LESSONS LEARNED IN INSTALLING CONCRETE PILES IN POTOMAC GROUP SOILS

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Geo Virginia 2013
Need for Projects

• Baltimore has 50’ deep federal channel

• Goal is to accommodate future “New Panamax” container ships

• Maryland Port Administration decides to construct new Berth 4 at Seagirt

• MPA also decides to construct a new wharf and berth at Masonville
What We Want to Tell You!

• Why HP Stingers Were Used in P/S Piles.
• Installation Challenges and Solutions.
• Why QA/QC (Integrity and Capacity) Testing Was Needed.
Pile Stresses

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P/S Pile Types

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Why P/S Concrete Piles

- Prestressed (P/S) Concrete Piles Selected for Both Terminals
- 300 to 400 ton Allowable Capacities
- High Stiffness
- Lower Initial Cost
- Lower Life Cycle Costs
## Recent Marine Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>P/S Pile Size (Inch)</th>
<th>Ultimate Capacity (Kips)</th>
<th>Hammer</th>
<th>Energy (ft-kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seagirt Berth 4</td>
<td>24/30</td>
<td>800 - 1640</td>
<td>D80 / D100</td>
<td>212 - 265</td>
</tr>
<tr>
<td>Masonville</td>
<td>30</td>
<td>1200</td>
<td>D80</td>
<td>212</td>
</tr>
<tr>
<td>GSP, NJ</td>
<td>30</td>
<td>1300</td>
<td>D160</td>
<td>393</td>
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<td>Paulsboro, NJ</td>
<td>24</td>
<td>1600</td>
<td>D100</td>
<td>265</td>
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<td>Dundalk Berth 12</td>
<td>24</td>
<td>800</td>
<td>D46</td>
<td>122</td>
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<tr>
<td>WWB</td>
<td>24</td>
<td>1500</td>
<td>B65-05</td>
<td>212</td>
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</table>
Geologic Setting

Cretaceous Age Potomac Group
Dense Sand, Stiff to Hard Clays
Cobbles and Gravel Layers
What Did Not Work

• Change Hammers
• Play with Pile Cushions
• Jetting
Pile Tip – Rock Point
Pile Tips-HP

TYPE 1

#10 BARS
TYP.
1" THICK IR.

TYPE 2

1" IR.
NOT TO BE USED IN 10" AND 12" PILES TYP.

TYPE 3

3½" TYP.

#3 TIES

SECTION ‘B’

SECTION ‘A’

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Construction Challenges

**PROBLEM 1:** Achieving sufficient penetration into hard clay stratum to achieve fixity for 30” waterside crane beam piles

**SOLUTION:** Install HP 14 x 89 stinger on bottom of pile. Cast inserts into pile for stinger assembly anchorage.
Geotechnical Considerations

- Piles must penetrate into hard clay and dense sand (possible gravel/cobble layer)
- Min. tip elevation of EL -83 for lateral fixity
Pile Construction

35-ft HP Stinger

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Masonville Marine Terminal

- Wharf was under design during the time of construction at SeaGirt
- Design called for 30 inch P/S concrete piles with a design load of 600 kips
- Test program had Cast In HP Stingers with Stinger lengths of up to 25 feet
- Project also allowed “Predrilling”
Masonville Wharf Section

30” P/S with 5-25 ft long Stinger

Similar geologic setting as Seagirt
MASONVILLE WHARF

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Predrilling with a Lubricated Bit

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“Driving a P/S Pile with a HP Stinger is Like Trying to Drive a Sailboat in Reverse Using Just the Rudder” B Fellenius.
Overview of Test Program

The Test Program consisted of:

- Static Load Testing
- Statnamic Load Testing
- High Strain Dynamic Testing
- Embedded Data Collector Testing
Seagirt Marine Terminal Berth 4

- 30-inch Crane Rail Test Pile – 95ft Long.
- Driven to Refusal 20 blows/inch at 3ft Below Minimum Tip.
- 110 ft-kip Hydraulic Hammer
- Design Capacity 410-tons.
- Ultimate Capacity 820-tons.
PDA Test

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Seagirt Marine Terminal Berth 4

- Dynamic Load Test – Initial and Restrike
- Superposition Capacity 1365 kips
Seagirt Load Test Frame

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Seagirt Static Load Test

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Static Load Test Results

Load vs Settlement at the Pile Top

- Elastic Line
- ASTM D1143-07 Procedure-A
- Davisson Line
- ASTM D1143-07 Procedure-C

