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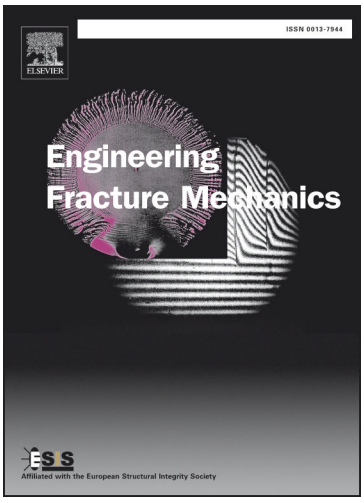


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# Determining initial fracture toughness of concrete for split-tension specimens based on the extreme theory

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**Abstract** A theoretical method to determine the initial fracture toughness $K_I^{ini}$ of concrete for central-notched split-tension specimens was developed based on the extreme theory. In this method, the $K_I^{ini}$, critical crack tip opening displacement $CTOD_c$, and half critical effective crack extension $\Delta a_c$ could be obtained by the experimental peak load of a single specimen. The measurement of critical crack mouth opening displacement $CMOD_c$ was unnecessary in this method. The fracture parameters were calculated using the cube and cylinder split-tension specimens. Results showed that the values of $K_I^{ini}$ obtained by the proposed method were slightly smaller than those obtained by the double-*K* method, and the difference between them generally decreases with the loading rates. And the values of $CTOD_c$ and $\Delta a_c$ obtained by the proposed method were more stable compared with those obtained by the double-*K* method.

**Keywords** Concrete; Initial fracture toughness; Central-notched split-tension specimen; Extreme theory; Dynamic load.

## 1. Introduction

A nonlinear micro-cracking zone or fracture process zone (FPZ) exists at the tip of a crack in quasi-brittle materials, such as concrete. The FPZ results in the size effect of fracture parameters if the FPZ is not sufficiently small compared with the specimen size [1]. In this case, the classical linear elastic fracture mechanics (LEFM) is not applicable to quasi-brittle fracture. Thus far, several nonlinear fracture models have been proposed to determine the fracture parameters and characterize the FPZ. These approaches primarily involve the fictitious crack model [2], crack band model [3], two-parameter fracture model [4], size effect law [5], effective crack model [6, 7], and the double-*K* fracture model [8].

The fictitious crack model [2] and crack band model [3] both consider the softening of material in the FPZ. The fictitious crack model proposed by Hillerborg et al. [2] divided the crack

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