

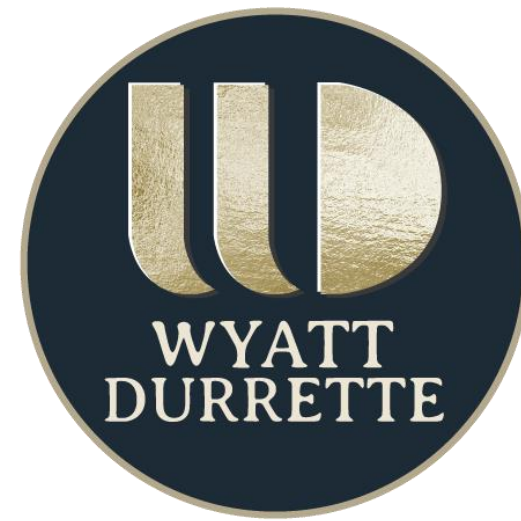


Ground Response to: Foundation and Ground Improvement Installation

Timothy C. Siegel, PE, GE, BC.GE
Dan Brown and Associates LLC

1989 Toyota Land Cruiser





NUMBER ONE SONGS:

Beautiful Crazy - Luke Combs

Chicken Fried – Zac Brown Band

Toes – Zac Brown Band

Whatever It Is – Zac Brown Band

Highway 20 Ride – Zac Brown Band

As She's Walking Away feat. Alan Jackson – Zac Brown Band

Knee Deep feat. Jimmy Buffett – Zac Brown Band

Colder Weather – Zac Brown Band

Keep Me in Mind – Zac Brown Band

Goodbye in Her Eyes – Zac Brown Band

Sweet Annie – Zac Brown Band

Homegrown – Zac Brown Band

Heavy Is the Head feat. Chris Cornell – Zac Brown Band

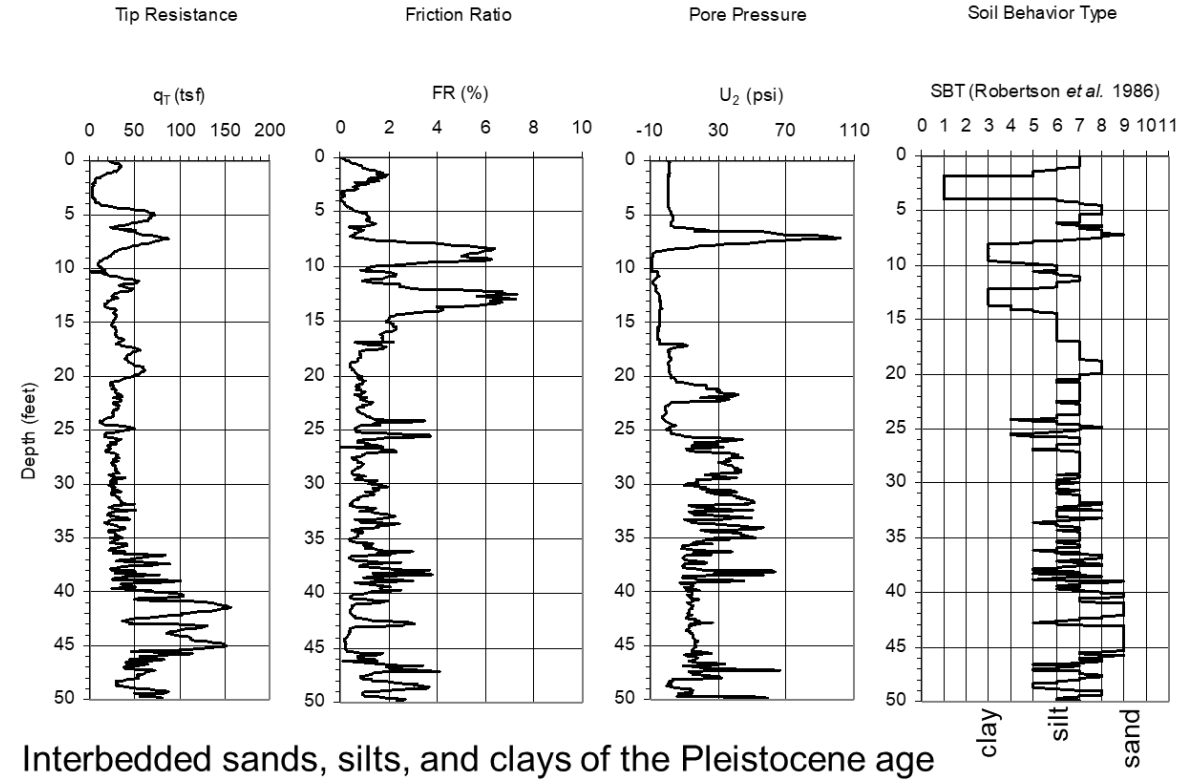
Residual Load on Piles

CPT Sounding

Test Site in Rincon GA



Test Pile

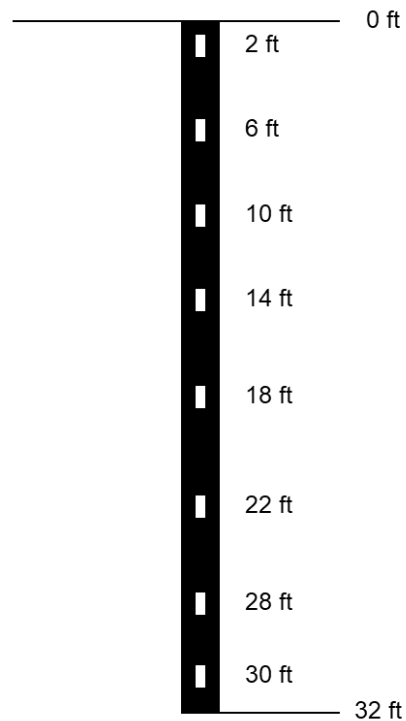


Siegel, T.C. and McGillivray, A. (2009) Interpreted Residual Load in an ACIP Pile, *Proceedings*, Annual DFI Conference.

