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Fluidization by gas pore pressure of dense granular flows: numerical simulations versus experiments

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In order to model dense gas-particle flows, we use the incompressible Navier-Stokes equations with a viscoplastic rheology based on a Drucker-Prager criterion, so that the yield stress is proportional to the pressure. The presence of air in the granular medium is accounted for by pore fluid pressure, whose effect is to decrease the yield stress. The pore pressure satisfies a convection-diffusion equation. A projection formulation is used to overcome the difficulty due to the non-differentiability of the constitutive law (see [1]). Therefore, no regularization is applied to compute the plastic part of the stress tensor and the rigid zones are accurately captured. A level-set function is used to track the interface between the granular medium, which is a dense mixture of solid particles and air, and the ambiant air, which is described using a Newtonian rheology. The time discritezation is achieved by means of a bi-projection scheme (see [1]).

Numerical simulations are validated by comparison with experimental results for the case of fluidized collapsing granular columnn (dambreak). The main characteristics (mass profile, runout distance, heigth, front velocity, deposition mechanics) of the collapse process are well reproduced (see [1] and [2]). The internal dynamics, consisting of a basal deposit overlain by a thin layer of moving particles whose base migrates upwards during the collapse, is well captured by the model (see [2] and [3]). Unlike the non-fluidized model, which is known to have instabilities in the sense that pressure small-scale oscillations appear and depend on the mesh size, the fluidized one has a regularizing effect.

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