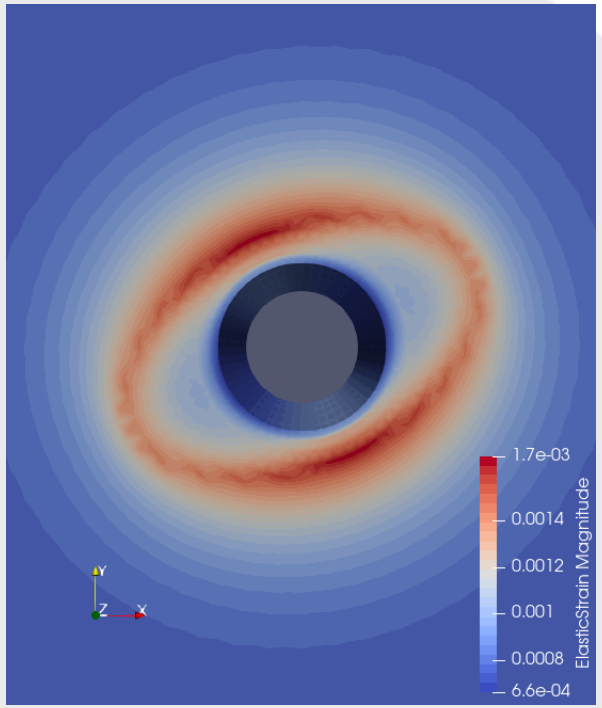
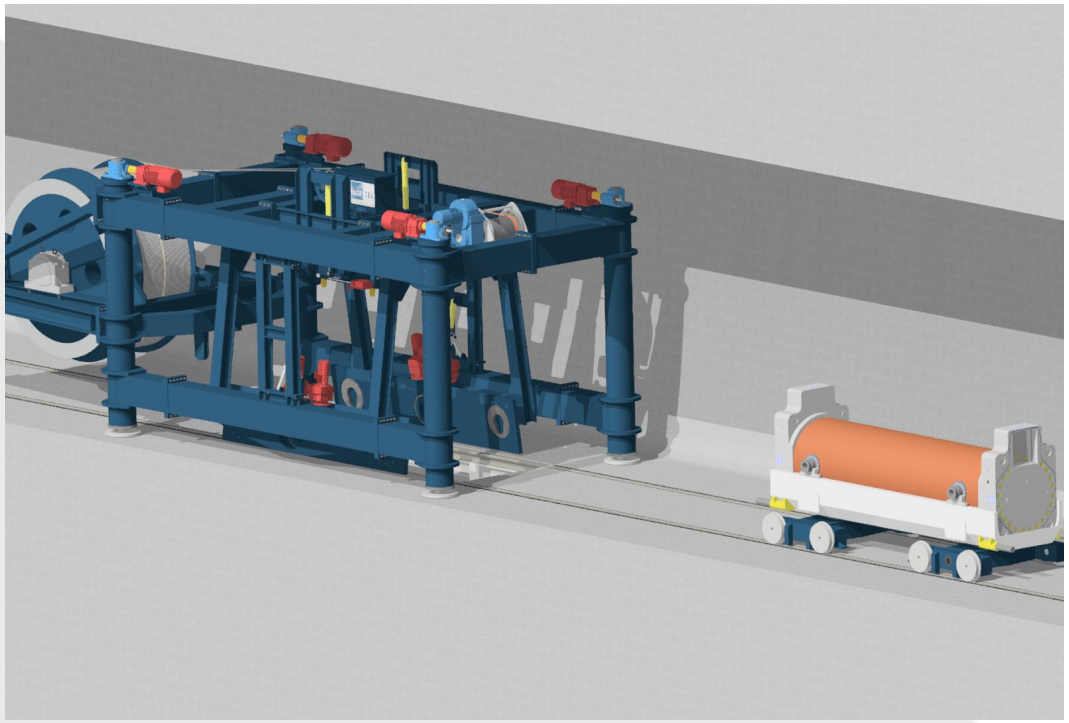




A novel approach of using existing model implementations in any numerical code interfacing with MFront

Eric Simo, T. Helfer, D. Mašín, T. Nagel, P. Herold

Motivation

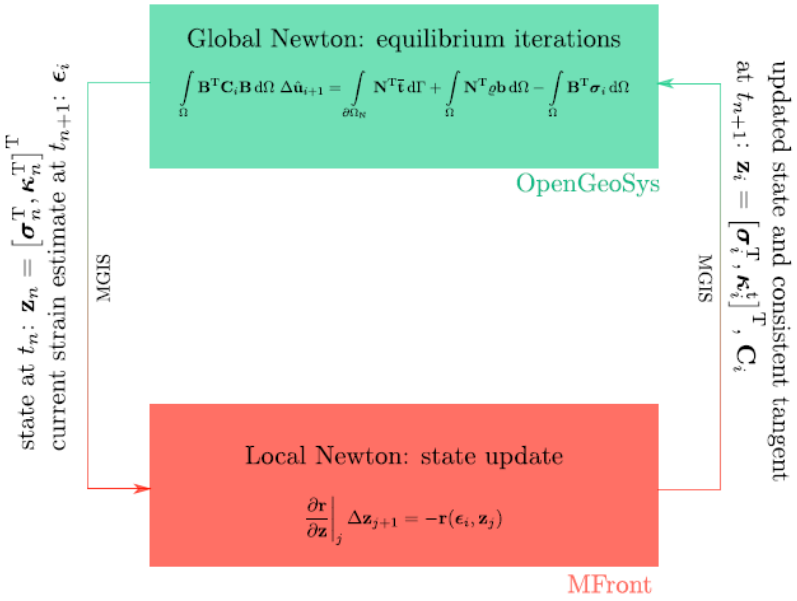
- The development of constitutive modelling is a tedious task reserved to experienced engineers and scientists
- Numerous software companies developed workflows to help engineers to implement their user-defined models within these codes
- However problems arise when in the scope of safety critical applications two-men-rules have to be applied and several software have to be used

  ➡ **Same models must be develop in different software**
- The development of the same model in different codes requires more resources, longer time and is prone to errors
- A novel approach of using existing model implementations in any numerical code interfacing with Mfront is presented

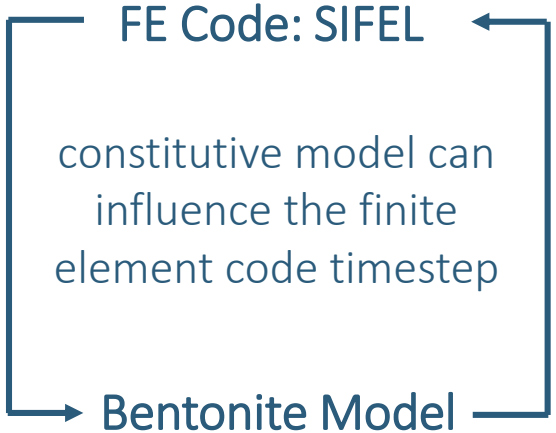
Conceptual approach

- Goal: How to use a bentonite model developed for the FE-code SIFEL in the FE-code OpenGeoSys (OGS)?

