

# WPI's 13th Annual Sustainability Project

## Topic: Enzymatic Self-Healing Materials

Department: Civil Engineering

Student name: Shuai Wang

Advisor: Nima Rahbar



**WPI**

# Preface

## Urgent Issue:

Concrete production is a primary factor of global carbon dioxide emissions.

## Answer:

A repaired concrete method: Enzymic catalyze

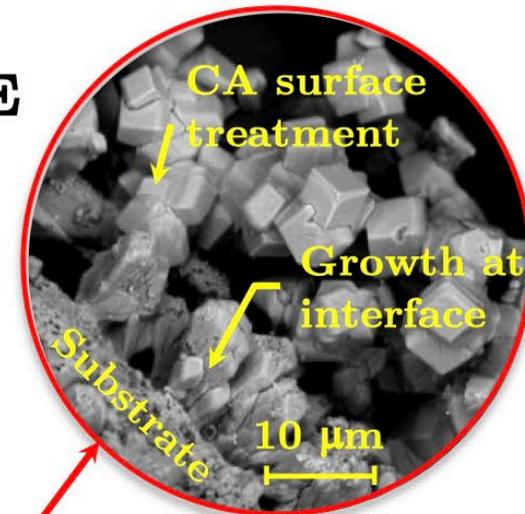
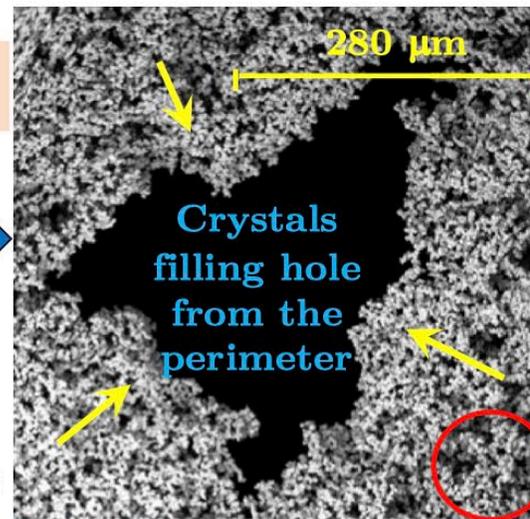
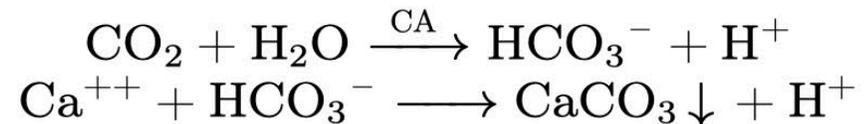
- { An Enzymatic Self-Healing Cementitious Material \*
- { A Novel Enzyme catalyze sand slurry materials (ECM)

\* J Rosewitz, S Wang, S Scarlata, N Rahbar (Applied Material Today)

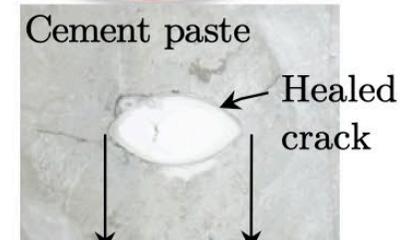
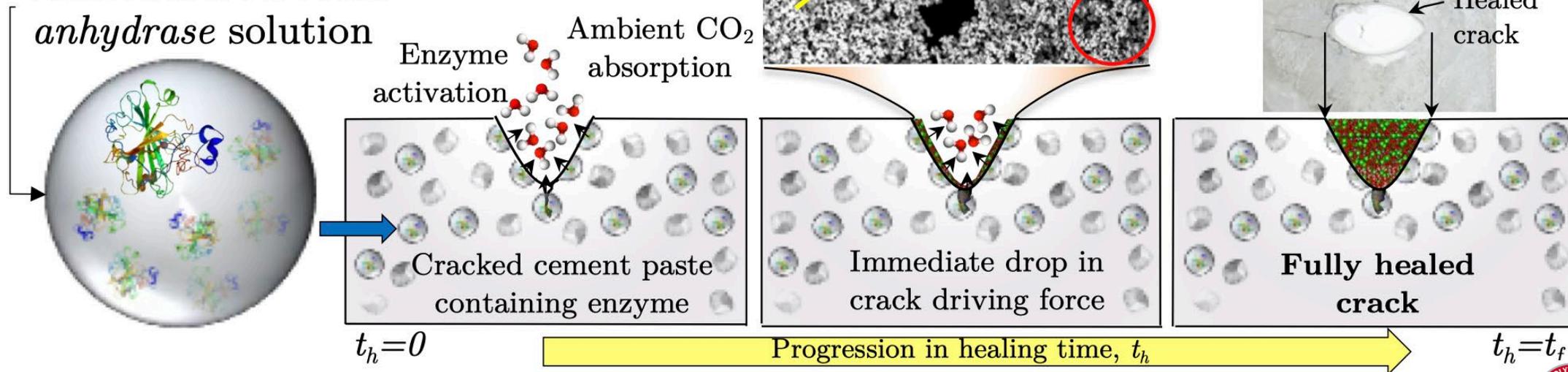
# An Enzymatic Self-Healing Cementitious Material

