ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Tunnels in saturated porous media

During the excavation of underground openings in saturated formations with low permeability, a quasi-instantaneous drop of pore water pressure is observed in the surroundings of the opening, as a result of hydro-mechanical coupling. Whereas this hydraulic disturbance is a significant phenomenon, it is relatively unknown and cannot be predicted by means of methods developed for monophasic media

On the other hand, an approach based on the mechanics of porous media, that accounts for the intrinsic properties of the solid skeleton and of the pore fluid, enables a better understanding and quantification of the phenomenon. In this framework, the LMR carries researches to determine the magnitude of the hydraulic and mechanical disturbances arising around such underground openings during their construction. The work consists essentially in:

- the development of simple analytical solutions based on restrictive assumptions, but that present the advantage to perform quick parametrical studies,
- more complex finite element calculations to account for the coupled character of the rock mass-supporting structure interaction problem.
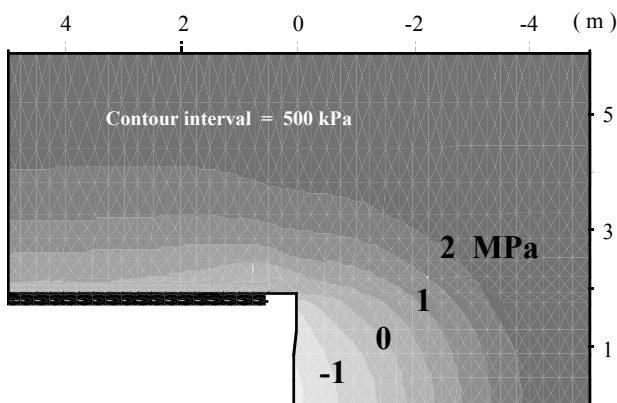

Fig. 1 Instantaneous drop of pore water pressure generated during the excavation of a tunnel. Results taken from finite element calculations.

A Ph. D thesis, supported by the Swiss National Science Foundation, is in progress at LMR. Its aim is to clarify the three-dimensional aspect of the stability of circular tunnels excavated at great depth in porous media having elasto-plastic behaviour (Mohr-Coulomb failure criterion). Not only should the equilibrium between the rock mass and the lining be determined, but also the amplitude of the hydraulic and mechanical disturbances brought about around such structures during their construction. The main factors to be studied are the lining stiffness, its placement distance behind the cutting face, its placement tolerance, as well as the tunnel excavation speed.

Finite element calculations are carried out for a two-dimensional axisymmetric configuration. They take into account the sequential process of tunnel excavation and analyse its influence on the hydro-mechanical disturbances generated in the porous medium.

Then, based on the results and the methodology used for the elaboration of simplified design models in monophasic elasto-plastic media, the research will endeavour to establish analogous relationships applicable to tunnels excavated in porous elasto-plastic media. Finally, the results of this study will be applied to a practical case study (underground laboratory HADES in Belgium) and compared to in situ measurements.

Publications

Labiouse V., 1997. Advanced hydro-mechanical modelling of excavations in the Boom Clay formation. *Proc. Boom Clay Seminar,* Alden Biesen, pp. 45 - 58

Labiouse V., Giraud A., 1998. Analytical solutions for the undrained response of a poro-elasto-plastic medium around a cylindrical opening. *Proc. Biot Conference on Poromechanics,* Louvain-la-Neuve, pp. 439 - 444