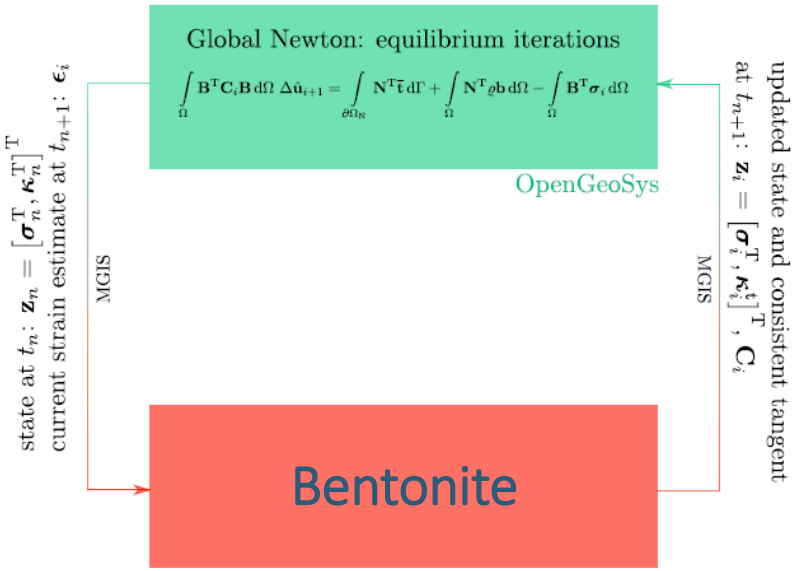
Model implementation in OGS



Actual implementation of the model in FE-Code SIFEL

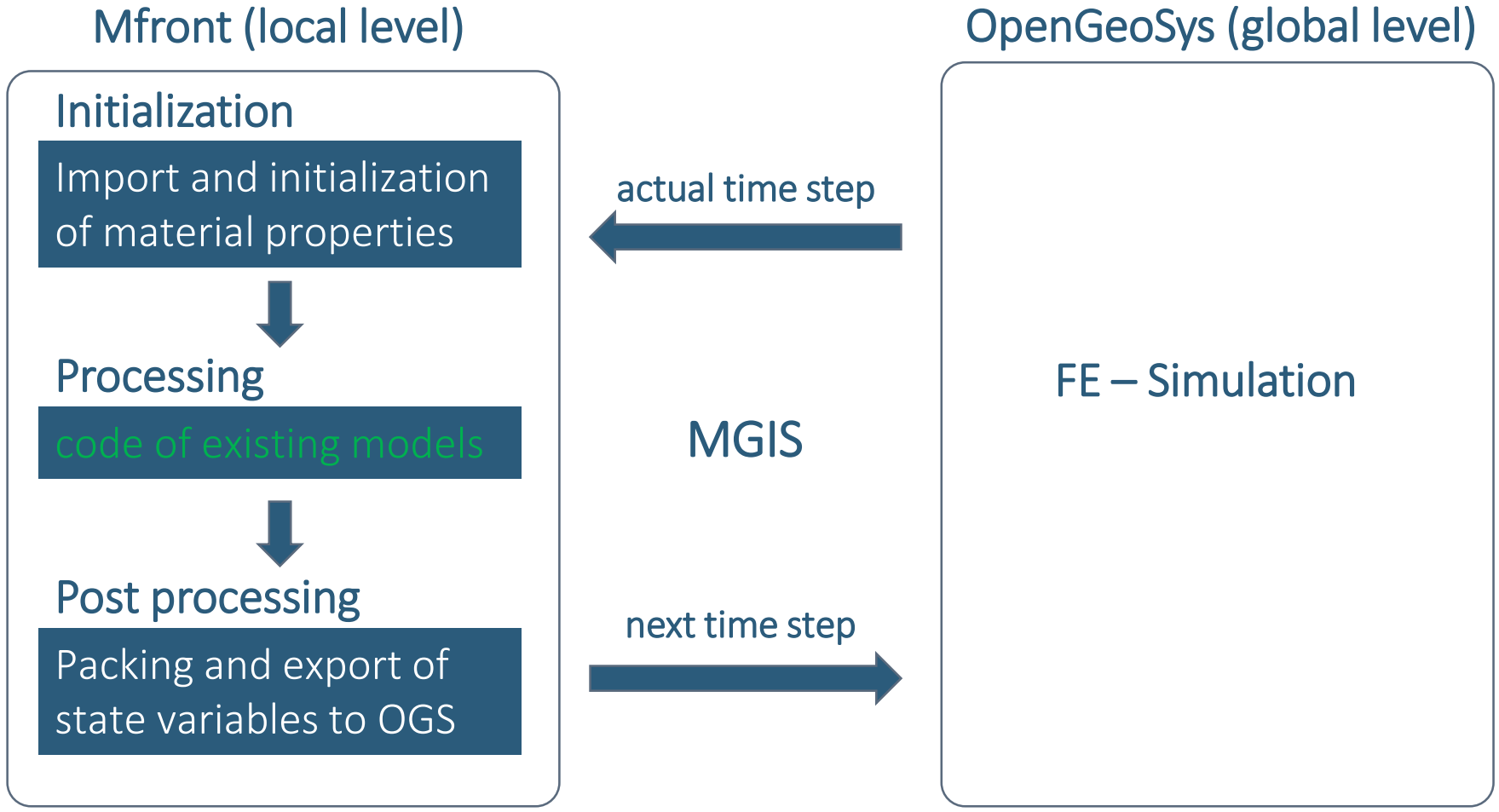


Integration of the bentonite model in Mfront



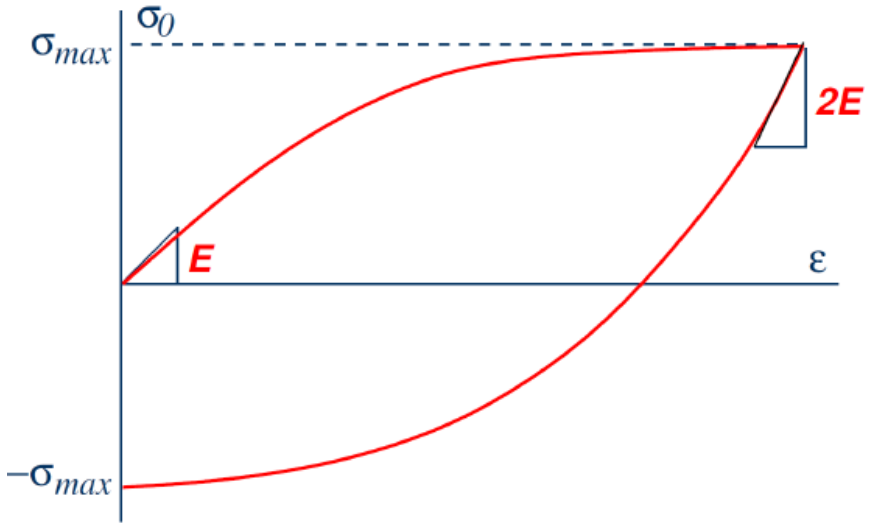
Implementation of a wrapper-interface in Mfront

- The implementation consists of „wrapping“ the existing code of the model in Mfront



Test of the wrapper using the hypoplastic model for clays

- The hypoplastic model for clays*



- Simple 1D hypoplastic model for shear:

