Development of New Concrete Mixes from Recycled Aggregates from known resources

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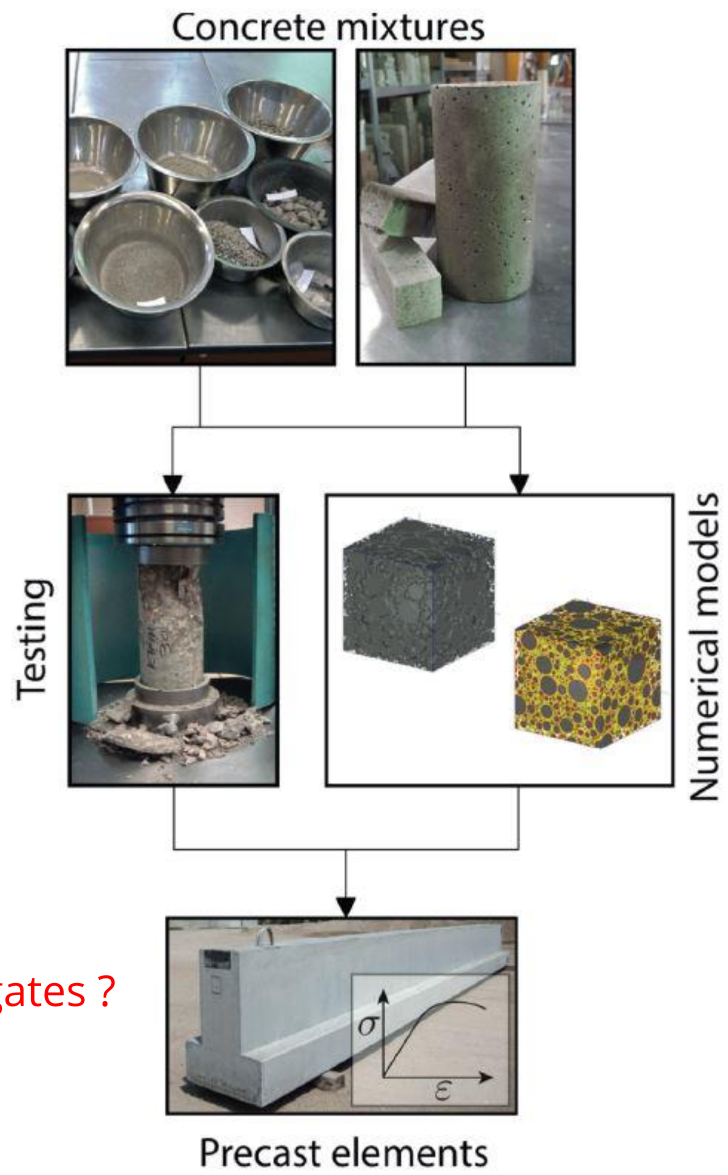
Aims and purposes

- Recycled aggregates for a sustainable development
    - How to face issues on earlier and long term behaviour?
        - Development of new mixes using recycled aggregates through the combination of experimental and numerical approach



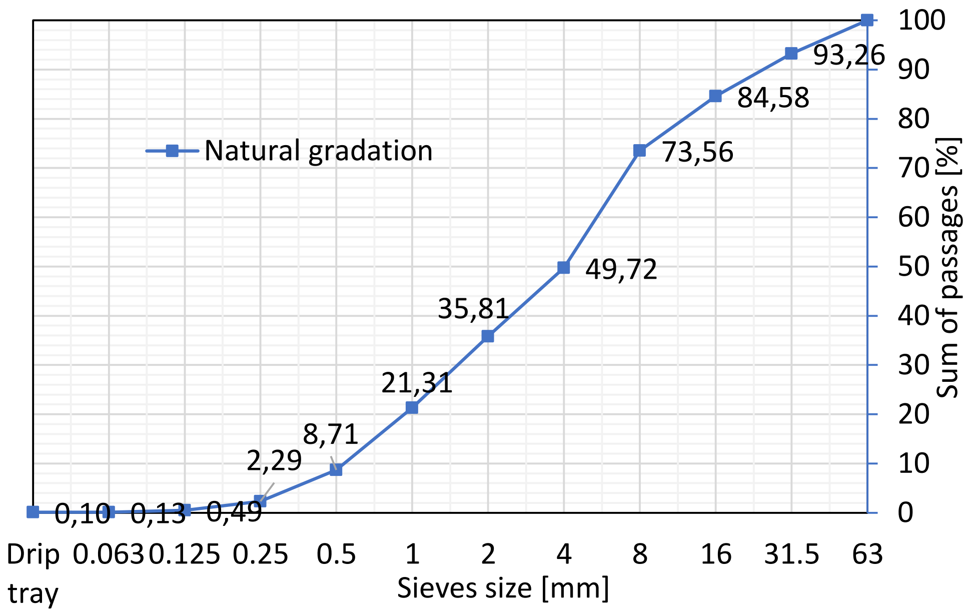
- What could be the best concrete class with a given recycled aggregates ?
- How to avoid the early age cracking ?
- How to improve the fracture resistance ?

