Development of laboratory tests to measure the growth kinetic of micro-algae of concrete in marine environment and comparison to in-situ experiments

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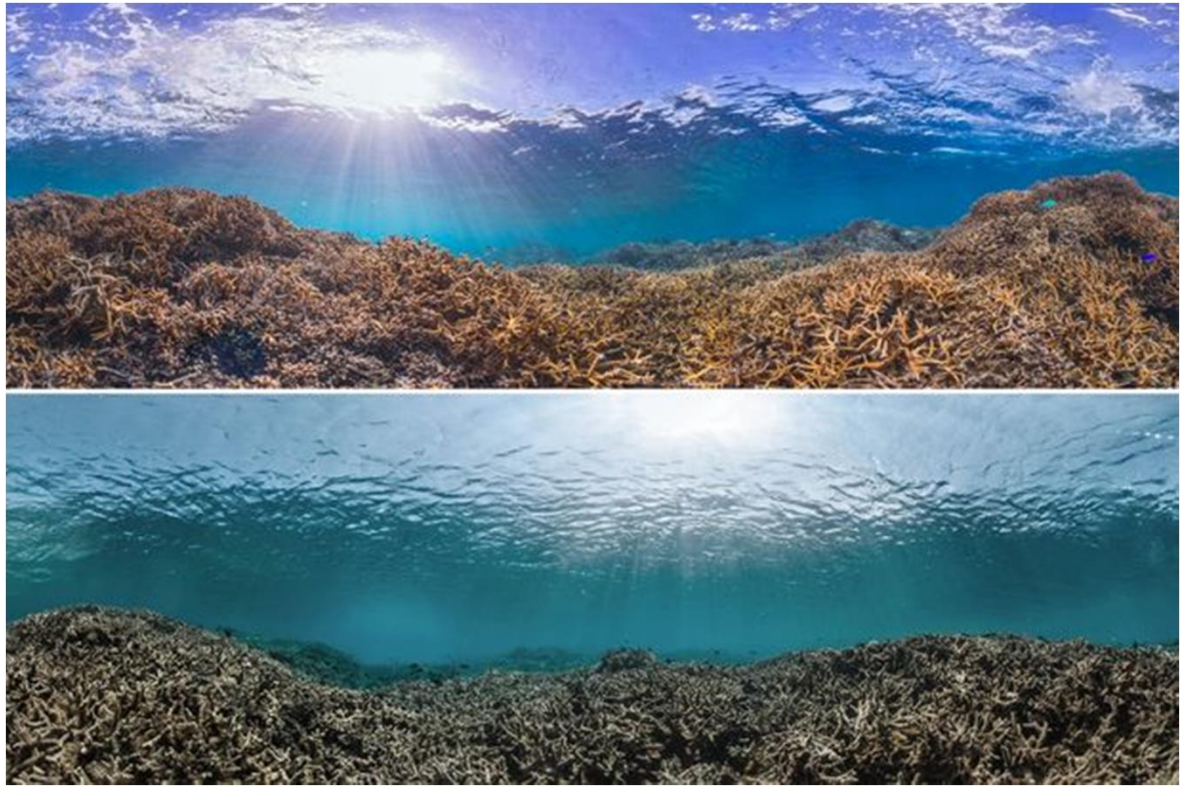
Marine habitats & biodiversity are highly declining
and the restoration of marine environment is an urgency

- 1/8 marine species may disappear by 2050
- More than 40% of ocean surface show signs of critical degradation
- +/- 50% of corals and seagrass des have disappeared since early 20th century



Rapport IPBES 2019

REXCOR project: *Restauration EXpérimentale des petits fonds côtiers de la calanque de CORtiou*

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Outlines

- **Bio-Active concrete technology**
- **Experimental set-up**
  - Experimental conditions
  - Influence of the class cement
  - Influence of the size aggregates
- **Field tests results**
  - REXCOR's project
  - ANTICELTO's project
- **Conclusions and Perspectives**

