

Modeling of self-healing in concrete and polymeric materials

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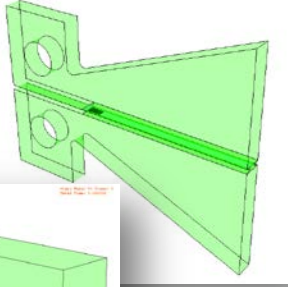
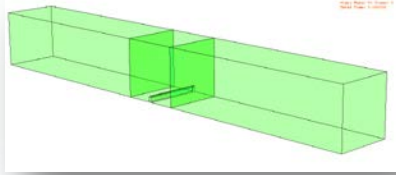
Research group
Mechanics of Materials and Structures
Ghent University
(UGent-MMS)



Outline

- Modeling methodology SHE materials
 - Contributions to SECEMIN and SEPOCOM
- Examples of collaborations
 - Characterization of mechanical properties
 - Interaction crack-capsules
 - Leakage of healing agent
 - Validation process
- Benefits acquired

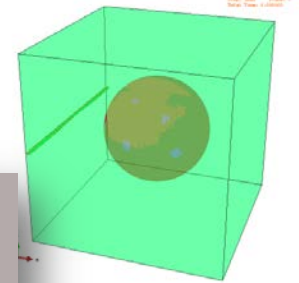
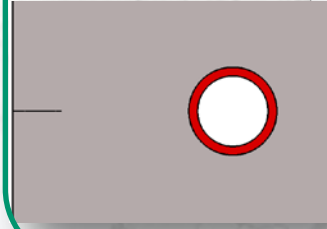
Macroscale
 simulation



Mechanical
 response



Microscale
 simulation

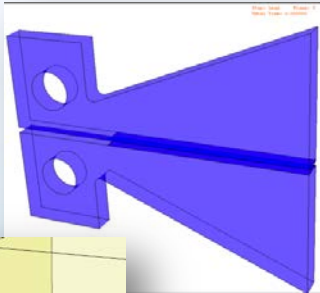
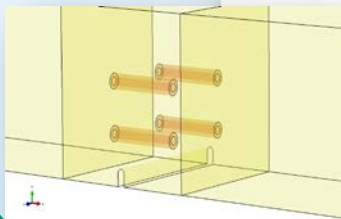


**UGent-MMS contribution:
 Modeling Methodology SHE materials**

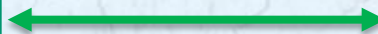
Agent
 incorporation



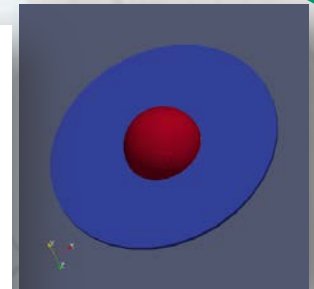
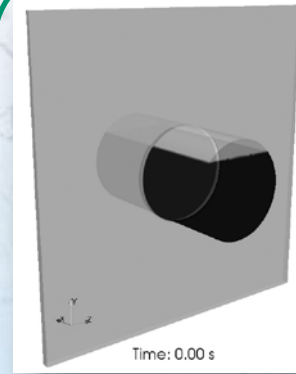
Healing
 simulation