## ENZYMATIC SELF-HEALING CEMENT PASTE

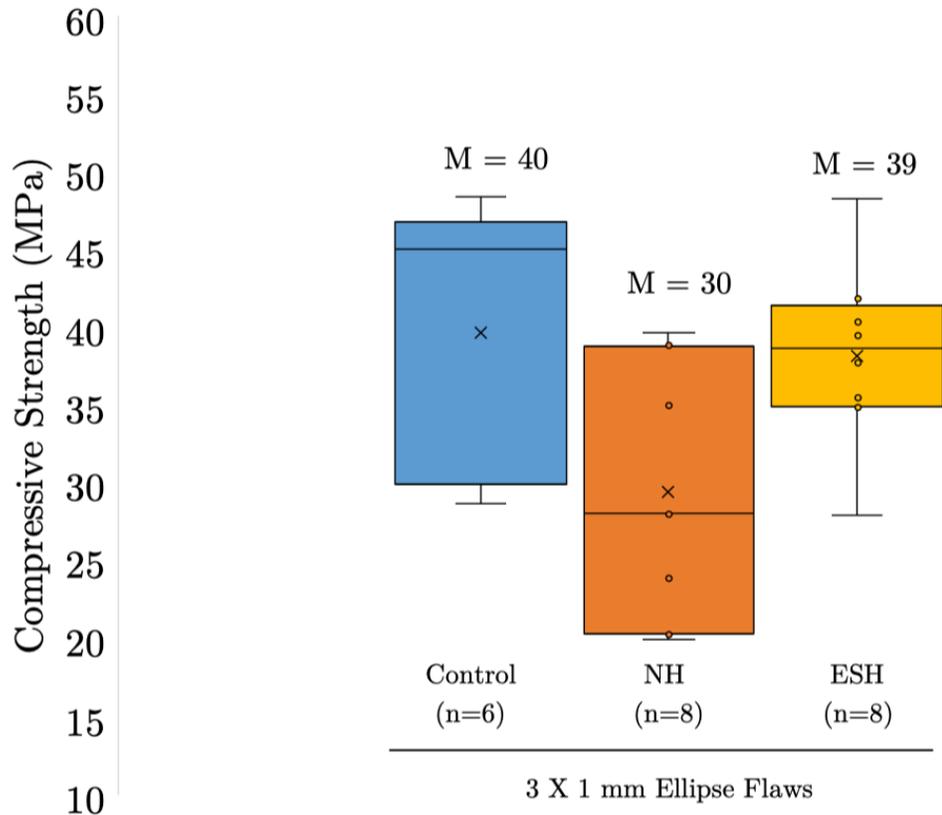
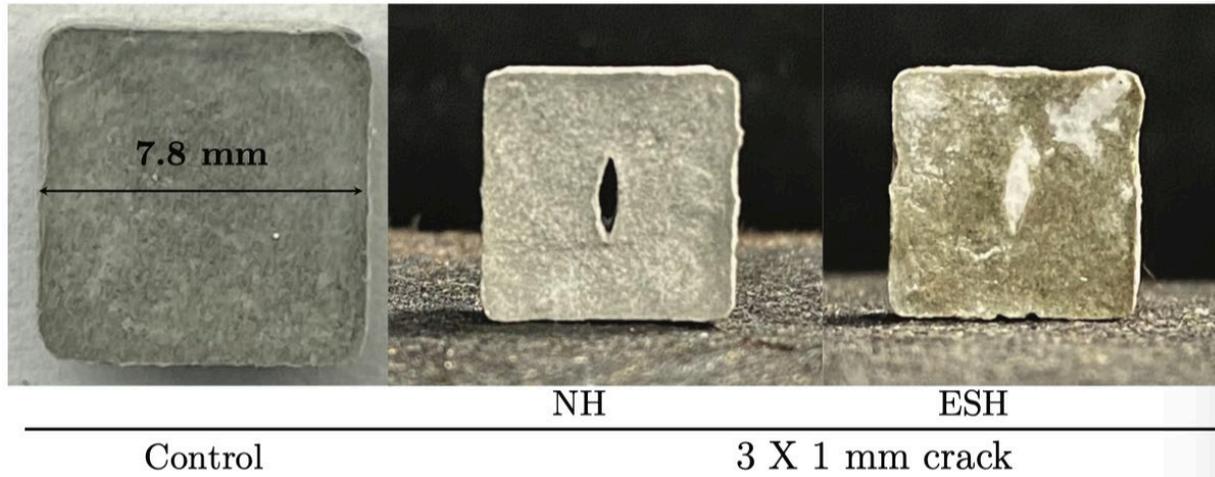
Rapid crystal precipitation by enzymes



