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Coupled DEM-FEM model for the estimation of loads induced by debris flow on structures

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Dams and barriers are often used as a mean to reduce the hazard posed by debris flows. However, their design is still based on simple empirical formulas, which simplify the multiple components of debris materials as an equivalent homogeneous fluid. This often obscures the complexity of the interaction dynamics given by the presence of the grains. This is especially true when the barrier features one or more slits, which can be clogged by the largest grains.

In this work, we present the results obtained by monitoring a sectional barrier located in St. Vincent, Italian Alps. The barrier consist of a concrete basement, topped by multiple steel beams that retain only the coarsest grains. Each beam is instrumented with strain gauges. From the measurements, the load induced by a debris flow can be inferred. However, the recordings are not interpretable using the equivalent-fluid approach. The presence of the grain, in fact, leads to a counterintuitive load pattern on the barrier.

For this reason, a three-dimensional model based on the Discrete Element Method (DEM) is employed to reconstruct the load on the barrier. The model correctly captures the grain jamming, and produces a prediction of the load. Using a Finite Element Method (FEM) software, we reconstruct the stress-strain distribution on the barrier, which is compatible with the experimental records. We further show how the in-plane load induces the most critical condition for the structural integrity of the barrier, a condition neglected by the empirical design approach.

References:

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