Hydro-mechanical behavior of Boom clay host-rock in interaction with a deep excavated gallery's lining

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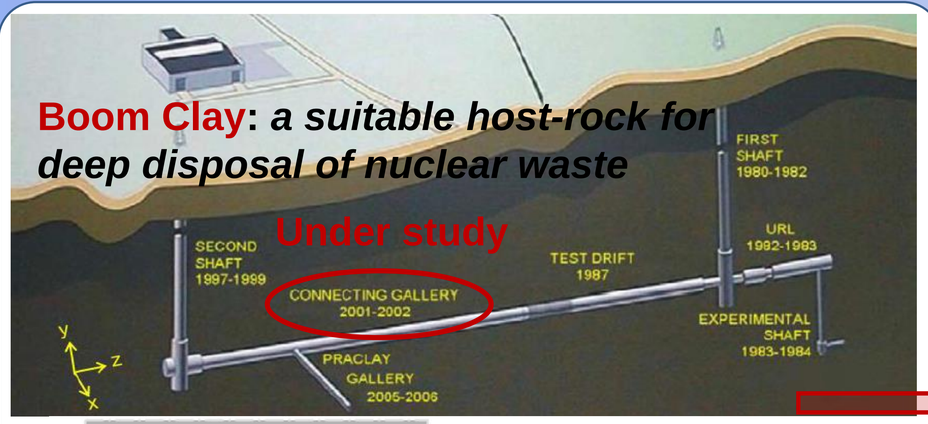
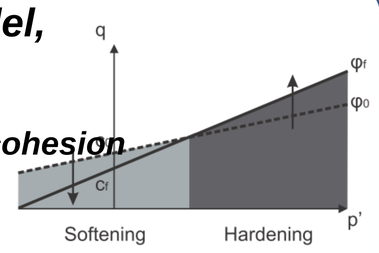


Gallery excavation
↓
Stress redistribution
↓
Triggering of fracturing and localized micro-crack propagation & Creation of EDZ
↓
Strain localization phenomenon
↓
Altering the favorable host-rock's properties

1.Elasto-plastic internal frictional model, Drucker-Prager yield surface /

***hardening of friction angle and softening of cohesion**



2.Coupled second gradient method

(Collin et al. 2006)

$$\int_\Omega \left(\sigma_{ij}\frac{\partial u_i^\star}{\partial x_i} + \sum_{ijk}\frac{\partial^2 u_i^\star}{\partial x_i \partial x_k}\right) d\Omega = \int_\Omega G_i u_i^\star \, d\Omega + \int_{\Gamma_\sigma}\left(\overline{t}_i u_i^\star + \overline{T}_i D u_i^\star\right) d\Gamma$$

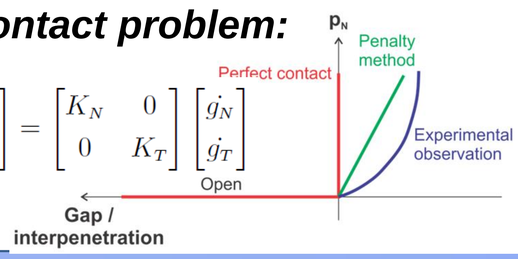
Coulomb criterion

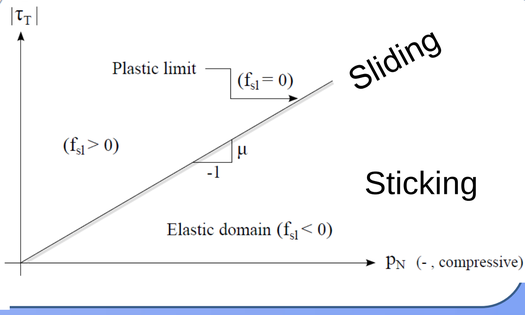
$$\int_\Omega \left(\dot{M} p_w^\star - m_i \frac{\partial p_w^\star}{\partial x_i}\right) d\Omega = \int_\Omega Q p_w^\star d\Omega - \int_{\Gamma_q} \overline{q} p_w^\star d\Gamma$$

$|\tau_T|$

Contact problem:

$$\begin{bmatrix}\dot{p}_N \\ \dot{\tau}_T\end{bmatrix} = \begin{bmatrix}K_N & 0 \\ 0 & K_T\end{bmatrix}\begin{bmatrix}\dot{g}_N \\ \dot{g}_T\end{bmatrix}$$





