

Modelling of WP5 test case BEACON 1st Annual Meeting

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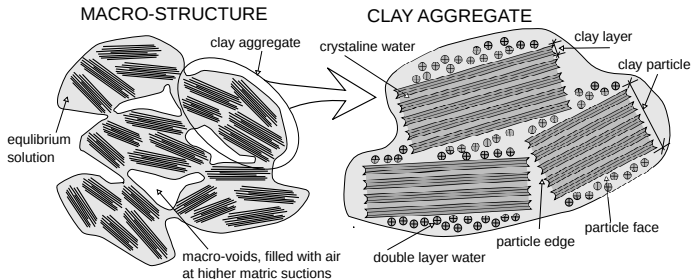
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Outline

- 1 THM hypoplastic constitutive model for bentonites
- 2 Modelling of WP5 test cases
- 3 Model calibration using MX80 experimental data, analysis update
- 4 Conclusions

THM hypoplastic model for bentonites

- The model is based on *hypoplasticity* and it considers two structural levels, based on (*double structure* modelling concept by *Alonso et al., 1999*).



THM hypoplastic model for bentonites

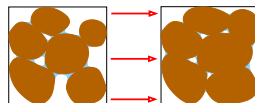
Double structure concept

During wetting:

- Low dry density - aggregates swell into macrovoids.

- High dry density - aggregate swelling imposes global sample swelling.

⇒ If global volume is constrained, the double structure features will control *swelling pressures*.

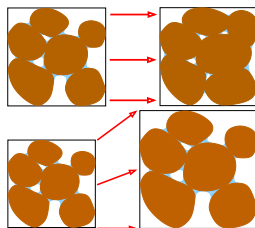


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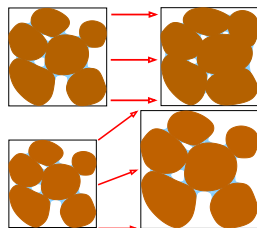
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THM hypoplastic model for bentonites

- Separate *mechanical models* for macrostructure ($\mathbf{G}^M$) and microstructure ($\mathbf{G}^m$), defined using *effective stresses* σ^M and σ^m .

$$\dot{\sigma}^M = \mathbf{G}^M(\sigma^M, \mathbf{q}^M, \dot{\epsilon}^M) \quad \text{with} \quad \sigma^M = \sigma^{net} - \mathbf{1}s\chi^M$$

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- Two *water retention models* ($\mathbf{H}^M$ and $\mathbf{H}^m$) using micro- and macrostructural S_r .

$$\dot{S}_r^M = H^M(\dot{s}, s, \dot{\epsilon}^M)$$

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- Hydro-mechanical coupling*: Hydraulic strain measure S_r^M depends on mechanical quantity $\dot{\epsilon}^M$. Mechanical response influenced by χ^M , which may depend on a hydraulic quantity S_r^M .

Modelling of WP5 test cases

- Test 1a01 and 1a02 simulated.
- Unfortunately, numerical issues in running fully coupled algorithm in software SIFEL (presentation by my colleague T. Koudelka) prevented us from simulation of the free swelling parts of tests 1a01 and 1a02.
- Therefore, only the swelling pressure part of test 1a01 presented here.

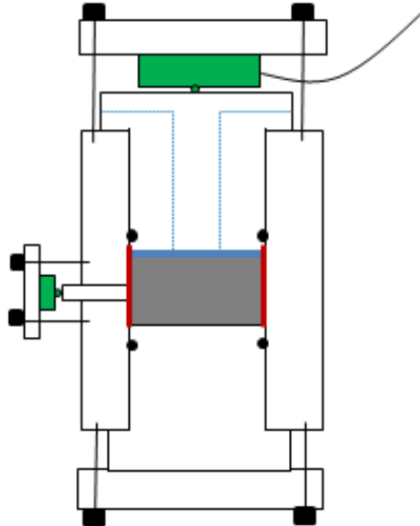
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Test 1a01 specification



