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Numerical modelling comparison of slow landslides: the Portalet case study (Central Pyrenees-Spain)

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Abstract
Slow-moving landslides are a wide-spread type of active mass movement that cause severe damages to infrastructures and may be a precursor of sudden catastrophic slope failures. In this context, modelling slow-moving landslide behaviour is an important task in order to quantify and reduce the risk associated to this geological process.

In practice, landslide occurrence and stability conditions are evaluated for a given scenario through a stability factor based on limit equilibrium analysis. This "static" approximation is hardly applied when boundary conditions are time dependent. Apart from earthquake studies, time dependent analysis is required when: (i) hydrological conditions change as in the case of rainfall; (ii) resistant parameters are reduced as in the case of strain softening or weathering processes and (iii) creep behaviour is taken into account. Different numerical models can be applied to reproduce the kinematic behaviour of large slow landslides. This paper compares four different models: i) a direct correlation with measured rainfall, ii) a simple 1D infinite slope viscoplastic model [1], iii) a 2D elasto-plastic finite element model [2] and iv) a 2D visco-plastic finite element model [3]. These models, ordered by increasing level of complexity, are compared by applying them to the Portalet case study.

The Portalet landslide (Central Spanish Pyrenees) is an active paleo-landslide that has been "reactivated" by the construction of a parking area at the toe of the slope in 2004. This landslide is still active despite the corrective measures carried out to stabilize it. The measurements obtained with different monitoring techniques (ground based SAR, advanced DInSAR processing of satellite SAR images, DGPS and inclinometers) indicate that the hillside is still moving today following two patterns. The first one corresponds to a slow continuous motion of constant speed of about 100 mm/year, the second one corresponds to accelerations of the moving mass when water table rises during rain events. In the last eight years the cumulative surface displacement exceeds two meters.

The comparison made in this paper provides that after a careful and difficult calibration, the proposed models reproduce qualitatively and quantitatively, more or less accurately depending on the complexity of the model, the observed deformation patterns. These models can give successful short-term and medium-term predictions during stages of primary and secondary creep, i.e. at nearly constant strain rate. However, long-time predictions remain uncertain, stability depends strongly on the position of the water table depth and new failures during tertiary creep due to soil temporal micro-structural degradation are difficult to calibrate.

References

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