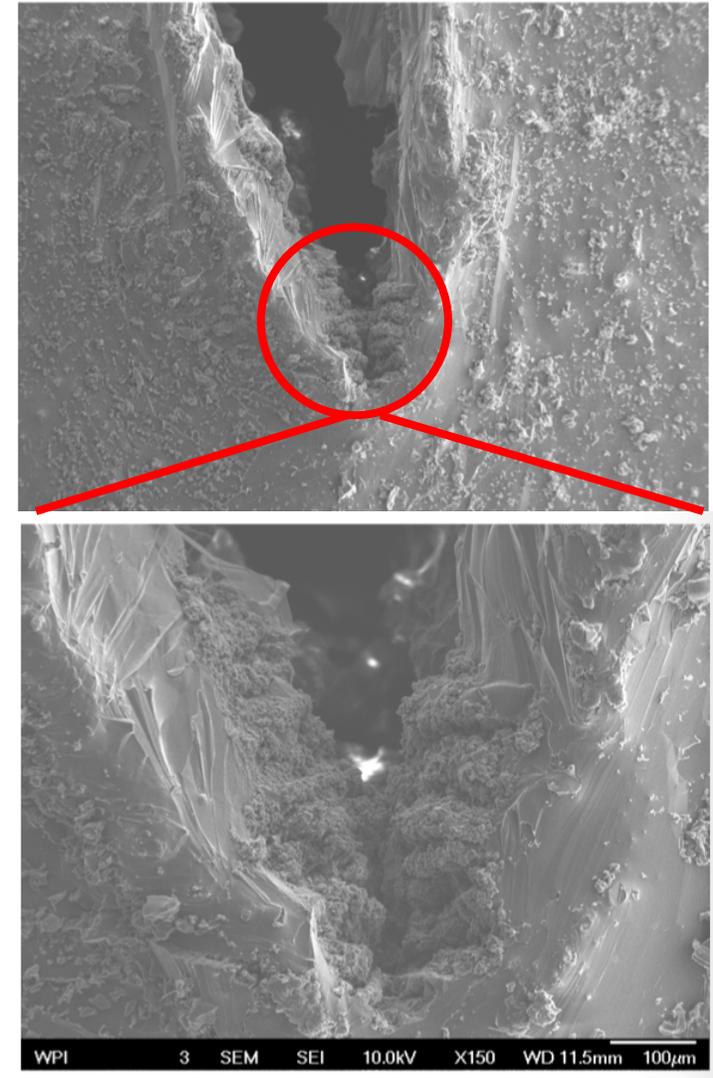
Embedded *carbonic anhydrase* solution



# Compression Test



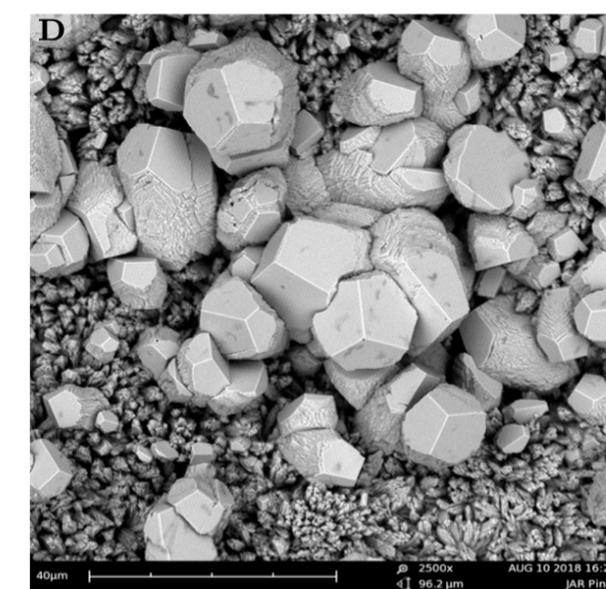
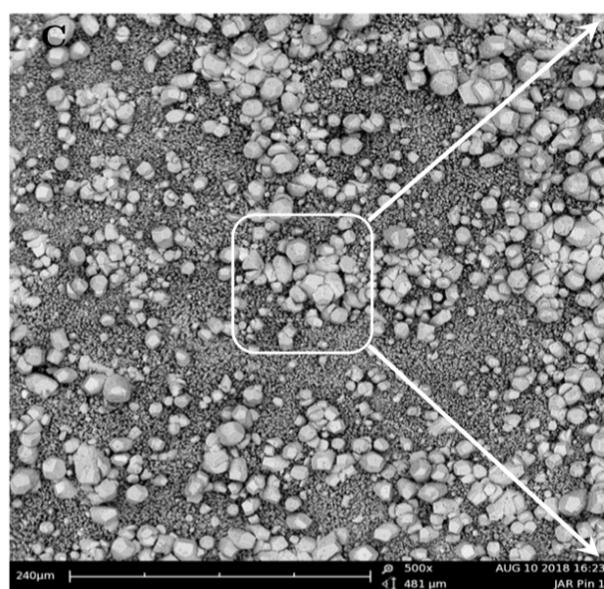
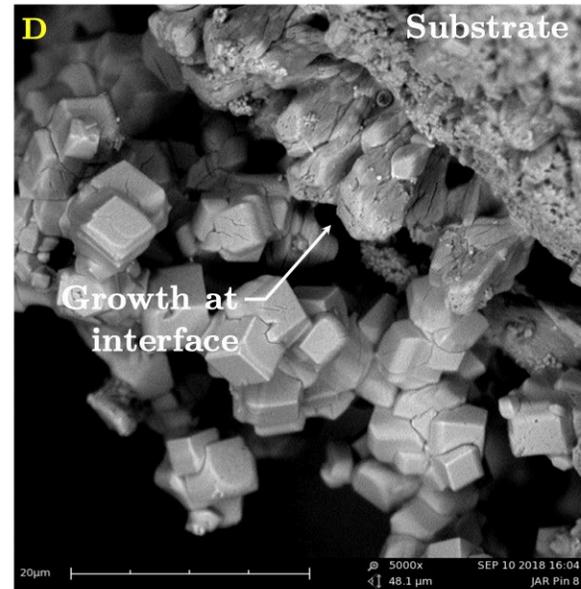
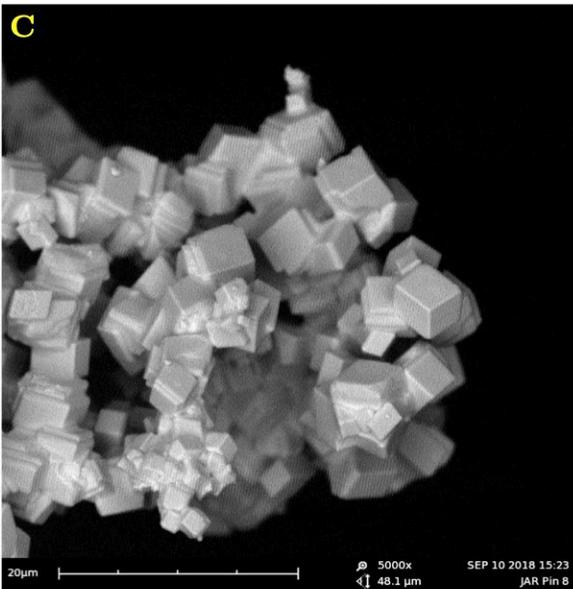