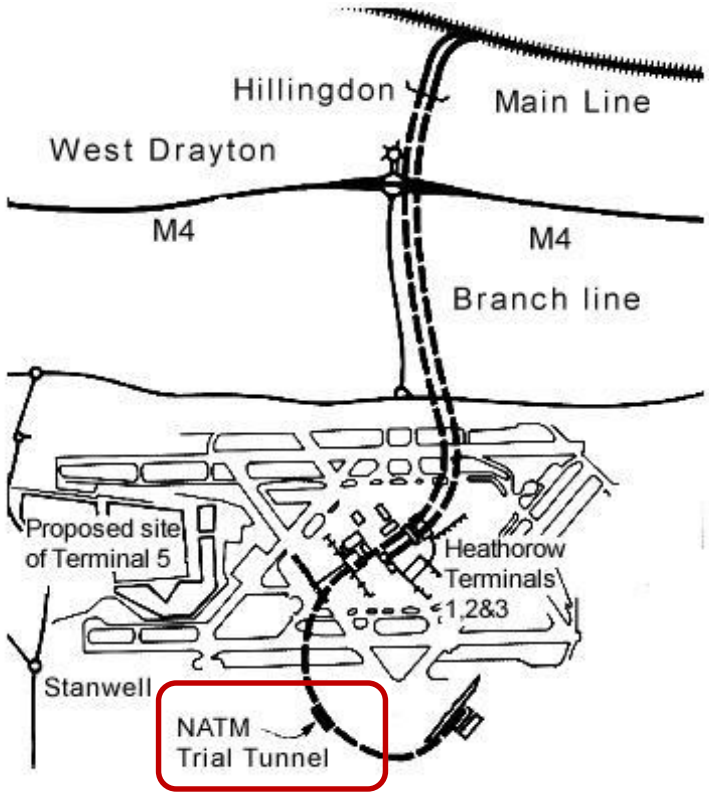
$$\overset{\circ}{\boldsymbol{\sigma}} = f_s(\boldsymbol{\mathcal{L}} : \dot{\epsilon} + f_d \mathbf{N}\|\dot{\epsilon}\|)$$

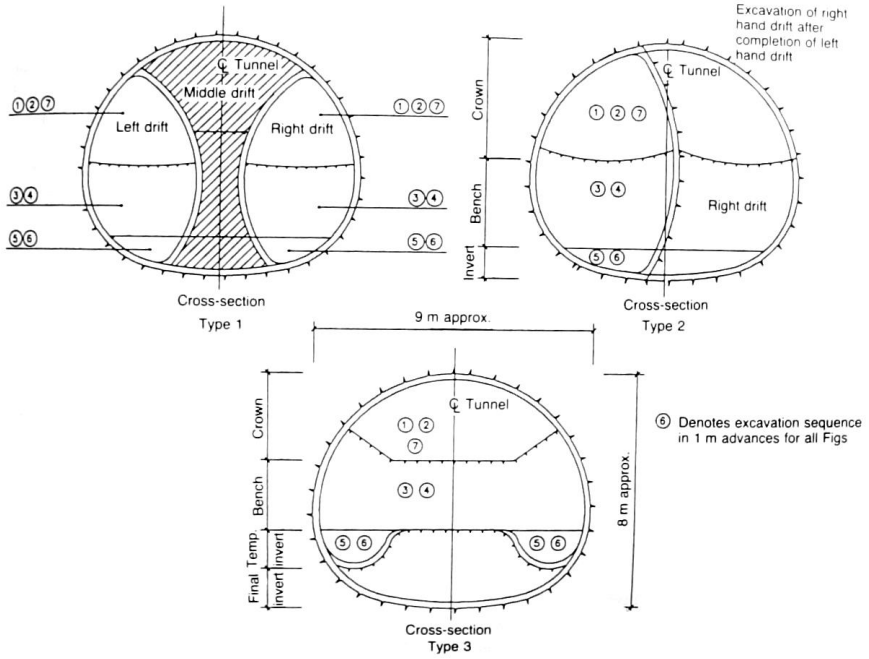
- When $\sigma = 0$ and loading ($\Delta\epsilon > 0$), then stiffness is E.
- When $\sigma = \sigma_{max}$ and loading, then stiffness is 0 (failure predicted): σ_{max} is approached *asymptotically*.
- When $\sigma = \sigma_{max}$ and unloading, then stiffness is $2E$.

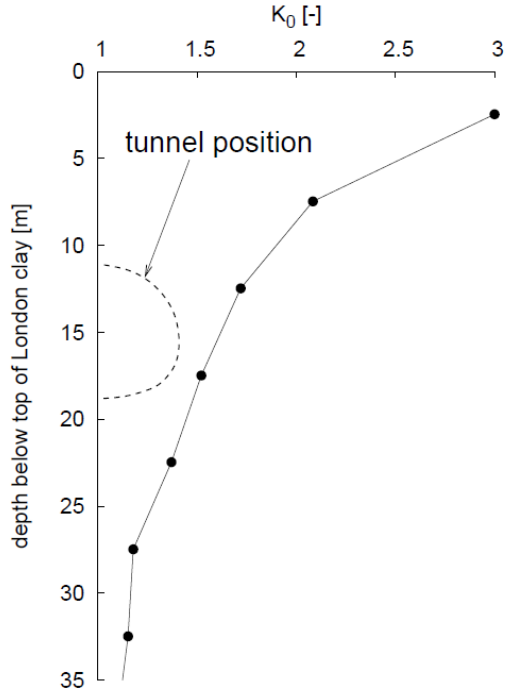
*Masin, D. (2014). Géotechnique 64, No. 3, 232–238 [http://dx.doi.org/10.1680/geot.13.P.065] TECHNICAL NOTE

