Remediation of Existing Communication Towers

April 25, 2013

www.HaywardBaker.com
Site Conditions

Limited Access
Low Headroom

Steele Street – Kansas City, KS

Speedway Site – Kansas City, KS
Subsurface Conditions – Speedway Site

Stiff Clay

Sandstone

Approximate bottom of shaft

$\sigma'_{c} \text{ avg } = 1,200\text{psi}$
### Subsurface Conditions – Steele Street Site

<table>
<thead>
<tr>
<th>Log</th>
<th>Elevation</th>
<th>Depth in Feet</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>959</td>
<td>0.0</td>
<td>0.0</td>
<td>BROWN SILTY CLAY MOIST, FIRM</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>5.0</td>
<td>UNDISTURBED SAMPLE LIGHT BROWN SILTY CLAY WITH IRON NODULES MOIST, STIFF</td>
</tr>
<tr>
<td></td>
<td>7.0</td>
<td>7.0</td>
<td>BROWN TO MOTTLED GRAY SILTY CLAY MOIST, FIRM, LIMONITE NODULES</td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>10.0</td>
<td>UNDISTURBED SAMPLE BROWN MOTTLED GRAY AND TAN SILTY CLAY WITH IRON NODULES SLICKENSIDE, TRACE OF GRAVEL MOIST, STIFF</td>
</tr>
<tr>
<td></td>
<td>12.0</td>
<td>12.0</td>
<td>YELLOW BROWN TO MOTTLED RUST BROWN SILTY CLAY MOIST, FIRM, LIMONITE NODULES AND ROCK FRAGMENTS</td>
</tr>
<tr>
<td></td>
<td>13.5</td>
<td>13.5</td>
<td>NX CORE BORING LIGHT BROWN FOSSILIFEROUS LIMESTONE WITH WEATHERED SEAMS RQD=60%</td>
</tr>
<tr>
<td></td>
<td>18.5</td>
<td>18.5</td>
<td>END RUN #1 (13.5-18.5') REC=90% TERMINATION OF BORING BORING DRY PRIOR TO CORING OPERATION</td>
</tr>
</tbody>
</table>

- **RQD = 60%**
- **$\sigma_c$ avg = 12,500 psi**

**Stiff Clay**

**Limestone**

**Approximate bottom of shaft**
Foundation solutions must consider

**Structural Aspects:**

- 182 kips of additional uplift load required
- 100 kips of additional compression load required
- Connection to the existing shaft
Foundation solutions must consider

**Geotechnical Aspects:**
- Native clay
- Sandstone and Limestone Rock

**Logistical Aspects:**
- Connection to Existing Shaft
- Low Headroom
- Limited Access
Micropile Solution

Limited access, deep foundation

End Bearing Pile

Tension Compression Micropile

-13.5' at Steele
-30.5' at Speedway

10' at Steele
12' at Speedway

Bot. Shaft - 13.5' to 14.5'

-13.5' at Steele
-30.5' at Speedway
Now let’s look at structural design

Micropiles – commonly used references:
- International Building Code 2009, [Section 1810.3.10]
- Federal Highway Administration (FHWA-SA-97-070)
  - Drilled and Grouted Micropile – State of Practice Review 1997

\[
P_{allow} = 0.4(F_y)(A_s) + 0.3(A_g)(f'c)
\]
Compression

Limited to 32 ksi per IBC

\[
P_{allow} = 0.6(A_s)(F_y)
\]
Tension
Geotechnical designs vary from site to site

Geotechnical references – Grout to Ground Bond:

- Post Tensioning Institute (PTI)
- Federal Highway Administration (FHWA-SA-97-070)
  - Drilled and Grouted Micropile – State of Practice Review 1997

