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Debris-flow surge dynamics

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Debris-flows occur when gravity-driven masses of poorly sorted sediment and clasts, agitated and saturated with water, course rapidly down hillslopes. Motion is characterised by unsteady, pulsing behaviour with distinct longitudinal sorting. Surge wave morphology typically consists of a steep, unsaturated granular snout propelled forward by a fine-grained slurry liquefied by high localised pore-fluid pressures. Current methods for forecasting the areal limits of debris-flow inundation, however, provide no explicit means of linking hazard potential to the geotechnical attributes of the unsteady surging motion. For example, size segregation coupled with pore pressure evolution can cause significant redistribution of frictional resistance, effecting the velocity and ultimate runout distance of the moving mass. This paper presents an experimental investigation of the dynamics of debris-flow surge fronts, with the aim of developing a conceptual framework in which to assess the effects of grain interaction on the dominant modes of energy dissipation and momentum transport. Stationary, free-surface, gravitational flows are generated within a novel instrumented flume in which a rotating conveyor system allows the motion of the bed to be controlled relative to the flowing granular mass. The mean velocity at any desired distance from the boundary can therefore be made zero relative to the observer without appreciably affecting the internal dynamics of the flow. A non-invasive laser tomography system is coupled with particle image velocimetry to track the individual grain trajectories and thereby visualise three-dimensional flow fields and velocity distributions within the interior of recirculating surge fronts. By matching the refractive indeces of the interstitial pore fluid and synthetic soil particles the role of fabric reorientation on the mediation of intergranular friction can be quantified.