Residual Load on Piles

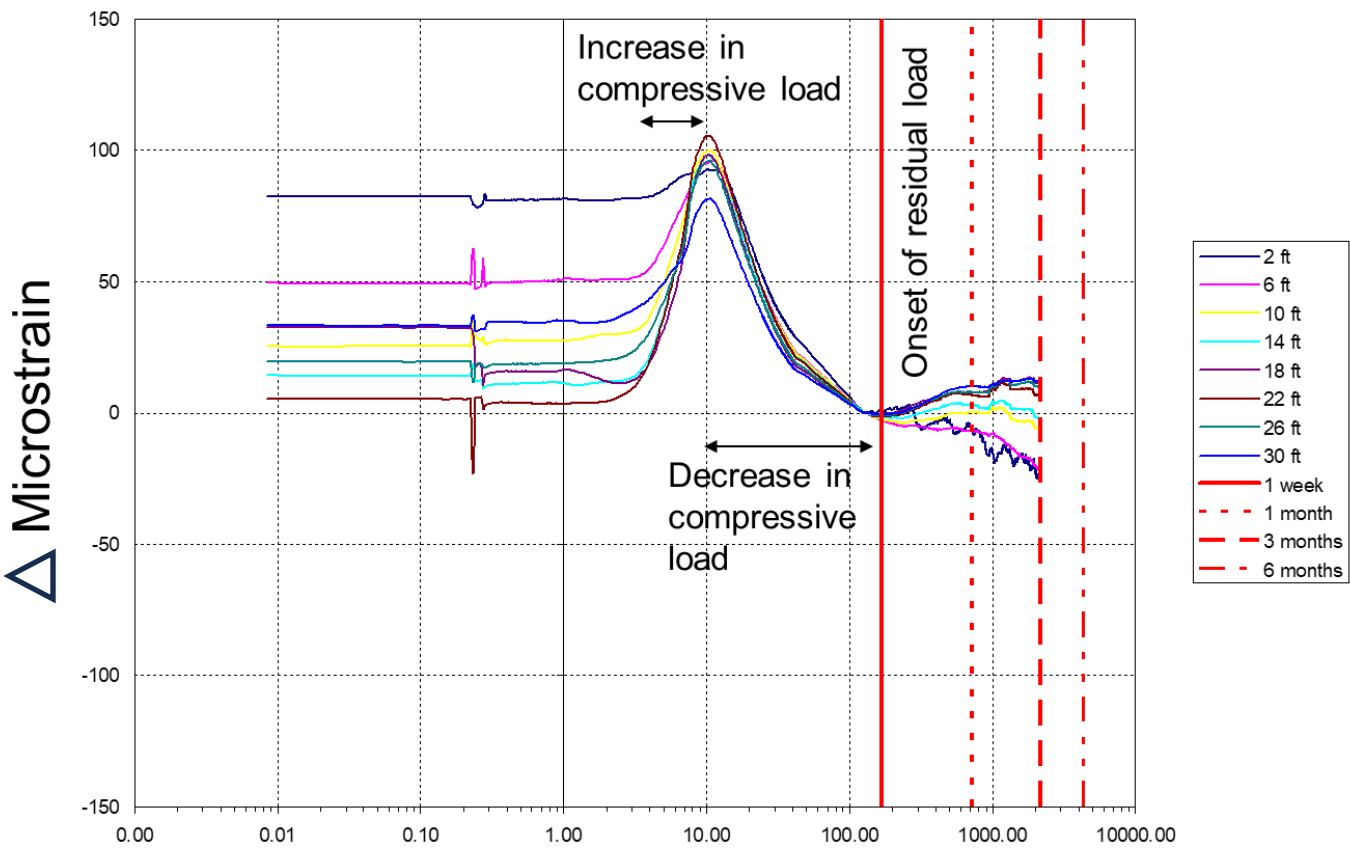
Test Pile Details

□ Strain Gage Location (Geokon 4911-4)



