GEOTECHNICAL ENGINEERING IN
DISTRICT 4
ABANDONED MINES, SLIDES,
SHORELINE EROSION, AND SOFT
SOILS

ODOT Geotechnical Consultants Workshop

May 13, 2009

Alex Bredikhin
District 4 Geotechnical Engineer
District 4 2007 statistics:

- ODOT let: $233M (95 projects total)
- Local let: $40M (24 projects total)
- General Preservation: $100M
- Geotechnical: $2.5M
Proudly serving Ashtabula, Mahoning, Portage, Stark, Summit, and Trumbull counties
District 4

- Covers 6 Counties: Ashtabula, Mahoning, Portage, Stark, Summit and Trumbull counties
  - 1,423 with 13,600,000 sq ft. of deck (2nd largest)
  - 412 mi of guiderail

- Pavement
  - 4,940 lane miles (2nd)
  - 820 urban miles (4th)
District 4 – Interesting Snow Facts:

- Lake Erie = Lake Effect Snow
  - Ashtabula County – the snowfall capital of Ohio (5 year average - 186 inches per season, record year - 213 inches per season)
  - District 4 plows and treats more than 1 million miles of highways during Winter Snow & Ice season...
Geotechnical Activities span all D-4 departments:

- Planning
- Production (in-house design and consultant reviews, project management)
- Construction
- Invoicing
- Maintenance and Preservation
The People of Ohio are in dire straits due to the unprecedented economic crisis.
Construction – the Economic Stimulator

![Bar chart showing construction contracts and D-4 employees over the years 1995 to 2010. The chart highlights a comparison between contracts and D-4 employees with notable peaks in 2006 and 2007.](image)
For FY 2006 thru 2010, each District 4 Production Project Manager has been responsible for an average of 20 projects.

Utilization of Consultant Task Orders:

- General Engineering Services            $500,000 / year
- Subsurface Utility Engineering          $500,000 / year
- Geotechnical Engineering               $250,000 / year
- Geotechnical Drilling                   $200,000/year
- Survey & Right-of-Way                   $250,000 / year
- Bridge Review                           $250,000 / year
D-4 DGE
Responsibilities:

- A DGE is a jack of all trades seamlessly spanning across Planning, Production, and Construction departments
- 2007 Geotech Services Task Order ($25M) and Drilling Task Order ($2M) management
- In-house design: slope stability, bridge foundations, salt dome spread footing foundations, pavement, mine/void remediation
- In-house geotechnical instrumentation (currently, there are 14 sites where inclinometers, piezometers, and/or settlement plates are installed)
- Project management (3 major or minor new projects, total budget $25.8M)
- Consultant submittal reviews (reviewed submittals for 67 projects in FY 2007, 52 projects in FY 2008, 59 up to date in FY 2009)
- Construction inspections where/if geotechnical issues arise
Completion of Red Flag Summary
- Be aware of new guidelines for Red Flag Summary Submittal
- May be modified in scope document
- Archive boring information very useful

Development of Scopes for Projects
- Generally occurs after completion of Red Flag Summary
- Inclusion of site specific items of geotechnical concern

Evaluation of Landslides
Project manager for consultant Task Order
Consultant preliminary design with D-4 in-house repair final design and plans/specs generation
Develop likely remedy and provide preliminary cost estimate
Apply for construction funding through the Geologic Site Management Program
Instability triggers:

- 2H:1V slopes with pockets of perched water within the soil mass (due to poor or failed drainage);
- Inadequate compaction of fill;
- Inadequate surficial (sheet-flow) drainage coupled with increased precipitation in NE OH
Surficial Instability (Erosion)
Inclinometer Reading of Surficial Erosion
Currently servicing 14 different slope failure sites (68 instruments total) in District 4
Shallow-seated Failure (Movement)
Shallow seated Failure (Movement)
Shallow-seated Failure (Movement)
Deep-seated Failure (Movement)
Inclinometer Reading of Deep-seated movement
Majority of time spent on construction plan development
- Includes review of geotechnical reports and drawings

Inclusion of geotechnical recommendations into the plans
- Limited communication between consultant and geotechnical consultants tends to be an issue

Answer geotechnical pre-bid questions

In-house design for “simpler” sites: drainage, embankment slope instability, etc.
In true spirit of D-4 philosophy to “do more with less”, most of the slide, instrumentation, analysis, and repair design have been done in-house.

