



# Ageing behaviour of cement-based materials: upscaling linear viscoelastic and thermal properties at early-age

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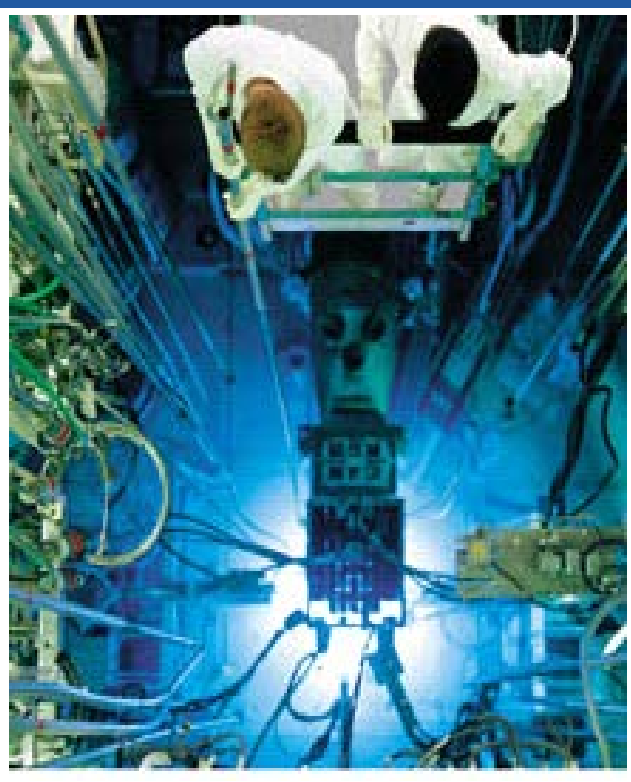
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# CEA - French Alternative Energies and Atomic Energy Commission LECBA - Laboratory of Concrete and Clay Behaviour Studies

Partner Project : Multiscale estimation of the thermo-viscoelastic properties of cementitious materials at early age

## Ageing behaviour of cement-based materials: upscaling linear viscoelastic and thermal properties at early-age

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### Background and Objectives

- Estimation of ageing viscoelastic properties: predict the behaviour at early age
- Multiscale character of cement-based materials, different phenomena potentially affecting the overall behaviour:

- **Goal: estimate ageing viscoelastic properties**
- **Bulk and shear relaxation and Creep functions**

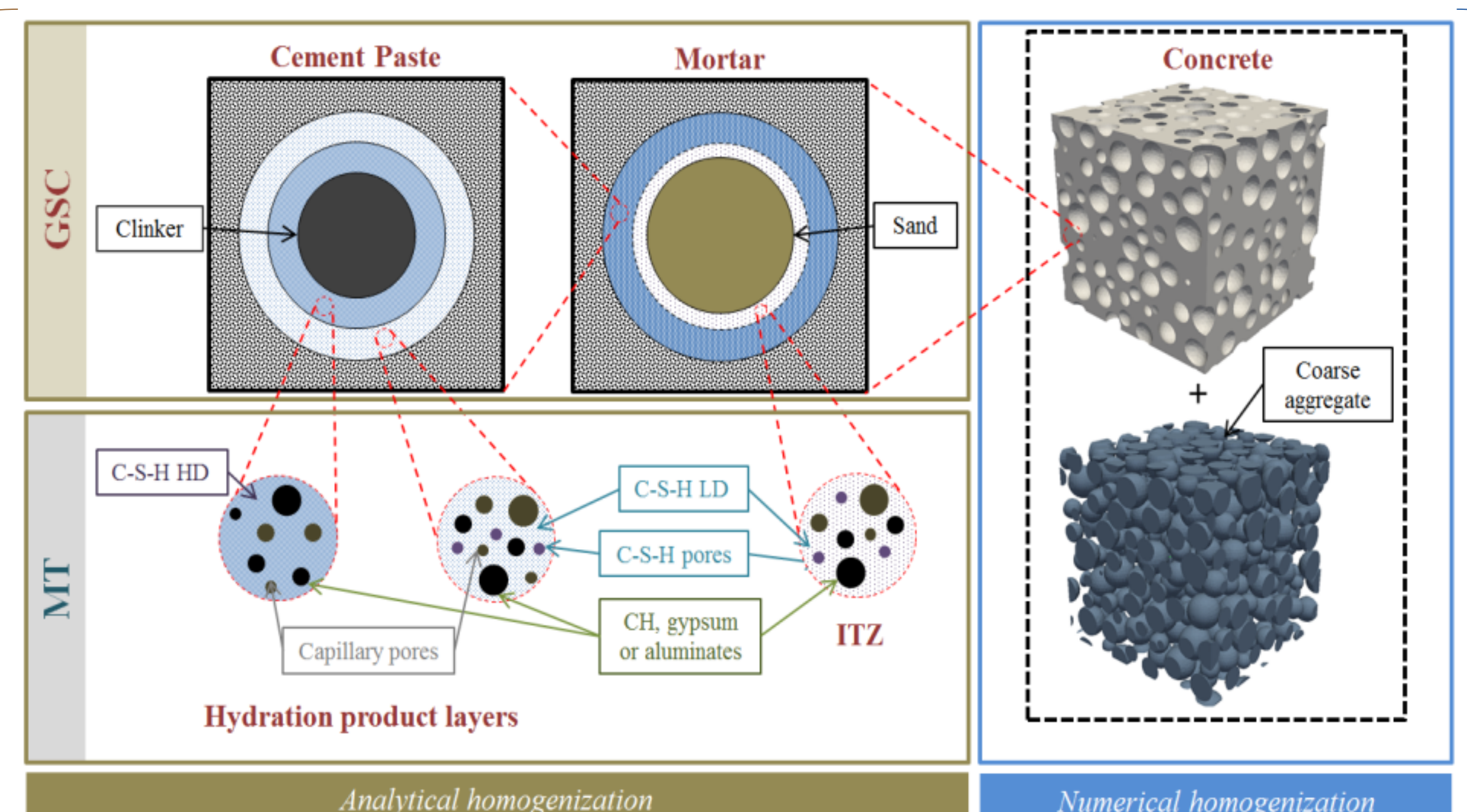
- Space-filling process on C-S-H evolution
- Solidification process
- ITZ composition and size
- Mismatch between aggregates and matrix properties

