Tip-Grouted Drilled Shaft Foundations for the Audubon Bridge

Steven Dapp, Ph.D., P.E.
Dan Brown, Ph.D., P.E.

www.danbrownandassociates.com

Acknowledgements

• Tip grouting used worldwide for more than 3 decades.

• Six years of research at USF, funded by the FDOT, has produced a rational design procedure.

• Gaining wide acceptance within the US.
Outline

• The Tip Grouting Process

• The Benefits of Tip Grouting

• Experiences: U.S. and Abroad

• John James Audubon Bridge

The Tip Grouting Process

1. As constructed, un-stressed.
2. Grout pressure applied, negative side shear reaction.
3. Some relaxation occurs.
4. Structural load applied.
Tip Grouting Process

Grouting Injection Mechanisms

- Tube-a-manchette (Sleeve-Port) w/ plate
- Tube-a-manchette (Sleeve-Port) w/ out plate

Stem or Orifice (Not Shown): Consider as a Remediation Option Only.
Benefits of Tip Grouting

• Increases the ultimate tip capacity.

• Tip component able to contribute to the “useful” capacity (i.e., within tolerable displacements).

• Provides a proof load of capacity for every grouted shafts on the site.
Benefit with Soil Type

Cohesionless Soils:
- Significant improvement as well as proof’s the load.
- Most improvement seen in loose to medium dense sands.

Cohesive Soils:
- Little improvement, but proofs the load.

Rock Socket:
- May be used to remediate soft toes in deep excavations (long construction times) where thorough clean-out can not be achieved/assured.

Grouting Procedures / Criteria

Sustained Grout Pressure:
Develops and proves the increase in “useful” tip resistance.

Excessive Grout Volume (without achieving grout pressure):
Stop, flush lines, and try staged grouting technique later.

Shaft Uplift (without achieving grout pressure):
Side shear is not as great as anticipated, and is inadequate to provide reaction for grout pressure.
When to Consider Tip Grouting

• Sandy bearing stratum

• Shaft tip cleanliness is difficult to achieve and/or maintain.

• Increase reliability by proof loading every shaft.

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TCM = \frac{\%D}{0.4 \cdot (\%D) + 3.0}
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My-Thuan Bridge
Vietnam (1998)

Taipei Financial Center
(a.k.a. “101”)  Taiwan, 1999
Experience with Tip Grouting in the U.S.

- 10 projects since 2003
  - 6 were DOT bridges (Florida, Mississippi, Texas and South Carolina.
  - 4 were commercial High Rise (Florida).

- Nearly 600 tip grouted drilled shafts, with 17 full scale load tests.


John James Audubon Bridge

- SR10 over the Mississippi River
- 1,583 ft Cable Stayed Span, Longest in North America
- $347 million, Design-Build Project
Summary

• Increase the “Useful” End Bearing Resistance
  – Greater Ultimate Resistance
  – End Bearing Develops within service limit displacement
  – Reduce Differential Settlement in Some Cases.

• Allows for Greater Reliability
  – Providing a “Proof Load” of Every Production Shaft
  – can use lower SF’s for ASD, or greater Φ factors for LRFD?

• Identify Unforeseen Construction and/or Soil Problems, and Provide the Means of Remediation.

Questions & Comments