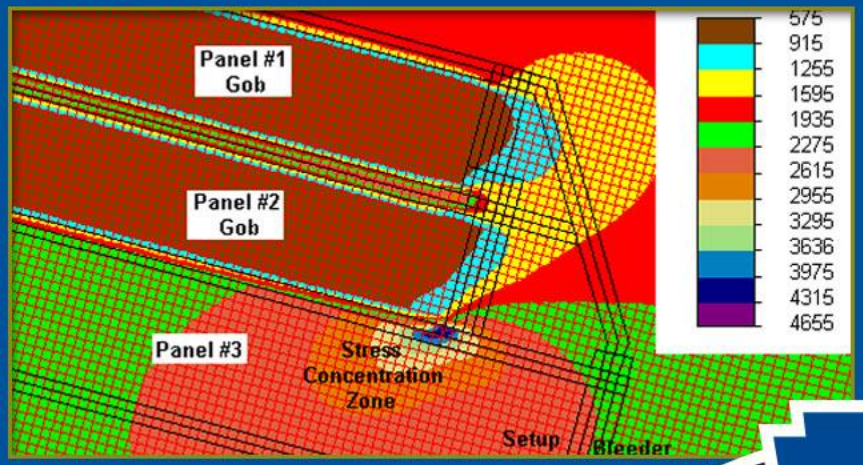
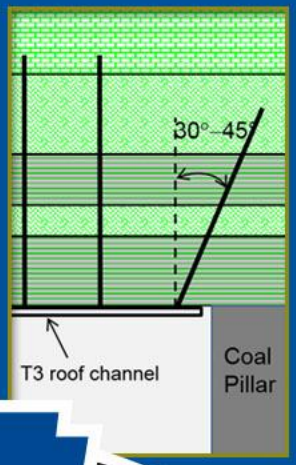




KMS SM
KEYSTONE MINING SERVICES

Ground Control Issues and Roof Support Practices in Illinois #6 Coal Seam

by Drs. John Stankus, Hanjie Chen, Xiaoting Li

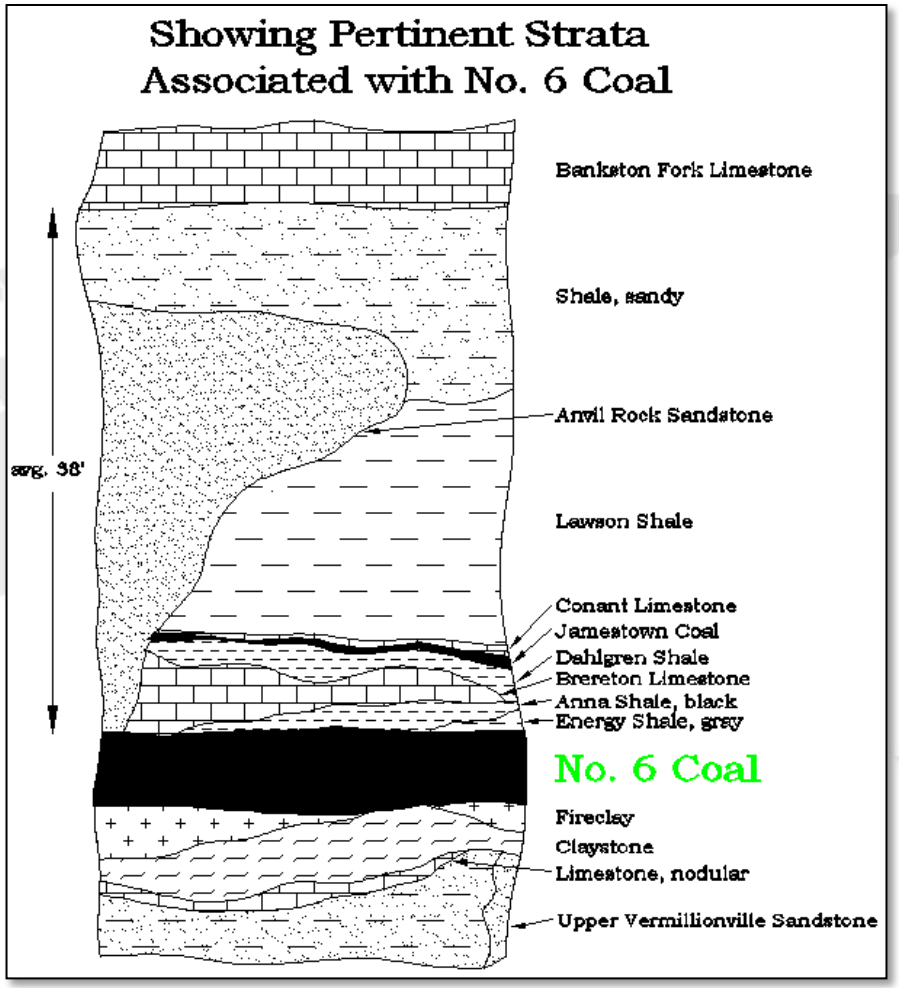
JM USA
A PROUD JENNMAR AFFILIATE

Outline

- **Main causes of ground control issues in the #6 coal seam of the Illinois Basin**
- **Effective roof control practices**
- **Questions**

Main Causes of Ground Control Issues

1. Regional horizontal stress
2. Weak immediate roof of #6 Herrin seam (Energy gray and Anna black shale)
3. Anvil rock sandstone is close to the roof line, water may occur
4. Presence of Jamestown coal rider

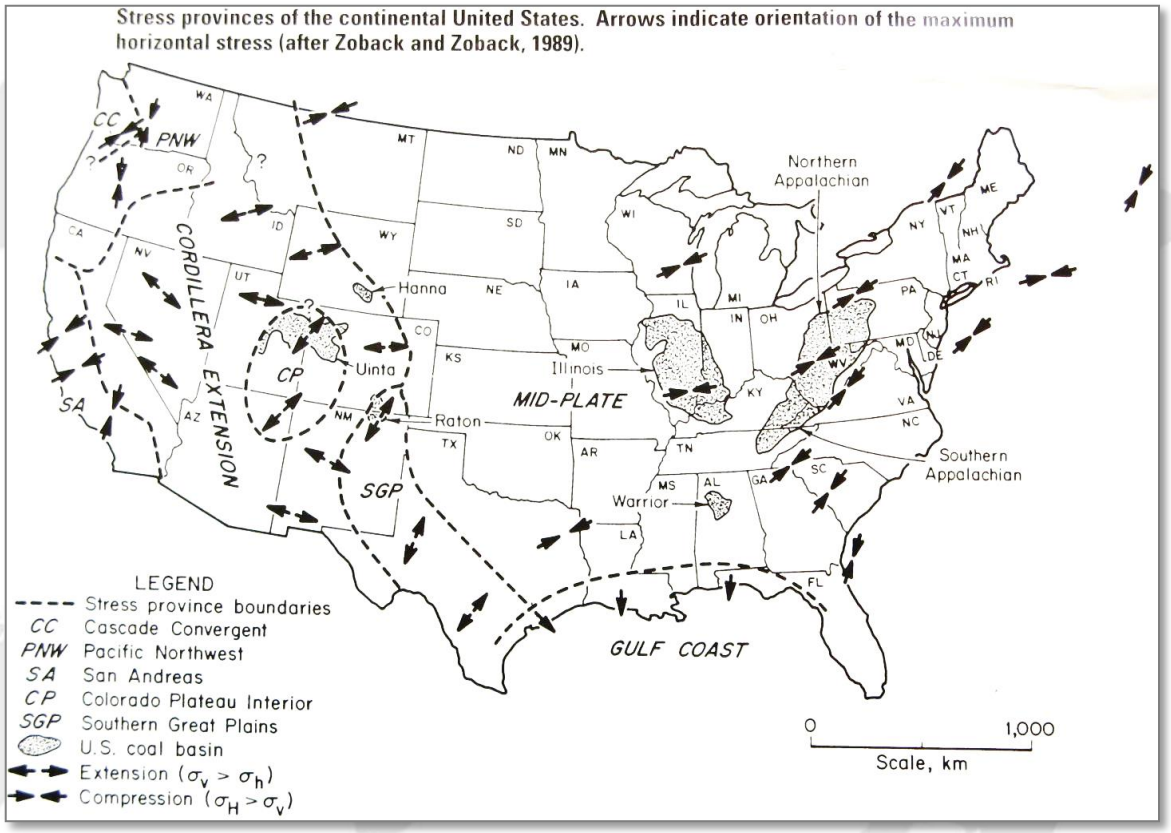


Typical stratigraphic column

Regional Horizontal Stress Effect

The effect of the major horizontal stress on an entry/crosscut stability is categorized as follows when the angle (α) between the major horizontal stress and the entry/crosscut orientation is:

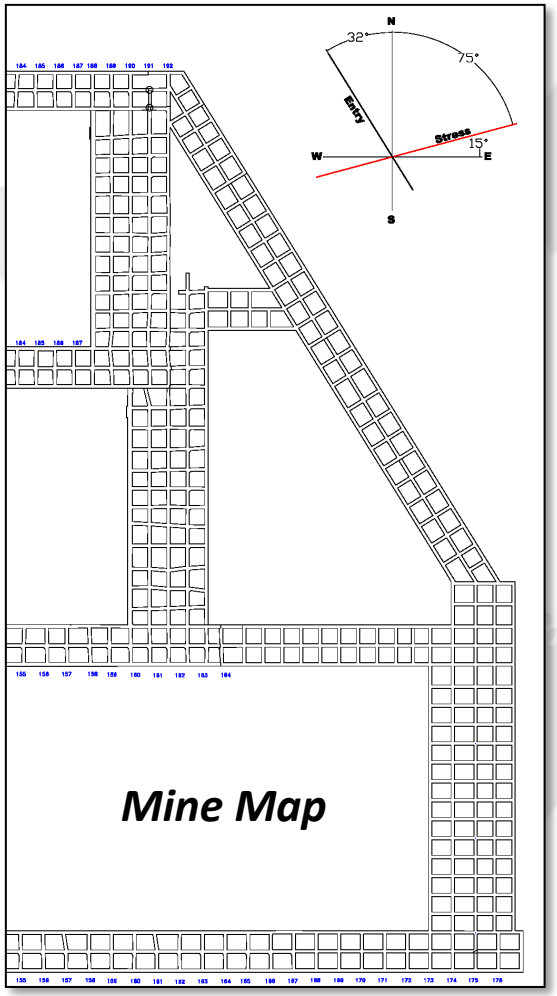
- **$\alpha \leq 30°$, highly favorable**
- **$30° < \alpha \leq 60°$, moderately favorable**
- **$60° < \alpha \leq 90°$, unfavorable**



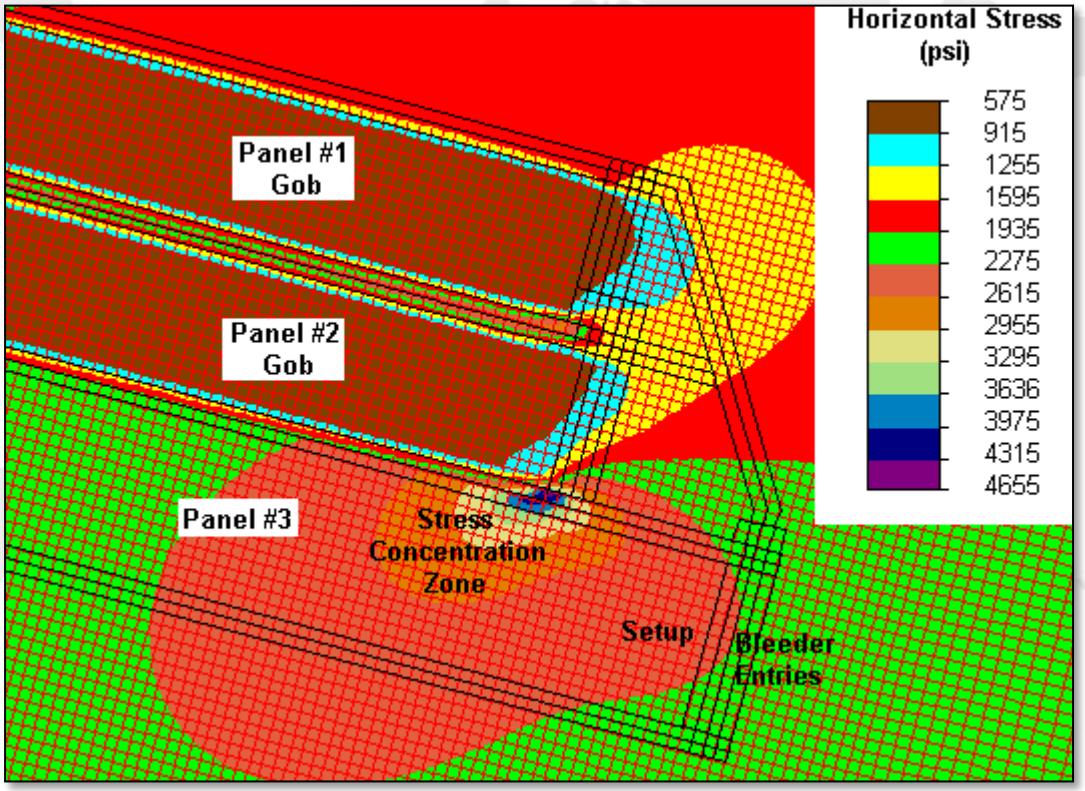
Regional horizontal stress distribution in USA

Generally, N75°E is accepted orientation of major horizontal stress in Illinois Basin

Simulation of Horizontal Stress Effect on Roof Stability of Set-Up Entries and Bleeder

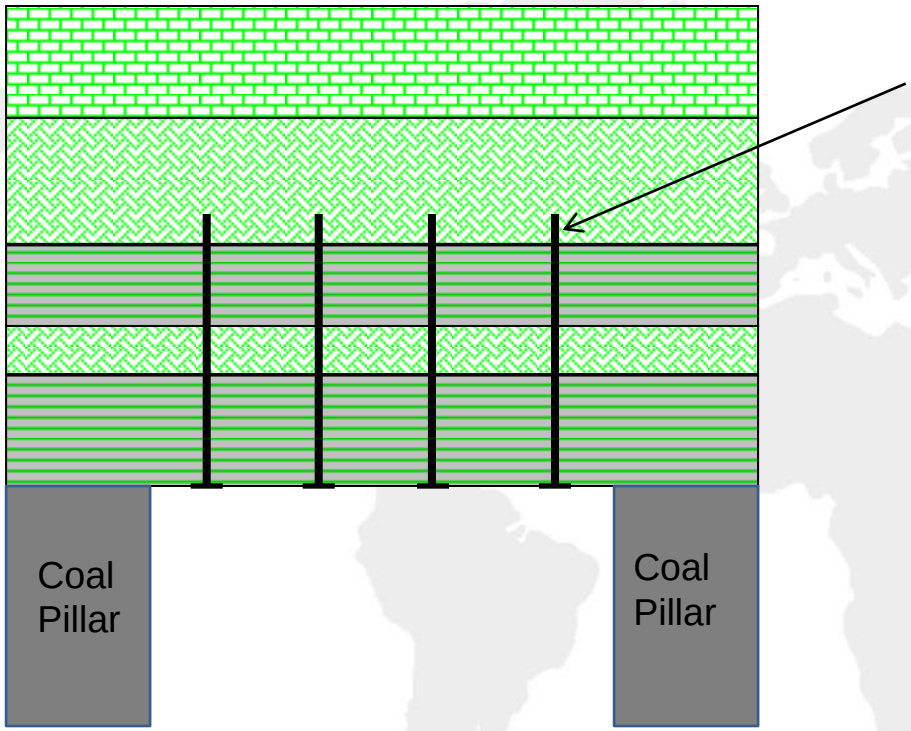


Due to the regional horizontal stress effect and longwall mining activity, stress concentrations may affect the roof stability in set-up or bleeder entries.