Model applications

- Heathrow express trial tunnel im London Clay, UK



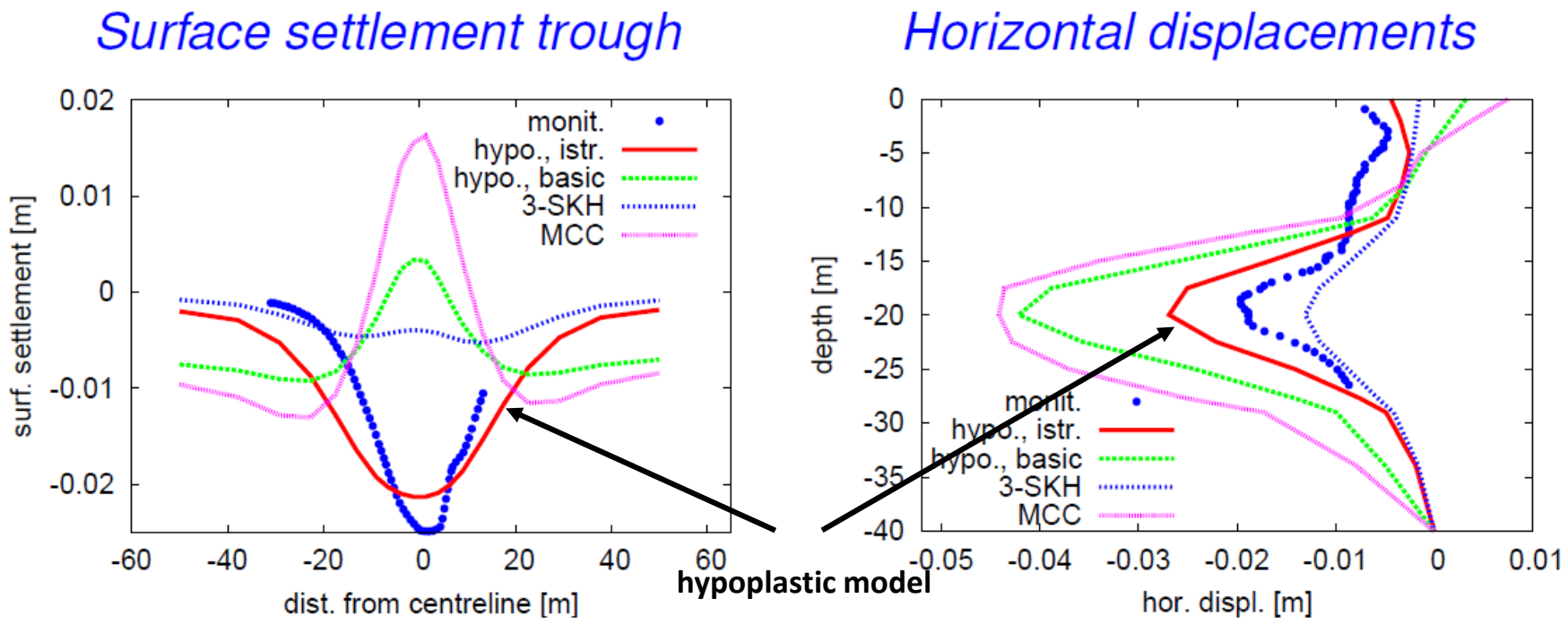




Model applications

- Heathrow express trial tunnel im London Clay, UK

Quantitative comparison of predictions and monitoring

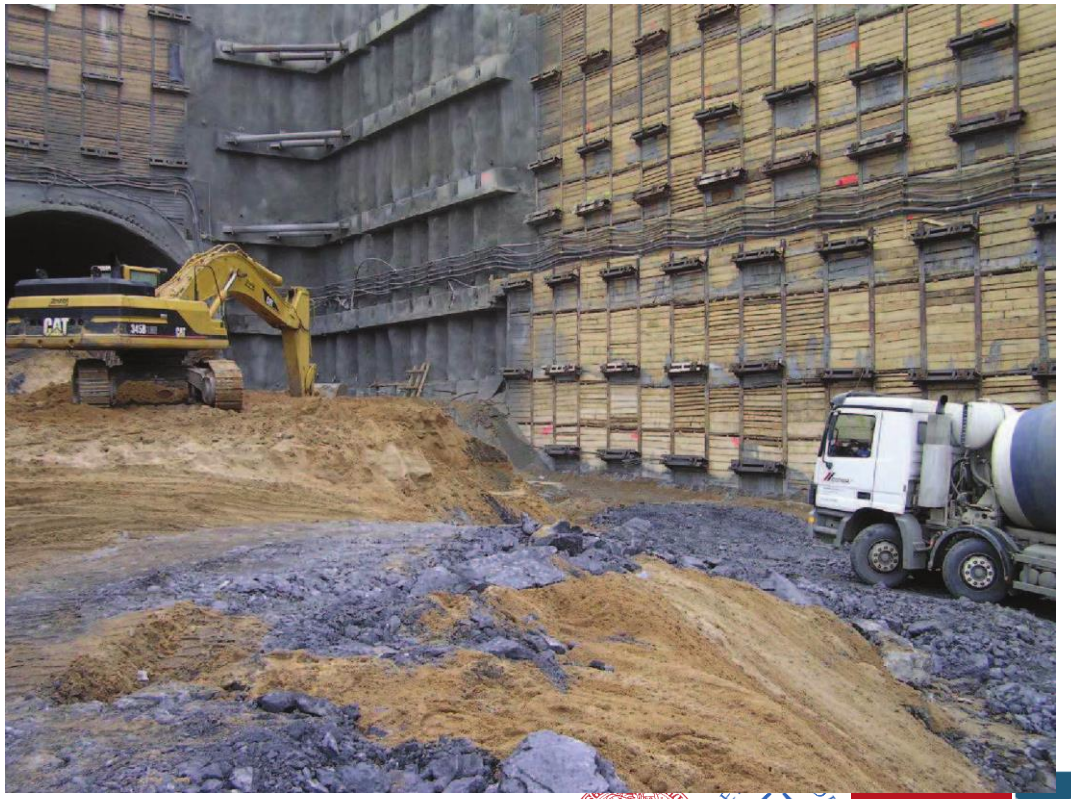


Model applications

- Excavation of Komorany tunnel in sand, Prague

The excavation is 170 m long, 50 m wide and up to 30 m deep

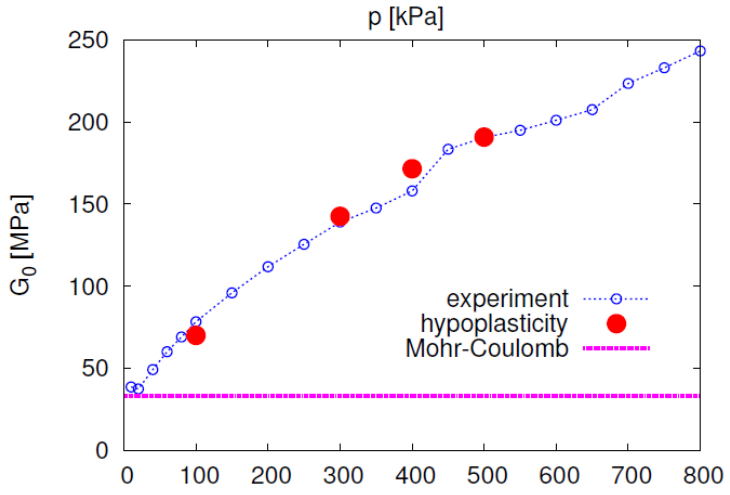
Two types of support: Corner area supported by bored pile wall, the rest of the excavation supported by timber lagging wall.

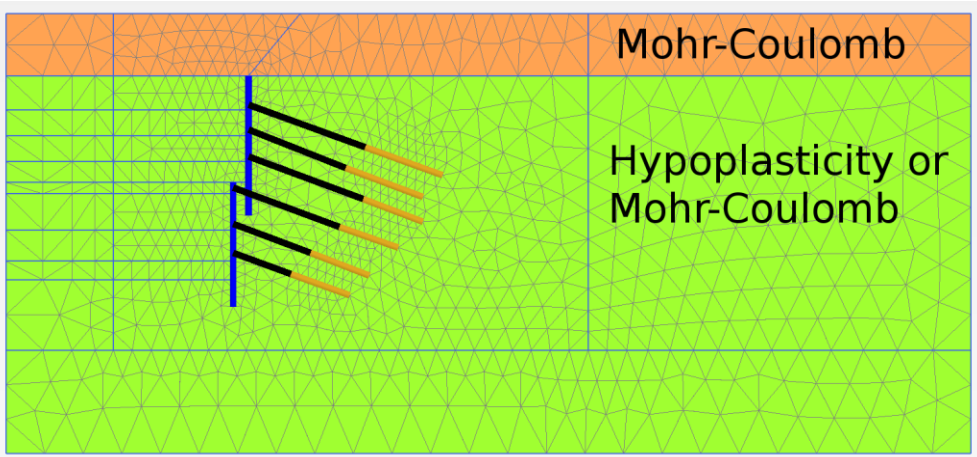


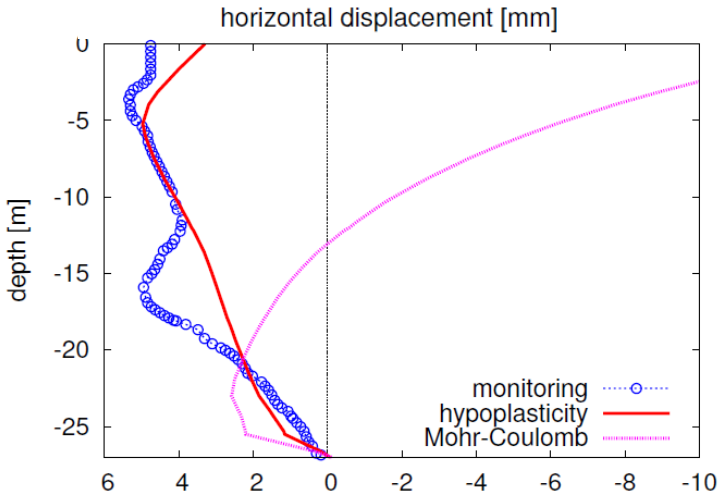
Zakládání staveb (2008)

