Université de Liège ULg

Hydro and hydro-mechanical modelling of ventilation test in clayey rocks

ArGEnCo

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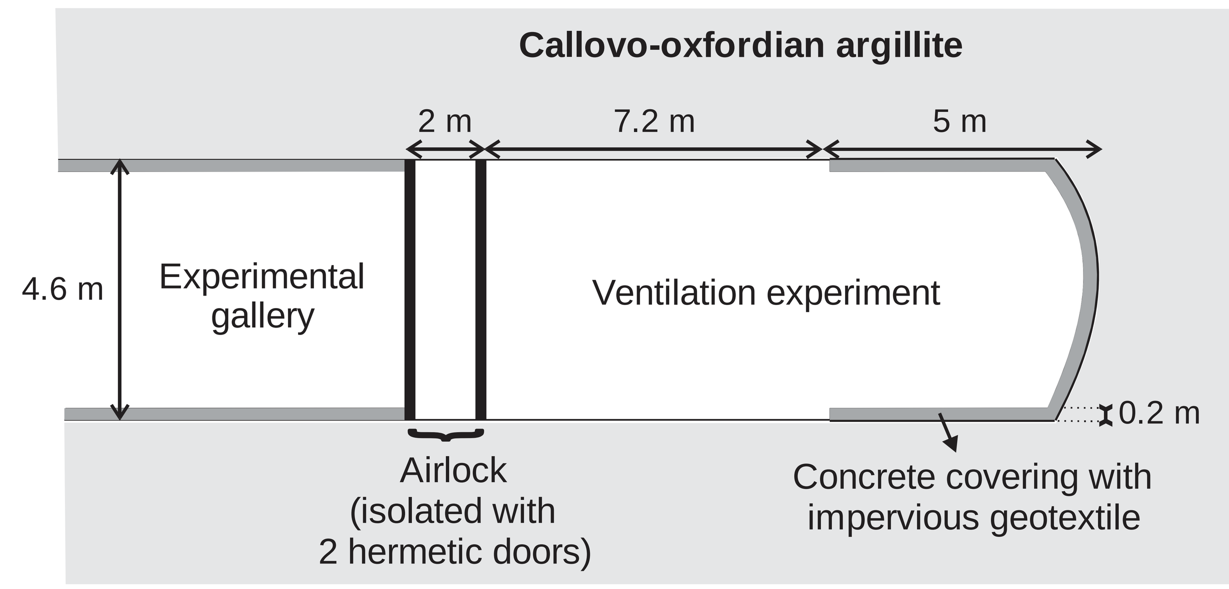
Study description

Long-term repository of radioactive waste is considered in deep argillaceous geological media with low permeability. Because of excavation and ventilation, the rock mass close to the galleries is damaged and its permeability is modified. A ventilation experiment is performed by Andra in an experimental gallery of the Meuse/Haute-Marne underground research laboratory. The aim is to study the behaviour of the damaged zone.

Numerical modellings are performed in order to acquire a better understanding of transfers occurring during the test.



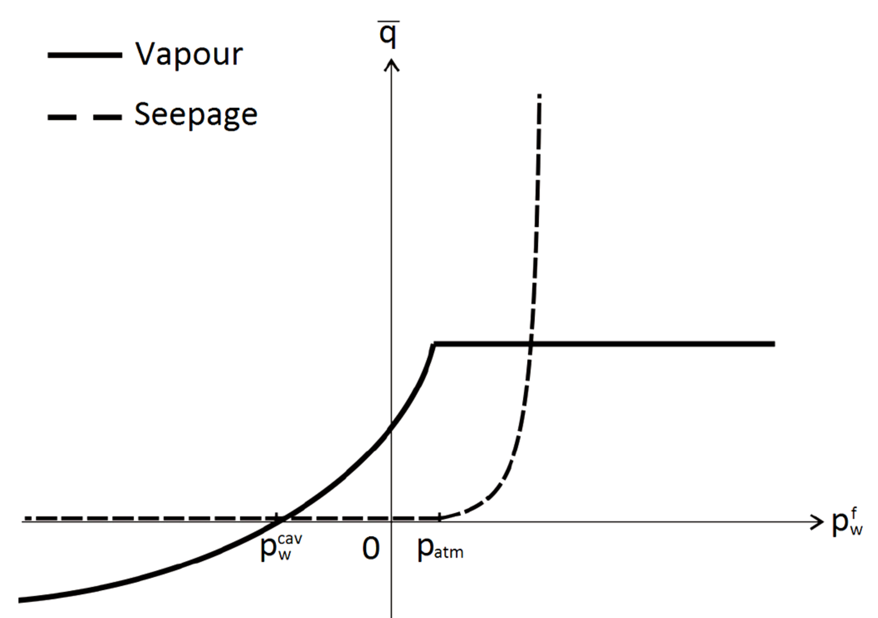
Experimental gallery and ventilation test zone

