Hydraulic Fracturing Tests in the Laboratory with Image- and Acoustic Emission Monitoring

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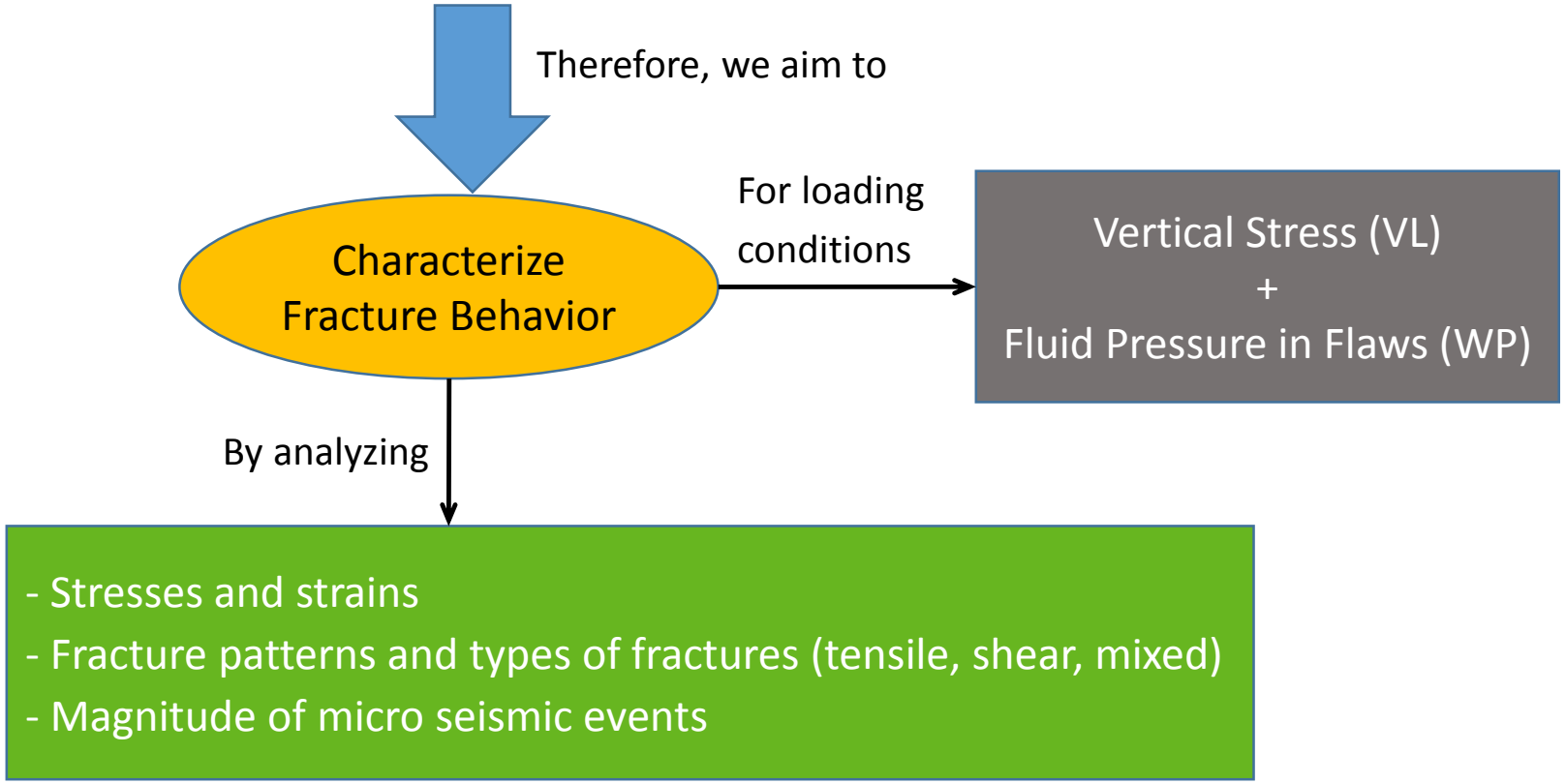
Outline

