From experimental granular collapses to a three-dimensional numerical solver for landslides

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A granular collapse can be regarded as an idealized case of slumping, e.g., landslides. It consists in a sudden release, by the mean of an apparatus, of a dry granular mass initially contained which elasto-plastically collapses under its self weight and flows upon it reaches a new equilibrium.

We investigated such process by, i) performing numerical simulations and observing experimental evidences thanks to a newly designed apparatus that minimizes initial influences of the retaining walls over the collapse dynamic and, ii) developing an analytical formulation for the run-out distance of the granular mass in agreement with both experimental evidences and numerical solutions obtained by a home-made Material Point Method (MPM) implementation in Matlab based on the Generalized Interpolation Material Point (GIMP) variant. Finally, we further iii) showcase the suitability of the MPM solver to study strain localization problems and associated deformations considering homogeneous or inhomogeneous material properties for dry slumping processes.

We report an excellent agreement of the analytical solution with the experimental data. However, numerical solutions are in a similar range of validity but tend to overestimate the runout distance of the collapse. Nevertheless, large deformations induced by the elasto-plastic collapse are well captured by the solver. In addition, we report similar runout distances regardless for elasto-plastic constitutive relation. We finally demonstrate the importance of heterogeneities over the strain localization and the role of initial geometry in the non-linear behavior of the slumps. Moreover, this also establishes MPM as a relevant numerical framework to address fundamental issues for the geomechanics of slumping.