18 inch diameter
 $f'_c = 5000$ psi
Single No. 8 bar
Grout factor = 128%

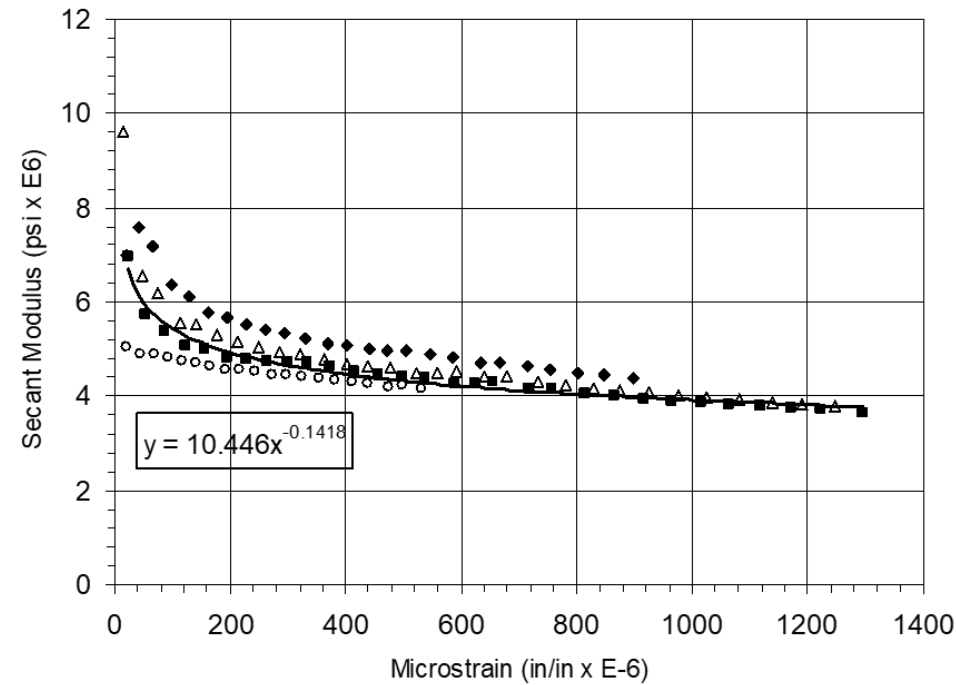
Results of Strain Monitoring



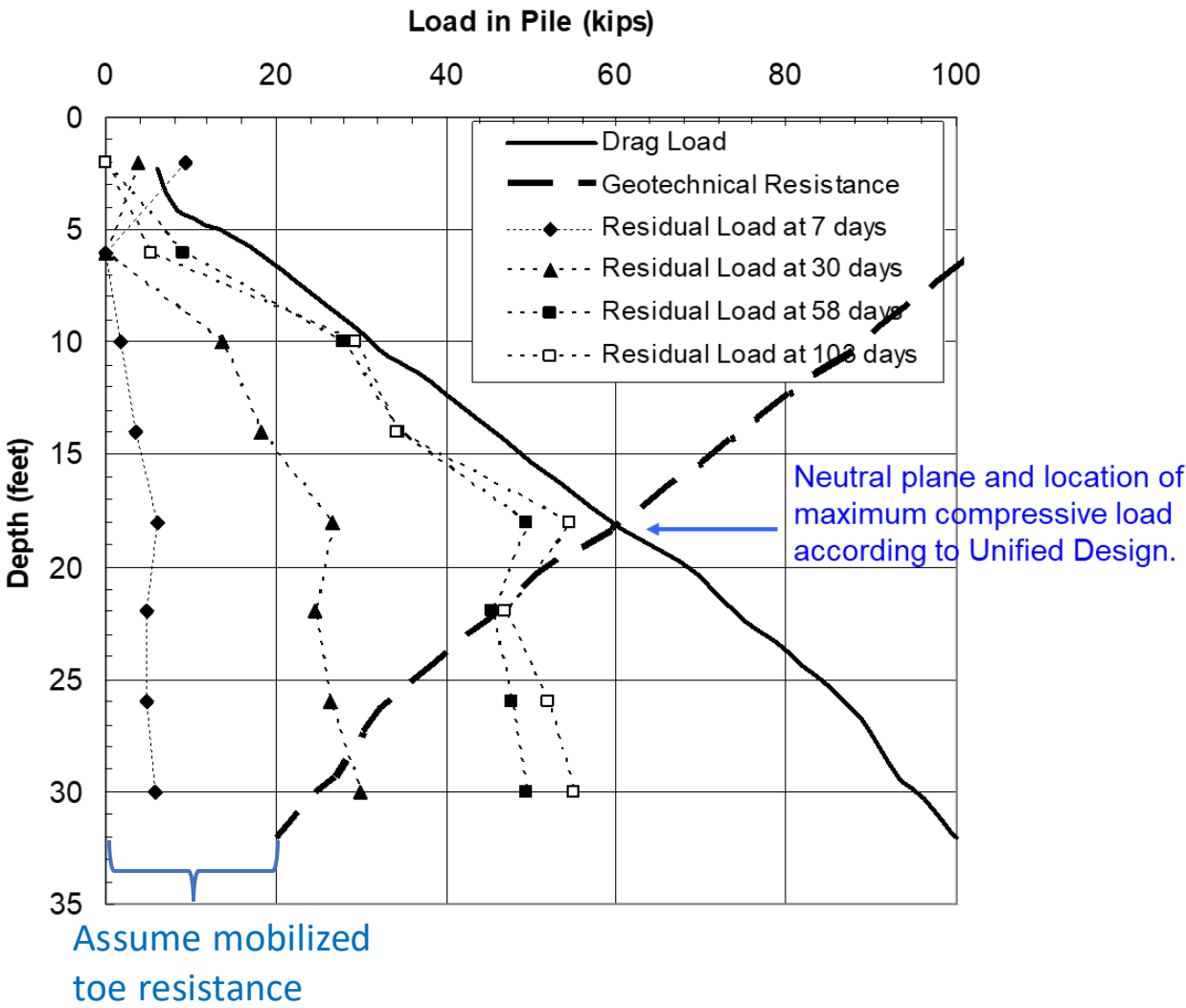
Residual Load on Piles

Transforming Strain to Load

$$Q = \epsilon EA$$

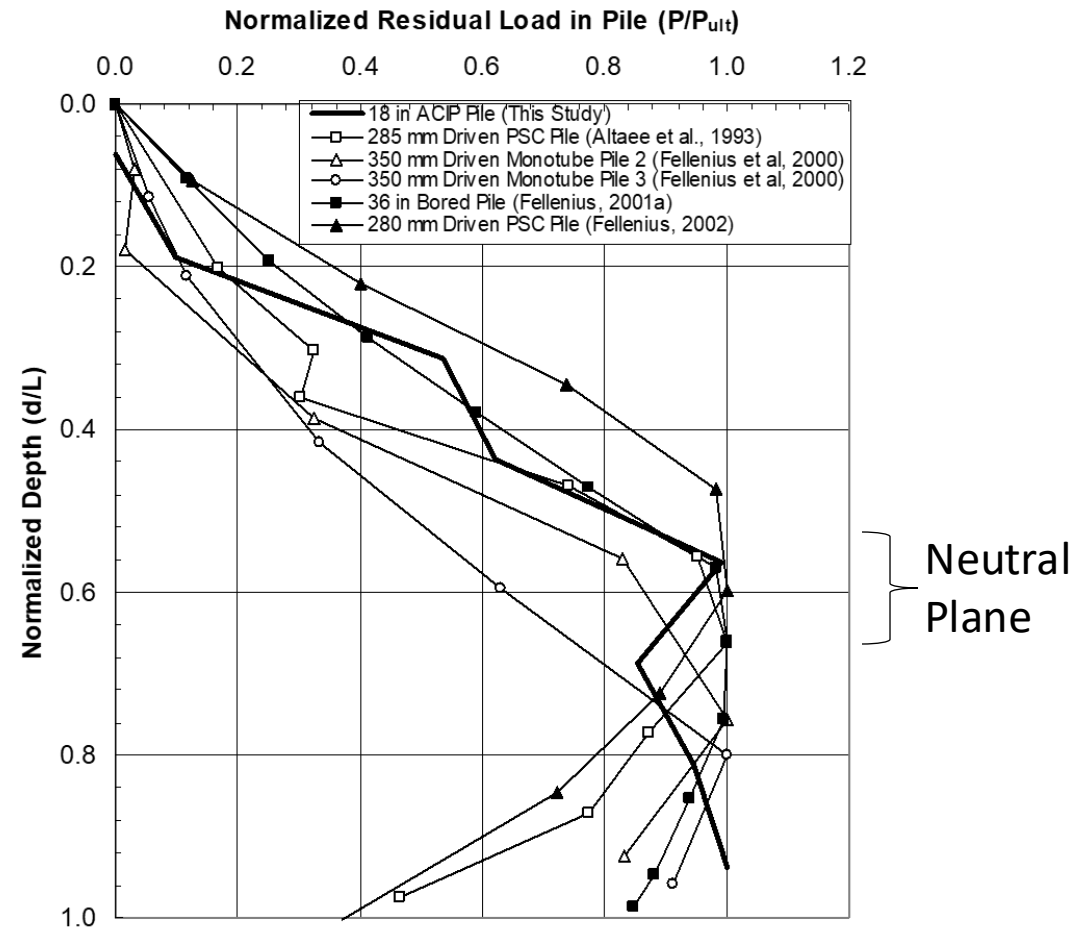


Interpreted Residual Load versus Depth



Residual Load on Piles

Profiles of Interpreted Ultimate Residual Load



Residual Load on Piles

Foothills Parkway

Wears Valley TN (near the Great Smoky Mountains)



Luna, R., Dixon, D.T., Kershaw, K.A., and Siegel, T.C. (2015) Monitoring micropile foundations of bridge during construction, IFCEE Conference.