- Problem Statement
- Test Setup
- Typical Data Obtained
- Conclusion

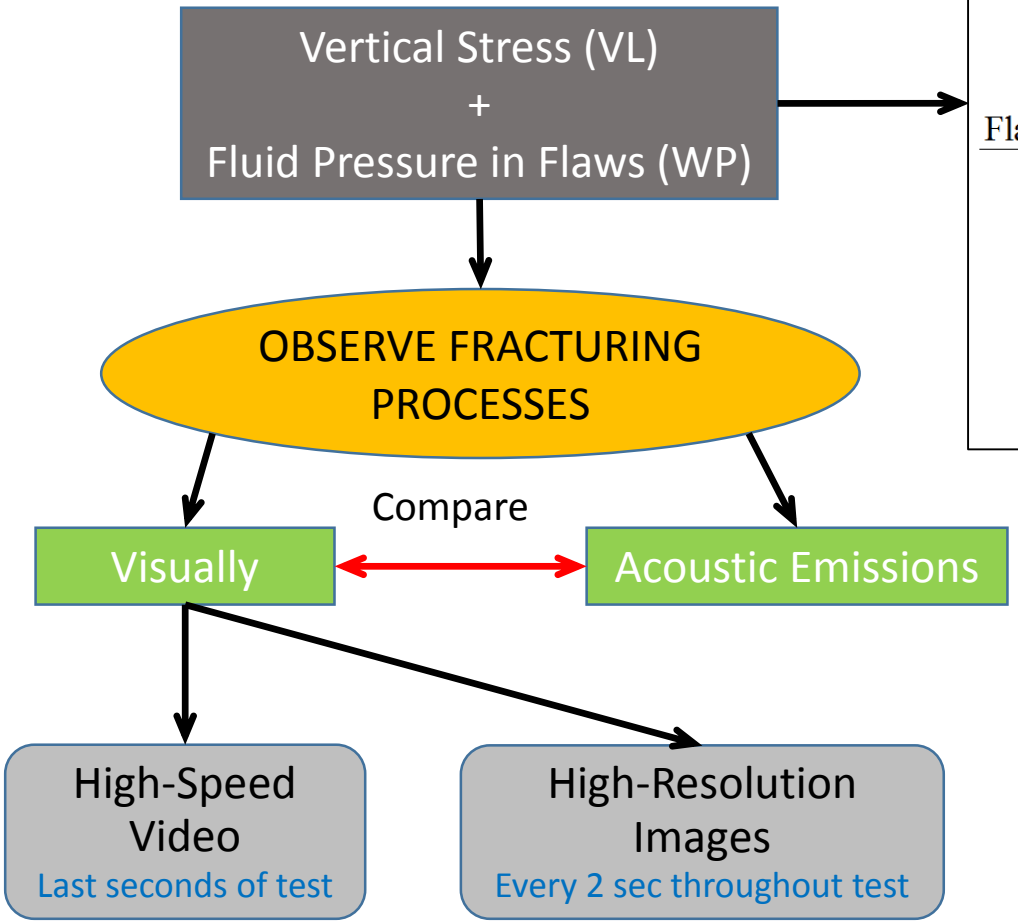
Problem Statement

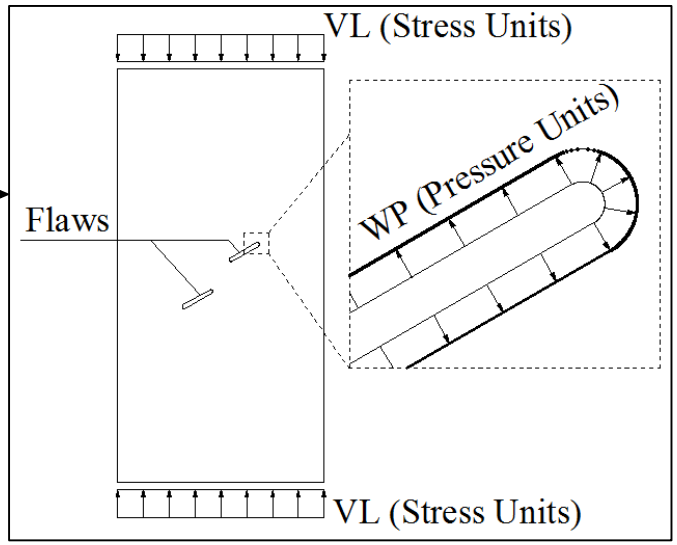
- Fracturing processes when a rock is hydraulically fractured
- Hydraulic fracturing causes seismic events of different magnitude