Stress Concentration Effect

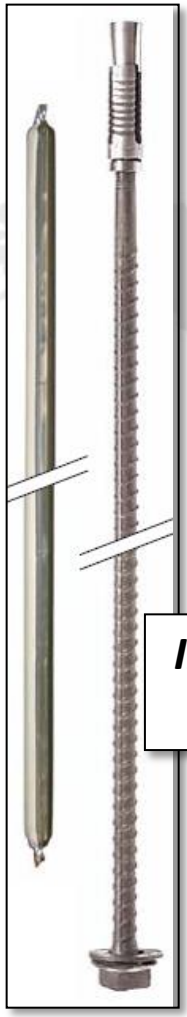
Roof Support Practices - Primary Roof Support



A tensioned bolting system works much better than a non-tensioned system in terms of the beam building effect and roof stability

Tensioned bolt systems: InStaL, Super-Twist torque/tension

Roof Support Practices - InStaL Bolt and “TT” Anti-Frcition Washer



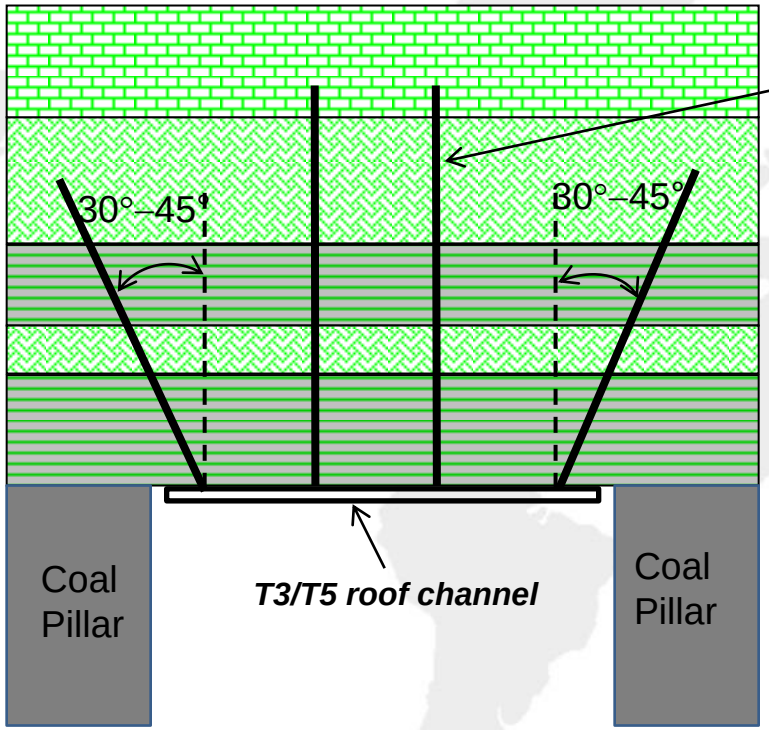
InStaL Bolt

- **“TT” anti-friction washer increases the installed load and tension/torque ratio by 20%**
- **Improves the beaming effect and roof stability in the highly stressed and laminated roof**

“TT” Anti-Friction Washer

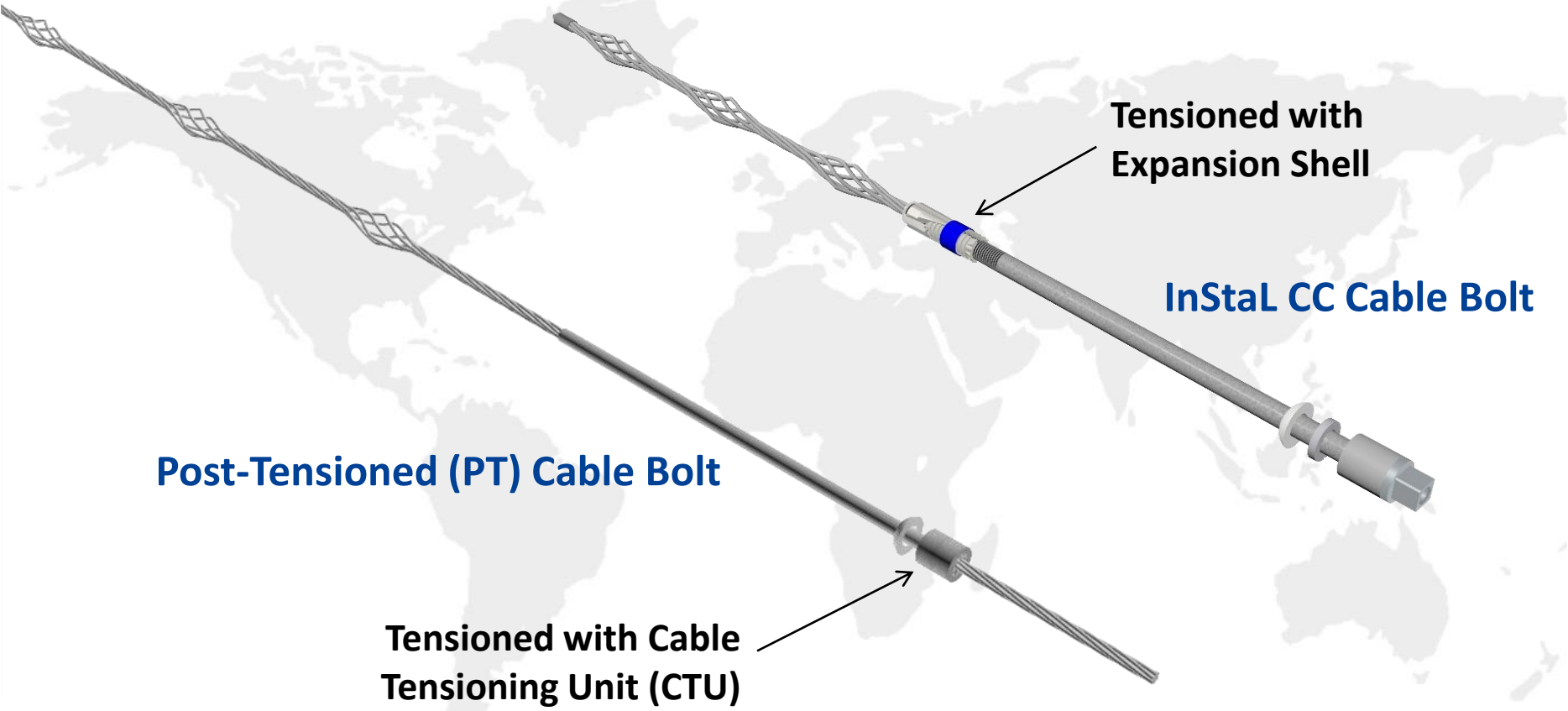
Underground Roof Condition w/InStaL Bolts & “TT” Anti-Friction Washer

Roof Support Practices - Supplemental Roof Support



In highly-laminated weak shale roof and horizontal stress condition, a tensioned cable (either Post-Tensioned or InStaL CC cable) works more efficiently than a non-tensioned cable

