OMSHR

Office of Mine Safety and Health Research

Support Design for Difficult Ground Conditions

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Unplanned ground falls in coal mines

- More than 1200 large unplanned ground falls reported per year
- Each fall represents failure of the support system
- NIOSH project to improve support design procedures

Problem Statement and Objective

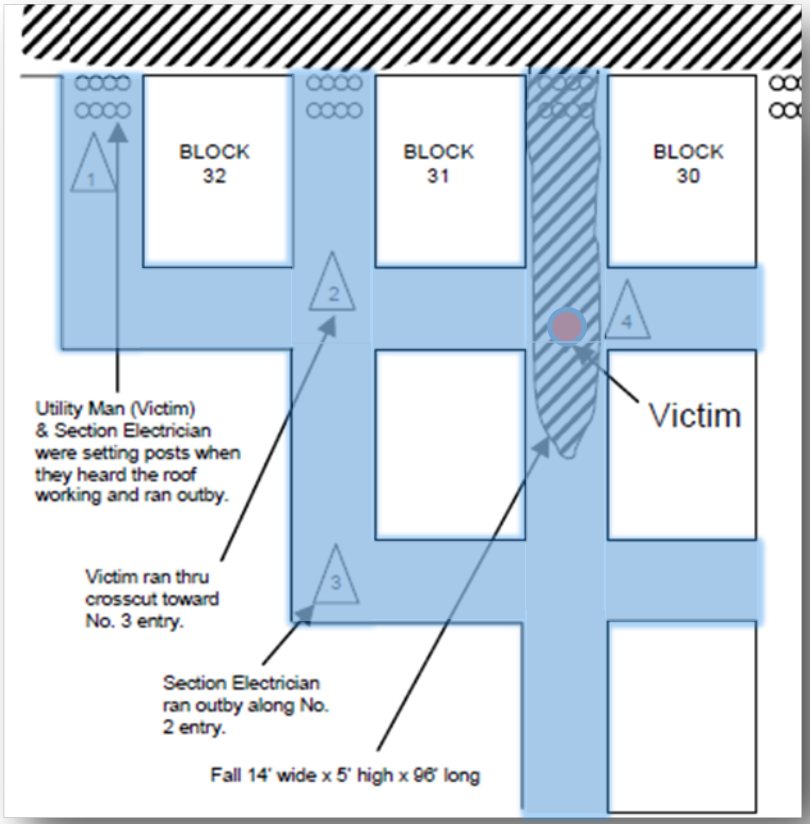
<u>Problem:</u> Failure of supported roof

- 38% of ground fall fatalities in room and pillar workings
- 1200 reportable non-injury ground falls per year

<u>Approach:</u> Safety through design

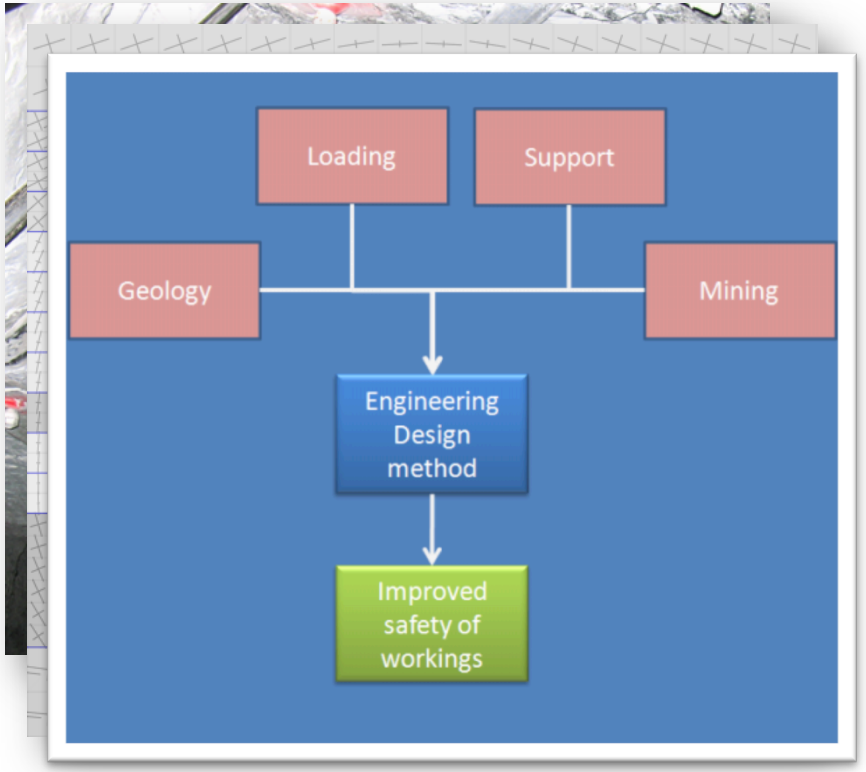
<u>Objective:</u> Develop improved design procedures to better match support systems to ground conditions