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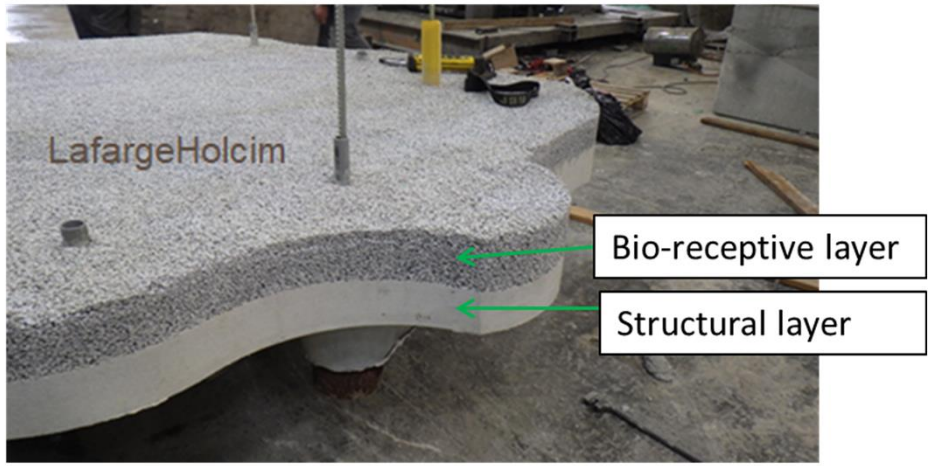
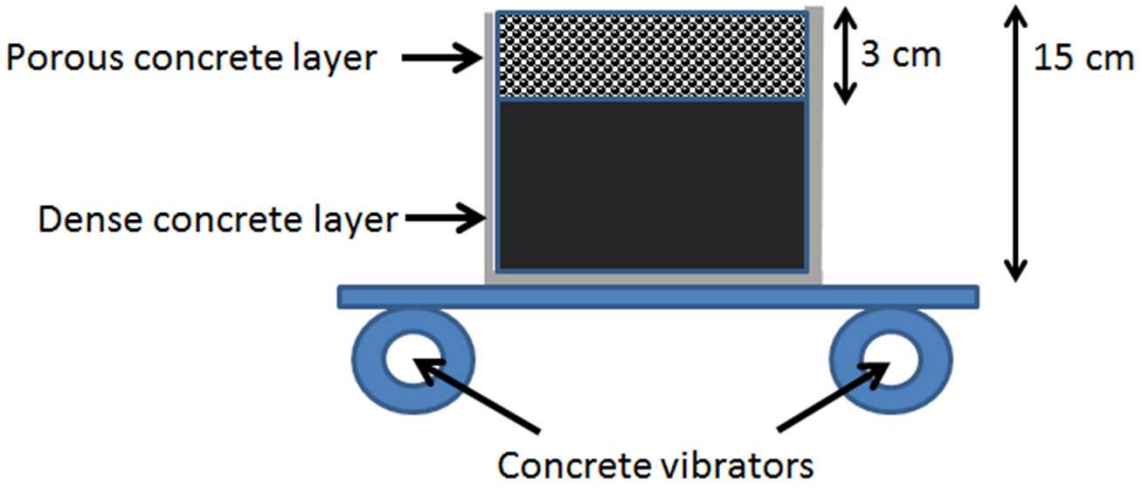
Bio-Active Concrete technology
material properties

1 concrete mix design → 2 layers





Compressive strength

Up to 10 MPa →

Up to 70 MPa →

- Strong mechanical strength without steel rebars
- Low pH and good durability in marine/river environment (50 years of service life)
- Bioactive concrete reduces impacts with a reduction in Global Warming Potential reaching 41% compared with traditional concrete *(LCA analysis)*

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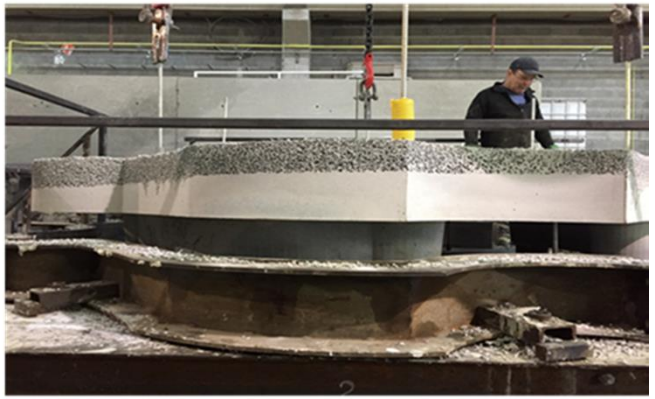
Bio-Active Concrete technology
manufacturing of slabs

