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Autogenous healing on the recovery of mechanical performance of High Performance Fibre Reinforced Cementitious Composites (HPFRCCs): Part 2 – Correlation between healing of mechanical performance and crack sealing

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ABSTRACT

This paper is the second part of a companion paper study focused on the autogenous self-healing capacity of High Performance Fibre Reinforced Cementitious Composites (HPFRCCs). In part 1 investigation has focused on the capacity of the material to completely or partially re-seal the cracks, as a function of its composition, maximum crack width and exposure conditions. Different flow induced alignment of fibres, with respect to the applied bending stresses have been also considered. The outcomes of the self-healing phenomenon, have been analyzed in terms of recovery of stiffness, strength and ductility, as measured by means of 4-point bending tests, performed before (pre-cracking) and after the conditioning exposure. In a durability-based design framework, self-healing indices quantifying the recovery of mechanical properties were also defined and their significance cross-checked. In this paper the crack closure will be evaluated, both through visual image analysis of the healed cracks as well as through a tailored indirect method, proposed by the first authors in a previous study. This method is based on the comparative analysis of the damage evolution curves built for both the pre-cracked and the healed stages from the evaluation of the flexural stiffness. Recovery of mechanical properties will hence be correlated to the identified amount of crack closure. In the authors' opinion, this step represents a fundamental contribution in order to reliably and consistently incorporate the effects of self-healing into tailored durability-based design approaches, based, e.g., on a "healable" crack width threshold concept.

1. Introduction

Self-healing cement based materials are a valuable asset for the XXI century civil engineering, able to provide a technically effective and economically competitive solution to the increasingly urging problem of deteriorating and hence repair-needing building structures and infrastructure facilities.

The huge amount of research data produced in the last decade [1,2] have made it possible the realization of the earliest demonstrative prototypes (the self-healing concrete pavilion in Breda, The Netherlands, [3]). but also a few pioneer full scale applications. Among these the following are worth citing: an irrigation canal built in Ecuador (a synergy between TU Delft and Universidade Catolica de Santiago de Guayaquil, [4]) with self-healing concrete containing bacteria; the underground/underwater structures of the Changi airport in Singapore where the use of crystalline admixtures, originally meant as porosity reducers for waterproofing also resulted into an effective crack sealing activity [5]; and a highway strip in the Netherlands A58 made with self-healing porous asphalt [6,7].

Evidence of the ability of the different aforementioned self-healing techniques to seal the cracks, depending on their width, exposure conditions etc. has been widely proved in the laboratory. In very recent years interest and concern has also arisen in the engineering community about the efficacy of these techniques not only to seal the cracks and restore material imperviousness to the

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Table 1
Mix-design of HPFRCC.

Constituent	Dosage (kg/m^3)
Cement	600
Slag	500
Sand (0–2 mm)	982
Water	200
Superplasticizer	33 (l/m^3)
Straight steel fibres (l_f = 13 mm; d_f = 0.16 mm)	100

ingress of water and other aggressive harmful substances but also to “heal” the material. This refers to the ability of providing a (partial) recovery of the pristine level of engineering and mechanical performance, in terms of, e.g., load and deformation capacity, stiffness etc., which are evidently impaired by cracks and damages [8].

As a matter of fact such a capacity of healing the material properties will depend not merely on the amount of crack healing but also on the nature of the healing products, and hence on the

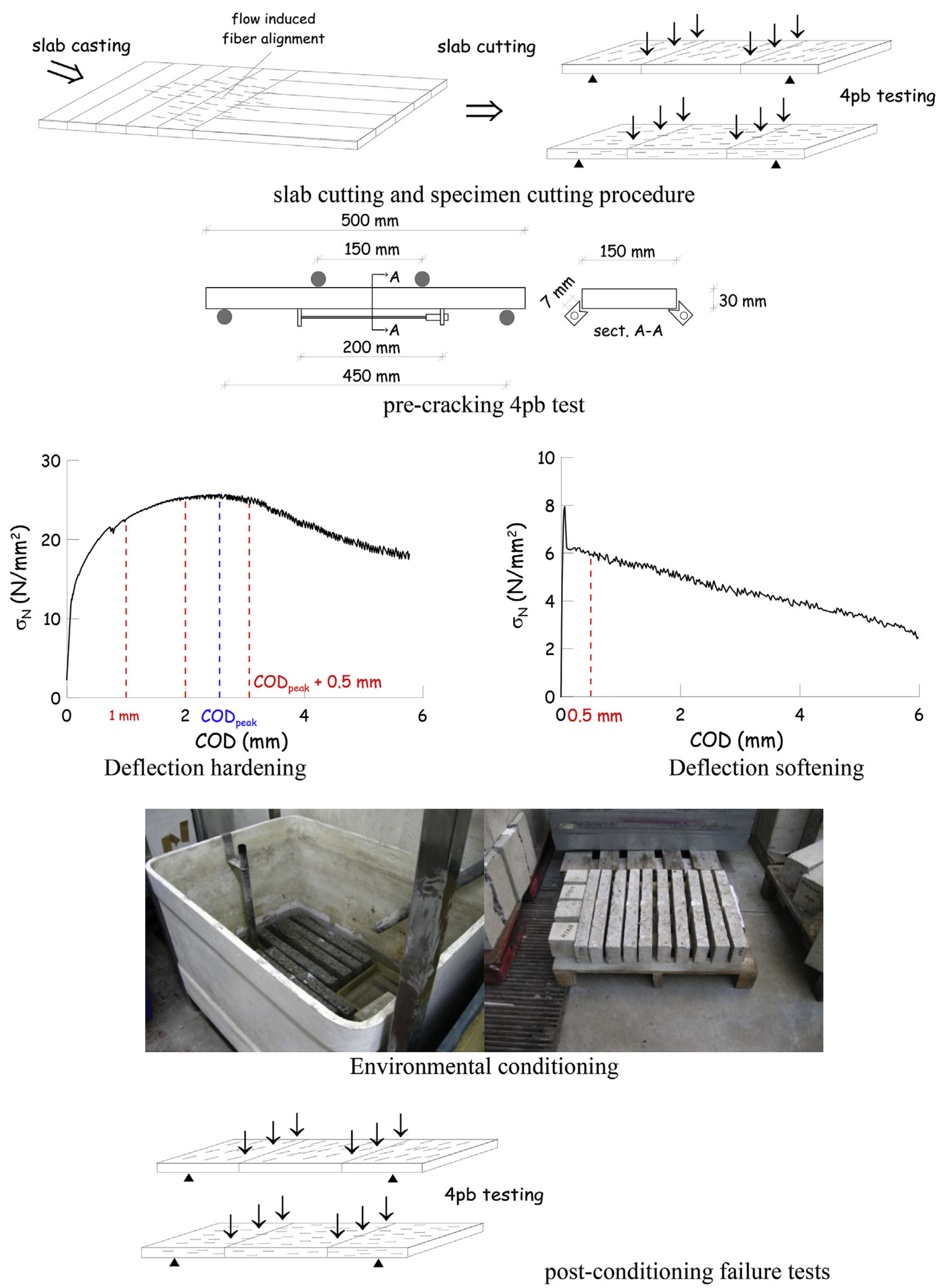

Fig. 1. Schematic of the experimental programme.