The consultants are still playing an important role by providing drilling and testing support to the D-4 Geotechnical Team.

The consultants are also actively participating in larger, more complex projects, which are too challenging for the District Geotech group.

Gannett-Fleming is the current Geotech Task Order Consultant.
An Example of an In-house PCSTABL Software Slope Stability Analysis (of Existing Conditions) Output
Possible Solutions to increase Slope Stability FoS:

- For **shallow** erosion movement: erosion protection
- For **intermediate** slope movement (up to 15 ft deep): benching and new fill & drainage placement earthwork (GB-2 style), soil nails
- For **deep-seated** failure: ??? Structural Fix (some sort of a retaining wall)? Massive earthwork?
Erosion Control – Shallow-seated Failure
Erosion Control – Shallow-seated Failure
Erosion Control – Shallow-seated Failure (Geoweb)
Erosion Control – Shallow to Intermediate Seated Failure
Soil Nails (Launched)
## Normal Method of Slices Analysis

<table>
<thead>
<tr>
<th>SLICE NO.</th>
<th>WIDTH</th>
<th>HEIGHT</th>
<th>SINE</th>
<th>EFFEC. WEIGHT</th>
<th>RESIS. MOMENT</th>
<th>DRIVING MOMENT</th>
<th>D-R MOMENT PRODUCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.152</td>
<td>2.376</td>
<td>-0.117</td>
<td>2.12E+03</td>
<td>4.21E+04</td>
<td>-9.97E+03</td>
<td>-5.21E+04</td>
</tr>
<tr>
<td>2</td>
<td>7.152</td>
<td>6.153</td>
<td>0.061</td>
<td>5.50E+03</td>
<td>1.09E+05</td>
<td>1.35E+04</td>
<td>-9.55E+04</td>
</tr>
<tr>
<td>3</td>
<td>7.152</td>
<td>8.633</td>
<td>0.24</td>
<td>7.72E+03</td>
<td>1.49E+05</td>
<td>7.42E+04</td>
<td>-7.48E+04</td>
</tr>
<tr>
<td>4</td>
<td>7.152</td>
<td>9.699</td>
<td>0.419</td>
<td>8.67E+03</td>
<td>1.57E+05</td>
<td>1.45E+05</td>
<td>-1.20E+04</td>
</tr>
<tr>
<td>5</td>
<td>7.152</td>
<td>9.022</td>
<td>0.598</td>
<td>8.07E+03</td>
<td>1.29E+05</td>
<td>1.93E+05</td>
<td>6.40E+04</td>
</tr>
<tr>
<td>6</td>
<td>7.152</td>
<td>5.199</td>
<td>0.777</td>
<td>4.65E+03</td>
<td>5.84E+04</td>
<td>1.44E+05</td>
<td>8.56E+04</td>
</tr>
</tbody>
</table>

