Modelling seismic- and rainfall-induced shallow landslide dynamics

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Earthquakes and rainfall are two of the main causes of landslide instability, which can have detrimental effects on the landscape and infrastructure. In light of climate change, the combination of these two factors has become even more significant, prompting the scientific community to develop increasingly accurate models for predicting landslide motion. Within this framework, the research activity carried out within the RETURN project dealt with the formulation of new theoretical tools for the study of seismic- and rainfall-induced landslides.

The seismic performance of natural slopes is often evaluated based on the evaluation of the earthquake- induced displacements, that for shallow and translational landslides often relies on the Newmark's approach and the scheme of infinite slope. For the Italian territory, this enabled the development of simplified semi-empirical relationships linking the permanent displacement to one or more synthetic ground motion parameters [1]. This tool has proven to be very versatile for assessing co-seismic slope movements on a regional scale, and has become part of the toolchains for landslide instability processes constituting the proof of concept of the RETURN project. Regarding rainfall-induced effects, a computationally efficient sliding consolidation model (SCM) has been developed to determine the impact of the inelastic soil deformation on the hydromechanical conditions of the landslide shear zone during rainfall cycles [2]. An enhancement to the SCM framework [2] included a more versatile Mohr-Coulomb-type frictional model incorporating Lode angle dependence to resolve the coupling between landslide motion and pore pressure build-up. This enables to simulate the onset of failure and subsequent movements during hydrologic cycles, and to detect different regimes of motion, characterized by a transition from a stable creep-like behaviour to a rapid increase in velocity. Finally, as the hydromechanical process is strongly governed by the soil constitutive response, a new constitutive model for clays has been formulated within the framework of thermodynamics with internal variables to account for two different scales of porosity (i.e. pores within and among the aggregates of particles) and the soil fabric defined as the orientation of these aggregates [3]. This allows the model to capture some relevant features of clays behaviour, such as small strain irreversibility, anisotropy and critical state - all of which are crucial to correctly reproduce landslide dynamics.

Keywords: landslides, multi-hazard scenarios, soils, constitutive modelling

References:

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