Residual Load on Piles

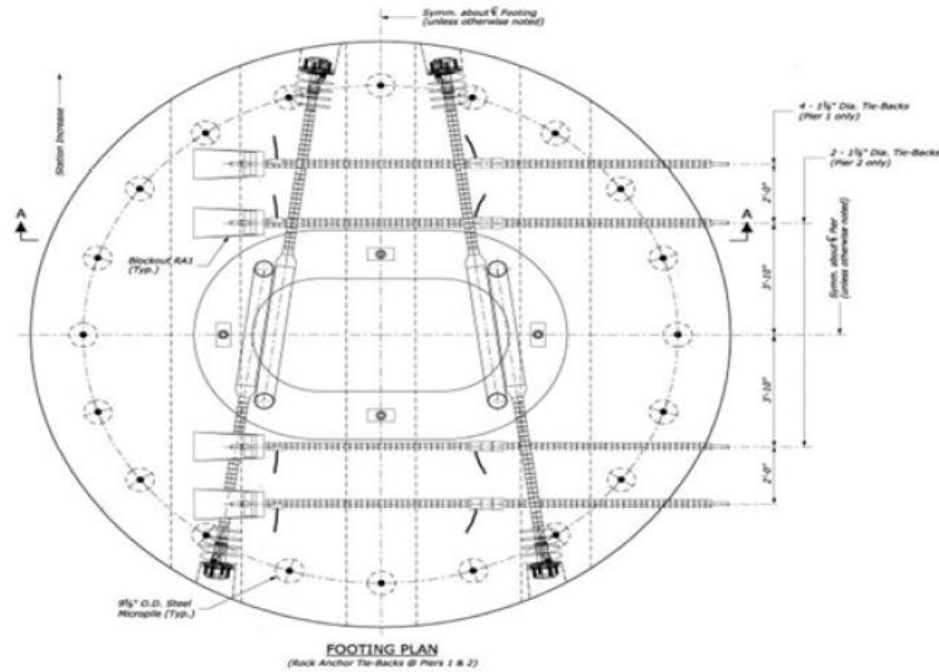


FIG. 3. Footing Plan (Corven Eng., Inc. & Palmer Eng., Inc., 2010)



Residual Load on Piles

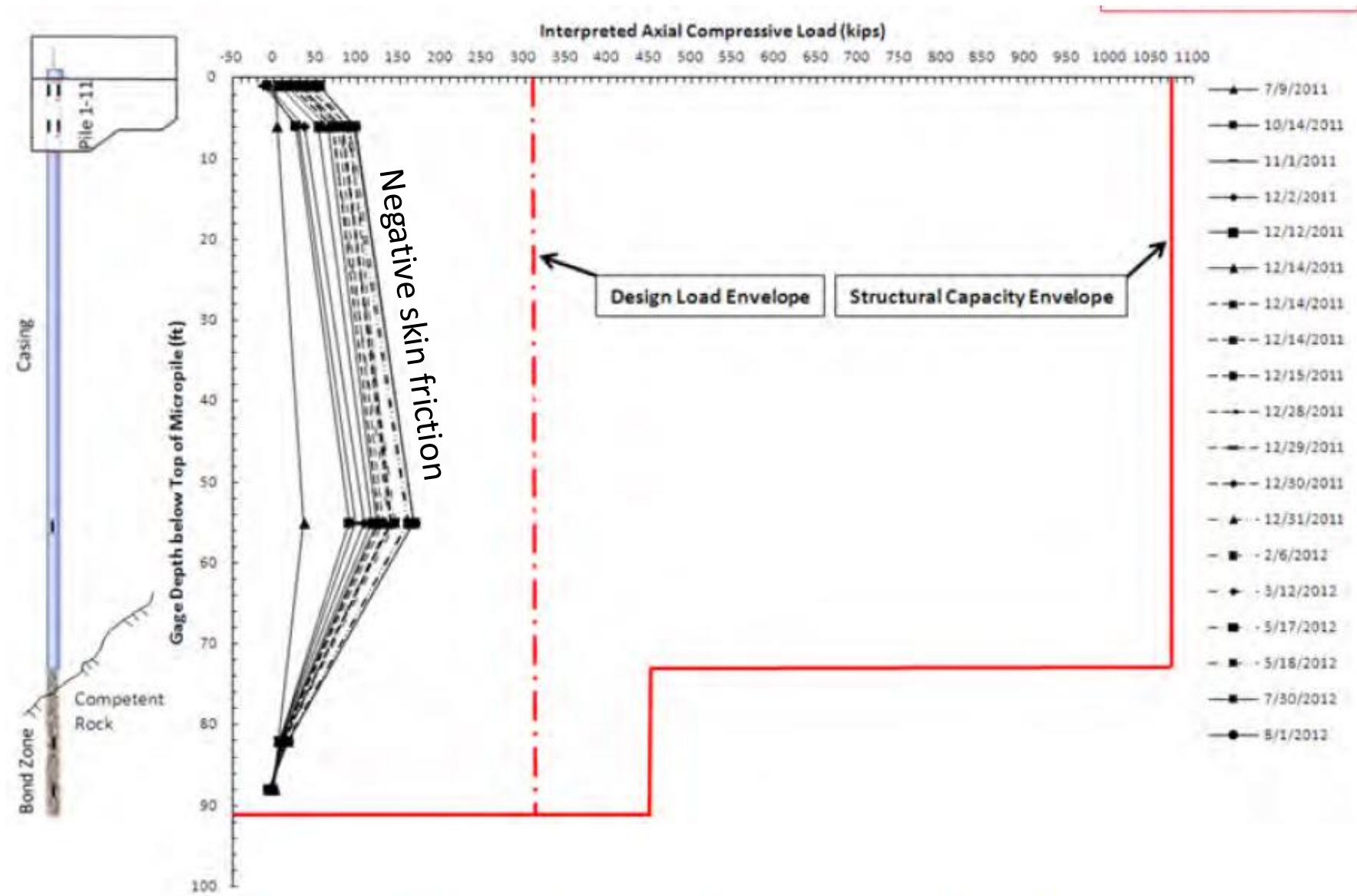
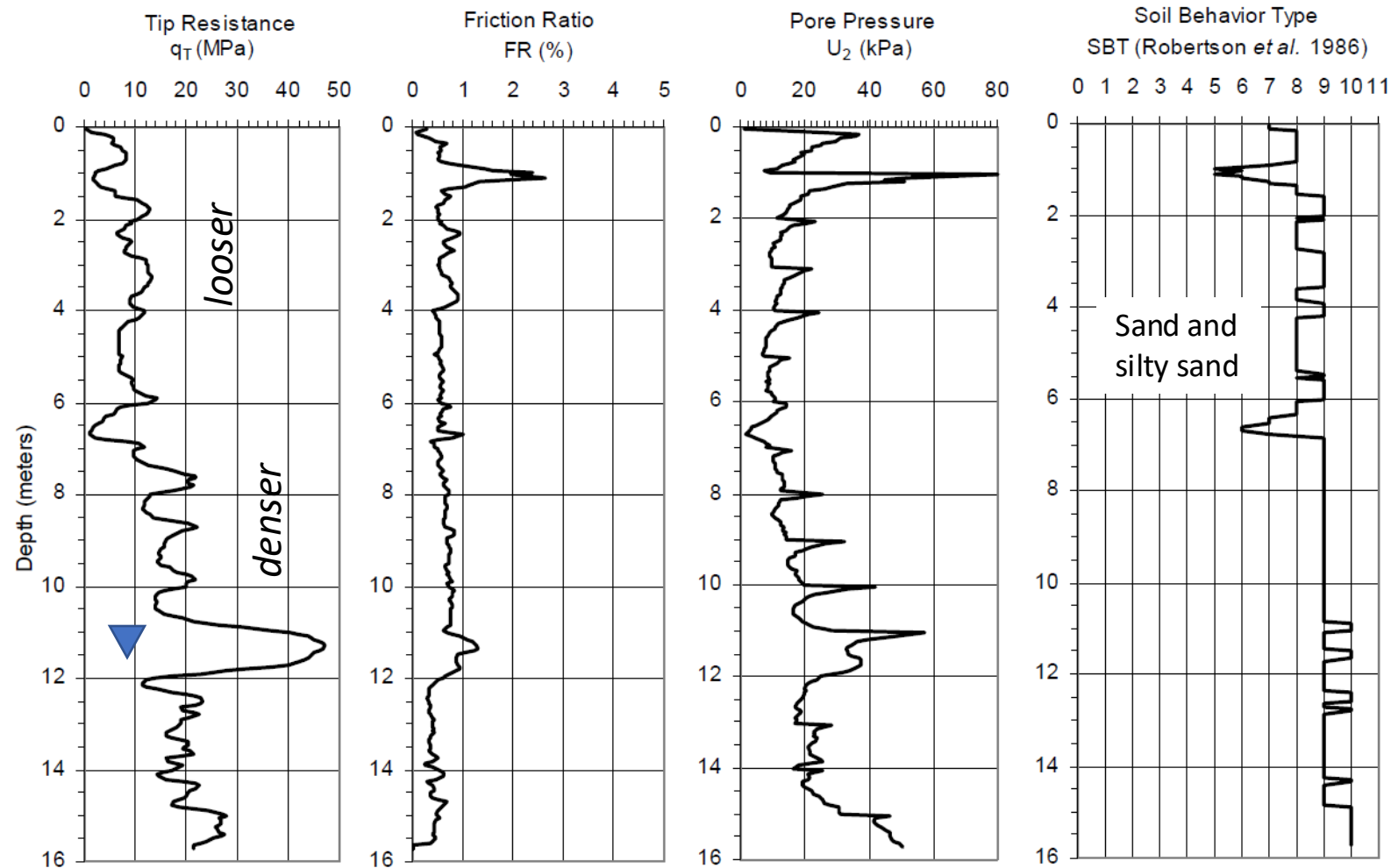