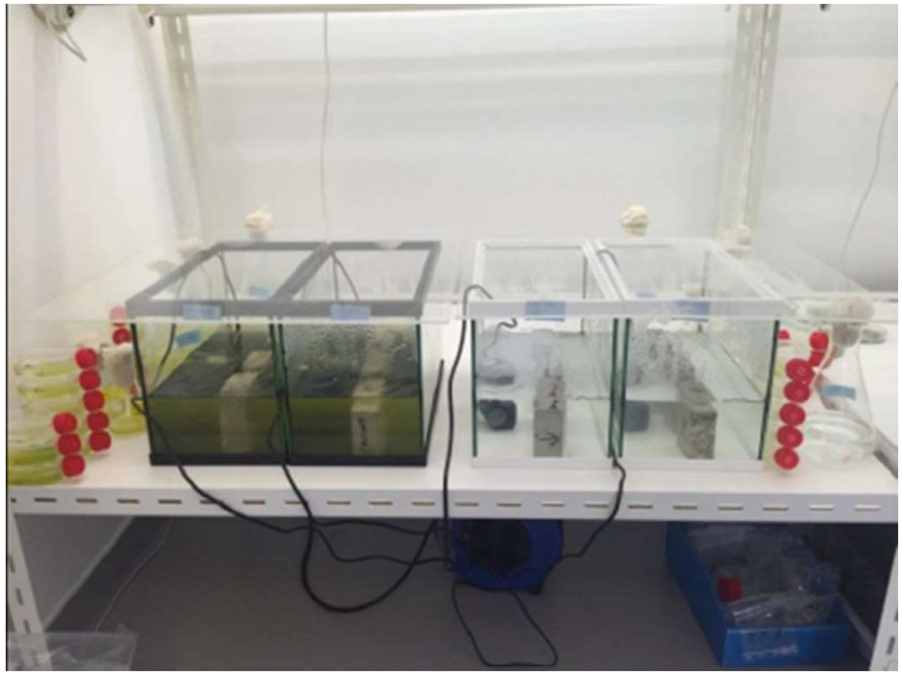
Mixer SAPB

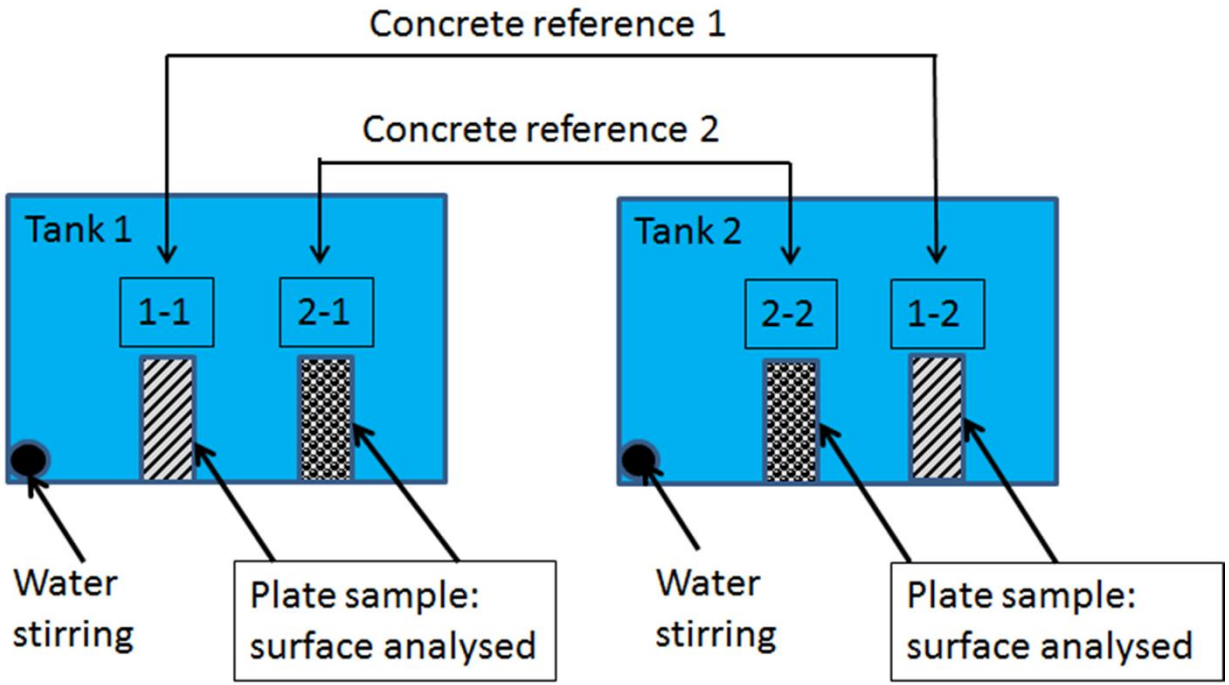
BioActive Mix-design

Slab after demolding@16hours



Experimental set-up: µalgae colonization kinetic of concrete surfaces
Description





- 2 sample plates and distribution at different locations in 2 tanks
- Immersion of sample plates after 28 days of maturation and storage

Experimental set-up: µalgae colonization kinetic of concrete surfaces
Main parameters and medium composition

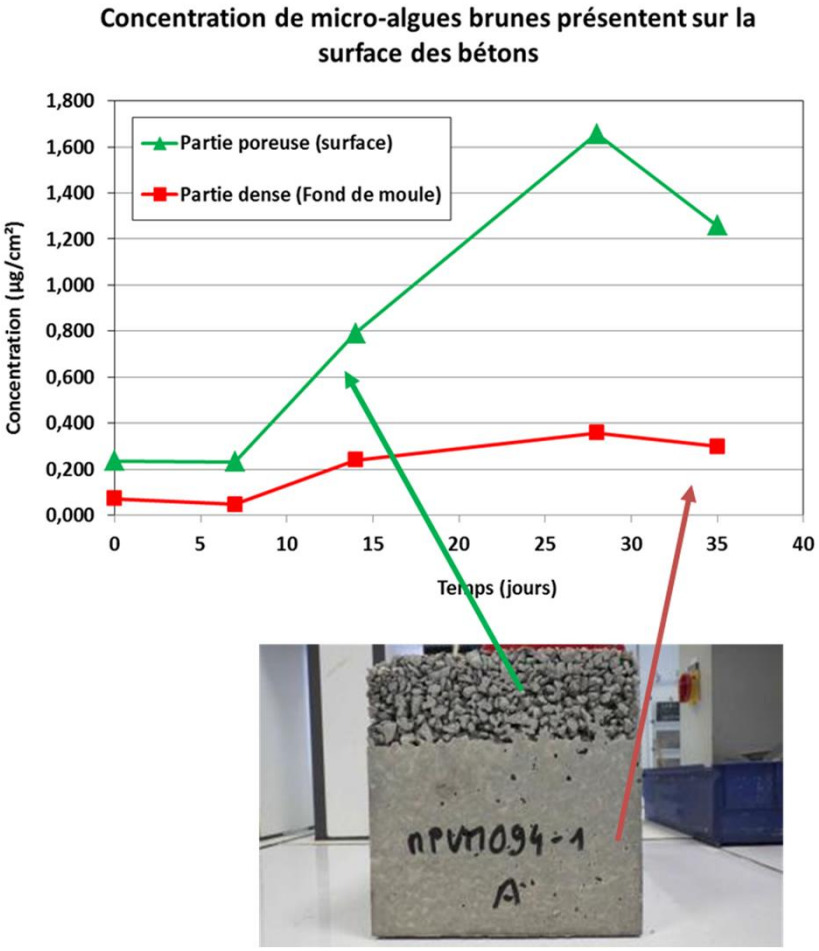
Medium			**Concrete sample**		**Vol. ratio: medium/samples (in each tank)**	**Pump stirring**
K medium in artificial seawater	Volume 10 L.	Temperature 20°C	Dimension 10x10x3cm	Volume 0.3 L.	~16	50-100 L/hour
Micro-algae		**Lights**		**Test duration**		
Entomoneis species	[C]: 10^4 /ml	Artificial light: 2500 Lux	Simulation of day/night alternation (12h/12h)	28 days with a complete medium regeneration at T0+14 days		