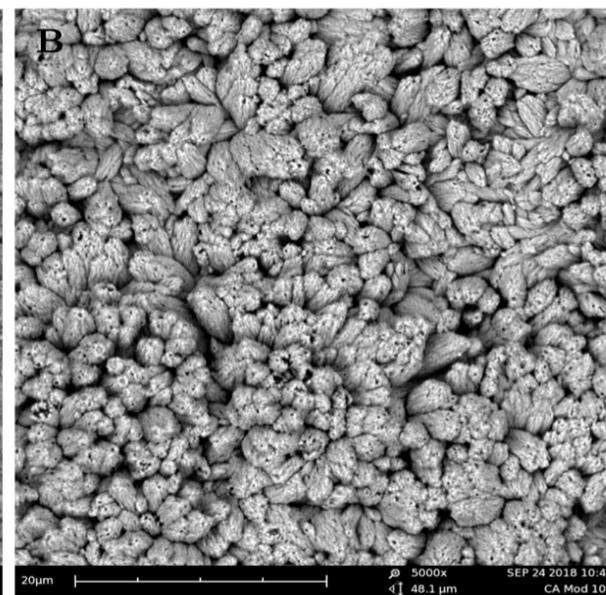
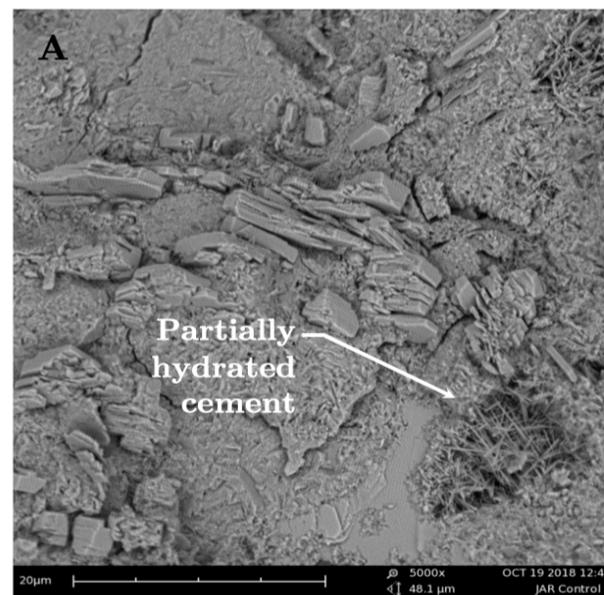
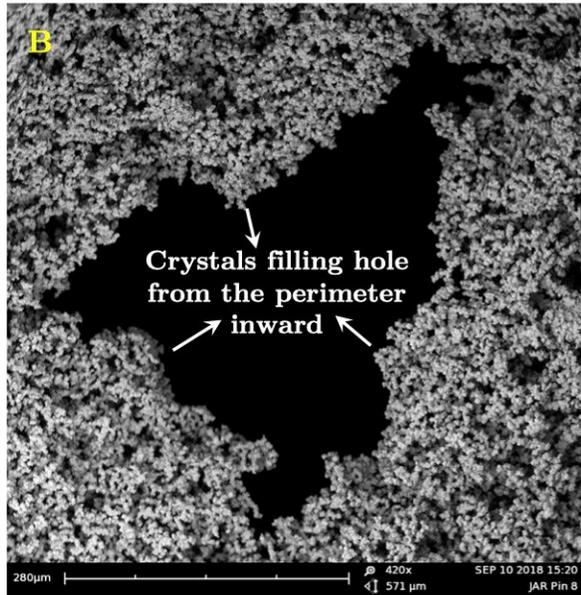
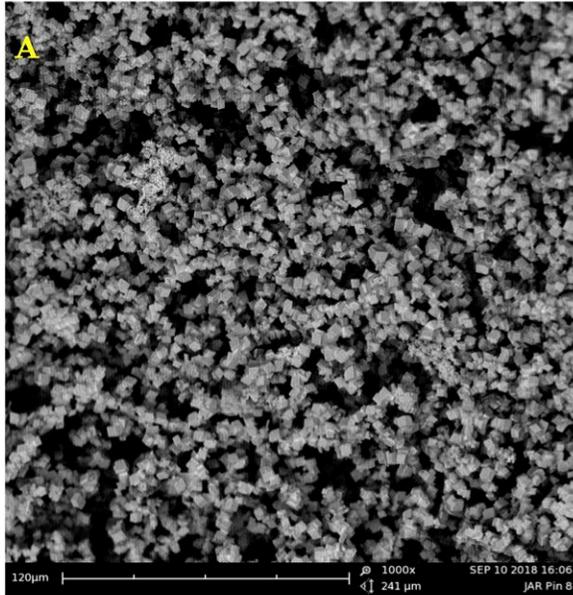
**Cement paste** (control)  
**NH** (Non healing)  
**ESH** (Enzyme self healing)