### Methodology

#### Analytical homogenization schemes in ageing viscoelastic framework:

- Definition of the division ring ( $F; +, \circ$ ) with  

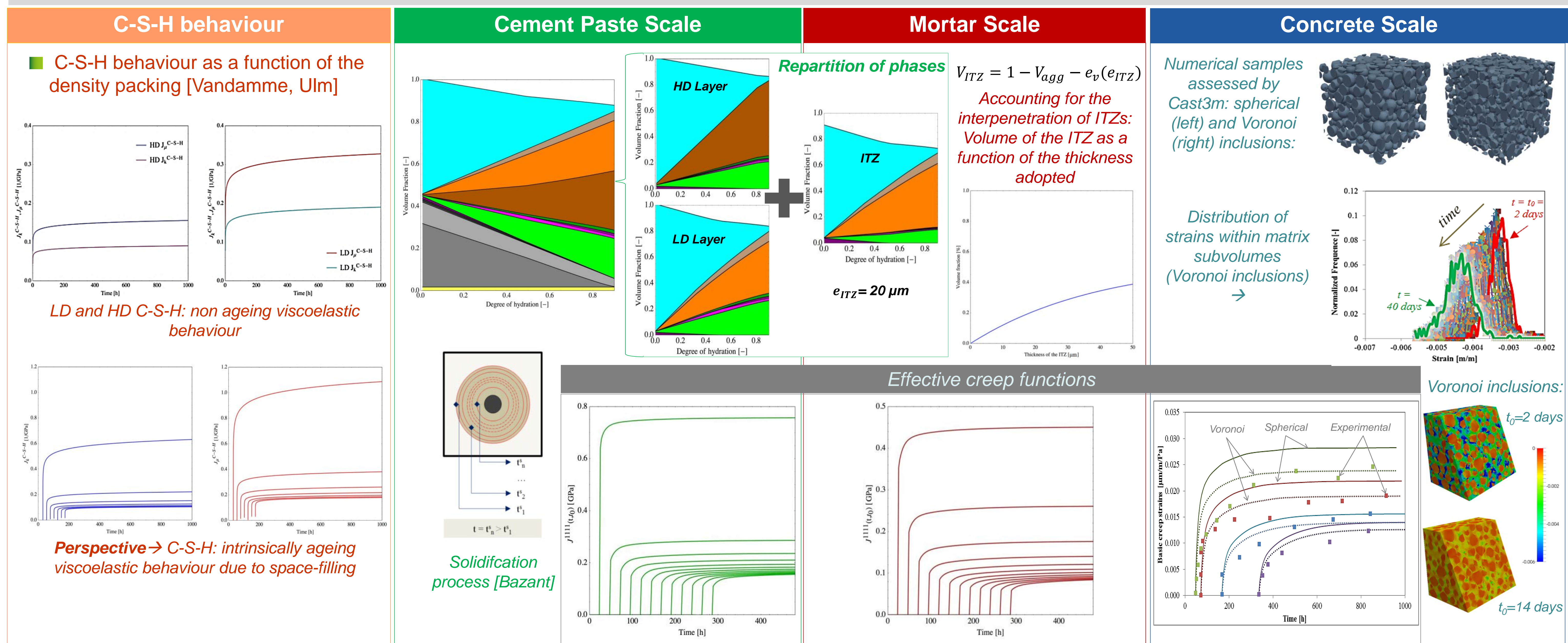
$$(f \circ g)(t, \tau) \equiv \int_{t'=-\infty}^t f(t, t') d_{t'} g(t', \tau)$$
- Volterra integral operator (valable for tensors)



#### Numerical homogenization in FEM simulations:

- Ageing linear viscoelastic behaviour implanted in Cast3m ([www.cast3m.fr](http://www.cast3m.fr))
- Evaluation of local information
- Investigation of more complex geometries

### Results



### Conclusions

- Development of a strategy combining analytical and numerical homogenization tools estimating the ageing viscoelastic behaviour of cement-based materials at early-age.
- The combined approach proposed here allows investigating different propositions of mechanisms leading to an ageing behaviour. Simulations taking into account the space-filling process as leading to an intrinsically ageing behaviour of C-S-H can be performed.
- The estimations of the creep response are in agreement with the usual values obtained experimentally for similar concretes.
- The local information obtained by numerical homogenization at the concrete level shows a similar dispersion in the strains for both inclusions shapes.

### What's next?

- Determination of thermal properties at early-age →

Preliminary estimation of the Coefficient of Thermal Expansion (viscoelastic effects considered)