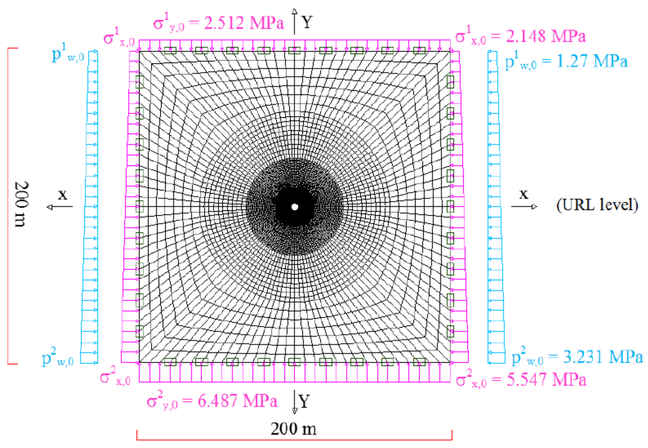
Numerical model

- 2D plane strain simulation
- HM coupled modeling
- **Initial anisotropic stress state:** σ_{yy}=4.5 MPa, $\sigma_{xx}=\sigma_{zz}$=3.825 MPa
- Initial pore water pressure: P_w= 2.25 MPa

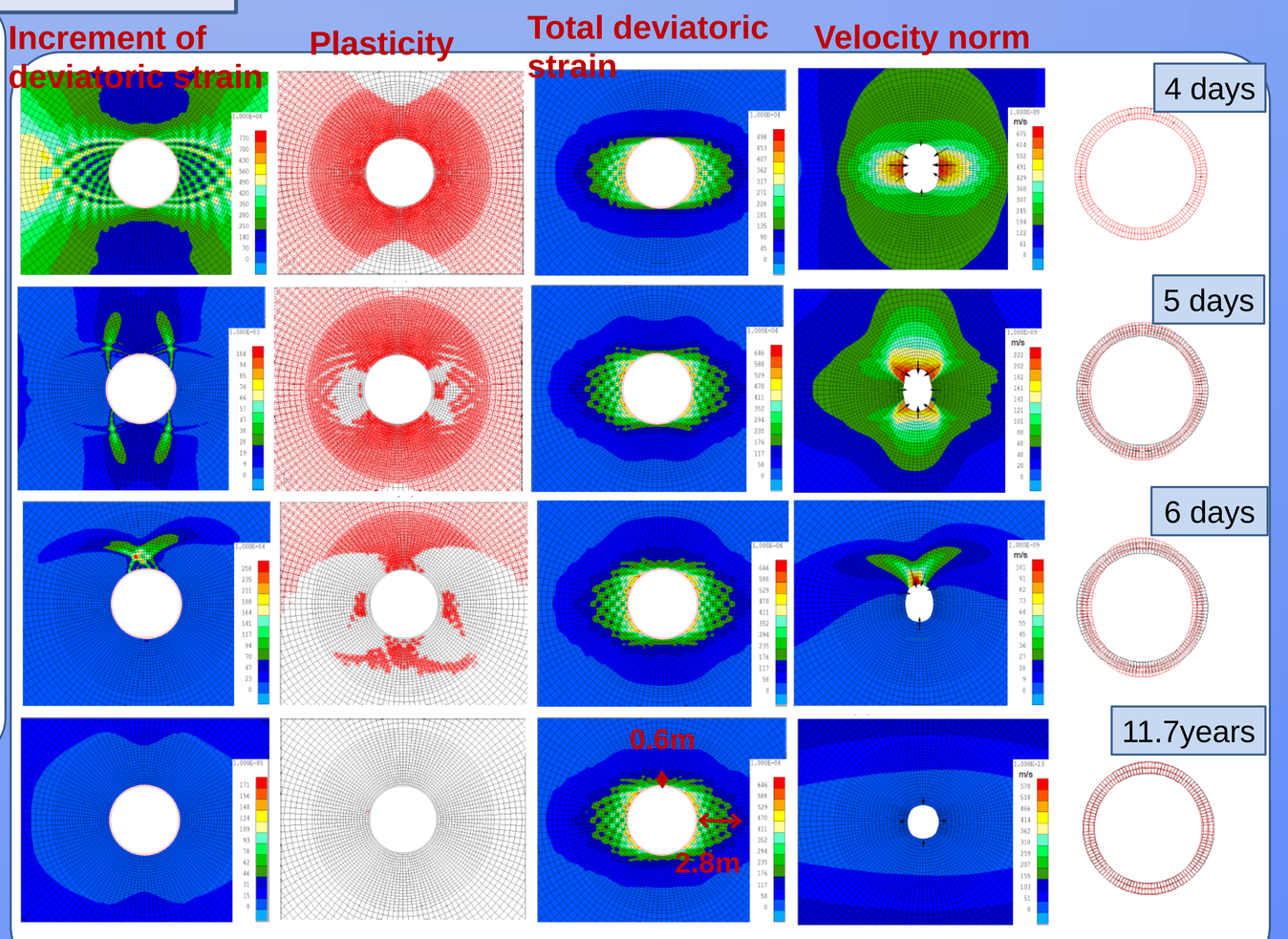
Released during the excavation, to 0.1 MPa