Reference	**volume**
Sterilized and filtered seawater	1 L
Sodium Nitrate ($NaNO_3$) at 75 g/l	1 ml
Ammonium Chloride (NH_4Cl) at 2.68 g/l	1 ml
Na_2-Glycérophosphate ($C_3H_7O_6PNa_2$), 5-6H_2O at 3.06 g/l	1 ml
Tri-base (pH 7.2) at 121,1 g/l	1 ml
K trace Metal solution	1 ml
Vitamin solution F/2	0,1 ml

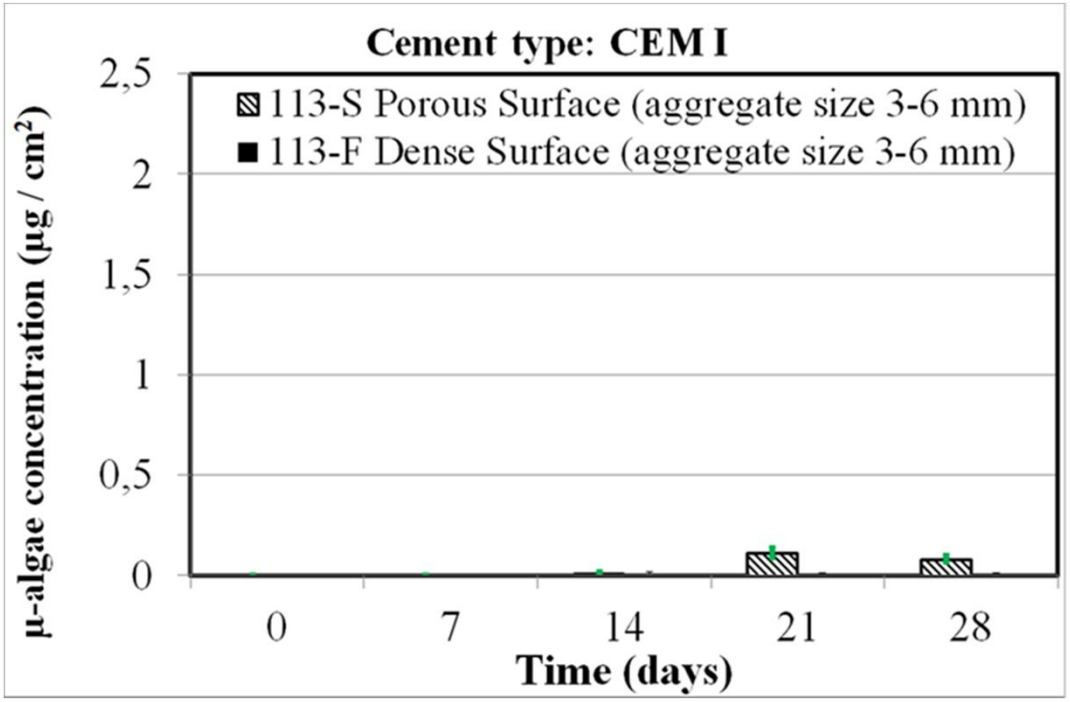
- Artificial seawater medium
- Stirring system to maintain liquid solution and to avoid micro-algae sedimentation *(Entomoneis, standard species)*
- To avoid pH perturbation in the tanks, the both sample plates are produced with the same cement
- Non-destructive method (BentoTorch, in-vivo fluorometer) to measure the micro-algae concentration over time

