Assessing Maryland’s Largest Highway Rock Cut Slope: Sideling Hill Rock Slope Hazard Study

2013 Geohazards Forum
July 31, 2013
Site Location
I-68 Through Sideling Hill
I-68 Through Sideling Hill
Lithology and Structure
Faulting
Cut Slope Construction

- Construction completed in 1985
- Four benches on both sides
- Benches up to 80 ft high
- Bench slopes as steep as 0.25H:1V
- 20 ft wide benches
- Reverse sloped benches
- 38 ft wide catchment area
- Shallow V-shaped rockfall ditch
Background and Scope

- Existing geometry significantly different than as-built plans
- Tapered maintenance program
- History of small rockfalls
- Rock slope hazard study and mapping
- Develop design concepts for hazard mitigation
Initial Site Visit: Hazardous Conditions
Highly Fractured, Loose Rock
Loose Rock
Thin Slabs at Face
Raveling Bench Edge
Raveling Bench Edge
Raveling Bench Edge
Overhanging Block
Overhanging Block
Differential Weathering
Differential Weathering
Overhang
Overhang and Raveling
Overhangs
Overhangs
Debris Wedge
Debris Wedge
Debris Wedge
Undermined Bench
Wall above Undermined Bench
Rockfall Catchment Area
Vegetation
Seepage
Seepage Flow over Bench Edge
Rock Slope Hazard Study

- LiDAR Survey
- Rock Structure Mapping
- Slope Stability Analysis
- Rockfall Hazard Analysis
LiDAR Survey
Topographic Site Plan
Topographic Site Plan
# Field and Digital Mapping

<table>
<thead>
<tr>
<th>Feature</th>
<th>FIELD</th>
<th>DIGITAL</th>
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</thead>
<tbody>
<tr>
<td>Lithology / Engineering Geology Units</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Areas of Loose Rock</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Overhangs (&gt;2 ft)</td>
<td>X</td>
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<tr>
<td>“Pop-outs”</td>
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<tr>
<td>Rockfall Debris Accumulations</td>
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<td>X</td>
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<tr>
<td>Major Joints</td>
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<tr>
<td>Major Fractures and Faults</td>
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<td>X</td>
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<tr>
<td>Potentially Unstable Blocks</td>
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<td>X</td>
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<tr>
<td>Seepage Areas</td>
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</table>
Rock Slope Hazard Map

South Face
Rock Structure Mapping
Kinematic Analysis
## Kinematic Analysis

### Summary

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>DOMAIN</th>
<th>FAILURE MODE</th>
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</thead>
<tbody>
<tr>
<td>South</td>
<td>Domain 1</td>
<td>Planar Sliding (Major Joint)</td>
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<tr>
<td>North</td>
<td>Domain 8</td>
<td>Wedge Sliding (Bedding and Joint Set)</td>
</tr>
<tr>
<td>North</td>
<td>Domain 10</td>
<td>Planar Sliding (Major Joint)</td>
</tr>
<tr>
<td>North</td>
<td>Domain 12</td>
<td>Wedge Sliding (Bedding and Major Fracture)</td>
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</tbody>
</table>
Limit Equilibrium Analysis

- Safety factors all > 1.5
Rockfall Hazard Analysis
Rockfall Hazard Analysis
Rockfall Hazard Analysis

- Inputs:
  - Profile (i.e., station)
  - Height (i.e., benches involved)
  - Debris on bench removed?
  - Block size (1ft, 3ft, 5ft)
  - Block shape
  - Analysis points
Rockfall Hazard Analysis

Results:
- Number passing
- Percent passing
- Maximum bounce height
- Maximum energy
Conclusions from Hazard Study

- Emergency Action Not Required
- Bench-Scale Failures Not Indicated
- Small-Scale Rockfall Hazard
- Inadequate Catchment
- Debris Wedges
- Marginally-Stable Rock Blocks
- Overhanging Rock Ledges
- Vegetation
Mitigation Strategies

Not to be considered:
- Mass grading
- Reconfiguration of the travel lanes

Systematic approach to evaluate treatment options for each hazard
Option 1: Scaling and Bench Cleaning

- “Routine” scaling
- Debris removal from benches and/or reshaping
- Reverse grade benches
- Periodic follow-up
- Shotcrete Surface Protection
- Spot Bolting and Anchored Mesh
Shotcrete Surface Protection

NOTE:
TYPICAL DIMENSIONS AND SPACING SHOWN ARE BASED ON ASSUMED MINIMUM REQUIREMENTS. THE FINAL DIMENSIONS AND SPACING WILL NEED TO BE DEVELOPED DURING FINAL DESIGN.
Spot Bolting and Anchored Mesh

- Rock Bolt and Spike Plate (Typ)
- Outline of Marginally Stable Rock
- Spiral Rope Net
- Wire Rope
Spot Bolting and Anchored Mesh

NOTES:
1. MANUFACTURER TO SPECIFY THE REQUIRED QUANTITY OF PERIPHERAL ROCK BOLTS.
2. ENGINEERING JUSTIFICATION FOR THE SPACING AND LENGTH OF ROCK BOLTS SHALL BE SUBMITTED WITH FINAL DESIGN.
Option 2: Rockfall Barriers
Option 2: Rockfall Barriers

ROCKFALL FENCE MESH

ROCKFALL FENCE POST

MDSHA CONCRETE BARRIER

4'-0" SHOULDER

2" MIN

#57 STONE

1.5

1.0

FOUNDATION CONCRETE

1'-0" MIN

ROADWAY PAVEMENT

HEIGHT VARIES
Option 2: Rockfall Barriers

- Rockfall Fence Mesh
- Rockfall Fence Post
- MDSHA Concrete Barrier
- Roadway Pavement
- Foundation Concrete
- Anchored Retention Rope
- #57 Stone
- Rope Anchor
- Height Varies
- 2" Min
- 1'0" Min
- Varies
Option 3: Rockfall Drapery
Option 3: Rockfall Drapery
Periodic Monitoring and Maintenance

- Debris removal (2 yrs.)
- LiDAR survey and engineering geologic evaluation (4 yrs.)
- Slope monitoring plan
- Qualified engineering geologist or geological engineer should be present during slope maintenance
Thanks to:
Eric Dougherty & Karen Kalbaugh of MDSHA

Questions?