Agent effects



Leakage
 simulation



Collaborations

Characterization of mechanical properties



Concrete

Traction-separation law

stress

separation

$\sigma_{T\alpha}$

G_{α}

Crack initiation
Crack propagation

α = matrix, capsule, interface

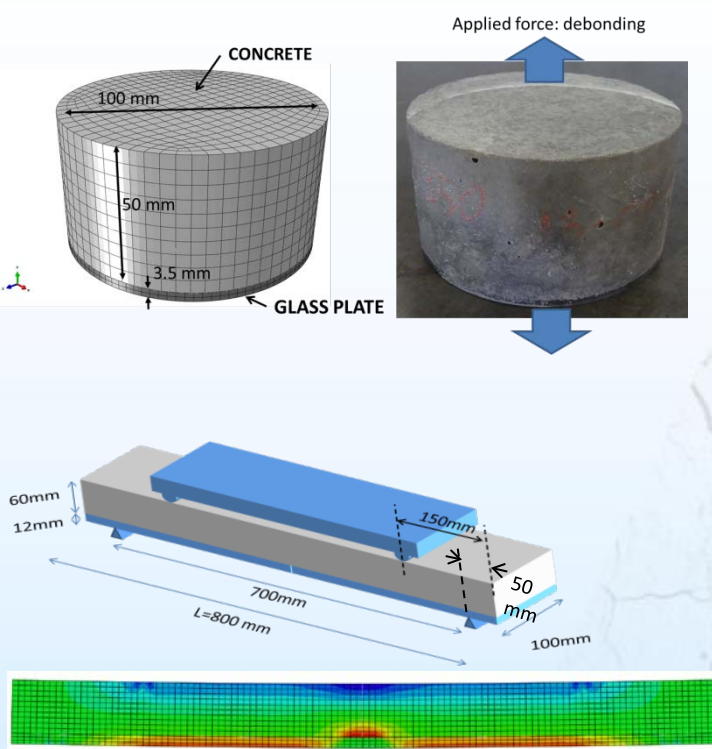
- Young's modulus (E)
- Poisson ratio (ν)
- Tensile strength (σ_t)
- Fracture toughness (K_{IC})

E	39.6 GPa
ν	0.17
σ_t	3.7 MPa
K_{IC}	1.2 MPa·m ^{1/2}

Collaborations

Characterization of mechanical properties

Concrete-Glass interface



Bonding strength

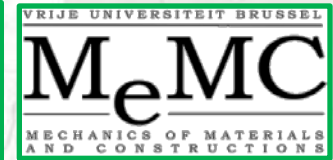
Interfacial fracture energy

- Two different tests are required
- Understanding interfacial crack
 - Initiation
 - Propagation
- Interfacial tensile strength (σ^*)
- Interfacial fracture energy (G^*)

