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Microbially Induced Calcite Precipitation Treatment of Naturally Fractured Concrete: From Micro-Scale Characteristics to Macro-Scale Behaviour.

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Concrete is the most consumed artificial material universally, and its production is responsible for about 1.5% of the UK's greenhouse emissions (Hibbert et al., 2022). Concrete assets are often exposed to harsh environmental conditions, including exposure to seawater, freeze-thaw cycles and temperature cycles, leading to degradation of the matrix. Reducing the permeability of degraded concrete is key to minimising further deterioration in order to prevent the ingress of corrosive chemical compounds and limit carbonation. Calcite bio-mineralisation provides a novel alternative to established concrete repair techniques. Microbially Induced Calcite Precipitation MICP offers excellent penetrability (even into micro-fractures), excellent adhesion and the ability to improve mechanical properties as well as reduce permeability. Yet, previous studies for MICP applications have mainly focused on treatment methods which are impractical for in situ application. Furthermore, assessment of the extent of crack repair has typically been limited to visual assessment at the surface. This study provides a comprehensive experimental and analytical investigation of MICP treatment of 3D fracture networks in degraded concrete with an emphasis on understanding the spatial distribution of calcium carbonate precipitated within the fracture networks. The experimental investigations were conducted on degraded concrete collected from the Ayrshire coast in Scotland. MICP treatment results showed successful repair of five fractured concrete cores, with two cores displaying 3 orders of magnitude reduction in permeability after only 3 treatment cycles. Additionally, Brazilian tests demonstrated recovery of up to 50% of the concrete's original tensile strength. Moreover, SEM-EDS analyses and X-CT imaging before and after MICP treatments provide insight into mineral localisation and the interactions between biologically induced precipitates and pre-existing salts within the concrete media. Finally, analytical studies based on an equivalent permeability model highlight the influence of fracture characteristics (i.e. fracture orientation, quantity, aperture, and morphology) on the efficiency of MICP treatments.

Participation

In-Person

References

Hibbert A.F., Cullen J.M., Drewniok M.P. (2022) "Low Carbon Concrete Technologies (LCCT): Understanding and Implementation", EPSRC IAA Final report No. ENG-TR.011, University of Cambridge, Cambridge, 2022

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