A fluid-particle model for the impact of debris flow on flexible barriers

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ABSTRACT

Debris flows are dangerous natural hazards, and a serious threat to mountain settlements. Recently, success in risk reduction has been registered by the use of protection structures characterized by a high flexibility [1]. These are usually constituted of a steel cable net, anchored to the channel bed and to the banks. The net can filter out and retain the largest debris, therefore reducing the risk associated with an event [2]. The computer-aided design of such structures is usually carried on under the assumption of the debris materials to be either a pure granular or a pure fluid medium. However, such an approach cannot correctly predict the filtering properties of the barrier, and the consequent influence on the flow impact, leading to an over-conservative design. In order to overcome this simplification, a computational framework is designed. The cable-net barrier is represented as a thin shell in a total-Lagrangian formulation, and is solved with the Finite Element Method. The debris flow is idealized as a hybrid discrete-continuum medium using the Discrete Element Method for the representation of the grains, and the Lattice-Boltzmann Method for the solution of the fluid phase [3]. The grains are coupled with both fluid and barrier, providing an elegant way to transmit the hydrodynamic load of the fluid to the barrier without the need of a further specific coupling. The obtained results are very realistic, and show how the impact force on the barrier can be expressed as a function of the flow grain content [4]. We further study the role of the flexibility of the barrier, and of the configuration of the channel. These early results are pivotal to the understanding of the fluid-structure interaction mechanisms, and offer a preliminary basis for the detailed in-field application of the method.

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