HIGHWALL STABILITY DUE TO GROUND VIBRATIONS FROM BLASTING

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PURPOSE

Objective: Study the effect of blast vibrations on the stability of highwalls and web and barrier pillars

Methods

- Numerical Modeling
- Field Testing
- Laser Scanning
- Vibrations Monitoring

PROGRESS

SASW Testing

Numerical Modeling

- FLAC3D – Web and Barrier Pillars
  - – Stress Distribution
  - – Pillar Stability
- 3DEC – Highwall Modeling
  - – Laser Scanning
  - – Displacement/Velocity

Field Data Collection

SASW Testing

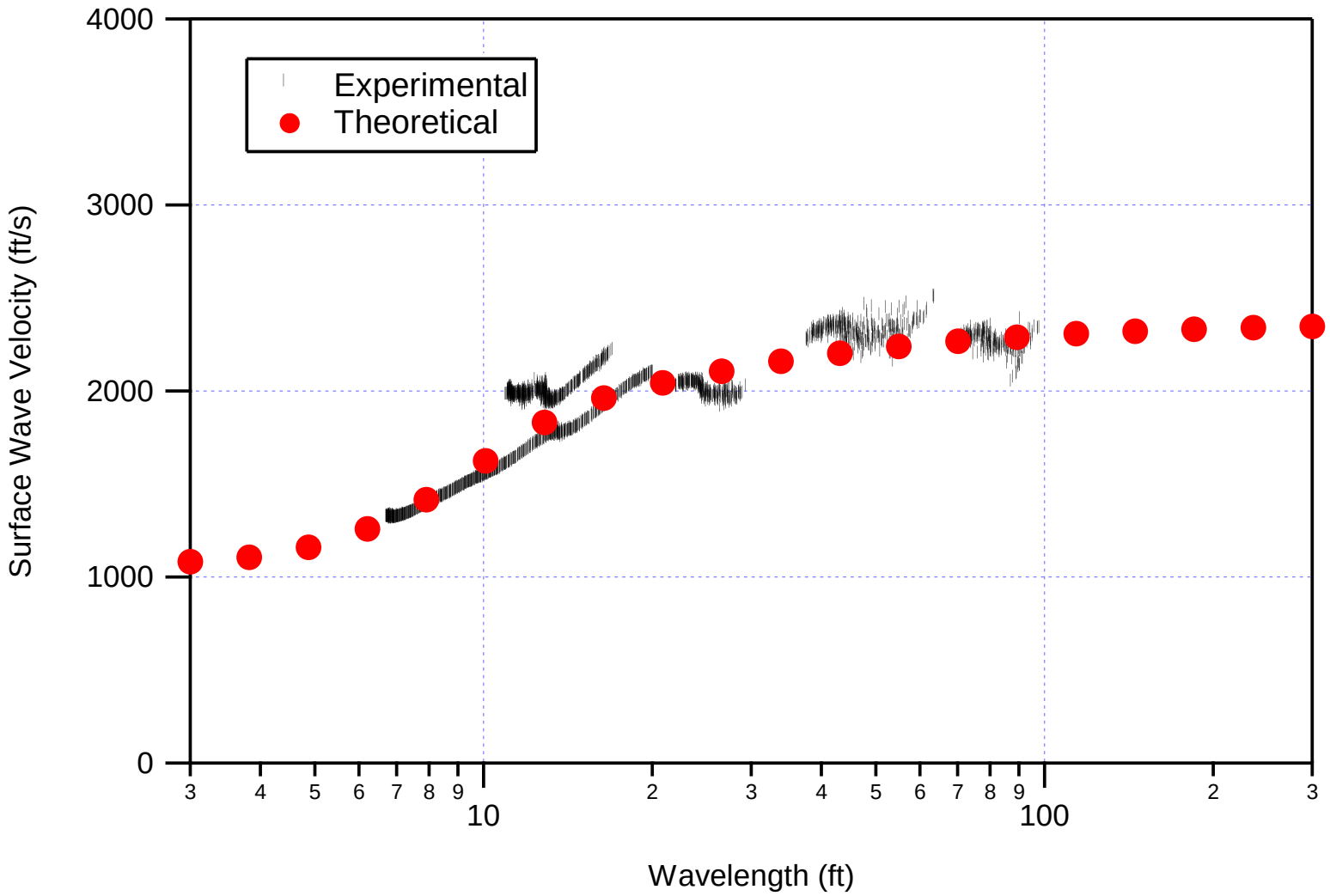
Dynamic Material Properties

- Shear Modulus
- Damping Ratio

Modulus/Damping Reduction Curves

- Dynamic Model Calibration
- Iterative Numerical Process

SASW Testing



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Numerical Modeling

Sub-Objective 1: Evaluate the influence of highwall mining progression on web/barrier pillar stability using FLAC3D