Aggregates characterisation

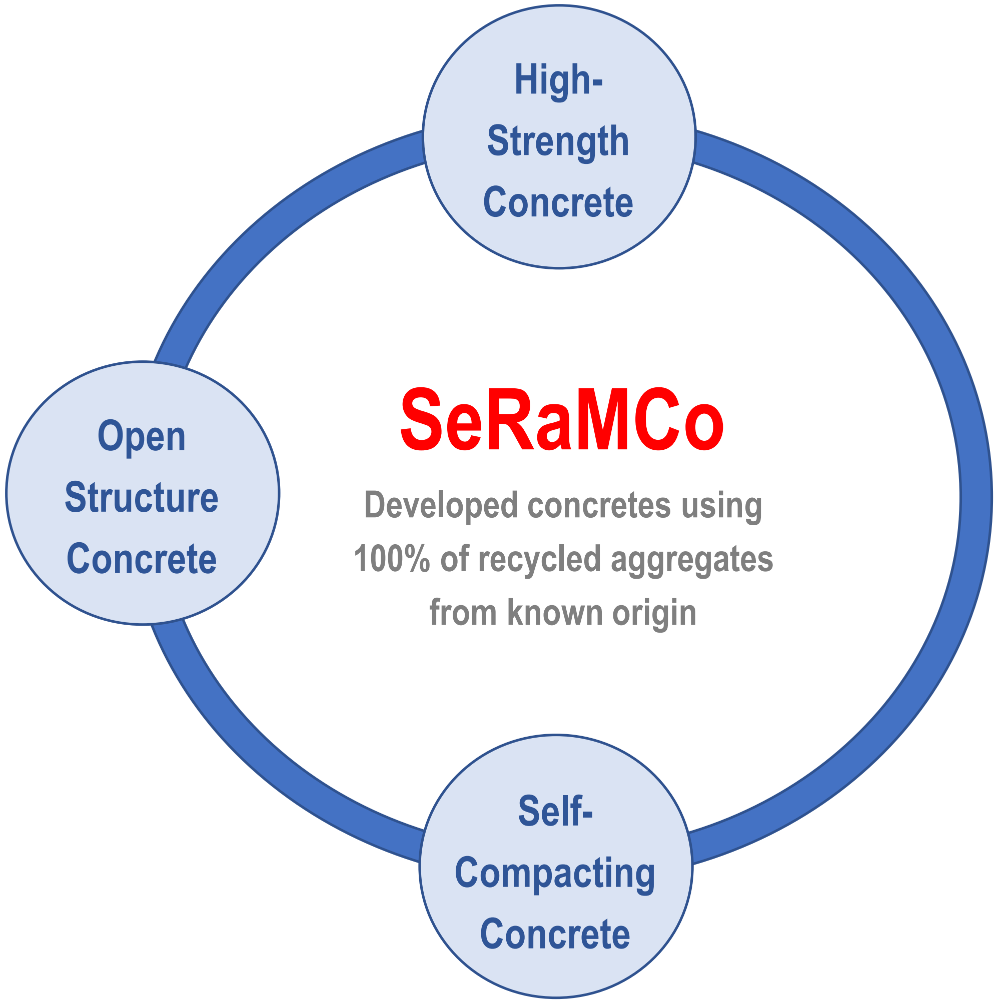
Bulk density test

Aggregate Crushing Value Test

Los Angeles Abrasion Test



New recycled concretes



❑ High-Strength Concrete

Micro-silica ~ 2% of the binder weight
Superplasticizer ~ 3 % of the binder weight
Binder to aggregate ratio ~ 1:3.6
Water to binder ratio w/b ~ 0.35
Particle size skeleton reconstructed