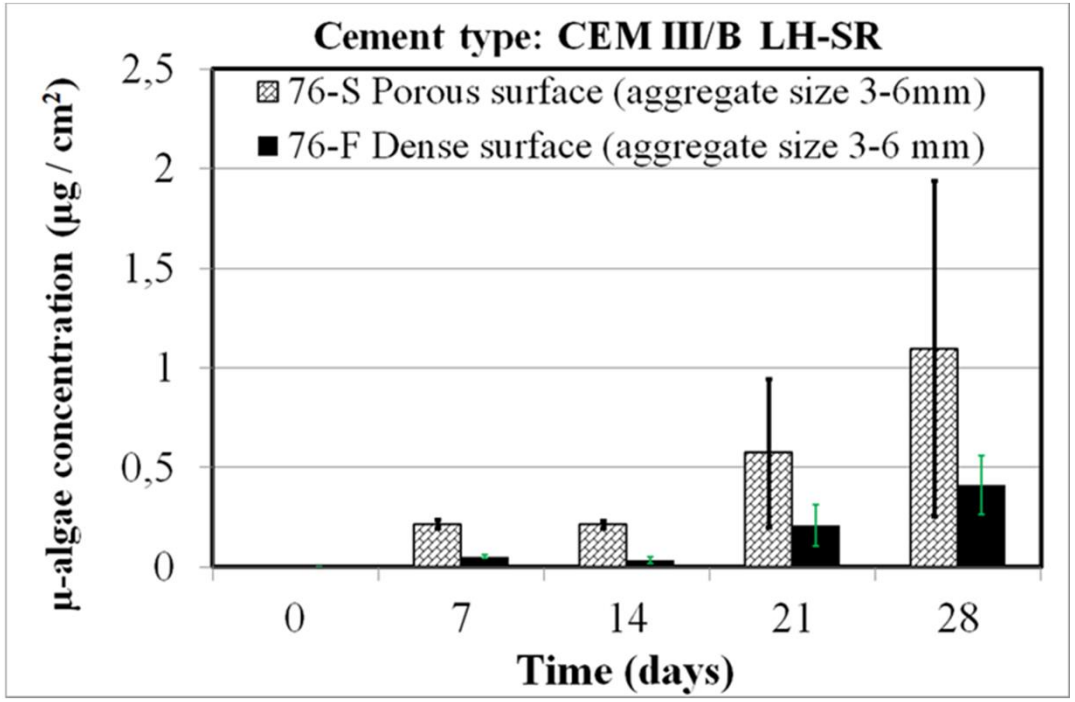
Experimental set-up: µalgae colonization kinetic of concrete surfaces
Example of results

- An activity of colonization for the “porous” section higher than for “dense” section
- “**Dense**” section: A slight increase of micro-algae concentration over time
- “**Porous**” section: A quickly and significant increase of micro-algae concentration over time



Experimental set-up: µalgae colonization kinetic of concrete surfaces
Influence of the class cement





- CEM III has a bigger algae concentration compared with CEM I
- CEM III cement is recommended to control the pH in the marine environment

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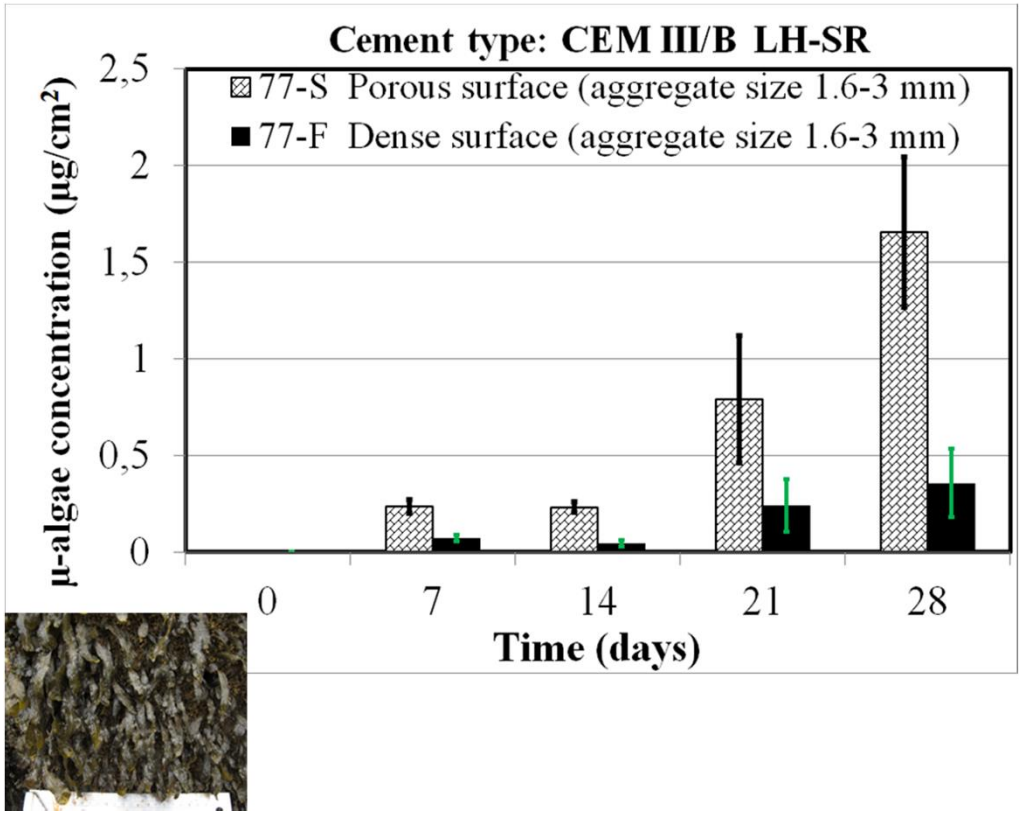
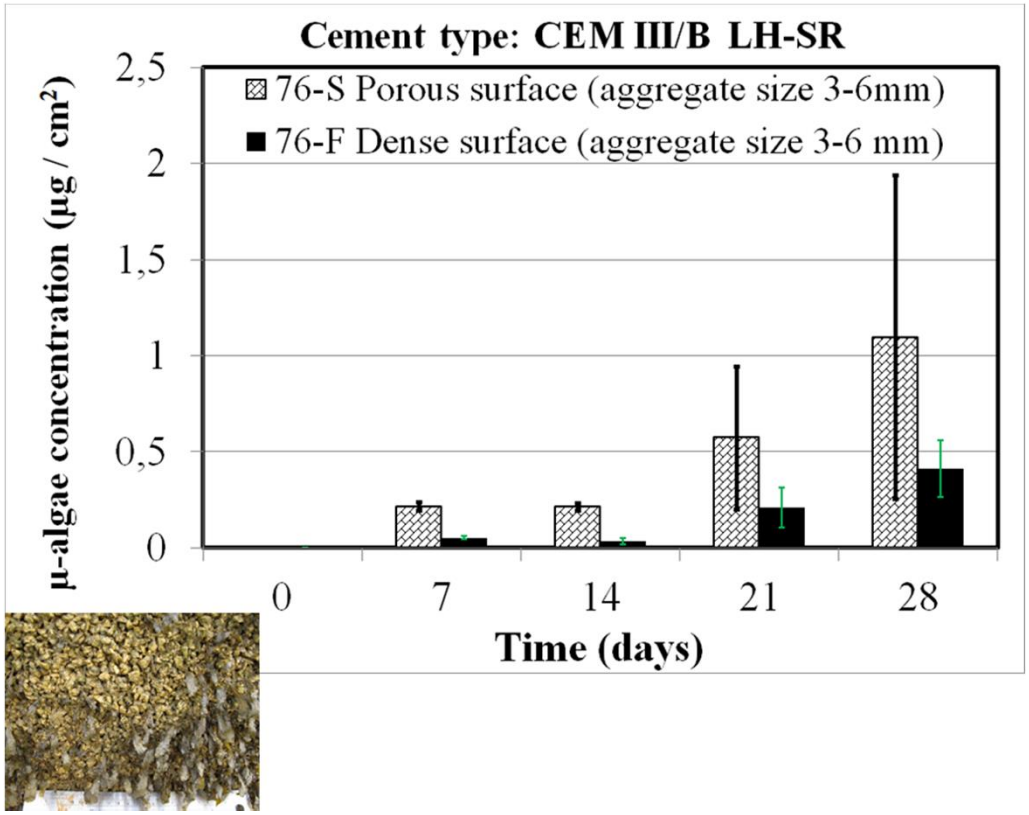
Experimental set-up: µalgae colonization kinetic of concrete surfaces
Influence of the size aggregates