The SEM images shows the growth process of crystal on the crack tip.



**WPI**



SEM images of the CA treatment on the CA-Mod-5x substrate.

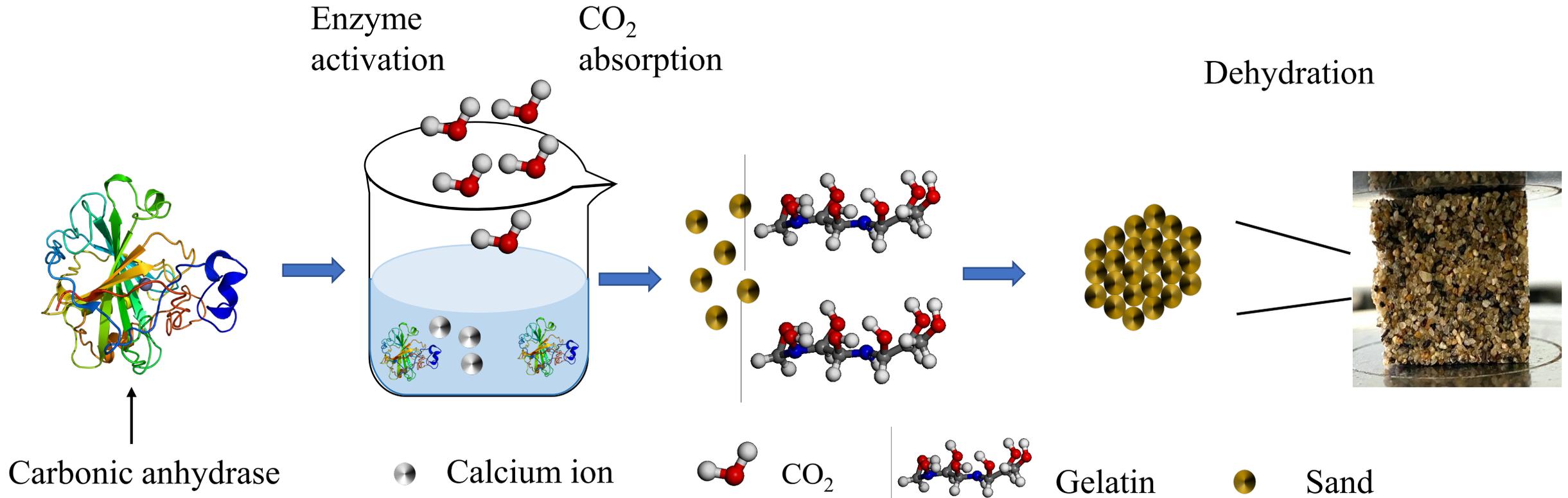
- A) control sample.
- B) CA-Mod-5x sample surface;
- C) Crystals develop on the surface of a CA-Mod-5x sample after soaking in DI water;
- D) A magnified view of the surface crystals on a CA-Mod-5x sample show evidence of cubic shapes and clustered formation.