Roof Support Practices - Post Tensioned and InStaL CC Cable Bolts



Roof Support Practices – FGCB Injectable Cable

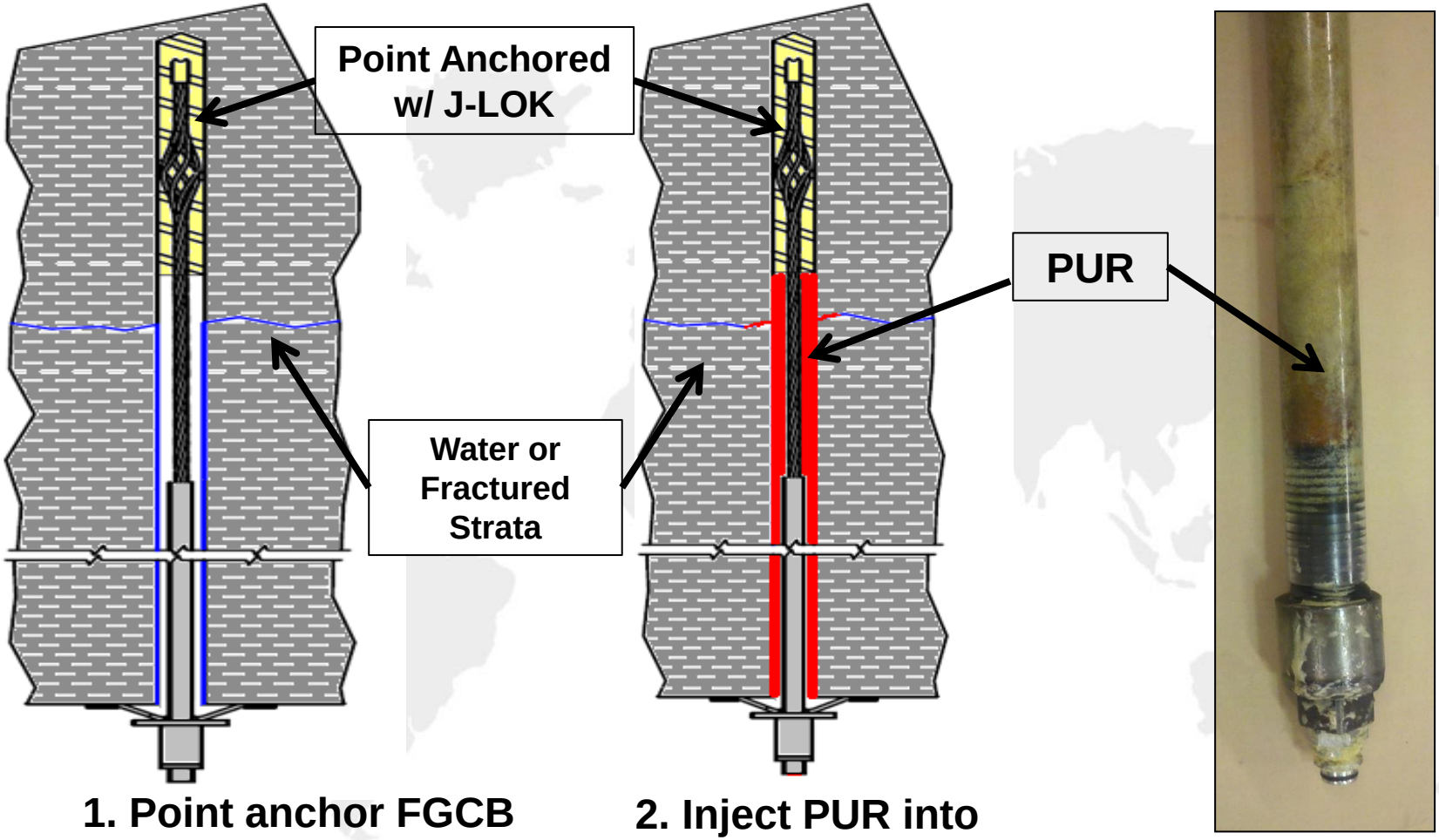
Fully-Grouted Cable Bolt (FGCB) can be injected with polyurethane (PUR) to fully encapsulate the cable bolt and drill hole.

- **Long term corrosion protection**
- **Water stoppage**
- **Strata stabilization**
- **Available as non-tensioned or tensioned InStal cable**

How does the FGCB work?

- **Modified drive head to allow injection of PUR.**
- **Stiffener tube serves as a grout tube.**
- **Addition of rubber packer to pressurize drill hole.**

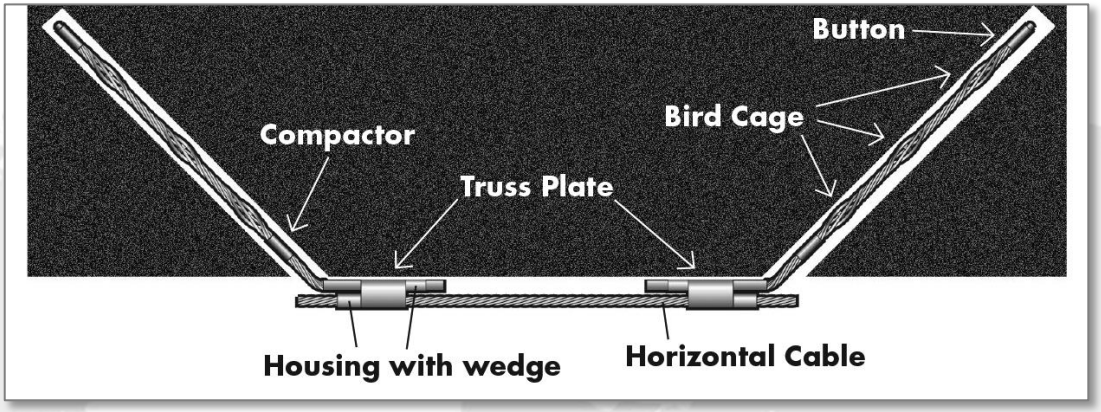
Installation Diagram



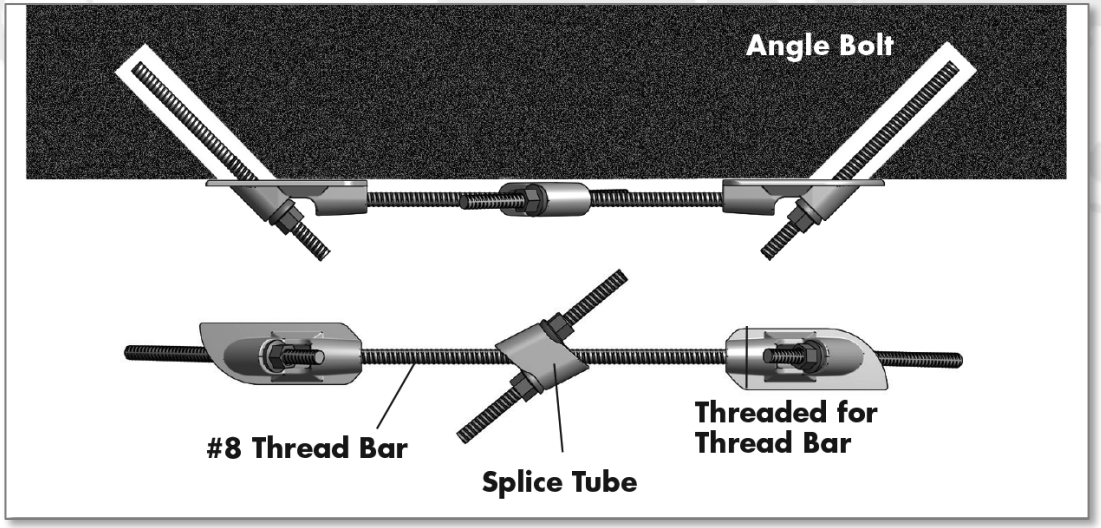
1. Point anchor FGCB into J-LOK resin

2. Inject PUR into drive head

Roof Support Practices - Trusses

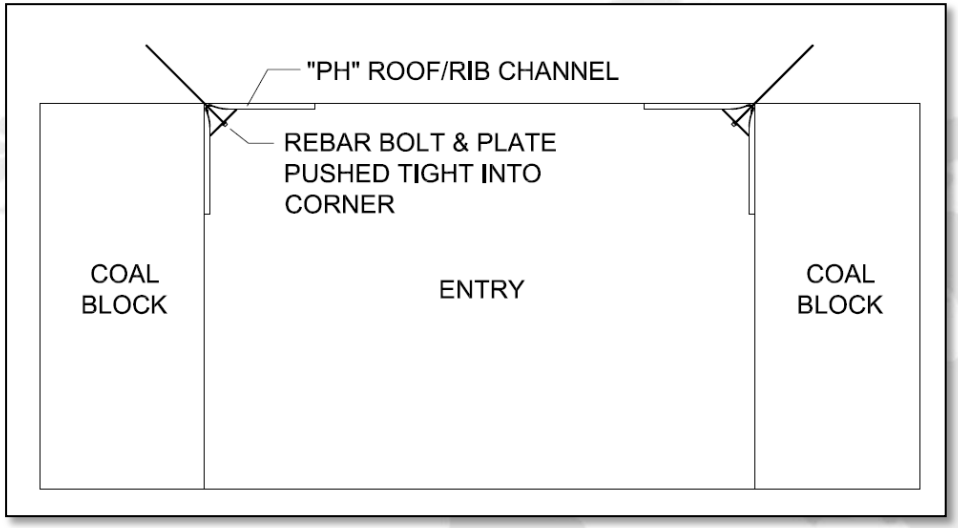


JMS
Truss System



BYTM
#8 Thread Bar
Truss System

Roof Support Practices - Roof/Rib Corner Control

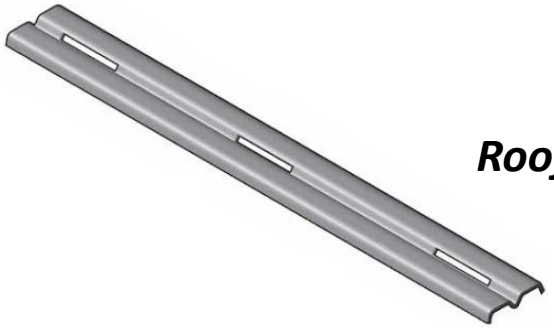


PH roof/rib channel installation

Installed underground

PH Roof/Rib Channel prevents roof cutter induced by horizontal stress, enhancing roof and rib stability

