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A preliminary study on rheological model of coarse particulate matter in debris flows

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Abstract: Debris flows are a kind of rapid geomorphologic processes, which lies in the range of phenomena intermediate between sediment-laden water floods and landslides and are regarded as a particular solid-liquid two-phase flow. The liquid-phase is the slurry, which is composed by water and fine-particles in debris flows with intensive mixing and behaves a non-Newtonian fluid modeled by Bingham model or Herschel-Bulkley model. The solid-phase is consisted of coarse-particles in debris flows. The enduring contact friction and instantaneous collision between coarse particles can cause the loss of kinetic energy of debris flows and inpede the motion of debris flows. The rheological model of solid-particles in debris flows is a research hotopic for the dynamics of debris flows all the time. Recently, the$\mu(I)$-rheology model of granular flow proposed by G.D.R. MiDi (2004), which is phenomenological one fitted by data of experiments and numerical simulations, where $I$is called as inertial number and represents the relative importance between inertial stress of particles and imposed pressure, shows that the friction coefficient μ depends on inertial number I and increases with increasing$I$. Although $\mu(I)$-rheology model has been a universal attention, the volume concentration of solid-particles could not be directly solved with governing equation since the absence of state equation. In present study, we have researched the character of solid-liquid two-phase flow of debris flows and the properties of $\mu(I)$-rheology model. The results show that $\mu(I)$-rheology model may not be directly used to model the dynamics of debris flows. On the other hand, the frictional-collisional rheology models have provided a specific physical significance and could model the friction and collision between solid-particles separately. Furthermore, according to the theoretical analysis and fitting experimental data, it points out that the frictional-collisional rheology models could be used to model dynamics of debris flows.

Keywords: Debris flows; two-phase flow; Granular flow; $\mu(I)$-rheology; Inertial number