FAST-TRACKED SLOPE REPAIR
INNOVATIVE COLLABORATION AND STATE-OF-THE-ART TECHNOLOGY
OTT-2-27.18

David M. Vovak, P.E.
Transportation Director
TTL Associates, Inc.

Steven N. Shadix P.E., P.S.
Senior Transportation Engineer
Stantec
I. Discovery of Problem
II. Location of Project
III. Collaboration
IV. Geotechnical
V. Design
VI. Construction
VII. Questions
November 9, 2018
November 16, 2018

OTT-2-27.18 - DISCOVERY OF PROBLEM
December 6, 2018
OTT-2-27.18 - DISCOVERY OF PROBLEM

December 14, 2018
OTT-2-27.18 LOCATION OF PROJECT
<table>
<thead>
<tr>
<th>Submittal</th>
<th>Submittal Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial inclinometer readings for Boreholes B-002-1 and B-002-2</td>
<td>December 16, 2017</td>
</tr>
<tr>
<td>Draft gINT boring logs for Borings B-002-1 and B-002-2, including</td>
<td>December 19, 2017</td>
</tr>
<tr>
<td>inclinometer readings</td>
<td></td>
</tr>
<tr>
<td>Preliminary Report including Boring Logs, Inclinometer Data, Electronic</td>
<td>January 12, 2018</td>
</tr>
<tr>
<td>Resistivity Data, Direct Shear Test Results, Slope Stability Results, GPR</td>
<td></td>
</tr>
<tr>
<td>and Pavement Cores</td>
<td></td>
</tr>
<tr>
<td>Preliminary Report No. 2 including Slope Stability Results and Drilled</td>
<td>January 19, 2018</td>
</tr>
<tr>
<td>Shafts for Stabilization Analysis</td>
<td></td>
</tr>
<tr>
<td>Preliminary Report No. 3 including updated Slope Stability Results and</td>
<td>January 26, 2018</td>
</tr>
<tr>
<td>Drilled Shafts for Stabilization Analysis</td>
<td></td>
</tr>
</tbody>
</table>
No Toe Bulge – Can it be Karst or Gypsum
E) ER-4: Electrical Resistivity Transect Inversion Model (mid-slope)

- Low Resistivity - gravel roadway fill
- Low Resistivity - silt and clay embankment fill (wet to saturated)
- Intermediate to High Resistivity - silt and clay with sand (undrained)
- Deeper localized low resistivity zones - possible seeps within sub-soil (mid-slope areas)
- Diode-diode array, Min-electrode spacing 6-ft.
- Model iterations: 8, RMS Error 2.94V, Norm L2: 0.09

Notes:
- ASI: Superficial w/ 16 electrodes • existing 20-ga pipe array
- 6-ft min electrode spacing
- Earthmodel Version 2.1.4 ER Inversion Program
- Survey dates: December 20th & 21st, 2017

Refer to Figure 1 for ERT transect location
OTT-2-27.18 GEOTECHNICAL

1643301 OTT-2-27.18 Janbu - ESSP

Safety Factors Are Calculated By The Modified Janbu Method
When an embankment is constructed over a layer of soft, weak soil, a shear failure may develop through the soft layer, failing the embankment. This may be remediated by excavating through the soft layer, and keying into a lower, firmer soil layer with a special benched embankment fill. Figure 5 shows an example of this case.

Figure 5
Special Benching for Embankment Stability over Soft Foundation Soil
### Shear Key and Toe Berm Requirements (FS = 1.3)

<table>
<thead>
<tr>
<th>Berm/Key Material</th>
<th>Cohesive</th>
<th>Dumped Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength Parameters</strong></td>
<td><strong>φ’ = 26° c’ = 100</strong></td>
<td><strong>φ’ = 38° c’ = 0</strong></td>
</tr>
<tr>
<td></td>
<td><strong>psf</strong></td>
<td><strong>psf</strong></td>
</tr>
<tr>
<td><strong>Key Elevation (feet)</strong></td>
<td>558</td>
<td>558</td>
</tr>
<tr>
<td><strong>Min. Key Width (feet) @ Elev. 558</strong></td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td><strong>Berm Height (feet)</strong></td>
<td>5</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Berm Width (feet)</strong></td>
<td>10</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Berm Back Slope (H:V)</strong></td>
<td>2.0:1.0</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Acid 20 feet to get offset to SR 2 Centline i.e. 115 + 20 = 135 feet

Parameters adjusted to create FS of 1.0 given the failure surface and layering from the original stability analysis.
Summary of Drilled Shafts for Stabilization (FS: 1.25 to 1.75)