- **Material anisotropy :** anisotropic elasticity/ cohesion (plastic anisotropy & permeability
- Gravity effects
- Excavation phase of 6 days waiting phase of 11.7 years

90 mm over-excavation radius

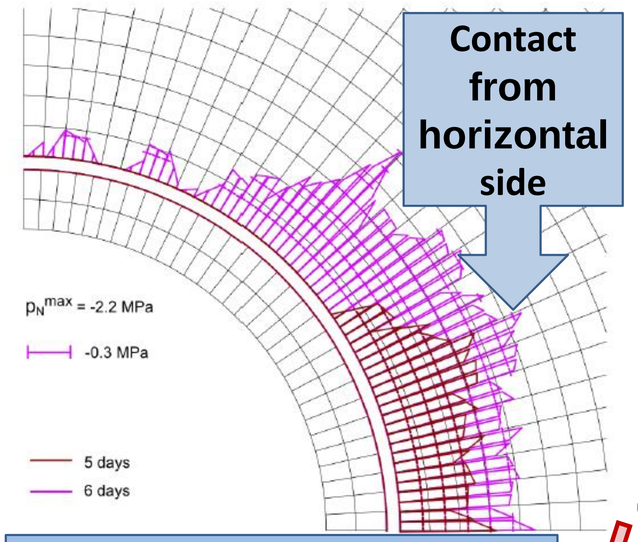


RESULTS

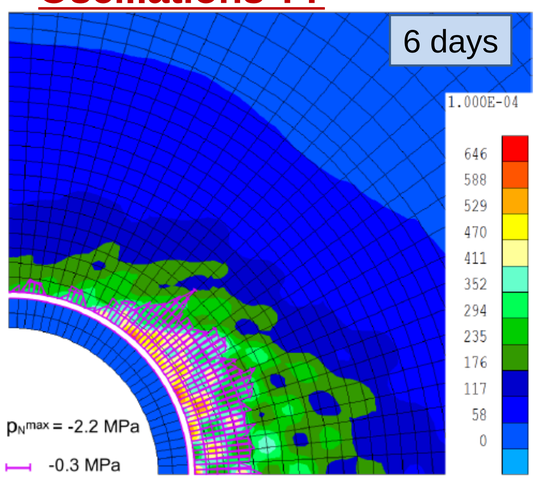


Less activity of localized shear bands after the excavation

Contact pressure on the interface between clay and lining

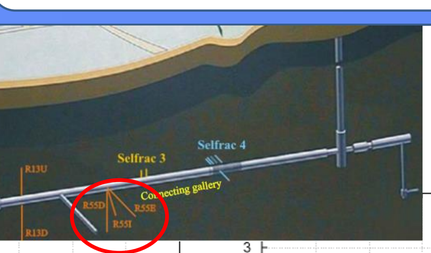


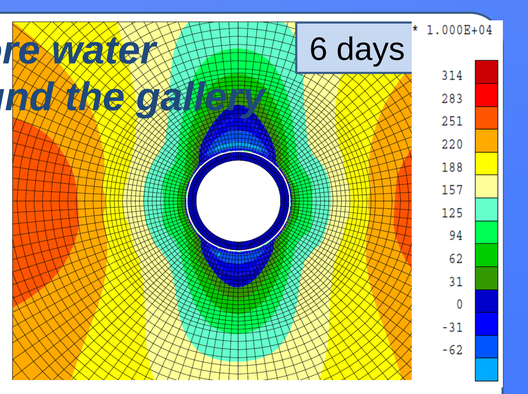
Oscillations ??