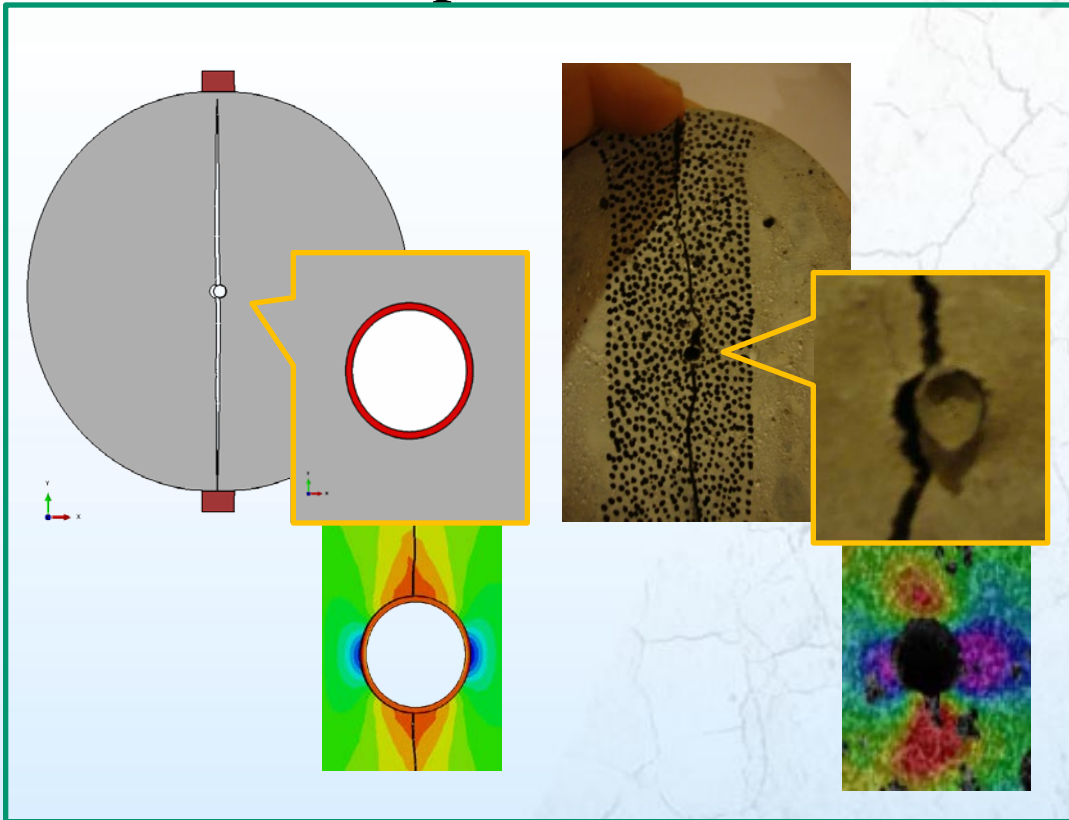
σ^*	0.92 MPa
G^*	< 1.0 J/m ²

Collaborations

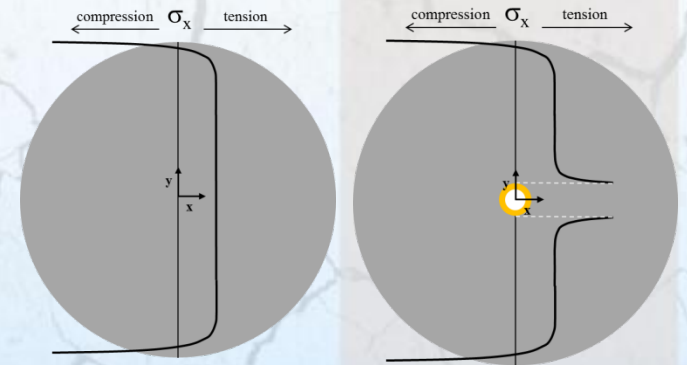
Mechanical Interaction Crack-Capsules



Modified Split test

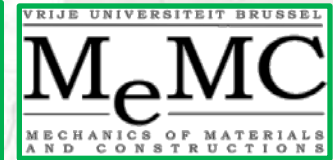


- Stresses around the capsule
- Understanding crack initiation
- Role of debonding/breakage
- DIC



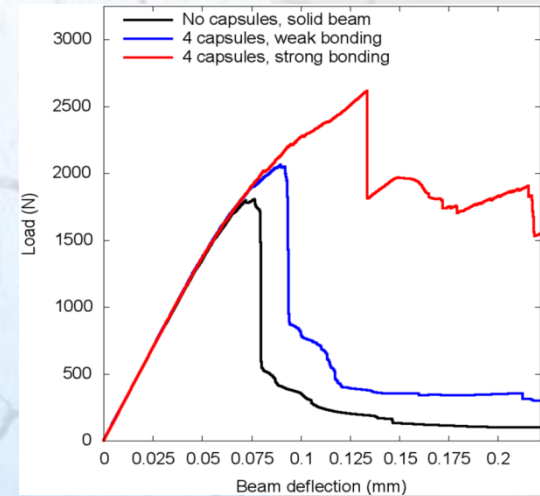
Collaborations

Mechanical Interaction Crack-Capsules



3-Point-bending test

- Effects due to capsules
- Crack propagation
- Role of debonding/breakage
- DIC

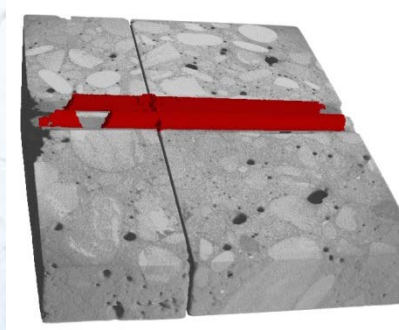
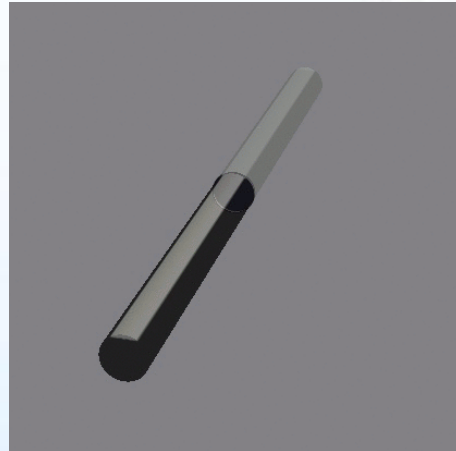


