Geophysical Research Abstracts,
Vol. 10, EGU2008-A-01423, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-01423
EGU General Assembly 2008

Study of granular step collapse by FEM model

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The collapse of a granular step or column is of great interest and has been only recently recognized as an important phenomenon useful for studying transient granular flow conditions. This type of process is quite similar to the dam break problem in fluid mechanics but in this case the material is a granular one. A series of very well detailed experiments is available in the literature (Lajeunesse et al. 2004, 2005; Lube et al. 2004, 2005; Siavoshi and Kudrolli 2005; Balmforth and Kerswell 2005) and have been performed with different granular materials and under different boundary conditions.. The different column or step geometry (low or high aspect ratio between height and width), the change in material properties, the use of smooth or rough basal surfaces, the mechanism adopted for releasing material and the width of the slot in 2D tests have an influence on the final results. Nevertheless, the available data are of great interest for model calibration and verification especially considering the type of phenomena we are interested in. These tests have been compared both with qualitative and theoretical models, aimed at finding some general scaling laws or at testing some two dimensional depth averaged shallow water models. Other authors used particle mechanics models to simulate these experiments (Staron and Hinch 2005) by assuming friction, and rigid collisions between grains. We present results obtained by the finite element code (Roddeman, 2002), allowing to analyse the motion of the moving mass along rough topographies and on materials with different properties. Final geometry, mass redistribution, velocities are used to validate the model capabilities. We present the results of a series of FEM simulations performed considering variable aspect ratios of the relased mass, and different properties for an elasto-plastic material with a Mohr Coulomb yield rule. The obtained numerical results are in very good agreement with experimental data. Failure occurs along a clear inclined plane but most

of the column is moving in a vertical direction with a free fall behaviour and only the more external and lower half of the material starts moving outward with a horizontal component. We are able to simulate the progressive increase in size of the static layer, the rotational failure mechanism and the progressive thinning of the moving mass. The general agreement in terms of geometry, pattern of velocity and position at different instants is good and have been compared through plots of normalized variables with experimental data from Lajeunesse et al. (2004, 2005;), Balmforth and Kerswell (2005) and Lube (2004, 2005). Results of these simulations and application of the model to other case studies demonstrate that the model is able to perform robustly in all these conditions overcoming some of the difficulties typical of 2D-3D solutions of shallow water equations .

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