

FLEXURAL STRENGTH AND ELASTIC MODULUS RECOVERY IN SELF-HEALING CONCRETE REPAIRED BY INORGANIC SOLUTIONS

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Architects and master-builders have been using nature as a source of inspiration long before the terms bioinspiration or biomimetics were introduced. So, which new findings can this scientific discipline biomimetics offer to architecture? New options can only result from an in-depth analysis and comparison of architecture and nature, both from a broader and deeper perspective as well as on a functional and methodological level.

Natural materials are remarkably efficient because they fulfill the complex requirements posed by the biological functions and they do so using as little material as possible. Most natural materials are complex composites whose mechanical properties are often outstanding, considering the weak constituents from which they are assembled. Moreover, most natural materials are sustainable, recyclable and, when disposal is necessary, biodegradable, making them a model for environmentally conscious engineering. These complex structures, which have risen from hundreds of millions years of evolution, are inspiring Materials Scientists in the design of novel materials.

Most living tissues or organisms can heal themselves, provided the incurred damage is moderate. Most engineered materials are developed on the basis of the damage prevention paradigm and deteriorate with time irreversibly, which limits the life of various components and sometimes causes catastrophic damage. It would be then very desirable to implement the ability of self-healing in inorganic materials.

Concrete is the most widely used construction material over the world because of its high compressive strength and low cost. However, it is sensitive to crack formation because of its limited tensile strength. These cracks endanger the durability of concrete buildings as aggressive liquids and gases may penetrate into the matrix along them and cause further damage. Hence, inspection, maintenance and repair of concrete cracks are all indispensable. It has been estimated that, in United States of America, the annual economic impact is around at \$18-21 billion, in Asia at \$2 trillion, in Europe, 50% of the annual construction budget is spent on rehabilitation and repair of existing structures, and for United Kingdom, almost 45%. In case of Netherlands, one third of the annual budget is spent. For these reasons, the self-healing ability would be desirable for concrete.

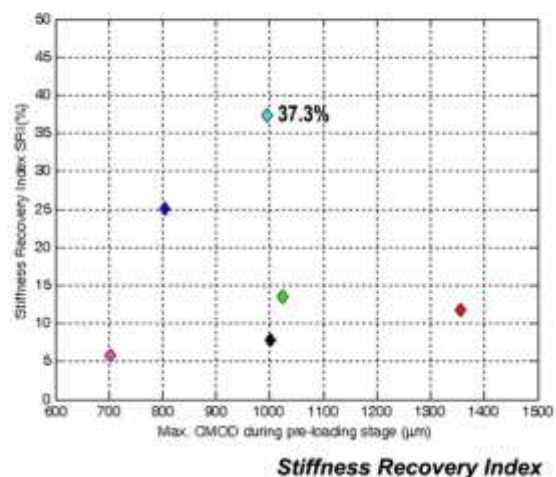
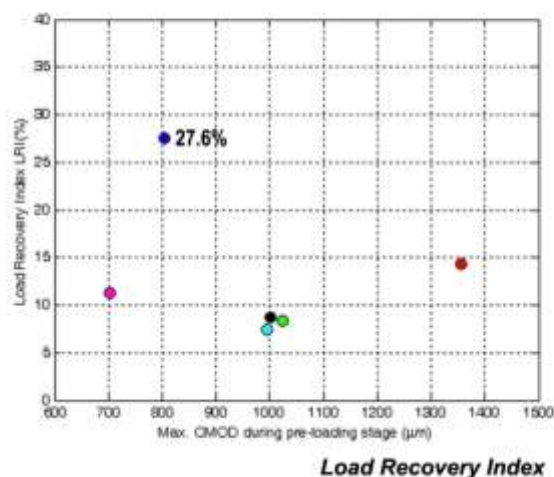
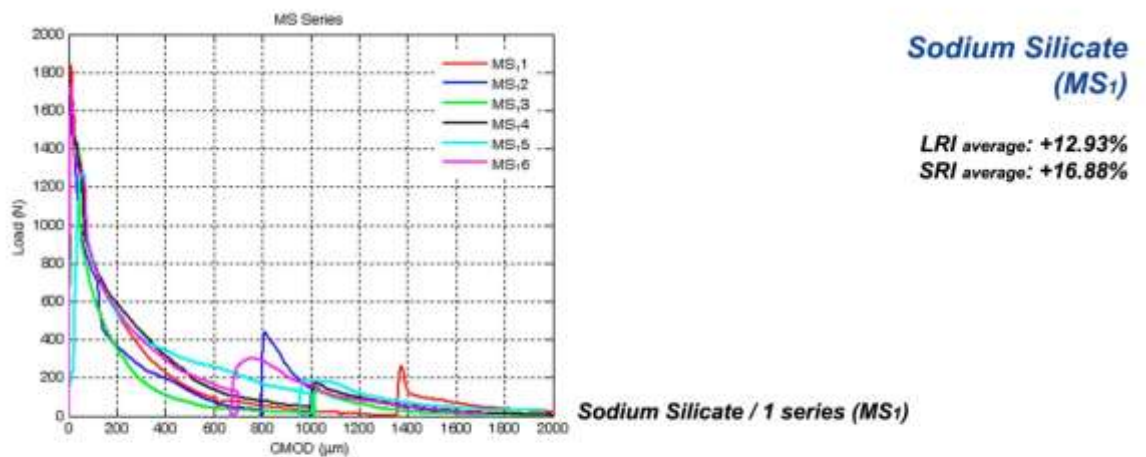
In this research, cementitious hollow tubes were produced by extrusion and used as healing agent containers that were embedded in the mortar matrix to obtain self-healing properties. Based on the results of preliminary mechanical tests, sodium silicate, potassium silicate and Primal (a commercial acrylic resin) were first selected as healing agents. To determine their efficiency, three-point bending test were

