1. Background

1.1. Barre Granite Specimens

Size: 2” x 4” x 1” (101.6[mm] x 50.08[mm] x 25.4[mm])

Notation of the double-flaw geometry developed by the MIT CEE Rock Mechanics Group:

C: Material composition
L: Ligament length (space between inner flaw tips)
\( \beta \): Flaw inclination with respect to the horizontal
\( \alpha \): bridging angle

1.2. Acoustic Emissions

When recording AE data during the experiments, the AT data handling can be done using the MATLAB code developed by Li, (2019) allowing one to interpret the following information:

- Hypocenter locations
- Focal mechanisms
- Moment magnitude of the events
- Time of occurrence of the events

2. Experimental Setup, Devices & Concepts

2.1. Overall Setup

High-Speed (HS) Camera:
  - Up to 10,000 frames per second

High-Resolution (HR) Camera:
  - Up to 20 mega pixels per image

2.2. Single Flaw Pressurization Device

Unique equipment developed by the MIT CEE Rock Mechanics Group allowing one to:

- Hydraulically pressurize one flaw
- Apply uniaxial/biaxial load
- Conduct visual observations of the front face of the specimen
- Record acoustic emissions

2.3. Research Questions Addressed in this thesis

1) Which are the main parameters (loading scenarios, flaw pair geometry) that induce hydraulic fracturing for this type of laboratory studies?
2) How do AE relate to visual observations in laboratory studies?
3) What are the relationships between the different experimental in terms of focal mechanisms and normalized radiated seismic energy?

2.4. Experimental Concepts

Concept I

- \( n_1 \): Increase until failure
- \( n_2 \): 7.5 [MPa]
- \( PP \): Increase until failure

Contrary to Concept I, the AE hypocenter locations were monitored to determine and confirm that the AE events coincided with the visual observations of the hydraulic fracturing.

Concept II

� Step 1:
- \( n_1 \): Constant at starting load
- \( n_2 \): 7.5 [MPa]
- \( PP \): Constant flow rate

◎ Step 2:
- \( n_1 \): Constant at increased load
- \( n_2 \): 7.5 [MPa]
- \( PP \): Constant flow rate

3. Numerical Study using MATLAB PDE Toolbox & Mohr-Coulomb Failure Criterion

- Structural, linear elastic, static-plane-stress analysis
- Model allowing one to apply:
  - Different loading conditions (biaxial/uniaxial and pressure in the flaw/s)
  - Analyze different flaw pair geometries

4. Experimental Results

4.1. Overview of the Experiments

- 14 analyzed experiments
- 9 conducted experiments
- AE hypocenter locations
- Focal mechanisms
- Energy calculations


- Gutenberg-Richter plot

- Normalized Radiated Seismic Energy

- Energy Calculations

  - \( M_w \)
  - \( M_o \)

5. Conclusions & Further Research

- Hypocenter location analysis shows that AE events are well aligned with the visual observations
- Visual observations of focal mechanisms are not entirely in agreement with focal mechanisms observed in the AE analysis
- Difference in normalized radiated seismic energy for different experimental concepts
- Cyclic pressurization could have an effect on the normalized radiated seismic energy and may thus cause larger seismic damage for similar external mechanical work done

Further Research: Conduct further cyclic pressurization experiments, notably biaxial experiments and compare the energy calculations to the uniaxial experiments → draw further conclusions concerning the effect of cyclic pressurization

In collaboration with