Roof Support Practices – Surface Control



Roof T-channel

Roof/rib Pan

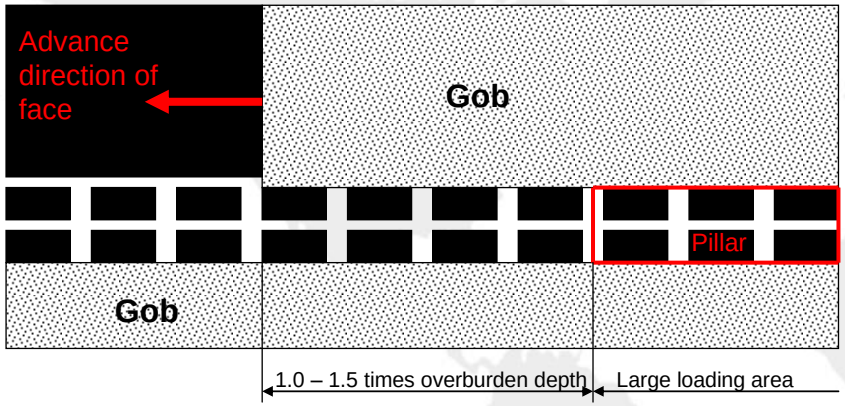
Roof Mat

Steel Wire Mesh

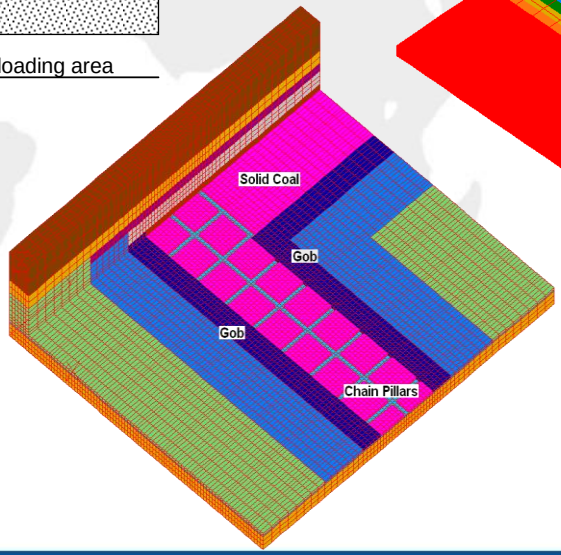
Surface control: roof channel, pan, mat, wire mesh are critical in preventing weathering effect and maintaining the roof stability

Gateroad Pillar Design and Evaluation

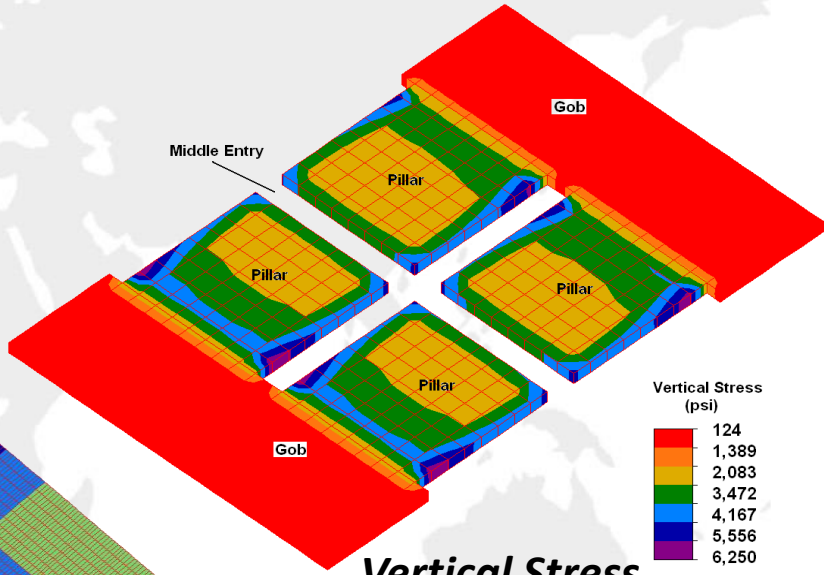
Pillars on the tailgate side of a panel are subjected to larger loading than those on the headgate side. To satisfy the ventilation requirements in longwall gates, the middle entry needs be maintained during longwall mining.



Tailgate Chain Pillars



Finite Element Analysis Model



Vertical Stress Distribution

Roof Support Practices - Standing Support - Pumpable J-CRIB and J-PAK I & II

Pumpable J-CRIB

J-PAK I

Before Test

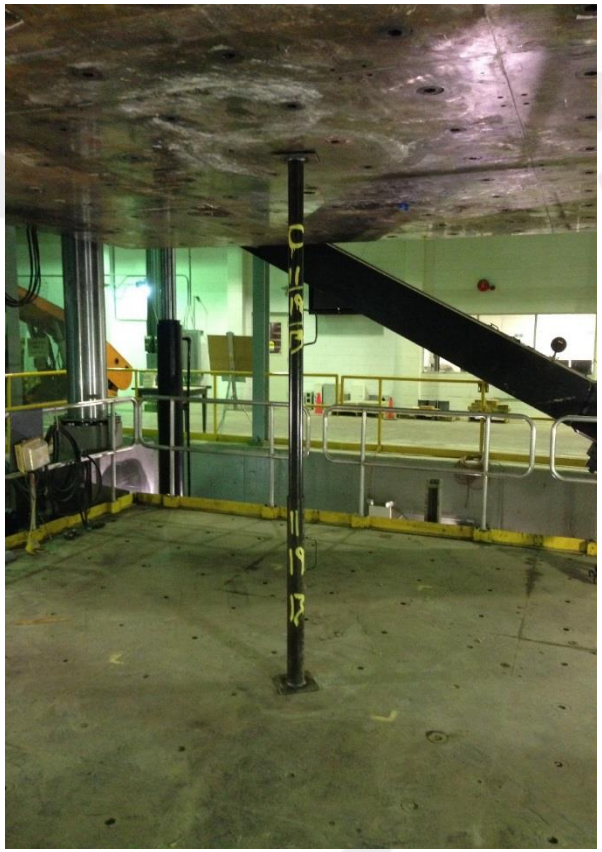
After Test

J-PAK II

Before Test

After Test

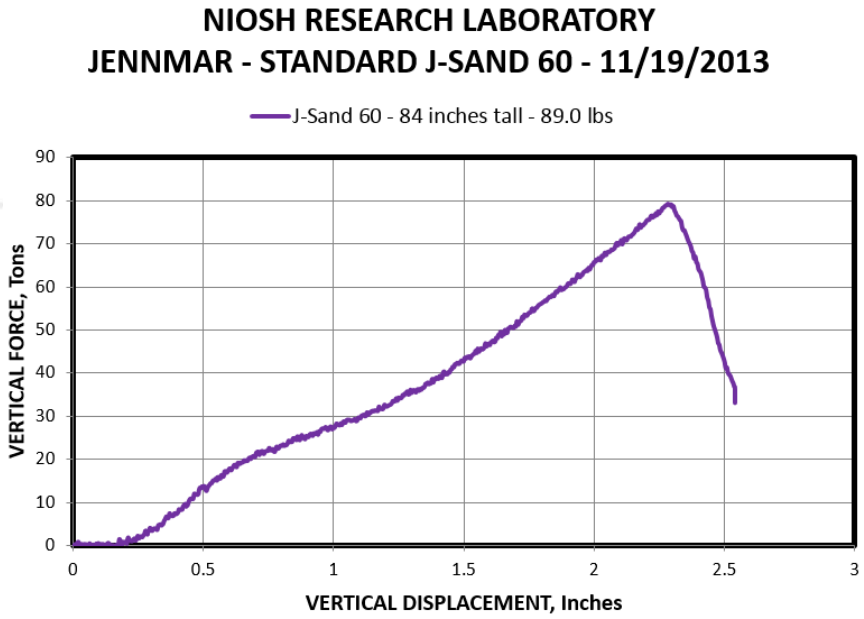
Roof Support Practices - J-SANDY and RIP Steel Props



