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Original Research Paper

Studies on the Development of Eco-friendly Self-healing Concrete - A Green Building Concept

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ABSTRACT

Cracks are the main cause for structural failure. One way to circumvent costly manual maintenance and repair is to incorporate an autonomous self-healing mechanism in concrete. This study exploited the potential to apply calcite-precipitating bacteria as a crack-healing agent in concrete. These bacteria were prepared in different cell concentrations and incorporated in the concrete mix. Compressive strength tests were performed at the stage of 28th day of curing. The effects of different cell concentrations of *Bacillus sphaericus* on concrete, reducing the crack, were studied. We used mortar cubes with 30mL of bacteria/mortar cube and sequentially increased up to 50mL (10, 20, 30, 40 and 50mL) in the ratio of mortar cubes in 1:6. The concrete grade used for the study was M25. At last, we had made concrete blocks of size 150×150×150 mm with concrete of grade M25. For those blocks, the compressive strength and non-destructive tests such as, rebound hammer and ultrasonic pulse velocity tests were performed. The results obtained in the work are that the compressive strength of blocks of size 150×150×150 mm is good when compared to control concrete. When load is applied to control concrete, the crack gets developed earlier and when bacterial concrete is used, the crack does not develop at an early stage.

INTRODUCTION

Concrete is a material, which is, by far the most used building material in the world. Concrete has a large load bearing capacity for compression load, but the material is weak in tension. That is why steel reinforcement bars are embedded in the material to be able to build structures. The steel bars take over the load when the concrete cracks in tension. The concrete on the other hand protects the steel bars from the attacks of the environment and prevent their corrosion. However, the cracks in the concrete are a serious problem. The "Bacterial Concrete" can be made by embedding bacteria in the concrete, that are able to constantly precipitate calcite. This phenomenon is called microbiologically induced calcite precipitation. Bacterial concrete refers to a new generation of concrete in which, selective cementation of porous media by microbiologically-induced $CaCO_3$ has been introduced for remediation of damaged structural formation or micro cracks. Recently, a novel concrete technology has been introduced, that is by incorporating biological approach in concrete (Henk 2007). Efficient sealing of surface cracks by mineral precipitation was observed when, bacteria-based solutions were externally applied by spraying onto damaged surfaces or by direct injection into cracks. These treatments resulted in regained material strength and reduction of surface permeability (Bang et al. 2001, De Muynck et al. 2008). An economical and practical perspective, autogenous self-healing is most attractive, the possibility to use viable bacteria as a matrix-embedded healing agent to obtain a truly self-healing system was explored (Jonkers 2007, Jonkers & Schlangen 2008). A major challenge in the latter approach was to identify bacteria, and their needed metabolic components, that are not only sustainable, but also do not negatively influence other concrete characteristics. This crossbreed between biology and engineering study of concrete is called bio-concrete, which involves the utilization of bacteria mineral precipitation to increase the strength and durability of the concrete (Ghosh et al. 2005). Bacterial induced calcium carbonate (calcite) precipitation has been proposed as an alternative and environmental friendly crack remediation, and hence the improvement of strength of building materials (De Belie et al. 2009).

The limited effectiveness appears to be largely due to the restricted expansive potential of exposed unhydrated cement particle surfaces as well as to the limited availability of CO_2 needed for the production of calcium carbonate-based minerals, which form the bulk of observed self-healing products (Li & Yang 2007, Nijland et al. 2007). Con-