Constitutive models

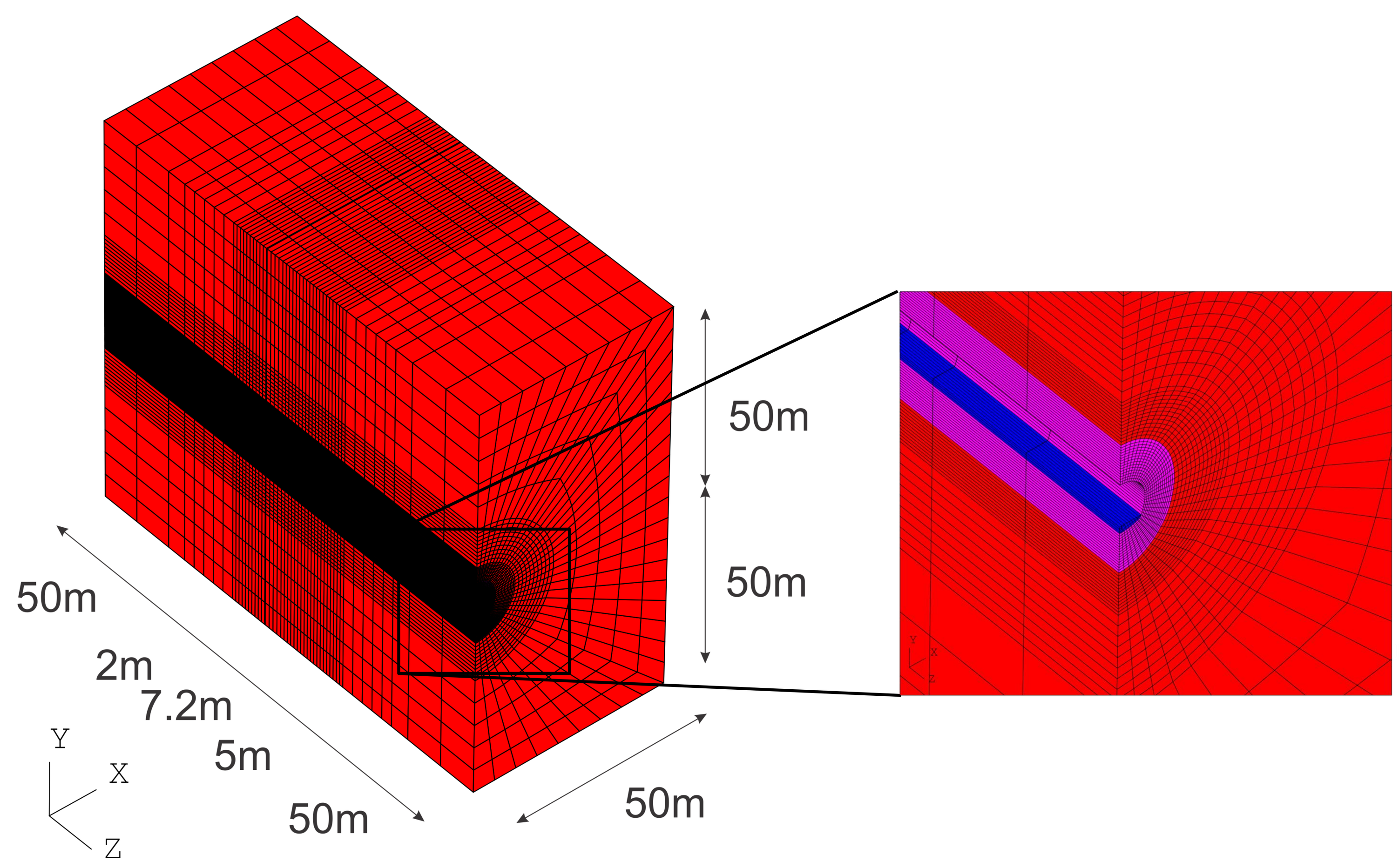
A biphasic flow model is used to reproduce water and air transfers in partially saturated porous media [1]. The constitutive mechanical law for the clayey rock is a linear elastic-perfectly plastic model with a Van Eekelen yield surface. A non classical hydraulic boundary condition with water and vapour exchanges has been developed to model the fluid exchanges between the cavity and the rock [2] :

- seepage flow : $\begin{cases} \bar{S} = K(p_w^f - p_{atm})^2 & \text{if } p_w^f \ge p_w^{cav} \text{ and } p_w^f \ge p_{atm} \\ \bar{S} = 0 & otherwise \end{cases}$
- vapour exchange flow : $\bar{E} = \alpha.(\rho_v^f - \rho_v^{cav})$

with p_w^f and p_w^{cav} the pore water pressure in the rock formation and in the cavity,
ρ_v^f and ρ_v^{cav} the vapour densities in the rock formation and in the cavity,
K a penalty coefficient for seepage,
α a vapour mass transfer coefficient.



