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Damage Mechanics Challenge: Simulation of Failure Load and Crack Geometry

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Abstract

We describe a benchmark laboratory data set that will form the basis of a damage mechanics challenge to compare computational approaches on damage evolution in brittle-ductile material. The experimental design was developed as a community effort at a Damage Mechanics Workshop held at Purdue in February 2019 that included lead computational scientists and engineers in the field of damage mechanics. The consensus of the workshop participants was to use a damage mechanics challenge to:

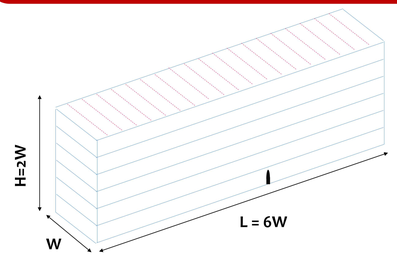
(1) Determine the state of the art and needed future directions to improve the community's ability to simulate crack formation and evolution in natural and engineered brittle-ductile materials;

(2) Identify the information provided by the different simulation approaches that gives insight into the prediction and interpretation of failure in rock;

(3) Identify model parameters that are currently not measured or cannot be measured in the laboratory;

(4) Determine whether there are other experimental measurements that are needed or better methods of performing measurements to monitor damage evolution.

Samples and 3PB Test Setup



Red lines: binder print direction.
Blue lines: layer orientation.
Layer thickness ~ 100 microns
(Line separations are not drawn to scale)

Figure 1: Sketch of 3D printed anisotropic gypsum sample.

W = 12.7 mm
L = 76.2 mm
H = 25.4 mm

Notch Width = 0.1 W (1.27 mm)

Notch Height = 0.4 W (5.08 mm)

Notch Locations from Left End = 0.5 L (38.1 mm)

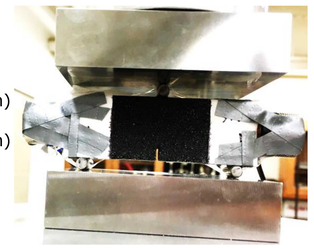


Figure 2: 3-point-bending test setup with active ultrasonic monitoring and digital image correlation technique.

3D Printing Process

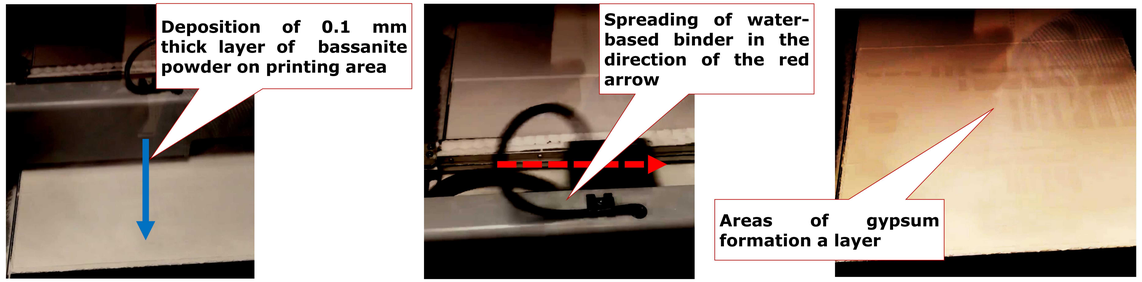
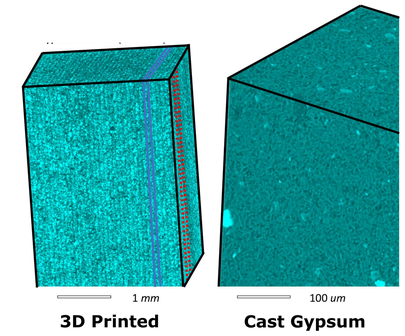


Figure 3: Depiction of 3D printing process of gypsum samples



3D Printed **Cast Gypsum**

Figure 4: Xray-CT reconstruction of cast and 3D printed gypsum samples.

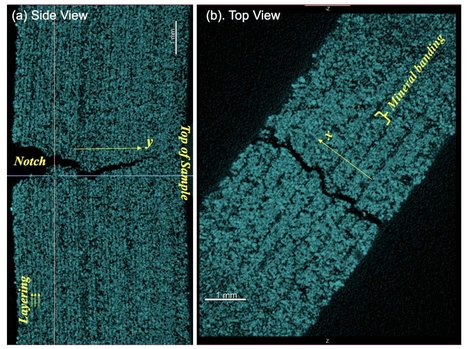


Figure 5: Image from 3D X-ray tomographic reconstruction of sample showing the fracture trace in two orthogonal directions.

Proposed Calibration Samples

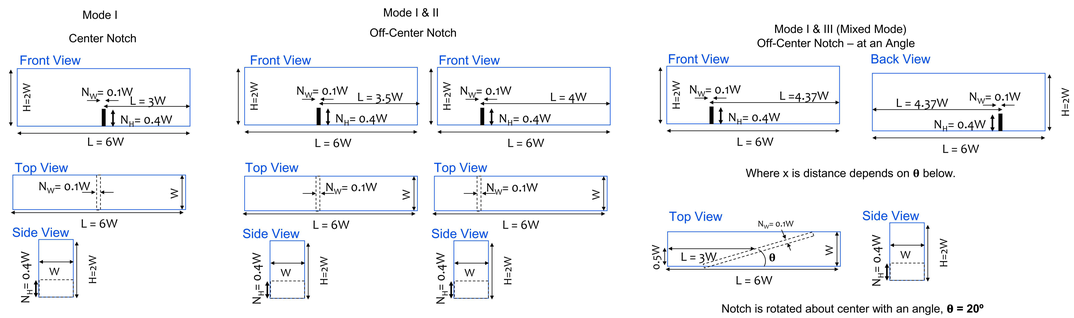


Figure 6: Orthographic projections of the proposed calibration samples with different notch designs.

Information Provided

Sample Geometry	**Load-Displacement Data**	**Porosity**
Chemical Composition	**Surface Displacement**	**Brazilian Test for Bond Strength**
X-ray CT	**Unconfined Compressive Strength**	**Images of Notch Geometry**
Surface Roughness	**Elastic Constants from Ultrasonic Measurements**	**Indentation Test**

Simulation Report

***Force vs Displacements (for 25%,50%,75% 100% of peak load)**

***Crack Path versus Load**

***Surface Roughness (wavelength, isotropic/anisotropic, micro-slope)**

***Fracture process zone**

***Variability of data versus variability of model**

Related Presentations

MR23C-0112 - Mixed-Mode Fracture Propagation in Layered Printed Rocks with Oriented Texture

MR23C-0120 - Acoustic emission analysis of fracture initiation and propagation using physics-informed machine learning methods

Join the Challenge

Please leave your contact information and any comments here so that we can provide with you with updated information regarding the date of this challenge.

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