Collaborations

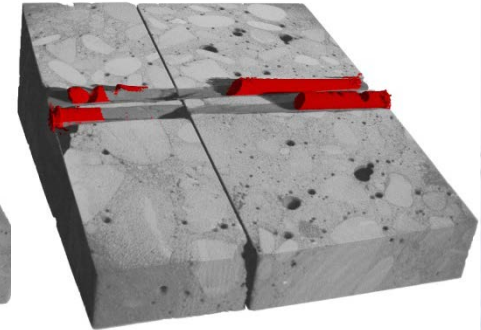
Leakage of healing agent



Capsules in concrete



Before breakage



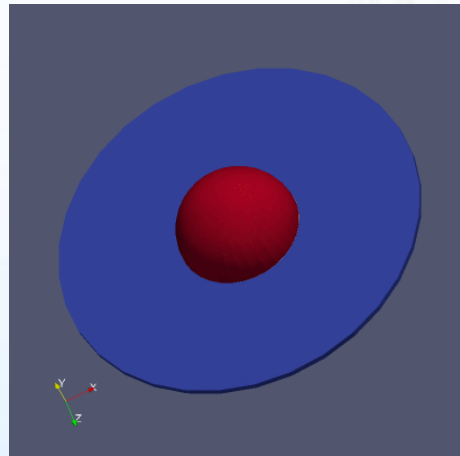
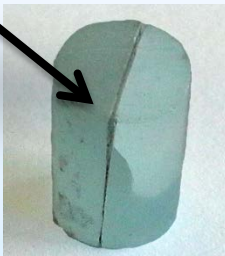
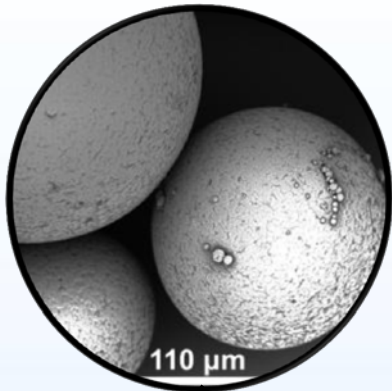
After breakage

