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Characterization of Mixed-Mode Fracture of the Mortar by using SCB Specimens: Experimental and Numerical Studies

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Abstract

A broad experimental and analytical effort using fracture mechanics as the prime tool was conducted to investigate and improve the understanding of the mixed-mode fracture behavior of a mortar. As a part of experimental efforts, mixed-mode fracture tests were performed using semi-circular specimen containing an edge crack under three-point-bending (*SCB*) specimen which by varying the direction of crack to load, mode-I, mixed-mode and mode-II fracture data were obtained. Finite element analyses were also carried out on *SCB* specimens. The main objective of this study was to determine the fracture toughness K_C and strain energy release rate G_C under mixed-mode loading conditions. Fracture toughness obtained at different mixed mode loading conditions were also discussed.

Keywords: Fracture mechanics, Mortar, Mixed mode, Finite element analysis.

1. INTRODUCTION

The applications of fracture mechanics to concrete were studied by Kaplan in 1961 [1]. Cement based composite is considered as a brittle or quasi- brittle material, primarily because of its low tensile strain capacity and poor fracture toughness [1-3]. For a given defect, crack propagation may be accomplished in opening-mode (mode-I), shearing-mode (mode-II), and tearing-mode (mode-III) (Fig. 1). Fracture mechanics can be applied to many engineering fields including civil and mining engineering. The principles, methods and techniques of fracture mechanics can play an important role in the analysis, design and construction of many civil engineering structures and have been investigated by many researchers, for review see e.g. [4]. The purpose of fracture-toughness testing of mortar is to determine the value of the critical stress intensity value, or fracture toughness K_C. Fracture toughness is the resistance offered by a material against crack propagation. A number of test methods have been proposed by many researchers to determine fracture toughness of cement based composite. In this study, among many different testing methods for mortar, the semi-circular bending (*SCB*) specimen was used. This investigation seeks to extend understanding of the mortar fracture behavior under mixed-mode loading conditions through numerical and experimental analysis. Using finite element results, correction factors were applied to the mortar specimen and a third- order polynomial fit was proposed to evaluate the stress-intensity factors of *SCB* specimen with a crack subjected to mixed-mode loading conditions. The main objective of this study was to determine the fracture parameters K_C and G_C for the mortar under consideration for a wide range of mixed-mode loading conditions.

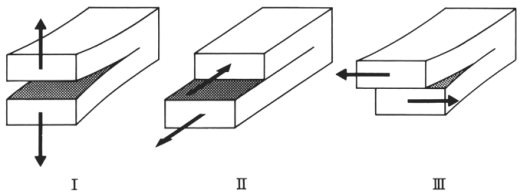

Figure 1. The three modes of fracture.

2. FE ANALYSIS OF MIXED-MODE FRACTURE

The method used to calculate the stress intensity factor was an interaction J-integral method performed in *ABAQUS*, and is required to separate the components of the stress intensity factors for a crack under mixed-mode loading in conjunction of finite element analysis. The method is applicable to cracks in isotropic and