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ORIGINAL PAPER

Experimental Investigation of Fracturing Processes Under Compression of Granite Specimens Containing Combined Defects Using DIC and AE Techniques

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Abstract

Cracks and other discontinuities may significantly influence the stability and integrity of the rock mass surrounding underground openings, especially in deep emplacements located in brittle rocks with sparse fractures. Although significant advances in the numerical modeling of such systems have been reported in the past years, there still exists a significant necessity of experimental data providing relevant case studies to verify the applicability and limits of these models. In this work, we present a complete series of unconfined compression experiments in a two-dimensional arrangement using prismatic granite specimens including a central circular hole (representing an underground opening in a brittle rock massif) and a paired arrangement of flaws (accounting for spread discontinuities within the massif) with multiple (up to 7) inclination angles. The experiments include the assessment of stress/strain relationships plus the concurrent observation/characterization of the evolving cracking phenomena based on acoustic emission (AE) and digital image correlation (DIC) techniques. The combined data obtained enables the identification and differentiation of the various cracking stages operating in the samples before its failure. The investigation also characterizes the type of crack initiation and failure around the circular opening, in line with theoretical crack distributions around excavations. Results indicate that combined defects reduce the mechanical performance of the rock specimens and that the crack angle also affects the fracturing mechanism through the propagation path, timing, number of cracks, and the energy released during the failure process. Furthermore, a distinct transition from tensile-dominant to shear-dominant failure has been observed as the flaw angle changes from 0° to 90°. To this respect, higher angle flaws lead to more brittle failure, whereas lower angle flaws result in a more progressive and gradual failure. The comparison of our experimental with published results of PFC models with similar specimens shows significant concordances after failure, while before failure, some important aspects are not sufficiently identified by the model. This study expands the available experimental database with new data amenable of model improvement and it also provides with valuable observations at the laboratory scale to better understand cracking processes in brittle rock massifs with sparse joints.

Highlights

- Uniaxial compression tests were conducted on prismatic granite specimens with a central hole and two overlapping flaws with seven different orientations.
- Acoustic emission, digital image processing, and stress–strain data were integrated to identify and differentiate cracking stages leading to failure.
- The flaw angle affects fracturing mechanisms, including propagation paths, timing, number of cracks, and energy release during failure.

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