Experimental Investigation of the Self-Healing Potential of Bacteria for Sustainable Concrete Structures Phase 2

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Introduction

Concrete, the backbone of the modern construction industry, is well known for its versatility, robustness, longevity, and strength. Concrete is a material that exhibits exceptional resistance to compression, rendering it well-suited for a wide range of structural applications. The material can be cast into molds or forms of various shapes and sizes, enabling the creation of a wide range of constructions, including buildings, bridges, highways, and dams.

However, concrete structures are susceptible to many factors that may deteriorate their integrity. One of the major issues usually found is the formation of cracks, which can lead to a reduction in structural integrity, increased permeability, and an increased chance of rebar corrosion, which, in turn, can threaten the structure and, if left untreated, the safety of those who rely on it. Innovative solutions must be introduced to mitigate this issue. In this respect, the development of self-healing concrete, as the name indicates, aims to provide concrete structures with an ability to repair or minimize cracks autonomously.

Study Methods

The scope of this research work is that of testing the self-healing potential of bacteria for sustainable concrete structures through the application of microbially induced carbonate precipitation (MICP) method. Three pure cultures are considered for this study, *Bacillus subtilis* (B-14596), *Bacillus megaterium* (B-350), and *Sporosarcina pasteurii* (ATCC Catalog no: 11859), which are laboratory cultivated. The experimental design included five distinct specimen groups: Control without Crack (Set-A); Control with Crack (Set-B); and three Cracked Specimen sets treated with different bacterial species (namely, *Bacillus subtilis* (Set-C), *Bacillus megaterium* (Set-D), and *Sporosarcina pasteurii* (Set-F)). Each group comprised 11 samples featuring a concrete grade of 40 MPa, aimed at securing statistical reliability.

The production of the concrete specimens entailed careful blending of a high-strength concrete mixture according to standards detailed below.

Concrete self-healing could help us build infrastructures with an extended lifespan and reduce costs related to their repair. This approach could prove to be very economical and environmentally friendly.

To ensure uniformity in material qualities across all specimens, the mixing technique was standardized. The curing techniques adhered to ASTM requirements, guaranteeing the most favorable concrete hydration and strength enhancement. The methodology section of this report describes the cultivation of bacteria, followed by concrete specimen preparation and curing. After curing, high alkaline tolerant bacteria are introduced three times into the cracks of the concrete samples. These self-healed specimens are tested in compression using a Humboldt Compression Machine (HCM-5000-iHA, HUMBOLDT) after 84 days from their manufacturing.

The findings showed a significant enhancement in compressive strength, ranging from 8.59% to 21.61%, in the self-repaired groups as compared to the control group (With Crack). *Bacillus subtilis* and *Bacillus megaterium* exhibited similar strength to the control specimens; however, *Sporosarcina pasteurii* surpassed them. The variations seen across the data set were consistently within an acceptable range, suggesting a high level of dependability.

Findings

The results demonstrate the effectiveness of using bacteria to initiate Microbially Induced Calcium Carbonate Precipitation (MICP) in concrete fissures (refer to Figure 1), thus improving the long lastingness of concrete structures. The use of the external application technique offers a very promising strategy for upgrading pre-existing buildings in an ecologically conscious way by extending the lifespan of structures and their components, therefore making a significant contribution to the advancement of sustainable growth within the construction sector. This study emphasizes the possibility of using bio-based solutions to solve difficulties related to the durability of concrete. It also identifies areas for further research and implementation.

Policy/Practice Recommendations

The external application method in which bacteria is applied manually to concrete surface cracks can be used to retrofit existing structures in an environmentally friendly way, promoting sustainable development for the future. Further studies on this topic, highlighting the applicability of the self-healing repainting method on a large scale, could provide results on the applicability of this technique to repairing large concrete-based infrastructures.

About the Principal Investigator

Dr. Andrea Calabrese is an Associate Professor specializing in Structural Engineering at CSULB. His research focuses on seismic protection methods and material engineering.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2331

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