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Propagation of large debris avalanches: analytical, DEM and FEMDEM modelling of granular and block flows.

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Why large debris avalanches show a high mobility is still an open question. Several theories have been proposed and even if some mechanisms could play an important role for some specific cases, it is difficult to decide which the most significant one is and how it controls the dynamics of the flow. In the present study, in order to investigate the mechanisms involved and the reasons of the large propagation of these phenomena, a sled block model, a discrete element one and a combined finite-discrete element one are used to simulate laboratory unconstrained granular and brick flows on a slope. This allows highlighting the characteristics of each of these models and how they can be useful in the simulation of the propagation of real events.

The sled block model represents the first attempt to describe the rock avalanche propagation (Heim, 1932). The flowing material is considered as a dimensionless point of mass M sliding along an inclined path, characterised by a constant friction angle. Internal deformation and its associated energy dissipation are neglected and the landslide is treated as a lumped mass (Mcdougall, 2006). With this type of model it is possible to predict pretty well the distance travelled by the centre of mass of the considered laboratory tests but, on the other hand, it cannot be used to predict the propagation of the distal end of the deposit because it considers the mass as a rigid block and it does not take into account the considerable spreading that takes place in the accumulation zone and the loss of energy within the mass, which play a significant role in the determination of the final runout.

A discrete element model is more suitable for the simulation of the propagation of a granular mass since it considers the mass as an assembly of elements (spheres or superquads) that can interact with each other but are free to move. For this reason we have simulated the flow dynamics by numerical discrete element simulations using the code WinMimes (Williams and O'Connor, 1999) developed at the Massachusetts Institute of Technology. Simulations confirmed the effects, detected in the experiments, of volume and periodic pulses on the final deposit characteristics even though the two-dimensional nature of the code cannot reproduce the empirical geometrical dimensions.

In order to simulate experiments carried out with parallelepiped terracotta bricks a Finite Element-Discrete Element Method (FEMDEM) has been preferred to the simple discrete element one since it can reproduce better the shape of the blocks and, as a consequence, the interactions between them. Also in this case though, even if simulations can satisfactorily reproduce the influence of the parameters varied during the experiments, such as the initial packing of the blocks and the regularity of the pathway, the two-dimensional nature of the code prevents a quantitative match.

As a conclusion, it can be seen how a combined use of different models allows for a more comprehensive study of a certain phenomenon since each one can complements some of the limits of the others. In addition, despite their limits, the models presented here are very useful to have a first approximation of the distance travelled by the centre of mass and to study the mechanisms which are likely to happen in the longitudinal propagation of granular mass flows.