Hydraulic boundary condition



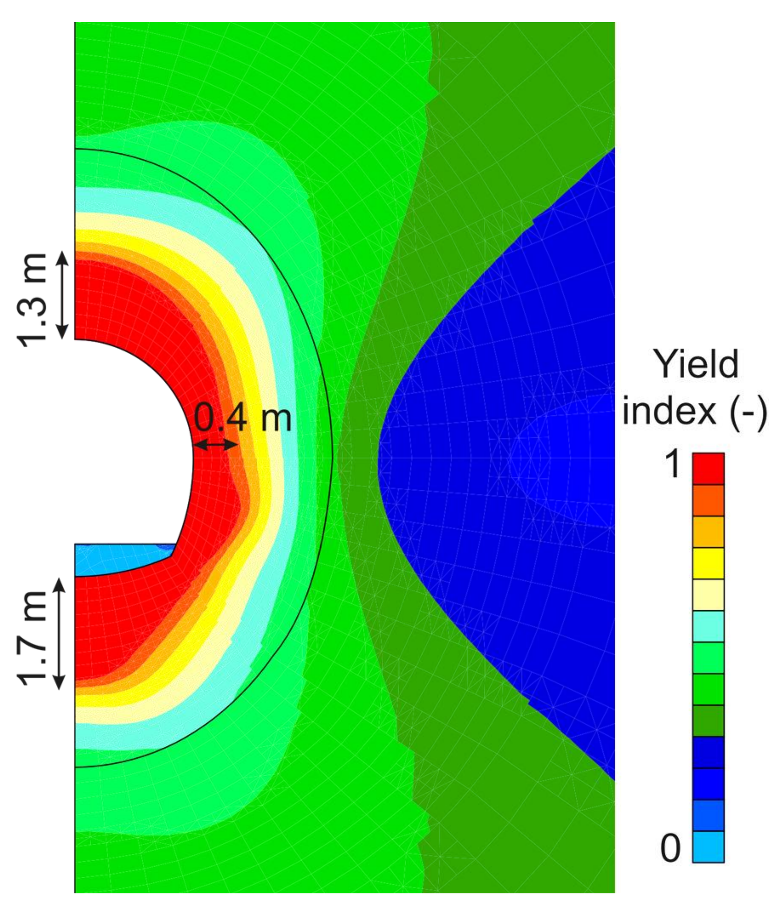
3D mesh

Numerical modelling and results

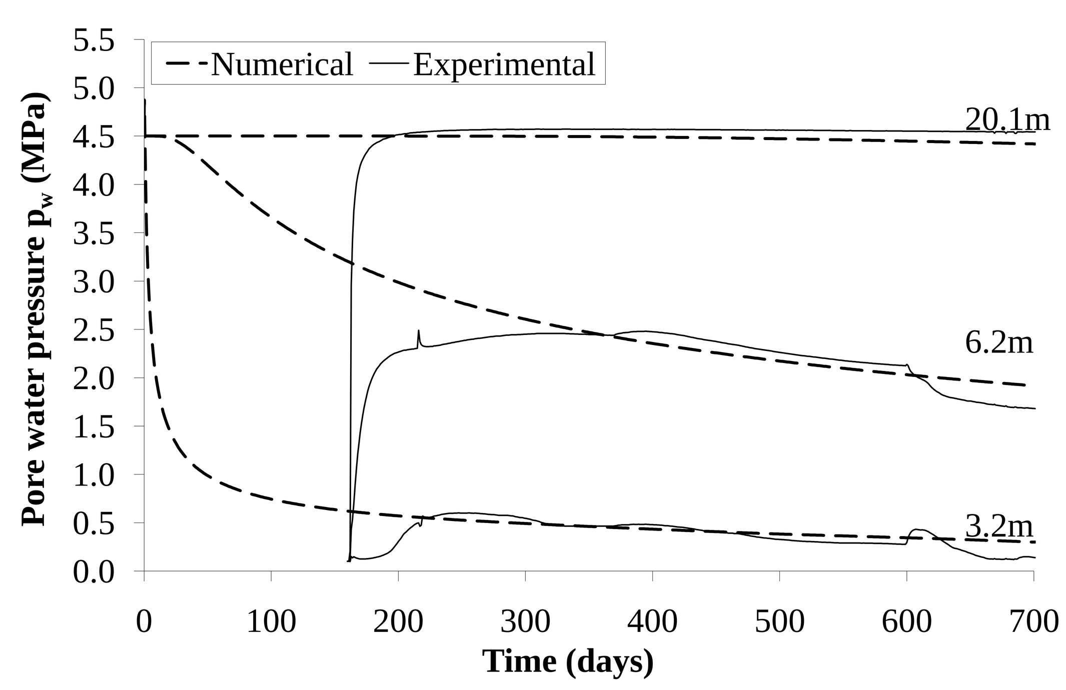
The models include permeability anisotropy and damaged zone which is implicitly defined. Firstly, only water transfer is considered in 2D plane strain state, 2D axisymmetric state and 3D state models.