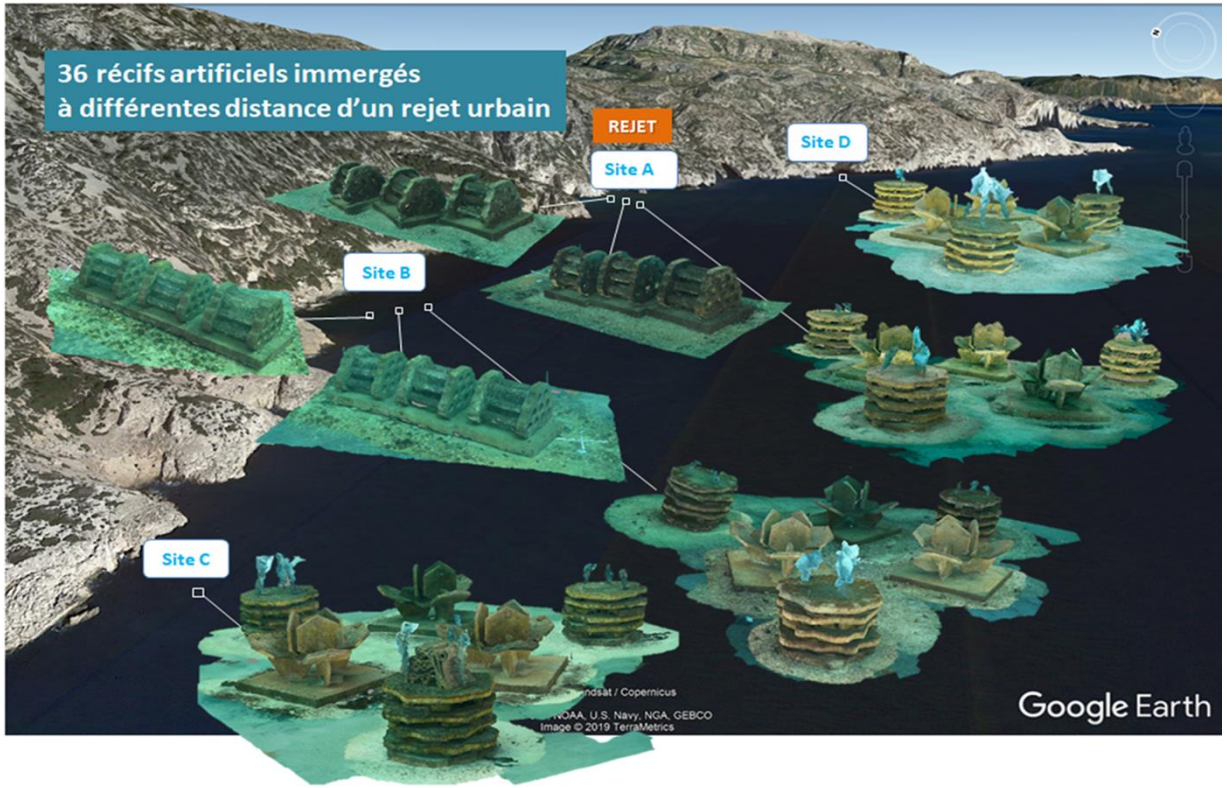




- The algae concentration on the porous surface is higher that on the dense surface (effect of the porosity)
- The aggregate size can influence the algae concentration for the porous surface

