ASSESSMENT OF THE CRACK HEALING CAPACITY IN BACTERIA-BASED SELF-HEALING CONCRETE

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ABSTRACT

Crack formation is a commonly observed phenomenon in concrete structures. Although micro crack formation hardly affect structural properties of constructions, increased permeability due to micro crack networking may substantially reduce the durability of concrete structures due to risk of ingress of aggressive substances (e.g. oxygen, water, chloride) particularly in moist environments [1]. This lead to the premature corrosion of steel reinforcement what results in high cost for preventive maintenance and repair. Under certain circumstances, small cracks in concrete can heal. This phenomenon is known as ‘autogenous healing’ of concrete. Precipitation of calcium carbonate has been reported to be the most significant factor influencing this autogenous healing. However, the maximum crack width which can undergo autogenous healing is in several studies estimated to be between 0.1 and 0.3mm, depending on exposure conditions [1-4].

The aim of the present study is the development and application of a bio-chemical self-healing agent to improve the crack self-healing capacity of concrete. The two-component bio-chemical healing agent is immobilized in expanded clay particles prior to addition to the concrete mixture. In this manner, the expanded clay particles not only represent an internal reservoir but also constitute both a structural element of concrete as well as a protective matrix for the self-healing agent. Such a system should increase the viability and thus the time-related functionality of the bio-chemical self-healing agent. Upon crack formation the two-component bio-chemical agent consisting of bacterial spores and calcium lactate are released from the particle by crack ingress water. Subsequent bacterially mediated calcium carbonate formation results in physical closure of micro cracks, what delays further ingress of water and decreases the inward diffusion rate of chloride and oxygen. Moreover, as the metabolically active bacteria consume oxygen, the agent may act as an oxygen diffusion barrier protecting the embedded passivated steel reinforcement against corrosion.

To compare the self-healing capacity of bacteria-based and control concrete specimens, the specimens were immersed in tap water after multiple cracks formation. In a first stage, weekly observations with stereomicroscope enabled the monitoring of the crack healing in time from a crack surface point of view. Then, the preparation of thin sections permits the observation and determination of the crack healing along the crack depth.

In parallel, the quantification of oxygen consumption of water submersed control- and biochemical healing agent-containing mortar specimens is performed with an optical oxygen microsensor. The measurements are performed on fresh fractured samples of 9 months-old specimens cured in tap water. These specimens are then stained using the Periodic Acid Schiff’s Reagent (P.A.S) staining procedure. This technique is applied to estimate the extent of microbial colonization [5]. Hence, compounds related to microbial activity/growth such as extracellular polymeric substances (EPS), glycogen, starch, glycolipids appear in pink to purple color.

Results quantitatively showed that, from a crack surface point of view, crack width up to 0.46mm were healed in bacteria-based concrete whereas the crack healing in control concrete was limited to crack width up to 0.18mm [6]. That the observed doubling of crack-healing potential was indeed due to
metabolic activity of bacteria was supported by oxygen profile measurements which revealed O\textsubscript{2} consumption by bacteria-based but not by control specimens [6]. The comparison and correlation of these results with those obtained with the thin sections analyses should provide an interesting assessment of the improvement of the crack healing capacity in bacteria-based concrete compared to normal concrete.

P.A.S staining revealed a pink coloration allover the specimen surface of bacteria-based concrete while only some located spot are stained on control specimen (Figure 1). This confirms the previous results that there is a bacterial growth and activity on bacteria-based concrete, contrary to control ones.

Figure 1: Observation with stereomicroscope. Bacteria-based concrete before (a) and after (b) staining. Control concrete before (c) and after (d) staining.

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REFERENCES