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On crack extension velocity in concrete SCB specimens: effects of aggregate size and fracture mode mixity

Rashid Afshar [a], Lohrasb Faramarzi [a,b,*], Mirmilad Mirsayar [c], Navid Omidvar [c]

[a] Department of Mining Engineering, Isfahan University of Technology, Isfahan, Iran
[b] State Key Laboratory for Tunnel Engineering, China University of Mining and Technology-Beijing, Beijing 100083, China
[c] Department of Aerospace, Physics, and Space Sciences, Florida Institute of Technology, USA

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ABSTRACT

In this paper, mixed-mode (I/II) fracture behavior and crack extension velocity (CEV) of concretes with wide range of aggregate sizes up to 20 mm in diameter are investigated using cracked semi-circular bend (SCB) specimens. Leveraging innovative electrical circuit implementations, the effect of different loading conditions including pure mode I, pure mode II, and mixed mode (I/II) as well as aggregate sizes on the crack extension velocity is comprehensively evaluated. The results showed that the mode of fracture and aggregate sizes remarkably influence crack extension velocity. Increasing the aggregate size from 0-5 mm to 0–19 mm resulted in mean CEV increases by factors of 3, 2.8, 2.33, 2.62, and 2.52 under different loading conditions including {$\beta = 0^{\circ}$ (pure mode I), 10°, 20°, 30° and 40° (pure mode II)} respectively. The effects of aggregate size on the fracture path and fracture toughness are experimentally obtained and compared to two criteria including extended maximum tangential strain (EMTSN), and minimum strain energy density (SED) criteria. The accuracy of these strain-based and energy-based mixed-mode I/II fracture criteria in prediction of the experimental results are discussed for specimens with varying aggregate sizes.

1. Introduction

Concrete components and structures generally contain microcrack networks due to their fabrication nature. The inherent cracks might grow unsteadily which in turn jeopardize structural integrity. Additionally, the quasi-brittle and heterogeneous nature of these materials adds to their complexity as a three-phase composite material consisting of a matrix, aggregate, and an interfacial transition zone (ITZ). The fracture mechanics framework is a requisite tool to address these issues and is widely used to predict and prevent catastrophic failures in engineering structures, especially those made from cement-based materials [1]. However, assessing concrete materials resistance to crack formation and propagation still is a challenge for engineers. In general, rocks and concrete as cement-based quasi-brittle materials often exhibit different fracture behaviors with respect to their mineral composition, loading conditions, specimen size and geometry, aggregate size and configuration, loading rate, moisture content, porosity, and the matrix [2–6]. Within the scope of this study, loading conditions, and aggregate size are given greater focus to be studied. The loading conditions play a significant role in the amount of elastic energy stored at the crack tip [7]. Therefore, understanding how different loading conditions

* Corresponding author at: Department of Mining Engineering, Isfahan University of Technology, Isfahan, Iran.
E-mail addresses: afshar.rashid@mi.iut.ac.ir (R. Afshar), lfaramarzi@iut.ac.ir (L. Faramarzi), mmirsayar@fit.edu (M. Mirsayar), nomidvar2024@my.fit.edu (N. Omidvar).

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