MSHA Fatalgram



Specific Objectives

- Understand the problem: Roof fall statistics, site visits, new field studies, laboratory testing
- Develop analysis methods: Numerical modeling procedures for rock-support interaction
- Design procedures: Parameter studies , validation, packaged design procedures

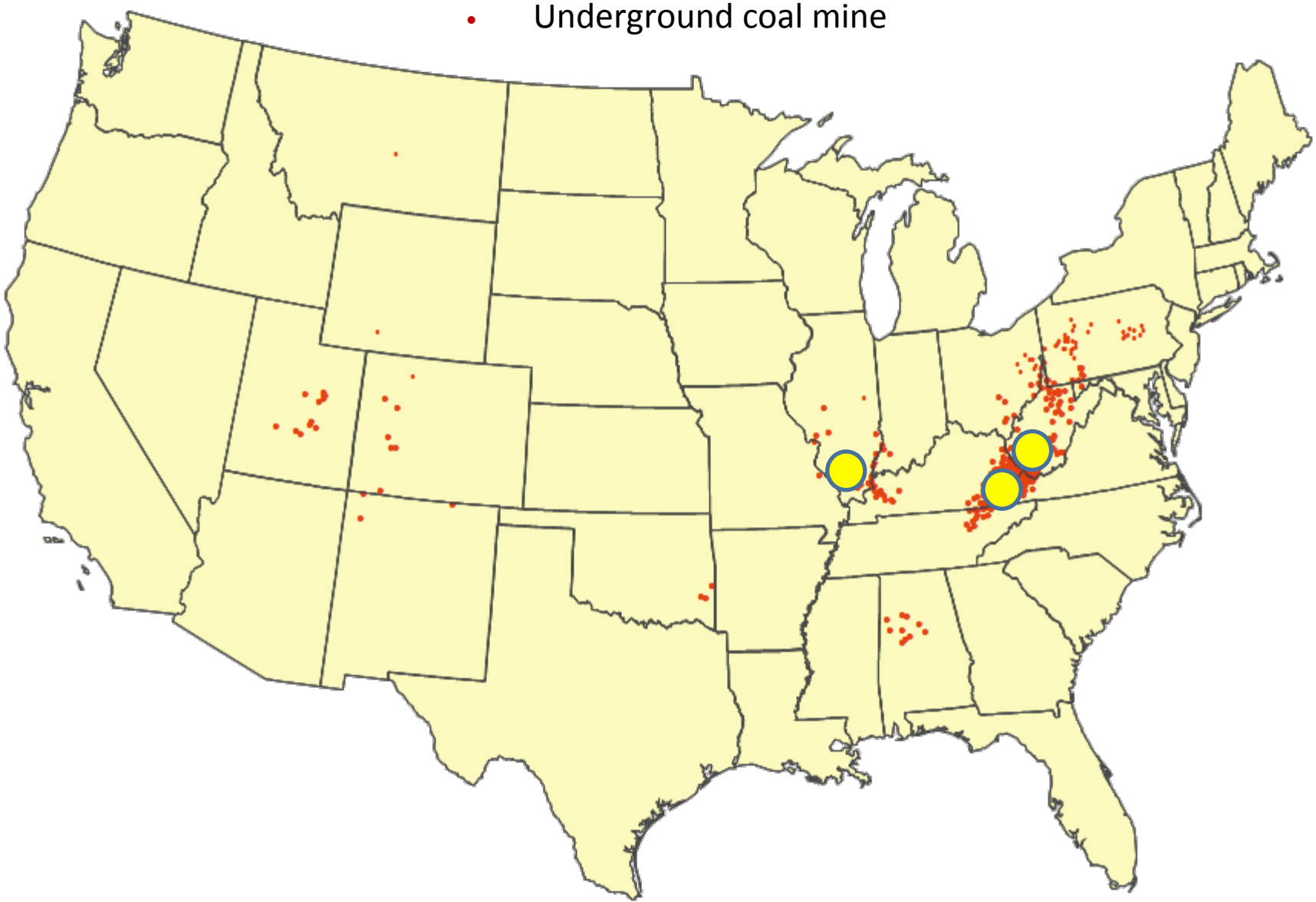


Understanding the Problem

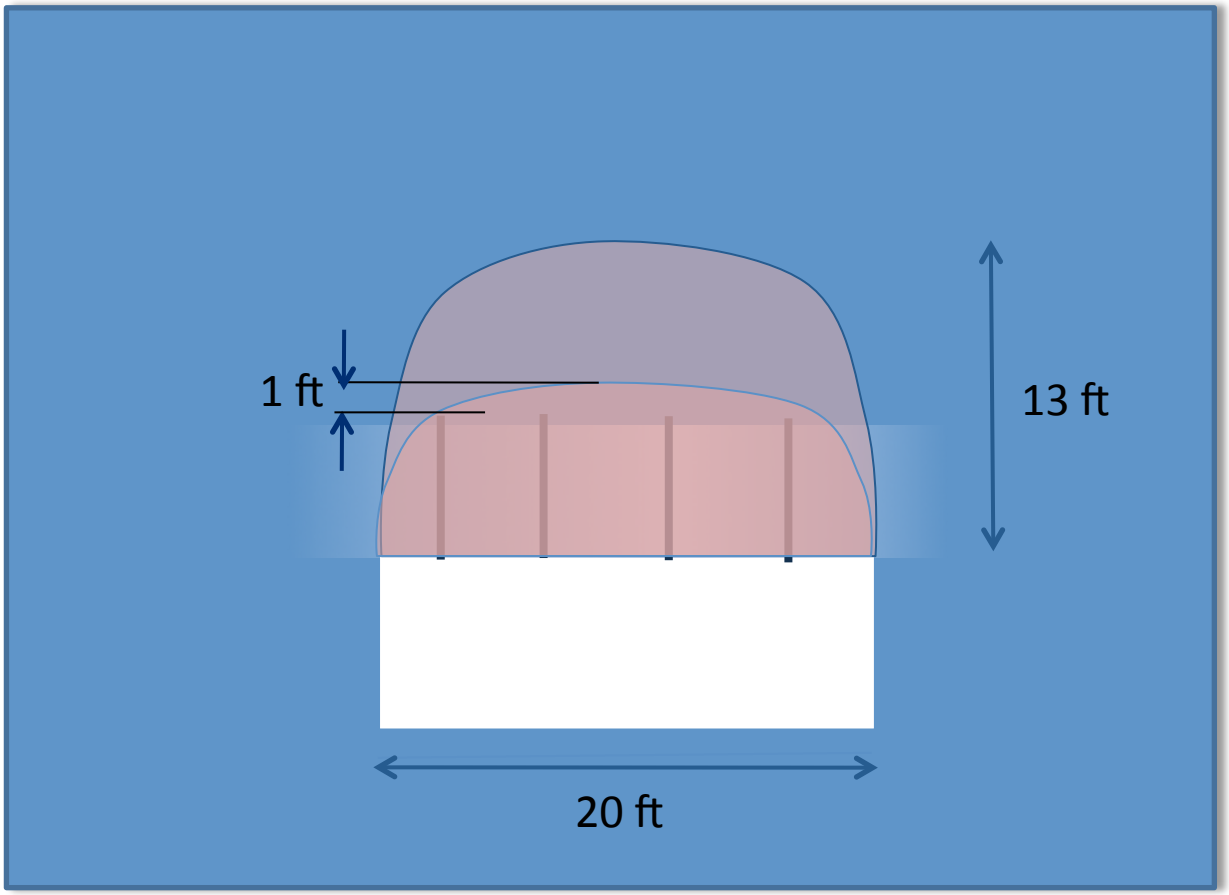
- Characteristics of Roof Falls
  - Is the problem regional
  - Dimensions of falls
- Current support systems
- Means of failure
- Observed failures

