Geophysical Research Abstracts
Vol. 19, EGU2017-19381, 2017
EGU General Assembly 2017

3D viscous time dependent analysis of a slow moving landslide by finite elements

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A methodology to study the cinematic behavior in time and 3D effects of slow moving landslides is presented by its application to the Portalet landslide, located in the Spanish Central Pyrenees. The area is characterize by the presence of several complex landslides triggered by glacial retreat and developed in weathered Devonian and Carboniferous slate materials. In summer 2004, the toe of two paleolanslides was excavated in order to construct a parking area, which reactivated the preexistent rupture surfaces and generated a new and smaller roto-translational landslide of about 5·105m3. Works were paralyzed and the road A-136 connecting Spain and France was temporary closed. In 2006 stabilizing solutions were performed, although surface and deep monitoring data reveal that the landslide is currently active. In this work the cinematic behavior of the Portalet parking landslide has been reproduced since the excavation in 2004 until 2016 by an advanced 3D finite element model (FEM) analysis. A detailed 3D litho-stratigraphic geometry has been defined using the information available from previous works(1-3): real topography, geological profiles, ground water level and material properties. The first step has been a stability analysis using the shear stress reduction (SSR) technique to calibrate the value of the friction angle of the soil layer where the rupture surface develops. In this step the sensibility of the mesh size has been studied, as is a critical parameter. Secondly, stability analysis results have been verified by simulating the parking excavation with a static analysis using Mohr-Coulomb elastoplastic failure criteria. In the last step the behavior of the landslide has been recreated using a hydromechanic coupled formulation for displacements and interstitial water pressure (u-pw), a simple elevation ground water model calculated from daily rainfall and a Perzyna viscous constitutive model of the solid skeleton which represent the creep detected by monitoring. The influence of the fluidity factor of the material has been explored, obtaining the best fitting value. Results show the advantages of performing a 3D analysis, mainly because they reflect the spatial extension of the landslide without the need of assuming a critical profile and allow to study the interaction of differential movements that occur within the same landslide. This methodology can be applied to other slow moving landslides where geological structure and geotechnical data are available.

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