sck cen

Belgian Nuclear Research Centre

Mechanical properties of degraded concrete: micro-macro modelling

EURAD-MAGIC

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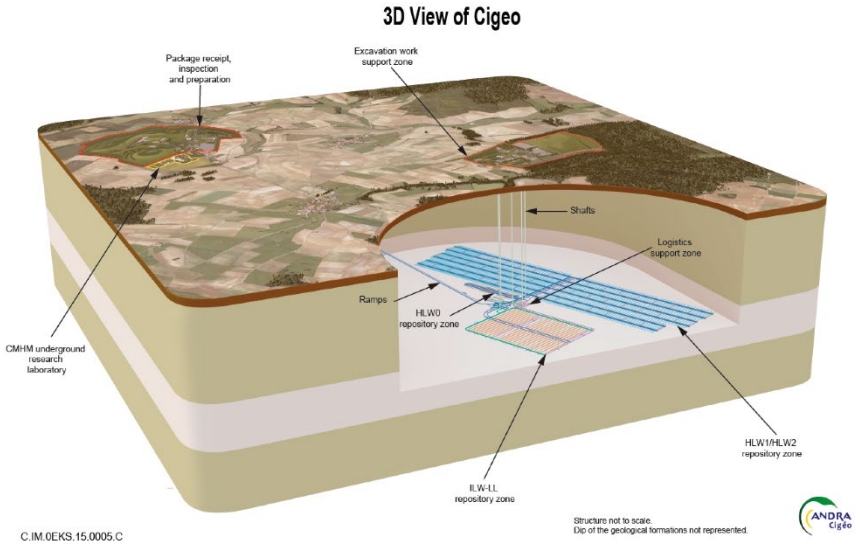
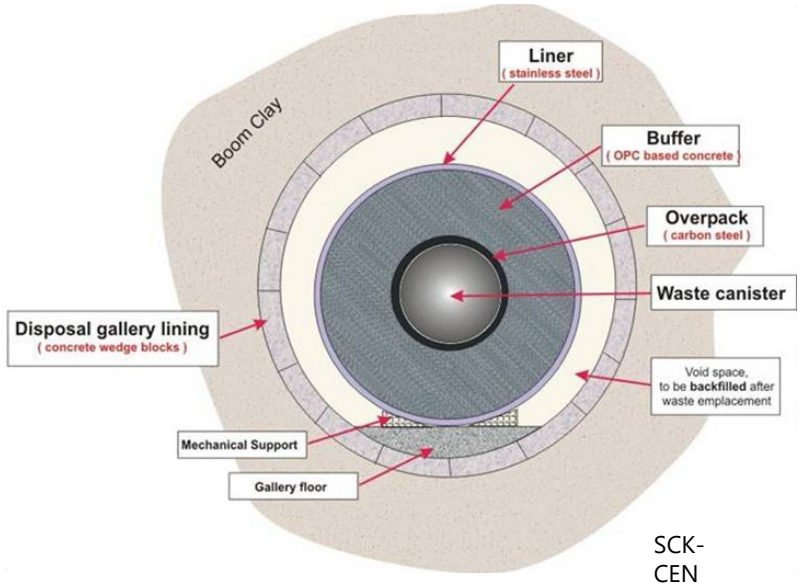
European context

Cementitious materials widely used for :

- Backfill
- Barrier
- Buffer material
- Massive plugs in sealing area
- Container
- Vault/liner





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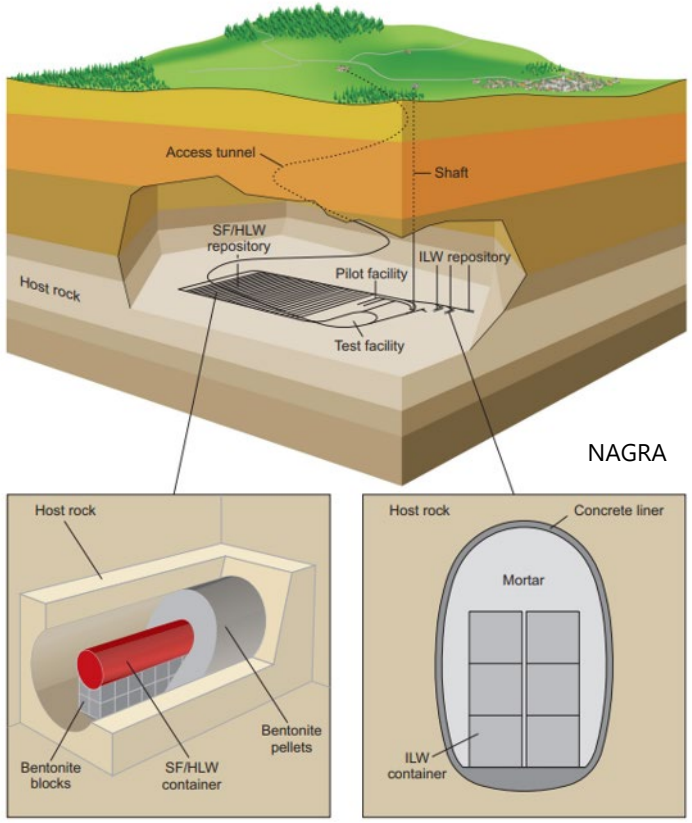