FIG. 6. Pile 11, Pier 1: Construction Loading

Residual Load on Piles

There is no such thing as a stress-free pile.

Ground Response to Auger Rotations on (Dry) Sand



* 10 Mpa ~ 100 tsf

Zone: Soil Behaviour Type:

- | | | |
|---------------------------|------------------------------|------------------------------|
| 1. Sensitive fine grained | 5. Clayey silt to silty clay | 9. Sand |
| 2. Organic material | 6. Sandy silt to clayey silt | 10. Gravelly sand to sand |
| 3. Clay | 7. Silty sand to sandy silt | 11. Very stiff fine grained* |
| 4. Silty clay to clay | 8. Sand to silty sand | 12. Sand to clayey sand* |

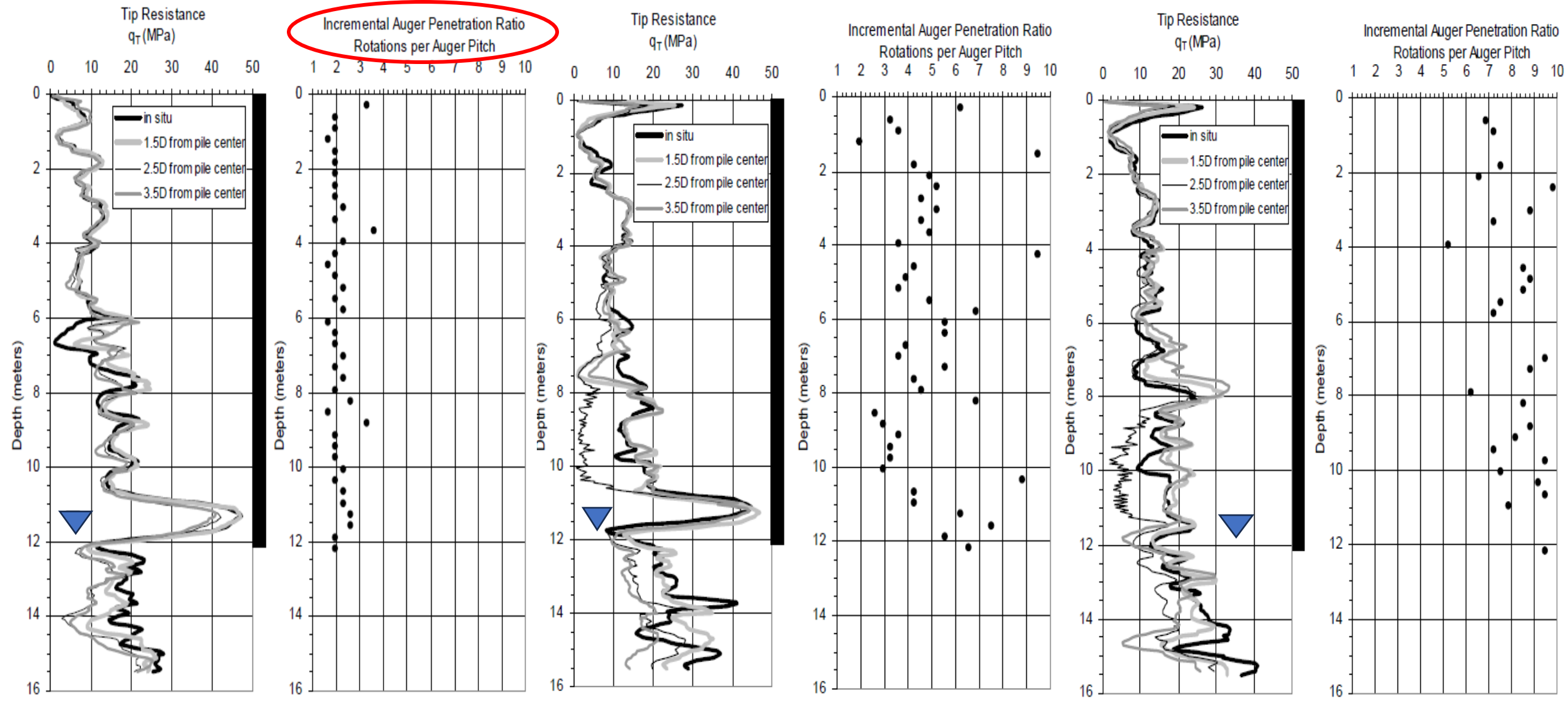
* Overconsolidated or cemented.