Problem Statement

- Methodology

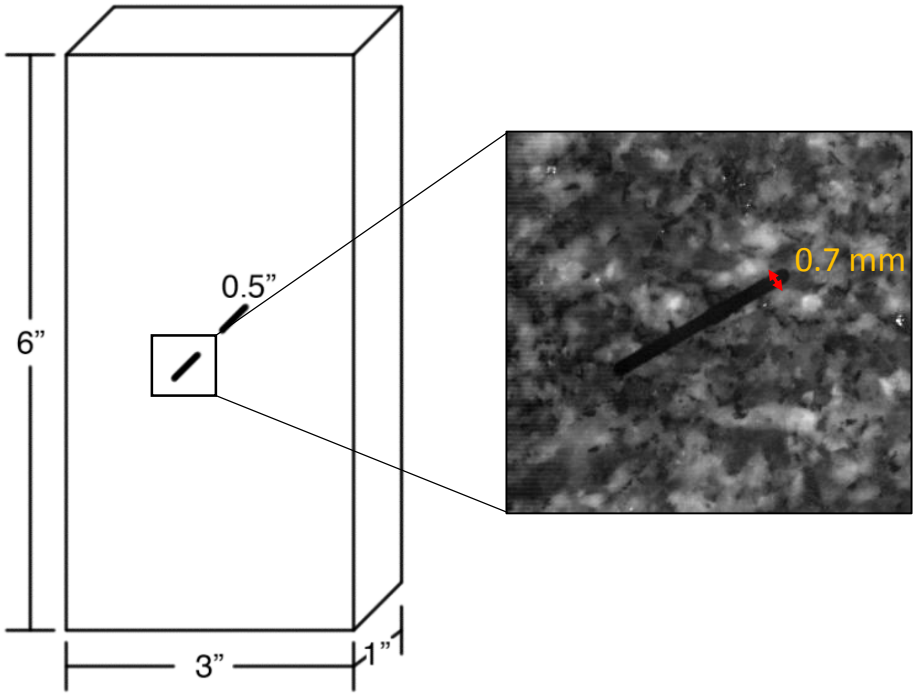


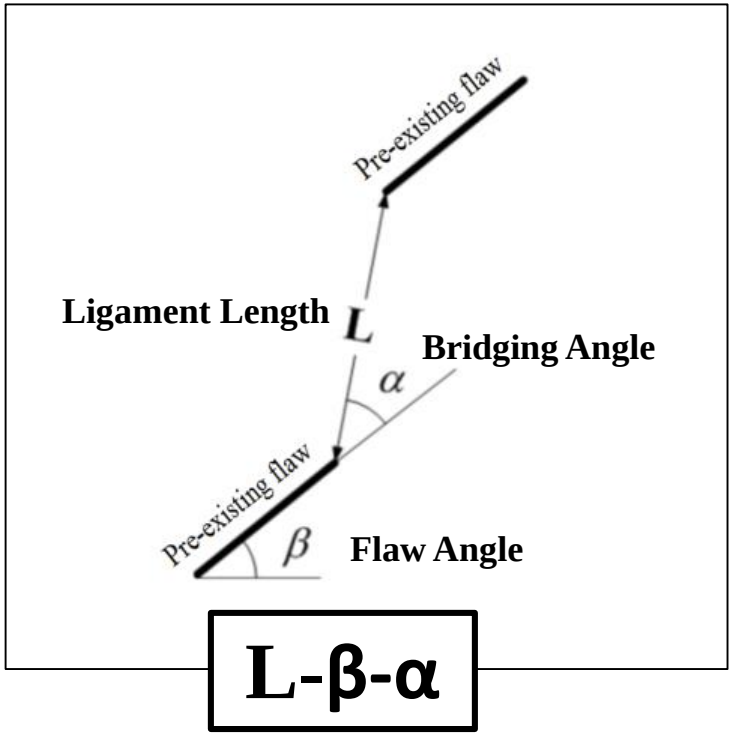


Loading Conditions

Test Setup

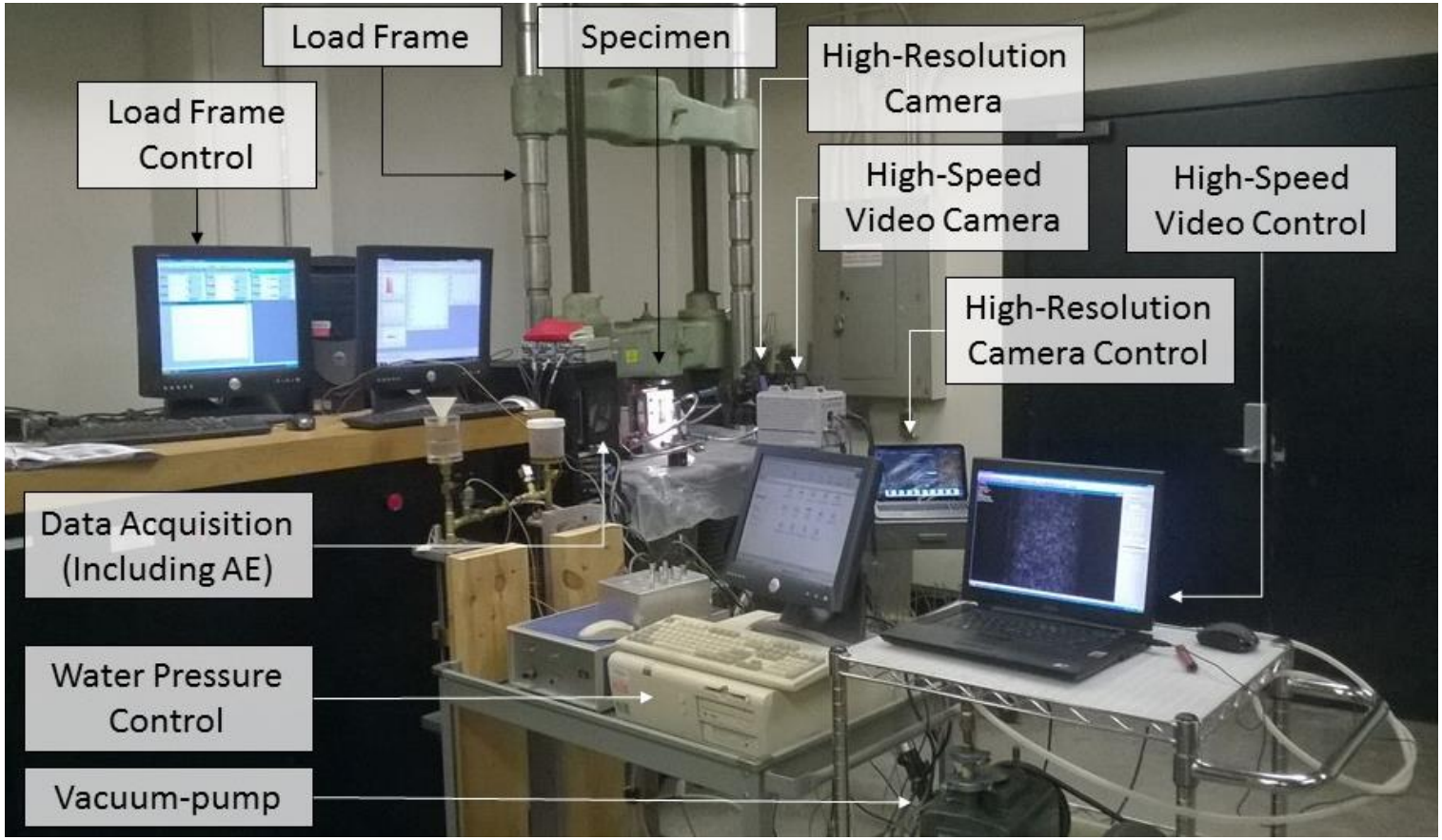
- Specimen and Flaw Pair Configuration