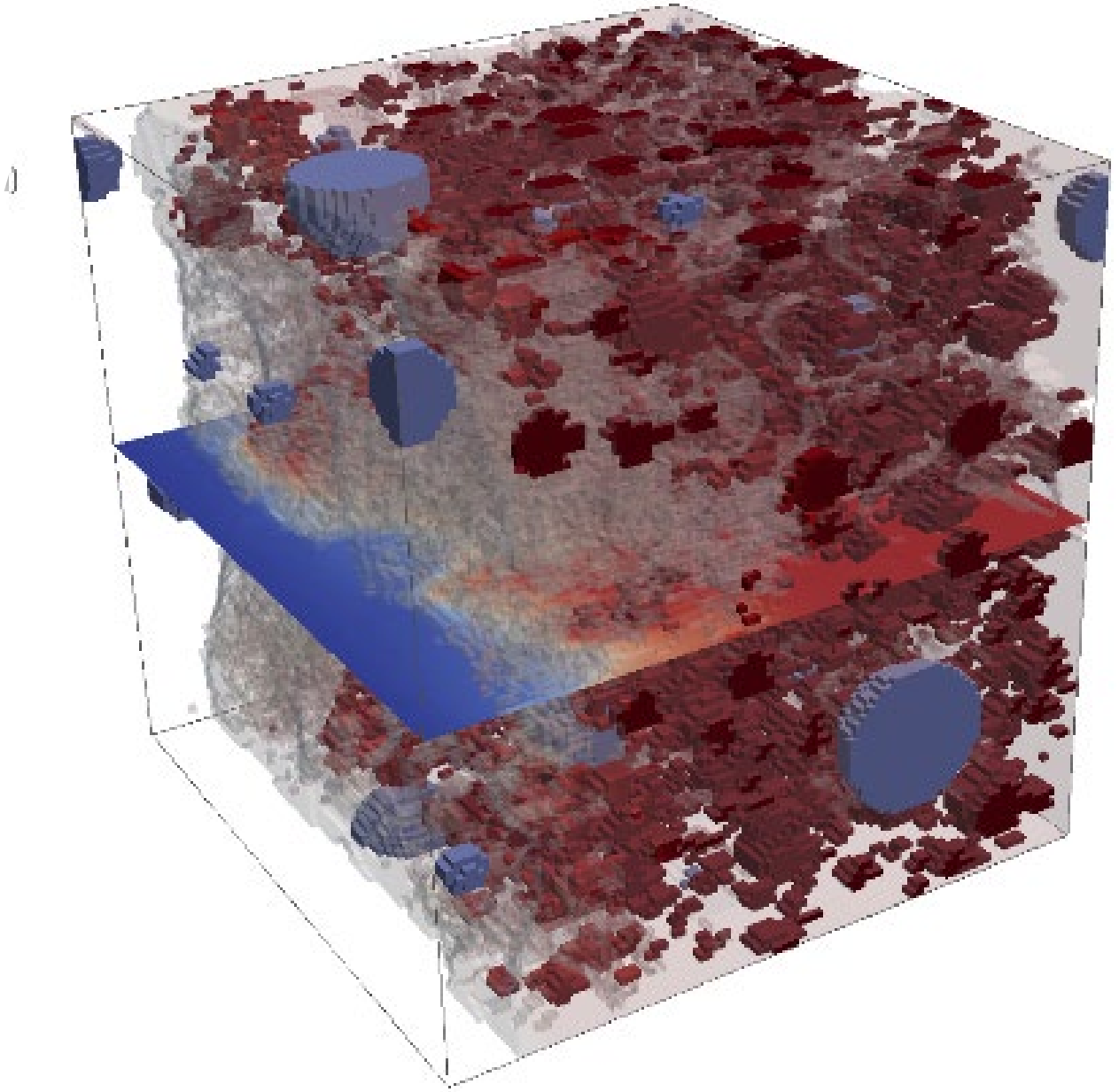
NAGRA

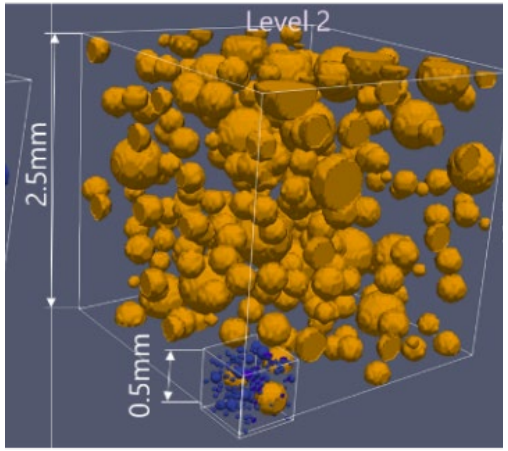
A use from the operating period to the long term

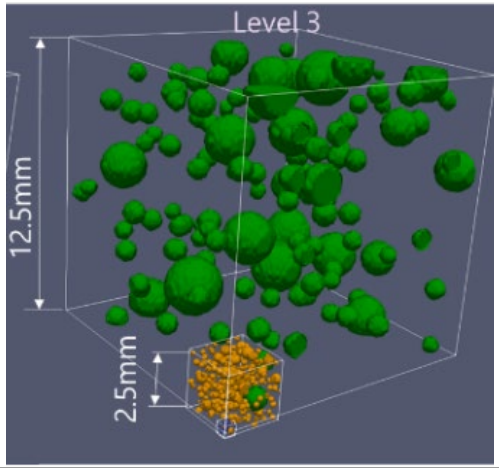
Material exposed to a set of disturbances

