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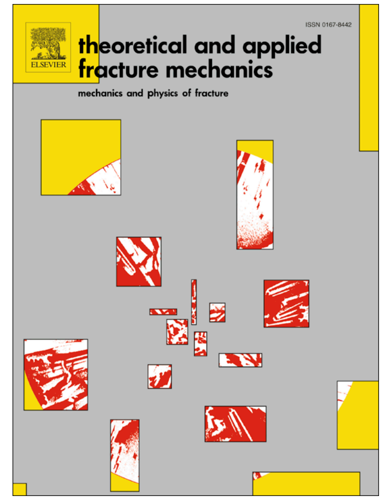

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Broad-spectrum fracture toughness of an anisotropic sandstone under mixed-mode loading

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Keywords: Broad-spectrum fracture toughness; Anisotropic rocks; Mixed-mode loading; Discrete Element Method; Fracture criteria

Abstract

Fracture toughness of anisotropic rocks can vary with many factors such as geological anisotropy, geometrical properties of specimens used in the laboratory (e.g., pre-existing crack properties), and loading conditions. This fact has been widely acknowledged. Yet the variation in fracture toughness remains enigmatic, as there is still lack of a comprehensive study on how those influential factors affect fracture toughness behavior of anisotropic rocks. The present paper shows a broad-spectrum mixed-mode fracture toughness of an anisotropic sandstone from a numerical scheme, which is based on the Discrete Element Method (DEM). In this study, a total of 340 semi-circular bend (SCB) specimens with various geological and geometrical conditions were numerically prepared by systemically varying the orientations of planar anisotropy (i.e. incipient bedding plane), as well as the magnitudes of the ISRM-suggested geometrical parameters of the SCB specimens (i.e. crack length, crack angle, and span length). The numerical model used in the study was calibrated against a series of laboratory experiments to select proper micro-parameters to reproduce the mechanical characteristics of anisotropic Midgley Grit sandstone (MGS). Additionally, four different fracture criteria, which are based on stress and strain analysis, and the analysis of energy density, were used to predict the mixed-mode fracture behaviour of MGS. Numerical findings from this study were compared with experimental