

WPI

Self-healing Concrete & Enzymatic Construction Material (ECM)

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Introduction

Concrete is the second most widely used substance on earth next to water. Annual concrete production accounts for 8% of worldwide CO₂ emissions. Climate change caused by increased CO₂ levels due to human activity is the biggest existential threat facing the world. Therefore, reducing CO₂ emissions to reduce the greenhouse effect and the rise in the earth's temperature is an urgent task



Crack in concrete

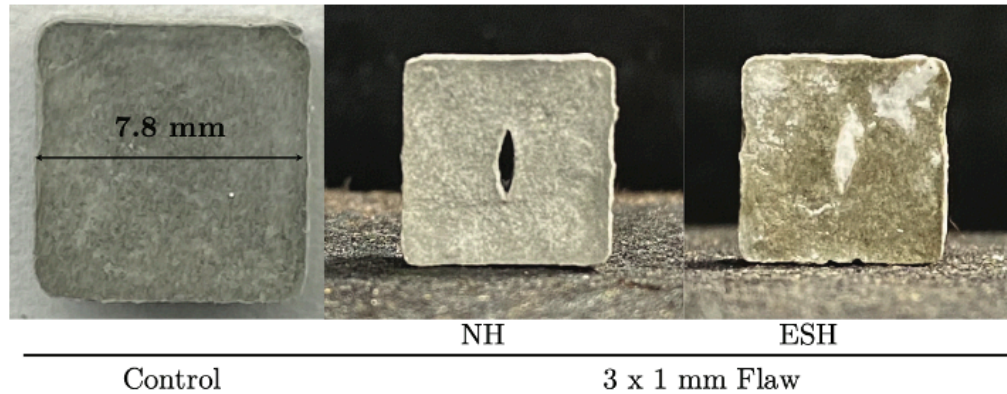


*A typical case of
corrosion in reinforced
concrete*

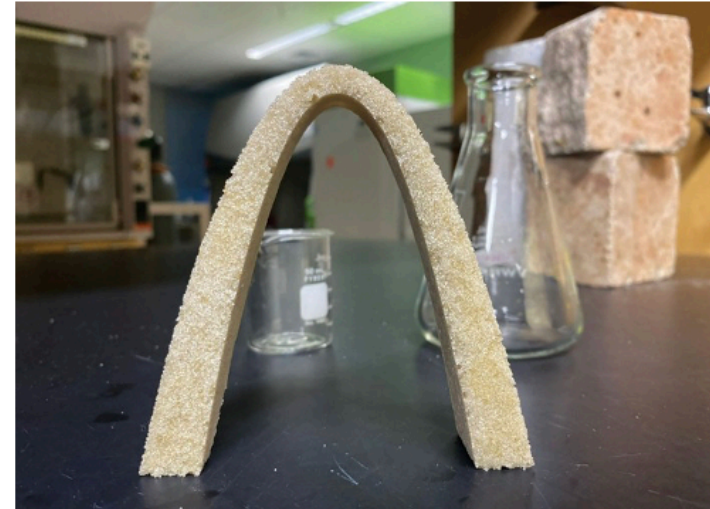
Objectives

We have developed three different applications that will have an extraordinary impact on worldwide concrete consumption and emissions.

- 1) The ability to repair cracks in existing concrete.
- 2) New concrete pours with enhanced (4x) lifetime.
- 3) A new building material similar to concrete that consumes CO₂ during its production



