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Poster n°24

Durability assessment protocol for marine structures

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CONTEXT

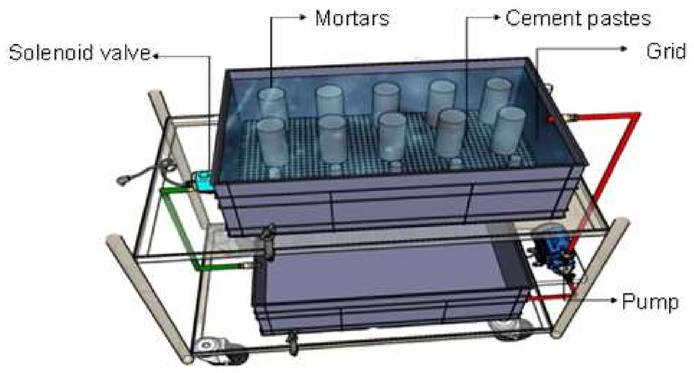
Prevent disasters related to the collapse of offshore structures.
- ✓Coupling chemo-mechanical phenomenon.
- ✓Crack effect and self healing process.
- ✓Effect of the tidal zone on the offshore structures behavior.

STATE OF THE ART/ INNOVATION

- ✓ Innovative chemo-mechanical coupling experimental prototype.
- ✓ Considering all ions presents in seawater.
- ✓ Micromechanical numerical approach, coupling between a creep-damage model and a chemical model at the microstructural scale.

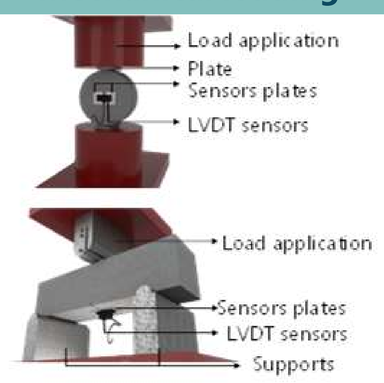
EXPERIMENTAL APPROACH

Chemical phenomenon



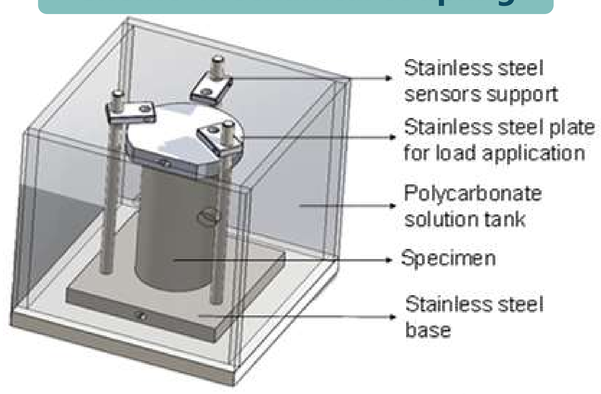
- ✓ Two solutions type: Tap water, laboratory reconstituted seawater.
- ✓ Two conditions: Immersion, tidal zone..
- ✓ Microstructural characterization.

Mechanical loading



- ✓ Monitoring crack width evolution via a 3D optical microscope.
- ✓ Crack and seawater attack effects on mechanical properties.

Chemo-mechanical coupling



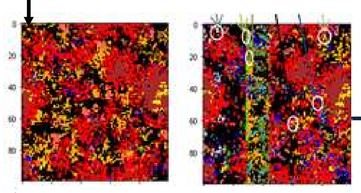
- ✓ Assessing chemo-mechanical coupling: Tracking delayed deformations during exposure to seawater and mechanical loads.

NUMERICAL APPROACH

CemPP/ VCCTL

Hydratation - Seawater

Heterogeneous cement matrix REV= 100 µm



Phases damage/ mechanical properties [1]

2D section at time ti

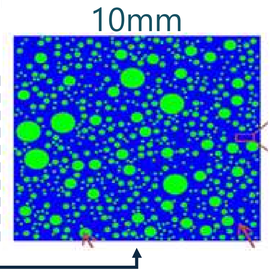
Cast3M

Mechanical Model

Damage Model [2]

Kelvin Voigt creep model

REV mortar = 10mm

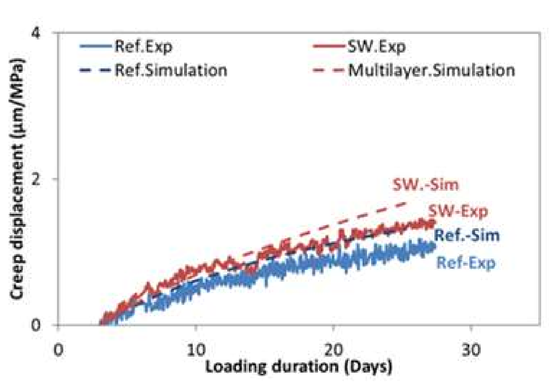


Homogenization

- ✓ CSH main creep phase.
- ✓ Creep load= 30%Strength.
- ✓ Reactant phases replaced by products phases (chemical reactions).
- ✓ Visco-elastic model.

RESULTS

Self-healing was faster in seawater compared to tap water. Brucite and $CaCO_3$ were detected.



Numerical and experimental studies confirmed chemo-mechanical coupling, with similar creep behavior in both solutions.[3].

CONCLUSION & PERSPECTIVES

- ✓ Seawater-exposed samples retained similar mechanical and creep properties as tap water ones, despite microstructure phase changes.
- ✓ Mortars demonstrate chemical and mechanical healing, seen in higher bending force with.when crack width decreases (heals).
- ✓ Test setup for all materials exposed to combined chemo-mechanical loading.

CONTACT

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[1] A. Rhardane, S. Y. Alam, and F. Grondin, "Microscopically informed upscale approach of modelling damage in mortar by considering matrix-to- grain interface and grain micro-fracture characteristics," Theor. Appl. Fract. Mech, vol. 109, no. April, p. 102725, 2020

[2] S. Fichant, G. Pijaudier-cabot, and C. La Borderie, "Continuum damage modelling : Approximation of crack induced anisotropy," Mech. Res. Commun., vol. 24, no. 2, pp. 109–114, 1997.

[3] M. El-khoury, E. Rozière, F. Grondin, M. Marcel, R. Cortas, and F. Hage Chehade, "A new protocol to evaluate the behaviour and durability of marine structures," Ocean Eng., vol. 302, no. March, 2024, doi: 10.1016/j.oceaneng.2024.117579.