Effect of Polymer Slurry Stabilization on Drilled Shaft Side Shear Over Time

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Civil & Environmental Engineering
Problem Statement (recall)

- Construction methods affect drilled shaft side shear resistance which is not fully addressed by design.

- The primary objectives of this study are to quantify the time effects on side shear (if any) from prolonged open excavation where polymer slurry is present and determine what changes would be needed in the specifications.
Bentonite showed tremendous drop in capacity at 1hr

- Low permeability soil
- No time to form “filter cake”
Low Permeability Silt, low/no filter cake potential

No appreciable filter cake can develop in 1hr even in sand

Yet bentonite noticeably lower

WHAT IS REALLY HAPPENING?

Not exposure time / Not filter cake
Concrete Flow in Drilled Shafts

Idealized Concrete Flow

Actual Concrete Flow

Steel Forms
Class IV Shaft Mix
SCC Shaft Mix
Volume of voided surface was trapped bentonite (not filter cake)
Polymer slurry not trapped

Both shaft specimens tremie-cast from same truck (Class IV shaft mix)
Problem Statement

- Bentonite and polymer slurries work differently (e.g. filter cake / no filter cake).

- Present specifications for bentonite largely do not apply to polymer.
FDOT 2014 455-15.11.5 specifications state:
Any unclassified excavation work lasting **more than 36 hours** (measured from the beginning of excavation for all methods except the Permanent Casing Method, which begins at the time excavation begins below the casing) before placement of the concrete requires **overreaming the sidewalls** to the depth of softening or **removing** excessive **slurry cake buildup**. Ensure that the minimum depth of overreaming the shaft sidewall is 1/2 inches and the maximum depth is 3 inches. . .
Research Approach

- Cast small and large scale shafts using three different polymer products
- Maintain open excavations with slurry prior to casting
- Perform pull out tests
- Small scale and full scale test program
Small Scale Test Shaft Program

- 32 shafts
- 4in diam., 7ft to 8ft long
- Sandy / silty sand
- 0, 1, 2, 4, 8, 24, 48 and 96h exposure times
- 3 different polymer types
- 1 pure bentonite
Small Scale Test Shaft Program

Not to Scale
Excavation
Static Load Test

- Modified Quick Test
- Load Increments of 500lbs
- Max. Displacement of 4in
Bentonite Load Tests

Length Corrected Pull-Out Load (kips)

Upward Displacement (in)

- B-0
- B-1
- B-2
- B-4
- B-8
- B-24
- B-48
- B-96
Cetco Polymer Load Tests

Length Corrected Pull-Out Load (kips)

Upward Displacement (in)

C-0
C-1
C-2
C-4
C-8
C-24
C-48
C-96
KBI Polymer Load Tests

Length Corrected Pull-Out Load (kips)

Upward Displacement (in)

- K-0
- K-1
- K-2
- K-4
- K-8
- K-24
- K-48
- K-96
Slurry Exposure Results
(32 small-scale shafts)

Measured (solid lines)
ALL POLYMER SLURRIES 26% higher

Predicted Capacity (dashed lines)
Measured / Predicted

Resistance Bias vs. Exposure Time (h)

- B
- C
- K
- M
- P

Exposure Time (h)
Viscosity vs Excavation Stability

- Polymers
- Water
## Full-scale testing

<table>
<thead>
<tr>
<th>Shaft ID</th>
<th>Slurry Type</th>
<th>Exposure Time (hr)</th>
<th>Target Viscosity (sec/qt)</th>
</tr>
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<tbody>
<tr>
<td>B48-40</td>
<td>Bentonite</td>
<td>48</td>
<td>40</td>
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<tr>
<td>P48-60</td>
<td>Polymer</td>
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<td>60</td>
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<tr>
<td>P0-60</td>
<td>Polymer</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>P0-100</td>
<td>Polymer</td>
<td>0</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>
Excavation staged over two day period
Concreting all conducted within 2hrs
Load testing and extraction
Measure as-built dimensions
Full-scale test results

- Polymer shafts showed no reduction in capacity (0.5 - 49hrs)
- Bentonite shafts showed no reduction in capacity (2 - 48hrs)

Polymer 16% higher
Slurry Exposure Conclusions

- Long-term polymer slurry exposure in sandy soils did not affect side shear resistance.
- Bentonite filter cake forms almost immediately and did not cause further degradation with time beyond 8hrs.
- Radial concrete flow through cages is thought to be primary cause of slurry cake formation (trapping not filter action).
- July 2018 specification removes time limit for polymer slurry.