$f_{c,28} = 58.5\ MPa$

$E = 29500\ MPa$

❑ Open Structure Concrete

Micro-silica ~ 2% of the binder weight
Binder to aggregate ratio ~ 1:2.9
Water to binder ratio w/b ~ 0.35
Particle size skeleton reconstructed

$f_{c,28} = 5.7\ MPa$

$E = 1500\ MPa$

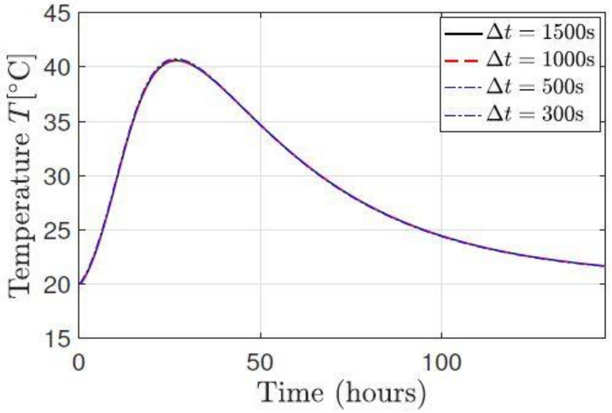
❑ Self-Compacting Concrete

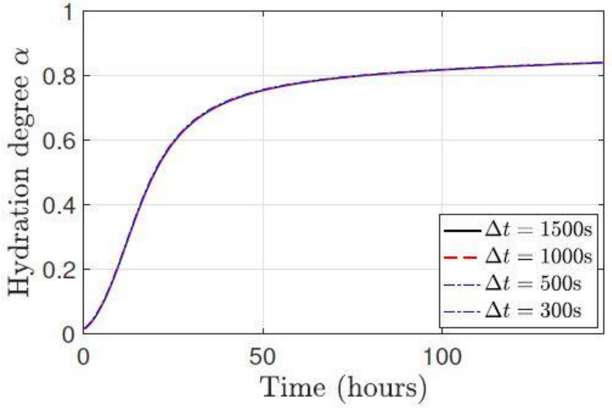
Master air ~ 0.15% of the binder weight
Superplasticizer ~ 1.5 % of the binder weight
Binder to aggregate ratio ~ 1:3.1
Water to binder ratio w/b ~ 0.35
Particle size skeleton reconstructed