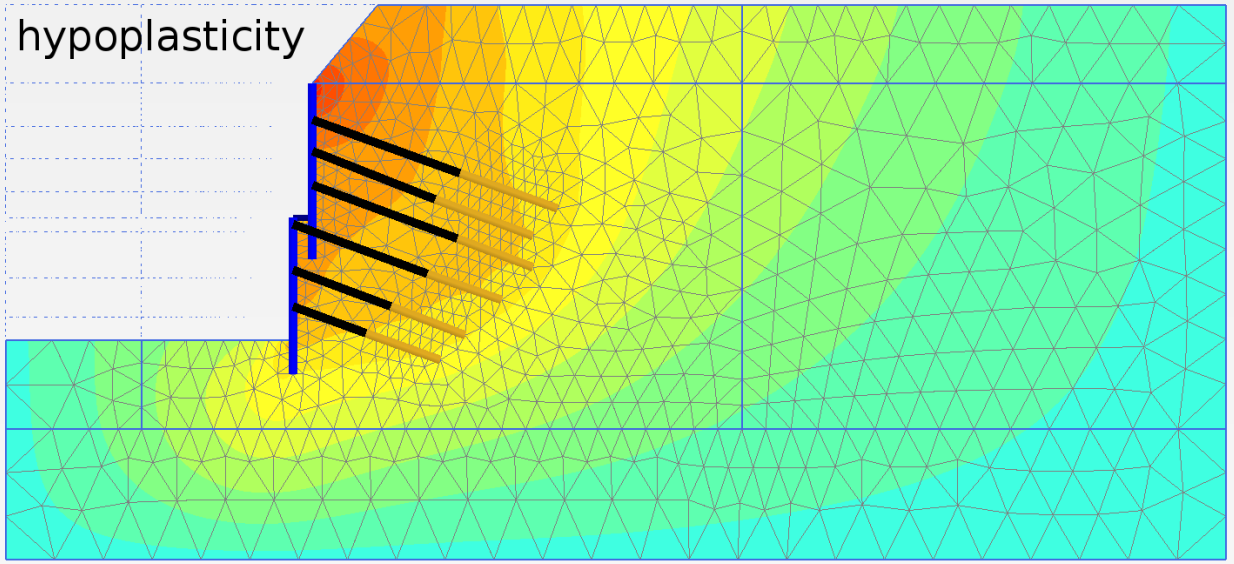
Model applications

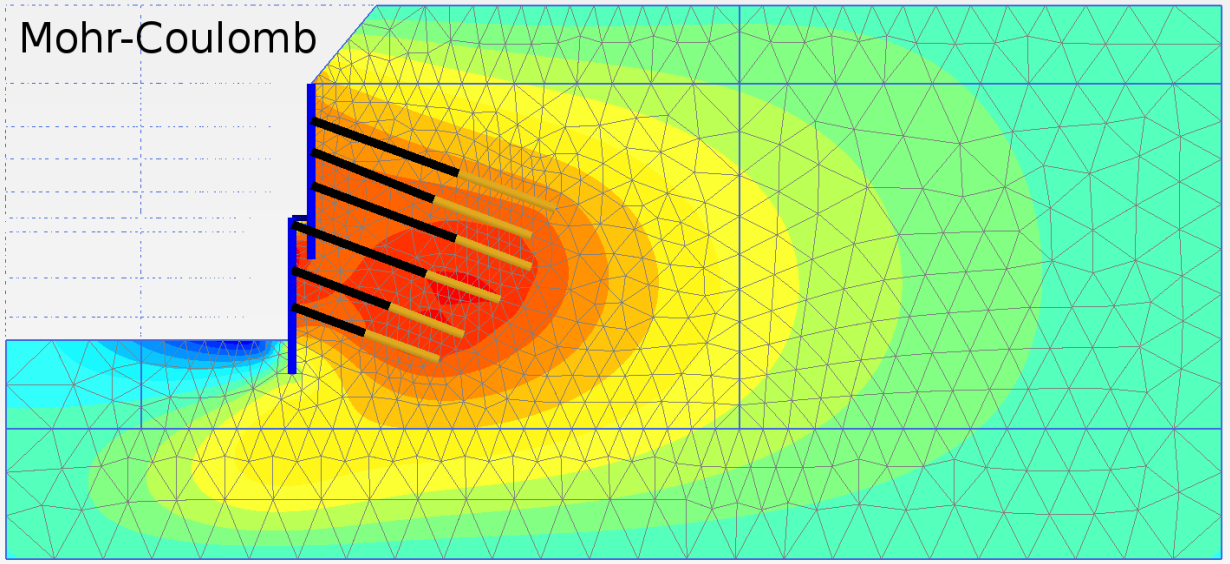
- Excavation of Komorany tunnel in sand, Prague