Self-healing Concrete

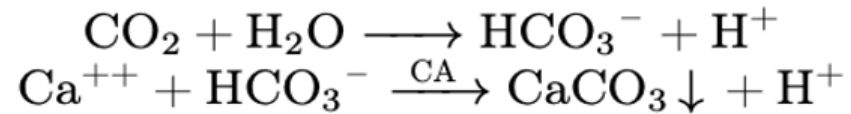


ECM

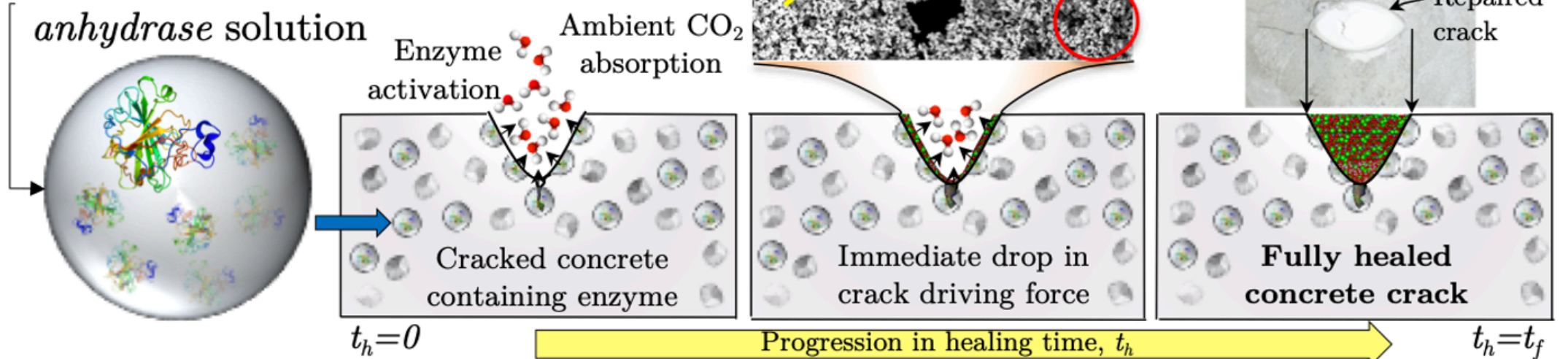
Schematic of Self-healing Concrete

ENZYMATIC SELF-HEALING PROCESS