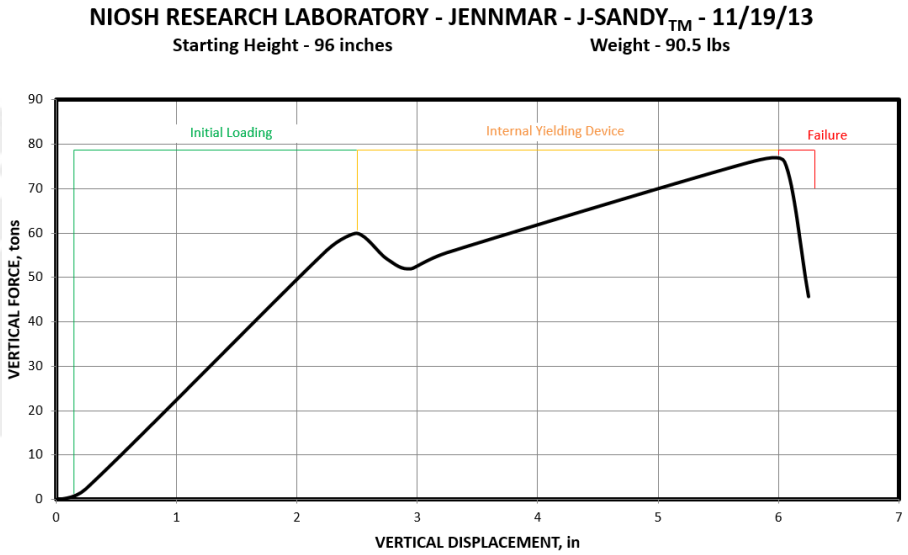
Yieldable
J-SANDY Prop

Rapid Installation
Prop (RIP)