The Influence of Auger Rotations on (Dry) Sand

S – 1 (GF=150%)

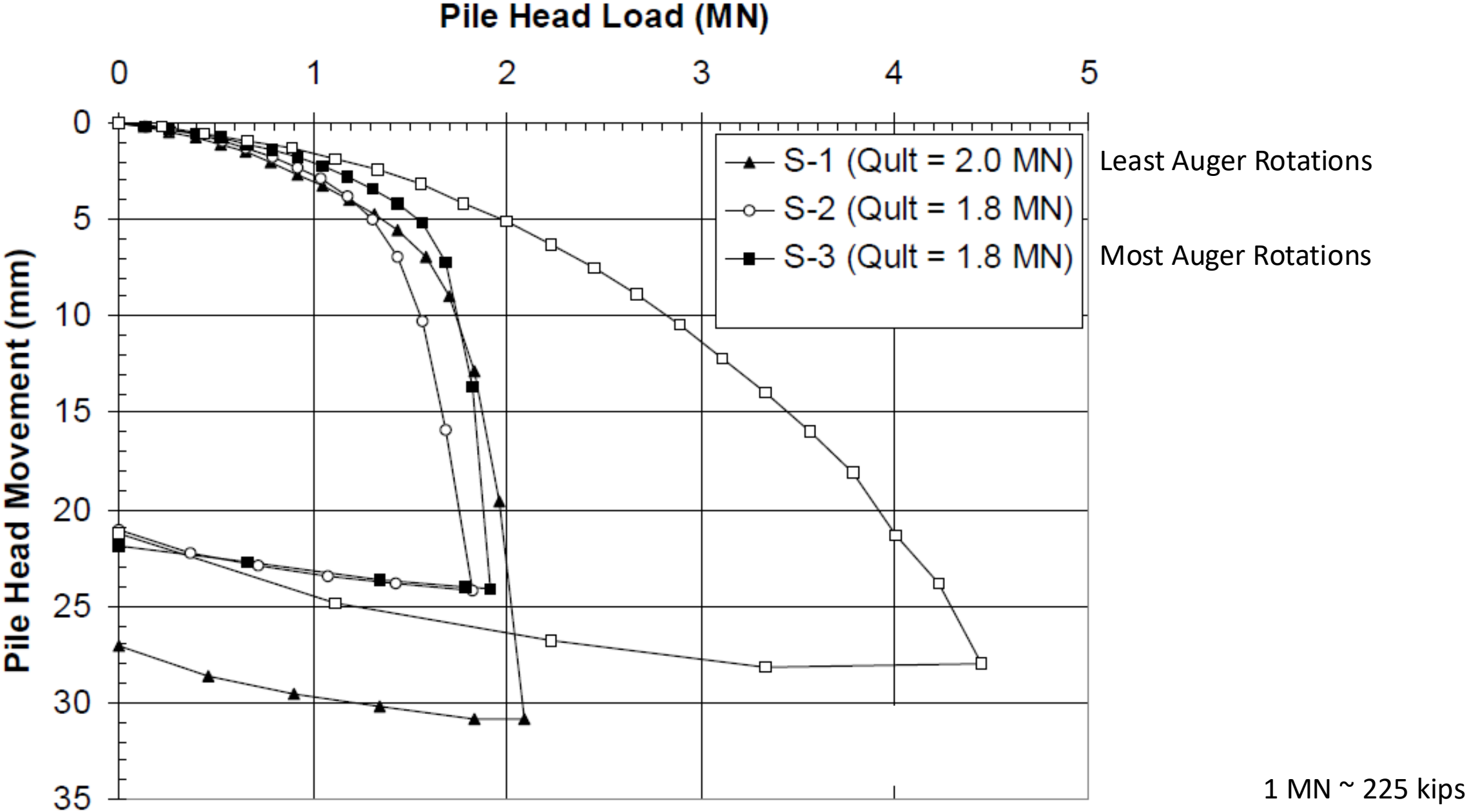
S – 2 (GF=151%)

S – 3 (GF=152%)



1 MPa ~ 10 tsf

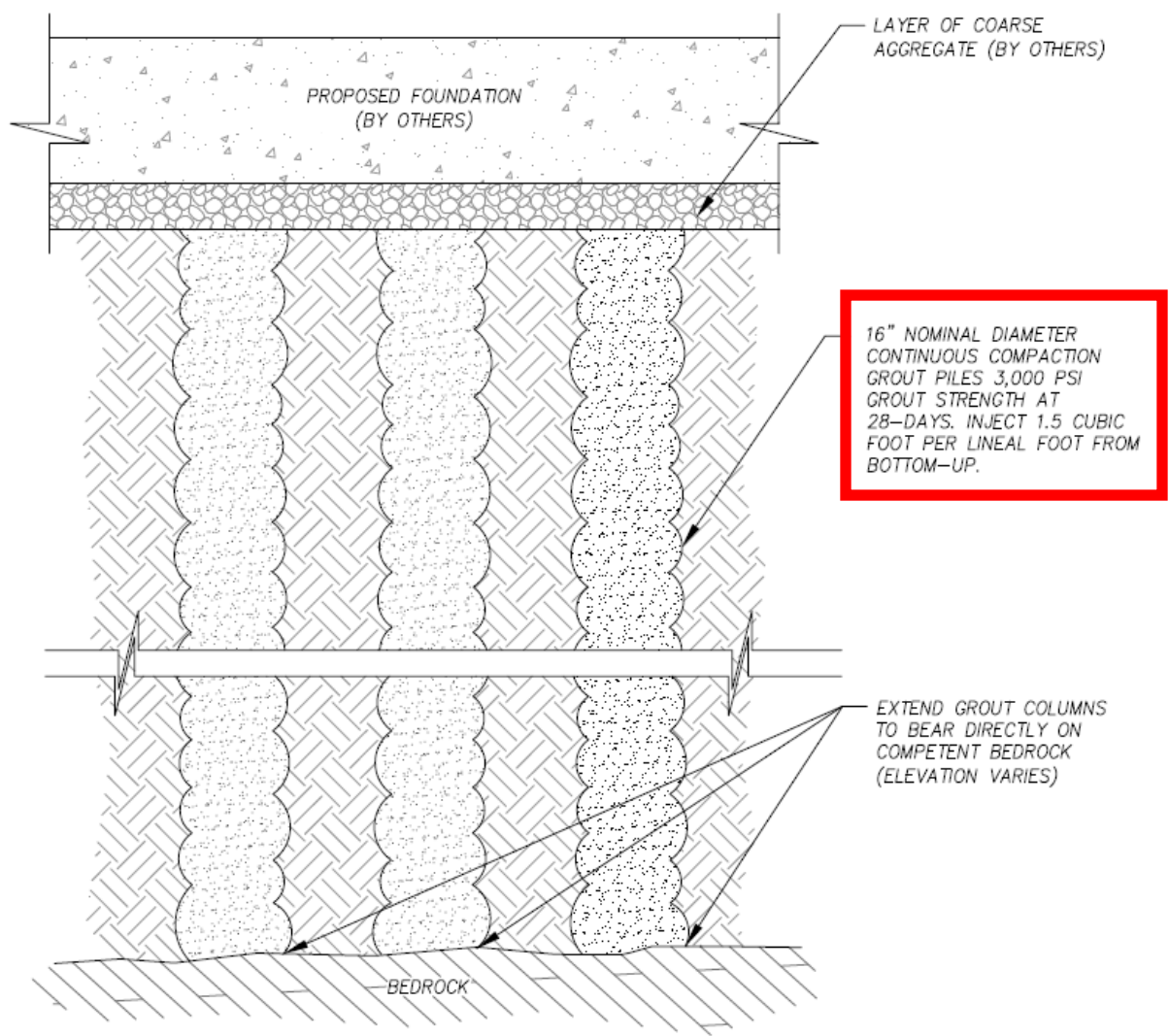
The Influence of Auger Rotations on (Dry) Sand



