Microcapsule-based self-healing cement-bentonite cut-off wall materials

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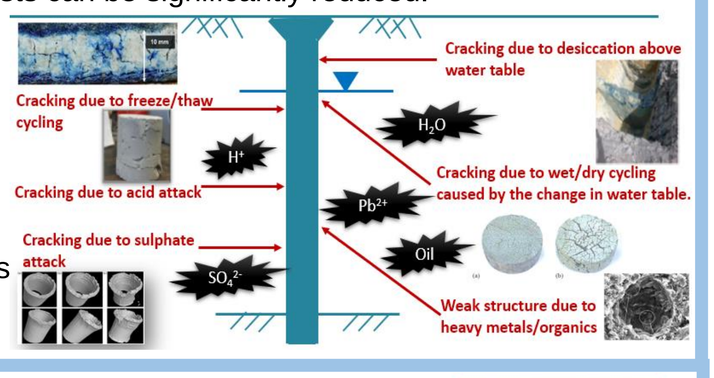
RESILIENTMATERIALS4LIFE

Background

Over 2.5 million sites across Europe are potentially contaminated. One commonly-used containment technology for land remediation is cement-bentonite (CB) cut-off walls that can prevent the migration of contaminants. However, problems related to their durability impact serviceability, leading to the need of repair with crack-originated damage and degradation. Therefore, CB cut-off wall materials need to be improved to be more resilient and exhibit self-healing capability, so that their whole life costs can be significantly reduced.

Causes of damage:

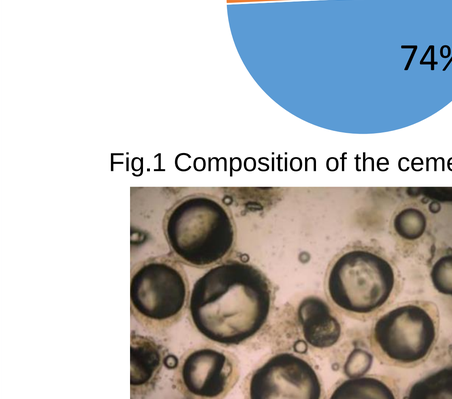
- Mechanical stress
- Chemical attack
- Environmental stress

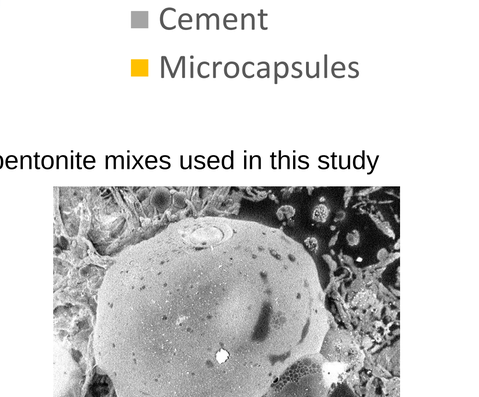


RM4L: Vision

EPSRC Pioneering research and skills

Biomimetic materials incorporating microcapsules for self-healing infrastructure:





Wound healing
Platelets release proteins to form a blood clot that can seal and heal the wound

Crack healing
Microcapsules release sodium silicate healing agent to seal and heal the cracks