Model calibration

- The first simulations using parameter set on MX80 bentonite using data by Tang et al. 2008. Poor agreement with experiment.
- Then, simulations with Czech B75 bentonite parameters. Swelling pressure reproduced reasonably, but this parameter set difficult to justify!
- New calibration using experimental data on MX80 from SKB reports (water retention tests, swelling pressure tests, oedometric compression test, swelling under constant load tests).
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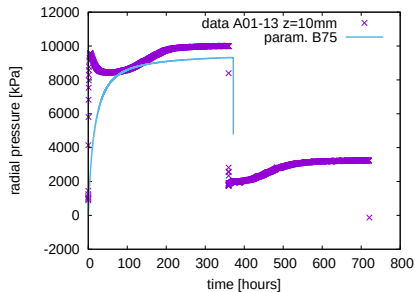
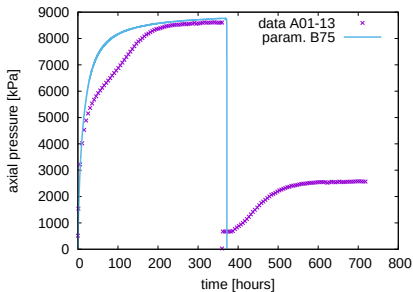
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Test 1a01 predictions with B75 parameters



Model calibration using MX80 experimental data

Results on water retention tests, swelling pressure tests, oedometric compression test, swelling under constant load tests taken from two SKB reports:

Thermo-Hydro-Mechanical properties of MX-80

Results from advanced laboratory tests

Ann Dueck and Ulf Nilsson, Clay Technology AB

December 2010

Report TR-10-55

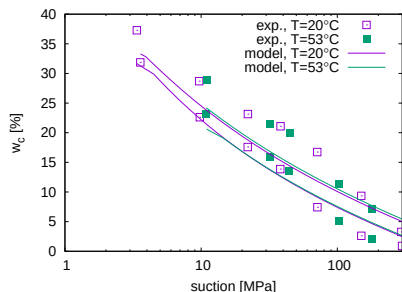
Mineralogy and sealing properties of various bentonites and smectite-rich clay materials

Ola Karnland, Siv Olsson, Ulf Nilsson
Clay Technology AB

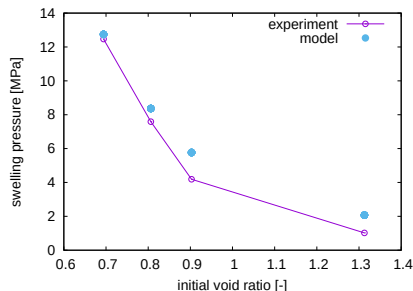
December 2006

Report TR-06-30

Model calibration using MX80 experimental data

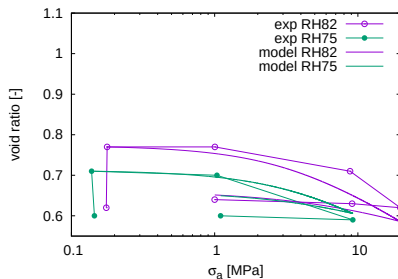


Water retention tests

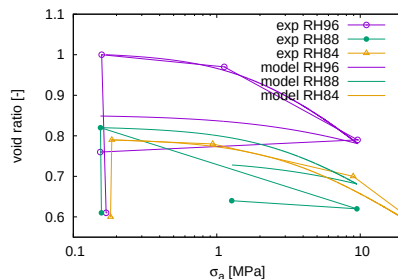


Swelling pressure tests

Model calibration using MX80 experimental data

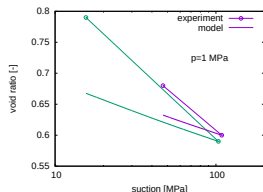


Oedometric tests, higher suction

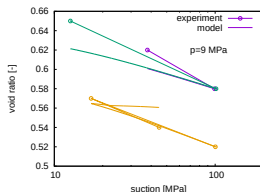


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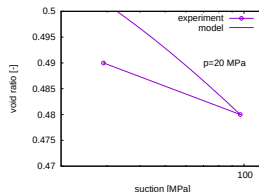
Model calibration using MX80 experimental data



