The Institution of Structural Engineers

International HQ
11 Upper Belgrave Street
London SW1X 8BH
United Kingdom
tel: +44 (0)20 7235 4535
fax: +44 (0)20 7235 4294
mail@istructe.org
www.istructe.org

2012 MSc Research Grant Scheme

Project title: Combined chemical/biological healing of cementitious materials

University: Cardiff University

Supervisor: Dr Michael Harbottle

Student: t.b.a.

Aims of research: Healing of cementitious materials using chemical or biological techniques is of current research interest. Cracking in these materials, which adversely affects the durability of the material, is addressed by plugging the gap either with chemical reaction products (e.g. cyanoacrylates) or products of microbiological metabolism (e.g. calcium carbonate). We will explore the efficacy of a novel, non-toxic, environmentally sustainable and inexpensive chemical reactant, sodium alginate, in providing a combined chemical and biological solution to crack healing, both immediately and also in the longer term.

Description of method: The proposed experiments are described below. A number of small-scale concrete specimens will be prepared from normal strength concrete, with and without artificial cracks, and cured under water for 7 days. Commercially available sodium alginate will be used as the initial healing agent. Sodium alginate is a soluble, non-toxic polymeric salt extracted from seaweed, which reacts with calcium ions (such as those present in concrete) to form an insoluble calcium alginate gel upon contact. Initial testing has shown that the gel can mobilise a significant tensile strength as well as limiting moisture ingress. The gel is in turn biodegradable - CO2 is a breakdown product, which will dissolve readily in any available moisture to form carbonate ions in the high-pH environment. It is expected that this will subsequently form mineral calcium carbonate as a permanent barrier in the crack.

Planned experiments can be divided into two broad areas of work:
(i) Application of sodium alginate solution to cracked specimens to explore its behaviour in terms of abiotic healing and subsequent mechanical properties. This will include the effect of sodium alginate concentration (and therefore rheology) on ability to heal cracks of various sizes. Strength development of the subsequent calcium alginate gel will be determined in similar situations. It is envisaged that a simple programme of three-point bending tests will be employed.
(ii) Longer term experiments will investigate biological growth on solid alginate both on concrete surfaces and in cracks, particularly in terms of development of biological mineralisation mechanisms. The bacterium Pseudomonas fluorescens will be used as a model degrading organism. These specimens will be incubated in a moist environment to encourage microbial growth, using the alginate as a source of nutrition. Analysis will be via microscopy (SEM and optical/fluorescent), x-ray diffraction for mineral analysis and additional simple biochemical tests.

Benefits to structural engineering: The proposed work offers a simple and inexpensive method for maintenance of concrete in service, with the potential for the technique to be introduced automatically through a self-healing system. Using only simple chemicals (extracted from seaweed) and natural biochemical processes, this process will enhance the durability of concrete structures, making it an especially sustainable process on all levels. As noted by W.F. Baker (The Structural Engineer, 21st July 2008), such novel materials and embracing the self-healing capacity of existing materials are part of the future of structural engineering and will 'engender new structural solutions' as well as offering economic benefits.

Proposed finish date: 09/2012