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# Physical modelling of granular flows at multiple-scales and stress levels

Andy Take (1), Elisabeth Bowman (2), and Sarah Bryant (3)

(1) Dept of Civil Engineering, Queen's University, Kingston, Canada (andy.take@civil.queensu.ca), (2) Dept of Civil and Structural Engineering,University of Sheffield, UK (e.bowman@sheffield.ac.uk), (3) Thurber Engineering, Calgary, Canada (sarah_k_bryant@hotmail.com)

The rheology of dry granular flows is an area of significant focus within the granular physics, geoscience, and geotechnical engineering research communities. Studies performed to better understand granular flows in manufacturing, materials processing or bulk handling applications have typically focused on the behavior of steady, continuous flows. As a result, much of the research on relating the fundamental interaction of particles to the rheological or constitutive behaviour of granular flows has been performed under (usually) steady-state conditions and low stress levels. However, landslides, which are the primary focus of the geoscience and geotechnical engineering communities, are by nature unsteady flows defined by a finite source volume and at flow depths much larger than typically possible in laboratory experiments.

The objective of this paper is to report initial findings of experimental studies currently being conducted using a new large-scale landslide flume (8 m long, 2 m wide slope inclined at 30° with a 35 m long horizontal base section) and at elevated particle self-weight in a 10 m diameter geotechnical centrifuge to investigate the granular flow behavior at multiple-scales and stress levels. The transparent sidewalls of the two flumes used in the experimental investigation permit the combination of observations of particle-scale interaction (using high-speed imaging through transparent vertical sidewalls at over 1000 frames per second) with observations of the distal reach of the landslide debris. These observations are used to investigate the applicability of rheological models developed for steady state flows (e.g. the dimensionless inertial number) in landslide applications and the robustness of depth-averaged approaches to modelling dry granular flow at multiple scales. These observations indicate that the dimensionless inertial number calculated for the flow may be of limited utility except perhaps to define a general state (e.g. liquid regime) for the material due to the high slip velocity encountered in the granular flows. Further, the depth-averaged approach to providing an empirically-calibrated estimate of landslide travel distance was observed to match all configurations tested using a single set of empirically back-calculated frictional properties. The empirically derived basal interface friction was found to be lower than the static interface friction determined by conventional testing, suggesting that new methods are needed for the a priori determination of suitable rheological parameters for high-speed dry granular flows.