

# MPM simulations of granular column collapse with a new constitutive model for the solid-fluid transition

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## ABSTRACT

Many natural phenomena (rock or snow avalanches, and debris flows) as well as industrial processes are characterized by the flow of solid particles. A key issue in the development of a numerical tool for the study of this problem is the implementation of a suitable constitutive model, capable of capturing the complex rheological behavior of the granular material in a wide range of strain rates. At the micro-scale level, the grains interact by enduring frictional contacts or by nearly instantaneous collisions. The first mechanism prevails at low shear rates, when the material behaves like a solid (quasi-static conditions); the latter prevails at high shear rates, when it behaves like a fluid or a granular gas (collisional conditions).

This paper summarizes very briefly a new constitutive model able to describe the behavior of granular materials from quasi-static to dynamic conditions and the transition in between, which has been recently proposed by [1]. The stress tensor is assumed to be the sum of a quasi-static and a collisional contribution: the former one is modelled by adopting an elasto-plastic model incorporating the critical state concept, whereas the latter stems from the kinetic theory of granular gases.

The constitutive model has been implemented in the MPM code Anura3D and applied to the simulation of the collapse of a dry granular column. We investigate in details the transitions between different regimes, the evolution of the state variables and the state of stress.

In this constitutive model, the energy is dissipated by plastic deformations and by particle collisions or it is stored as elastic energy or kinetic fluctuation energy. These contributions are computed separately allowing interesting considerations on the energy dissipation mechanisms characterizing the process.

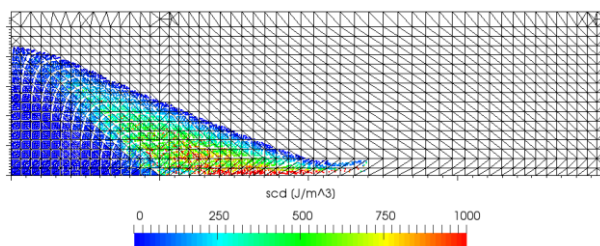


Figure 1 Specific collisional dissipated energy at the MP at  $t=0.25s$

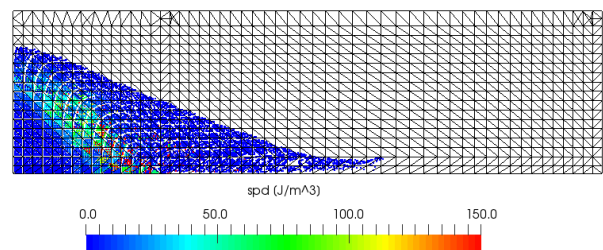


Figure 2 Specific plastic dissipated energy at the MP at  $t=0.25s$

## REFERENCES

- [1] I. Redaelli, C. di Prisco, D. Vescovi, A visco-elasto-plastic model for granular materials under simple shear conditions, *Int. J. Numer. Anal. Methods Geomech.* (2015) n/a-n/a. doi:10.1002/nag.2391.