Constitutive mechanical modelling of bentonite behaviour by THEBES way

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Bentonite homogenisation

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THEBES ultimate aim: estimate saturation time of buffer material, load on the copper container, effects of salinity on the above – with numerical simulations based on experiment

Aalto University current work :

- **constitutive modelling** of unsaturated soils & bentonite, including modelling of thermal, hydraulic & chemical interaction in bentonite
- creation of **thermo-hydro-chemo-mechanical coupled computer code** within the Numerrin framework (in cooperation with Numerola Oy)
- **numerical simulations of the buffer material saturation** in different salinity conditions
- **water retention behaviour** of bentonite partially saturated with **salt solutions**

Work that could be done in a joint project: **Aalto is keen to cooperate** on the subjects above with the international partners and to **extend the reserach** as needed.

Aalto University coordinates THEBES network, its international cooperation and maintains the website: http://civil.aalto.fi/fi/research/geoengineering/soil/numerical/thebes_project/

Univ. of Jyväskylä and Numerola Oy
Data for testing and validation of THM models

- Issues that are resolved: Producing detailed experimental data for testing and validation of THM models for bentonite buffer behaviour.
- Current work: X-ray imaging and X-ray tomographic techniques are used to monitor water transport and swelling deformation of bentonite samples (4D imaging). The experimental results are compared with those from computational models.
- Work for a joint project: More extensive joint effort including both modelling and experiments (dedicated to best serve the needs of modelling).
- Resources available: X-ray tomographic laboratory at JyU. In-house numerical modelling software at Numerola Oy.
- Estimated resources needed to complete the work:
  A PhD student + supervisor + some man months per year for Numerola Oy – all this for four year

VTT: structural studies, THM data and modelling

- Issues that are resolved: Experimental data production like Jyväskylä, in addition changes in bentonite structure at changing conditions investigated to improve the understanding of system needed to create predictive models and application of new bentonite model of Pulkkanen
- Current work: X-ray scattering, nuclear magnetic resonance and electron microscopy used for structure characterization, tri- and uniaxial experiments, model development
- Work in a joint project: incorporating more study methods and more clay types, application of Pulkkanen model to larger set of experiments
- Resources available: own or domestic collaborators' equipment to experimental work, both model, modellers and needed computational resources for modelling
- Estimated resources needed to complete the work: 7 person months for experimental work and 5 for modelling for four years (about 50 pm)

Univ. of Helsinki: Chemical and mechanical bentonite erosion in the buffer and the backfill

- Issues that are resolved: Understanding properties of bentonite after reduction in density of the buffer and backfill owing to mechanical erosion caused by hydraulically conductive channels (pipes) formed in bentonite due to flowing water.
- Current work: Chemical bentonite erosion experiments: Suspension → gel → mass loss in colloidal form *and* Study of salinity effects on colloid formation and stability
- Work that could be done in a joint project:

  Mechanical/chemical erosion in static and dynamic experiments - Kuru grey granite block: natural fracture (0.9 x 0.9 m) intersected by nine vertical boreholes.

  Modelling the bentonite properties and erosion mechanisms
- Resources available and estimated resources needed to complete the work:

  Experimental set-ups for static and dynamic erosion experiments (artificial and rock fractures) *and* Characterization methods (PCS, ICP-MS, ICP-OES, XRD, SAXS, FESEM, AFM)

  Needed funding for the experimentalist and modeller (Pirkko Hölttä and Eini Puhakka) (40 person-months/4 years)