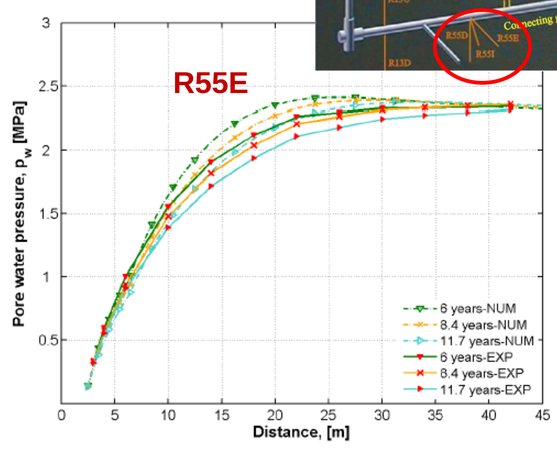


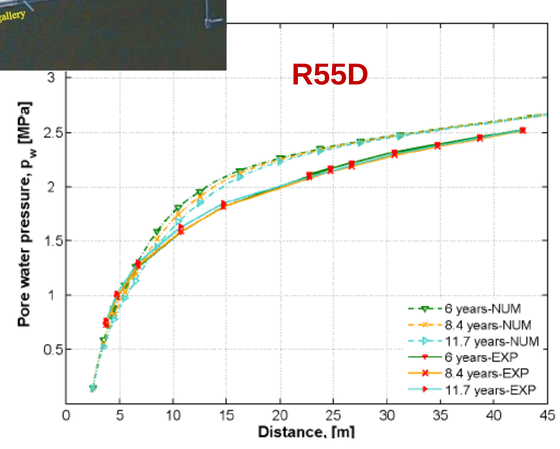
Superposition of the contact pressure and total deviatoric strain

Oscillations are consistent with localized shear bands
(Salehnia et al. 2015)

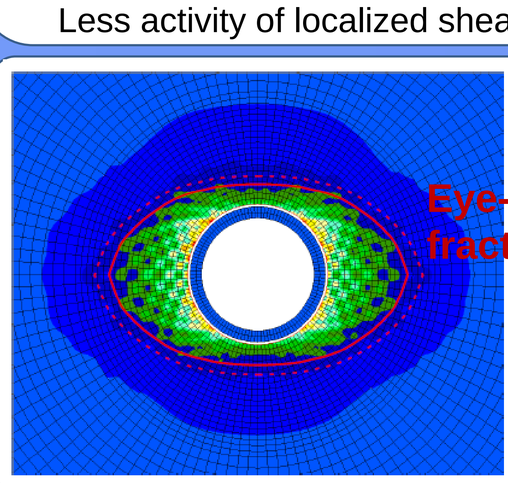




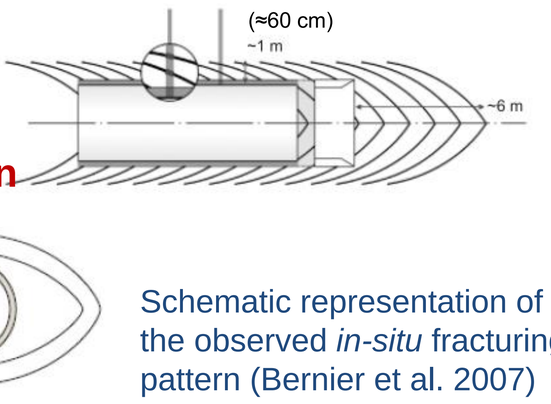




A local increase of Pw is noticed horizontally at the vicinity of the gallery while a local decrease of Pw is observed along the vertical direction

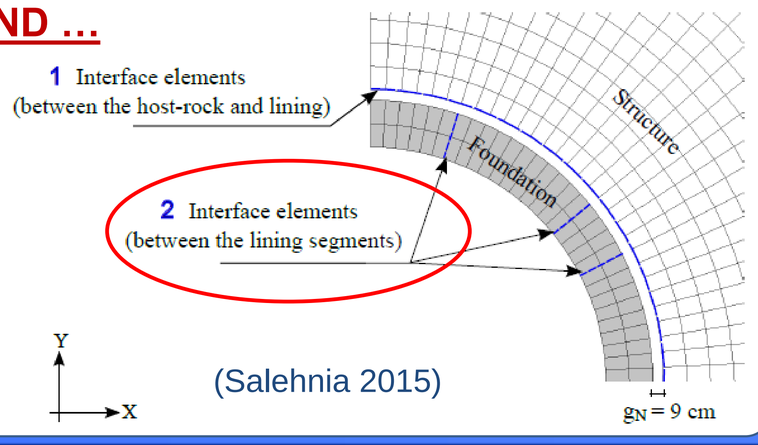


Eye-shape fracturing pattern



Schematic representation of the observed *in-situ* fracturing pattern (Bernier et al. 2007)

AND …



(Salehnia 2015)

Main References:

- Salehnia F, Collin, F, Li XL, Dizier, A, Sillen, X, Charlier, R. Coupled modeling of Excavation Damaged Zone in Boom clay: Strain localization in rock and distribution of Contact pressure on the gallery's lining. Comput. Geotech., 2015; 69:396-410. http://authors.elsevier.com/a/1RFBF,63b~XrRb
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- Collin F, Chambon R, Charlier R. A finite element method for poro mechanical modelling of geotechnical problems using local second gradient models. IJNME, 2006;65(11):1749–72.

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