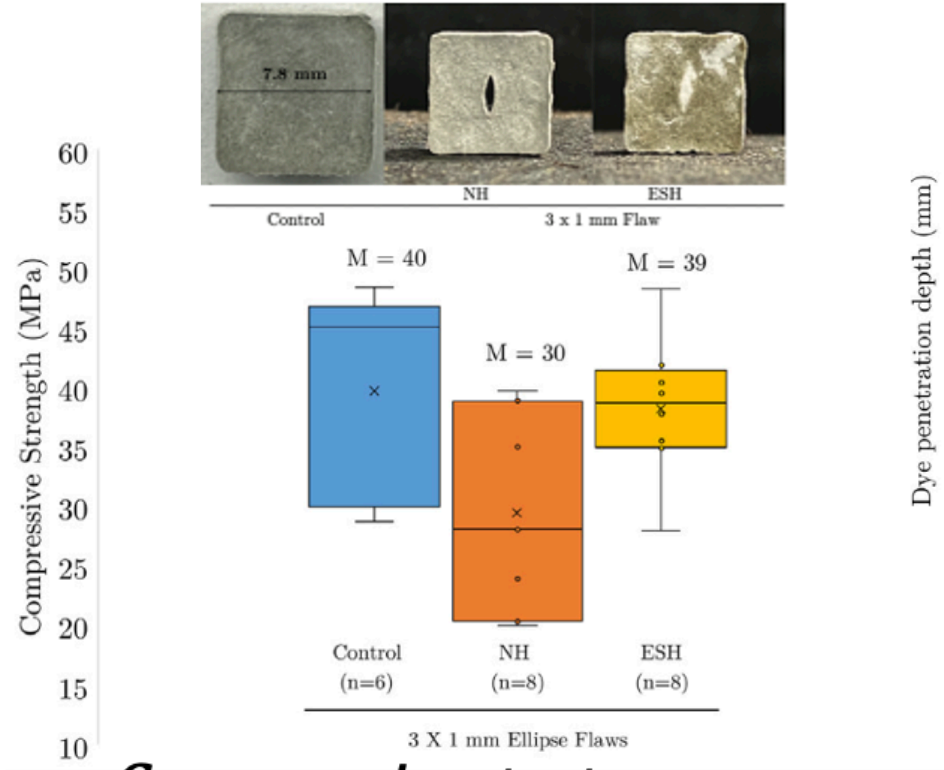
Rapid crystal precipitation by enzymes



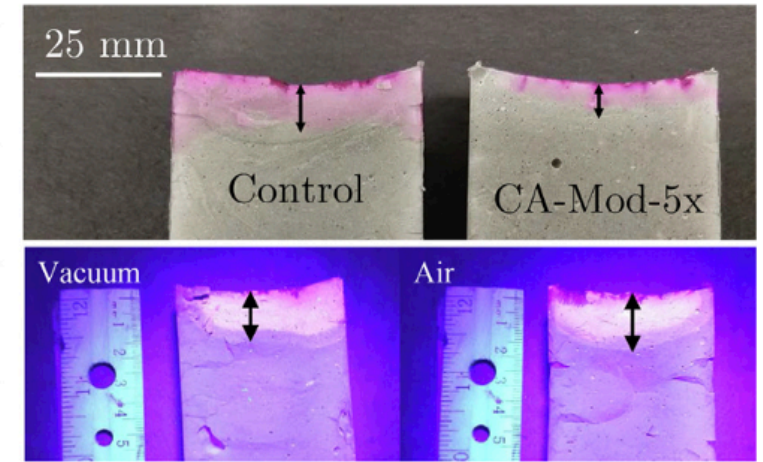
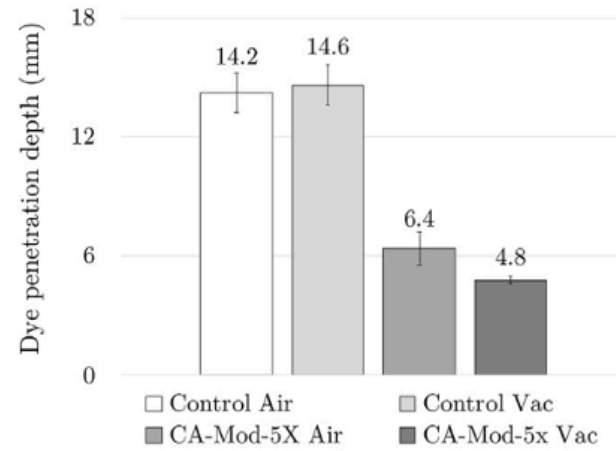
Embedded *carbonic anhydrase* solution