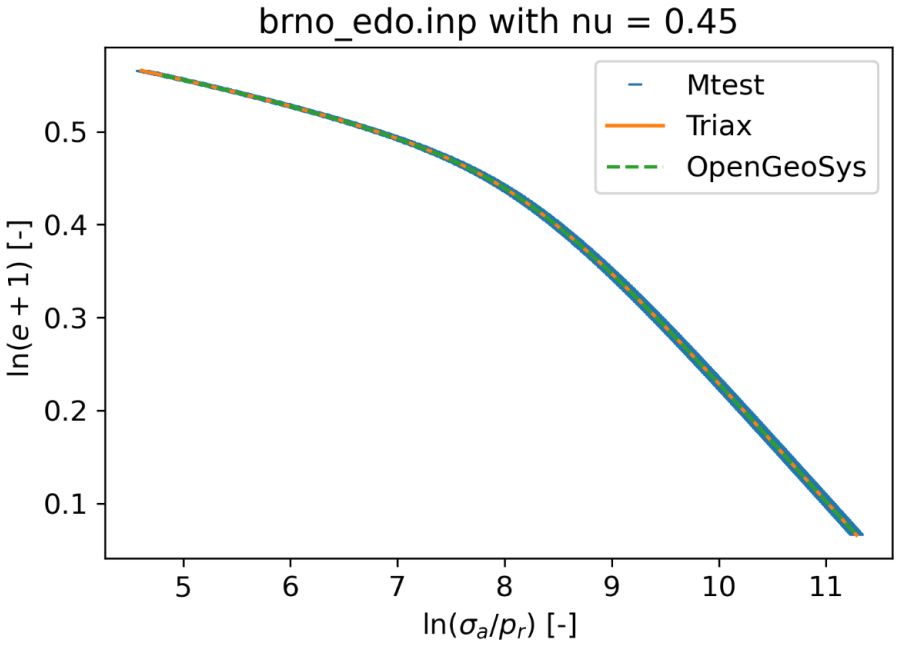


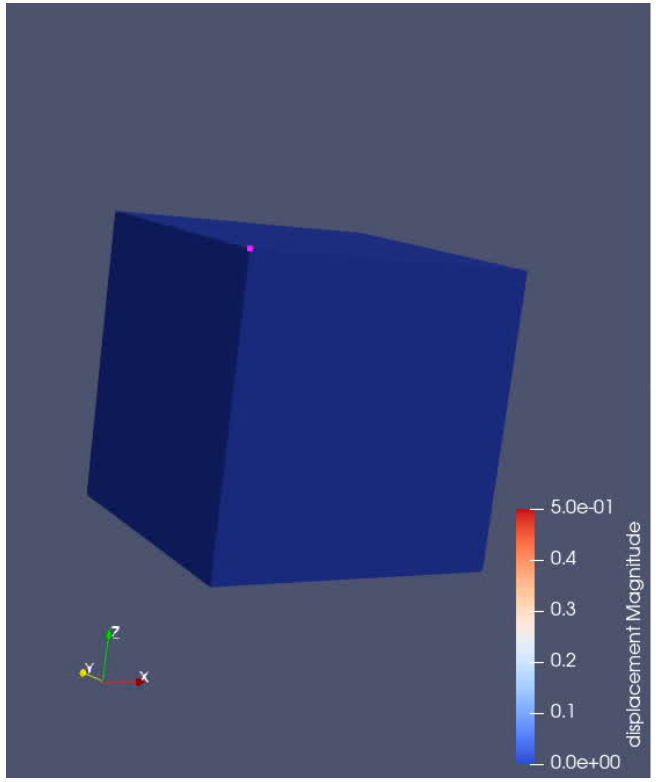


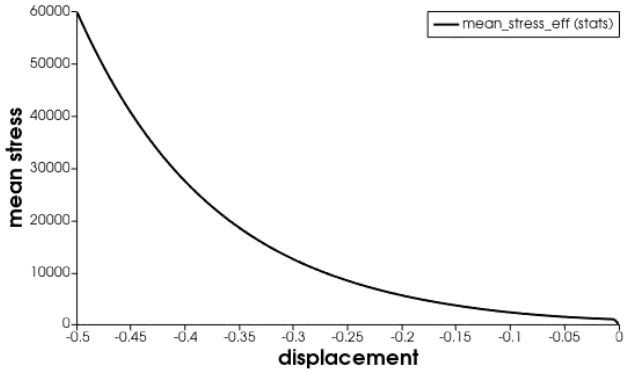


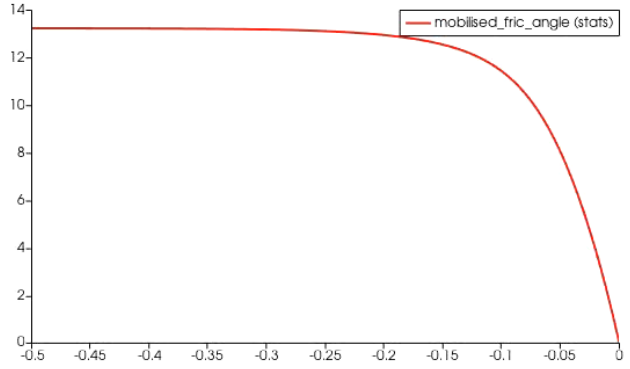
Tests at the local level

- **Triaxial compression test:** test of the volumetric behaviour of the model



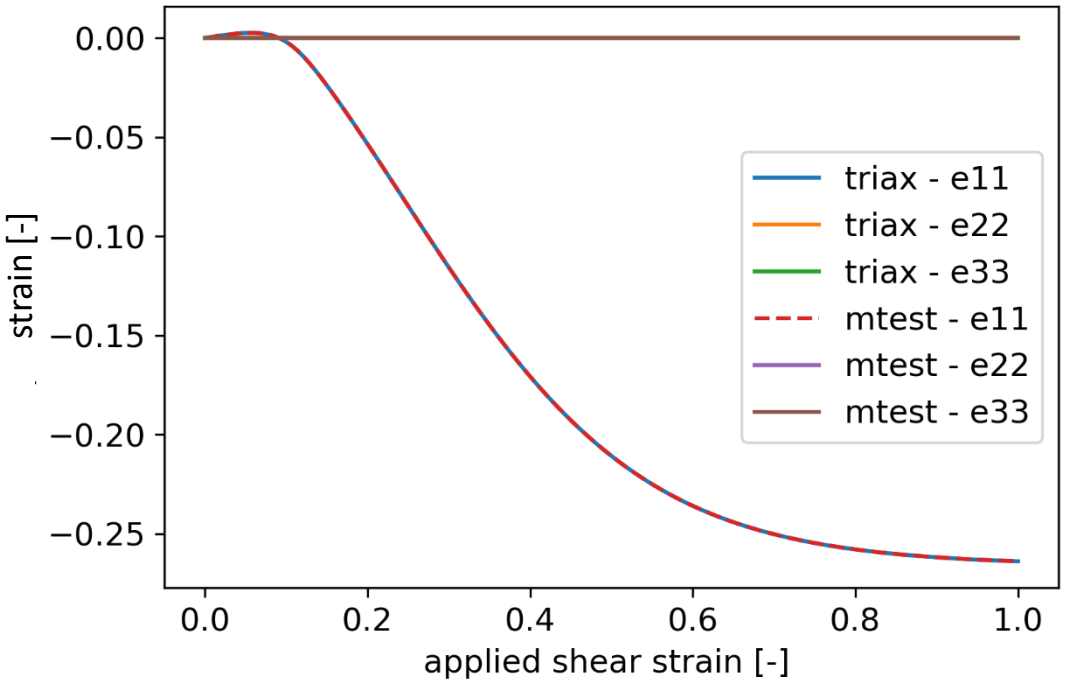


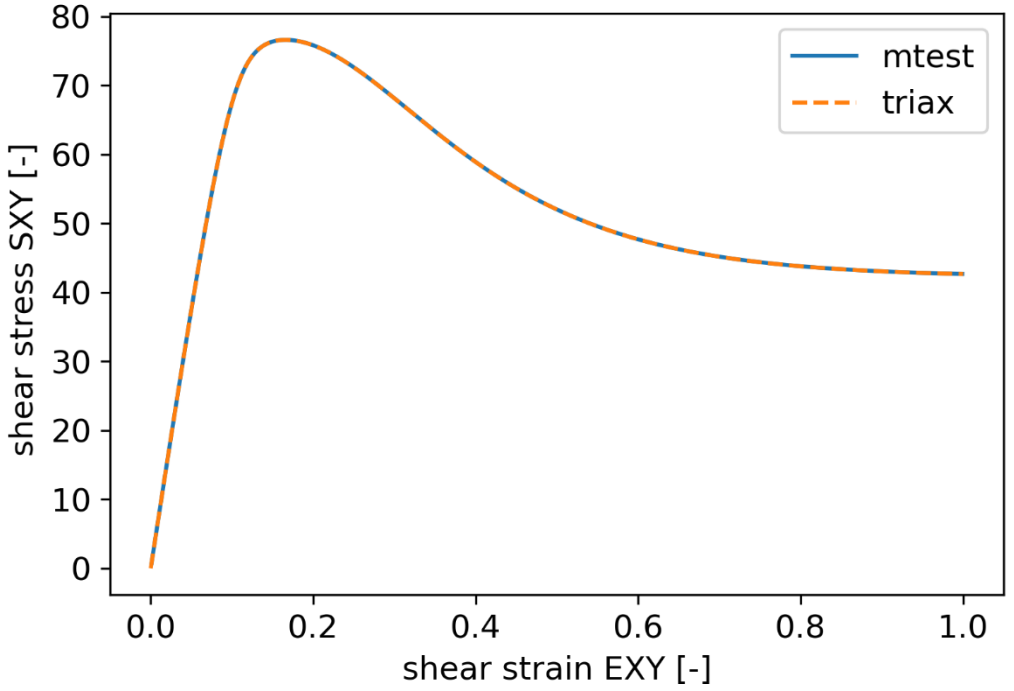




Tests at the local level

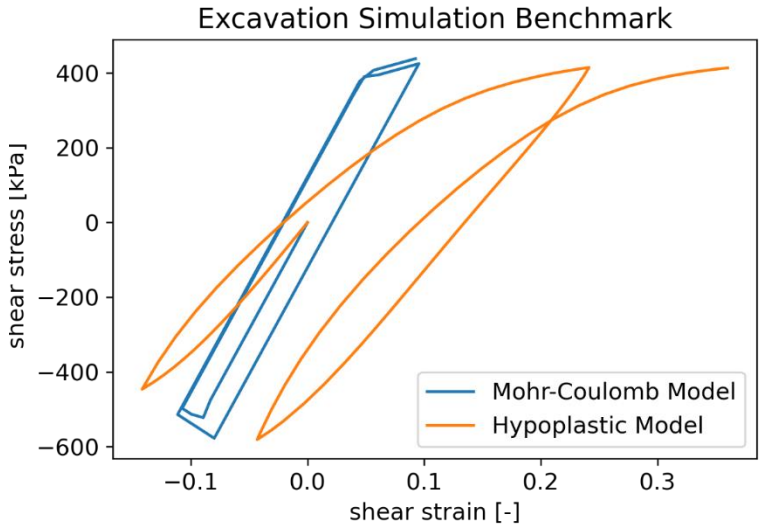
- **Shear test:** test of the deviatoric behaviour of the model