performed on samples with the different healing agents and load, as well as, stiffness recovery indexes were determined. It was first observed that modulus of rupture and elastic modulus were not affected because of the presence of the capsules inside the samples with respect to plain mortar samples.

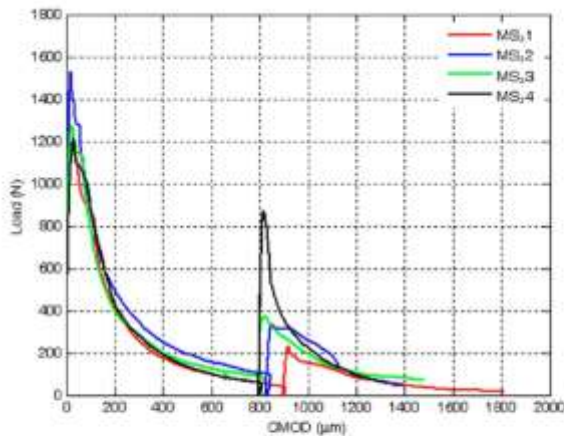


Fig. 1.: Production Process of the samples

The best results were achieved with the sodium silicate solution. The Load Recovery Index, ranged from +7.4% to +27.6% and the Stiffness Recovery Index, ranged from +5.8% to +37.3%, one month after damaging the samples.



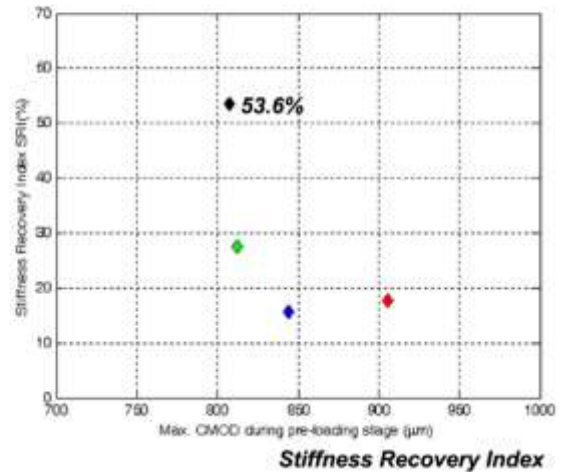
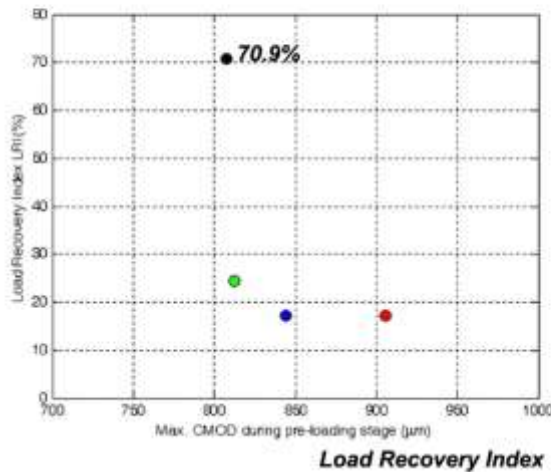
After six months of rest, the Load Recovery Index ranged from +17.1% to +70.9% and the Stiffness Recovery Index, ranged from +15.7% to +53.6%. A longer time for repairing seemed to increase the efficiency of sodium silicate as a healing agent.



**Sodium Silicate
(MS₂)**

LRI average: +32.43%
SRI average: +28.67%

Sodium Silicate / 2 series (MS₂)



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