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The fracture extreme theory for determining the effective fracture toughness and tensile strength of concrete

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Abstract: A theoretical method for determining the effective fracture toughness K_{IC}^{e} and tensile strength f_t of concrete was proposed based on the fictitious crack model. With the fracture extreme theory (FET), only the experimental peak load of one specimen in fracture test is required for the calculation. The application of the proposed method was illustrated by the three-point bending notched concrete beam. The K_{IC}^{e}, f_t, critical crack tip opening displacement $CTOD_c$, and critical crack propagation length Δa_c of beams with different initial notch ratio a_0/h were obtained. The results obtained by the proposed method were in good agreement with those by the experimental data and existing analytical method, which confirmed its applicability. And the calculated values of K_{IC}^{e} are insensitive to a_0/h using the proposed method.

Keywords: Effective fracture toughness; Tensile strength; Fracture extreme theory; Three-point bending beam; Fictitious crack model

1. Introduction

It's widely recognized that an obvious fracture process zone (FPZ) exists at the crack tip in quasi-brittle materials, such as concrete, rock, tough ceramics, and fiber composites. The existence of FPZ results in its very complicated fracture mechanism. Hence, the linear elastic fracture mechanics (LEFM) is not applicable to quasi-brittle fracture if the FPZ is not small enough compared with specimen size [1]. Since Kaplan [2] firstly applied the fracture mechanics to concrete, a number of fracture models have been established and used to predict the nonlinear fracture behavior of concrete, such as fictitious crack model (FCM) [3], crack band model (CBM) [4], two parameter fracture model (TPFM) [5], size effect model (SEM) [6, 7], effective crack model (ECM) [8, 9], double-*K* fracture model [10], and boundary effect model (BEM) [11–14], among others.

The FCM [3] proposed by Hillerborg et al. treated FPZ as a fictitious crack which can transfer cohesive

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