$f_{c,28} = 32.4\ MPa$

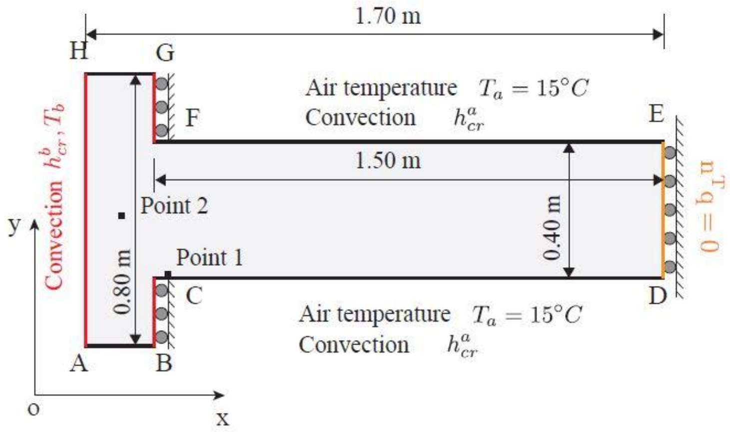
$E = 6700\ MPa$

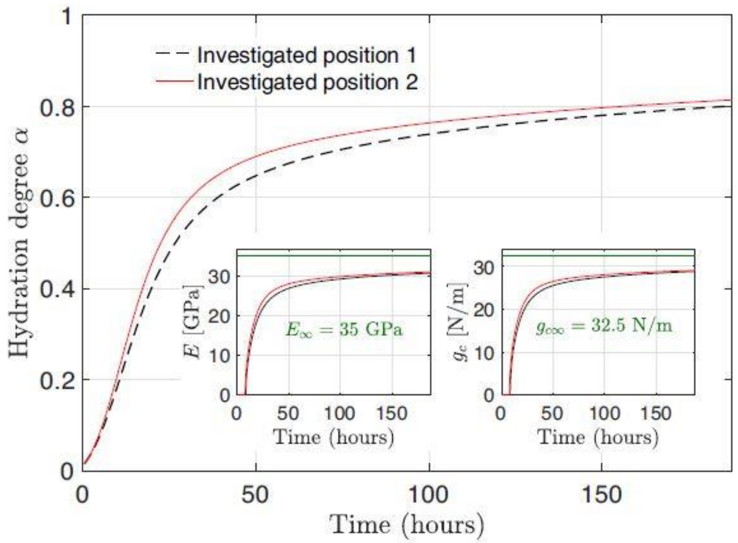
Hydration process





- Temperature reaches is maximum at t=22.5h, and then decreases, corresponding to the decelerated period of the hydration process
- Similar phenomenon is observed regarding the development of the material strength: Young's Modulus and fracture resistance





Early-age behaviour

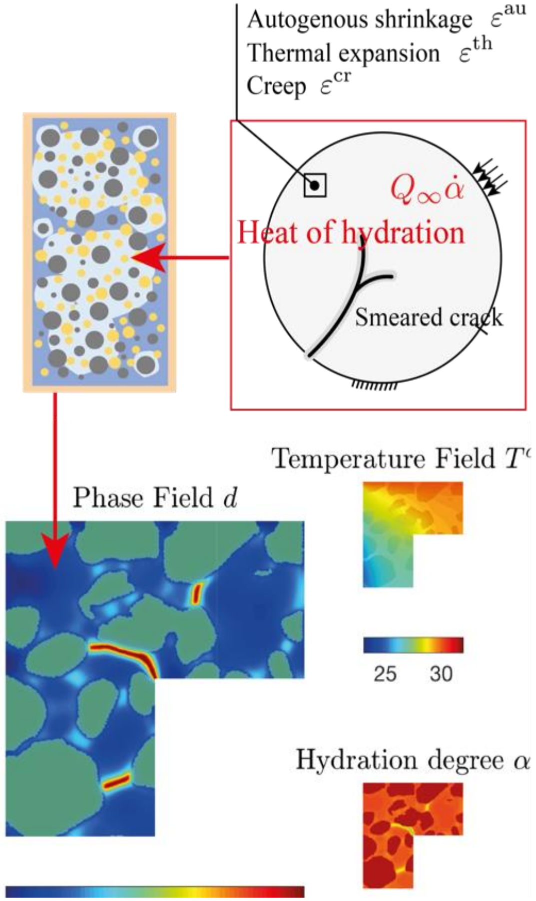
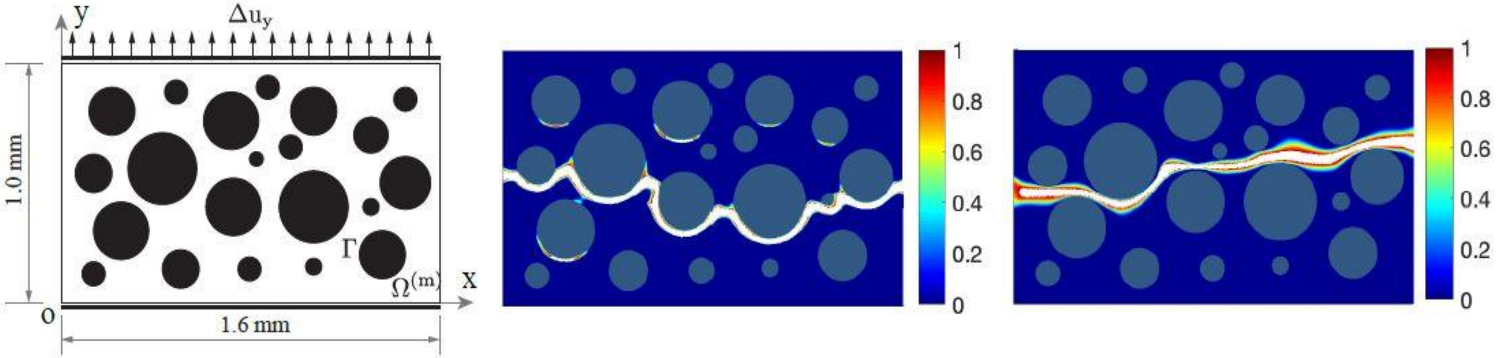


