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Fracture simulation with coupling moisture diffusion effect and external loading in fiber reinforced cementitious composites

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Summary

Fiber reinforced cementitious composites (FRCC) are the most recently used materials in the civil engineering field due to their mechanical advantages over the cementitious materials. While, the durability performance of cement-based composites can affect the service life of the structural component or system. Sometimes, incompatible behaviors (e.g. thermal expansion, moisture diffusion) among components cause micro-cracking and further durability problems. Physical experimentations have generally been used for understanding the durability of cementitious composites, but increasingly computational simulations are being used to gain new insights. However, the most of existing simulation models are limited in coupling with micro-cracking due to moisture diffusion effect and fracture behavior of cemenetitious composites. Moreover, the phenomena in FRCCs are not enough understood yet by model-based simulations.

In this study, three-dimensional random lattice models are used to simulate the moisture transfer process in, and the load-deformational behavior of cementitious composites. The Delaunay-Voronoi tessellation is applied for discretizing both physical domains and to couple these two models in simulating hygral-mechanical problems, such as fracture induced by drying shrinkage [1]. A semi-discrete fiber model [2] is used to form lattice models of fiber reinforced cement composites. This enables analyzing the behavior of an individual fiber, and collection of fibers within the composite material.

This study presents the simulations of the fracture behavior of FRCC due to external loading condition with micro-cracking and internal stress differences caused by moisture diffusion such as drying shrinkage in cementitiouus composites. The results are verified through comparisons with cementitious experimental works [3,4]. Finally, the fracture behaviors of the FRCC "dog-bone" are simulated during the shrinkage with various volume fractions, lengths, and shapes of fibers. The maximum crack width, crack development time, and crack plots are produced in order to present the advances of fiber reinforcement in the shrinkage of FRCCs.

References

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