum at 55% solid concentration. For the lower concentration, the decrease of flow height causes a decrease of impact pressure and for the higher concentration, a decrease of flow velocity causes a decrease of impact pressure. The magnitude of the force was compared to empirical formulas: the hydrodynamic one is more appropriate.

The effectiveness of different types of structural countermeasures is finally evaluated.