Figure 1. Simulation of the early-age behaviors of recycled concrete by using a phase field model. A high risk of cracking is noted [22, 23]

- Sensitive to early age cracking triggered by an increased shrinkage deformation in comparison to conventional concrete.
- The shrinkage behavior is proportional to the amount of recycled aggregates used as a replacement for natural aggregates
- A high risk of cracking is captured

Fracture behaviour



(a) Geometry/boundary conditions (b) Soft interphase (c) Stiff interphase

- Strong impact of the interfacial properties on the fracture behavior of heterogeneous material.
  - Soft interface provides a major interfacial cracking mode
  - Stiff interface induces a main bulk cracking behaviour

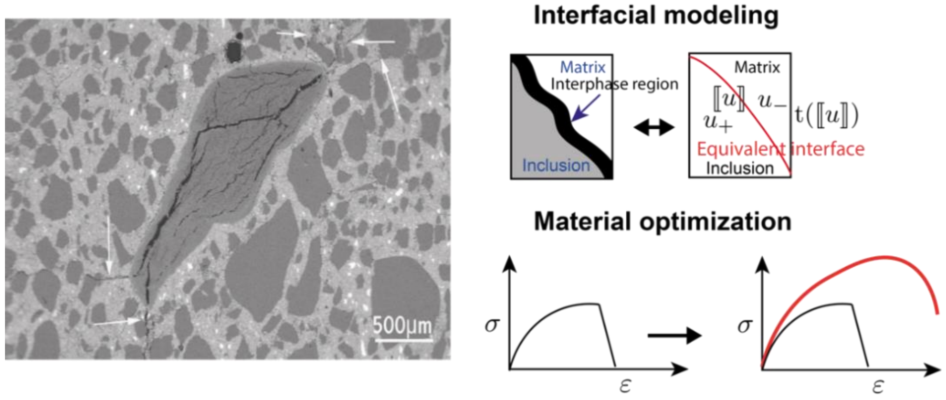
Table 1. Material properties of the spring/coherent interface model.

Parameter	Matrix	Inclusion	Soft interphase	Stiff interphase	Unit
λ	18	60	4.5×10^{-2}	6×10^{3}	GPa
μ	12	32	3×10^{-2}	4×10^{3}	GPa
g_c	5×10^{-4}	3×10^{-3}	$g_c^{si,n} = 3.75 \times 10^{-5}$, $g_c^{si,t} = 3.18 \times 10^{-5}$	5×10^{-3}	[kN/mm]

Interfacial behaviour

- the interfacial transition zone governs the performance of recycled concrete.

- The red line of loading curve shows the expected mechanical performance after performing the interfacial designing



In a nutshell

- The phase field model shown a critical shrinkage properties of non-reinforced concrete of normal strength class C20/25 with high w/c ratio. A high risk of cracking was also captured with the major damage caused by the autogenous shrinkage.
- Phase field method for accurately reproduce the complex early-age behavior of cement-based materials.
- HSC, OSC and self-compacting concrete formulated with satisfactory mechanical results.
- The reduction of both the E-Modulus and the flexural strength of the OSC with respect to the HSC demonstrated the influence of the granulometry on the mechanical performance of recycled concrete

Villmools Merci!