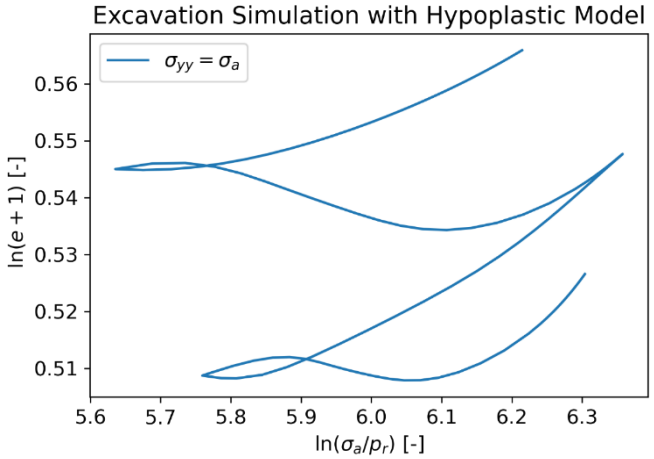


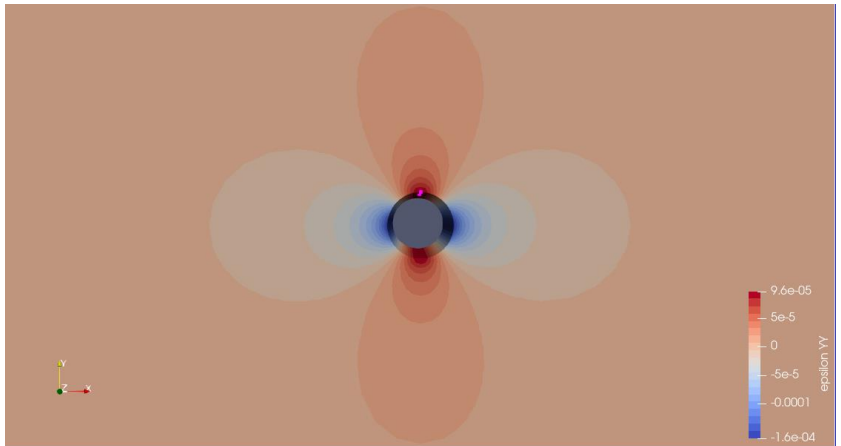


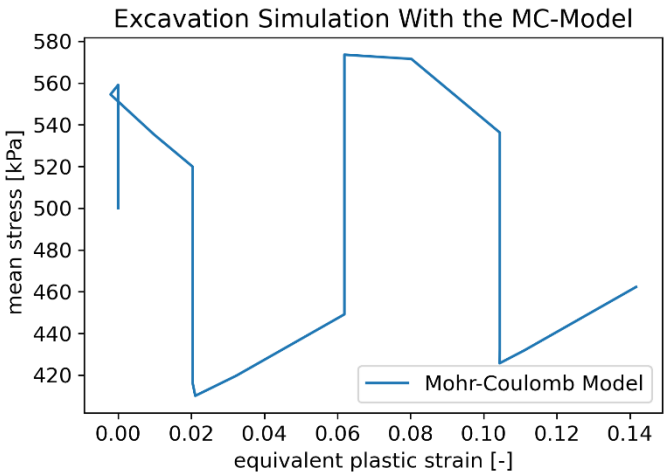
Tests at global level

- **Loading cycle test at the contour of a tunnel in clay medium :**
  - **Model benchmark:** hypoplastic model vs. elasto-plastic Mohr Coulomb model



