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HAMMER-GROUT PILES
FOR THE
BRONX-WHitestone Bridge

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HAMMER-CAST-IN-PLACE PILES FOR THE BRONX-WHITESTONE BRIDGE

- Background
- Subsurface Conditions
- Proposed Means & Methods
- Collaboration by Stakeholders
- Pre-Production Load Testing
- Production Results
BRONX-WHITESTONE BRIDGE

- Owned and operated by Tri-Borough Bridge and Tunnel Association (TBTA) – a division of the MTA
- Constructed in 1939
- Main span of 2,300 feet
- Carries 200,000 vehicles per day
- One of three bridges connecting The Bronx and Queens boroughs of New York City
REPLACEMENT OF BRONX APPROACH

- General contract awarded to The Conti Group in January 2009
- Contract value $192 million
- Contract duration 48 months
- Complete replacement of 1,800 feet of approach ramp
- Maintain traffic throughout duration
- Install new foundations and support around the existing approach ramp
- Avoid settlement of existing foundations
MINI-PILE FOUNDATIONS

- Mini-pile subcontract awarded to Intercoastal Foundations & Shoring
- Urkkada Technology hired as mini-pile design consultant to mini-pile subcontractor
- 772 mini-piles
- Design loads from 120 to 150 US tons
- Anticipated minimum pile depth of 75 feet
- Perform 15 static axial compression load tests to 250% of design load
- Approximately 50% of mini-piles to be installed in restricted headroom as low as 15 feet
**SUBSURFACE CONDITIONS**

- Soil borings from the original bridge construction revealed varied soil conditions along the approach.
- New soil borings were performed – 2 for each new bent – one on either side of the approach.
SUBSURFACE CONDITIONS
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- *Bedrock at depths of 60 to 130 feet*
- *Thick layers of decomposed rock in some locations*
- *Glacial overburden - from Geotechnical Report:*

The glacial materials consist of dense to very dense stratified sand and gravel with boulders, cobbles, and silt, and clay. These strata are inter-bedded with fine-grained layers of very stiff to hard organic-rich silt and clay, dense fine sand and silt with varying amounts of gravel.
SUBSURFACE CONDITIONS

[Diagram showing subsurface conditions with various stratigraphic layers and information on elevations and stations.]
**MINI-PILE DESIGN CHALLENGES**

- **Owner’s Engineer/Designer:**

  *Find a single deep foundation type that is reasonably suited to varying soil conditions and can be installed in low headroom condition*

- **Sub-contractor:**

  *Find means and methods to drill efficiently through soils which normally call for different types of tooling*
CONTRACT SPECIFICATIONS

- Contractor design
- Follow the design methodology detailed in Geotechnical Report, including FHWA bond values:

<table>
<thead>
<tr>
<th>Table 5.6</th>
<th>Recommended Ultimate Ground/Grout Bond Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratum</td>
<td>Material Type</td>
</tr>
<tr>
<td>Glacial Deposits</td>
<td>Sand and Silt</td>
</tr>
<tr>
<td></td>
<td>Sand and Gravel</td>
</tr>
<tr>
<td></td>
<td>Clay and Silt</td>
</tr>
<tr>
<td>Decomposed Rock</td>
<td>Composite</td>
</tr>
</tbody>
</table>

- Means and methods to be capable of drilling through cobbles, boulders, and sound rock
PROPOSED MEANS AND METHODS

- **Risks**
  - restricted headroom
  - stringent settlement criteria of $\frac{1}{4}$ inch maximum – existing approach supported on spread footings
  - schedule - large quantity of piles – how many rigs would be required?
  - difficult soil conditions leading to
    1. low productivity (long duration and high cost)
    2. dispute over use of DHH
PROPOSED MEANS AND METHODS

The contract specifications restricted the use of down-hole-hammer (DHH) to drilling of obstructions and sound rock.

The sub-contractor would be expected to drill with casing, rotary bits (e.g. roller bits), and water flush until an obstruction was encountered, “trip-out”, use a DHH to drill and extend the casing through the obstruction, “trip-out” again, and return to cased rotary drilling to the full depth.

