

POLITECNICO DI TORINO
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Honors theses

Application to architecture of biomimetics instructions: self-healing cement paste, state of the art and experimental study

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The main theme of the thesis is the design of self-healing materials, particularly in cement composites. It analyzes the state of the art on the subject and it experiments a possible strategy of self-healing.

Self-healing materials arise from a biomimetic approach, the observation of nature, where the perfect mechanism of each organism is able to repair internal and external damage independently.

The mimesis of the principles that govern the nature constitutes a new methodological approach, which seeks to create a link between the artificial and the natural world.

The thesis is organized in three parts.

The first part introduces the concept of biomimicry, explaining its meaning and possible applications in architecture and in technology of materials.

The nature, in billions of years, has evaluated and determined what works and what is convenient, therefore it is appropriate and useful to follow this example.

Biomimetics has possible implications in different aspects of our life, even if some solutions may be utopian, through the development of technical and scientific knowledge, could soon be feasible.

The second chapter discusses the various strategies tested until now to realize self-healing cementitious materials. The researches on the self-healing materials are still at an initial phase of experimentation.

The possible creation of materials able to control their own integrity and having the ability to self-repair in a timely manner, would bring great economic benefits, especially as it would significantly lower costs of maintenance.

Finally, the thesis describes the laboratory activities performed to test a strategy of self-healing concrete.

The experiments carried out, based on previous research in the literature, have focused on the search for possible repairing agents.

Compared to researches already been developed, the work tried to simplify the use of the materials, and have been made various tests.

A first attempt was made with a new natural resin, Finlan, with the intention of using it as a single repairing agent, with the advantage of simplifying the system, since it would require a catalyst.

Then it tried to experiment with a two-component system, that incorporated cement anhydrous in the cement paste and water particles.

Finally it conceived another two-component system, composed by metakaolin and calcium hydroxide, which, when reacting, cause an expansion and an increase of volume, raising the possibility to fill the crack.

The latter method has shown the best results. Capsules of calcium hydroxide and metakaolin have been incorporated in the cement paste, producing some specimens of potentially self-healing cement.



The specimens were subjected to mechanical tests, in particular in a three-point bending test with crack mouth opening displacement (C-MOD), to verify precisely the ability to repair itself.

From the results of the tests the process doesn't seem to be successful, probably because the width of the crack is not wide enough to break the capsules, or the time left to the system to react may be insufficient.

There is ample room for improvement regarding the chosen self-healing system, particularly in the production of capsules.

The manufacture of calcium hydroxide capsules should be simplified and rendered faster and more efficient, and at the same time it should produce them in a smaller size.

In addition, further studies are necessary on the timing and on the kinetics of the reaction of calcium hydroxide and the metakaolin inside the cement paste, so as to determine how much time is required to observe an effect of self-healing.

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