Field test results

Rexcor project – National Park of Calanque (Marseille)

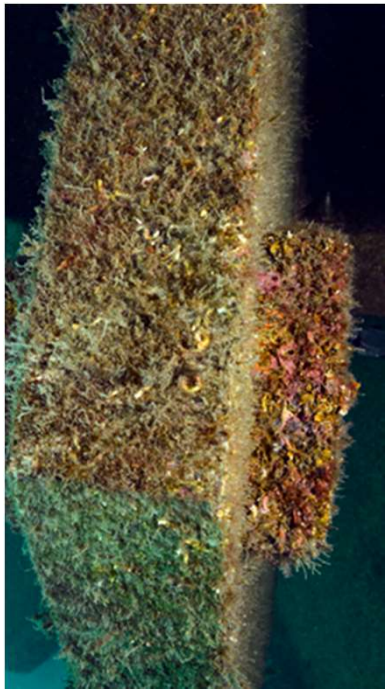


Field test results
Rexcor project

- The results confirm the results observed in the laboratory with the accelerated experimental set-up

- Corallinacea micro-algae develop more rapidly on Bio-active concrete materials (A-B-C) compared with the smooth “reference” ordinary concrete (D)

- After 3 years of immersion, not big differences between Bio-active samples. Additional monitoring showed the colonization of later species such as bryozarians, sponges and gorgonians



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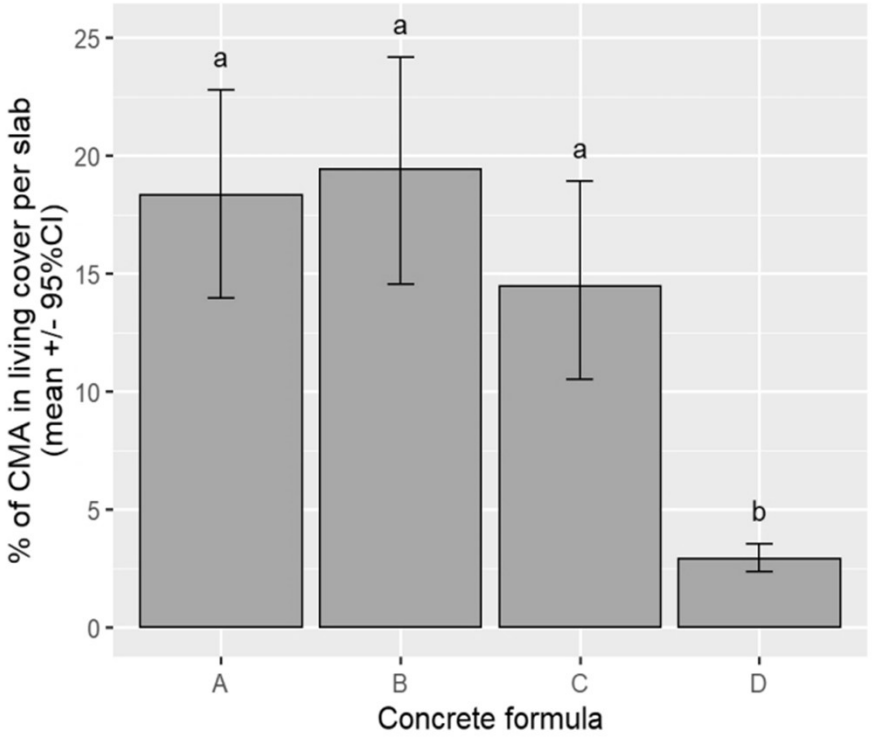
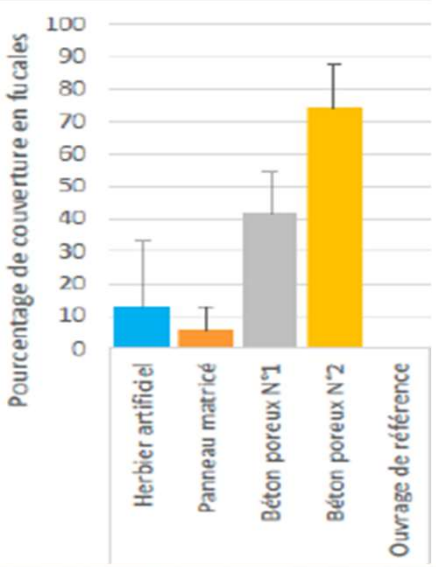