Methodology

- Simplification – 2D Section
- Validation – Mark-Bieniawski
- 5 Case Studies

Material Properties

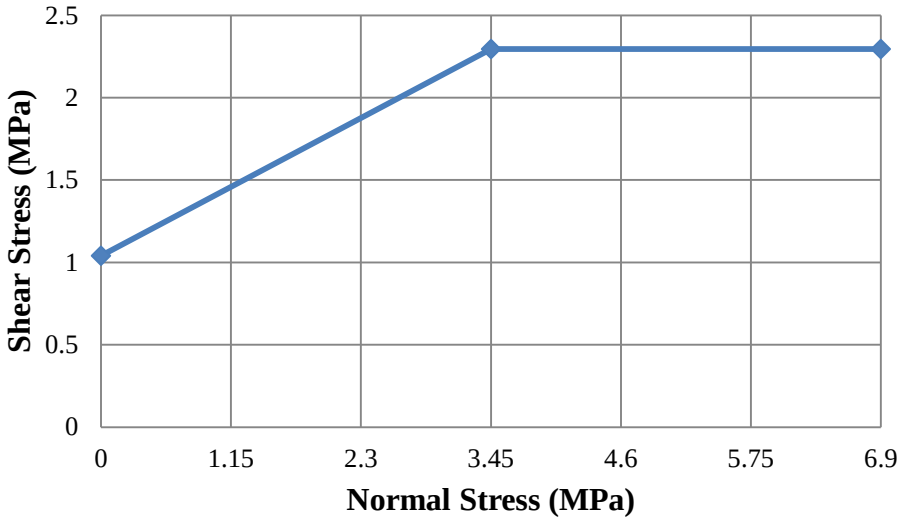
Coal Material Model

- Strain Softening Mohr-Coulomb

Roof/Floor Interface

- Bi-linear Mohr-Coulomb

Property	Value
Elastic Modulus (GPa)	3
Poisson Ratio	0.25
Cohesion (MPa)	
Initial	1.81
Final	0.41
Friction Angle (deg)	28
Plastic Strain Range	0.015



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Material Properties

Rock Material Model

- Ubiquitous Joint Model with Softening

	Rock Matrix Properties							Bedding Plane Properties		
	UCS	Elastic Modulus	Poisson Ratio	Friction Angle	Cohesion	Tensile Strength	Dilation	Friction Angle	Cohesion	Tensile Strength
	MPa	GPa	---	Deg	MPa	MPa	Deg	deg	MPa	MPa
SS	100	40	0.25	40	13.52	5.8	12	30	6.76	4.64
SH	30	10	0.25	20	7.3	1.74	19	7	0.5	0.17

Matrix Softening									
	Cohesion			Tensile Strength			Dilation		
	Maximum	Residual	Range*	Maximum	Residual	Range	Maximum	Residual	Range*
	MPa	MPa	---	MPa	MPa	---	Deg	Deg	---
SS	13.52	0	0.005	5.8	0	0.001	12	0	0.005
SH	7.3	0	0.005	1.74	0	0.001	19	0	0.005
Bedding Plane Softening									
	Cohesion			Tensile Strength			Dilation		
	Maximum	Residual	Range*	Maximum	Residual	Range	Maximum	Residual	Range*
	MPa	MPa	---	MPa	MPa	---	Deg	Deg	---
SS	6.76	0.68	0.005	4.64	0	0.001	12	0	0.005
SH	0.5	0.05	1.005	0.17	0	0.001	19	0	0.005

