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Meso-scale investigation of failure in the tensile splitting test: Size effect and fracture energy analysis

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ABSTRACT

In this paper, a meso-scale analysis is performed (1) to study the size effect on the nominal stress at failure and, (2) to quantify the evolution of the fracture process zone (FPZ) in the context of the tensile splitting test. The meso-structure is based on a two-phase 3D representation of heterogeneous materials, such as concrete, where stiff aggregates are embedded into a mortar matrix. In order 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 micro-cracking. This model is cast into the framework of the Enhanced Finite Element Method (E-FEM). Based on the Finite Element simulations, size effect on the nominal stress at failure is numerically investigated and then compared to the so-called Bažant size effect law. In addition, an analysis based on the spatial distribution of the fracture energy is also regarded, leading to the 3D representation of the FPZ and to its volume value estimation.

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1. Introduction

Like all brittle-type failures of concrete, tensile splitting test failure can be expected to exhibit a size effect. In general, size effect is studied in terms of nominal stress at failure σ_N versus size of the specimen. On one hand, the experimental works of Lundborg [1], Sabnis and Mirza [2], Hasegawa et al. [3], Chen and Yuan [4] and Ross et al. [5] all stress that the tensile splitting test strength depends on a characteristic dimension chosen as the cylinder diameter. On the other hand, as pointed out in Bažant [6], this size effect on the nominal stress can be approximately described by the so-called Bažant size effect law:

$$\sigma_N = \frac{Bf_t}{\sqrt{1+\beta}}, \tag{1}$$

where σ_N is the nominal stress at failure, f_t is a strength parameter - for instance the direct tensile strength, β is the brittle-