Top 20 mines with a high frequency of ground falls

- Underground coal mine



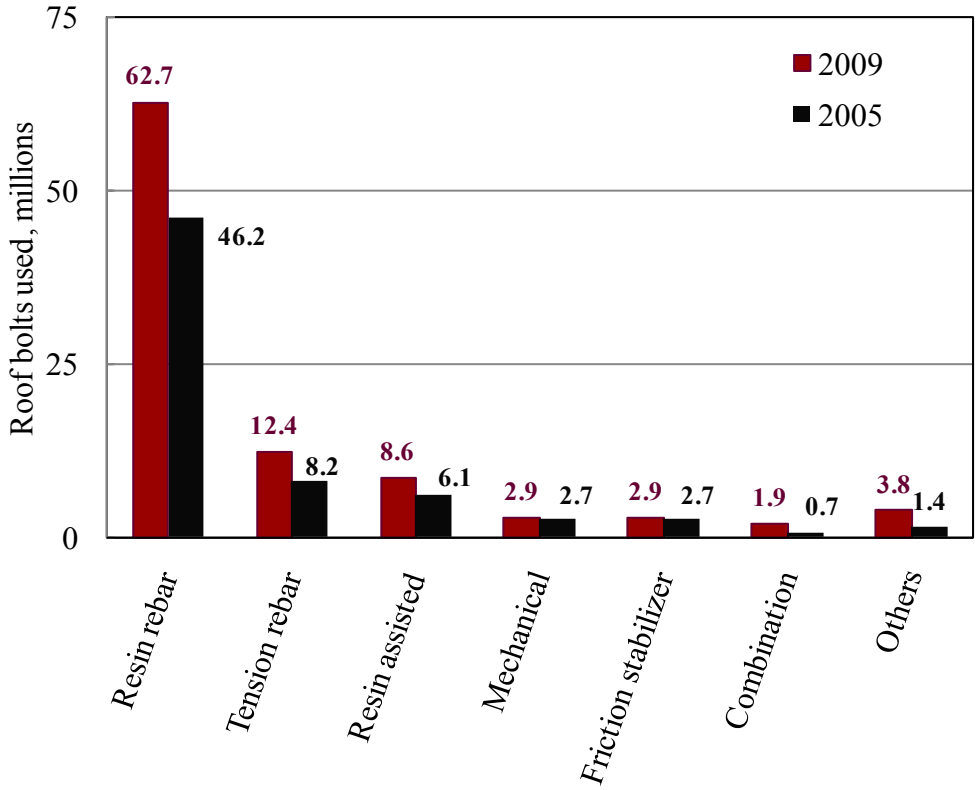
Large roof falls



- 50% of falls extend less than 1 ft above the bolted horizon
- 95% of reportable falls extend less than 13 ft above the roof line

Support practices

- Targeted field visits
- Review of ground control plans
- Statistics on support element usage



Large roof falls are a safety hazard in coal mines

- 1200 large roof falls reported annually
- Horizontal stress is a significant factor
- Roof consists of bedded rocks
- Develop support design protocol
- Need to understand mechanics of failure