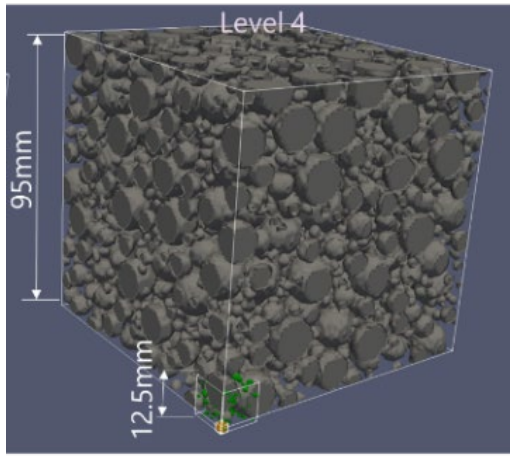
Scientific gaps

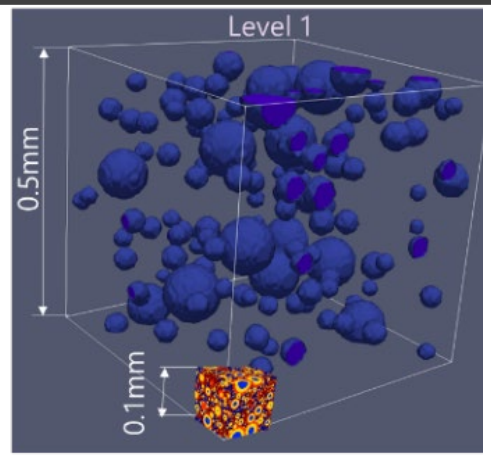
- Impact of various **chemical degradation** phenomena on the **mechanical behavior** of massive cementitious materials?
- Impact of **microbiologically** induced processes in the **chemo-mechanical** behavior of cementitious materials?
- **Reference model** for OPC and low pH concrete

