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A unified formulation for the initiation of failures and Debris Flows using the fixed mesh PFEM2

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Debris Flows are natural hazards that happen when a large amount of solid material flows down the slope of a mountain. In most cases the trigger mechanism is caused by heavy rainfall, which reduces the strength of the soil until the terrain becomes unstable and accelerates, mobilizing more mass in the process.

While the infiltration and degradation of the soil's properties is a slow phenomena that takes several hours to fully develop and is driven by the soil porosity, the flow down the slope is usually a fast dynamic process, reaching speeds of several meters per second. Due to these differences, the modelling of debris flows is usually split in two steps. First the initiation is simulated and once the failure area has been determined, the debris flow is simulated taking this area as the starting point.

In this work we propose a new alternative, modelling both the initiation and the flow within a single strategy using the Particle Finite Element Method second generation (PFEM2). To model the initiation of the phenomena, a mixed formulation for solids using velocities and pressure as variables is chosen. Once plastic deformations become too large for the solid solver to handle correctly, the plastic zone is simulated as a fluid with a non-Newtonian rheology. This hybrid strategy allows for a fast and accurate simulation at all the stages of the phenomena. Also, since the variables of the solid were chosen to match those of the fluid solver, the whole process is simulated without the need of changing the framework.