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Mode I fracture toughness determination of granite specimens using pseudo-compact tension method

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ABSTRACT: Mode I fracture toughness (KIC) is one of the most important parameters in the fracture mechanics of brittle material. Several laboratory methods have been suggested to determine the mode I fracture toughness. However, many of these methods deal with the lengthy sample preparation procedure, premature failure of samples, and difficulties in obtaining the precise value of the fracture toughness property. In this paper, a recently proposed pseudo-compact tension method is used to evaluate mode I fracture toughness of a middle-grain granite benefiting the advantages of this method including; simplicity of the test, high level of test control, and high accuracy of the KIC value. For this purpose, granite samples in four different diameters and with six test repeats per diameter have been prepared and tested using the pseudo-compact tension method. For each sample, in addition to recording the load and displacement data, the acoustic events during the loading process were also recorded simultaneously by an acoustic emission equipment. First, the resulting fracture toughness value for each sample has been determined, then the size effect has been evaluated and analyzed. Finally, the results of the acoustic emission method, as the monitoring tool in the fracturing process of tested samples, have been analyzed. The qualitative evolution of acoustic emission parameters well illustrates the mechanical process occurring in the tested samples with well-matched coinciding with the mechanical transitions observed in samples during the loading process. Experimental results show that mode I fracture toughness is positively related to the specimen size and there is a noticeable size effect in KIC value up to a certain diameter.

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1- Introduction

Fracture toughness has paramount importance in engineering projects involving rock materials, in which cracks are omnipresent [1, 2]. Since the tensile strength of rock material is comparatively lower than its compressive and shearing stresses, the mode I fracture toughness (K_{IC}) arises as the most relevant and studied parameter in rock fracture mechanics. To measure the mode I fracture toughness of rock material, the International Society for Rock Mechanics (ISRM) endorses four suggested methods, namely the short rod (SR), chevron bend (CB), cracked chevron notched Brazilian disc (CCNBD), and semi-circular bend (SCB) methods [3-5]. Some of these methods may be difficult to apply on a routine basis due to a number of issues, such as: a) the small failure initiation and propagation loads require excellent test control; b) a relatively large sample volume is needed (CB); c) cumbersome or difficult sample preparation (SR, CB, and CCNBD); d) imprecisions in the computation of the stress intensity factor (CCNBD); e) the indirect generation of tensile loads via sample compression (especially in SCB and CCNBD). To overcome some of these limitations, in this contribution we present an alternate simple approach, referred to as *p*seudo-compact tension (*p*CT), to measure K_{IC} in rocks using cylindrical single-edge-notched specimens loaded in pure tension.

2- Methodology

Granite specimens originating from Spain were used to assess the specimen size effect on the corresponding K_{IC} obtained by the recently developed *p*seudo-compact tension (*p*CT) approach. The *p*seudo-compact tension test [6] cell is based on a modification of the compact tension (CT) specimen described in ASTM standard methods [7] for testing metallic materials. The specimen geometry of the test is outlined in Figure 1.

This study investigates the effect of specimen size (diameter) on the corresponding K_{IC} of a crystalline rock.

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