Permeability changes induced by microfissure closure and opening in tectonized materials.

Effect on slope pore pressure regime

M. De La Fuente 1, 2, J. Vaunat 1, G. Pedone 1, F. Cotechia 4, F. Sollecito 4, F. Casini 5
1. Department of Geotechnical Engineering and Geosciences, Universitat Politècnica de Catalunya, E-08034 Barcelona, Spain.
2. BoschiVentayol Geoservices S.L., Barcelona, Spain
3. South Hampton University, South Hampton, United Kingdom
4. Politecnico di Bari, Bari, Italy
5. Universita degli Studi di Roma Tor Vergata, Roma, Italy

ABSTRACT:
Tectonized clays are complex materials characterized by several levels of structures that may evolve during load and wetting/drying processes. Some mesostructural patterns, as fissures, have a particular influence on the value of permeability which is one of the main factors controlling pore pressure regime in slopes. In this work, the pore pressure regime measured in a real slope of tectonized clay in Southern Italy is analyzed by a numerical model that considers changes in permeability induced by fissure closure and opening during the wetting and drying processes resulting from climatic actions.

Permeability model accounts for the changes in Pore Size Distribution (PSD) observed by Mercury Intrusion Porosimetry.

STUDY CASE
Pisciolo hill-slope is located in a tectonized clayey formation on the right side of the Ofanto River valley in the Lucanian Apennines (Melfi, Italy). The low resistance of the fissured tectonized clays and the high level of pore pressures provide the conditions for the development of a complex landslide zone composed by up to 14 landslide bodies over the whole hill slope (Cotechia et al. 2014a).

Comparison between monitored pore pressures and rainfall events (Fig.1) evidences a hydrogeological response controlled by relatively high permeability values, resulting from fissuring at the different scales of observations. They are one of the key controlling mechanism for the stability of the Pisciolo landslide complex (Cotechia et al. 2014b).

SOIL MICROSTRUCTURAL ANALYSIS
Mercury Intrusion Porosimetry technique is used in this investigation for the microstructural analysis of Pisciolo clay (Fig. 4). MIP tests are performed on representative undisturbed samples (Fig. 2 & 3) for (field porosity and humidity) and final conditions (flooded sample under in situ vertical stress in order to reproduce soil saturation during heavy rains).

Figure 2: Sample of undisturbed Pisciolo soil (M. De La Fuente 2014).

MIP measurements allow for the characterization of the pore size distribution of the natural and flooded soil. They lead to the identification of soils dominant pores families and their evolution during wetting (Fig.5).

Data particularly evidence the sealing of the largest pores (identified as fissures by fractal analysis) during sample saturation.

Figure 3: Cubic sample for MIP test (M. De La Fuente 2014).

MODEL FOR PORE SIZE DISTRIBUTION AND PERMEABILITY EVOLUTIONS
According to Romero et al. (1999), Mercury Intrusion Porosimetry and soil water retention curves can be linked together provided that a correction is applied to switch from soil/air/mercury to soil/water/air interface effects. Consequently, under the assumption of undeformable soil skeleton, there is a direct relationship between degree of saturation at a target suction and the pore volume non intruded at the same value of mercury intrusion pressure. This similarity is exploited in this study to relate permeability and Pore Size Distribution through relationships classically used between permeability and degree of saturation in unsaturated materials.

To that aim, the Cumulated Pore Size Distributions of the natural and flooded samples are expressed into the form of a water retention curves and modelled by overlapping several van Genuchten’s expressions, each one corresponding to one pore size distribution mode. Fig. 6 shows the fit obtained for the natural sample.

Figure 6: Model of the retention curve obtained from the MIP of the natural soil sample, using a trimodal retention model defined by different subcurves of Van Genuchten adjusted to the effective saturation values corresponding to the domain of each modal pore families identified by MIP (M. De La Fuente 2014).

In a second step, the soil water retention curve is derived for any microstructural arrangement between the natural and flooded states by setting an adequate description of PSD change. It is based on the definition of coupling parameter (ψ), equal to the change of water content (or non intruded pore volume) over the change in porosity (or total pore volume) (Casini et al., 2014).

Figure 7: Computation of the current WRC from the initial WRC curve, obtained by MIP and the knowledge of ψ parameter, defined as the ratio of variation in water and void content in the sample (M. De La Fuente 2014).

Finally, the permeability for a given microstructural state is inferred from a pore series model and Mualem closed form relationship.

Figure 8: Equation of the permeability for one pore family. It is based on the effective saturation values derived from the trimodal Van Genuchten curve updated for a given microstructural state by application of a parameters (M. De La Fuente 2014).

REFERENCES