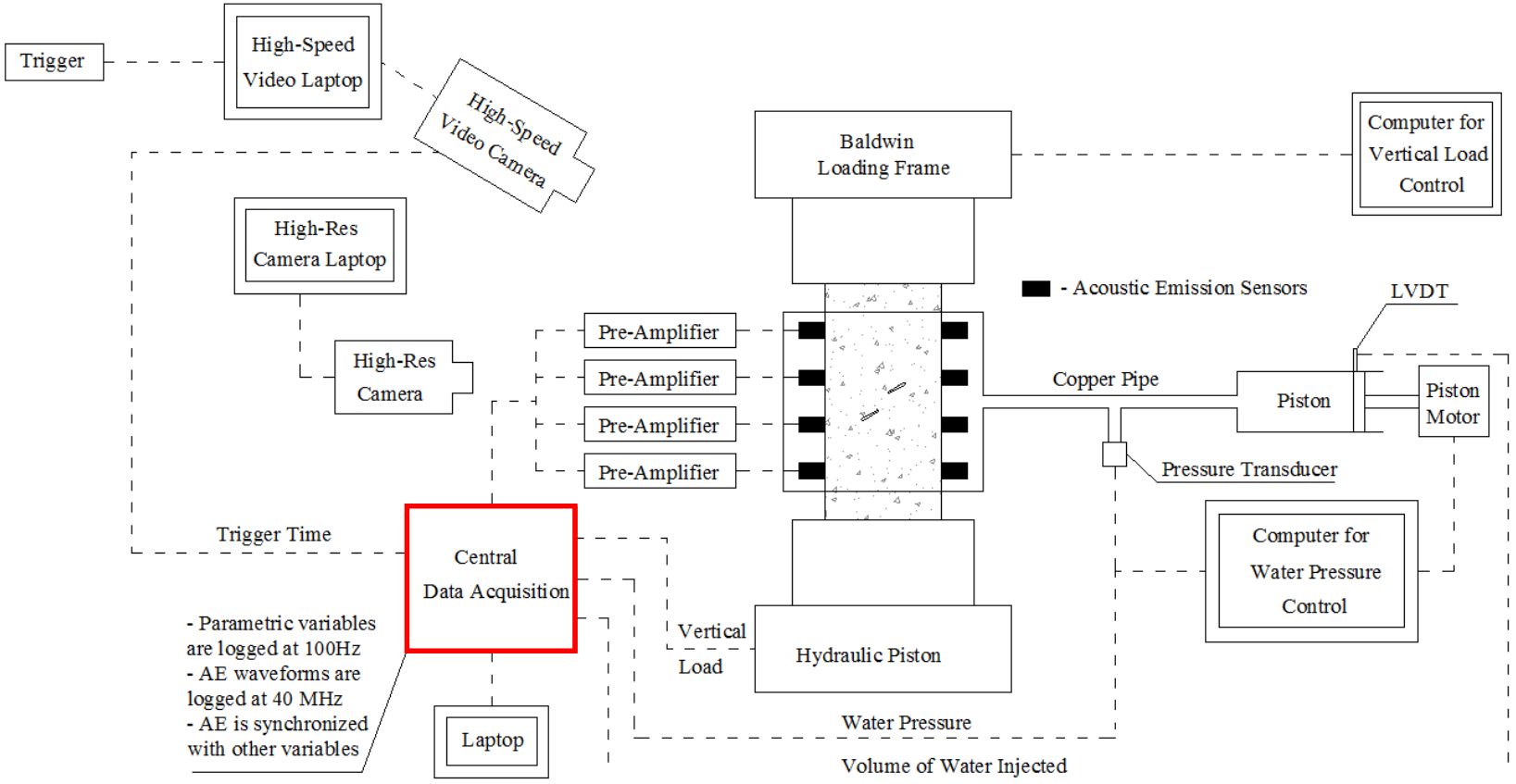
Test Setup

- Overall View



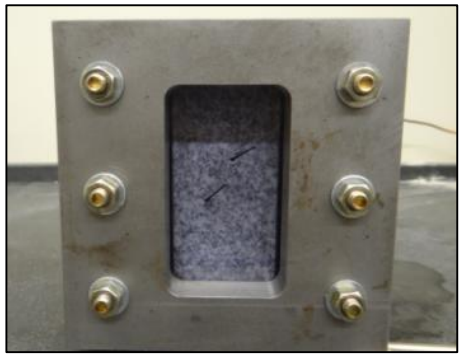
Test Setup

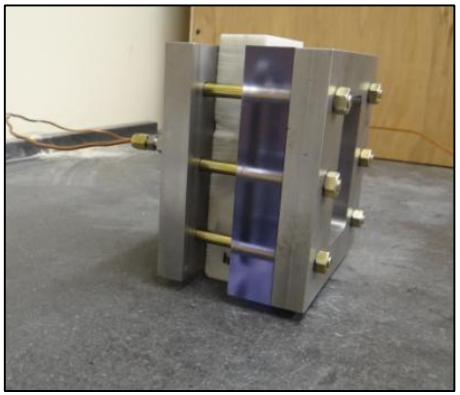
- Diagram

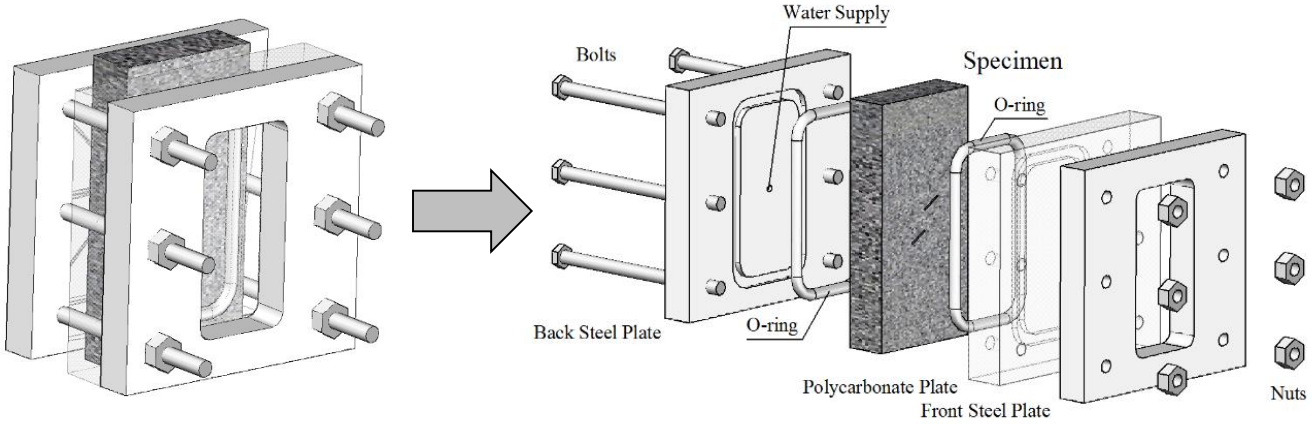


Test Setup

- Water Pressure Device