Roof Support Practices - J-SANDY NIOSH Test Curves

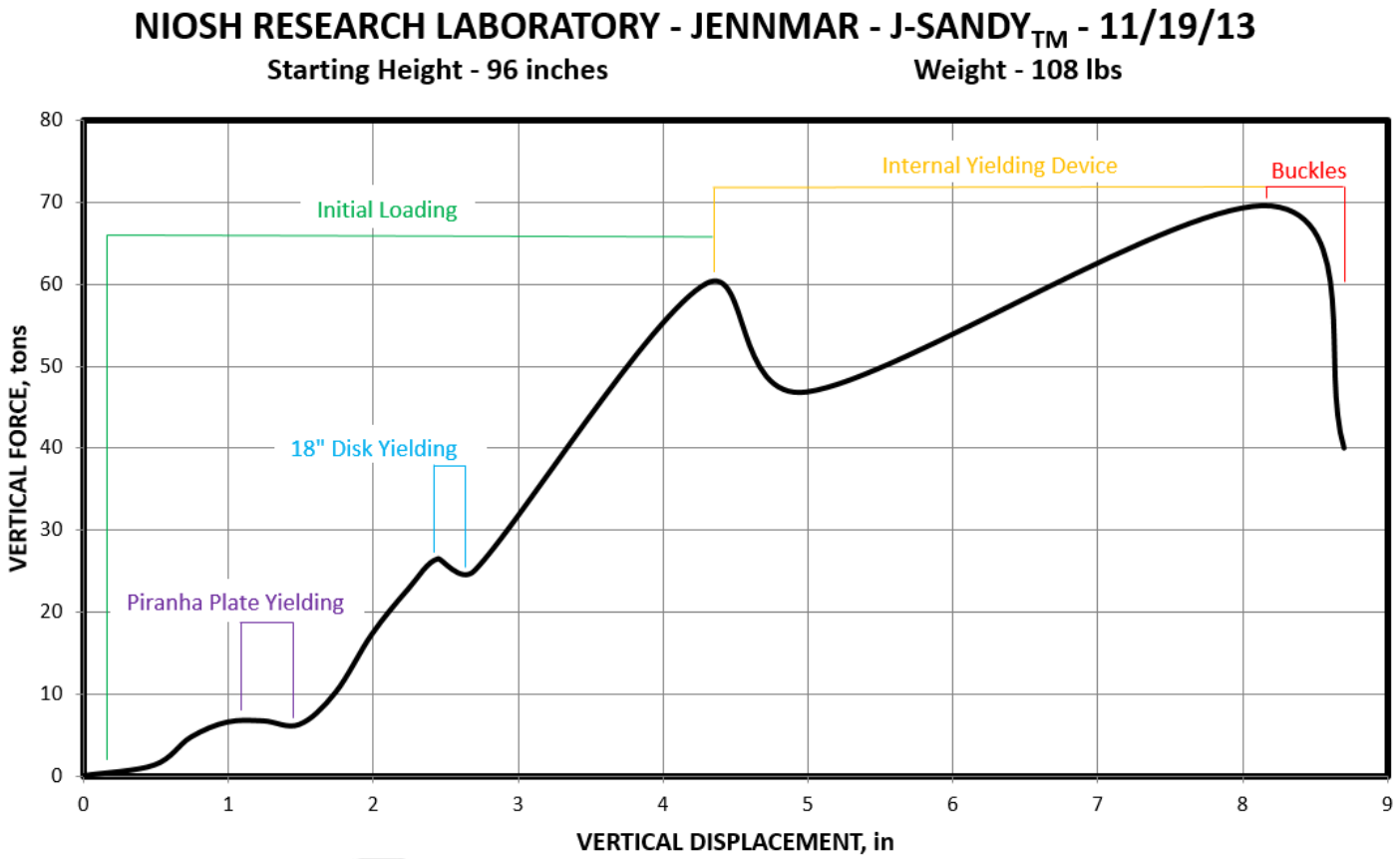


Standard J-Sand Test Curve



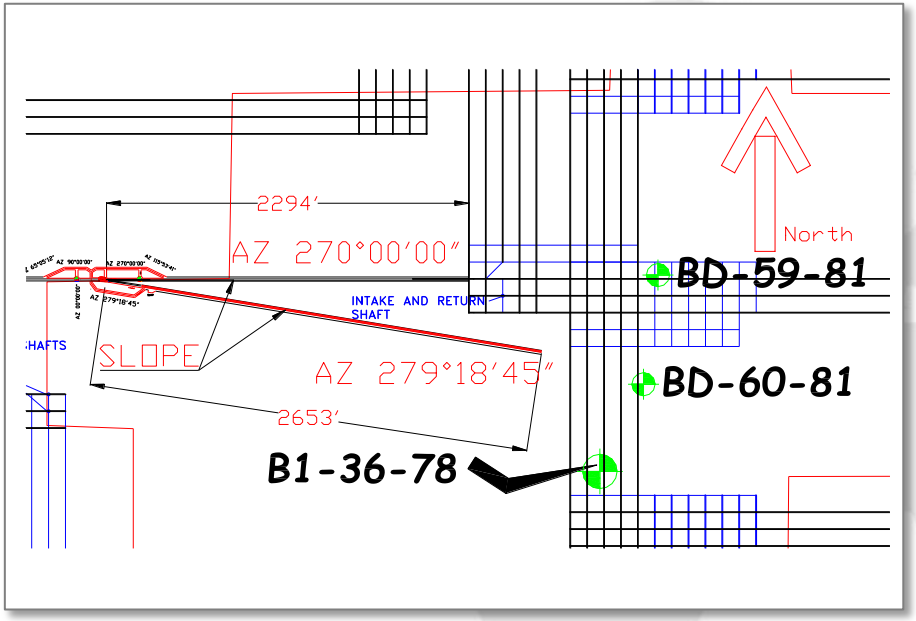
J-SandY Test Curve

Roof Support Practices - J-SandY NIOSH Test Curves

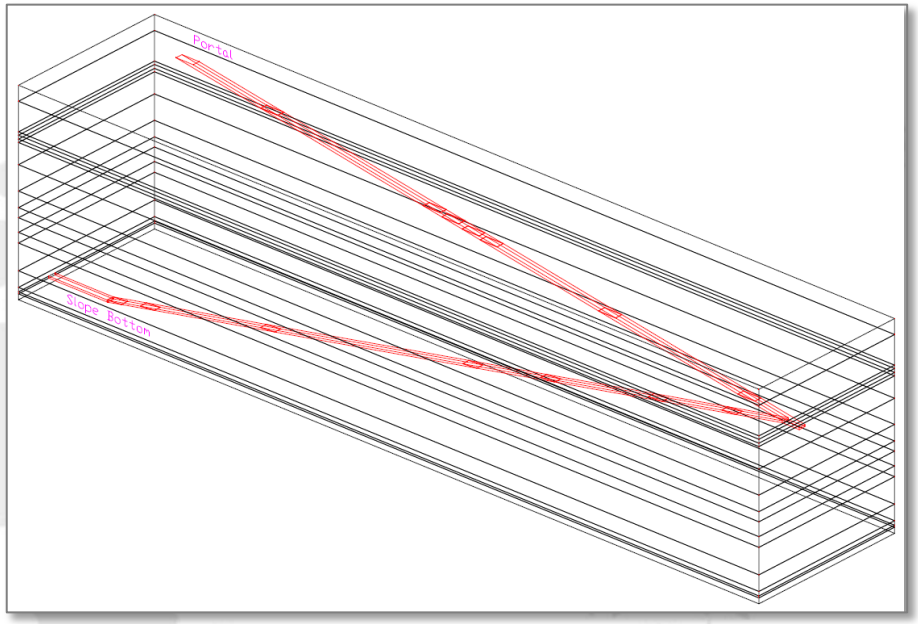


J-SandY Test Curve with Yield Disk and Piranha Plate

Ground Support for a Slope - Geological Analysis

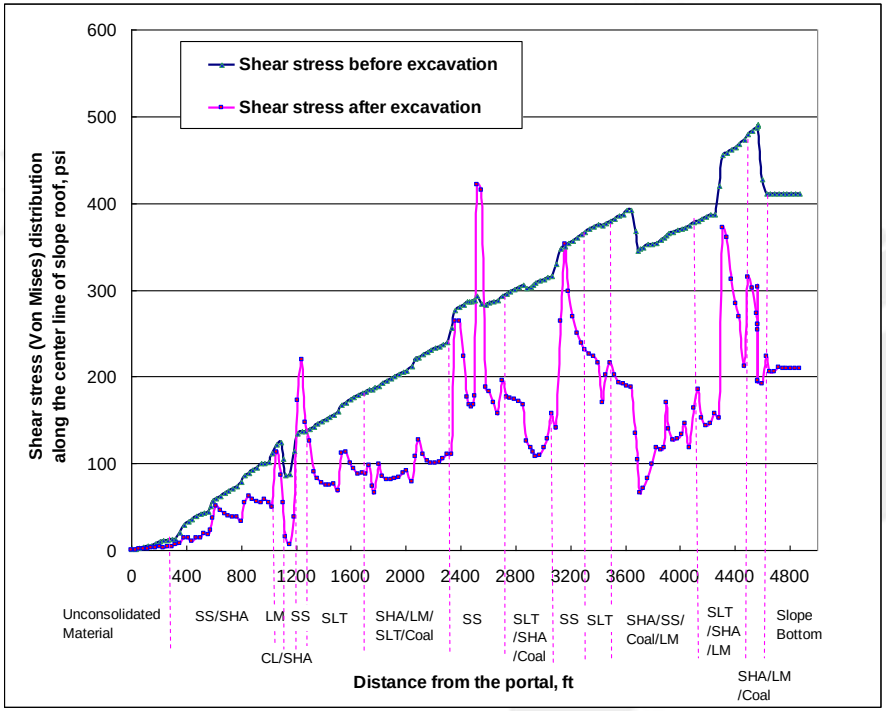


Slope Orientation and Drill Holes

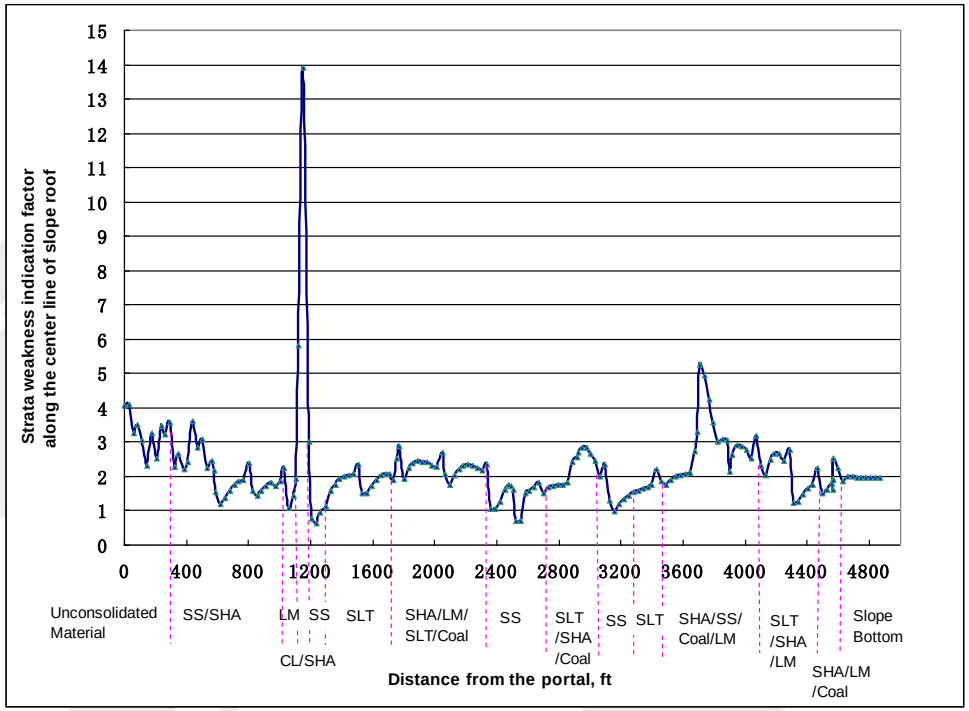


Computer Model

Ground Support for a Slope – Geological Analysis



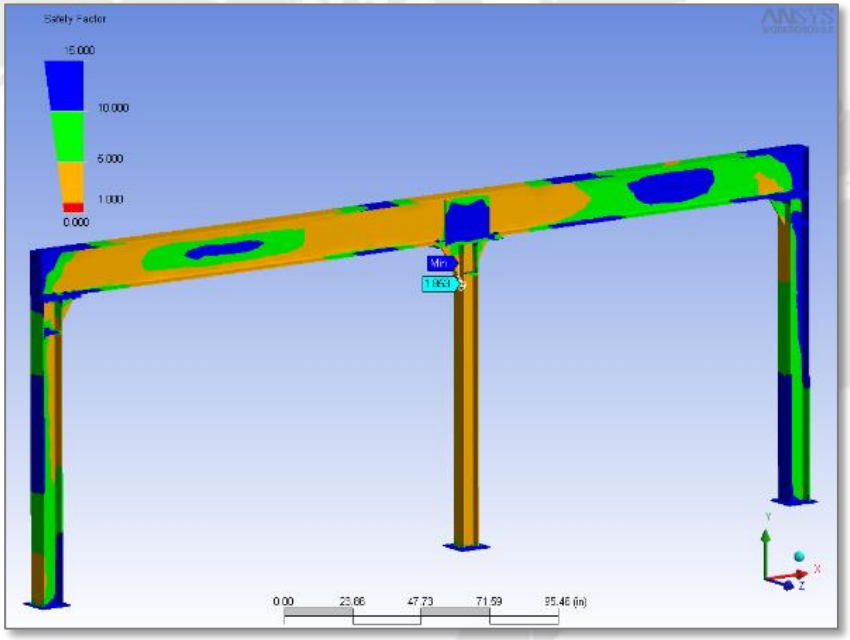
Shear Stress Distribution Along Roof Center