Collaborations

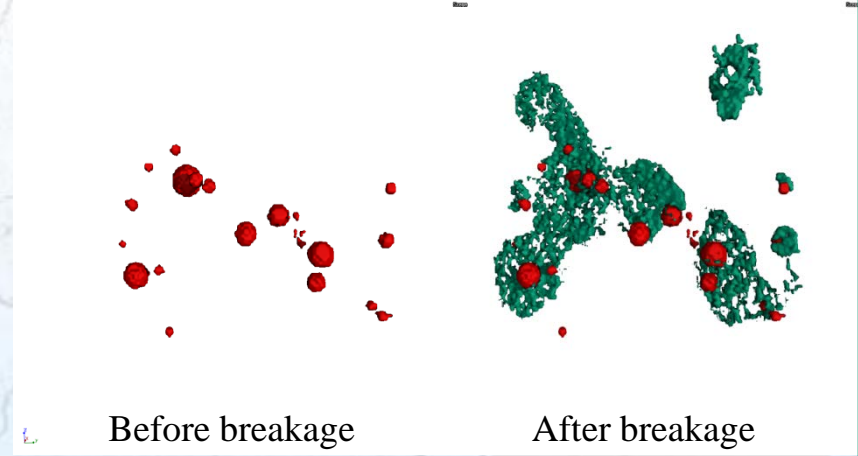
Leakage of healing agent



Micro-capsules in polymers

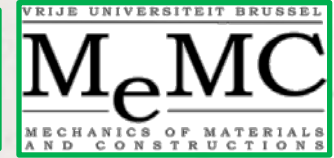


Differential scan of the crack surface

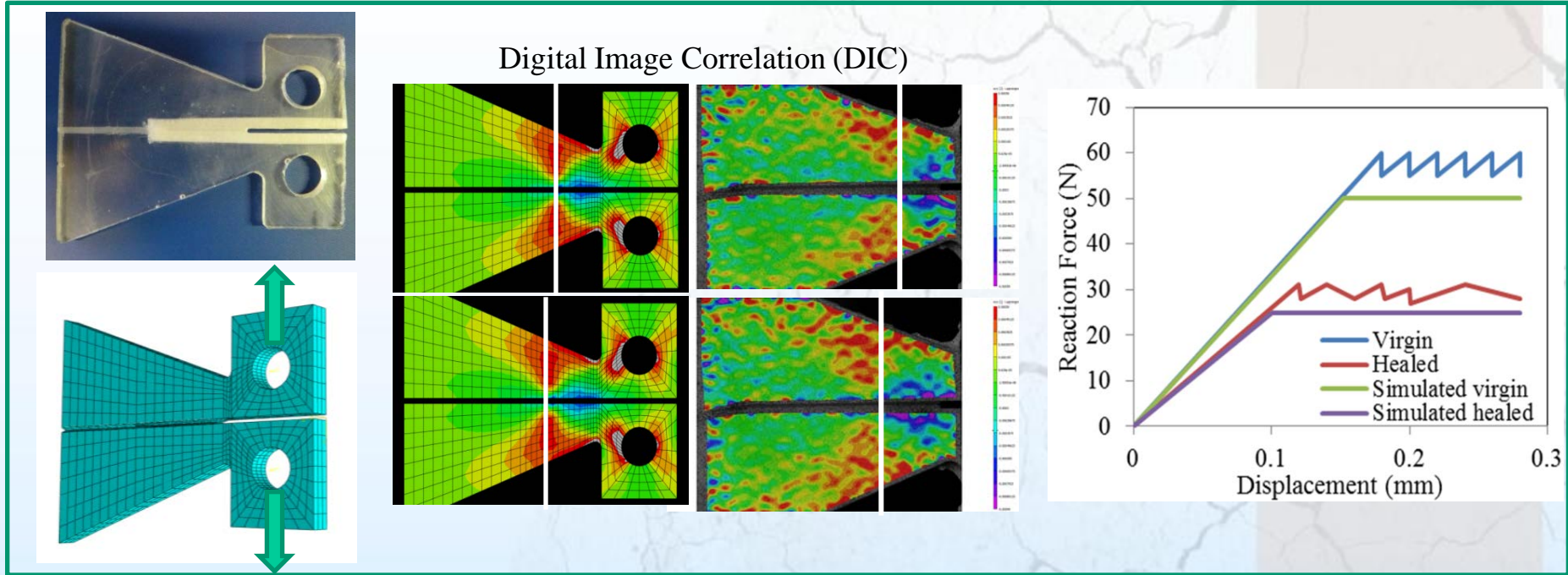


Collaborations

Crack propagation: validation




Tapered **D**ouble **C**antilever **B**eam test for self-healing polymers




Benefits acquired

- ✓ Computational fracture mechanics in multi-materials (2D/3D)
- ✓ Management of solid-fluid problems
- ✓ Design of new experimental setups + associated models
- ✓ Models easily expandable to other research scopes
- ✓ Modeling stage provided:
 - ✓ Better insight into problems involving coupled physical effects
 - ✓ Valuable feedback for Software Developers (in particular Simulia/Abaqus®)

Spill-over

- Insights in Discrete Fracture Mechanics:
Damage representation at the Meso-Scale Level 

very useful in **M3 Program**
(SBO M3Strength)
- Optimization of experimental techniques (TDCB, SENB):
Pre-cracking, geometry issues, clamping, friction 

very useful in **Nanoforce** and
other project on **nanofibres**

Thanks to **SIM** for the financial support and
to all partners for the fruitful collaboration

Dr. Francisco A. Gilabert

Dr. David Garoz

Prof. Wim Van Paepegem



And do not forget to have a look at our poster !!



Modelling self-healing: a solid gear in a collaborative multidisciplinary framework

David Garoz, Francisco A. Gilabert and Wim Van Paepegem



Ghent University - Group of Mechanics of Materials and Structures