Biomimetic vascular self-healing systems for cementitious materials

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Abstract

Infrastructure, such as roads, skyscrapers is used by everyone in the city. They enable trade, power businesses, and protect cities from an increasingly unpredictable natural environment. Most of infrastructure is made out of cementitious materials. But, the fact is, they all crack, no matter how carefully they are stored or reinforced. Most of the damaged cementitious structures will end up being replaced and reconstructed.

To address this national critical challenge, nature has always been a source of inspiration in engineering applications and vascular networks, as in human skin and in a tree leaf, are one attribute that has received attention in the design of resilient structures. A vascular system houses healing agents within its interconnected networks which are incorporated within a cement matrix. It is perhaps the only self-healing approach that has the capability to address different scales of damage in cementitious materials.

The main aim of the work is to develop novel vascular networks inspired by nature for self-healing in cementitious systems. Thus, the objective of this research was to explore the self-healing plastic-based networks/connected channels and healing mechanisms for both physically and chemically triggered self-healing in cementitious materials.

To achieve this, biomimetic three-dimensional (3D) vascular networks were designed and generated circulatory blood volume transfer. The designed structures were constructed through 3D printing and assessed in a cement-based matrix. Mechanical testing assessed the compatibility of the system with the surrounding matrix as well as the functionality of the network in delivering and releasing the healing agent at the location of the damage. This initial proof of concept work confirmed the ability of the vascular systems to deliver the healing agent via physical and chemical triggers and demonstrated a significantly enhanced healing performance.