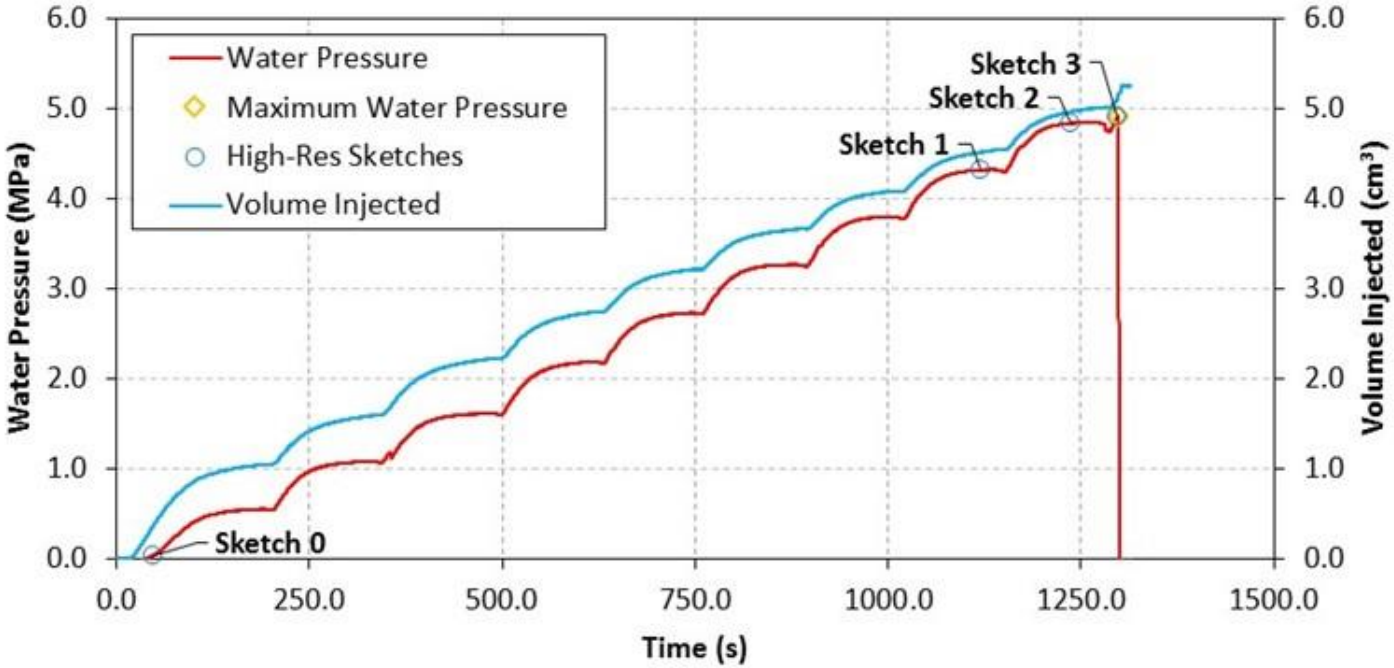




- Designed to withstand 10 MPa of water pressure

Typical Results

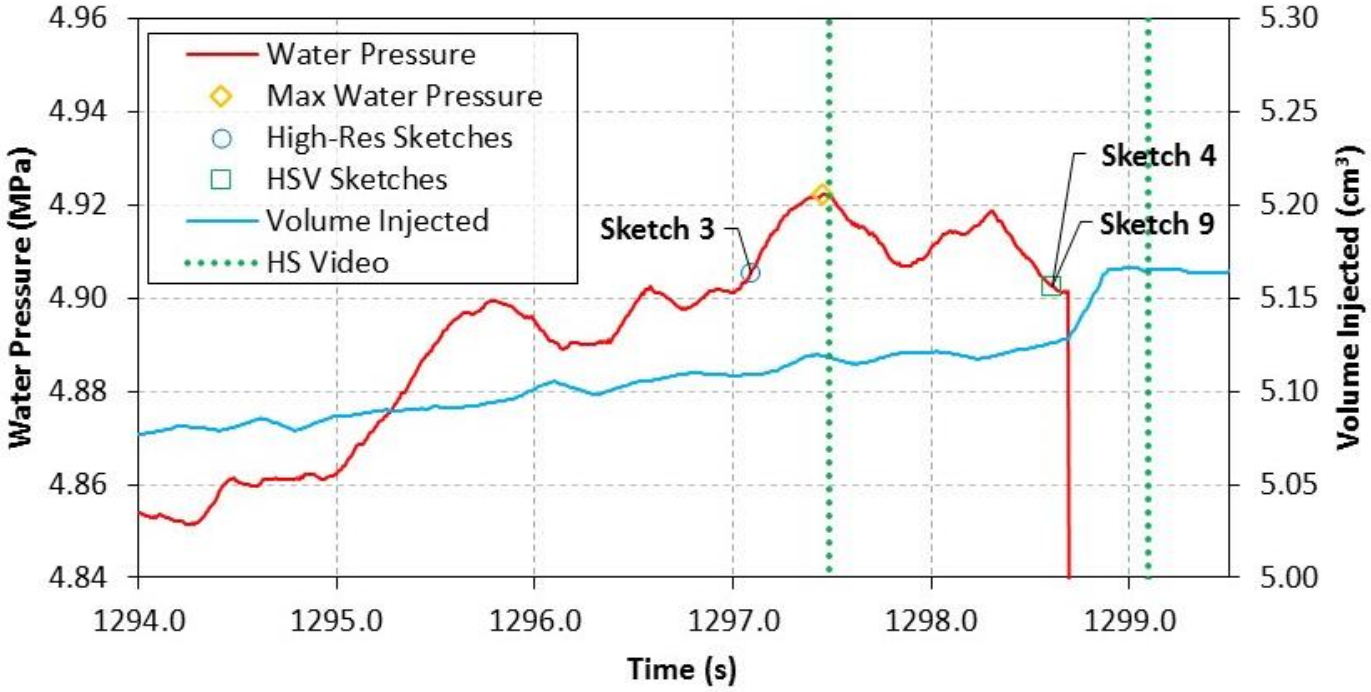
- Example of water pressure and volume injected data obtained from test – 2a-30-60-VL0



- **WP and Volume Injected vs Time** for the **entire test**
- Test was performed on specimen with geometry 2a-30-60 with 0 MPa of vertical stress

Typical Results

- Example of water pressure and volume injected data obtained from test – 2a-30-60-VL0