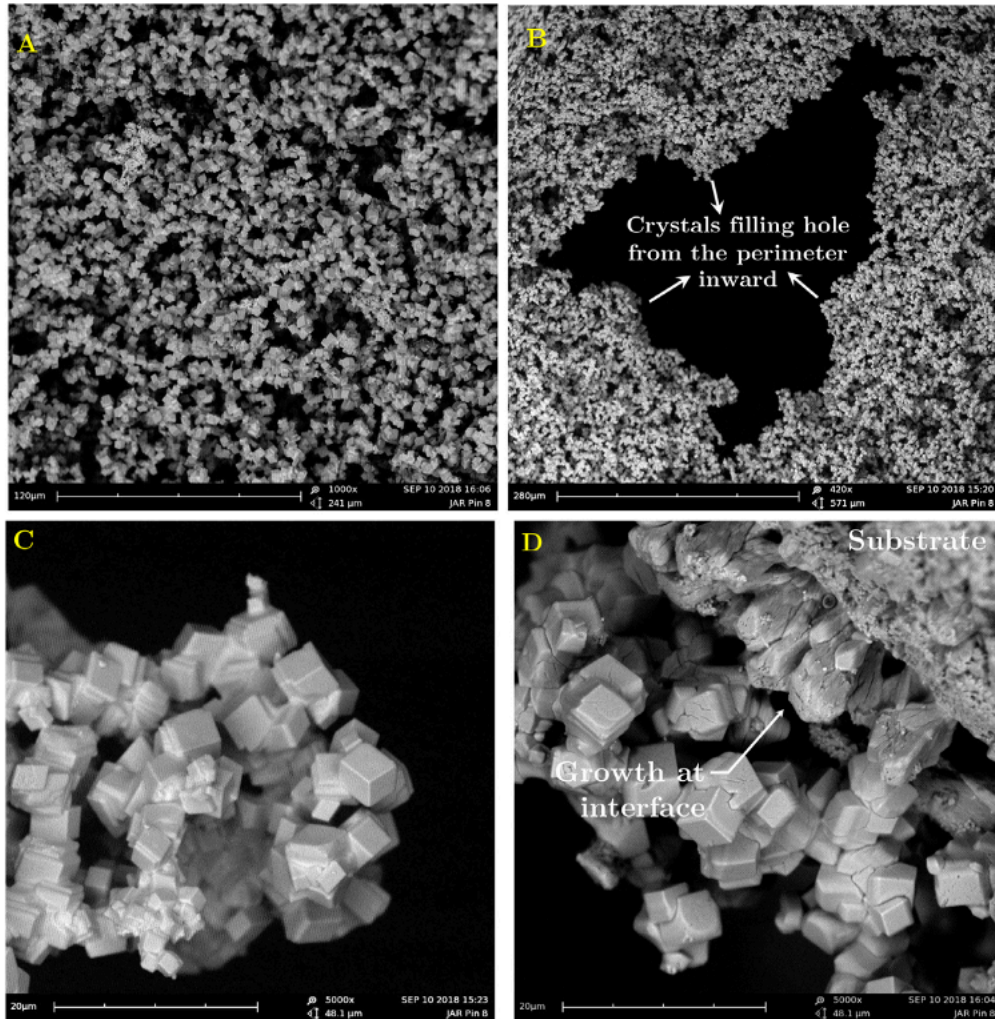
Enzymatic concrete properties