Observed failures

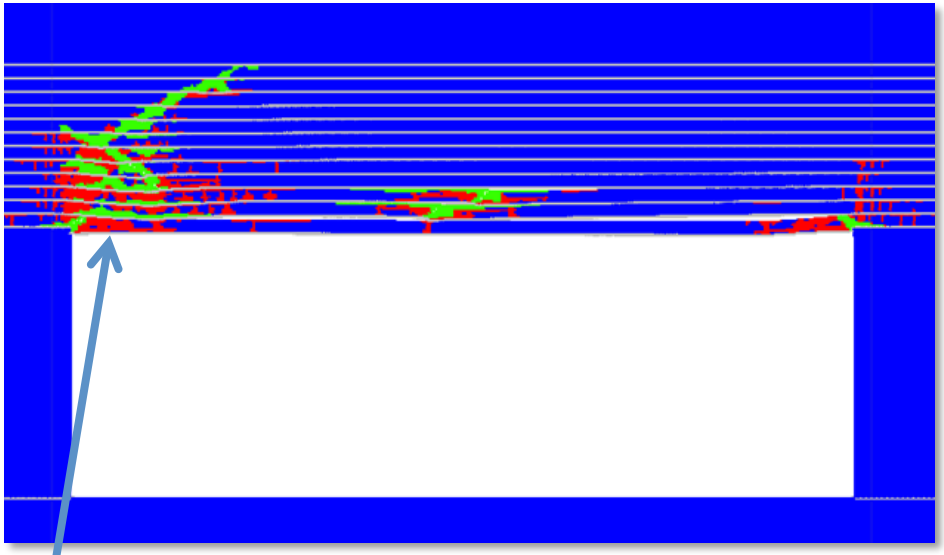
Develop Analysis Procedure

- Credibility of analysis procedure
  - Systematic method for input data
  - Realistic failure mechanics
  - Model validation against field
- Meaningful outputs
  - Problem is large scale collapse
  - Measure of entry stability

Rock strength parameters for models

- Standardized procedure based on CMRR
- Unit rating of each bed
  - UCS of intact rock
  - Diametral point load strength
  - Bedding strength
  - Bedding intensity
- Spreadsheet to generate “best estimate” inputs for FLAC models