**SUM**: 6.45E+05  5.60E+05  1.15
# Normal Method of Slices Analysis

<table>
<thead>
<tr>
<th>SLICE</th>
<th>SLICE</th>
<th>SLICE</th>
<th>BOTTOM</th>
<th>EFFEC.</th>
<th>RESIS.</th>
<th>DRIVING</th>
<th>D-R MOMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO.</td>
<td>WIDTH</td>
<td>HEIGHT</td>
<td>SINE</td>
<td>WEIGHT</td>
<td>MOMENT</td>
<td>MOMENT</td>
<td>PRODUCT</td>
</tr>
<tr>
<td>1</td>
<td>7.152</td>
<td>2.376</td>
<td>-0.117</td>
<td>2.12E+03</td>
<td>4.21E+04</td>
<td>-9.97E+03</td>
<td>-5.21E+04</td>
</tr>
<tr>
<td>2</td>
<td>7.152</td>
<td>6.153</td>
<td>0.061</td>
<td>5.50E+03</td>
<td>1.09E+05</td>
<td>1.35E+04</td>
<td>-9.55E+04</td>
</tr>
<tr>
<td>3</td>
<td>7.152</td>
<td>8.633</td>
<td>0.24</td>
<td>7.72E+03</td>
<td>1.49E+05</td>
<td>7.42E+04</td>
<td>-7.48E+04</td>
</tr>
<tr>
<td>4</td>
<td>7.152</td>
<td>9.699</td>
<td>0.419</td>
<td>8.67E+03</td>
<td>1.57E+05</td>
<td>1.45E+05</td>
<td>-1.20E+04</td>
</tr>
<tr>
<td>5</td>
<td>7.152</td>
<td>9.022</td>
<td>0.598</td>
<td>8.07E+03</td>
<td>1.29E+05</td>
<td>1.93E+05</td>
<td>6.40E+04</td>
</tr>
<tr>
<td>6</td>
<td>7.152</td>
<td>5.199</td>
<td>0.777</td>
<td>4.65E+03</td>
<td>5.84E+04</td>
<td>1.44E+05</td>
<td>8.56E+04</td>
</tr>
</tbody>
</table>

![Diagram of Slices Analysis](image)
Benching and Sliver Filling—Intermediate to Deep Seated Failure
Retaining Wall–Deep-seated Failure
An Example of a PCSTABL Software Slope Stability Analysis (GB–2 Repaired Conditions) Output
Proposal Preparation

- Outline the proposed boring plan clearly in the cost proposal
  - Boring number, depth, soil drilling, rock coring
  - Type/quantity of field and lab testing
  - Proposed location designation
- Utilize archive boring information
- Think of advancing borehole below anticipated groundwater level (possible mud-rotary?)
Lake Erie – the Untamed Beast of D-4
ATB–531 Lake Erosion
ATB-531 Lake Erosion

Forensic Cross-section

LEGEND:
- UPPER BROWN CLAY
- LOWER GRAY CLAY
- COLLUVIUM
- BEDROCK
The Forensic Analysis: failure with fully softened conditions ($\phi' = 35^\circ$, $c = 0$) and the piezometric water level 1.1 ft below the level measured in the field.

Multiple failures:
- First failure: deeper, rotational failure through the toe of the slope and penetrating both the brown and gray clays. The hummocky ground surface in the Proposed Revetment Area is another indication of slope instabilities.
- Second failure: shallow, rotational or translational failure at the crest. When slope failures occur at the crest, the scarp leaves behind a steep surface at the edge of the crest. The steep slope at the crest contributes to progressive failure of the crest.
ATB-531 Possible Solutions

- Ground Water Level Lowered 12 ft BGS
- Drainage Trench Detail A (See Figure 6)
- SR 531
- Regrade Crest 3H:1V
- Rock Key
- Existing Ground Surface
- Lake Erie 100 yr Flood Elev. 577 ft MSL

Datum Elev 580.00
ATB-531 Possible Solutions

GRADE

3'

2' COMPACTED CLAY

12'