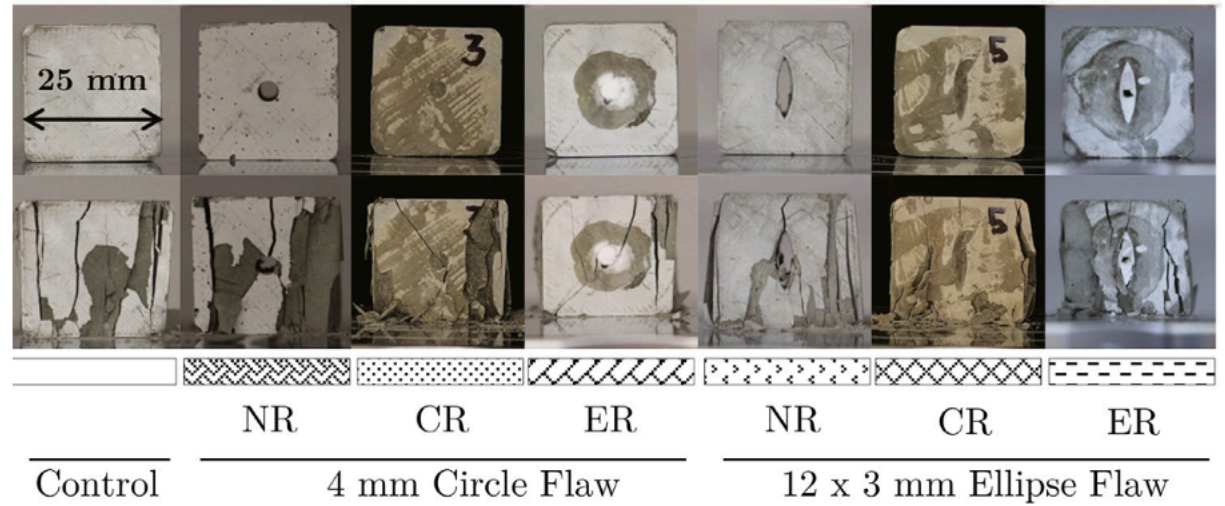
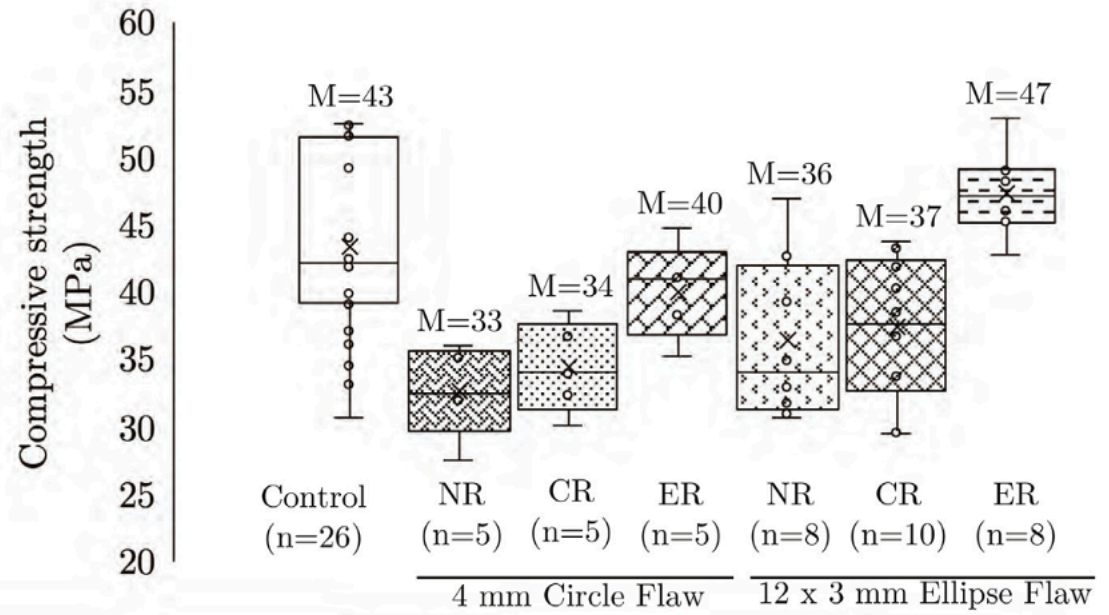
Compression test



