

DEVELOPMENT OF A SELF- HEALING SKIN FOR MORE DURABLE CONCRETE STRUCTURES

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ABSTRACT

The development of a self-healing skin for concrete is investigated as an innovative system and an alternative structural solution for more durable constructions with longer service life. Textile Reinforced Concrete (TRC) and fibre reinforced Inorganic Phosphate Cement (IPC) skins are capable to reduce the width of the cracks occurred during loading. IPC and TRC component could be used as a thin ply to cover and reinforce concrete elements (beams) in areas where damage and crack propagation is expected. During the loading of a concrete specimen, cracks firstly appear at the matrix of the composite. In order to achieve self-healing (SH) procedures at the regions of damage of the skin and protect the RC element from crack propagation hollow glass fibres (HGF) filled with healing agents (resin and catalyst/hardener) can be integrated in the cover. At a critical crack width the HGF break and release agent. Bleeding of healing agent into the crack bridges the two sides of failure. To monitor and become aware of internal damage, cracking process, rate of degradation and recovery of the mechanical properties after healing (future work) Non Destructive Techniques as Acoustic Emission and Digital Image Correlation are used.

Cracks in Reinforced Concrete structures reduce service life since they lead to corrosion of the reinforcements and deterioration of the concrete. Consequently, making more durable concrete constructions which allow less maintenance, longer service life, requiring less cement and thus reducing the environmental impact is an ever increasing concern for engineers. From a practical implementation viewpoint, studies have shown that self healing (SH) in concrete is managed only in regions of damage with tight crack width, likely less than 100-150 μm , which is very difficult to achieve in a consistent manner for concrete in the field. In our work, the feasibility of yet another solution to the problem is investigated namely the use of two glass fibre reinforced cementitious composite skins as a self healing systems which are able to limit the crack width to less than 50 μm (ideal for the healing efficiency). At the same time the skin will contain hollow glass fibres (HGF) filled with healing agents.

Over the last years researchers in VUB-MeMC have been developing a chemically bonded Inorganic Phosphate Cement (IPC) for structural applications. IPC is a room hardening, non alkaline, two component ceramic system (mixture of reactive powder and liquid) which after hardening, has material's properties similar to those of cement based materials. The IPC cementitious composite is combined with glass fibre reinforcement, producing very thin laminates with small crack width (<10 μm) at failure. Actually, the thickness of a single ply laminate can be 0.3mm. Few laminates of IPC were combined to prepare concrete reinforcement skin achieving strain at failure of 1%.

On the other hand, TRC is a composite material comprises a cementitious matrix made of high strength fine grained concrete and alkali resistant (AR) glass fibre reinforcement. AR – glass filament yarns are set in concrete in the form of textile grid structures between thin layers of the cementitious medium and reach about 1% of the total component volume. Crack propagation of TRC elements with thickness of 10-20 mm with many applications as a lightweight skin of reinforcement in concrete structures is investigated. Following the ACK theory, during loading firstly macro-crack appears in the cementitious mortar and later micro-cracking (5-10 μm) begins while textile reinforcement carries the

occurring forces. The load transfer from the matrix to the reinforcement can be more ductile with an innovative system that can obtain finer crack pattern limitation of micro-cracking.

Achieving the appropriate crack pattern on these two skin reinforcement systems, the second part of this study is focused on searching for the conventional healing mechanism. Hollow glass fibres (HGF) are “tube like” continuous structural fibres and will be used filled with healing agent for this purpose. The outer diameter ranges from 10 to 60 μm , the length ranges from few mm to several cm and the hollowness from 50 to 65%. They offer increased flexural rigidity, higher compressive strength and a greater capacity of “tailoring” by adjusting the wall thickness or the degree of hollowness in order to contain more healing agent. The agents contained within the fibres have been either a one-part adhesive, or a two- part system (resin and hardener). Resin and hardener can be loaded separately in adjacent fibres or one might be embedded into the matrix and the other inside fibres. As the fabrication process is similar to glass fibre reinforced polymer matrix composites (for instance hand lay-up) it is expected that HGF can be easily integrated into the IPC and TRM cementitious composite without damaging the fibre. During the loading of both cementitious specimens, cracks firstly appear at the matrix. At a critical crack width the hollow fibre should break and release agent into the crack plane through capillary action.

The ability to “see” and become aware of the failure behavior of the two skin reinforcing systems is critical in our effort to apply the appropriate mechanism of healing. On this direction, the primary stage of the study presented on this conference is focused on the investigation of crack propagation in IPC and TRM specimen by the use of different Non Destructive Techniques (NDT).

More specifically, Acoustic Emission (AE) could be a useful tool to understand the failure mechanism of concrete under external loading since analyzing the complex AE activities of our heterogeneous composite can give a reasonable explanation of deformations and failure process. At the cracking process, by investigating the AE source distribution with the use of the signal approach method, reduction of energy and amplitude of the focused signal is observed by the sensor system. At the following healing stage, the sensor system is expected to observe recovery of the focus signal and the healing efficiency will be investigated by comparing the impedance spectra of the sensor system before and after the HGF activation. Simultaneously, a Digital Image Correlation (DIC) system is used for optical measurements. According to these techniques, 2D or 3D deformation fields of the surface of the specimen could be obtained from the comparison of digital images. Visualisation of the crack propagation and measurement of strain distribution at the virgin unhealed specimen of TRM and IPC skin give in details the fracture and crack opening of these two cementitious composites. In the future, the results of the optical analysis will be compared with the behaviour of the healed specimen.

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