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A numerical approach for simulating damage, healing and capillary flow in cementitious materials

Tony Jefferson[†] and Brubeck Freeman[†]

[†] Cardiff University, School of Engineering
Queen's Buildings, The Parade
Cardiff, CF24 3AA, UK
e-mail: JeffersonAD@cardiff.ac.uk
e-mail: FreemanBL@cardiff.ac.uk

ABSTRACT

Damage and healing processes in self-healing cementitious materials can occur simultaneously, which implies that a comprehensive damage-healing model should not be based on the assumption that the two processes can always be decoupled. However, a number of damage-healing models employ restrictive assumptions that do partially –or fully- separate these two processes[1]; for example, a number of models assume that (i) healing always takes place under zero-strain conditions, and (ii) healing and damage are never concurrent. There are scenarios for which these assumptions may be reasonable but there are many other situations which cannot be properly simulated with such restrictive assumptions. Simultaneous damage-healing behaviour has been observed in a number of experimental test series, including in a set of tests undertaken at Cardiff University on concrete samples with inbuilt vascular networks containing cyanoacrylate[2]. The present contribution describes a new model that addresses this issue. The approach adopts a crack-healing cohesive zone formulation in which both the damaged and healed proportions of the cohesive zone can both grow and diminish. The cohesive zone model is implemented in a finite element with strong discontinuity and coupled to a capillary flow model. The flow model simulates the transport of healing agents within the damage zone[3]. A particular feature of the approach is the way that flow and curing of the healing agent is tracked within the damage zones, which encompass both virgin damage zones as well as regions that have re-damaged after healing. Another important aspect of the damage-healing component of the model is the way that permanent strains are computed so as to satisfy the second law of thermodynamics. The new coupled model is assessed using data obtained from a number of recent experiments conducted at Cardiff University. The main conclusion from the work is that the new model is able to represent multiple and simultaneous damage-healing *events* with good accuracy.

REFERENCES

[1] Jefferson AD, Javierre E, Freeman BL, Zaoui A, Koenders EAB, Ferrara L (2018). Research progress on numerical models for self-healing cementitious materials Advanced Materials Interfaces, Accepted for publication 24/01/2018

[2] Joseph C, Jefferson AD, Isaacs B, Lark RJ and Gardner DR. (2010). Experimental investigation of adhesive-based self-healing of cementitious materials. Magazine of Concrete Research 62(11), 831-843.

[3] Gardner D, Jefferson AD, Hoffman A and Lark R. (2014). Simulation of the capillary flow of an autonomic healing agent in discrete cracks in cementitious materials. Cement and Concrete Research 58, 35-44.