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Meso-scale analysis of the aggregate size influence on the mechanical properties of heterogeneous materials using the Brazilian splitting test

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Abstract

The effect of the aggregate size on the behavior of the hardened concrete under splitting tensile loading is studied in this paper. The studies of Tasdemir et al., 2001 [19], Appa et al., 2011 [2], Li et al., 2014 [13] show that the behavior of heterogeneous materials which are subjected to loading depends on many parameters such as volume fraction, aggregate type, and aggregate size, etc. In this paper an investigation was made to study the effect of aggregate size on the mechanical properties of heterogeneous materials such as concrete in the context of the Brazilian splitting test.

Five finite element simulations have been carried out in this research to study the behavior of concrete under diametral compression load. Cylinder specimens of concrete with 50 mm of thickness and 110 mm of diameters have been regarded. Five diameters of aggregate have been employed in the analyses, ranging from 4 to 16 mm.

This study has employed a meso-scale model (mechanical model) based upon a 3D lattice approach, representing with explicitly heterogeneity and failure mechanism of the concrete. This model considers the concrete to be a two-phase material in which aggregates are melt within the cement paste. Because of using a non-adapted meshing process to mesh the microstructure, a weak discontinuity (jump in the deformation field) is introduced in the kinematics.

The results of the numerical simulations show the ability of the meso-scale model to evaluate the mechanical failure in the context of the Brazilian splitting test. Also, the results show that (1) the maximum tensile stress, (2) the fracture energy and (3) the maximum crack opening are all have been increased when the aggregate diameter was increased.

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Keywords: Brazilian test, heterogeneous materials, meso-scale model, weak discontinuity, strong discontinuity, aggregate size.