POLITECNICO DI TORINO

Honors thesis

Master of Science in Sustainable Architecture

Abstract

Self-healing cementitious materials: Evaluation of the healing efficiency of cementitious and recycled PET capsules

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The growing concern for the safety and sustainability of the structures has drawn the attention of professionals and researchers towards the experimentation and development of self-healing materials and preventive repair methods.

In fact, the appearance of cracking phenomena in concrete is almost inevitable due to its low tensile strength. This aspect does not necessarily represent a risk of collapse for the structure, but compromises its functionality, accelerating its degradation and decreasing its service life with consequences also for sustainability.

In order to make cementitious materials more reliable and long-lasting through the addition of bespoke technologies, research activities have provided illuminating contributions to the understanding of self-healing and crack healing mechanisms, leading to the development of a number of technologies, the efficacy has been amply demonstrated in laboratories and, in some cases, also with field applications with continuous performance monitoring.

The self-repair technology experimentally investigated in this thesis is the encapsulation of appropriate repairing agents within (macro) capsules inserted into the cement matrix. The self-repair system is activated when the hard shell of the capsule breaks, causing its contents to pour into the crack repairing it. However, it is necessary that the shell is sufficiently resistant to cope with the concrete mixing and casting phases, resisting the basic environment of the matrix and degradation over time, while preserving the characteristics of the agent inside intact.

Two types of tubular capsules were studied: the first was produced using a modified cement mixture with the addition of polymers; the second was produced using additive manufacturing techniques using a recycled polyethylene terephthalate (PET) filament.

In both cases, a liquid polyurethane repairing agent was encapsulated inside. Polyurethane was evaluated as a sealing agent as it is able to spread through cracks and partially restore the initial mechanical properties of the cementitious material.

The repair effect offered by the addition of the capsules was evaluated through their insertion inside cement mortar specimens.

After an initial damage phase and subsequent independent repair, the performance of the self-repair system was quantified in terms of recovery of characteristics related to the durability of the material (reduction of water permeability) and recovery of the load-bearing capacity in static conditions. Furthermore, the stability of the system in the face of dynamic load cycles was evaluated in order to validate their possible use in real structures.

Positive results were achieved, with a load recovery index higher than 46%, a reduction in the permeability of the system up to the complete sealing of the crack and a good stability of the system against cyclic degradation, obtained by applying a peak force corresponding to 75 % of the estimated load capacity of the repaired samples brought to failure in static condition and corresponding to about half of the bearing capacity of the samples still intact.

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