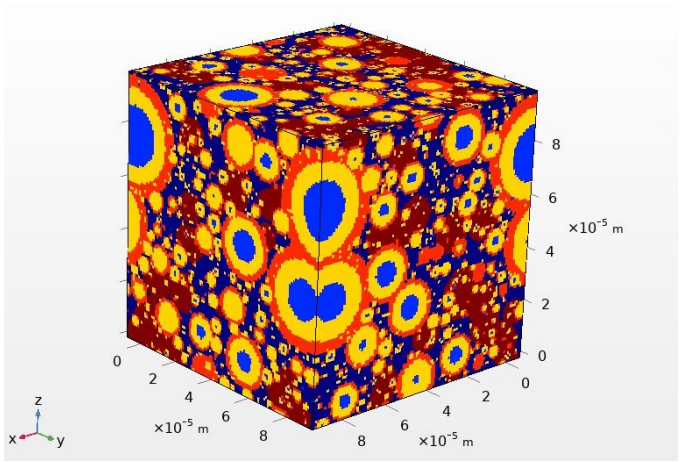










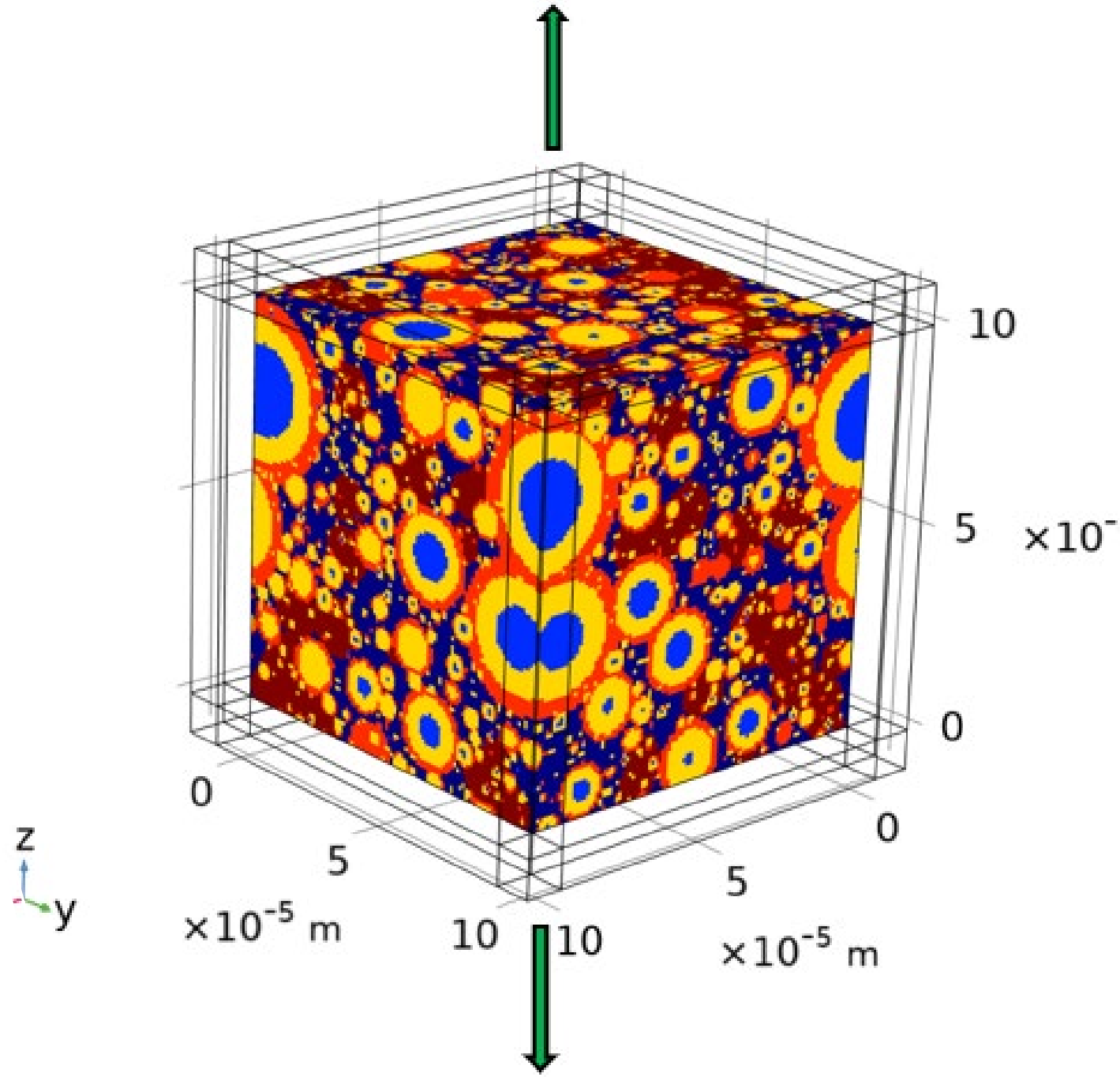


Micro-macro modelling using synthetic microstructures

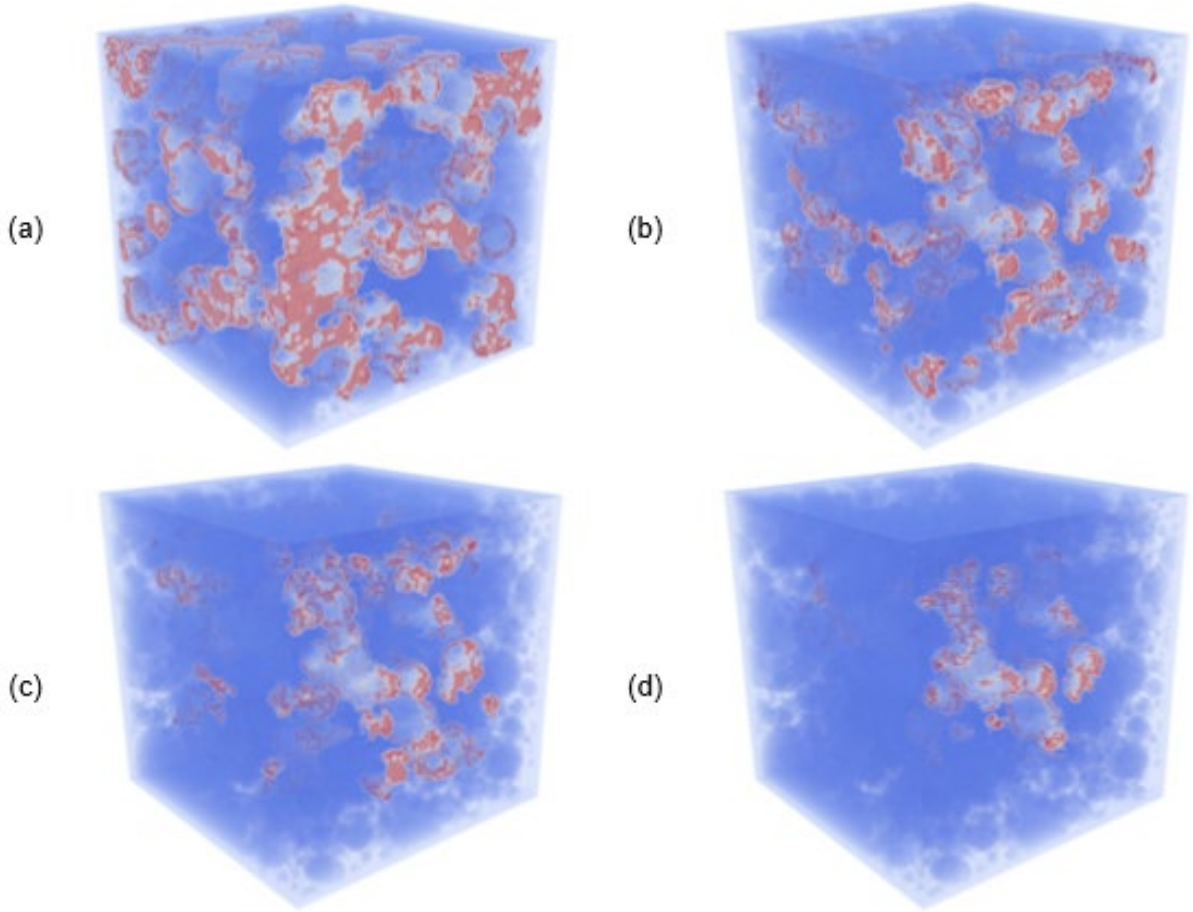
- Microstructure obtained from HYMOSTRUC for real cement paste.
- Concrete aggregate distribution obtained from in house code, based on real data.