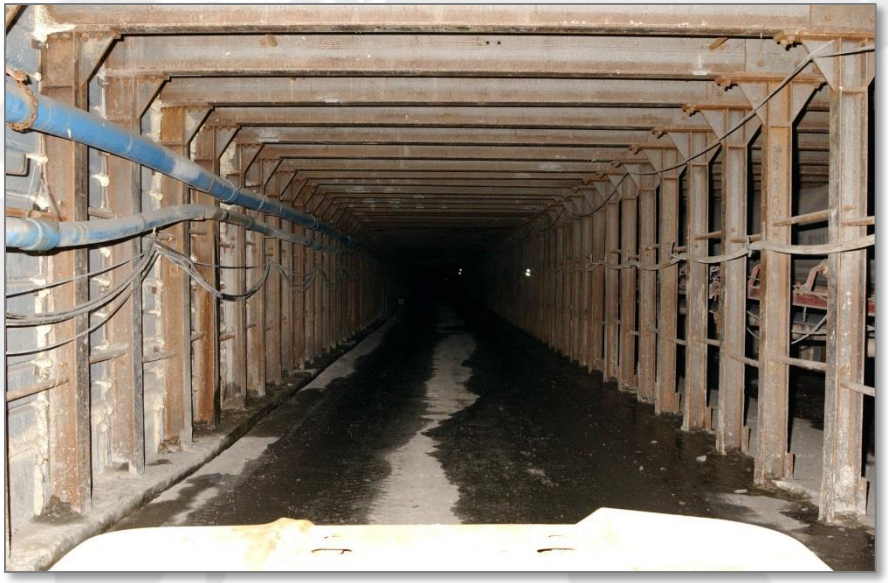
Strata Weakness Indication Factor (SWIF) Distribution Along Roof Center (weak strata with a SWIF > 2)

Ground Support for a Slope - Square Set Design

Square set design follows the American Institute of Steel Construction (AISC) national standard, and is based on actual geological and mining conditions

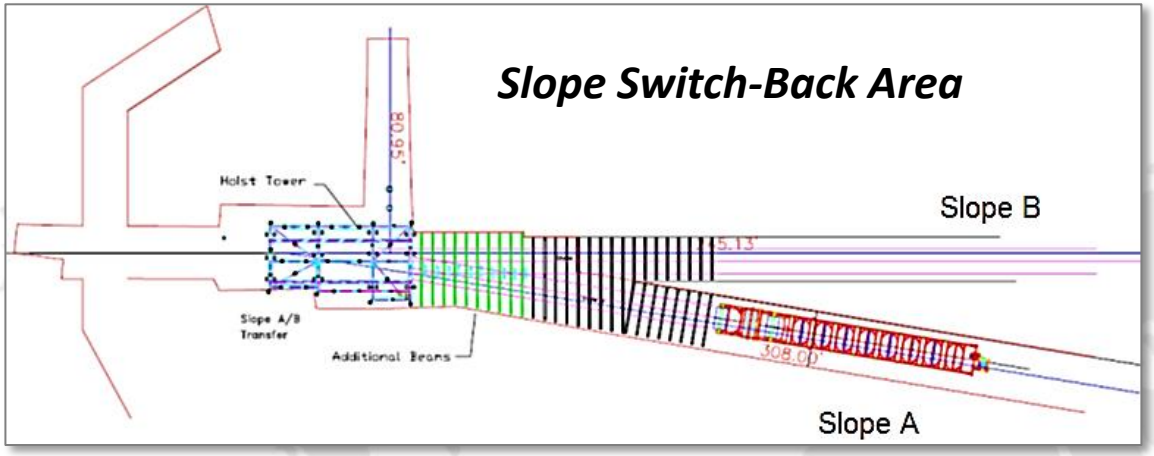


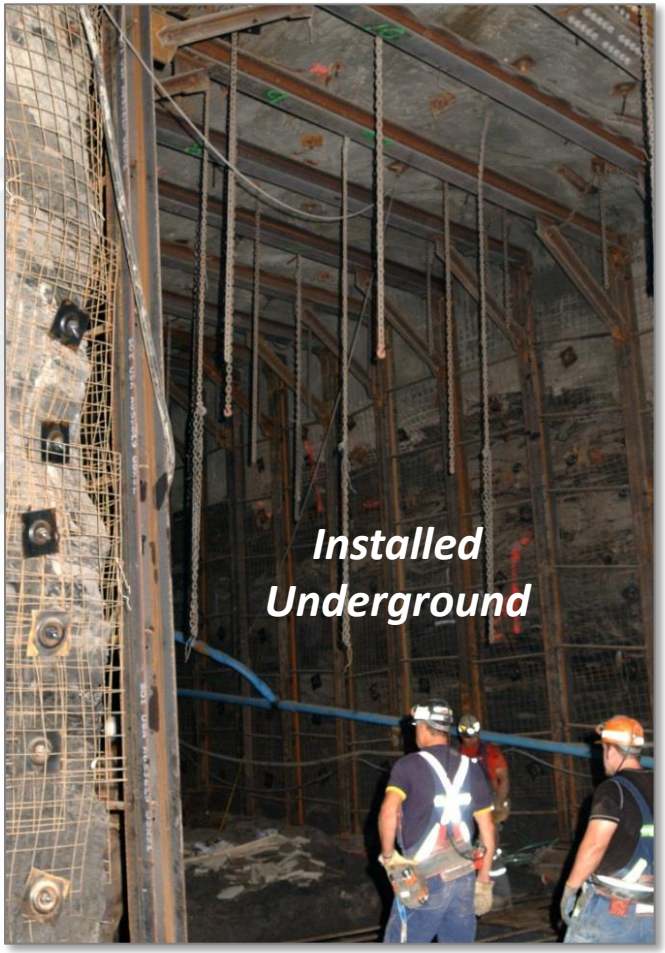
Safety Factor (SF) Distribution (SF > 1)



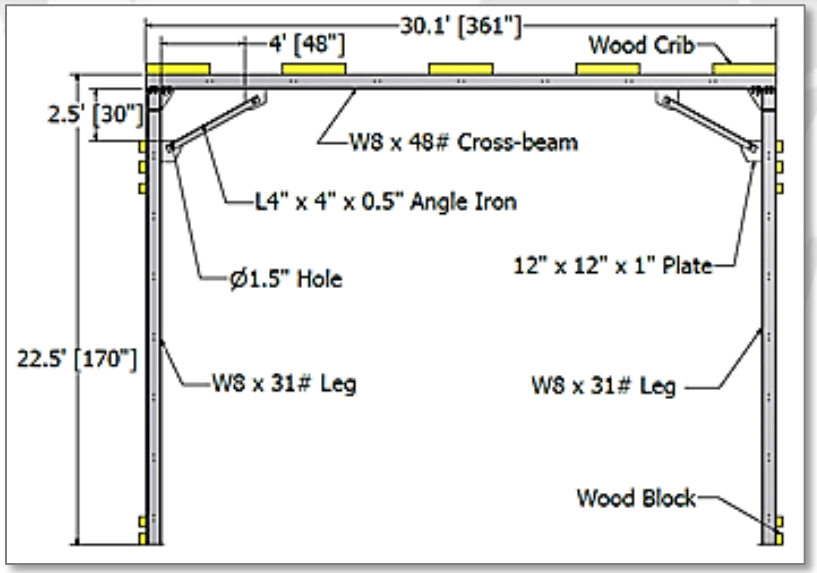
Installed Underground

Square Set Design for a Slope Switch-Back Area





Components and Dimensions



Questions & Comments

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Thank You!