Accelerated vacuum dye penetration test



Micro scale view

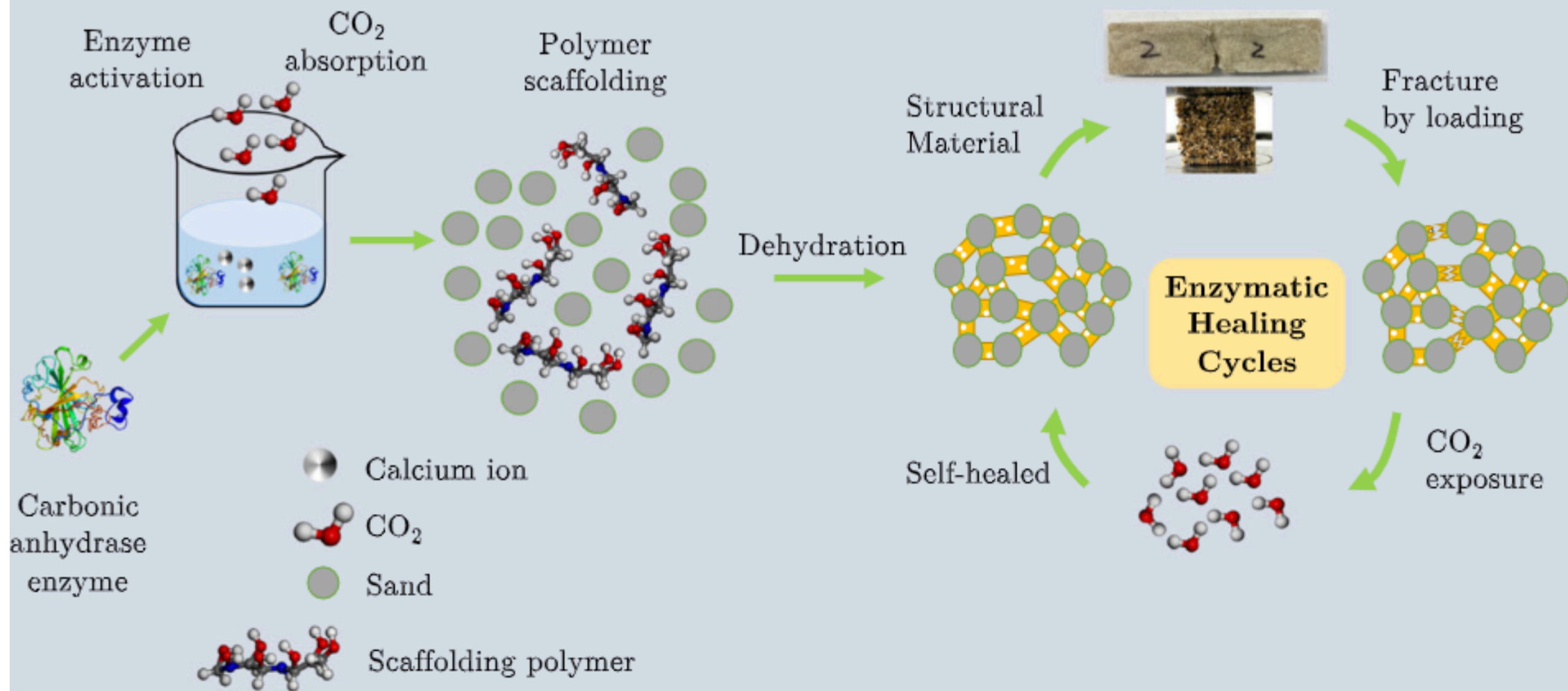
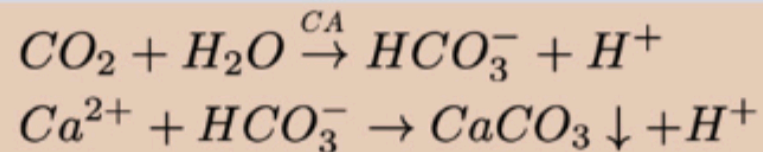


Repaired test

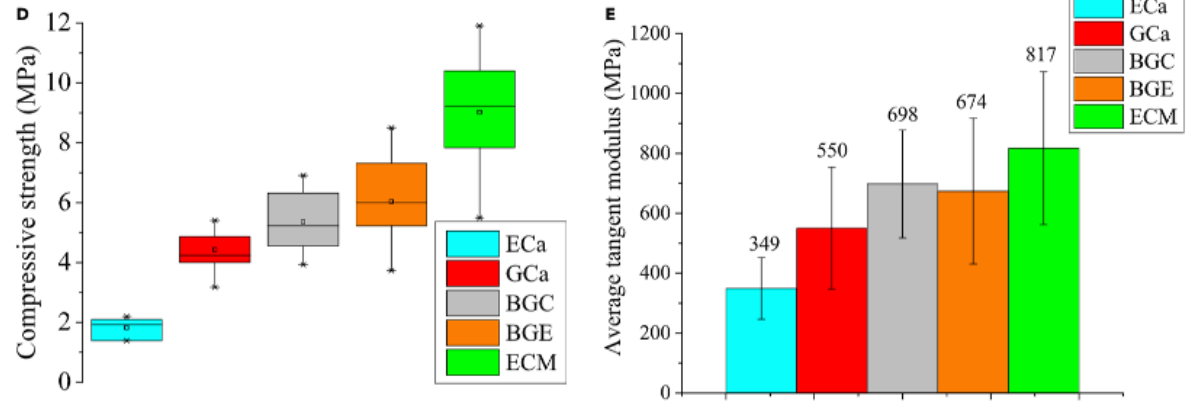
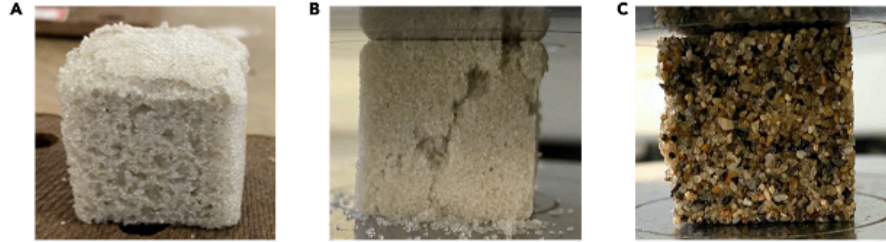
Schematic of ECM