<table>
<thead>
<tr>
<th>Pile No.</th>
<th>A49 Out Board Crane Rail</th>
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<tr>
<td>Design Capacity, ton</td>
<td>390</td>
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<tr>
<td>Installation Date</td>
<td>10-Aug-10</td>
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<tr>
<td>Test Date</td>
<td>2-Sep-10</td>
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<tr>
<td>Pile Type</td>
<td>30° Sq. Prestressed Concrete Pile</td>
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<tr>
<td>Pile Hammer</td>
<td>ICE-275</td>
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<tr>
<td>Length (ft)</td>
<td>94.5</td>
</tr>
<tr>
<td>Pile Area (sq. in)</td>
<td>900.00</td>
</tr>
<tr>
<td>E (ksi)</td>
<td>6346</td>
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<td>Project</td>
<td>Seagirt Marine Terminal Berth-IV Reconstruction</td>
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<tr>
<td>Job No.</td>
<td>09202.P</td>
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<tr>
<td>Calculated by</td>
<td>GG</td>
</tr>
<tr>
<td>Checked by</td>
<td>D Kozera</td>
</tr>
<tr>
<td>Date</td>
<td>7-Sep-10</td>
</tr>
</tbody>
</table>

PDA Capacity on Restrike: 600 Tons at 20 Blows/0.5
Masonville Marine Terminal

- 30-Inch Square Concrete Pile with HP14x89 Stinger.
- Design Capacity 240-tons.
- Concrete Pile Length 80-91ft. Stinger length 5-25 ft.
- Pre-augured to within 5-ft of Concrete Tip.
- 260 and 212 ft-kip Open End Diesel Hammers.
List of Tests

• Traditional Top Only Externally Mounted Dynamic Test
• Top and Tip Embedded Data Collector Dynamic Test
• Fully Instrumented Statnamic Load Test.
Statnamic Load Test - Set
Statnamic Load Test - Fire

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Statnamic Load Test Results

Statnamic Reported Capacity Pile C11  1284 kips.
Dynamic Load Test - PDA

Restrike capacity Pile C11 1095kips. Restrike penetration resistance 2 blows/inch.
Embedded Sensor Data

• Strain and accelerometer Embedded at the top and the tip of concrete pile.
• Sensors are cast in the casting yard.
• Need to pre plan the test pile
• Data transmitted wirelessly to the recorder.
Embedded Data Collector

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Embedded Data Collector

• UF Method Pile Capacity Evaluation.
• Direct Stress Measurement at the Tip.
• Compares Direct Measured Tip Stress with Estimated Tip Stress from Top Only Gauges.
• Measures Change in Pre-Stress During Driving in Real Time.
Pre-Load Delta

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EDC Results - Pile C2 (25-ft Stinger)

Pre-Load Delta (microstrain)

- Preload Delta Top Strain (uStrain)
- Preload Delta Tip Strain (uStrain)

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EDC Data Pile C2(25-ft Stinger)

(Estimated - Measured) Tip Compression versus Tip Preload Delta

Preload Delta Tip

Reference Only (CSBE - CSB)

Blow

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EDC Results Pile C2 25-ft Stinger

• Likely Prestress Loss at the Tip
• But No Significant Variation Between Measured and Estimated Tip Compression Stress
• Tip Accelerometer Water Damaged After Two Day Waiting Period for Restrike.
• What Does that Mean?
• What Do We Do?
EDC Results Pile C2 25-ft Stinger

What does that mean?
Possible damage due to the stinger deflecting.

• What did we do?
  Shorten the stinger length to 5-ft.
  Increase the preauger depth and the concrete portion of the pile.
EDC Results Pile C11 5-ft Stinger

Pre-Load Delta (microstrain)

- Preload Delta Top Strain (uStrain)
- Preload Delta Tip Strain (uStrain)

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EDC Results Pile C11 5ft Stinger

Estimated - Measured Tip Compression versus Tip Preload Delta

Preload Delta Tip

Reference Only (CSBE - CSB)

Blow

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Lesson Learned

• Direct Strain Measurement at the Tip Provides Valuable Information When a Stinger Connection is Used.
• Longer Stinger May Present Challenge Under Certain Soil Conditions.
• Appropriate Predrilling Techniques Can be Used Effectively.
Lesson Learned

- Need to Mobilize the Pile During Dynamic Test.
- Hammer Size Limited by Driving Stress.

<table>
<thead>
<tr>
<th>Project</th>
<th>Static Load Test</th>
<th>Statnamic Test</th>
<th>Restrike PDA</th>
<th>Restrike Blow Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonville</td>
<td>NP</td>
<td>1284 kips</td>
<td>1095 kips</td>
<td>2 blows/inch</td>
</tr>
<tr>
<td>Seagirt</td>
<td>2200 kips</td>
<td>NP</td>
<td>1365 kips</td>
<td>40 blows/inch</td>
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</tbody>
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QUESTIONS!
ENJOY THE BREAK