Numerical analysis of debris-flow interaction with open barriers

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ABSTRACT

Debris flows are fast gravity-driven flows consisting of multiple interacting phases. Due to their rapid movement and destructive power, structural mitigation measures have become essential in order to prevent extensive damage to property and life. Among these structures, rigid barriers constitute an efficient system of mitigation, which induces sediment deposition in case of an event. The optimal design of these structures requires the impact force estimation, which has recently become a crucial issue. Because of this, numerous experimental and numerical investigations have been carried out in recent years concerning debris flow and their impact energy on rigid closed barriers [1]. However, there is a lack of information in the framework of rigid open barriers, especially for what concerns the influence of the outlet dimension. In this regard, many studies have examined the jamming of a single-outlet silo [2], where the mass discharges in the direction of gravity, but the jamming of particles on an inclined slope has not been sufficiently investigated yet.

The present numerical study investigates the formation of arching behind an open barrier that partially arrests the flow of particles on an inclined plane. The nature of jamming, and the impact energy on the barrier are examined using DEM simulations for a fixed discharged mass, using different outlet sizes and inclines. The applied model is an improvement of the LBM-DEM code developed by Leonardi et al. [3]. Static friction is implemented with the spring-dashpot linear model and a directional constant torque model is included in order to describe rolling resistance due to elastic deformation and the effect of non-spherical particle shape.

The resulting force and momentum at the flow base are analysed in detail together with the kinetic energy and the distribution of particles in the slot. The study focuses on the jamming of a barrier with a single outlet, but some preliminary results that investigate the case of adjacent outlets are presented too. The dynamic impact of the solid component alone is analysed in order to rationalize the design of open barriers. Indeed numerical examples show that a single outlet could jam with a probability that decreases with the slope and the outlet size, but two adjacent outlets do not necessarily jam in the same configuration.

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