The Influence of Auger Rotations on (Dry) Sand

We are all susceptible to groupthink - mode of thinking in which individual members of small cohesive groups tend to accept a viewpoint or conclusion that represents a perceived group consensus

Ground Response to Compaction Grouting



Grout Properties

- Low Slump
- Pumpable Mix



Ground Response to Compaction Grouting

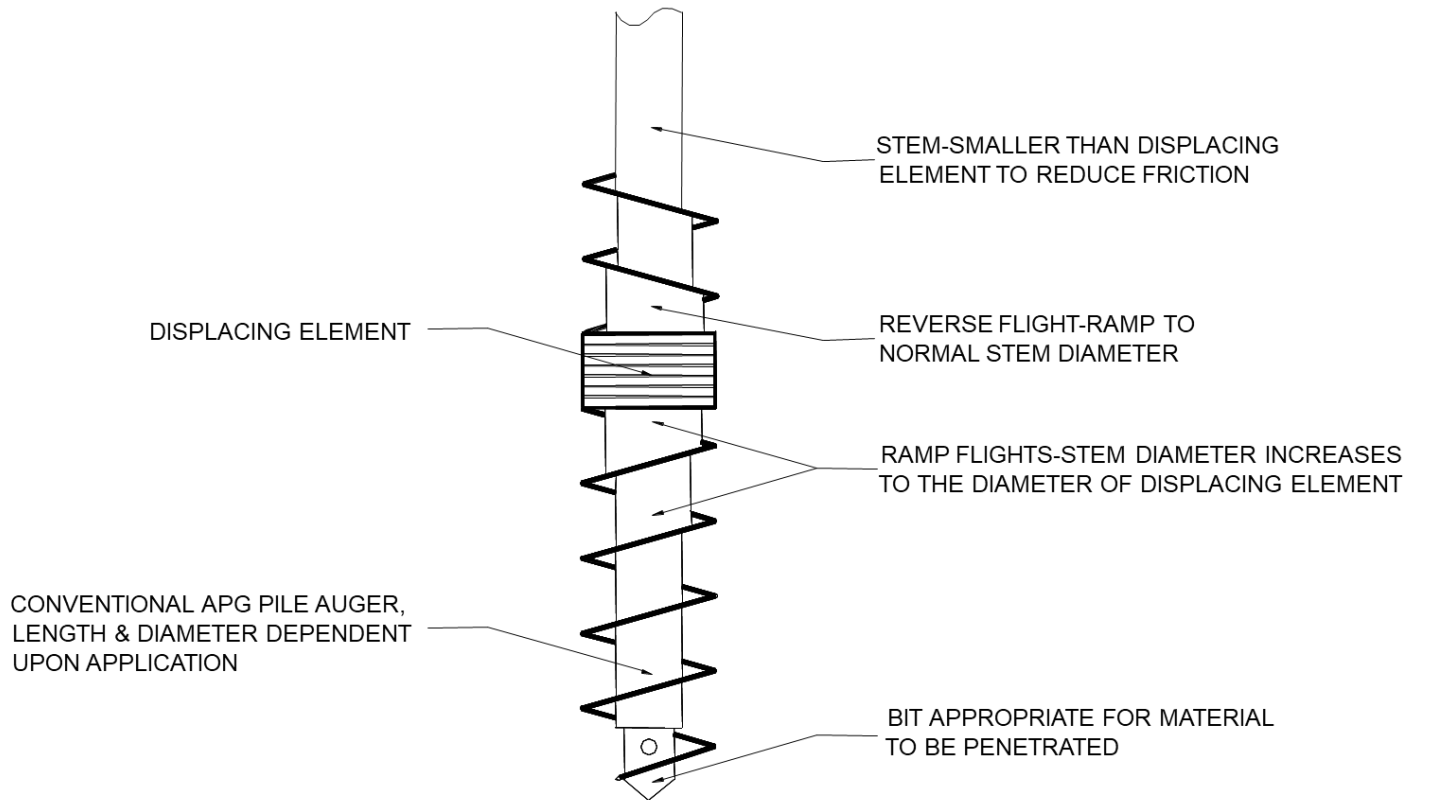
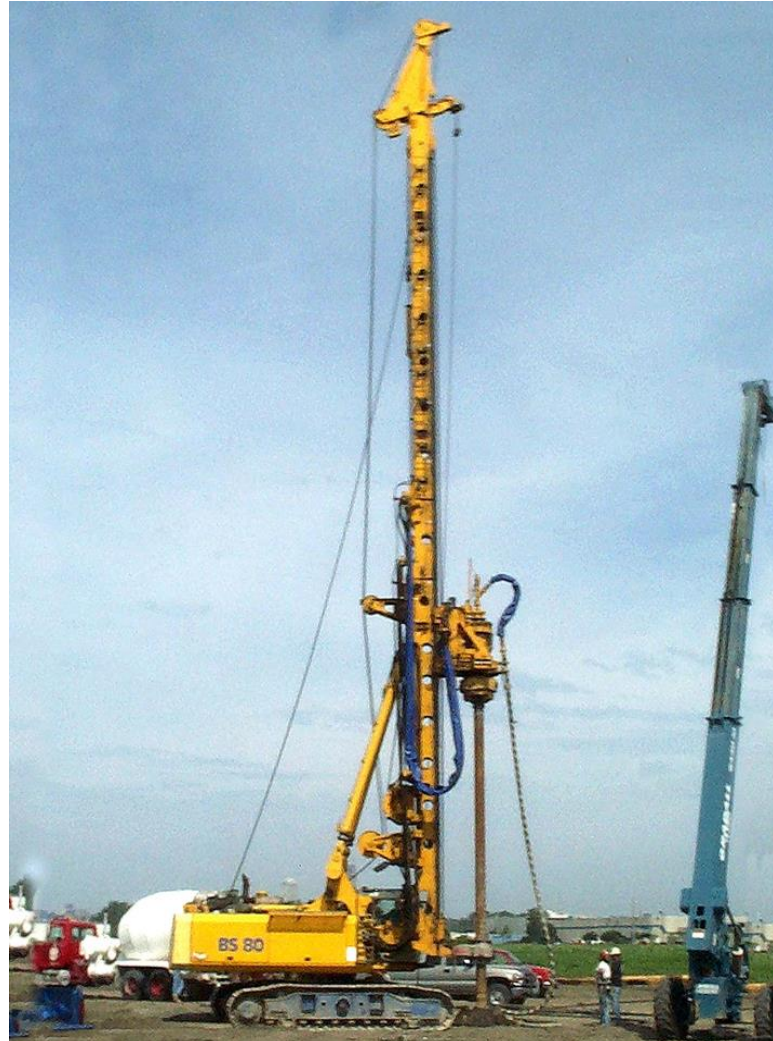