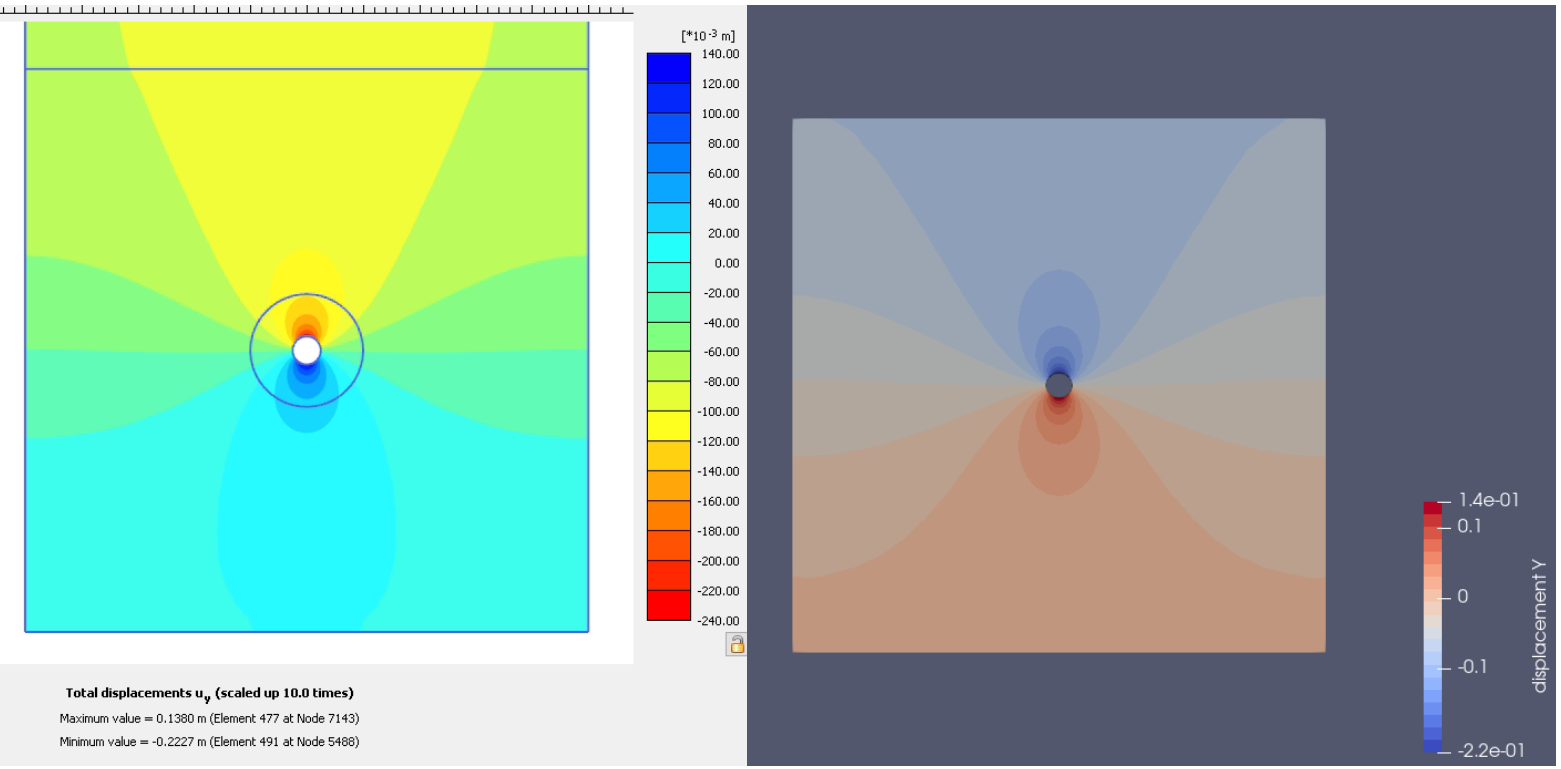


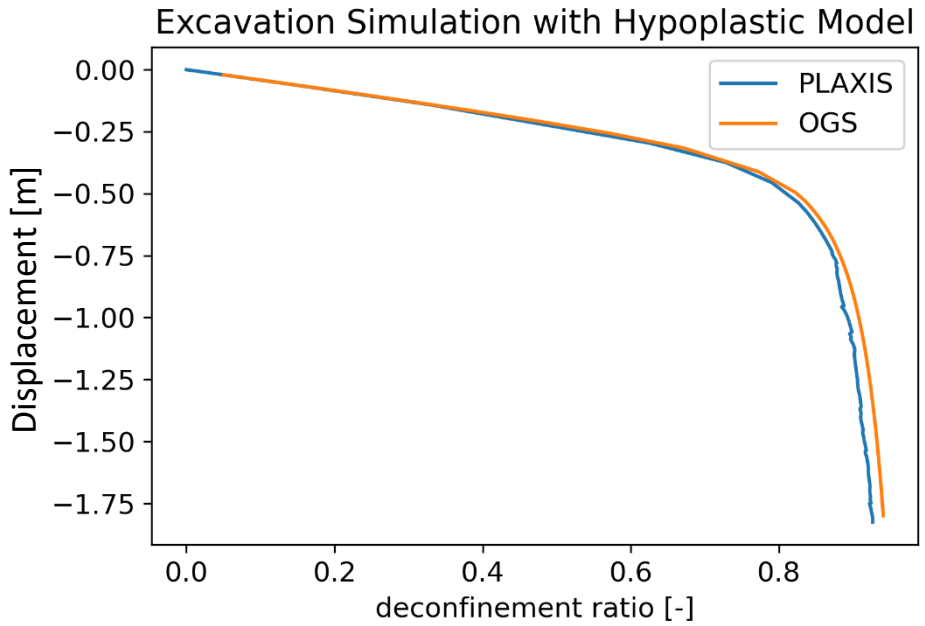




Tests at global level

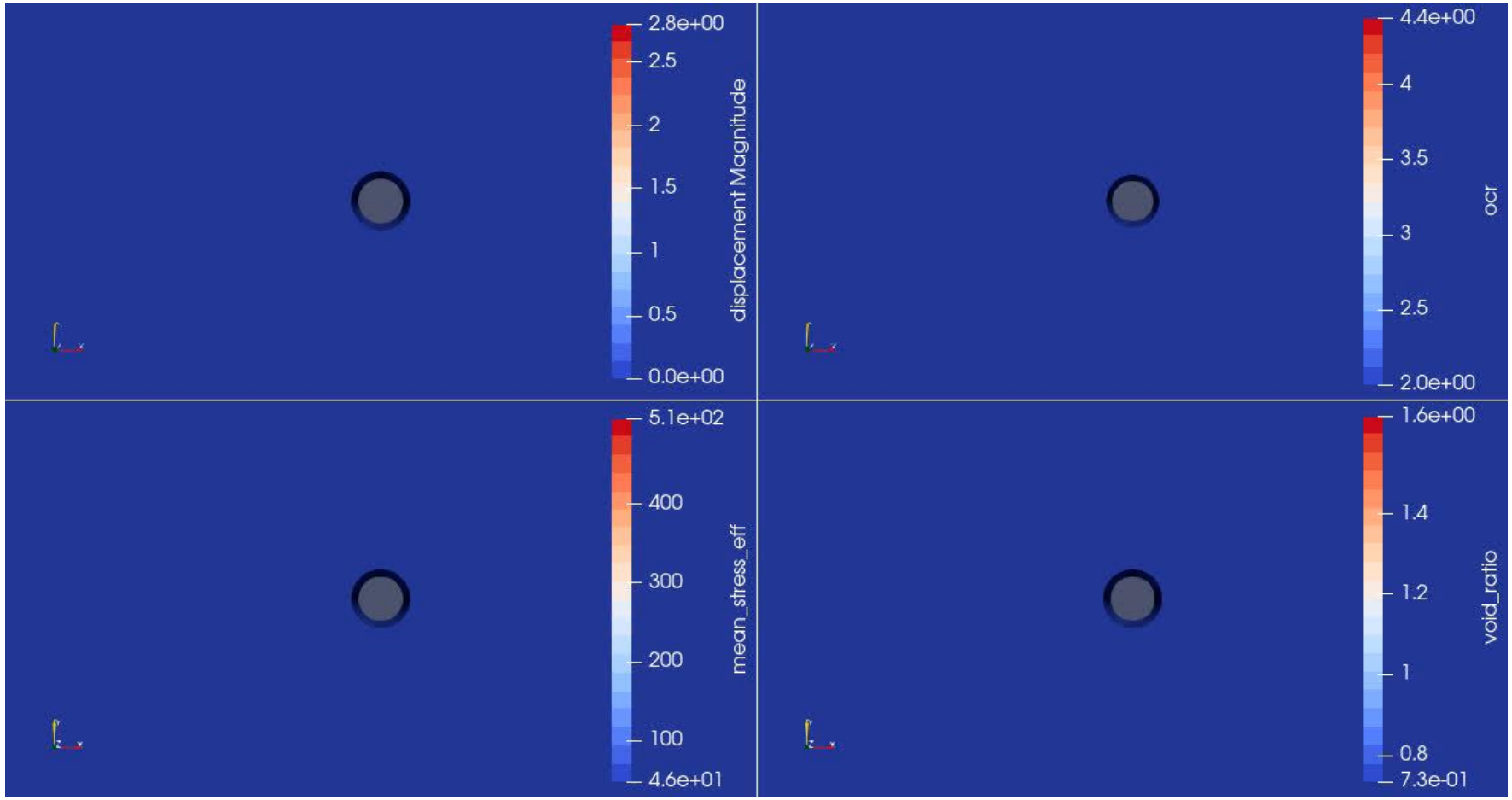
- Excavation simulation of a tunnel in clay medium :
  - **Software benchmark:** Comparison PLAXIS vs. OGS





Tests at global level

- **Excavation simulation of a tunnel in clay medium :**
  - Visualisation of the state variables of the model



Outlook

- **The feasibility of the proposed approach has been demonstrated**
- The approach has been tested so far with UMAT-, C++- and Fortran-models→ the approach is universally applicable
- The hypoplastic model now available in OGS will be used for benchmark activities in the EURAD project: Modelling of EDZ in BOOM (WP HITEC)
- The approach will be tested for more complex models (with double porosity) and for coupled processes (THM)

Next steps

- MGIS Interface between OGS and Mfront works actually with mechanical models only
- OpenGeoSys does not take into account models with a double porosity structure
- Thus, further developments are needed in OGS prior to the implementation of more complex models
- The THM-model of bentonite with double structure porosity will be made available in OGS using the proposed approach

Thank you for your attention!