Modelling strategy

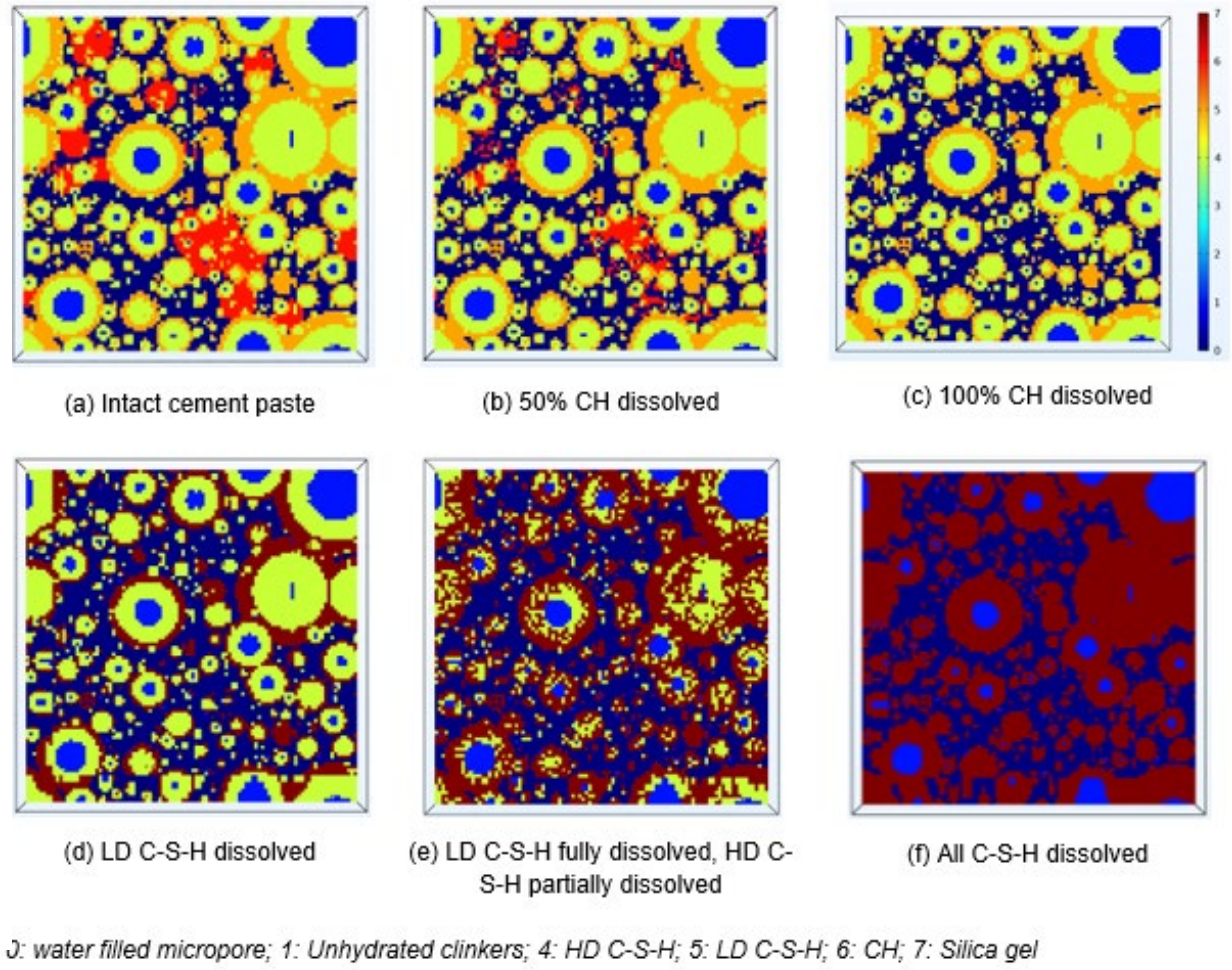
- Voxelized FE model.
- Numerical homogenization.
- Solve reactive transport model for leaching, also artificially generated leached random microstructure.
- Only artificially generated carbonated random microstructure.