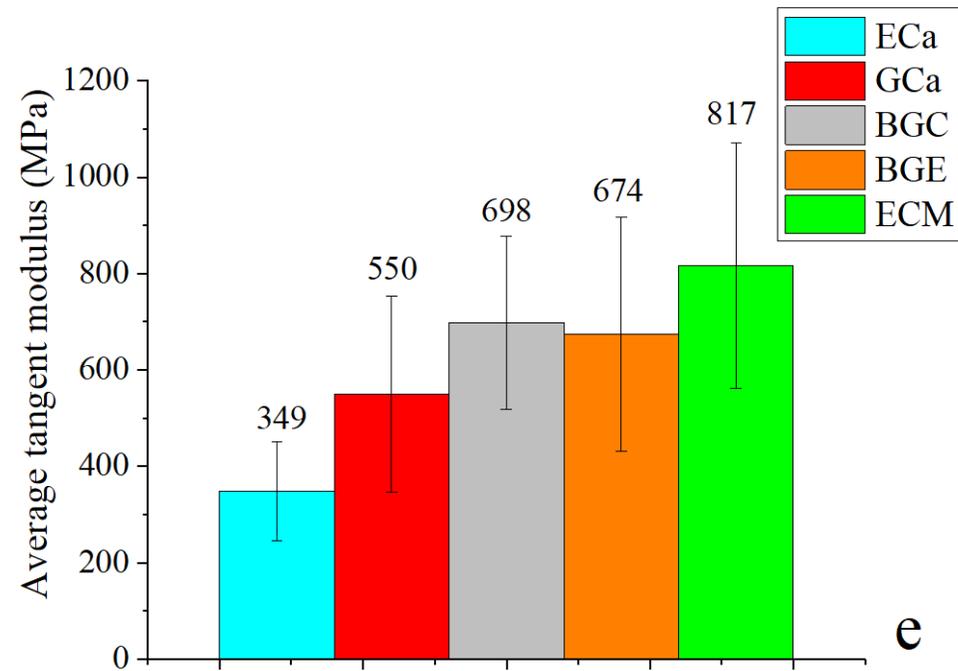
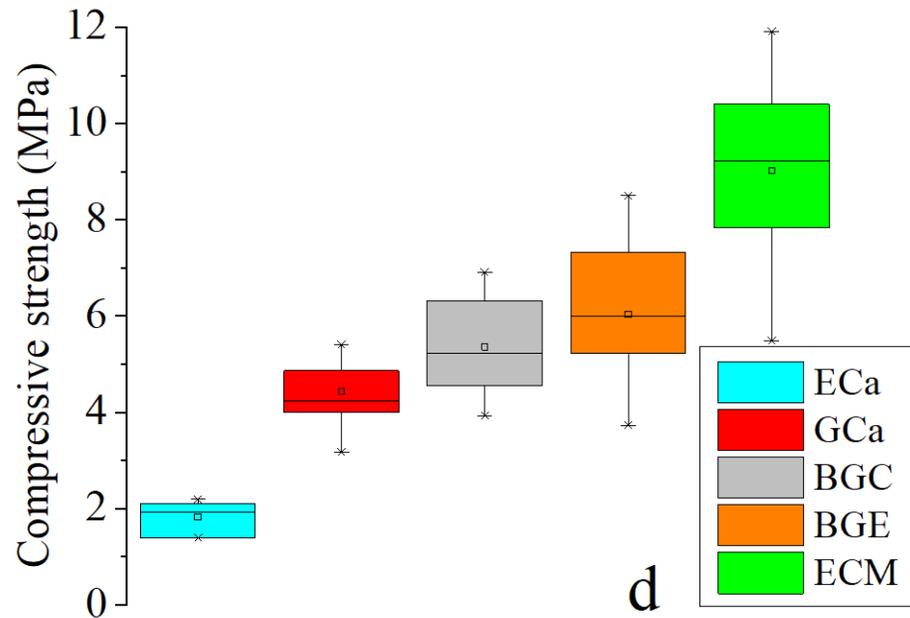
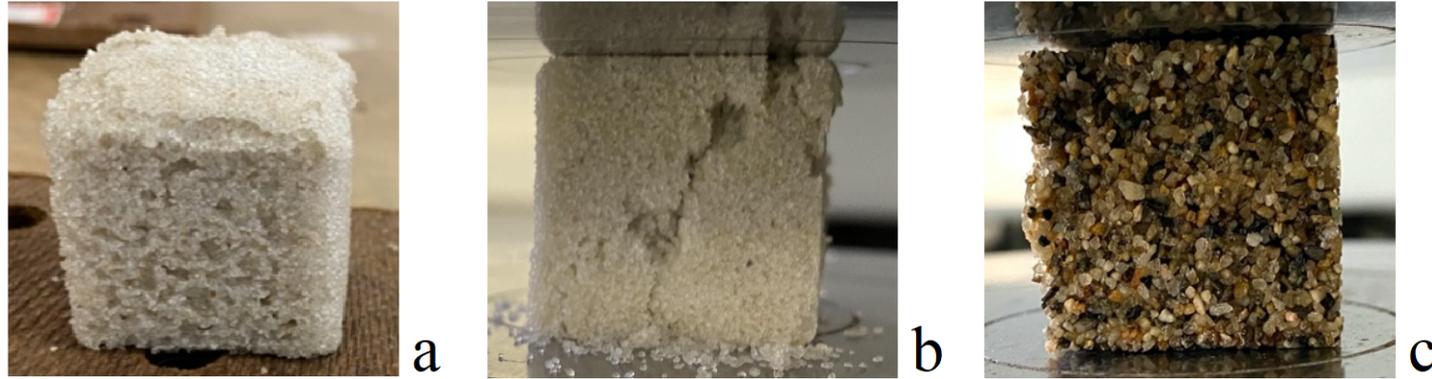
A Novel Self-Healing  
Enzymatic Construction  
Material

(ECM)