Among several parameters which were calibrated, the vapour mass transfer coefficient has a significant influence on the reproduction of experimental measurements of pore water pressure. Results also highlight that fluid transfers take place in the damaged zone.

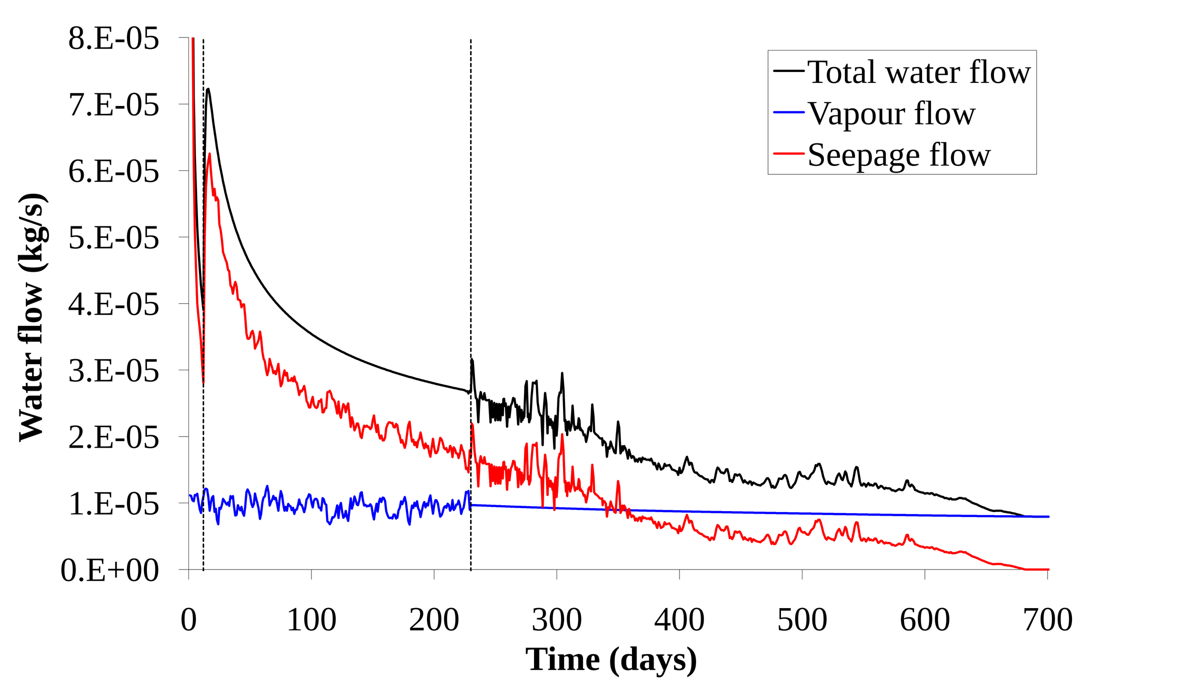
A hydro-mechanical coupling, taking into account the anisotropic stress state and the excavation, is realised in 2D plane strain state model. The plastic zone obtained numerically corresponds relatively well to the experimental measurements of the damaged zone extension.



Plastic zone



Matching of numerical and experimental results at different distances from the gallery wall (3D model)



Evolution of radial water flow directed toward the experimental zone of the gallery (axisymmetric model)

References : [1] Collin F, Li XL, Radu JP, Charlier R (2002) Thermo-hydro-mechanical coupling in clay barriers. Eng. Geol., 64: 179–193
[2] Gerard P, Charlier R, Chambon R, Collin F (2008) Influence of evaporation and seepage on the convergence of a ventilated cavity. Water Resour. Res., 44: W00C02

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