Presentation Outline

- Why Rigid Inclusions
- What are Rigid Inclusions
- Common Applications
- Design Overview
- Quality Control
- Questions
Why Rigid Inclusions?

• Geotechnical
  – Reduce Settlement
  – Increase Bearing Capacity

• Structural
  – Shallow Spread Footing
  – Slab-on-grade replaces structural slab

• Environmental
  – Little to no spoil (contamination)
  – Quiet compared to pile driving
Benefits

♦ Cost: Shallow spread foundations and slab-on-grade vs. pile caps and structural slab

♦ Schedule: Gain time compared to surcharge or surcharge with wick drains

♦ Reduce settlement more than aggregate piers

♦ Minimizes spoil created at ground surface

♦ Quality verification through data acquisition and testing
What are Rigid Inclusions (RI)?

- High modulus grout columns

- Typical diameters 12” to 18”

- Works in conjunction with a load transfer platform (LTP)

- Less compressible than an aggregate pier or stone column
Installation

- Tool is driven/drilled to bearing layer.
- Displace soil → minimal spoil generated
- Refusal based on design and feedback from installation process
- Grout is backfilled into cavity while extracting the tool.
RI System Installation Overview

1. Working platform preparation and control (Safety)
2. RIs are installed using drilling or vibratory methods
3. RI heads are lowered (as needed)
4. Load transfer platform (LTP) is installed per design
Typical RI Installation
# Geologic Conditions

<table>
<thead>
<tr>
<th>Description</th>
<th>Depth (ft)</th>
<th>Sample Type</th>
<th>Blow Counts</th>
<th>&quot;N&quot; Value</th>
<th>Mc (%)</th>
<th>GR</th>
<th>Remarks</th>
</tr>
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<tbody>
<tr>
<td>FILL TOPSOIL (&lt;1&quot;)</td>
<td></td>
<td>SS-1</td>
<td>5-10-6</td>
<td>16</td>
<td>15.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILL - Black cinders and ash with little clay and organics, damp</td>
<td></td>
<td>SS-2</td>
<td>5-6-12</td>
<td>18</td>
<td>18.2</td>
<td></td>
<td></td>
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<tr>
<td>Brown/gray sandy SILT, trace gravel, trace organics, very loose, wet</td>
<td>5</td>
<td>SS-3</td>
<td>2-1-1</td>
<td>2</td>
<td></td>
<td>---</td>
<td>Groundwater Encountered - 6.6'</td>
</tr>
<tr>
<td>Brown/gray silty SAND, very loose, wet</td>
<td>10</td>
<td>SS-4</td>
<td>1-0-1</td>
<td>1</td>
<td>26.6</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>WOH-WOH-1</td>
<td>1</td>
<td>24.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>SS-5</td>
<td>WOH-WOH-1</td>
<td>1</td>
<td>24.6</td>
<td></td>
<td>Auger Refusal - 17.5'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS-6</td>
<td>1-2-2</td>
<td>4</td>
<td></td>
<td>---</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>SS-7</td>
<td>3-5-18</td>
<td>23</td>
<td>14.3</td>
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<tr>
<td></td>
<td></td>
<td>SS-8</td>
<td>38-50/0.4</td>
<td>50/0.4</td>
<td>7.0</td>
<td></td>
<td>Recovery = 100 RQD = 16</td>
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<tr>
<td></td>
<td></td>
<td>NQ-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Recovery = 96 RQD = 0</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>NQ-2</td>
<td></td>
<td></td>
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</tbody>
</table>

End of Boring - 25.0'
Applications: Foundation Support
Applications: MSE Walls
Applications: Warehouses
Quantifying Benefits

Estimated settlement without ground improvement – 6 inches
Estimated settlement with aggregate piers – 1.5 to 3 inches
Estimated settlement with rigid inclusions – less than 1 inch
Finite Element – Axisymmetric/Unit Cell

- Behavior of a single RI that is part of an infinite grid of RIs
- Load-displacement
  - Designer must account for the relative movement between the RI tip and the adjacent soil and the relative movement between the RI head and the LTP
Load Transfer Platform

- A load transfer platform (LTP) is used to transfer load from the structure to the Rigid Inclusions
- Structural Fill – Granular soil (VDOT 21B)
- LTPs may include 1 to 3 layers of embedded geogrid or steel mesh
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- Structural Fill - Granular soil (VDOT 21B).
- LTPs may include 1 to 3 layers of embedded geogrid or steel mesh.
HBI Data Acquisition System (DAQ)
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Rigid Inclusion Installation Report
77 Court Street

<table>
<thead>
<tr>
<th>RI Name: 299</th>
<th>Installation Date: 5/2/2016</th>
<th>Neat Volume: 23.66 cf</th>
<th>Stroke Count: 45</th>
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<tbody>
<tr>
<td>Job No.: 200384</td>
<td>Diameter: 12.00 in</td>
<td>Actual Volume: 27.43 cf</td>
<td>Stroke Factor: 0.61 cf</td>
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<tr>
<td>Location: Newton, MA</td>
<td>Installed Length: 30.08 ft</td>
<td>Grout Factor: 1.159</td>
<td>Target Grout Factor: 1.1</td>
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</tbody>
</table>

**Graphs:**
- Penetration/Withdrawal (ft/min)
- Torque/Crowd Pressure (psi)
- Grout Pressure (psi)
- Grout Volume vs. Time (min)

**Legend:**
- Drilling Rate
- Withdrawal Rate
- Torque Pressure
- Crowd Pressure
- Grout Volume
- Target Volumes
- Neat Volume
RI Load Testing

- Static Load Testing
  - 150% to 200% Design load
  - Design load from Finite Element Analysis

![Graph showing deflection vs load](image-url)
Thank You!! Questions?