Leached microstructures of cement paste

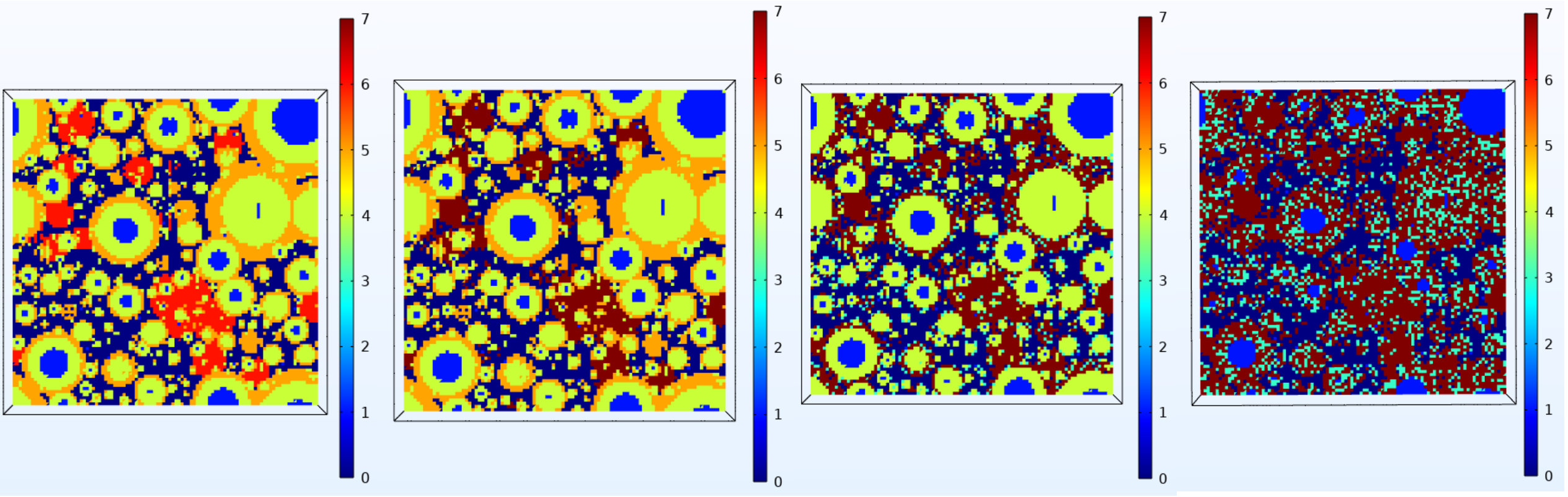


Lattice-Boltzmann simulations



Randomly created leached microstructure

Artificially generated random microstructures of carbonated cement paste

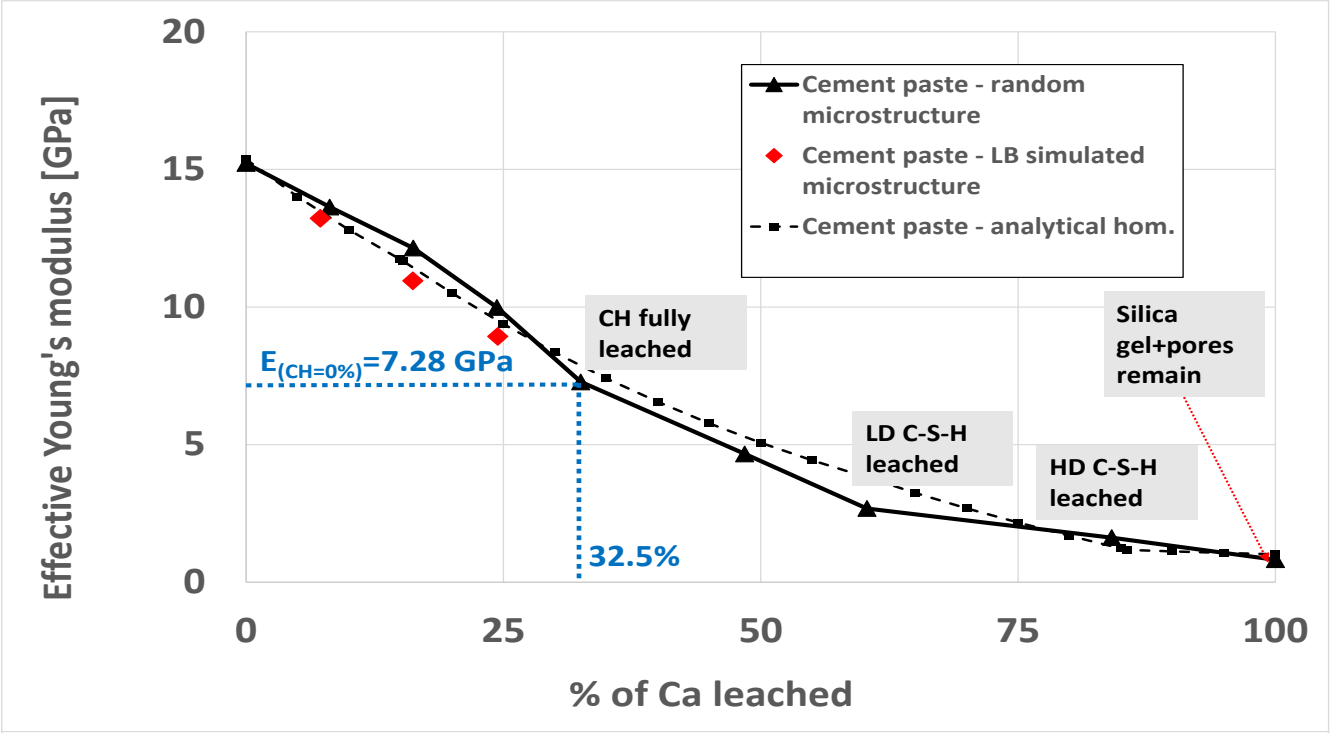


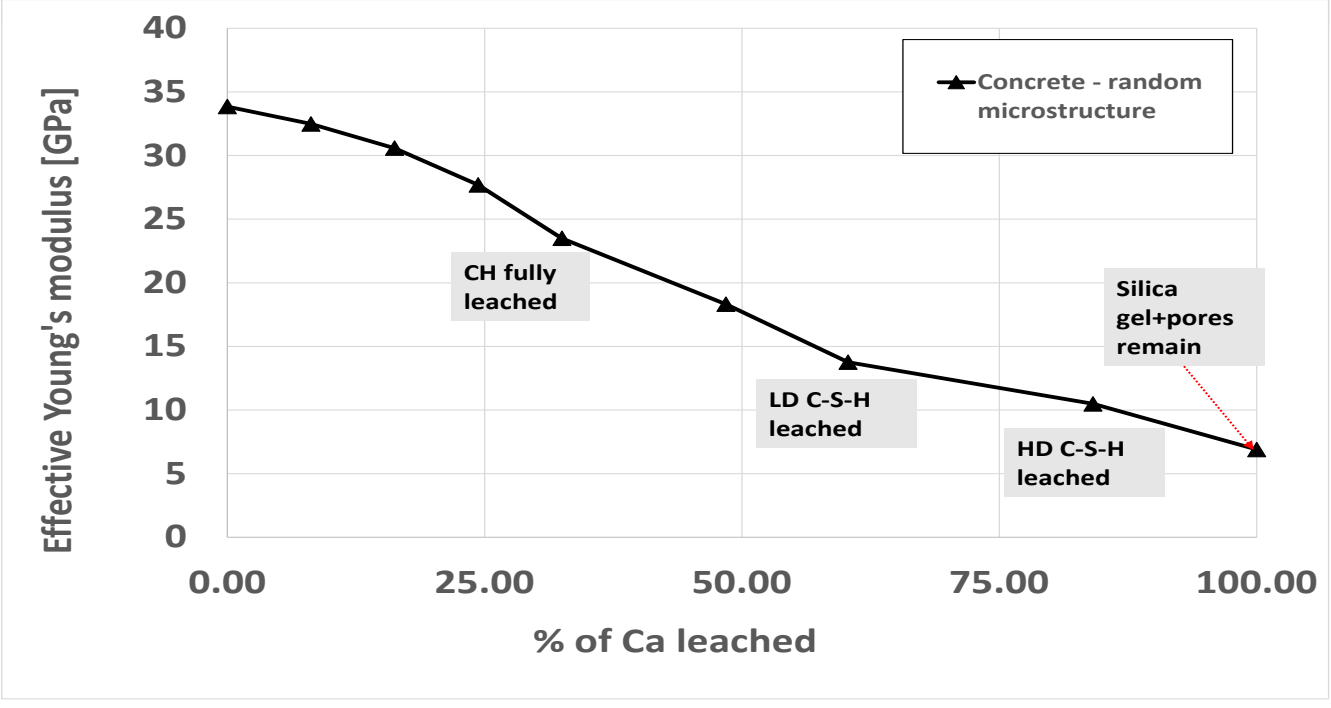
Intact cement paste | CH fully carbonated | LD C-S-H fully carbonated | HD C-S-H fully carbonated