The pile was then to be tremie-grouted and pressure grouted as the casing is withdrawn.
PROPOSED MEANS AND METHODS

- Develop a single drilling method capable of drilling efficiently through the varied soil conditions.
- Take advantage of higher productivity of large fixed mast drill rigs, where possible, in order to reduce the need for a larger number of crews in order to meet the schedule.
- Eliminate the risk of obstruction claims by drilling with a down-hole-hammer (DHH) throughout the process.
- Reduce potential settlement by utilizing “true” reverse-circulation drill rods together with grouting through the DHH and bit.
PROPOSED MEANS AND METHODS

In general, the proposed method is most similar to a traditional auger-cast-in-place pile

1. Drill down
2. Grout up
3. Place reinforcing
IMPORTANT FEATURE: AIR ESCAPE HOLE (PREVENTS PRESSURIZING GROUND WHEN THE BIT PLUGS)

THIS FEATURE ALSO ALLOWS THE HAMMER TO KEEP RUNNING SO BIT WILL UNPLUG IT’S SELF

TAPERED HOLE FEATURE: THE BIT FACE HOLES ARE SMALLER THAN THE CUTTINGS EVACUATION TUBE ENSURING ROCKS THAT ENTER THE BIT TRAVEL FREELY

IMPORTANT DEBRIS REMOVAL FEATURE: THE HOLES WHERE THE DEBRIS ENTER THE BIT ARE RIMMED WITH CARBIDE BUTTONS TO BRAKE OVERSIZE ROCKS
COLLABORATION BY STAKEHOLDERS

- Owner: TBTA
- Owner’s Engineer: PB/Sells
- Construction Manager and Resident Engineer: GPI/Parsons
- General Contractor: The Conti Group
- Subcontractor: Intercoastal
- Subcontractor’s Design Engineer: Urkkada
CHALLENGES TO ACCEPTANCE

- Would continuous use of the DHH lead to unacceptable settlement of the existing structure?
- Could grout quality be assured when placing the grout through the center tube of the RC rods and DHH bit?
- Could grout-ground design bond values be achieved and verified during load tests?
- Could the reinforcing be placed with sufficient control so as not to slough the sides of the drilled and grouted hole?
- Could the procedures be monitored, inspected and controlled so as to provide assurance of continued performance throughout the production pile installation?
PRE-PRODUCTION LOAD TESTING

- Pre-production load test program:
  - 4 bents
  - a sacrificial test pile plus 4 sacrificial reaction piles at each of the 4 bents
  - strain gages installed in test piles at 5 depths of interest: full reinforcing, casing and bar, immediately below casing, mid-depth of bond zone, and pile tip
  - PIT testing of all test and reaction piles
- A successful pre-production load test on a sacrificial pile would be required at each bent prior to starting production at the given bent
ADDITIONAL PRODUCTION QUALITY CONTROL

- Pile Integrity Testing (PIT) to be performed on up to 5% of the production piles. Selection of these piles would be by PB/Sells.

- “Proof” static testing up to 2% of production piles to 200% of design load. Selection of these piles would be by PB/Sells.
Successful load tests were performed at bents 8, 9, 11, and 12

Acceptance based on the gross movement (Davisson Criteria) and creep (< 0.01”/hour and 0.03”/log cycle of time) during a 48-hour hold period at 100% of design load

Test load was increased to 250% of design load (12-hour hold and < 0.01”/hour) to verify the achieved grout-ground bond values
SUBSURFACE CONDITIONS
Test Pile TP 8
Total Pile Length: 72.6 ft
Length of Casing: 25.3 ft
Closest Boring: 8B-R

Test Pile TP 9
Total Pile Length: 67.3 ft
Length of Casing: 25.3 ft
Closest Boring: 9B-R

Test Pile TP 11
Total Pile Length: 74.3 ft
Length of Casing: 30.3 ft
Closest Boring: 11B-R

Test Pile TP 12
Total Pile Length: 73.8 ft
Length of Casing: 30.3 ft
RESULTS

- Pre-production testing did not result in any changes to means & methods or design lengths
- Some modifications were made to bit geometry to reduce air loss into soil formation
- All load tests (pre-production and production “proof” testing) were successful
- Maximum measured settlement of existing bridge structure was 1/8 inch
- Production Rates:
  - 5 piles per rig-shift in unlimited headroom
  - 2+ piles per rig-shift in 20-ft headroom
- No claims for obstructions
- 20% reduction (conservative) in piling costs compared to conventional methods
ACKNOWLEDGEMENTS

- Robert Sackaris and William Lozito of Intercoastal Foundations & Shoring
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- Art Holte of Holte Manufacturing