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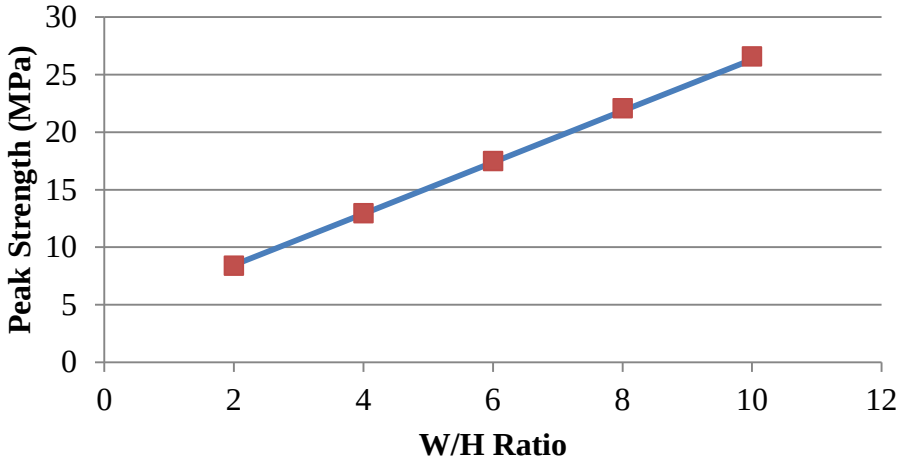
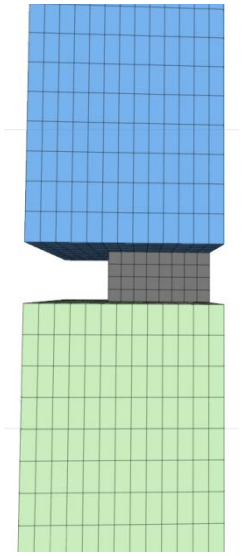
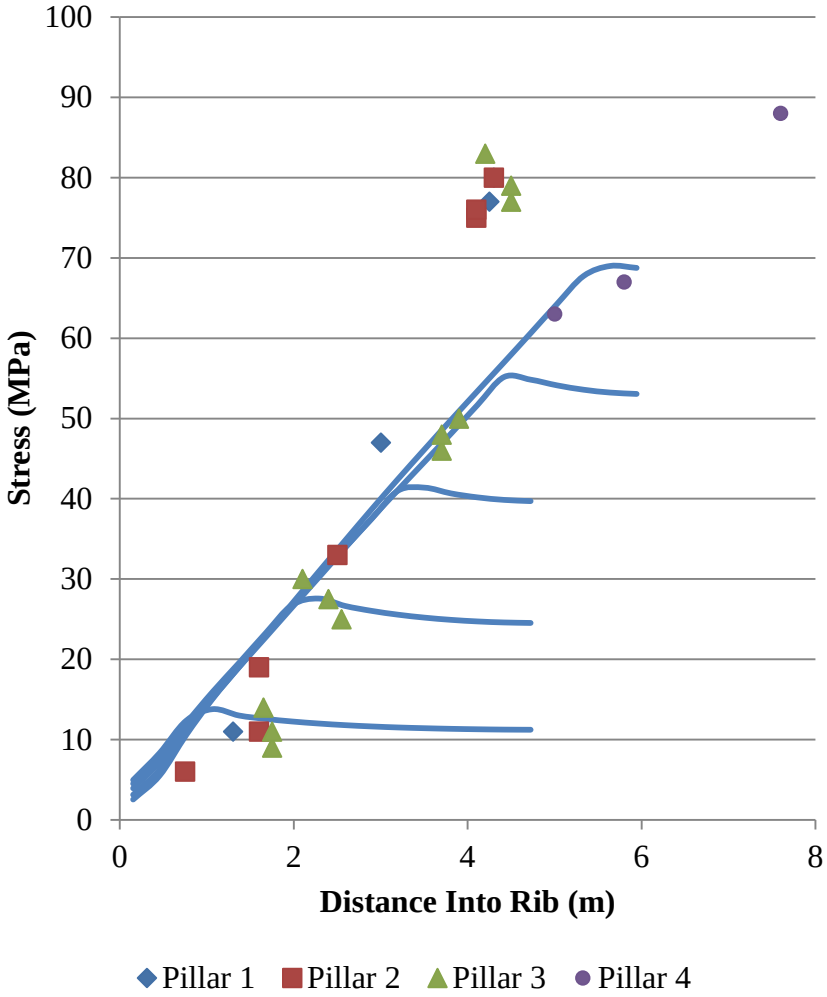
Model Validation







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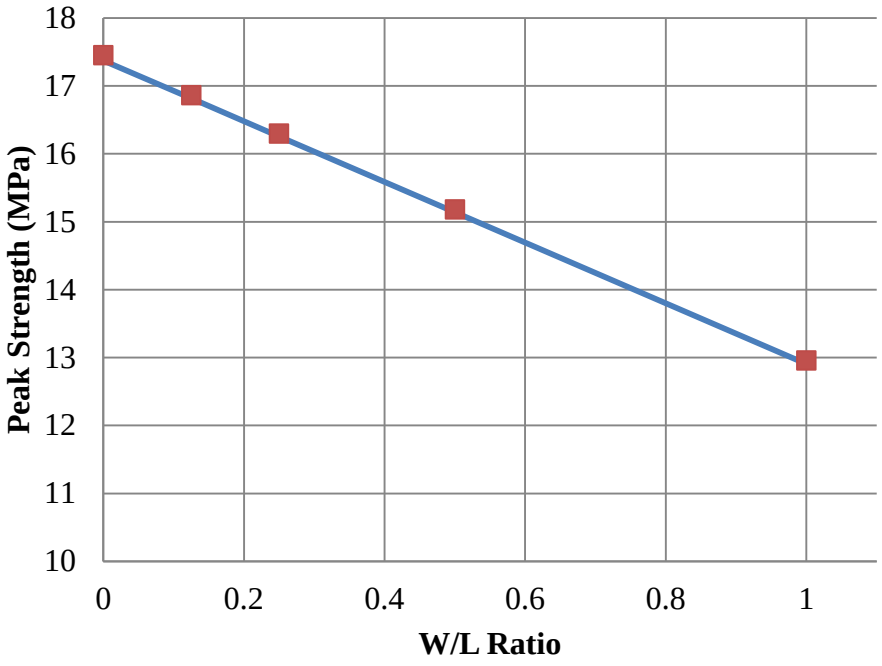
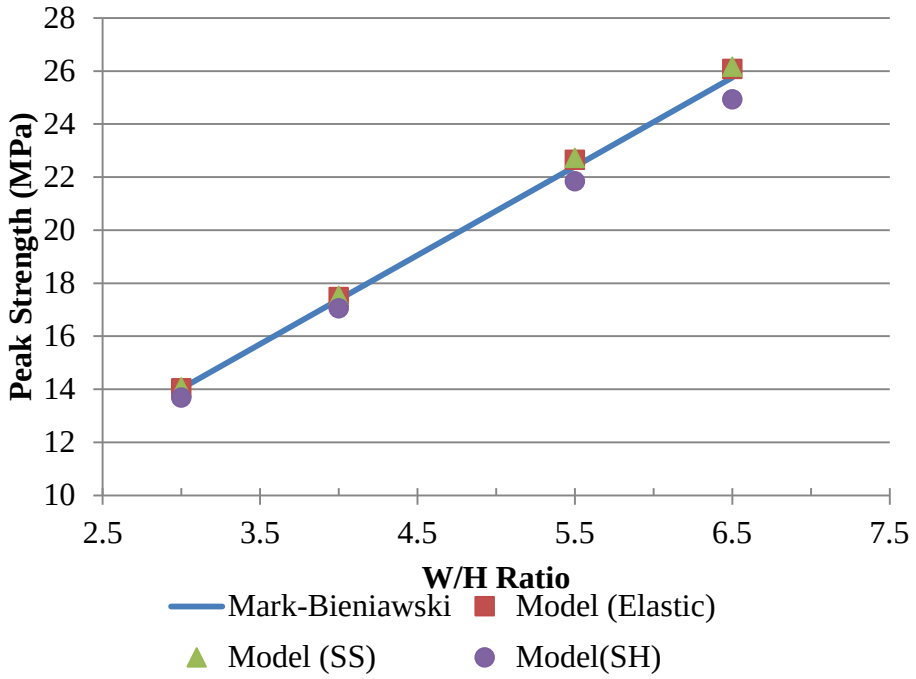
Model Validation





