An application of the MIBSA model to the Little Chief Landslide

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The prediction of a landslide behavior is fundamental for the design of early warning system (EWS) as well for the hazard and risk assessment. The evaluation of expected landslide volume (or extent), displacement, velocity and acceleration is mandatory. Very often empirical formulas are used for landslide volume determination whereas semi-empirical methods like the inverse velocity approach are used for time to failure definition.

Various approaches have been proposed in the literature to reproduce the landslide behavior in terms of displacement for landslides which are already in an active state or for which displacement data are available for calibration. Some approaches introduce the material viscosity to reproduce the slow motion of the landslide when the driving factor is the fluctuation of the ground water table. Another strategy consists in using numerical methods in which the material strength reduction is introduced. In other cases more sophisticated constitutive models are employed to reproduce the material behavior.

In this work, we propose an extension of a simple one dimensional mathematical model which reproduces the post failure behavior considering the landslide as an assembly of blocks interacting between each other and moving along the bedrock. In particular, the model takes into account the shear band mechanical behavior by means of a viscous-plastic model based on the Perzyna’s approach with strain-hardening. The interactions between blocks are modelled by formulating an interaction law which takes into consideration also the tangential effects due to friction along the lateral block boundaries. The forcing factors can be the piezometric level oscillation, the seismic shaking and the oscillation of external water reservoir level.

To validate the mathematical model the numerical results are compared with the Little Chief Landslide located in the North Western Canada along the upper Columbia River valley. The landslide involves a mass of about 800 million of m³ with the stable bedrock depth ranging between 100 and 300 meters. This is an extremely slow landslide which has been investigated since 1960’s and for which displacements, piezometric levels and their evaluation in time are available for long time out-wards allowing to test the model. The landslide shows a periodic trend for displacements with cyclic accelerations and stable creeping. This allows for the calibration of the model parameters.