

Federico C. Antico, Pablo D. Zavattieri, W. Jason. Weiss
 School of Civil Engineering, Purdue University, West Lafayette, IN 47907- 2051

Motivation / Objective

Motivation

- Understand causes of concrete cracking at early ages caused mainly by drying shrinkage to improve concrete durability

Objective

- Develop micro and macro structural models to predict damage at early ages
- Lay the foundations of a multiscale model that captures and translates heterogeneities at the binder (e.g. sand and hydrated and unhydrated cement particles) to the micro level (binder and aggregates) and then macrostructure of concrete

Restrained shrinkage test (ASTM C1581)

Determine the effect of:

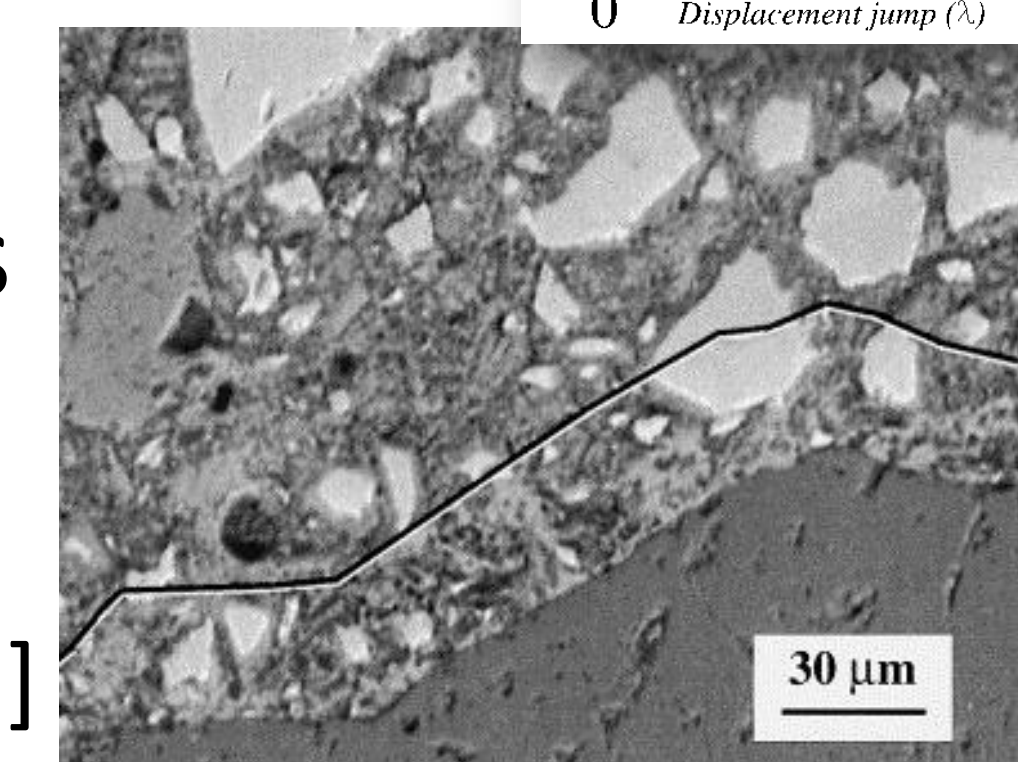
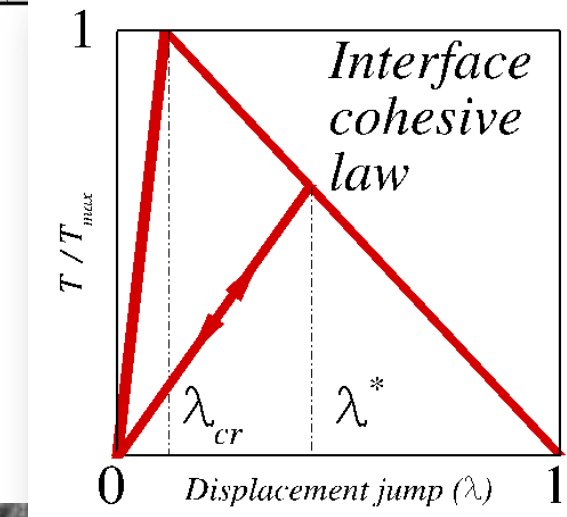
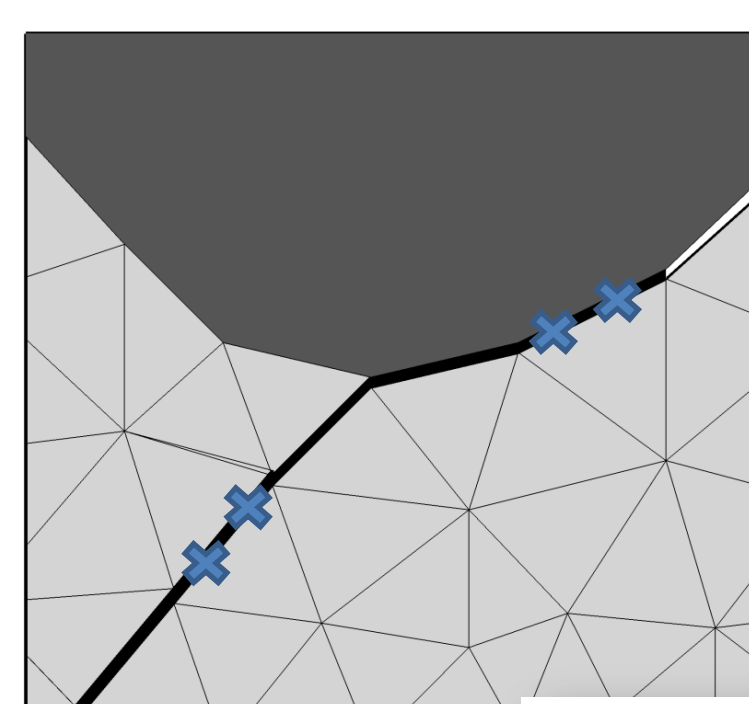
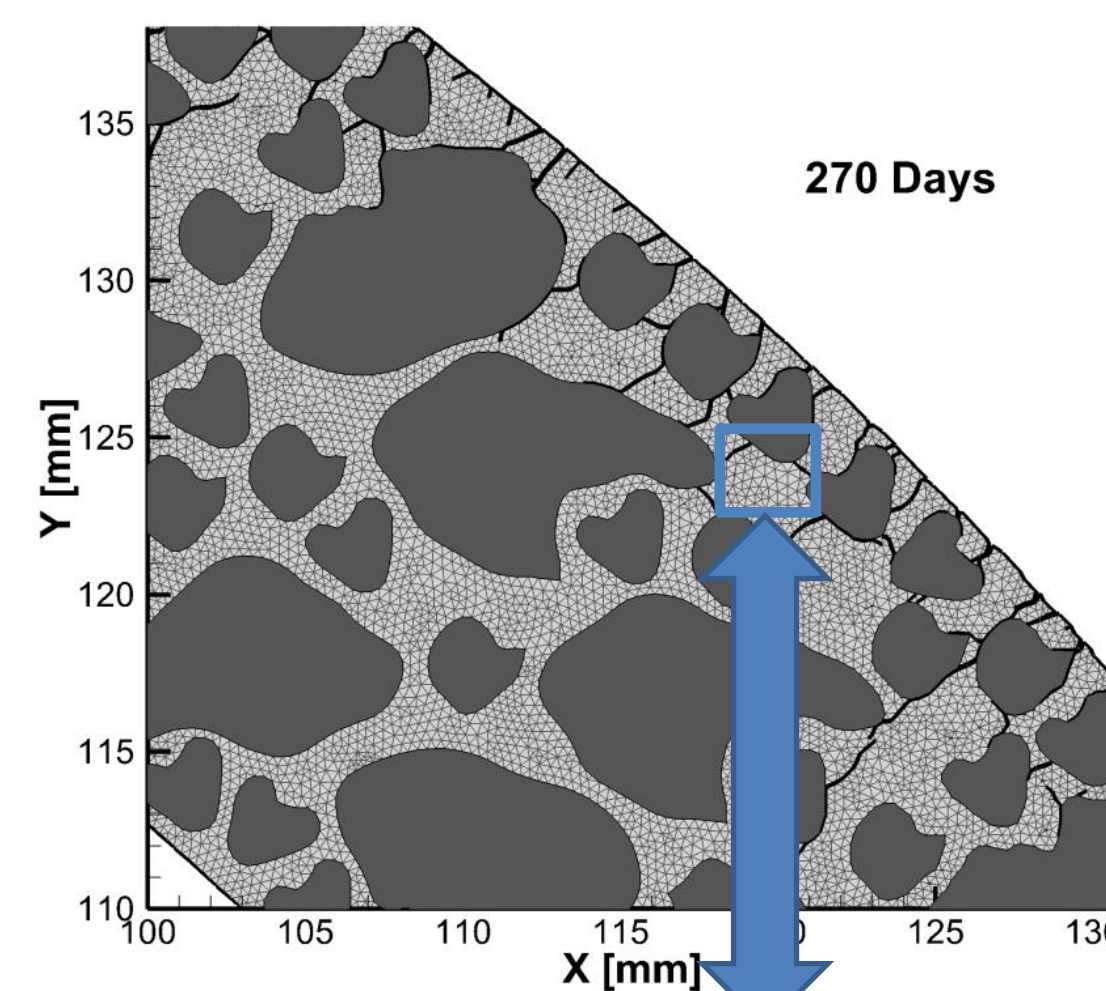
- Material proportions
- Drying shrinkage at early ages