Realistic roof failure mechanics

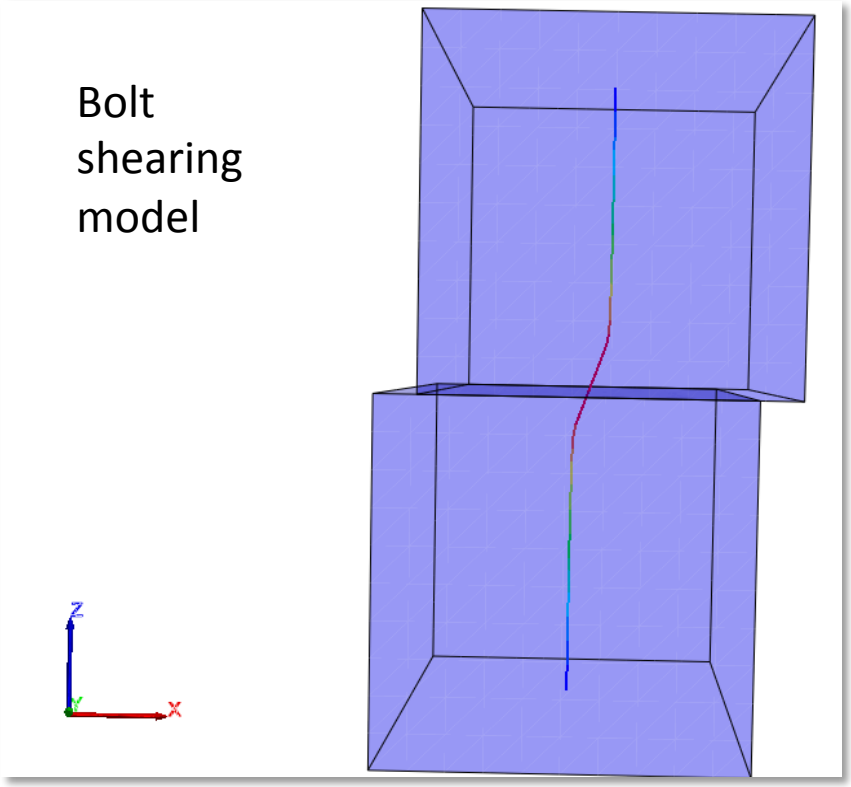


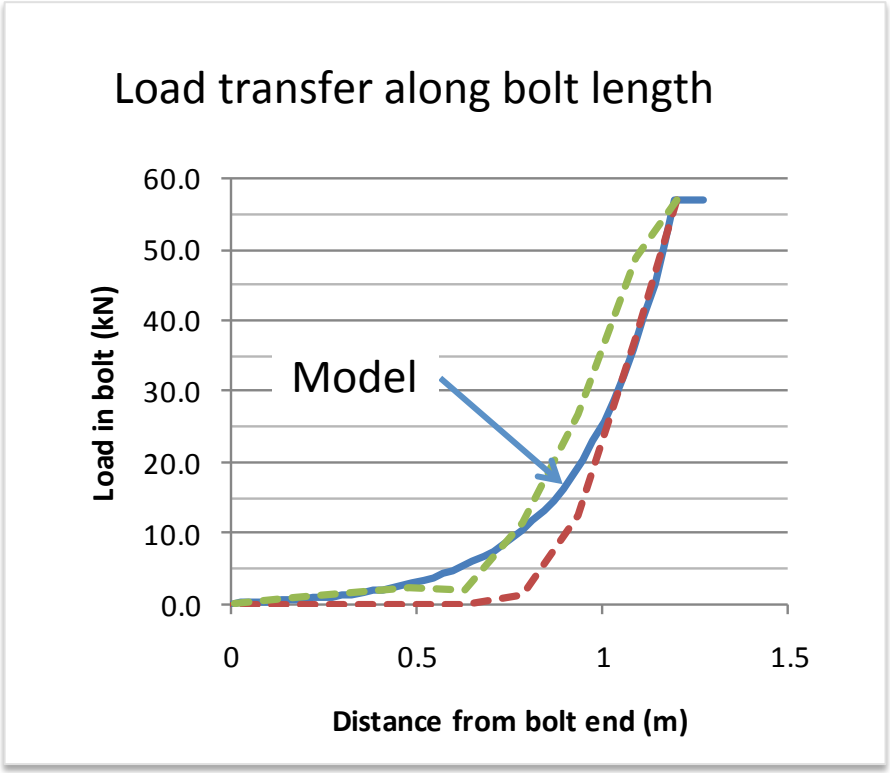
Cutter formation

Publication: Esterhuizen, Bajpayee. Horizontal stress related failure in bedded mine roofs—insight from field observations and numerical models, US Rock mechanics Symposium, 2012

Realistic bolt modeling

Bolt shearing model





Publication: Tulu, Esterhuizen, Heasley. Calibration of FLAC3D to Simulate the Shear Resistance of Fully Grouted Rock Bolts – US Rock mechanics Symposium, 2012

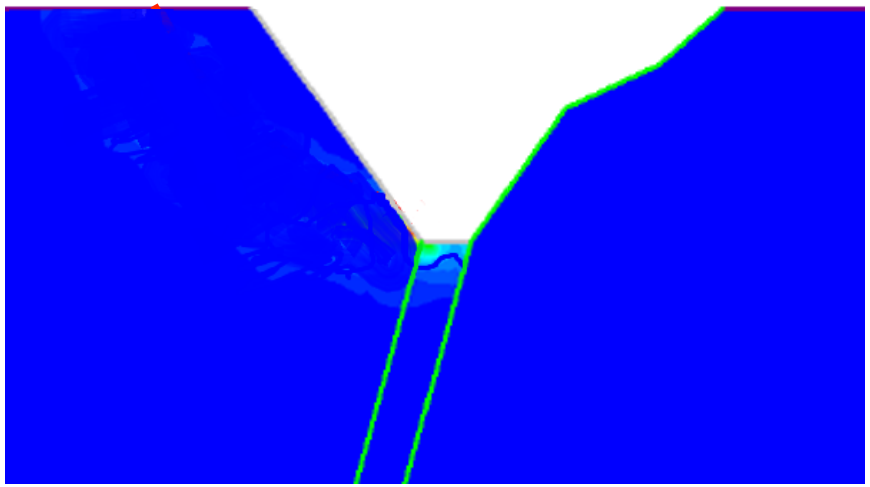
Need a technique to evaluate effectiveness of design

- How far is the roof from failing – what is the margin of safety?
- How does stability change if support is changed?
- Stability factor approach: Strength/Load
- For entries: What strength? What load?

Obtaining a stability factor

- Strength reduction technique:
  - Slope stability (1975)
  - Create model of slope and reduce strength until failure is indicated
  - FOS = 1/strength reduction factor at slope failure

SRF = 0.82
FOS = 1.21



Stability factor for entries

SRF = 0.56
FOS = 1.78

- Stability Factor:
  - SF = 1/strength reduction factor at entry failure
- Definition of failure:
  - Roof collapse at or above bolted horizon
  - Assume smaller falls between supports taken care of
- Give it a try: