Modeling the behavior of flexible barriers impacted by granular flows using Discrete Element Method

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ABSTRACT

The urbanization of mountainous areas raised the importance of mitigating natural hazards such as landslides and granular flows. Granular flows are characterized by their high flowing velocity, destructive impacting force and long runout distance. Forces exerted by granular flows on protection barriers generally vary with the slope angle of the channel bed, thickness of flowing material and flowing velocity.

In this study, a numerical model for the interaction between granular flows and flexible barriers has been developed. The flow was modeled as a visco-elastic material composed of poly-dispersed course-grained particles. With the use of experimental data, the flowing material has been calibrated based on flow thickness measurements and the shape of flowing particles; a single-sphere and a clump [1]. The flexible barrier was composed of several components: net elements, sliding rings, main horizontal cables and breaking elements. These components were modeled using a series of connected cylinders. Each cylinder connects two nodes, where the impact force is transformed from the flowing particles to the nodes through the cylinder. The cylinders were modeled as an elastic perfectly-plastic material that has characteristic tensile strength properties.

The net elements were composed of lozenge-shaped mesh that is attached to the main cable by rigid rings that are allowed to slide allowing the curtain effect to take place. Mesh properties were calibrated using experimental data of punch test measurements on a 3x3 m net [2]. After calibration, the response of the flexible barrier to different loading conditions was studied in details. Impacting forces on the structure, internal forces developing in the barrier's components and the deformation of the barrier were recorded. The effect of barrier stiffness, granular flow velocity and slope inclination angle were analyzed in addition to comparison with analytical solutions [3]. Furthermore, the effect of breaking elements on the structure response was observed for different impacting flows. Finally, guidelines and recommendations for designing such barriers are introduced based on the obtained results.

REFERENCES

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