Swelling, 1 MPa

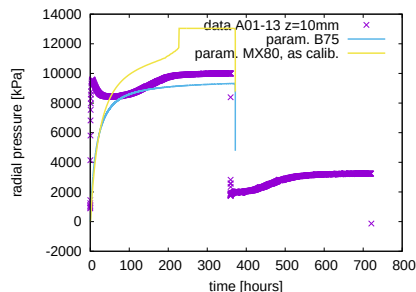
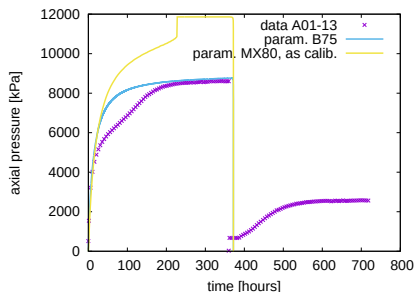


Swelling, 9 MPa



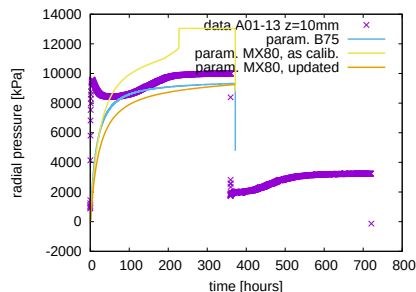
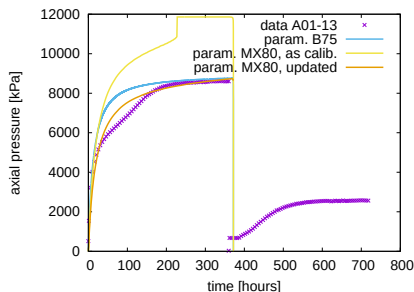
Swelling, 20 MPa

Test 1a01 predictions MX80 calibrated parameters

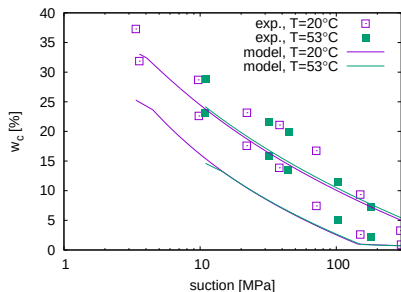


Test 1a01 predictions MX80, updated parameters

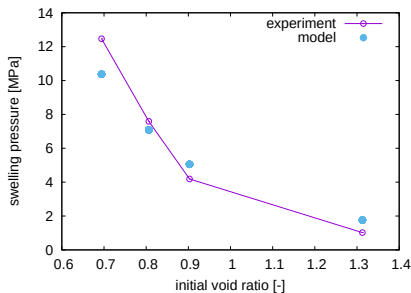
Parameters of MX80 were updated so that swelling pressure was correctly predicted (decrease of microstructural void ratio e_m).



Laboratory tests predictions, MX80 updated parameters



Water retention tests



Swelling pressure tests

Conclusions

- Verification cases for WP5 modelled, problems in simulation free swelling portions of the tests (see pres. by T. Koudelka).
- For the swelling pressure part of the tests, we identified problems in definition of material parameters. In fact, results could reasonably be predicted with MX80 unjustifiable parameters.
- Calibration of the model using MX80 element test data: model deficiency identified in predictions of oedometric free swelling under constant load - to be corrected.
- What approach to calibration to follow? In our opinion: *calibrate the model using element test experimental data, then update on the particular test.*
- Peak in the radial stress of 1a01 could was not be predicted.

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