0: water filled micropore; 1: Unhydrated clinkers; 4: HD C-S-H; 5: LD C-S-H; 6: CH; 7: Calcite

Young's modulus of leached cement/concrete

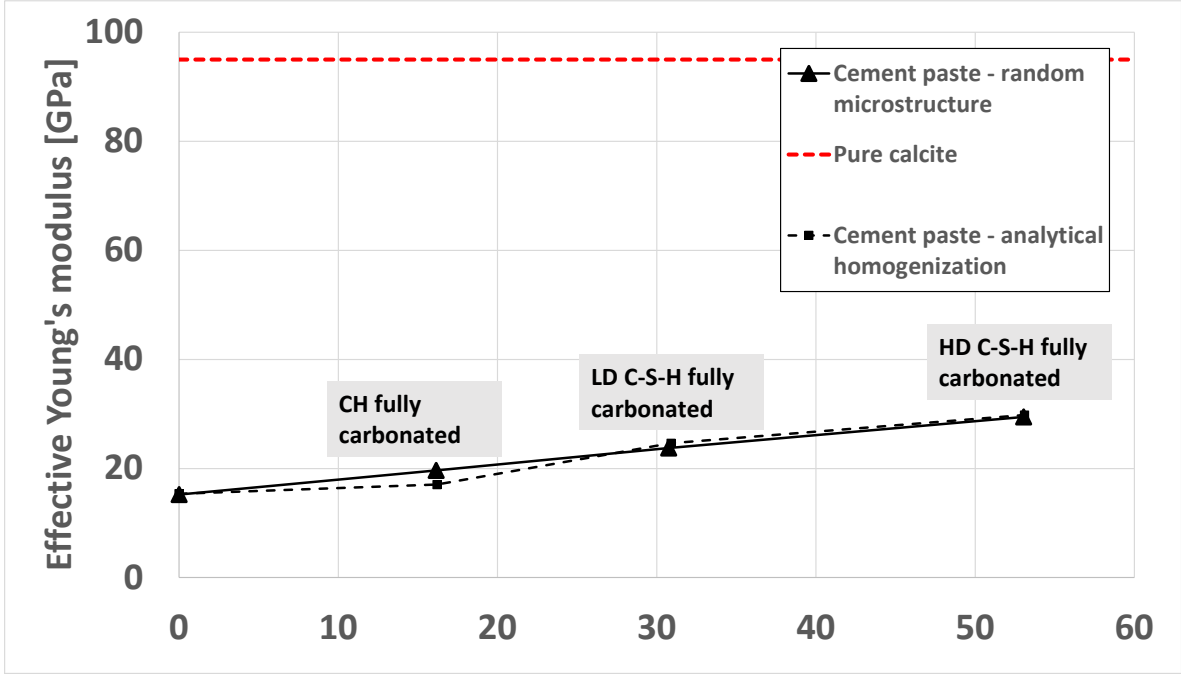
- Significant reduction in the stiffness even if all Portlandite is leached out.
- Not defined as a function of time, depends on the scenario.

