ON THE FRONT OF A GRANULAR FLOW DOWN A ROUGH INCLINE

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Granular material flowing on complex topographies are ubiquitous in industrial and geophysical situations: civil engineering, food-processing industry, rock avalanches, pyroclastic flows, ... Even simpler controlled granular flows are difficult to understand and predict. To date, the frictional rheology $\mu(I)$ allows unifying different configurations of granular flows: plane shear flow, inclined plane flow, ... [1, 2, 3]. However, the rheology $\mu(I)$ does not succeed in describing some transient flows or some phenomenologies: creep flow, deposit height, ... Is it attributable to the rheology, to non-local effects, to the choice of the function $\mu(I)$, ...? Also, it is not obvious to solve the general equations of movements for a granular flow or to impose the right boundary conditions in order to predict the response of a granular fluid of $\mu(I)$ rheology to a complex sollicitation. To study these questions, our general approach is to compare experimental results, numerical simulations and analytical solutions when possible. Here, we study the small-scale model of a granular layer flowing on a rough incline and we focus on the front of the flow by using both experimental and analytical computational approaches [4]. Our experimental data of front profiles are quantitatively compared with analytical solutions obtained from some generalization of mass and momentum equations [5, 6, 7] incorporating the frictional rheology $\mu(I)$. These equations are depth-averaged equations (shallow water or St-Venant equations), usually used for classical liquids, snow avalanches or granular flows. However, some assumptions made to write these equations for granular flows still need to be clarified. Unlike previous studies where a plug flow is assumed in the depth, we consider the case of a general vertical velocity profile by introducing a shape factor to determine the solution of the front profile of a steady flow on an incline. Such a way, we put in evidence an effect on the front profile of inertia through the Froude number and the shape factor. The analytical predictions are compared with previous experimental results [6] and with our new experimental data obtained at higher Froude numbers. A good agreement between theory and experiments is found when assuming a Bagnold-like velocity profile. However some discrepancies appear at the head of the front where the height vanishes, suggesting that here the velocity profile is different.

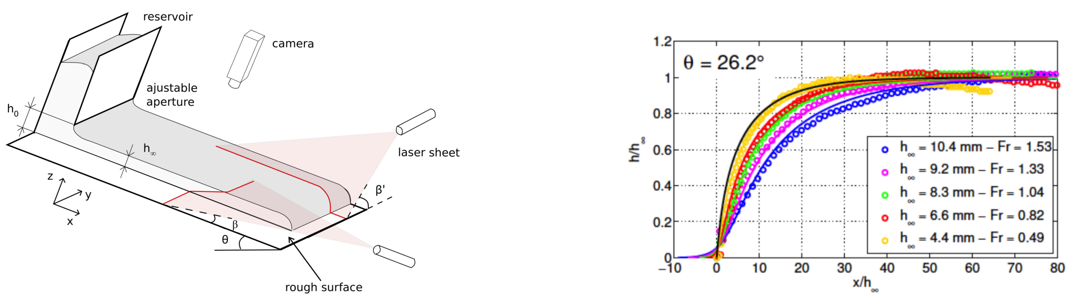

Figure 1. Inclined plane. Superposition of front profiles of granular flows from experiments and analytical solutions.

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