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Model Validation

Material Properties

- Peak Strength
- Calibration Reasonable

Web/Barrier Pillars

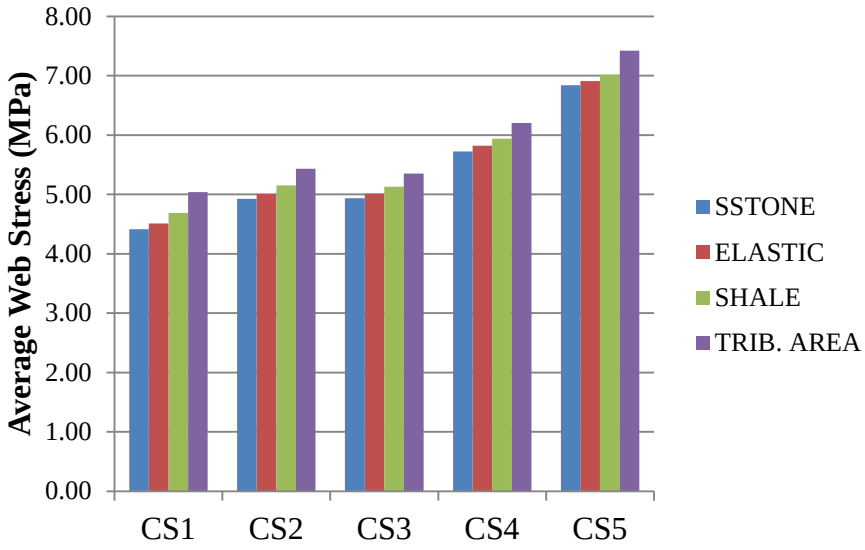
- “Infinite Length” Assumption

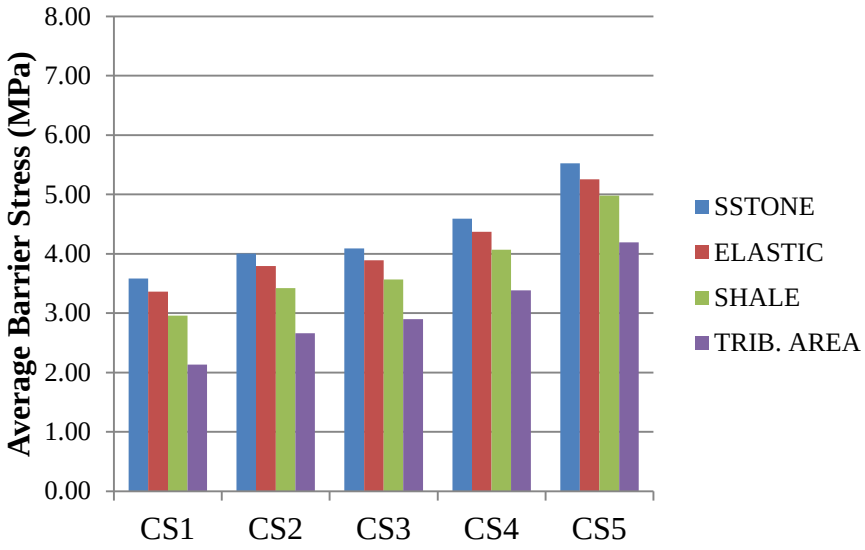
2D Cross Section

- Plane Strain Validation

Case Study Results

Case	Height (m)	Web (W/H)	Barrier (W/H)	Cover (m)
C1	1.219	0.75	3	45.7
C2	1.219	1	4	60.9
C3	1.219	1.25	4	70.1
C4	1.219	1.5	5	91.4
C5	1.219	1.75	6.5	118.9





