Selmon Expressway in Tampa, Florida: Case History of Drilled Shaft Design For Extreme Variability

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Original Structure

- Constructed in late 60’s and early 70’s
- Prestressed girder bridge with typical span lengths of approximately 65’ to 100’
- Existing bridge founded on groups of 18” square concrete piles with H-piles in limited locations
Reversible Elevated Lanes (REL) 2003-2005

- Precast box structure supported on monoshaft piers.
- 6’ diameter shafts (a few 8’ diameters crossing the canal).
- All 3-lanes into Tampa in morning, out of Tampa in afternoon.
Deck Widening (2012)

Project alignment approximately 1.5 miles long
Site Overview

Project alignment approximately 1.5 miles long
Project Location
Site Stratigraphy

- **Loose Fine Sand**, Often Silty
  - SP or SM
  - Color Varies

- **Clay with Sand**
  - CH or SC
  - Green Gray

- **Highly Weathered Limestone**
  - Light Brown or Light Gray

(Figure after Kuhns et al., 2003)
Seismic Tomography Results at Pier 97

Three-dimensional S-wave velocity images of the ground around Pier 97.

Note: Boreholes marked by red dots (sources) and blue dots (receivers).

Three views of the ground image around Pier 97, labeled as View from SE, View from SW, and View from NW:
- Weak ground zone
- Weathered limestone?
- Softer, less competent ground - irregular
- Limestone?

Color code:
- 3,500 Seismic velocity, ft/s
- 8,000

Velocities matching color in the ground image:

Shaft Tip

Geology at Pier 97 from core drilling:
- SC
- CH
- SM
- CL
- Weathered Limestone
- Limestone

Surveyed: August 18, 2004
REL Failure (2004): View from Pier 98 toward 97
REL Failure (2004): View from Pier 97 toward 96
REL Failure (2004): Pier 97
REL Remediation

218 Shafts Total

- 50 required no remediation
- 87 required Micropile remediation
- 67 required Sister Shaft Remediation
- 14 new shafts, with alternative design
Micropile Remediation
Sister Shaft Remediation
Widening Project (2012)

• Owner: THEA (Tampa Hillsborough Expressway Authority)
• Operator: FDOT (Florida Dept. of Transportation)

The Design-Build Team

• Contractor: Granite Construction
  • Drilled Shaft Sub-Contractor: ATS Drilling
  • Load Testing Specialist: AFT (Applied Foundation Testing)

• Designer: PTG (Parsons Transportation Group)
  • Foundation Engineer: DBA (Dan Brown and Associates)
  • Geotech Partner: Ardaman and Associates
Widening Design (2012)

- Existing SPT, and New boring at each shaft.

- Side Resistance only.

- Initially based on REL correlations.

- Adjusted based on 5 Statnamic load tests.
The Challenges For Design

• A means of identifying and quantifying that strata is too hard for SPT, but too soft for coring is needed:

• Design Process MUST account for variability of the weathered rock bearing formation.
The Challenges For Design

• A means of identifying and Quantifying the strata: too hard for SPT, but too soft for coring

• Design Process MUST account for variability of the weathered rock bearing formation.
Design Methodology

Step 1: Compile SPT data for each pier (multiple borings) → Also, look at the existing driven pile tip elevations.

Step 2: Divide into layers based SPT N and soil descriptions.

Step 3: Calculate shaft capacity: based on boring at location and existing surrounding data.

Step 4: Correlate design based on comprehensive load testing.

Step 5: Exercise judgment when setting the final tip elevation.
Step 1: Compile existing SPT data for each new pier
Step 2: Divide into layers based on SPT N and soil descriptions.
Step 2: Divide into Layers
Step 2: Divide into Layers

Step 3: Calculate Resistance
Step 4: Correlate/Verify Based on Load Tests

### Side Resistance

<table>
<thead>
<tr>
<th>Average $\bar{N}$ (bl/ft)</th>
<th>Geomaternal Category</th>
<th>Side Resist.</th>
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<tbody>
<tr>
<td>$\leq$ 60</td>
<td>Soil</td>
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Step 4: Calibrate/Verify Based on Load Tests

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- SPT blow counts were systematically lower, even with auto-hammer corrections.
- Borehole roughness and concrete over-break are proportionally greater for smaller diameter shafts.

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- Side resistance derived from a combination of the different materials in shear.

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- Base Resistance governed by the weaker matrix with the stronger inclusions going along for the ride.
Step 5: Use judgment to set final tip elevation
Load Testing at the REL
Load Testing During the Widening
All construction utilized temporary casing to weathered rock with water only unless otherwise noted.

Bentonite Used to Assess Effect

Permanent Casing Left In Overburden to Assess Effect

Flow-Filled to Stabilize and Re-Drilled

Excess Measured Resistance Primarily in Overburden
Design of Non-Redundant Foundations in Highly Variable Conditions Requires:

1. Through Investigation: Simple SPT delineation used
   (a) with a large sample population, and
   (b) boring at each location.

2. Comprehensive load testing across range of conditions.
   (a) Assign Resistances based on material, and
   (b) Resist temptation to delineate into finer segments.

3. Design must be robust to achieve reliability:
   (a) Capture the low end of the performance,
   (b) Then carefully consider your \( \phi \)-factor.

4. Rigorous QC/QA is required, and the designer must remain engaged during construction.