Rock Slope Stability of the Smart Road
Rock Cut in Blacksburg, Virginia

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Smart Road Proposed

- **Test Bed**
  - 1.7 miles
  - Complex Geologic Setting

- **Vertical Rock Cut**
Planning & Design

  - Limited outcrop exposure
  - Rockslides vs. rock falls
    - Vertical slopes not best in folded and faulted rock
Smart Road Goes to Construction

Construction
- June 1998
  - Rock Slides
    - Oozing
  - Rock Falls
  - Delays, stop work
Smart Road – Field Mapping

- July 1998
- Detailed Mapping
  - Concurrent with construction
  - Windows
  - Other significant areas
    - ID, Group and Prioritize
Smart Road – Discontinuities

- Rock Structure/Discontinuities
  - Orientation
- Bedding
- Joints/Faults
- Characteristics
  - Lithology
  - Continuity
  - Infilling
  - Water
  - Roughness
- Samples
  - Shear testing
    - 34° vs 19°
Smart Road – Kinematic Assessment
RockPack II

- Kinematics
  - Geometry
    - Potential for motion only
    - Mass and force not considered

- Stereonets

- Discontinuities
  - Plot as clusters
  - Limiting equilibrium analysis
    - Friction Angle
    - Daylight
Smart Road – Kinematic Assessment
South/Right Slope

- **90 Degree Slope**
  - Planar Failures
    - Large, steeply dipping joints

- **60 Degree Slope**
  - Planar failures
    - Significantly reduced
Smart Road – Kinematic Assessment
South/Right Slope

- 90 Degree Slope
  - Wedge Failures
    - Bedding
    - Large Joints

- 60 Degree Slope
  - Wedge Failures not eliminated
Smart Road – Kinematic Assessment
North/Left Slope

- 90 Degree Slope
  - Planar Failures
    - Large, steeply dipping joints
- 60 Degree Slope
  - Significantly reduced
Smart Road – Kinematic Assessment
North/Left Slope

- 90 Degree Slope
  - Planar Failures
    - Large, steeply dipping joints

- 60 Degree Slope
  - Slightly reduced potential
Smart Road – Initial Study Results

- Vertical slopes will not be safe
  - Subject to large scale falls and slides
- Reduce slope angle to 60 degrees
- Implement monitoring/protective measures
Smart Road – Problematic Areas

- ID problem areas
  - Safety Factor Calculations
    - Some as low as .86/1.3
  - One third of planned depth
    - Significant potential for continued problems
- October 1998
  - Delayed for redesign and construction
Smart Road – Reevaluation

- Design Change Proposed
  - 1.5 H : 1.0 V (34 degrees)
- New Shear Strength Testing
  - Powder-coated bedding planes, zeolite
  - Friction angle of 28 degrees, c=0
- October 1998
  - Delayed for redesign and construction
Smart Road – Redesign
South/Right Slope

- 34 degree Slope
- Planar virtually eliminated
Smart Road – Redesign
South/Right Slope

- 34 Degree Slope
- Pesky wedgies
Smart Road – Reevaluation
North/Left Slope

- 34 Degree Slope
  - Planar Failures
    - Virtually eliminated
Smart Road – Kinematic Assessment
North/Left Slope

- 34 Degree Slope
  - Wedge Failures
    - Virtually eliminated

Previously identified discontinuity intersections no longer lie within the critical zone.

Structure Key
- Bedding
- Small Joints
- Large Joints
- Sealed Joints
- Foliations
- Faults

MARKLAND TEST PLOT: c:\rkpk2-04\data\a1830714.DAT
Friction Angle = 20 degrees
Slope dip direction = 210 degrees, Dip = 34 degrees
Number of Stations = 38
Smart Road – Final Recommendations

- **Left Slope**
  - 60 Degrees: monitoring, protective measures
  - Less ROW acquisition, less excavation

- **Right Slope**
  - Would need to be dealt with regardless

- **Final Slope**
  - VDOT announces 30 - 40 degree slopes
    - $2.7 million
Valley and Ridge Province
- Structurally complex, folded and faulted - discontinuities
- Steep to vertical rock cuts dangerous without protective measures

Pre-construction
- Understand regional and site-specific geology
- Valuable information from pre-construction mapping, even if limited

During Construction
- Verify pre-construction assessment(s)
- Changed conditions can be recognized early