Geophysical Research Abstracts
Vol. 15, EGU2013-14212, 2013
EGU General Assembly 2013

Mechanics of submerged granular flows driven by gravity

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This work presents a model for gravity driven granular flows saturated with water, particularly suited for modeling of debris flows.

To describe these natural phenomena a two–phase approach is necessary: the liquid-phase (the interstitial fluid), which usually is water treated with a Newtonian rheology, and the solid phase (the granular fluid). Here we will consider only the rheology of a mixture of a liquid and a granular fluid *without cohesion*. The rheology of granular fluid depends of the type of interaction among particles. In this respect, it is possible to identify two different behavior: the *collisional regime*, where the contacts are instantaneous, and the *frictional regime* with long lasting contacts. The model is based on the observation that the two regimes are *not stratified but coexist* in a large part of the flow depth [2]. The kinetic theory of dense gas is adopted as rheology for the collisional regime [4], while we propose a new *rheological formulation* and a new *equation of state* for the frictional regime. This rheological formulation boils down to the Coulombian condition on the static, loose bed and extinguishes gradually its influence, while approaching the free surface region dominated by collisional contacts.

In particular, we propose an heuristic rheological model for the frictional regime based on dimensional considerations of the forces involved, which end up with the introduction of the Savage numbers as a significant dimensionless group: $I_s = \rho_s (d_p \dot{\gamma})^2 / p^g$. ρ_s is the material density of the grains, $\dot{\gamma}$ the shear rate, d_p the diameter of the particles and p^g the granular pressure. We will then integrate the set of mass, momentum and energy equations in steady uniform 2D flow [3] and compare these results with the experimental data [1]. Finally, we will analyze in detail the balance of the total kinetic energy of the granular flow and the balance of the kinetic energy of the collisional component. We highlight the mechanism of transfer of energy between the two regimes.

Bibliography

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