Geophysical Research Abstracts
Vol. 12, EGU2010-11940, 2010
EGU General Assembly 2010

Coupled hydrogeological and geomechanical modelling for the analysis of large slope instabilities.

Lyesse Laloui (1), Alessio Ferrari (1), and Christophe Bonnard (2)

(1) Soil Mechanics Laboratory, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland (lyesse.laloui@epfl.ch, alessio.ferrari@epfl.ch), (2) Presently independent consultant, PBBG SA, Lausanne, Switzerland (christophe.bonnard@pbbg.ch)

Slowly-moving landslides (average velocity between 2 and 10 cm/year) are quite frequent in mountainous or hilly areas and they may display occasional crises, generally due to exceptional climatic conditions. The hazard related to these events cannot be analysed in terms of probability analysis, as the number of recorded past events is generally very small and climate changes could significantly modify the environmental setting. Quantitative relationships relating climatic condition fluctuations and sliding area velocity must then be pursued by taking into account the most relevant physical processes involved in the landslide behaviours. Conventional stability analyses are unable to deal with such questions because they do not allow the velocity fields to be determined.

With regard to the behaviour of large slope instabilities, a methodology is presented which aims to describe the behaviour of slow-moving landslides by means of a coupled hydrogeological and geomechanical modelling framework. As it is well known, the evolution of the pore water pressure within the landslide body is often recognized as the main cause for the occurrence of displacement accelerations. In this sense the interaction among the hydrological and the mechanical responses must be considered to analyse the landslide behaviour, with the aim of quantitatively relating pore water pressure variations and movements.

For a given case study, pore water pressure evolutions in space and time are obtained from a duly calibrated finite element hydrogeological model, which can take into account the role of several key factors such as infiltration, preferential flows and vegetation. Computed groundwater pressures resulting from the hydrogeological simulations are introduced as nodal forces in a finite element geomechanical model in order to calculate stress evolutions and displacements. The use of advanced constitutive models based on the generalised effective stress concept allows taking into account specific behavioural features such as the effects of the changes in the degree of saturation, associated to the fluctuation of the groundwater level. The geomechanical model is calibrated comparing computed and measured displacements in relevant points of the slope. When appropriate, the outcomes from the geomechanical model can be used in an iterative way to update the hydrogeological model settings. In this way it is possible to simulate the evolution of critical factors (such as permeability or retention properties of the involved materials) associated to the cumulated displacements. Once calibrated, the coupled models can be used to assess the landslide behaviour under different scenarios, including modified climatic conditions and the implementation of mitigation measures.

Applications to relevant case studies are presented in order to demonstrate the adequacy and the usefulness of the proposed modelling framework.