Instructional Objectives

1. Explain the different rock bolting mechanisms.
2. Select a type of rock bolt for a given situation.
3. Explain the difference between grouted and non-grouted rock bolts.
4. Explain the difference between pre-tensioned and un-tensioned rock bolts.
5. Propose a plan of action for all contingencies when monitoring SMART rock bolts.
6. Explain the different types of rock bolting systems.

Rock Bolting Mechanisms

- Strata suspension from stronger strata
- Beam building – making thicker beams
- Keystones or keyblocks
- Forming natural stress arch
- Increasing radial stresses
- Increasing effective normal stresses

Strata suspension from stronger strata
Keystones or keyblocks

Forming natural stress arch

Increasing radial stresses

Increasing effective normal stresses

Types of Rock bolts

- Slot and wedge
- Expanding shell
- Cement grouted dowel
- Perfobolts
- Resin grouted
- Split set
- Swellex

Slot and Wedge / Expanding Shell
Relative Costs

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<th>Shell</th>
<th>Split Set</th>
<th>Swellex</th>
<th>Resin</th>
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Grouting

- Ungrouted – short term
- Grouted long term
- Grout fills cracks
- Grout eliminates stress concentrations
- Grout protects against corrosion
- Grout resists dilation and bending moments
- No use for mechanical anchor

Tensioning

- Tension vs. untensioned
- Needs faceplate
- Tensioning and Testing

Testing

- Section testing of Grouted testing panel for evaluating embedment and 
shear...
Monitoring

- Stress increase from ground movement = bad
- Stress decrease from bolt failure = bad
- Stress decrease from relaxation of ground = good
Considerations

• Pressure grouting
• Corrosion protection
• New FRP bolts

Bolting Systems

• SPOT BOLTING - bolts placed where someone thinks there is a problem, estimating the length of bolt needed
• PATTERN BOLTING - bolts put in on a systematic pattern on a predetermined grid, at a predetermined angle, with fixed length bolts.
• WIRE MESH between bolts - (screen) to catch falling small rocks, or to use as reinforcing for shotcrete.
• STRAPS - steel plate connecting two or more rockbolts, distributing the load
• CROWN PLATES - curved rigid straps over the roof of the tunnel
• ROOF TIES - flexible straps over the roof of the tunnel
• TRUSSES - designed structural beams to support loads, bolted into the tunnel wall or roof

“Smart” rock bolts and anchors

• Stretch Measurement to Assess Reinforcement Tension (SMART)

Slide Show