Geotechnical Investigations – Water Main Construction
Water Main Construction
Why Consider Geotechnical Evaluations?

- Not a typically a part of routine watermain construction
  - Open cut in previously excavated areas, known conditions
  - Minimum depth installation (4’ to 5’) cover
  - Leave any needed subsurface explorations up to contractor
Water Main Construction
Why Consider Geotechnical Evaluations?

- Special Watermain Construction Conditions
  - Trenchless Construction
  - “Cross Country” projects
  - Information for Bidders
  - Other
Water Main Construction
Why Consider Geotechnical Evaluations?

• Other subsurface concerns – not included
  • Existing utilities
  • Soil contamination
  • Seismic concerns
  • Foundation designs – above ground piping
Water Main Construction

Why Consider Geotechnical Evaluations?

- Trenchless
- Auger Bores/Jacking/Ramming
- Horizontal directional drill
- “Cross Country” projects
- Use of native material for backfill/bedding
- Information for bidders
- Rock & groundwater
- Other
- Corrosive soils
- Undermined areas
- Sinkholes/caves
Water Main Construction
Why Consider Geotechnical Evaluations?

- Review geotechnical information for these special conditions
  - Benefits & Risks
  - Application on Projects
  - Discussion
Geotechnical Evaluations – Goals*

- Determination of soil & stratification
- Soil samples for testing
- Depth and nature of bedrock
- *In situ* tests
- Special construction conditions
- Water table

Geotechnical Evaluations – Preliminary Design Information

- Site survey
- Preliminary layout
- Depth to trench bottom/Planned subgrade
- Scope of Work
- Review existing geologic and soil surveys, previous geotechnical evaluations
Geotechnical Evaluations – Field Investigations

- **Borings**
  - Varied drilling rigs, sizes, and capabilities
  - Small footprint/limit of disturbance
  - Greater depths
  - Sampling – split spoon samples
  - Penetration testing
  - Rock corings & characterization

- **Test Pits**
  - Open cut excavation
  - Larger footprint and disturbance
  - Limited depth
  - Safety for open cut
  - Less expensive, faster
Geotechnical Evaluations – Lab Tests

- Gradations
- Moisture-density relationship
- Acidic soils and chemical content
- Expansive soils
- Other

Test specification: ASTM D 698-96a Method C Standard

<table>
<thead>
<tr>
<th>Elev Depth</th>
<th>Classification</th>
<th>Nat. Moist.</th>
<th>Sp.G.</th>
<th>LL</th>
<th>PI</th>
<th>% &gt; 3/4 in.</th>
<th>% &lt; No.200</th>
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<td>15'-72'</td>
<td>CL</td>
<td>A-4(3)</td>
<td>30</td>
<td>10</td>
<td>0.0</td>
<td>53.3</td>
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</table>

Test Results:
- Maximum dry density = 118.9 pcf
- Optimum moisture = 14.3 %

MATERIAL DESCRIPTION: brown sandy LEAN CLAY
Geotechnical Evaluations – Report*

- Report
  - Scope and general description
  - Geologic conditions
  - Details of boring/test pits
  - Description of subsoil conditions
  - Recommendations/limitations

- Figures
  - Location of bores/test pits
  - Boring logs
  - Lab test results

Geotechnical Evaluations
Trenchless Construction

- Types of Trenchless Construction
  - Auger Bores
  - Pipe Ramming/Jacking
  - Horizontal Directional Drills (HDD)
  - Tunnelling/ Microtunnelling
Geotechnical Evaluations
Trenchless Construction - HDD

• Materials
  • HDPE, PVC, & DIP
  • Casings less common

• Classifications
  • Micro HDD – Services
  • Mini HDD – 12” dia. & less, couple hundred foot length, <15’ depths
  • Midi HDD – Between Mini & Maxi
  • Maxi HDD – Up to 48” dia., several thousand foot length, >25’ depths
Geotechnical Evaluations
Trenchless Construction - HDD

• Maxi HDD Standard
  • ASTM F1962 Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings
• Mini HDD Standard
  • Plastic Pipe Institute (PPI) TR-46 Guidelines for the Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe
Geotechnical Evaluations
Trenchless Construction - HDD

- Maxi HDD
  - Significant design and construction undertaking
  - Extensive geotechnical and related information recommended
- Mini HDD
  - More routine design and construction
  - Geotechnical determination dependent on project scope
Geotechnical Evaluations
Trenchless Construction - HDD

- Mini HDD
  - Soil conditions impacts
    - Suitability for HDD
    - Cost per LF
  - Rock vs. cobbles
  - Worst case pricing
Geotechnical Evaluations
Trenchless Construction – Auger/Ramming/Jacking

- Materials
  - HDPE, PVC, & DIP
  - Casings more common - steel
- Common Applications
  - PennDOT highway
  - Railroads
Geotechnical Evaluations
Trenchless Construction – Auger/Ramming/Jacking

• Many of the same concerns with HDD
  • Cost per linear foot impacts
  • Cobbles
  • Casing design
## Geotechnical Evaluations
### Trenchless Construction – Cost

<table>
<thead>
<tr>
<th>Job Number</th>
<th>Diameter</th>
<th>Length (ft)</th>
<th>Pipe Material</th>
<th>Number of Drills</th>
<th>Cost per foot</th>
<th>Bid Date</th>
<th>Details</th>
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**Average cost per foot:** $117

<table>
<thead>
<tr>
<th>Job Number</th>
<th>Diameter</th>
<th>Length (ft)</th>
<th>Material</th>
<th>Number of Drills</th>
<th>Cost per foot</th>
<th>Bid Date</th>
<th>Details</th>
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**Average cost per foot:** $436
Geotechnical Evaluations
“Cross Country” Projects

• Raw Water Mains
• Transmission Mains
• Pipe selection and design
• Bedding and backfill design, reuse of existing material
• Minimize imported material
Geotechnical Evaluations
Cross Country Projects - Experience

• 24” Transmission Main project – 17,000 feet
  • Goals for Geotechnical Evaluation
    • Trench detail to minimize impact to the site
    • Minimize use of stone
    • Characterize if feasible to crush onsite rock for bedding
Geotechnical Evaluations
Cross Country Projects – Scope of Evaluation

• 24” Transmission Main project – 17,000 feet
  • Scope of Geotechnical Evaluation
    • Test pits planned about every 1,000 ft
    • Lab testing of soil
    • Report on findings
Geotechnical Evaluations
Cross Country Projects – Findings

• 24” Transmission Main project – 17,000 feet
  • Test pit locations were adjusted based on soil types and geotech engineer’s judgement
  • More emphasis put on field work vs. lab work
  • Test pits excavated to about 7’ below grade
  • Bedrock not encountered
  • More groundwater than expected
Geotechnical Evaluations
Cross Country Projects – Project Bidding

• 24” Transmission Main project – 17,000 feet
  • Two bid alternates in bid form
    • Use of all native bedding and backfill (stone bedding as directed in wet areas)
    • Stone bedding and initial backfill, remaining native backfill
    • 11,000 lf in alternate (remainder within gravel road)
Geotechnical Evaluations
Cross Country Projects – Project Bidding

NOTES:
1. ALL STONE GRADATIONS ARE AASHTO CLASSIFICATION, UNLESS OTHERWISE NOTED.
2. SPREAD ROCKS OVER 24" IN SIZE ON SURFACE WITHIN LIMITS OF DISTURBANCE.
3. SUITABLE NATIVE MATERIAL SHALL BE LOAM, CLAY, SAND, OR GRAVEL AND SHALL BE FREE OF CINDERS, ASHES, REFUSE, VEGETABLE OR ORGANIC MATERIAL, BOULDERS, ROCKS OR STONES OVER 2" PARTICLE SIZE, FROZEN SOIL OR OTHER UNSUITABLE MATERIAL.
Geotechnical Evaluations
Cross Country Projects – Project Bidding

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Geotechnical Evaluations
Cross Country Projects – Bid Results

• 24” Transmission Main project – 17,000 feet
  • Average two low bidders (Installation only)
    • All native bedding/backfill - $24/ft
    • 6” of stone bedding/native backfill - $27/ft
    • Stone bedding & initial backfill - $31/ft
    • Stone bedding & stone backfill - $41/ft
• Alternate cost savings - $64,000 on $1.34 million
• Geotechnical Cost - $8,000 to $10,000
Geotechnical Evaluations
Cross Country Projects – Bid Feedback

- 24” Transmission Main project – 17,000 feet
  - Talked to Bidders on project on use of geotechnical report
    - Wide range of feedback
    - All indicated report was helpful
    - One bidder noted it allowed them to reduce bid by around $50,000
Geotechnical Evaluations
Information for Bidders – Contract Documents

• EJCDC Documents – C-700, 2007
  • “Technical Information”
  • Contractor may rely on accuracy of “technical data” contained in subsurface reports and drawings, but documents are not contract documents
    • May not rely on technical data for completeness, application to contractors means, methods, techniques, contractor interpretation
    • Possible claims due to differing subsurface conditions if technical data is inaccurate, materially different
    • Must be something not known to contractor and could not be reasonably discovered as required by bidding documents
Geotechnical Evaluations
Information for Bidders – Benefits

• More accurate bid prices
• More equitable information to bidders, less bid variation
• Assist in estimating quantities
Geotechnical Evaluations
Information for Bidders – Scope & Risks

• How much to be representative
  • Cost
• Differing conditions & characterizations
• Why should Owner pay for geotechnical
• Part of Bidding Document requirements
• Claims
• Rock clause
• Blasting
Geotechnical Evaluations
Information for Bidders – Rock Clause

• Rock Clause language
  • Measurements, equipment, attempts
  • Estimation of quantity
• Re-bid one projects with rock clause added
  • 3,000 feet of 20”, 2,000 feet of 8”
    • Increased project cost by $50,000
    • Used about half of estimated quantity
Water Main Construction
Geotechnical Evaluations - Conclusions

• Project by Project determination based on size and scope of project, materials and techniques to be utilized
  • Trenchless applications
  • Cross Country projects
Water Main Construction
Why Consider Geotechnical Evaluations?

• Questions & Discussion
At a glance

leading engineering, architecture and environmental consulting company

operating in 5 continents

100+ offices worldwide

80+ years in operation

6500+ people

2012 revenue: AUD 1118 million

serving 5 global markets

70+ service lines
Where are we?
Strategy

Our goal is to be a leader in our five global markets

We seek to achieve this through a client-centered culture and a One GHD collaborative network