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RESEARCH ARTICLE

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3-D mesoscale simulation of crack-permeability coupling in the Brazilian splitting test

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Summary

In this paper, mesoscale hydromechanical simulations are performed to study (1) fracture features and (2) crack-gas permeability coupling evolution in the context of the tensile splitting test. The mesostructure is based on a 2-phase 3-D representation of heterogeneous materials, such as concrete, where stiff aggregates are embedded into a mortar matrix. To take into account these heterogeneities without any mesh adaptation, a weak discontinuity is introduced into the strain field. In addition, a strong discontinuity is also added to take into account microcracking. This mechanical model is cast into the framework of the enhanced finite element method. Concerning the coupling with gas permeability, a double-porosity method is used to simulate the flow through the cracks and the porosity. The apparent gas permeability is afterwards evaluated by a homogenization method. On the basis of finite element simulations, influence of aggregate size on ultimate crack opening, macroscopic ultimate tensile stress, total dissipated energy, and gas permeability evolution is numerically investigated. Furthermore, gas permeability evolution is also compared with experimental results from the literature. In addition, in the spirit of a sequential multiscale approach, macroscale gas permeability equations are identified from the hydromechanical results coming from the mesoscale computations. These equations lead to a relation between macroscale gas permeability evolution and crack opening. Besides, we show how the aggregate size influences the percolation threshold and that after this threshold, a cubic relation between macroscale gas permeability and crack opening is obtained.

KEYWORDS

aggregate size, Brazilian test, cracking, durability, E-FEM technique, gas permeability, strong discontinuity approach

1 | INTRODUCTION