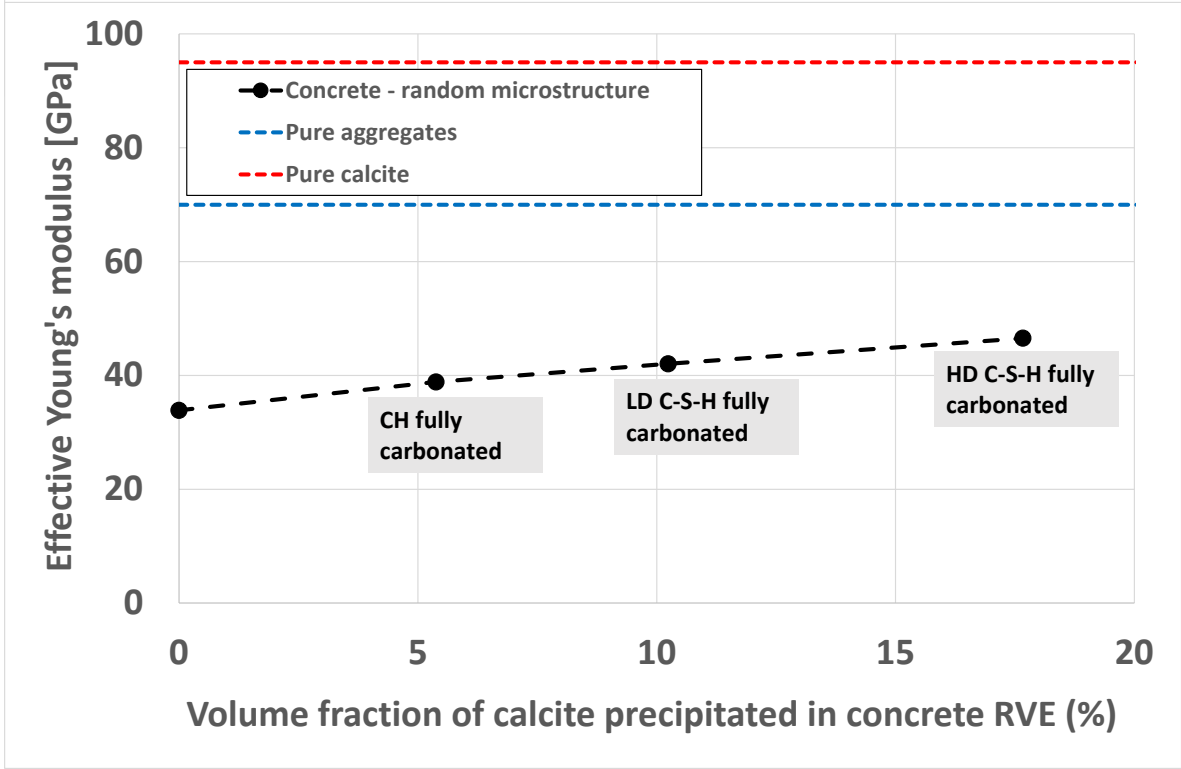




Young's modulus of carbonated cement/concrete

- Maximum 30% increase in the stiffness.
- Not defined as a function of time, depends on the scenario.



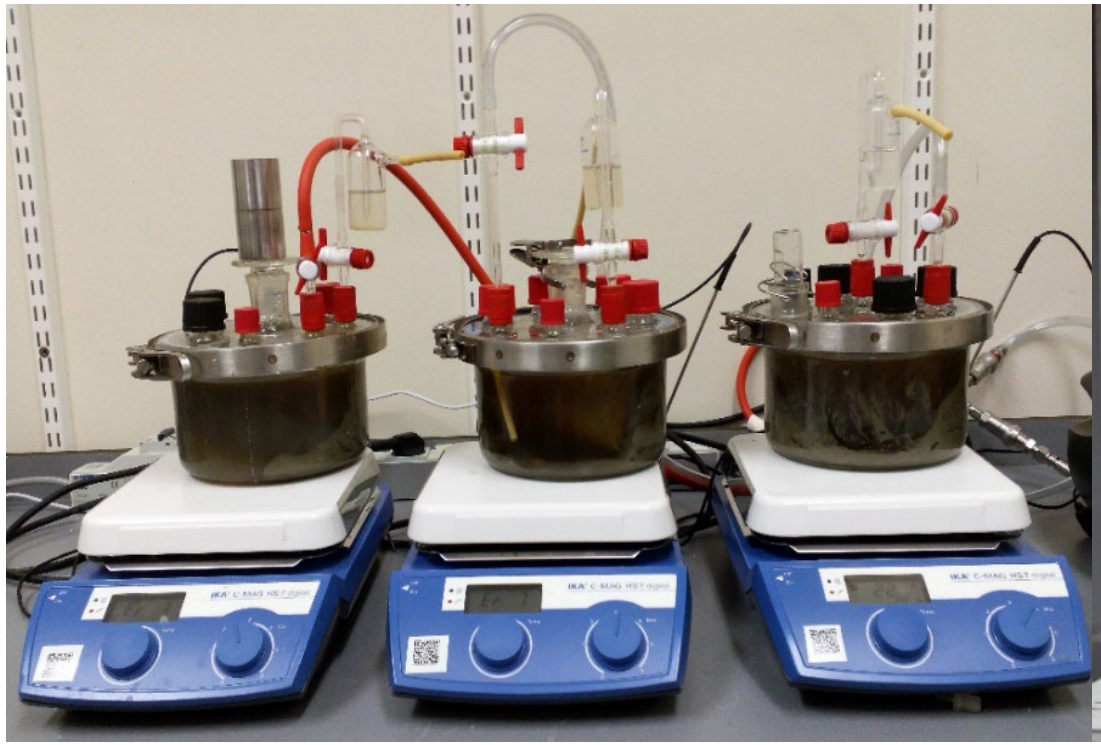


Still ongoing experiments

- **Batch type experiments**
  - Concrete – clay slurry
  - Bubbled by CO_2 0.4% to mimic CO_2 concentration
  - Follow up chemical, pH and transport properties evolution

- **Percolation type experiments**
  - Representative for the backfill concrete in the Belgian disposal concept
  - The conditions in the HADES URF are mimicked:
    - Chemical compositions
    - Advective flow

Microbial: sterilized conditions (γ-irradiation + T)



Relevance to Belgian scenario

- Note: Leaching and carbonation are extremely **slow** process.
- Geological disposal - **Operational period**, e.g. tunnel lining – high carbonate, low pH water from BC.
- Near surface disposal - **Monolith** degradation in the long term. Infiltration over long term.