Materials used for developing self-healing cement-bentonite walls

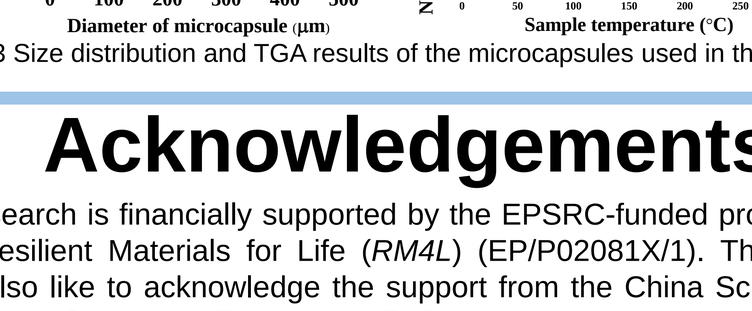


Fig.1 Composition of the cement-bentonite mixes used in this study

Fig.2 Microscope and SEM Images of the microcapsules used in this study

Fig.3 Size distribution and TGA results of the microcapsules used in this study

Acknowledgements

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Results

X-ray computed microtomography (μCT) imaging analysis

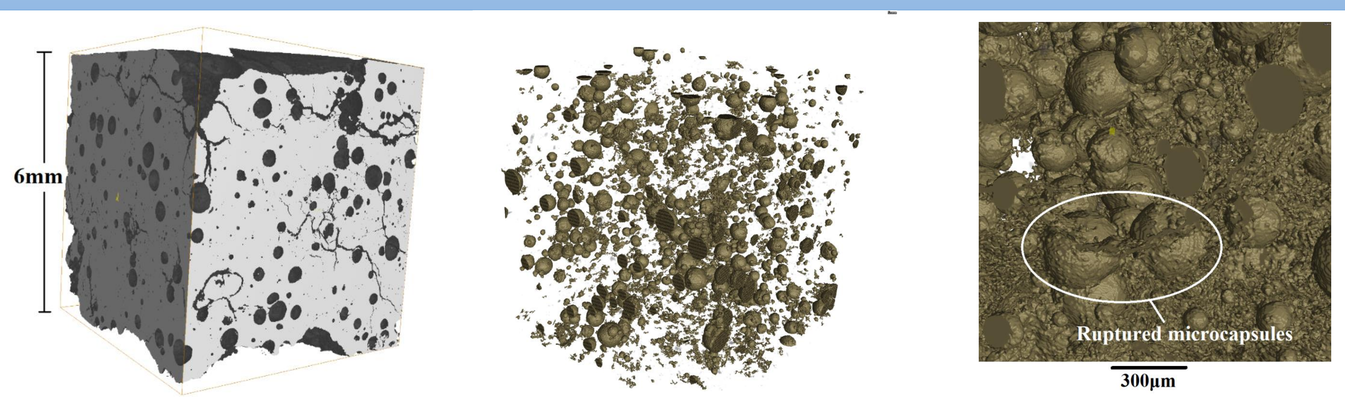

Fig. 4 3D CT images of CB sample reconstruction, microcapsule extraction and microcapsule rupture

SEM-EDX analysis

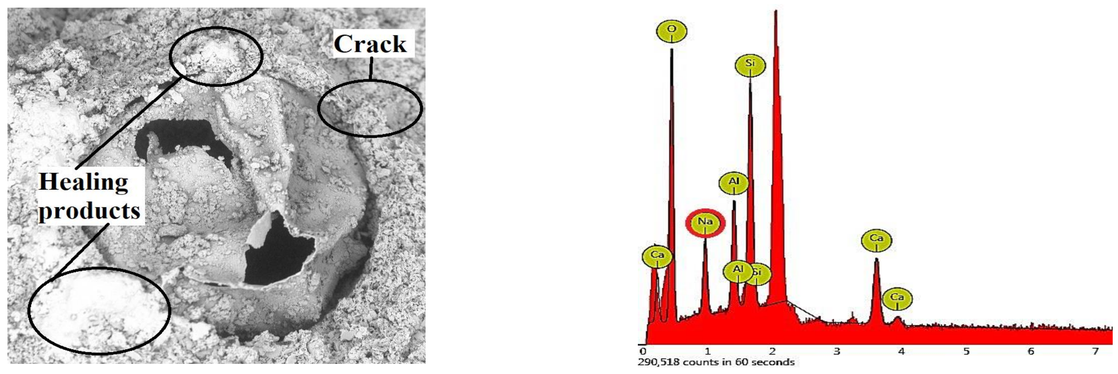

Fig. 5 SEM image of a ruptured microcapsule and EDX analysis of a point near the ruptured microcapsule