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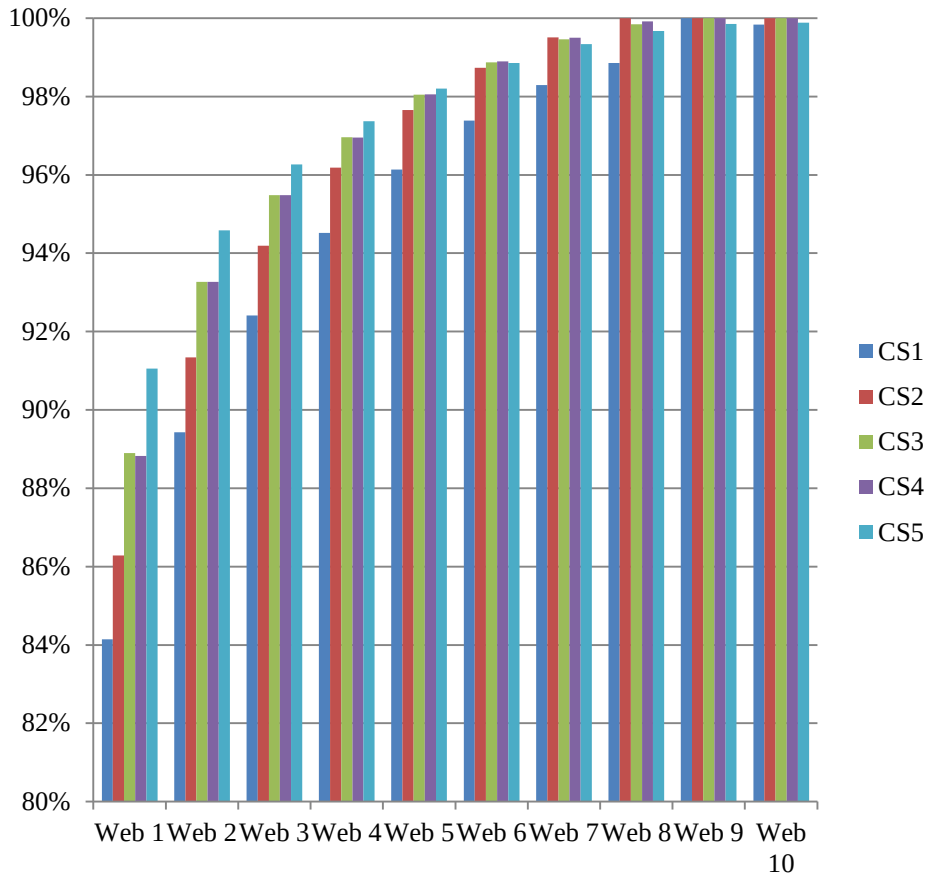
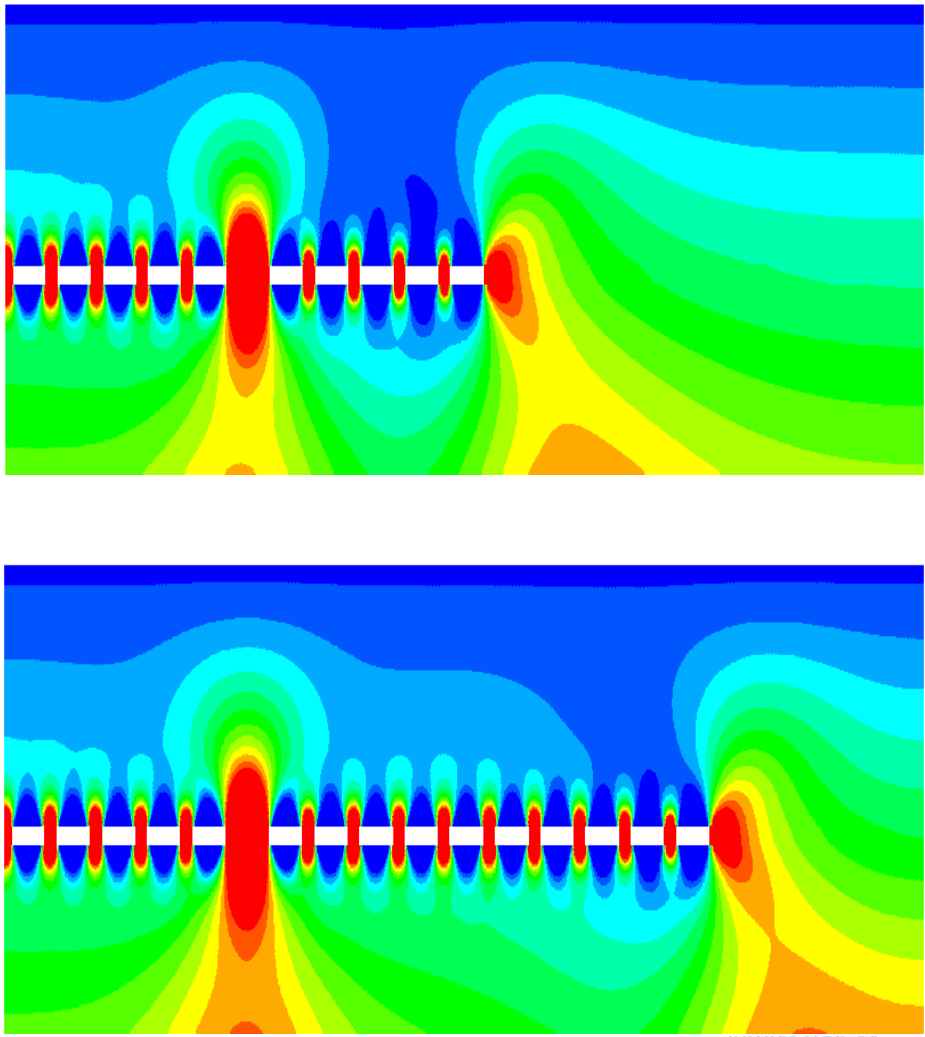
Mining Progression Results