10 OZ. NON-WOVEN GEOTEXTILE ENCLOSET DRAINAGE FILL

ODOT 307 DRAINAGE FILL

8" Ø PERFORATED PIPE
# Geo Project Performance, as of 3/3/09

## District Performance

<table>
<thead>
<tr>
<th>District</th>
<th>Geo CO Amount ($)</th>
<th>Geo Bid Amount ($)</th>
<th>Geo CO / Geo Bid (%)</th>
<th>Geo Change Amount ($)</th>
<th>Geo Change / Geo Bid (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$108,936.93</td>
<td>$28,369,267.46</td>
<td>0.38%</td>
<td>$9,258,839.65</td>
<td>32.64%</td>
</tr>
<tr>
<td>2</td>
<td>$1,263,940.10</td>
<td>$7,561,581.56</td>
<td>16.72%</td>
<td>$1,924,073.06</td>
<td>25.45%</td>
</tr>
<tr>
<td>3</td>
<td>$1,151,582.55</td>
<td>$10,447,218.63</td>
<td>11.02%</td>
<td>$2,546,684.43</td>
<td>24.38%</td>
</tr>
<tr>
<td>4</td>
<td>$849,853.07</td>
<td>$13,447,931.70</td>
<td>6.32%</td>
<td>$2,629,108.41</td>
<td>19.55%</td>
</tr>
<tr>
<td>5</td>
<td>-$424,809.48</td>
<td>$3,050,534.48</td>
<td>-13.93%</td>
<td>$1,301,251.62</td>
<td>42.66%</td>
</tr>
<tr>
<td>6</td>
<td>$25,755.47</td>
<td>$7,398,793.55</td>
<td>0.35%</td>
<td>$1,902,207.33</td>
<td>25.71%</td>
</tr>
<tr>
<td>7</td>
<td>$216,118.18</td>
<td>$8,894,756.38</td>
<td>2.43%</td>
<td>$1,590,779.70</td>
<td>17.88%</td>
</tr>
<tr>
<td>8</td>
<td>$695,988.83</td>
<td>$7,270,488.91</td>
<td>9.57%</td>
<td>$1,660,398.49</td>
<td>22.84%</td>
</tr>
<tr>
<td>9</td>
<td>$16,580,670.76</td>
<td>$13,208,250.27</td>
<td>125.53%</td>
<td>$18,032,748.90</td>
<td>136.53%</td>
</tr>
<tr>
<td>ODOT</td>
<td>$20,468,036.41</td>
<td>$99,648,822.94</td>
<td>20.54%</td>
<td>$40,846,091.59</td>
<td>40.99%</td>
</tr>
</tbody>
</table>

## Work Type Category Performance

<table>
<thead>
<tr>
<th>Work Type Category</th>
<th>Geo CO Amount ($)</th>
<th>Geo Bid Amount ($)</th>
<th>Geo CO / Geo Bid (%)</th>
<th>Geo Change Amount ($)</th>
<th>Geo Change / Geo Bid (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expansion</td>
<td>$3,225,682.50</td>
<td>$30,733,743.62</td>
<td>10.50%</td>
<td>$10,665,374.54</td>
<td>34.70%</td>
</tr>
<tr>
<td>New Alignment / Profile</td>
<td>$16,605,266.43</td>
<td>$46,628,134.53</td>
<td>35.61%</td>
<td>$29,241,292.87</td>
<td>62.71%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>-$198,947.53</td>
<td>$6,177,852.38</td>
<td>-3.22%</td>
<td>$849,510.39</td>
<td>13.75%</td>
</tr>
<tr>
<td>Preservation</td>
<td>$290,354.31</td>
<td>$11,748,483.36</td>
<td>2.47%</td>
<td>$2,545,166.77</td>
<td>21.66%</td>
</tr>
<tr>
<td>Safety</td>
<td>$140,418.87</td>
<td>$4,343,560.44</td>
<td>3.23%</td>
<td>$585,305.93</td>
<td>13.48%</td>
</tr>
<tr>
<td>Other</td>
<td>$320,259.07</td>
<td>$7,388,574.29</td>
<td>4.33%</td>
<td>$1,074,627.65</td>
<td>14.54%</td>
</tr>
</tbody>
</table>
Abandoned Underground Mines (Investigation and Remediation)

- Completed major new designs: STA-30-18.3, MAH-80-0.97
Abandoned Coal Mine Remediation
Support of Construction for geotechnical items
- Walls, foundations, pile driving, earthwork operations

Review of contractor submittals
- Chemically stabilized subgrade
- VE proposals for geotechnical items
Compaction Grouting

STA-77 at US-30
Geophysics - art or science (or a little bit of both?)
Geophysics: GPR results (STA-77 @US-30)

- Bottom of Concrete Roadway
- Delamination?
- Overlay?
- Rebars
- High Amplitude Reflections Suggestive of Potential Voids
- Buried Pipe

- 10'
- 17"
Geophysics: Seismic results (STA-77 @US-30) - Shear Wave Velocity

LEGEND

- Low Shear Wave Velocity Anomaly Suggestive of Potential Void.