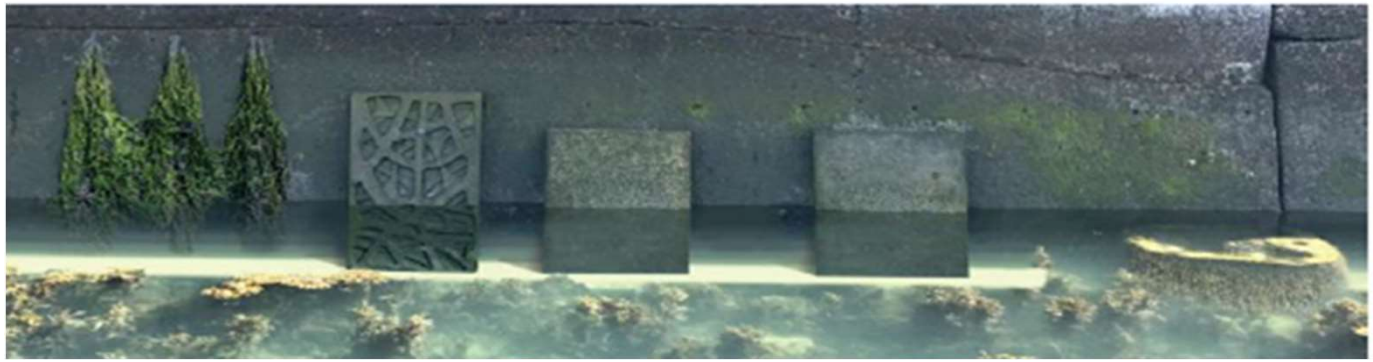
Average Corallinacea coverage – A-B-C: Bio-Active concrete / D: Ordinary concrete

Field test results
Anticelto project – Quiberon port



Significant effect of bio-active concrete samples compared with other solutions

Objective: Bio-restoration of the marine diversity and limit the multiplication of invasive species



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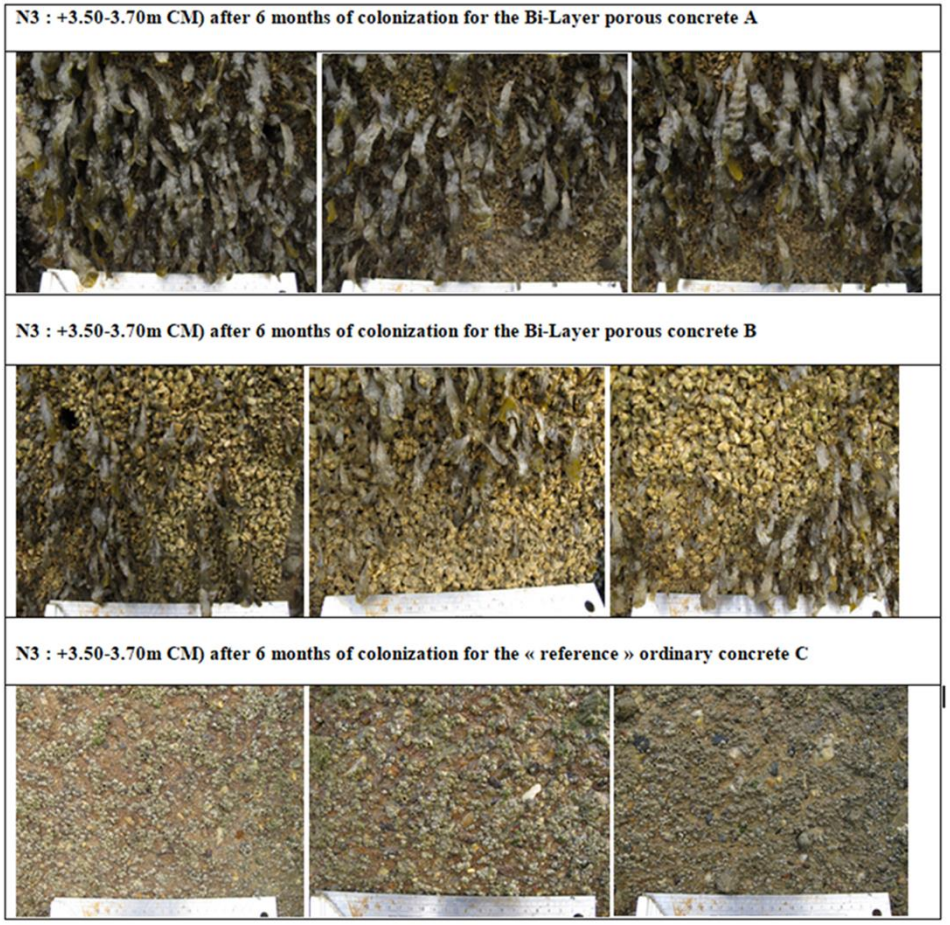
Field test results
Anticelto project

- The results confirm the results observed in the laboratory with the accelerated experimental set-up

- In a nutshell there was no algae “fucale (focus visiculosus)” on the normal concrete “reference”. The quantity of algae on the panel B is very small (and also a big data variability). The quantity of algae observed on the panel A is impressive
  - For the BioActive porous concrete A, the percentage of coverage is on average 70% with maximum greater than 90% and minimum around 60%.
  - Contrary, for the “reference” normal concrete C, the result is “zero”.



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Conclusions and Perspectives

- This study has showed the interest to develop an accelerated laboratory test to measure the colonization of micro-algae at the surface of concrete samples and compare different concrete surfaces and mix-designs.
- The tendencies observed at the lab scale were confimed by field tests after many years of monitoring.
- This first experimental set-up could be improved by testing different types and mixes of micro-algae in order to be more selective.
- New monitoring technologies could be also investigated at field test scale to facilitate and increase the monitoring data over time (Is e-DNA technology relevant?).


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