<table>
<thead>
<tr>
<th>Diameter (feet)</th>
<th>Spacing (feet)</th>
<th>Offset from SR 2 Centerline (ft)</th>
<th>Factor of Safety</th>
<th>Load (kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>6</td>
<td>105</td>
<td>1.58</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td></td>
<td>145</td>
<td>1.45</td>
<td>76</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>105</td>
<td>1.29</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td></td>
<td>115</td>
<td>1.36</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125</td>
<td>1.33</td>
<td>104</td>
</tr>
<tr>
<td>3.5</td>
<td>7</td>
<td>105</td>
<td>1.52</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>135</td>
<td>1.65</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td></td>
<td>145</td>
<td>1.31</td>
<td>67</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>105</td>
<td>1.47</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td></td>
<td>135</td>
<td>1.47</td>
<td>105</td>
</tr>
</tbody>
</table>
Design Components

- Slide Repair
- Roadway Reconstruction
- Median Catch Basin Repair
- Lighting
- Overhead Signing
- Maintenance of Traffic
- Environmental Commitments
- No new Right-of-Way
OTT-2-27.18 STABILIZATION ALTERNATIVES

1. Shear Key - Dig out with Rock Replacement

2. Drilled Shaft Wall at Mid-Slope
   - 48” Dia Shafts
   - Spaced 4’ c/c

3. Drilled Shaft Wall at Toe of Slope
   - 48” Dia Shafts
   - Spaced 8’ c/c
**OTT-2-27.18 - ALTERNATIVE COST COMPARISON**

Alt 1: $2.2M  Alt 2: $3.5M  Alt. 3: $2.2M

<table>
<thead>
<tr>
<th></th>
<th>Shear Key (Dig Out) Alternative 1</th>
<th>Drilled Shaft Wall @ Mid-Slope Alternative 2</th>
<th>Drilled Shaft Wall @ Toe of Slope Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Alternative Cost</td>
<td>$2,221,000</td>
<td>$3,521,000</td>
<td>$2,215,000</td>
</tr>
<tr>
<td>Comparison</td>
<td>1.00</td>
<td>1.59</td>
<td>1.00</td>
</tr>
<tr>
<td>Right of Way impact</td>
<td>Proposed ditch extends beyond right of way into drainage easement at east end of project.</td>
<td>Toe berm required which may extend beyond right of way limits into drainage easement at east end of project.</td>
<td>Proposed ditch extends beyond right of way into drainage easement at east end of project.</td>
</tr>
<tr>
<td>Wetland impact</td>
<td>None anticipated</td>
<td>None anticipated</td>
<td>None anticipated</td>
</tr>
<tr>
<td>Requires excavation below elevation of lake water level</td>
<td>Yes. Shear key may require dewatering.</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Note: This estimate is for comparison of alternatives only and does not represent total construction cost of the project.
Collaborative conference calls between ODOT D2, ODOT OGE & Consultant Team produced sounding board for ideas and streamlined preferred alternative selection process.
OTT-2-27.18 - PREFERRED ALTERNATIVE SELECTION

- **Cost**
- **Impacts**
  - Shear Key required excavation below Sandusky Bay water level
- **Constructability**
  - Availability of Materials
    - Drilled Shafts required steel beam reinforcing up to W36x300
    - Shear Key required Type C dump rock (7,800 CY)
  - Construction Time Required
    - Sequence of Construction
    - Use of Lime Stabilized Embankment
OTT-2-27.18 - PREFERRED ALTERNATIVE

SHEAR KEY (DIG OUT)

TYPICAL BENCHING DETAIL
To expedite plan production, Stantec advanced design work on aspects not related to stabilization option chosen.

Plan set over 50% complete by time preferred alternative was selected.
Plan package sent to ODOT District 2, processed same day, and sent to Columbus for Estimating to sell as Emergency Type C project.
OTT-2-27.18 - CONSTRUCTION

- Project Sale Date on March 22, 2018
  - Two bidders
- Project Awarded to low bidder Independence Excavating on March 29, 2018
  - Bid $3,322,667.50
- Construction Start - April 16, 2018
- Ramp open on weekends starting May 25, 2018
- Road reopened June 16, 2018
OTT-2-27.18 - TIMELINE SUMMARY

- 11/9/2017 - Crack First Noticed
- 11/30/2017 - Ramp Closure of WB SR 269 Exit
- 12/4/2017 - Consultant Team under Contract
- 12/7/2017 - 1/11/2018 - Geotechnical Drilling
- 1/12/2018 - Preliminary Design Complete
- 1/26/2018 - Geotechnical Report Complete
- 1/30/2018 - Preferred Alternative Selected
- 2/15/2018 - Design Plan Package Complete
- 3/22/2018 - Project Sale
- 3/29/2018 - Project Award
- 4/16/2018 - Construction Start
- 5/25/2018 - Ramp Open
- 6/16/2018 - Roadway Open
QUESTIONS
THANK YOU

David M. Vovak, P.E.
Transportation Director
TTL Associates, Inc.
dvovak@ttlassoc.com

Steven N. Shadix P.E., P.S.
Senior Transportation Engineer
Stantec
steve.shadix@stantec.com