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Shock waves in rapid flows of dense granular materials: Theoretical predictions and experimental results

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Strong shocks in rapid dense granular flows are studied theoretically and analyzed in detail to compare with benchmark experimental data. The experimental data includes Particle Image Velocimetry (PIV) measurements of dry granular flow following its continuous release from a silo. The rapidly moving material down the chute impinges on an obstruction wall erected perpendicular at the end a long and steep channel. Impact leads to a sudden change in the flow regime from a fast moving supercritical thin layer to a stagnant thick heap with variable thickness. This flow configuration is particularly interesting because it is analogous to some hydraulic and aerodynamic situations. We present new results about the depth and the velocity evolution and their comparisons with theoretical predictions associated with the frictional granular flow equations. These flow equations are integrated by implementing NOC differencing TVD schemes. The dynamical and geometrical effects of the flow will be discussed in detail. These include geometry evolution and depositions at the super- and sub-critical flows, the impact velocity, shock speed, its position and evolution. A very good agreement between theoretical predictions and experimental observations will be demonstrated. These results can be applied to estimate impact pressures exerted by avalanches on defense structures and infrastructure along the channel and in the run-out zones, and to study the complex flow dynamics around the obstacles and in depositions when the mass comes suddenly to a standstill. Importantly, these results can form a basis for calibration of numerical simulations when strong shocks occur in granular flows.