On:

- Cracking potential
- Induced tensile stress



[1]



[2]

Model development

- Maxwell chain model [3]

$$s(t) = \int_{-\infty}^t v(\tau)G(t-\tau)\dot{\epsilon}(\tau) d\tau$$

Deviatoric Stress

- Solidification models [4 – 6]

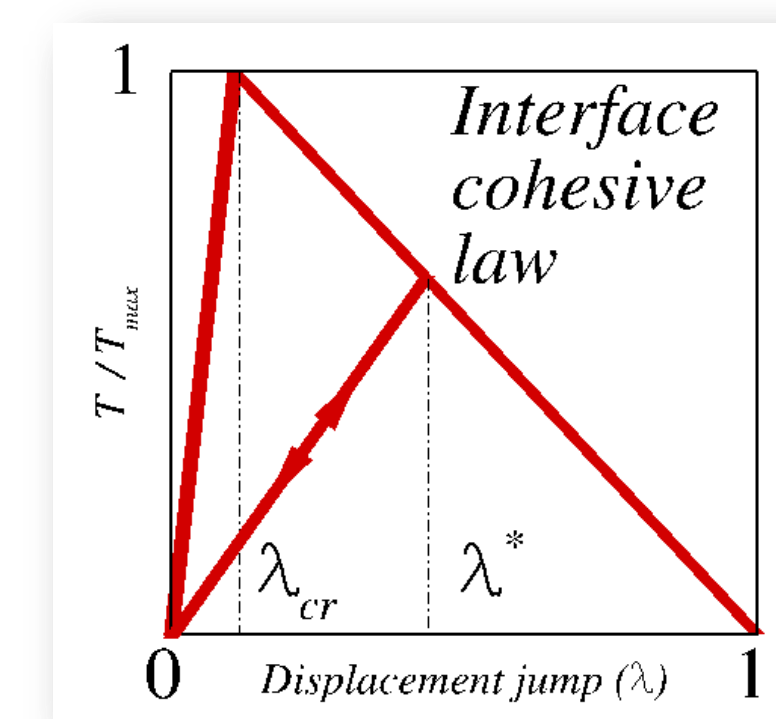
$$v(t) = \kappa[1 + \exp(-\lambda t)]$$

$$G(t) = G_0 \left[\mu_0 + \sum_{i=1}^N \mu_i \exp\left(-\frac{t}{\lambda_i}\right) \right]$$