# A Novel Self-Healing Enzymatic Construction Material



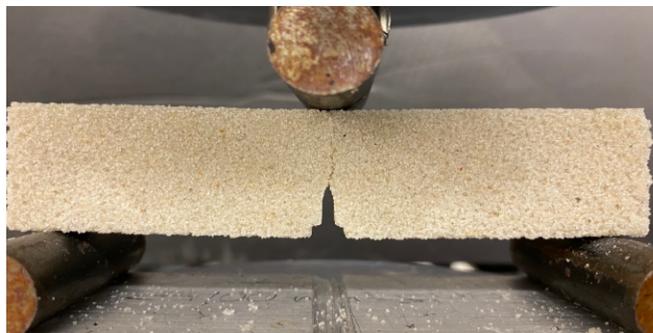
# Compressive test and Results



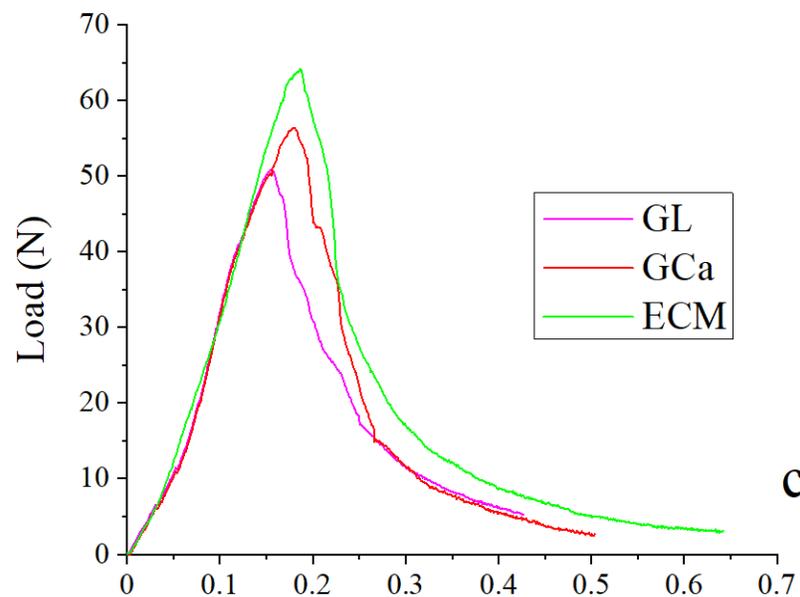
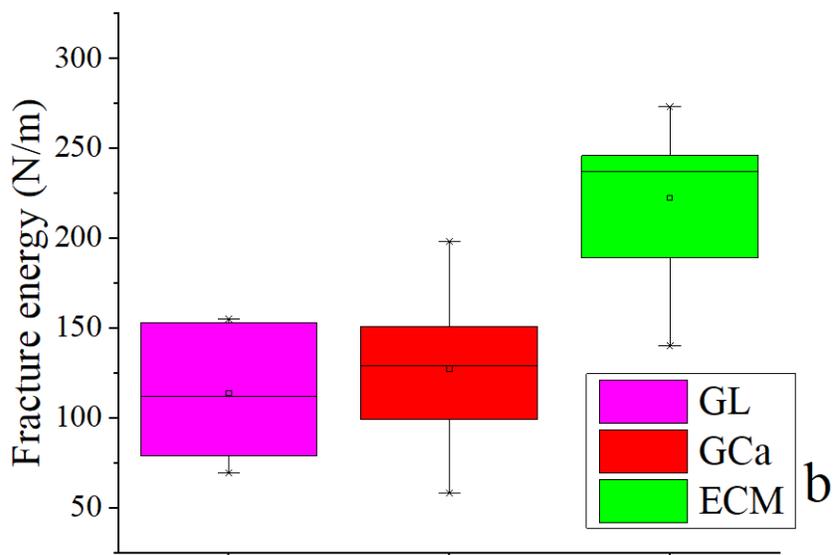
The compressive strength and tangent modulus



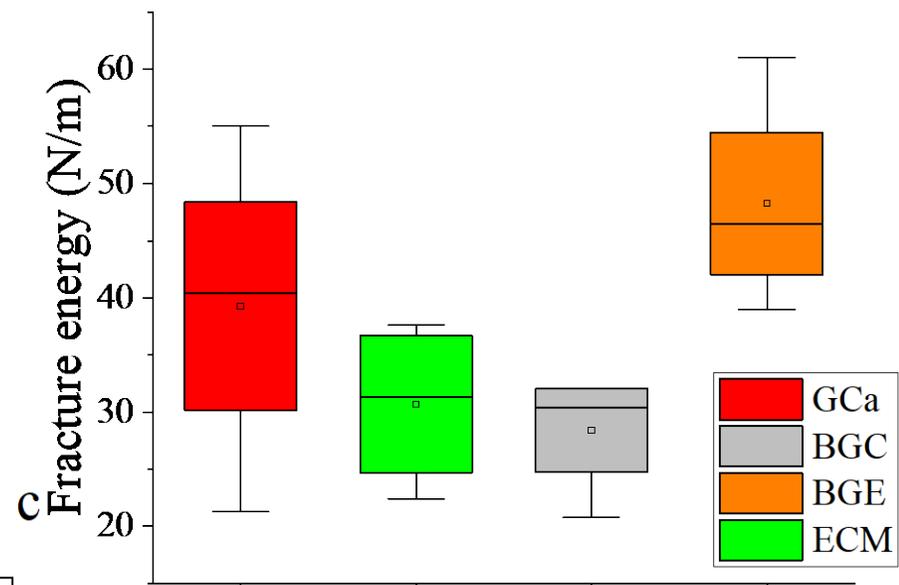
# Tensile Test for Fine and Coarse sand



a

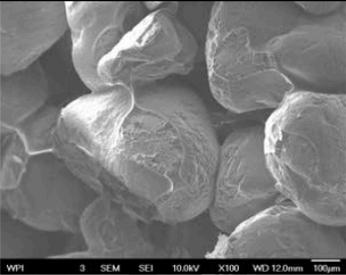
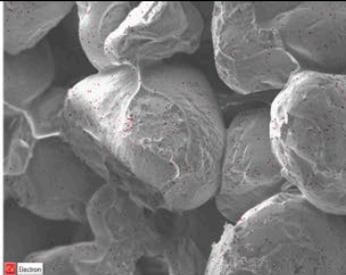
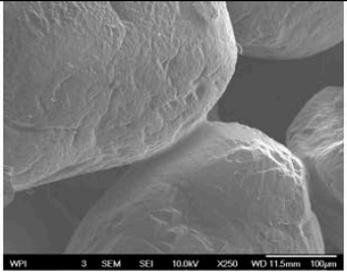
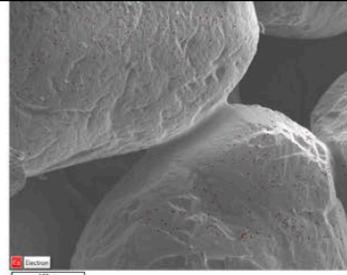
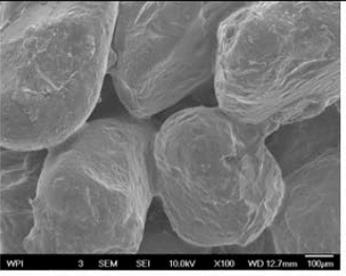
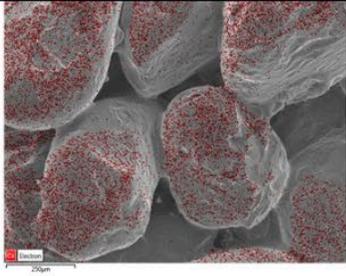
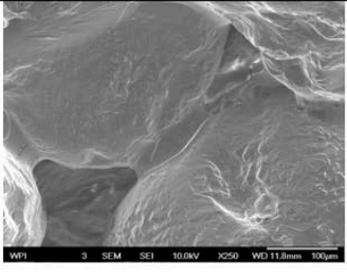
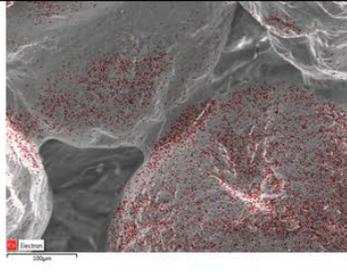
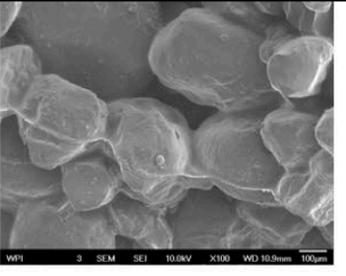
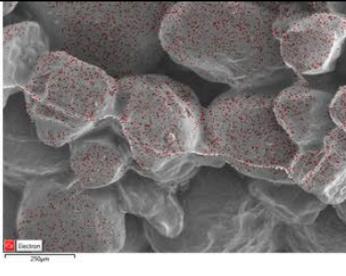
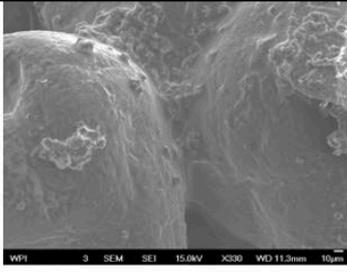
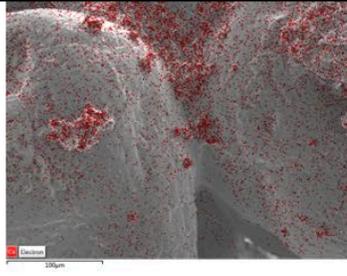
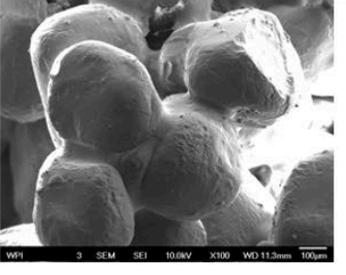
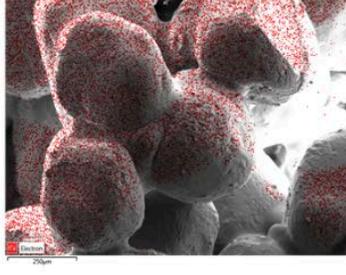
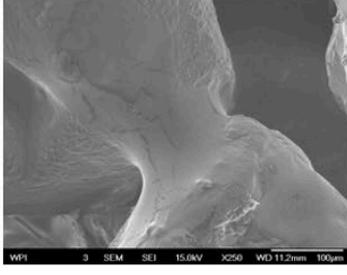
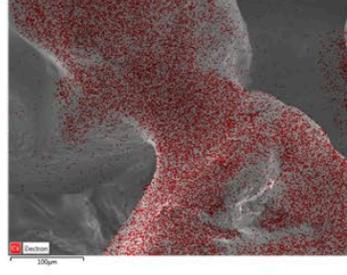