---

[X][X']

[Legend]

- Low Shear Wave Velocity Anomaly Suggestive of Potential Void.

---

[Z][Z']

[Y][Y']

Shear Wave Velocity (ft/sec/ft)

---

Depth (ft)

---

Distance (feet)

---

Z [Z']

[Y][Y']

Shear Wave Velocity (ft/sec/ft)

---

Depth (ft)

---

Distance (feet)
Include the County, Route and Section as well as the PID number on all submittals
- For example ATB-90-0.00 PID: 22345

Sampling and testing should be adequate, but not excessive (use ODOT Specs for Geotech Exploration (SGE) as your guide)

Perform internal quality control review

Provide a contact in the report or cover letter

Provide a PDF of entire report along with hard copy.

Do not overrun budget w/out prior authorization!
In general, quality of consultant submittals has improved

Provide backup calculations for piles, drilled shafts, settlement, slope stability, etc.

Follow the SGE

Reduce conservative recommendations
  - i.e., pile load testing for rock bearing H-piles, secant walls for slide stabilization, etc.
Drawings are the key to ODOT projects
- Geotechnical consultant should review Stage plan submittals
  - Section 105 of SGE ("thou shall not...", etc.)
- Become familiar with OGE guidelines for drawing preparation and Micro Station Standards
- Use the Geotechnical Checklist
Common Drawing deficiencies
- No top of rock designation
- Not using X/Y/Z format for SPT sampling
- Asphalt and topsoil thickness missing
- USCS classification on the logs instead of AASHTO
- Scales of plan and profile do not match
- Index Testing Results missing on boring logs
D4 - Award winning team of professionals

State of Ohio Quality Award for Asphalt Paving

Presented to
Ohio Department of Transportation District 4

For achieving the Highest Quality Award Value Points by Superior Workmanship and Diligence.

2002

The Akron District Society of Professional Engineers

1999

Outstanding Engineering Achievement Award is Presented to
Ohio Department of Transportation, District 4

For
Summit-77–3.97

in recognition of excellence in professional engineering for highway planning & construction

National Value Engineering Award

Ohio Department of Transportation District 4

with
The Rahlin Company and Palmer Engineering

Project 412-99, ATB US-20 20.921

for demonstrating outstanding value engineering approach to savings, streamlined construction schedule that resulted in an overall improved project.

Presented by the AASHTO Value Engineering Committee
July 17, 2003
Questions?

"That's why we wear Hard-hats!"

Alex Bredikhin, P.E.
ODOT District 4
2088 South Arlington Rd.
Akron, Ohio 44306
330-786-3100

Why do freeways come to a stop?

1. Traffic is rolling along at 60 mph when someone slows to 50 mph. In this example, the driver of Car B does so to avoid hitting Car A, whose driver swerves at the last second to suit.

2. The next driver slows to 45 mph to maintain a safe distance from cars A and B.

3. Drivers farther back ease the brake lights and begin slowing down.

4. The pattern continues, and more drivers apply their brakes until traffic comes to a crawl. By the time the rear of the jam catches up to where the shockwave began, the offending parties are long gone and there is no sign of what caused the problem.

- The funnel effect
  - Cleveland
  - Exit

Cuyahoga County Transportation engineer Jamal Husain compares rush-hour traffic to a funnel.

The right amount of water can go through as fast as it's put in the funnel.

But add extra water to the funnel, and the whole thing backs up.

"The first few drivers could have a big impact," Husain said. "Their behavior in the peak time has a huge ripple effect, even if it doesn't look that bad to them."
Alex Bredikhin, P.E.
ODOT District 4
2088 South Arlington Rd.
Akron, Ohio 44306
330-786-3100