Evaluating Rock Fall Hazards for the US 460 Connector Project, Southwestern Virginia

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Objectives of Presentation

– Describe the project
  • US 460 Connector – Phase I Project
– Discuss local rock slope performance
  • Nearby cut slopes in the same formations
– Give some examples
  • Stratigraphy and rock source zones
  • Bench configurations and accumulation
  • Roadway cut slopes
  • Construction slopes for bridge piers
US 460 Connector – Phase I

- Twin high-level structures (~1,600 feet long)
- Mainline four-lane divided highway (~4,800 feet long)
- Two-lane connector road to Route 80
- Project Partners
  - VDOT
  - Bizzack/ENTRAN
  - MACTEC
US 460 Connector

- Design-Build
- Cut slopes up to 150 ft high
- 2.7 million yards of fill
- Grassy Creek Bridge – 250 ft tall (tallest in the Commonwealth)
US 460 Connector
Nearby Slope Performance

Rte 460 Buchanan County VA / Grundy
Nearby Slope Performance

Rte 460 Phase I Cuts
Nearby Slope Performance

Rte 460 Vansant Cuts

1994 1997
US 460 Connector Examples

3GSM ShapeMetrix3D Model
US 460 Connector Examples

3GSM ShapeMetrix3D Models
RockPack III Dip Vector Plots
US 460 Examples
US 460 Examples
Stratigraphy and Rock Quality
Stratigraphy and Rock Quality

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<thead>
<tr>
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09BH-069
Rock Structure Conclusions

• Nearby rock cuts perform well
• Sandstone includes cross bedding and cut-and-fill structures
• Joints are short or discontinuous
• Rock mass properties control slope stability
• Sandstone formations produce a few rocks
• Falling rock dimensions ~ 1 ft x 1/3 ft
CRSP Model

• Design cut slope with benches
• Coefficients
  – Roughness
  – Tangential
  – Normal
• Analysis points
  – Intermediate
  – Crest of bench above pavement
  – Edge of pavement
CRSP Model

- Coefficients
  - Roughness
  - Tangential
  - Normal

Surface roughness = Slope variation over distance = to radius of rock

<table>
<thead>
<tr>
<th>Description of Slope</th>
<th>Tangential Coefficient ($R_t$)</th>
<th>Remarks</th>
<th>Normal Coefficient ($R_n$)</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Smooth hard surfaces and paving</td>
<td>0.90 – 1.0</td>
<td>-$R_t$ is not very sensitive compared to $R_n$, but may be important for hard or significantly vegetated slopes</td>
<td>0.60 – 1.0</td>
<td>-For short slopes try lower values in applicable range.</td>
</tr>
<tr>
<td>Most bedrock and boulder fields</td>
<td>0.75 – 0.95</td>
<td></td>
<td>0.15 – 0.30</td>
<td>-If max. velocity/KE* are design criteria, use lower values in range; if avg. velocity/KE* are design criteria, use higher values in range.</td>
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<tr>
<td>Talus and firm soil slopes</td>
<td>0.65 - 0.95</td>
<td>-Use lower $R_t$ as the density of vegetation on the slope increases.</td>
<td>0.12 – 0.20</td>
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<td>Soft soil slopes*</td>
<td>0.50 - 0.80</td>
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<td>0.10 - 0.20</td>
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### CRSP Model

**Coefficients**

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<th>Cell</th>
<th>Rock Type</th>
<th>Surface Roughness</th>
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<th>Normal Coefficient</th>
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CRSP Results

Rock Source Zone

1000 rocks

Discoidal Rocks
1 x 0.3 ft

86, 84, 76
64, 71, 94 rocks

17.28 ft/s
0.2 ft bounce
Stopped in lane

14, 7, 6
10, 8, 9 rocks
0, 0, 0
0, 1, 0 rocks

Sta. 94+00
CRSP Results

Rock Source Zone

Discoidal Rocks
1 x 0.3 ft

1000 rocks
101 rocks

40 rocks
1 rock

Sta. 94+00

5.42 ft/s
0.3 ft bounce
Stopped in lane
CRSP Results

Discoidal Rocks
1 x 0.3 ft

1000 rocks
127 rocks
0 rocks

Sta. 94+00

Rock Source Zone
CRSP Results

Discoidal Rocks
1 x 0.3 ft

1000 rocks

Sta. 85+50

98, 83
76, 76
106, 79
rocks

98, 83
76, 76
rocks

10, 6
8, 1
3, 3
rocks

Cumulative # stopped
Rocks Stopped

Distance (ft)
Temporary Cut Slopes

Bolts, Straps, Wire Mesh OK
Conclusions

• Nearby cut slopes perform well
• Sandstone formations produce small rocks
• Benches are effective (*no maintenance*)
• Other mitigation not permitted (wire mesh)
• Good blasting practices and thorough construction scaling are required
• Temporary cut slopes can use bolts, straps, and wire mesh
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