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Numerical modelling of slow landslides through the exploitation of DInSAR and inclinometric measurements: the Ivancich case study (Assisi, Central Italy)

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Risk management of slow landslides requires both the assessment of slope stability conditions and the analysis of the dynamic evolution in terms of displacement, velocity or acceleration during the deformation phase. To this purpose, we analysed the kinematical evolution of a slow landslides through a numerical model implemented in Finite Element Environment (FEE) and compared with monitoring data based on DInSAR interferometry technique and conventional inclinometric investigation. In our study we analyse the Ivancich slow landslide (Assisi, Central Italy). The landslide body is formed of detritus (or debris) material sliding on a arenaceous marl substratum, with a thin shear band detected using borehole and inclinometric data, at depth ranging from 20 to 60 m. Specifically, we considered the active role of this shear band in the control of the landslide evolution process.

Ground surface displacement measurements have been also retrieved via an advanced space-based Differential SAR interferometry analysis. ERS-1/2 and ENVISAT SAR images taken in the 1992-2010 period have been used to generate long time-series showing the temporal evolution of surface movements of the unstable slope, that indicate different displacement rates for the various portions of the landslide body. A large field monitoring dataset of the landslide process, including at-depth piezometric and inclinometric measurements acquired in the last decade all over the landslide body, was available to us. The piezometric data do not show appreciable variation of the pore water pressures at the level of the sliding surface.

We performed a two-dimensional time-dependent Finite Element Model (FEM) of the active ground deformation field aimed at simulating the kinematical evolution of the different sectors of the unstable mass. In particular, a deviatoric creep law, accounting for a time dependent shear deformation over constant deviatoric stress, has been used to describe the shear band behavior. An optimization procedure based on the at-depth inclinometer measurements and DInSAR interferometry data has been applied to the time-dependent numerical results to derive the optimized model parameters (creep shear rate). The results show that this numerical approach is able to simulating quite well the kinematical evolution of the different portions of this specific landslide process and that this phenomenon can be active for at least one thousand years. Furthermore, the landslide model allows us to localize two different region: (i) a region under extension near the landslide crown area and (ii) a compressive region in the landslide toe area, with the tensile stress region being more enhanced than the compressive stress region. The translational movement of such landslide portion results to be the reason for the long-term instability.

We conclude that the development of advanced physical model built up by the integration of data derived from geological information, the available field measurements by different platforms and the results of suitable numerical methods represent an important methodology to investigate the possible scenarios of slow landslide risk management.