Important Findings

Tributary Area Loading

- Common Assumption
- Arching Effect – Geology Dependent
- Importance of Barrier Pillar Design

Mining Progression

- De-stressing near Barriers
- Asymmetric Loading

Probability of Pillar Failure/Highwall Collapse

Dynamic Impact on Web/Barrier Pillars

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Numerical Modeling

Sub-Objective 2: Correlate active highwall sites with 3DEC for validation and additional testing

Methodology

- Routine trips collect scan data
- Digitize geometry for mesh generation within 3DEC

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Primary Mine Site

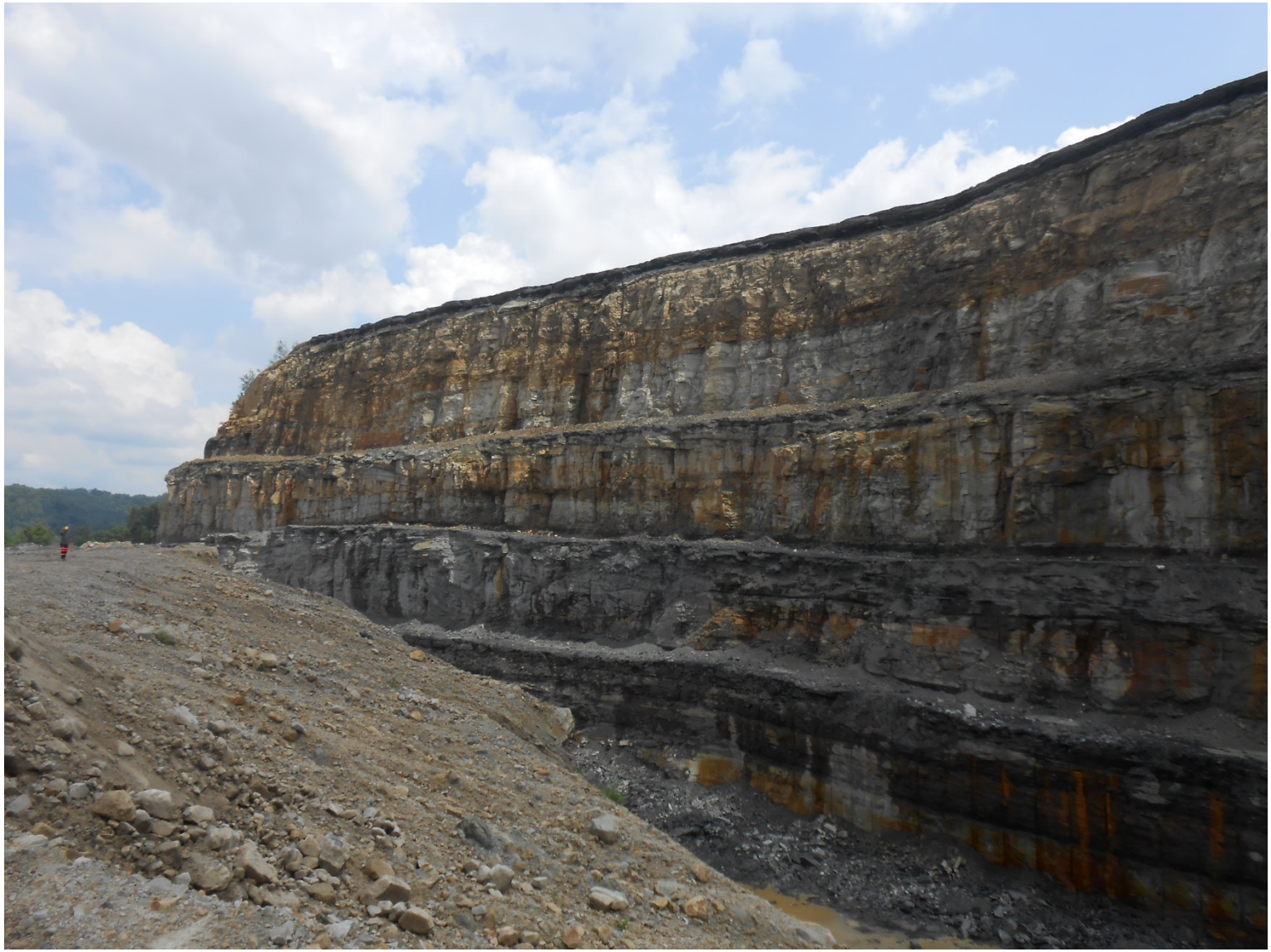
Pine Branch Mine

- Perry County, KY
- Mountaintop/Contour
- Hazard 7 – Hazard 10 seams
- 200’ – 300’ Highwall
- Massive Sandstone

Important Mine Data

- Corehole Data
- Mapping

Primary Mine Site



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VIBRATION AND SCAN DATA

Laser Scanning

- Pre/Post Blast Capture
- Mesh Generation for 3DEC
- Geologic Data
  - 2 Primary Joint Sets
  - 85 Degree Dip
  - 110, 185 Direction