<table>
<thead>
<tr>
<th>ROCK</th>
<th>AVERAGE ULTIMATE BOND STRESS ROCK/GROUT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MPa</td>
</tr>
<tr>
<td>Granite &amp; Basalt</td>
<td>1.7 - 3.1</td>
</tr>
<tr>
<td>Dolomite Limestone</td>
<td>1.4 - 2.1</td>
</tr>
<tr>
<td>Soft Limestone</td>
<td>1.0 - 1.4</td>
</tr>
<tr>
<td>Slates &amp; Hard Shales</td>
<td>0.8 - 1.4</td>
</tr>
<tr>
<td>Soft Shales</td>
<td>0.2 - 0.8</td>
</tr>
<tr>
<td>Sandstones</td>
<td>0.8 - 1.7</td>
</tr>
<tr>
<td>Weathered Sandstones</td>
<td>0.7 - 0.8</td>
</tr>
<tr>
<td>Chalk</td>
<td>0.2 - 1.1</td>
</tr>
<tr>
<td>Weathered Marl</td>
<td>0.15 - 0.25</td>
</tr>
<tr>
<td>Concrete</td>
<td>1.4 - 2.8</td>
</tr>
</tbody>
</table>

Steele

Speedway
Geotechnical designs specifics

Maximum Load on Rock Socket is 182 kips per shaft

Given:

- 5.5” diameter rock socket
- 75 psi grout to bond
- FS of 2 on grout to ground bond
- 91 kips tension capacity

Yields a 12-foot rock socket in the sandstone
Now back to the Structural Design

Must check that all sections can structurally handle the load

\[ P_{allow} = 0.6 (A_s)(F_y) \]
\[ = 0.6 \times 2.25 \times 75 = 102 \text{ kips} > 91 \text{ kips} \]

\[ P_{allow} = 0.4 (A_s)(F_y) + 0.3 (A_g)(f'_c) \]
\[ = 0.4 \times 2.25 \times 75 + 0.3 \times 21.5 \times 4 = 93 \text{ kips} > 50 \text{ kips} \]
Now how to we get the load to the micropile?
Pile Cap Checks Required

Must check that all sections can structurally handle the load

Determine maximum factored loads on the system
Moments and Shears

Determine resistance in reinforced pile cap and connection
  Bending in the pile cap
  Shear transfer from tower leg to pile cap and pile cap to micropile
  Plate bending and shear
  Bolted connection to existing shaft
    Pryout strength of bolts
    Edge failure
Now let’s get to the installation

Speedway site access
General Sequence

1. Locate, protect and relocate existing utilities after confirm rig can actually access all the locations and raise its mast.
2. Drill and install casing with bit to get through bell.

3. Went inside cased hole and drilled with a roller cone to drill out rock socket.

4. Install threadbar with centralizers and grout shaft.
Three feet of clearance between existing structures
Casing installation and inner rod with roller-cone
External power pack can be placed away from the drill rig.
Management of Drill Spoils also critical

Use filter lined containment tanks when drilling with water
Sequence, continued

5. Hand excavate, dowel, set steel and place concrete
6. To be tested, locked-off and backfilled as if we were never there
Performance or Proof Tests were conducted on all micropiles

Criteria that was required to be met – per PTI:

1. Creep
   Less than the required 0.040 inches for the 1-10 minute hold and 0.080 inches for the 6-60 minute hold

2. Minimum and Maximum Apparent Free Tendon Length
   \( \delta > 80\% \text{ of free length } + \text{jacking length} \)
   \( \delta < 100\% \text{ of free length } + 50\% \text{ of bond length} \)
Closing Thoughts

- Micropiles are very versatile
- In our industry everything is a variable
- There are a lot of solutions out there – many great resources for information
- Coordination between Owners, Engineers and Contractors essential for project success and can never start early enough
- Be knowledgeable of risks and specify work to minimize risks
- Gather as much information as possible so everyone is aware of project conditions – this will only enhance the value you get in the field
- Insist on engineered solutions and understand what you are buying
- Monitor, document and inspect field work – demand the best
Acknowledgements

- ASCE and organizers of the event
- UMKC
- Sponsors
- Casey Jones with Foundation Testing and Consulting
- KC Board of Public Utilities