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Large-scale flume testing of saturated monodisperse debris flows

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While the concept of effective stress links pore pressure and basal shear stress, surprisingly few data are available describing the nature of particle interactions during multiphase flows or the potential for pore pressure generation due to volume change as the flow deforms. To this effect, a series of tests were conducted to compare particle interactions within dry granular flows to multiphase flows, in context of their significantly different mobility.

An indoor flume was used to release over 1000 kg of pseudo-spherical ceramic beads of a nominal 3 mm particle diameter in both a dry and saturated state. The source material volume varied from 0.2 to 0.8 m^3, to investigate pore pressure generation and dissipation processes that may cause experimental scale effects. The granular material accelerated down a 2.1 m wide and 6.7 m long 30° slope into a 33.0 m long horizontal flume.

The shear behaviour was captured at the particle scale by an ultra high-speed camera at up to 25,000 fps. The high-speed video was analyzed using both Particle Image Velocimetry (PIV) and Particle Tracking Velocimetry (PTV) methods. Good agreement was seen between the velocity profiles generated by each method. PTV results were utilized to assess the collisionality of the flow and the volume fraction. These insights into particle-scale behaviour enabled preliminary classification of the flow regime over the flow thickness. Pore-pressure transducers mounted in the base of the flume provided an indication of basal pore pressures as the landslide mass passed. These pore water pressure values were compared with the visible phreatic surface on high-speed video. The insight into particle-scale interactions afforded by the analysis of ultra high-speed video analysis is intended to stimulate discussion between the geotechnical engineering, fluid mechanics, and granular physics fields.

At the conclusion of each trial, the flow mobility was recorded by terrestrial laser scanning. The results revealed a marked decrease in the travel angle (angle of declination between the center of mass of the source volume and center of mass of the resultant deposit) for saturated deposits over the range of source volumes tested, indicating the effects of scaling experiment size. Contrastingly, the travel angle remained relatively constant for dry deposits.