- **WP and Volume Injected vs Time** for the **last 5 seconds** of the test

Typical Results

- Example of imaging data obtained from test – 2a-30-60-VL0

High-Res Frame: Sketch 3 showing white patching

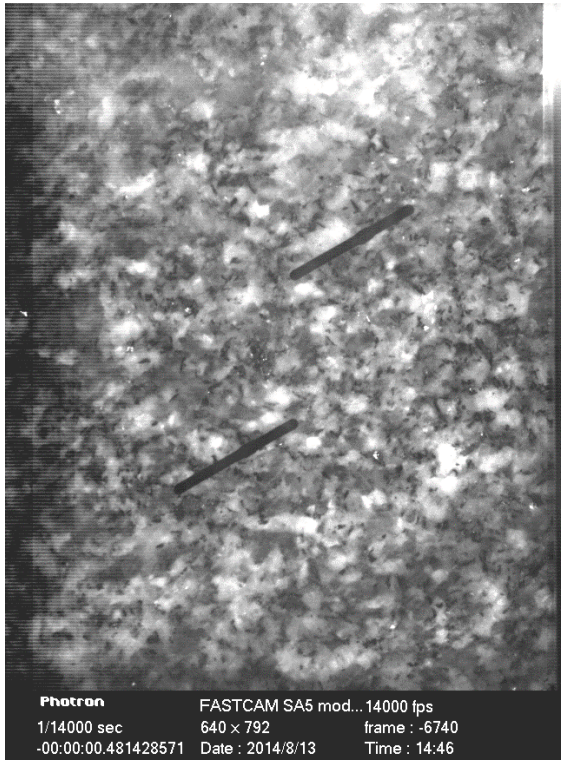
p_{water}: 4.91 MPa

$\sigma_{vertical}$: 0.00 MPa

HSV Frame: Sketch 9 showing visible cracking

p_{water}: 4.90MPa

$\sigma_{vertical}$: 0.00 MPa

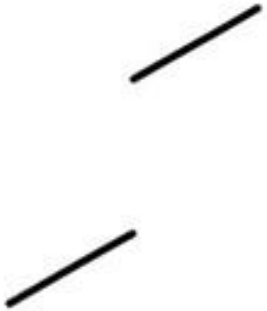


- High-resolution images captured every 5 or 2 seconds throughout the test
- High-Speed Video (HSV) Frames capturing approximately last 1.613 sec of the test

Typical Results

- Example of imaging analysis from test – 2a-30-60-VL0

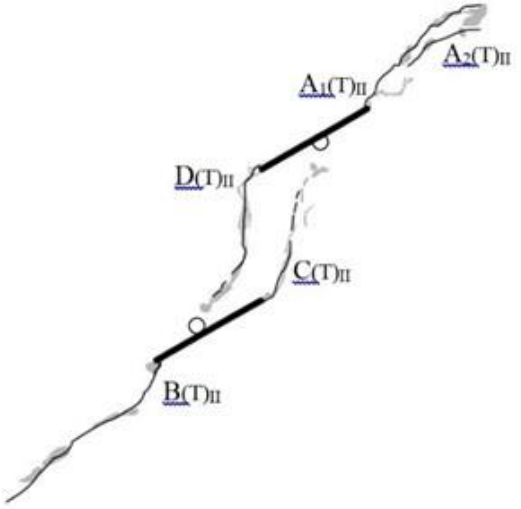
Sketch 0 (From High-Res.)



Development of "white patching" (micro-cracking)

Sketch 3 (From High-Res.)

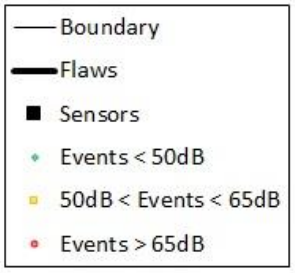
Sketch 9 (High-Speed Video)



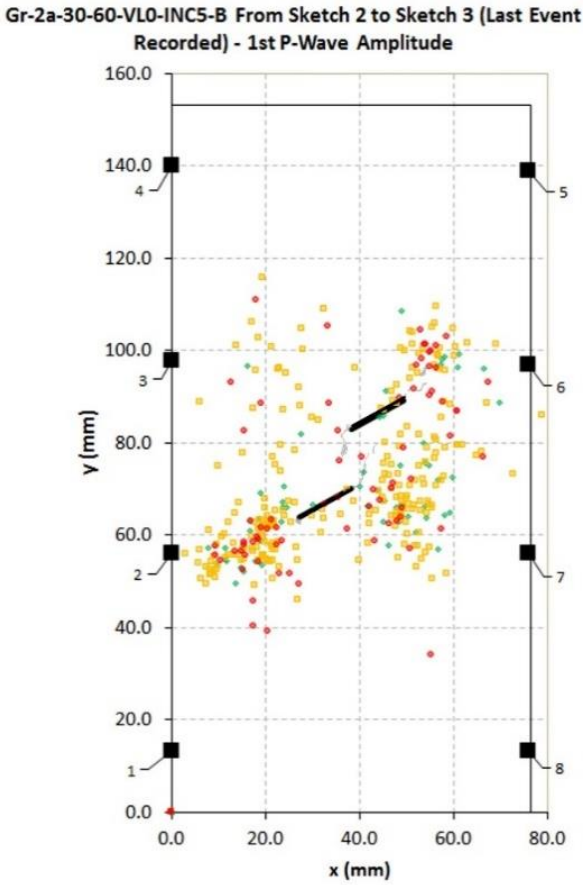
Initiation and propagation of macroscopic cracks