A New Paradigm

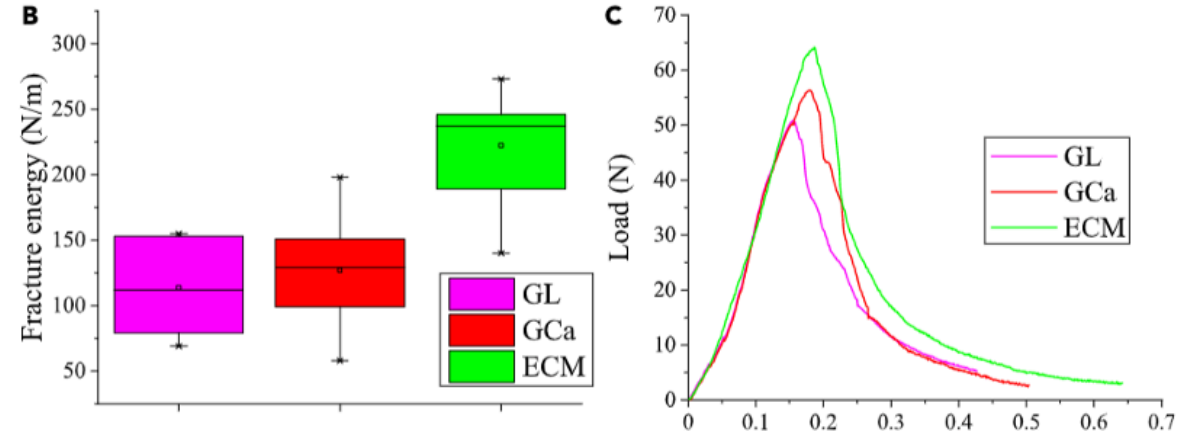
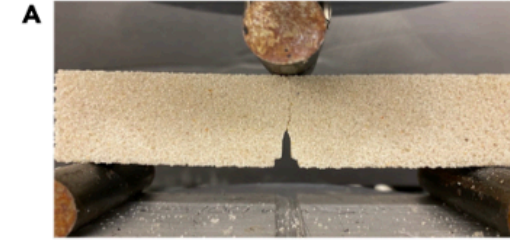
**Rapid crystal precipitation
by enzymes**



