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Granular flow over inclined channels with constrictions

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Study of granular flows down inclined channels is essential in understanding the dynamics of natural grain flows like landslides and snow avalanches. As a stepping stone, dry granular flow over an inclined channel with a localised constriction is investigated using both continuum methods and particle simulations. Initially, depth-averaged equations of motion (Savage & Hutter 1989) containing an unknown friction law are considered. The shallow-layer model for granular flows is closed with a friction law obtained from particle simulations of steady flows (Weinhart et al. 2012) undertaken in the open source package Mercury DPM (Mercury 2010). The closed two-dimensional (2D) shallow-layer model is then width-averaged to obtain a novel one-dimensional (1D) model which is an extension of the one for water flows through contraction (Akers & Bokhove 2008). Different flow states are predicted by this novel one-dimensional theory. Flow regimes with distinct flow states are determined as a function of upstream channel Froude number, F, and channel width ratio, Bc. The latter being the ratio of the channel exit width and upstream channel width. Existence of multiple steady states is predicted in a certain regime of F - Bc parameter plane which is in agreement with experiments previously undertaken by (Akers & Bokhove 2008) and for granular flows (Vreman et al. 2007). Furthermore, the 1D model is verified by solving the 2D shallow granular equations using an open source discontinuous Galerkin finite element package hpGEM (Pesch et al. 2007). For supercritical flows i.e. $F > 1$ the 1D asymptotics holds although the two-dimensional oblique granular jumps largely vary across the converging channel. This computationally efficient closed 1D model is validated by comparing it to the computationally more expensiveaa three-dimensional particle simulations. Finally, we aim to present a quasi-steady particle simulation of inclined flow through two rectangular blocks separated by a gap, investigate the channel formed by the dead zones and compare it with our analytical
calculations.

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