Crack mouth healing under optical microscopy

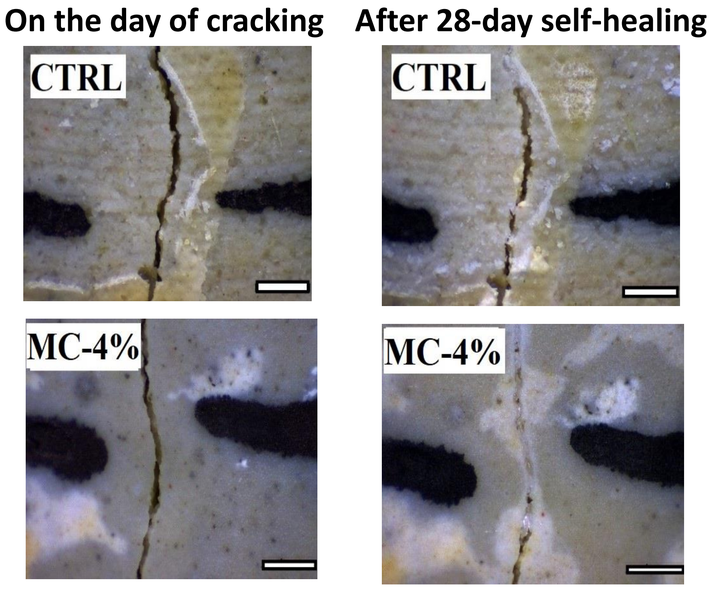

Fig. 6 Typical images of crack mouths taken on the day of cracking and after 28-day self-healing for the control and microcapsule-containing samples (Solid bars correspond to 1mm)

Unconfined compressive strength and permeability recovery

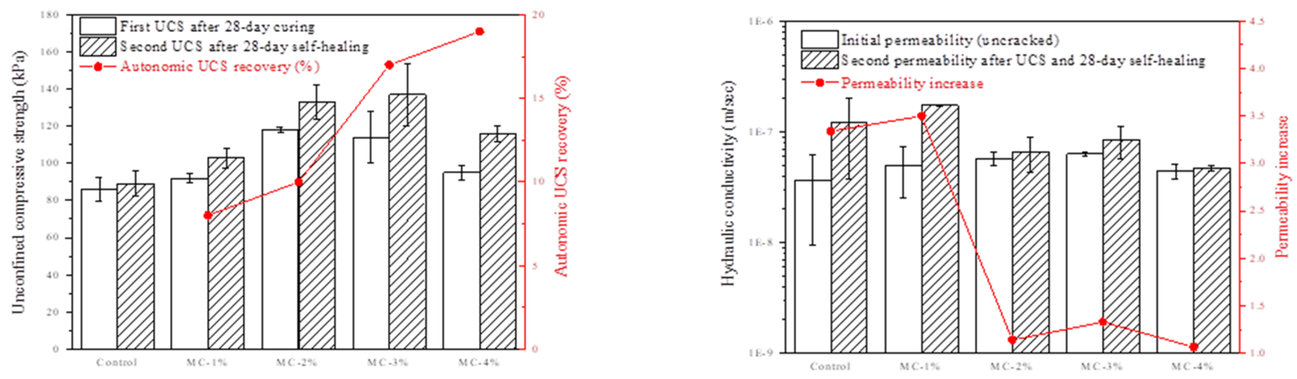

Fig. 7 UCS and permeability recovery of CB samples with different dosage of microcapsules after 28-day self-healing

Conclusions

- The work presented here is the first attempt to introduce the concept of self-healing to CB cut-off wall materials by incorporating microencapsulated sodium silicate into CB mixes.
- The uniform dispersion, survivability and crack-triggered rupture of microcapsules were observed using CT-scanning, and the release of healing agents as well as the formation of calcium silicate hydrate, as the main healing product in addition to the formation of calcium carbonates, were confirmed by SEM-EDX analysis.
- The microcapsule-containing CB samples demonstrated enhanced average crack mouth healing. The effective healing of cracks was also verified by the recovered permeability.
- The results demonstrated the significant potential of microcapsules as a self-healing approach for the development of more resilient and reliable cut-off wall materials.