Innovative retaining wall with narrow footing and vertical rock anchors

October 26, 2016

HUR-99-13.77
a Value Engineering Change Proposal
Peter Narsavage, PE
Original Design

- 7" precast concrete wall panel
- 3½" x 3½" x ½" plate washer (typ.)
- ⅝" bearing pad @ anchor locations
- ½" dia. x 13" adhesive anchor with nut and washer (typ.)
- 6" clear
- 6" rock anchor
- ⅛" spiral bar
- 10-#10 bars
- 36" dia. column
Geotechnical Exploration
## Rock Quality

<table>
<thead>
<tr>
<th>BORING NO.</th>
<th>SAMPLE NO.</th>
<th>SAMPLE DEPTH</th>
<th>SAMPLE ELEVATION (MSL)</th>
<th>RECOVERY OF TESTED CORE RUN (%)</th>
<th>ROD OF TESTED CORE RUN (%)</th>
<th>UNCONFINED COMPRESSIVE STRENGTH (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-004-0-10</td>
<td>NQ2-8</td>
<td>27.2' - 27.7'</td>
<td>699.1 - 699.6</td>
<td>97</td>
<td>62</td>
<td>2342</td>
</tr>
<tr>
<td>B-004-0-10</td>
<td>NQ2-10</td>
<td>37.3' - 37.8'</td>
<td>689.0 - 689.5</td>
<td>100</td>
<td>72</td>
<td>62</td>
</tr>
<tr>
<td>B-006-0-10</td>
<td>NQ2-8</td>
<td>23.0' - 23.5'</td>
<td>705.0 - 705.5</td>
<td>100</td>
<td>62</td>
<td>25</td>
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<td>B-006-0-10</td>
<td>NQ2-9</td>
<td>30.3' - 30.8'</td>
<td>697.7 - 698.2</td>
<td>100</td>
<td>63</td>
<td>8775</td>
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<tr>
<td>B-008-0-10</td>
<td>NQ2-12</td>
<td>43.2' - 43.7'</td>
<td>684.8 - 685.3</td>
<td>100</td>
<td>75</td>
<td>213</td>
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<tr>
<td>B-007-0-10</td>
<td>NQ2-12</td>
<td>35.8' - 36.3'</td>
<td>693.0 - 693.5</td>
<td>93</td>
<td>40</td>
<td>213</td>
</tr>
<tr>
<td>B-007-0-10</td>
<td>NQ2-12</td>
<td>42.3' - 42.8'</td>
<td>686.5 - 687.0</td>
<td>93</td>
<td>40</td>
<td>8060</td>
</tr>
<tr>
<td>B-001-0-03</td>
<td>NQ2-12</td>
<td>27.1' - 27.6'</td>
<td>702.0 - 702.5</td>
<td>100</td>
<td>29</td>
<td>1260</td>
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<tr>
<td>B-002-0-03</td>
<td>NQ2-12</td>
<td>26.7' - 27.1'</td>
<td>701.8 - 702.2</td>
<td>100</td>
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<td>7930</td>
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<tr>
<td>B-002-0-03</td>
<td>NQ2-12</td>
<td>40.1' - 40.5'</td>
<td>688.4 - 688.8</td>
<td>100</td>
<td>67</td>
<td>1480</td>
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<td>B-002-0-03</td>
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<td>41.3' - 41.8'</td>
<td>687.1 - 687.6</td>
<td>100</td>
<td>67</td>
<td>11,340</td>
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</tbody>
</table>

**Note:** Data for borings B-001-0-03, B-002-0-03, and B-003-0-03 obtained from FMSM report dated September 6, 2005.
Initial Concept

- Narrow footing
- Tie down anchor to resist overturning and increase vertical force for sliding
ODOT District 3’s concerns

- Footing is 6” into shale while bid design has 10 ft rock socket for drilled shaft
- Lack of redundant load paths
- Cannot inspect tie-down anchors
- $45,000 shared savings is small
Other ideas
If at first you don’t succeed, Try, try again

“The Department has reviewed your response to the rejection of the Conceptual VECP Proposal ... The Department does agree that a monolithic wall has some benefits when exposed to debris and flow in the river.”

Still concerned about:

- Scour and erosion
- Rock anchors totally inaccessible at completion
Design Coordination

MOSSER CONSTRUCTION, INC.

geotech services, inc.

CONTECH ENGINEERED SOLUTIONS

E.L. ROBINSON ENGINEERING
Wall stability calculations

### Conventional Retaining Wall Design

**AASHTO LRFD Bridge Design Specification, Section 11.6**

#### Soil and Rock Parameters

<table>
<thead>
<tr>
<th>Retained Soil</th>
<th>Foundation Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>210 lb/ft³</td>
<td>135 lb/ft³</td>
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<tr>
<td>57.6°</td>
<td>72.6°</td>
</tr>
</tbody>
</table>

#### Geometry

- **H**: design height of wall
- **B**: width of footing
- **d**: thickness of wall footing
- **t**: wall offset from edge of footing
- **b**: wall stem thickness at top
- **s**: wall stem thickness at bottom
- **2V**: height of slope above wall
- **h**: depth of cave above wall
- **2V**: slope of ground above wall

#### Tiedown Anchor in Footing

- Distance from head of footing to anchor: 25 ft

#### Surcharge Load and Unit Weight of Concrete

<table>
<thead>
<tr>
<th>surcharge load</th>
<th>unit weight of concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>240 psf</td>
<td>145 lb/ft³</td>
</tr>
</tbody>
</table>

#### Fence Loads

- Distributed load: 290 lb/ft
- Fence height: 6 ft
- Horizontal load at top of wall: 0.12 k/ft

### Load and Resistance Factors

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Strengths</th>
<th>Resistance Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td>Min</td>
<td>Design Factor</td>
</tr>
<tr>
<td>Tr</td>
<td>1.25</td>
<td>1.00</td>
</tr>
<tr>
<td>Ty</td>
<td>1.35</td>
<td>0.90</td>
</tr>
<tr>
<td>T</td>
<td>1.50</td>
<td>0.50</td>
</tr>
<tr>
<td>T</td>
<td>1.75</td>
<td>0.25</td>
</tr>
</tbody>
</table>

#### Stability Checks

- Factored bearing resistance = 48.84 k/ft
- Bearing resistance = OK
- Factored shear resistance = 28 k/ft
- Shear resistance = OK

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E.L. Robinson Engineering
Uplift anchor calculations

UPLIFT CAPACITY OF UPLIFT ANCHORS IN ROCK

ASNTO LRFD does not specifically address this issue. Use GEI No. 4, Sec. 5.4.2 to calculate minimum uplift resistance of foot of anchor and \( \phi_{\text{H}} = 0.5 \) from Table 10.3.5.2.8-1 and 90.8.1.
Final design
Anchor design
Construction
Present Day
Strand gage readings

Load in strand, kips

-40 -30 -20 -10 0 10 20 30 40 50

10/25/13 11/1/13 11/14/13 11/21/13 9/8/16

8-4 5-11 6-11 4-18 7-4 2-25
ASK MORE QUESTIONS