ECM properties

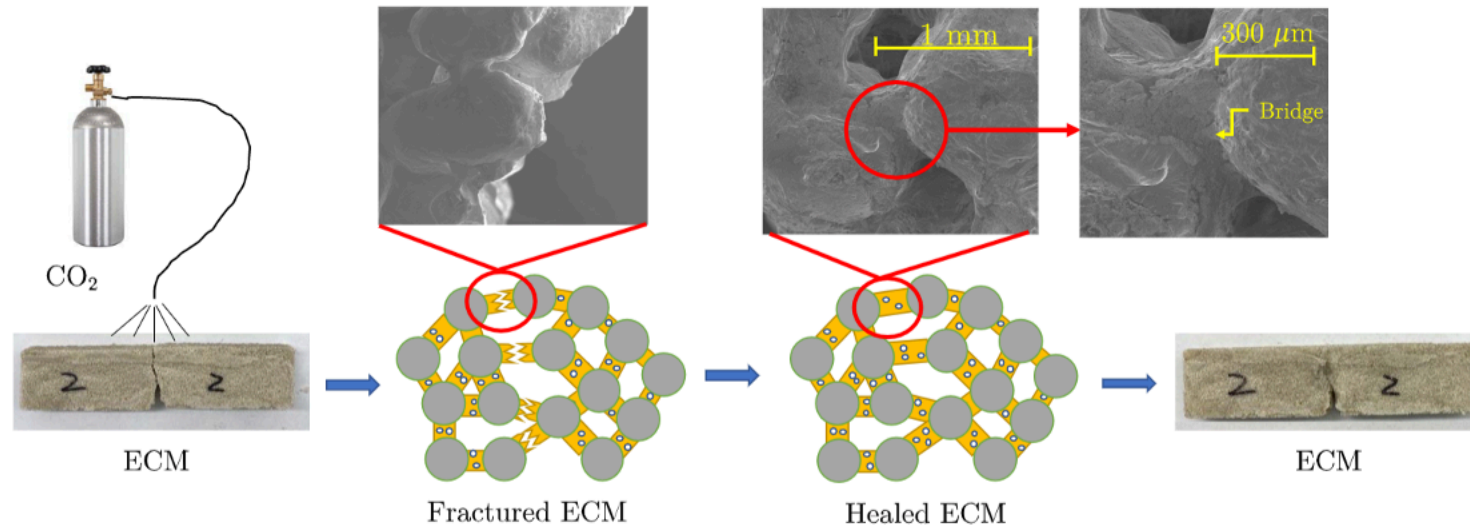


Compression test

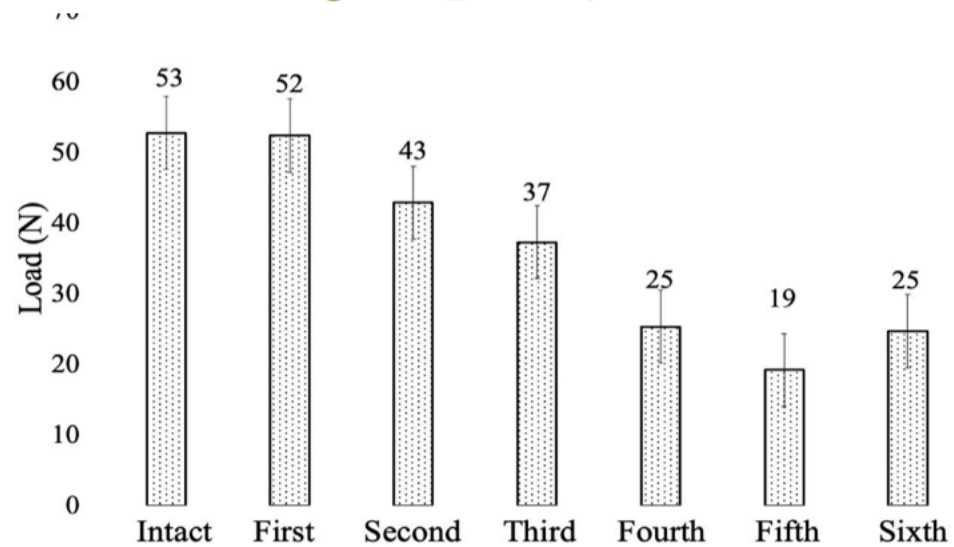


Fracture test

Self healing paradigm





● Sand ■ Gelatin ○ Calcium carbonate



Self-healing fracture test

Conclusion

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- We have developed a self-activated healing mechanism in cement paste structures using enzymes.
 - Large cracks repaired by our method were similar in strength and physical properties as the original material.

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- ECM shows a maximum compressive strength around 10 MPa.
 - Six cycles of self-healing test were examined and consumed CO₂ during the procedures.

Thank you!