Seismograph Deployment

- Highwall Peak and Bottom
- Single Event Vibration Data

3DEC_DP 5.00

Step 0
7/15/2014 2:03:07 PM

Geometry
Polygon

3DEC_DP 5.00

Step 0
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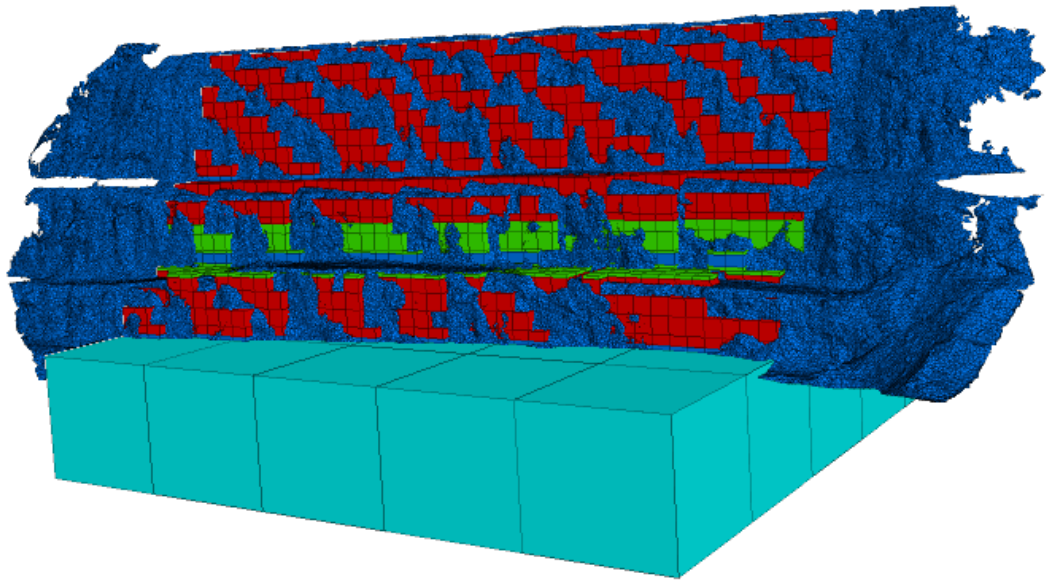
Block

Colorby: Block Group Slot: Any

- Base
- COAL
- GR MS SS
- LT GR SH

Geometry

- Polygon



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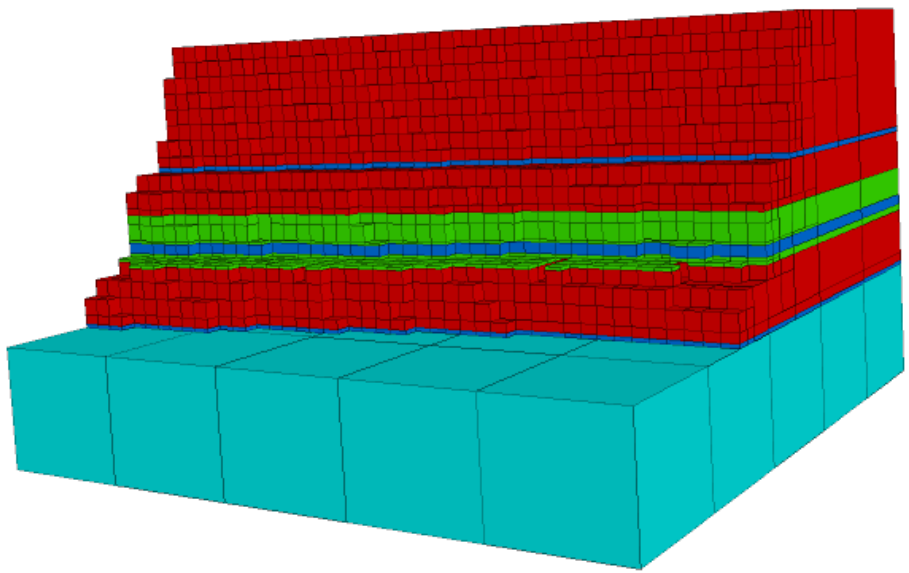
Block

