Zero-Thickness Interface Formulation for Fracture Analysis of Self-Healing Concrete

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ABSTRACT

Worldwide increasing consciousness for sustainable use of natural resources has made a challenging task the apparently contradictory requirements of using low cost materials and at the same time with high performance in the field of Structural Engineering. The importance of sustainability as a requisite which has to inform structure concept and design has been also recently highlighted in the new Model-Code (2010) [1]. In this context, the availability of self-healing technologies, by controlling and repairing early-stage cracks in concrete structures, where possible, could, on the one hand, prevent permeation of driving factors for deterioration, thus extending the structure service life, and, on the other hand, provide partial recovery of relevant engineering properties of the material.

A discontinuous-based poro-mechanical model for concrete subjected to time-evolution self-healing phenomena is presented in this work. The model is an extension of a fracture energy-based elastoplastic interface formulation which now includes porosity evolution induced by self-healing mechanisms [2]. The formulation accounts for the characterization of concrete failure behaviour under mode I and II types of fracture. Therefore it is considered by means of specific work softening rules in terms of work spent and porosity evolution. Self-healing processes have also been investigated through an experimental program on normal strength concretes under different types of exposure: i.e., air exposure and water immersion. The effects of the self-healing phenomena on the recovery of stiffness and load-bearing capacity have been evaluated by means of three-point bending tests performed up to controlled crack opening and up to failure, respectively, before and after conditioning [3]. Those tests have been employed as benchmark to validate the proposed model formulation. Particularly, after outlining the mathematical formulation of the constitutive model for interface elements, numerical analyses are presented to validate its soundness and capability against the aforementioned experimental results.

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REFERENCES

[1] new Model Code 2010 - First complete draft, Vol. 1. Comite Euro-International du Beton-Federation International de la Precontrainte, Paris, (2010).

[2] I. Carol, P. Prat and C. Lopez, "Normal/shear cracking model: Applications to discrete crack analysis", *J. of Engrg. Mechanics - ASCE*, **123**, 765-773 (1997).

[3] L. Ferrara L., V. Krelani and M. Carsana, "A fracture testing based approach to assess crack healing of concrete with and without crystalline admixtures", *Construction and Building Materials*, **68,** 535–551 (2014).