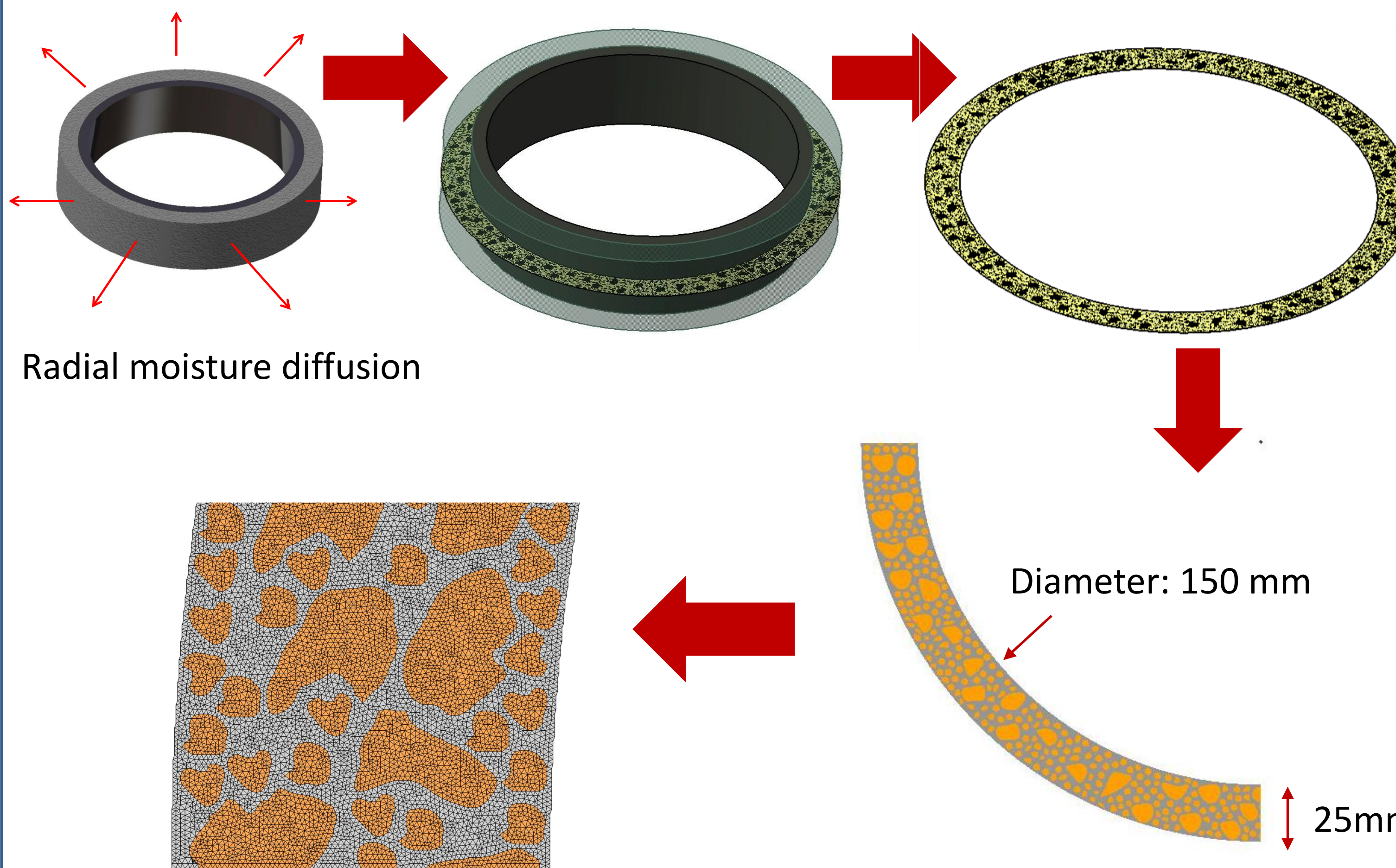
Shear modulus

$$\frac{1}{v(t)} = \left[\frac{\lambda_0}{t} \right]^m + \alpha$$

- Cohesive zone damage model (binder and the ITZ) based on LEFM and NLFM



- Finite Element Model



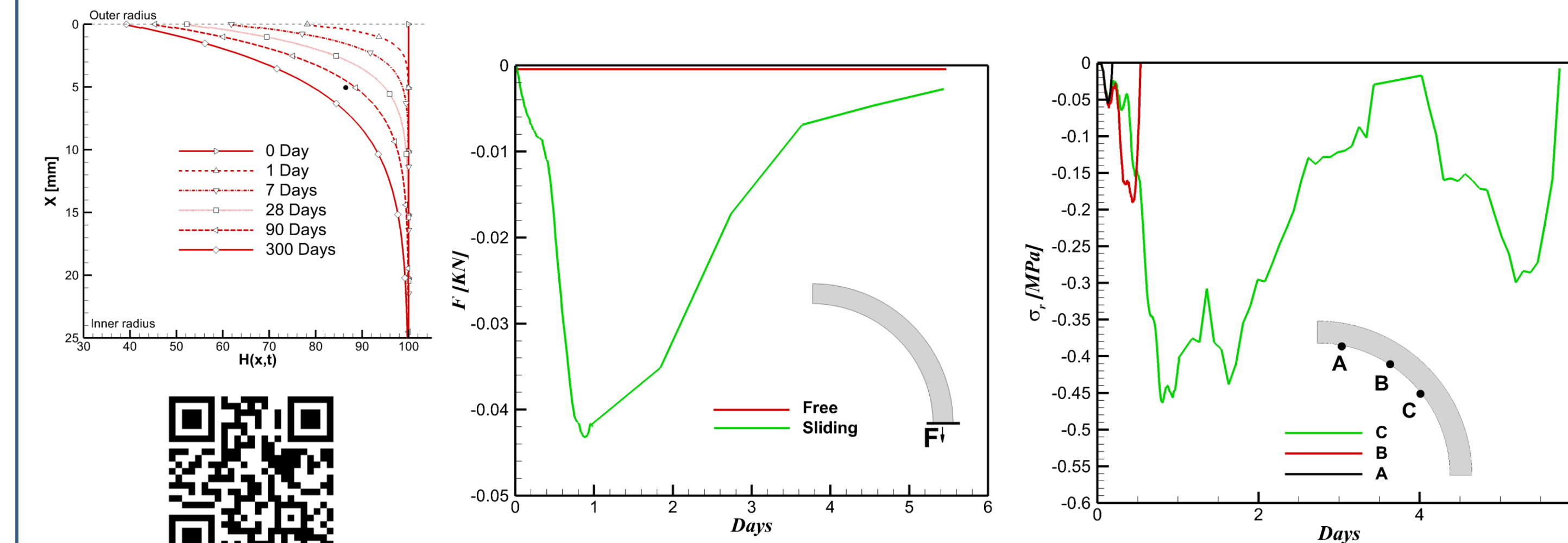
Radial moisture diffusion

Diameter: 150 mm

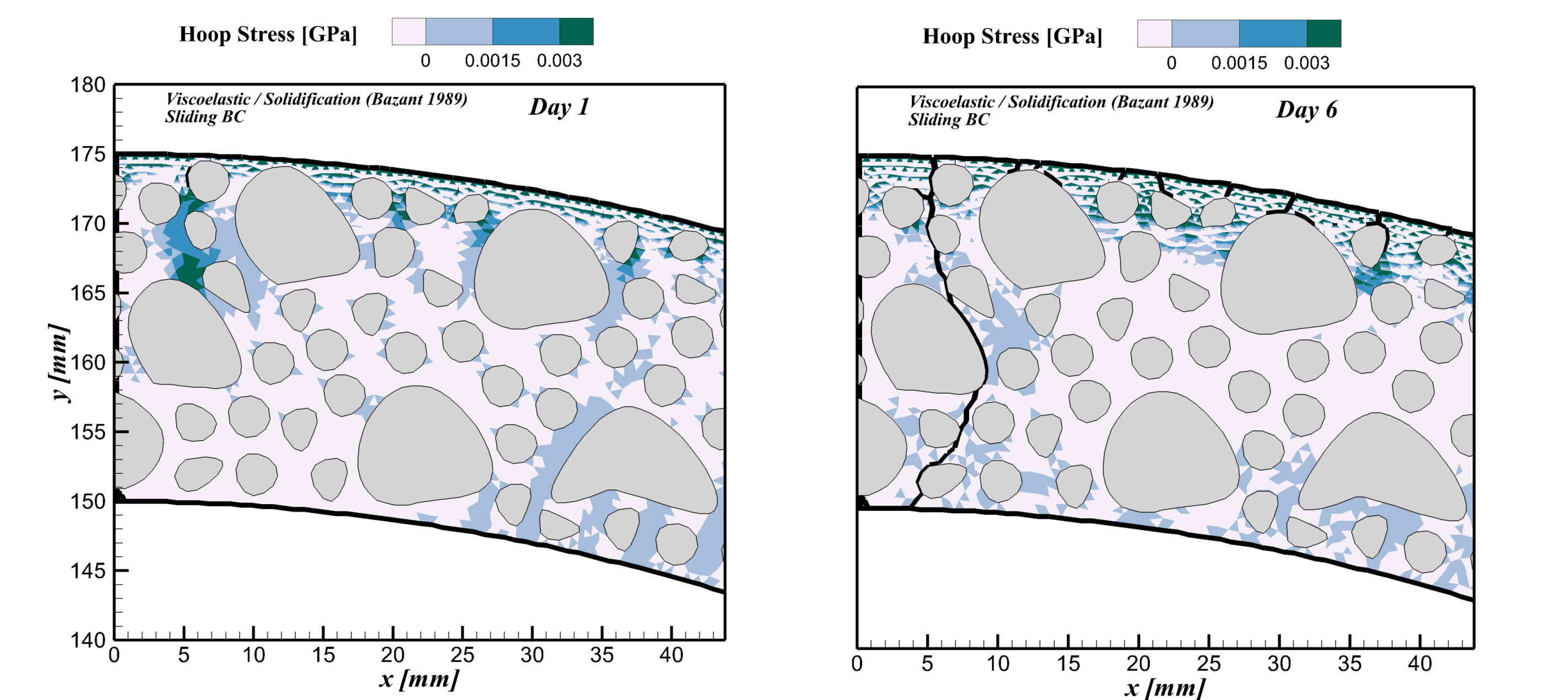
25mm

Preliminary results

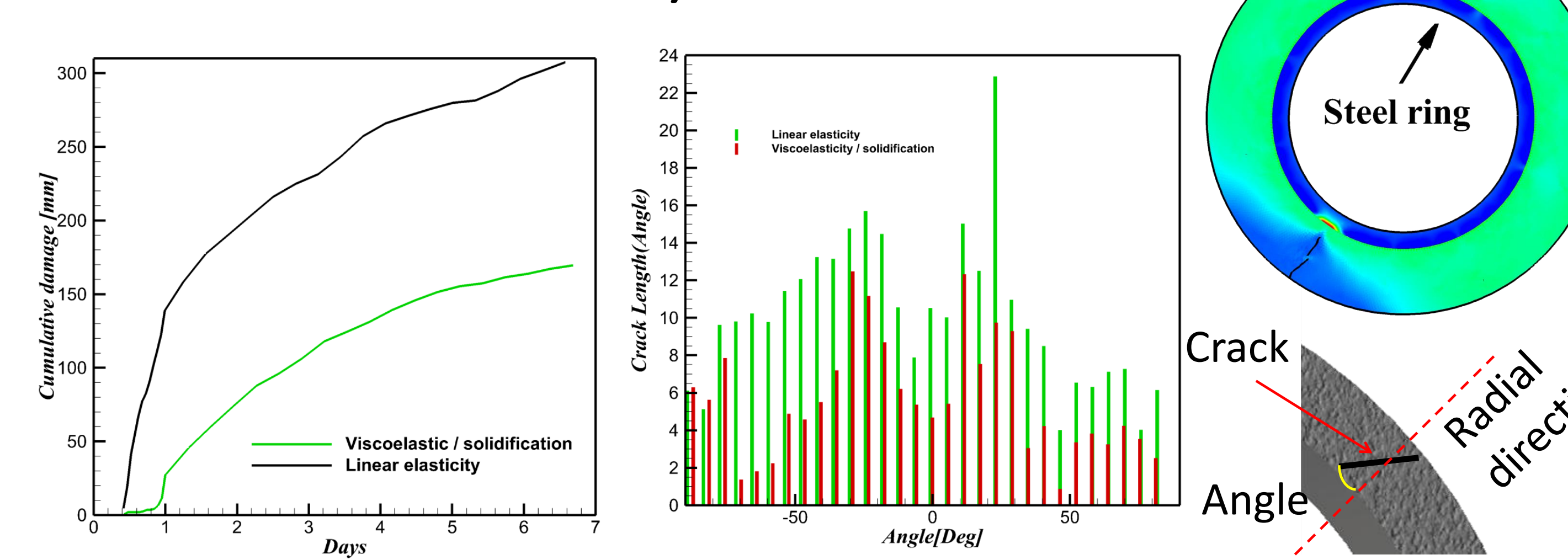
Mean cross section force & radial stress at inner ring



Crack propagation



Crack evolution analysis



- A 2D heterogeneous model of concrete has been implemented; accounting for NL and time dependent evolution of its mechanical properties that affects microcracks growth and nucleation at early ages.
- This model is intended to link fine scale response with concrete macroscale response via a multiscale analysis that is under development.

References

- [1] www.cement.org
- [2] Diamond S., Huang Jingdong. Cement & Concrete Composites 23 (2001) 179-188

- [3] Bazant, Wu, *Matériaux et Constructions*, 1974
- [4] Carol, Bazant J. *Eng. Mech.* (11) 1993
- [5] Grasley, D'Ambrosia, *Cement & Concrete Composites* (33) 2011
- [6] Bazant, Prasannan, *Journal of Engineering Mechanics* (115) 1989