Colorby: Block Group Slot: Any

- Base
- COAL
- GR MS SS
- LT GR SH



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Step 179805
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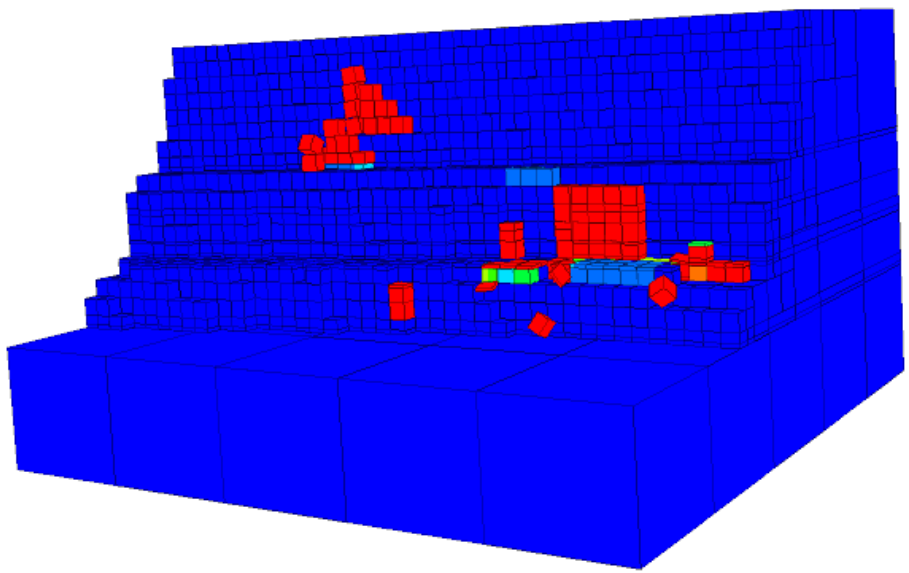
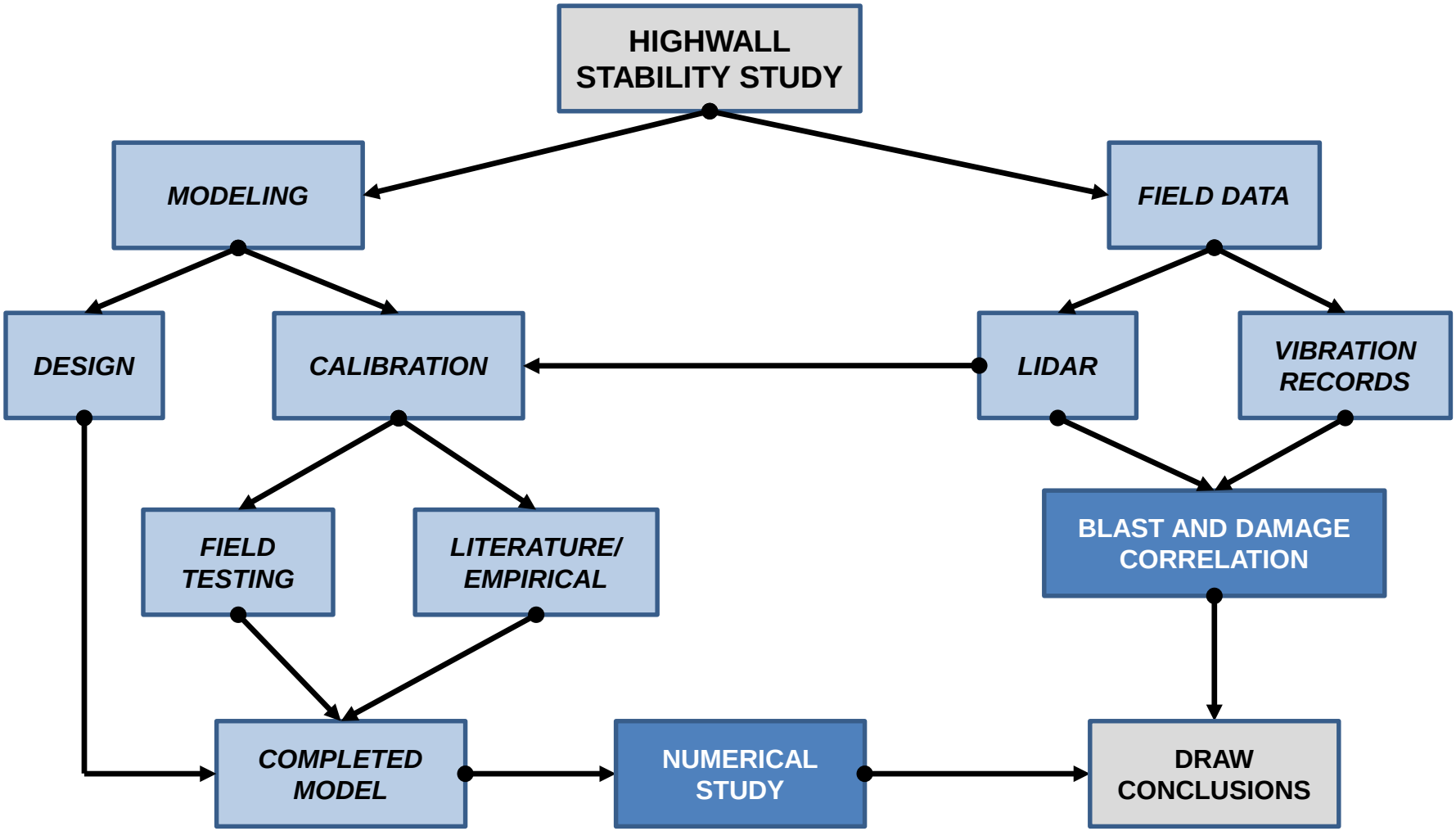
Displacement magnitude

- 1.0000E+00
- 9.0000E-01
- 8.0000E-01
- 7.0000E-01
- 6.0000E-01
- 5.0000E-01
- 4.0000E-01
- 3.0000E-01
- 2.0000E-01
- 1.0000E-01
- 0.0000E+00



SUMMARY



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Project Direction

FLAC3D Modeling

- Probability of Pillar Failure/Highwall Collapse
- Dynamic Impact on Web/Barrier Pillars

3DEC Modeling

- Solidify Static Model
- Quantify/Correlate Damage and Vibrations
- Sensitivity Studies
  - Ratio of PPV
  - Geology
  - Highwall Geometry

QUESTIONS?

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