Typical Results

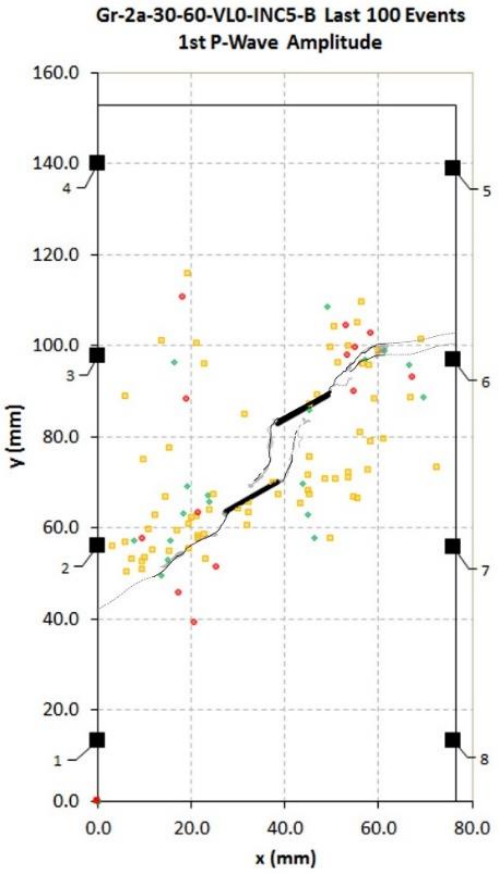
- Example of acoustic emission analysis for test – 2a-30-60-VL0



The colors of the dots indicate different first P-wave amplitudes.



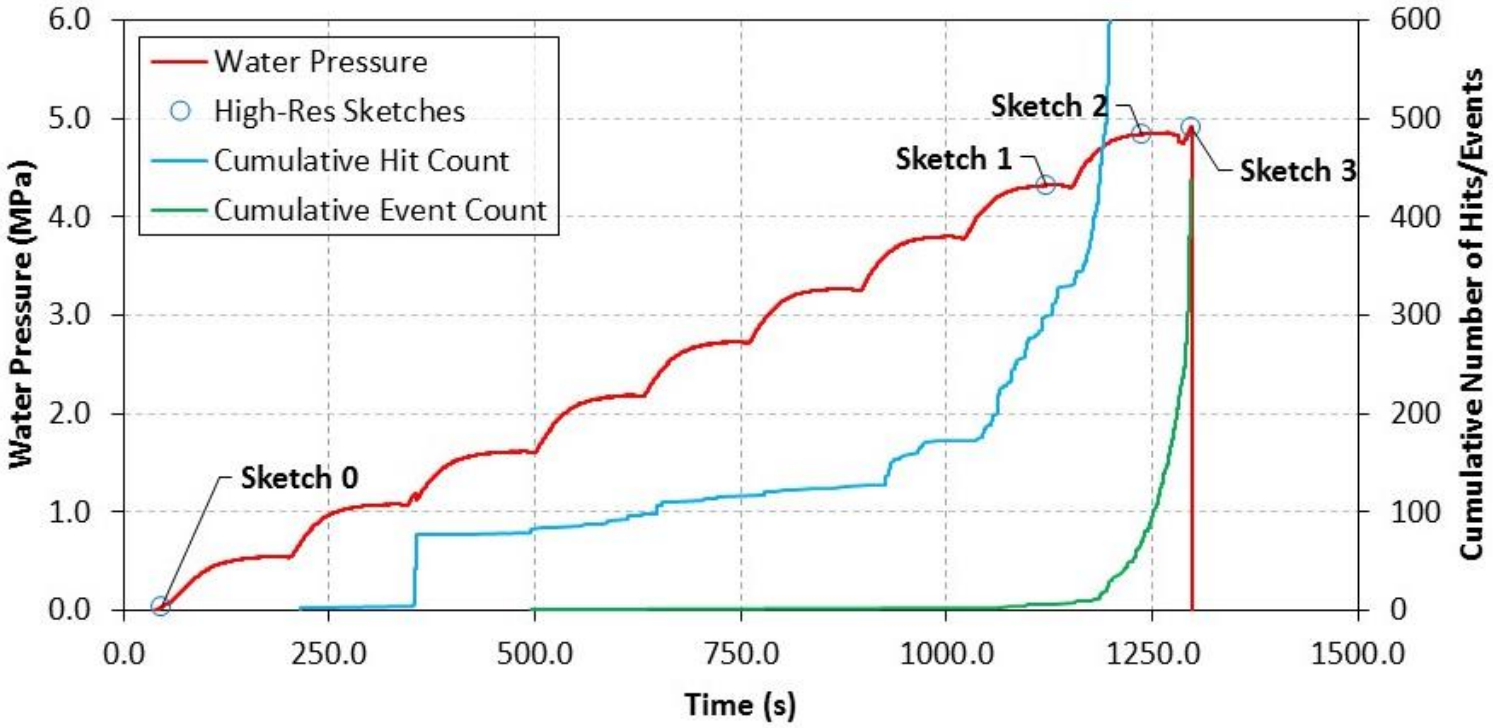
AE events from Sketch 2 and Sketch 3



Last 100 AE events of the test

Typical Results

- Example of acoustic emission analysis for test – 2a-30-60-VL0



- Number of hits and events start to increase substantially at approximately the same time as Sketch 1, the first sketch in which white patching is observed with the High-Resolution camera

Conclusions

- The water pressure device and test setup developed at MIT are capable of simultaneously applying water pressure in pre-existing flaws and vertical load on rock specimens
- The test setup includes visual and acoustic emission monitoring
- The test setup has been successfully used in several tests performed on granite specimens