The fracture energy and ultimate load of ECM



The fracture energy of Coarse sand ECM

# SEM and EDS Images of Microstructure

	Surface	EDS view	Bond	EDS view
GL	 WPI 3 SEM SEI 10.0kV X100 WD 12.0mm 100µm	 20µm	 WPI 3 SEM SEI 10.0kV X250 WD 11.5mm 100µm	 100µm
GCa	 WPI 3 SEM SEI 10.0kV X100 WD 12.7mm 100µm	 20µm	 WPI 3 SEM SEI 10.0kV X250 WD 11.3mm 100µm	 100µm
BGE	 WPI 3 SEM SEI 10.0kV X100 WD 10.9mm 100µm	 20µm	 WPI 3 SEM SEI 15.0kV X250 WD 11.3mm 100µm	 100µm
ECM	 WPI 3 SEM SEI 10.0kV X100 WD 11.3mm 100µm	 20µm	 WPI 3 SEM SEI 15.0kV X250 WD 11.2mm 100µm	 100µm

The SEM and EDS images comparison of the effect of the CA enzyme and control groups.



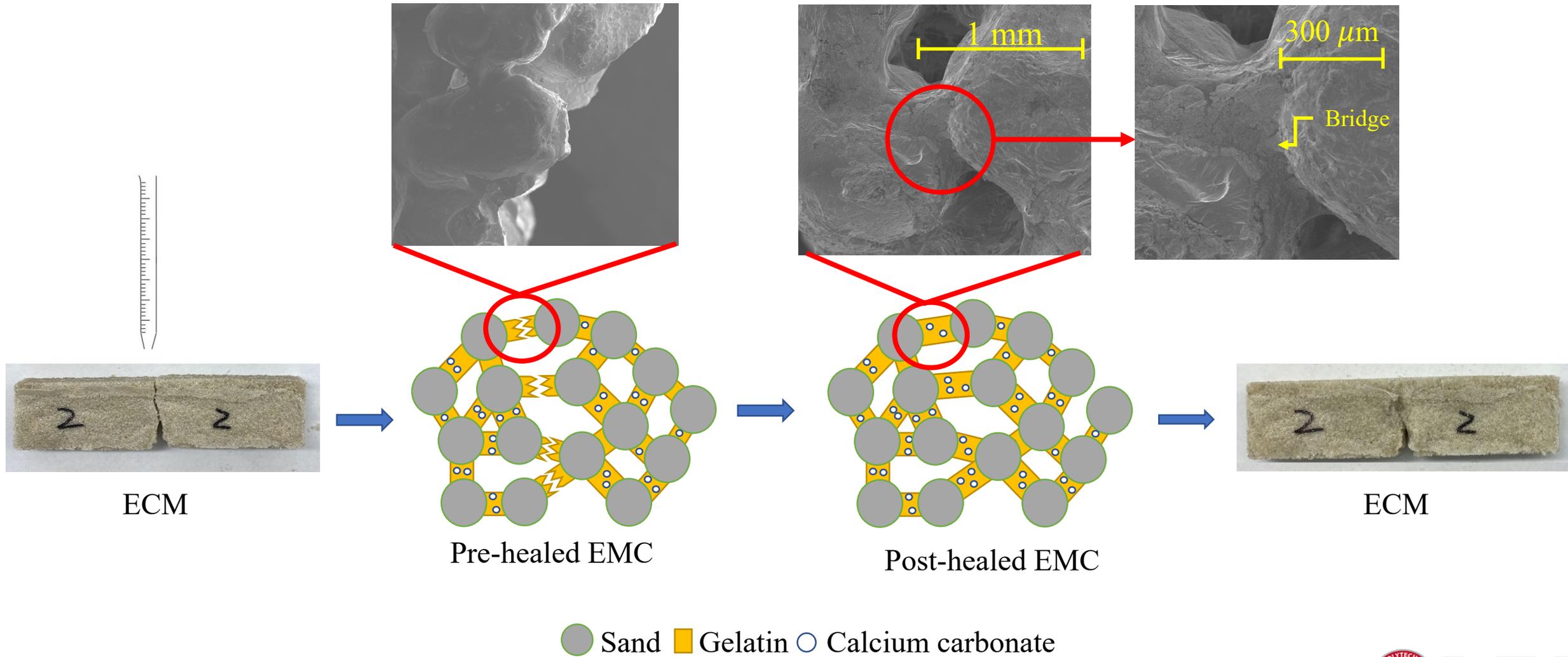
**GL:** Gelatin

**GCa:** Gelatin + Calcium

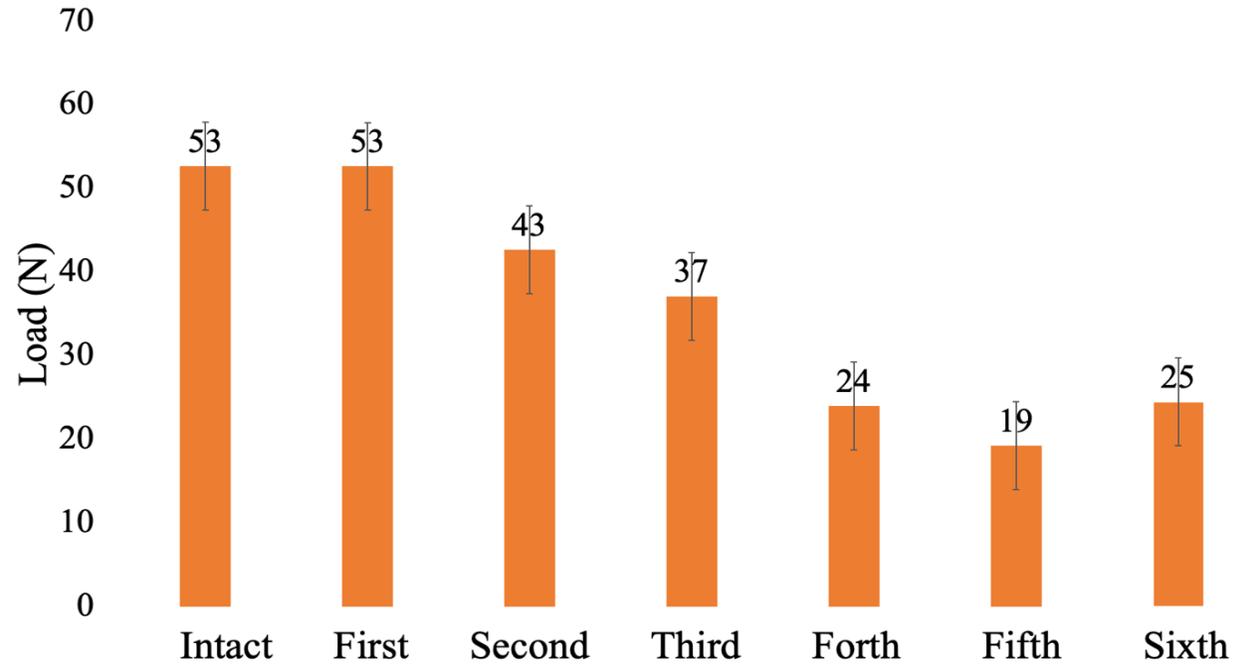
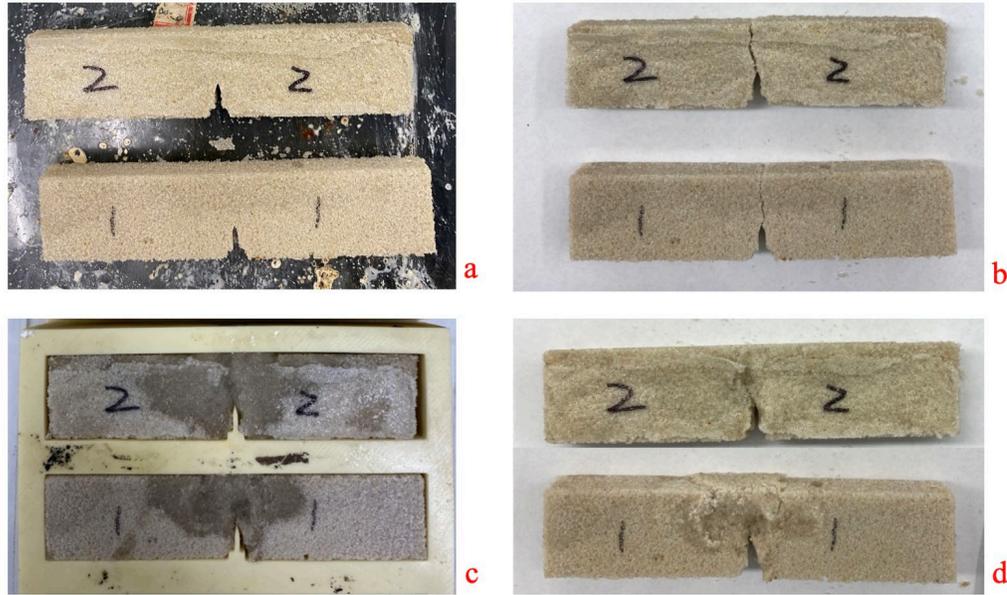
**BGE:** Base + Gelatin + Enzyme

**ECM:** Gelatin + Calcium + Enzyme

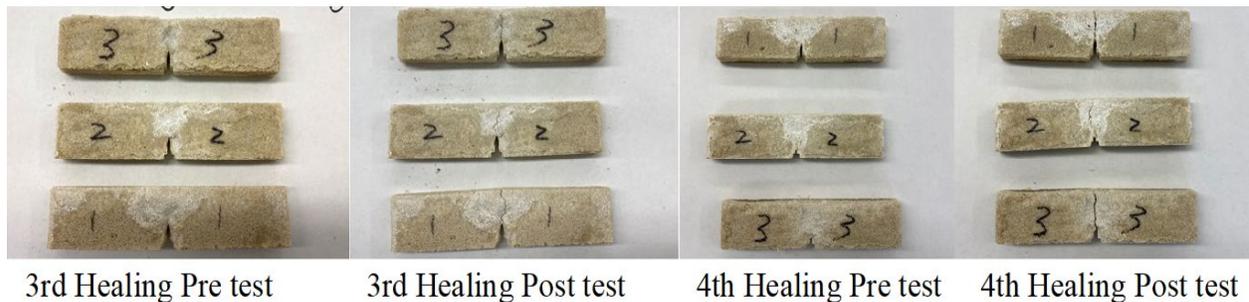
# Self-healing Process of ECM



# Cycle Self Healing Ability of EMC



Ultimate load vs Cycle healing



**a:** before & **b:** after Fracture test

**c.** Fractured samples healing process

**d.** Crack healed

**Bottom figure:** An example of Third and Forth cycle samples

Thank you!