Ground Response to Compaction Grouting



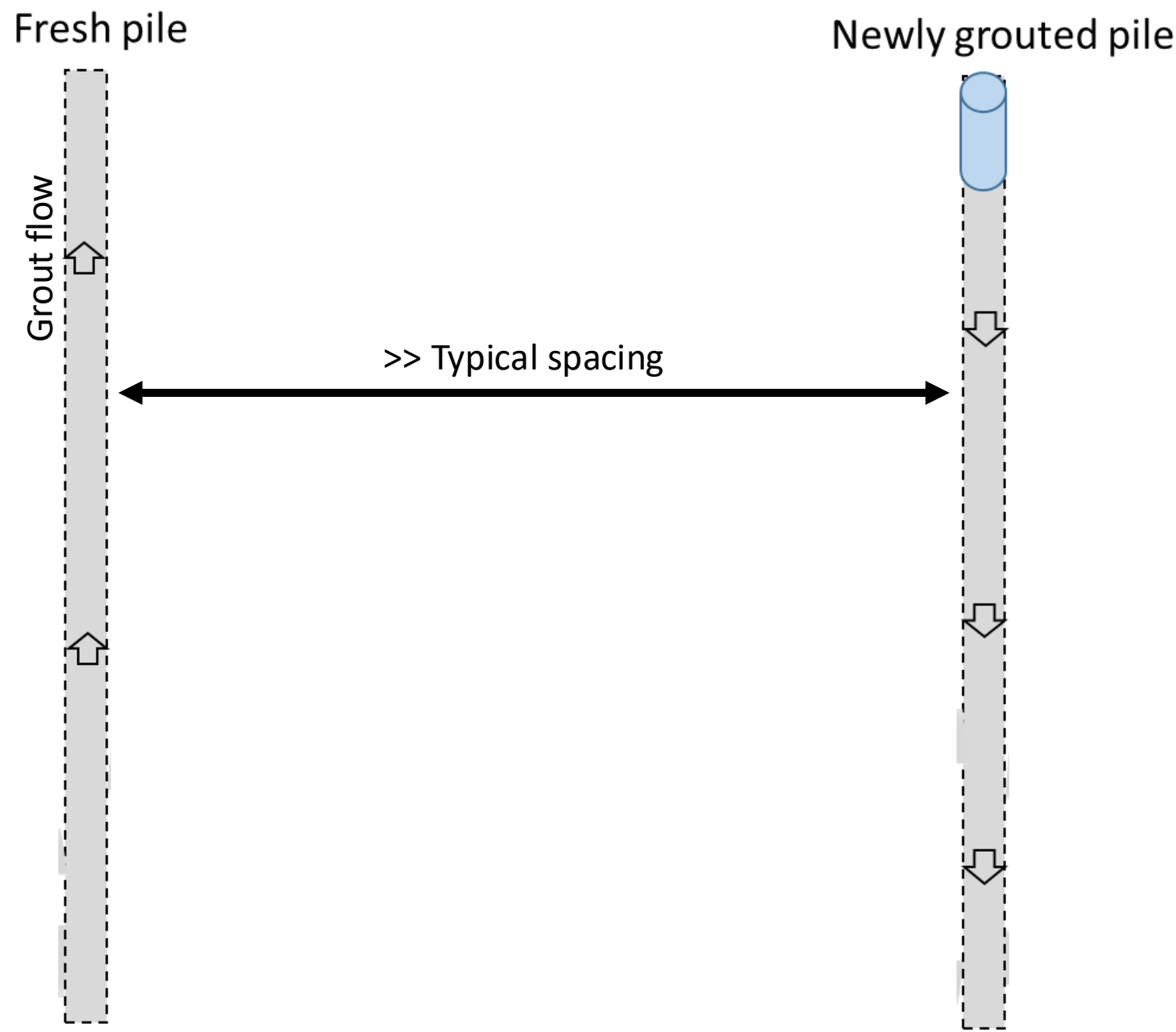
Accept that there are unknown unknowns.

"Brittle" Clay Behavior and Drilled Displacement Piles (Confidential Site)

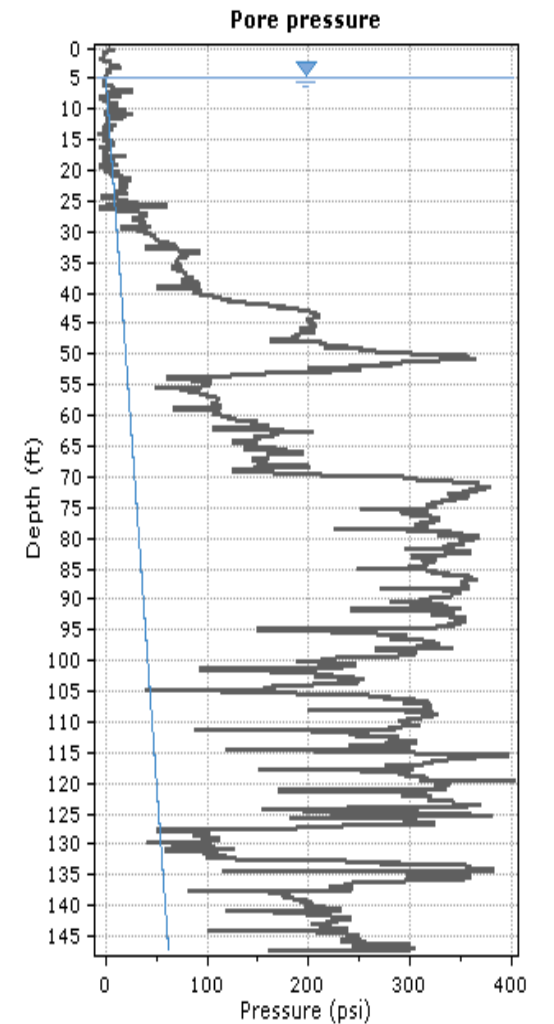
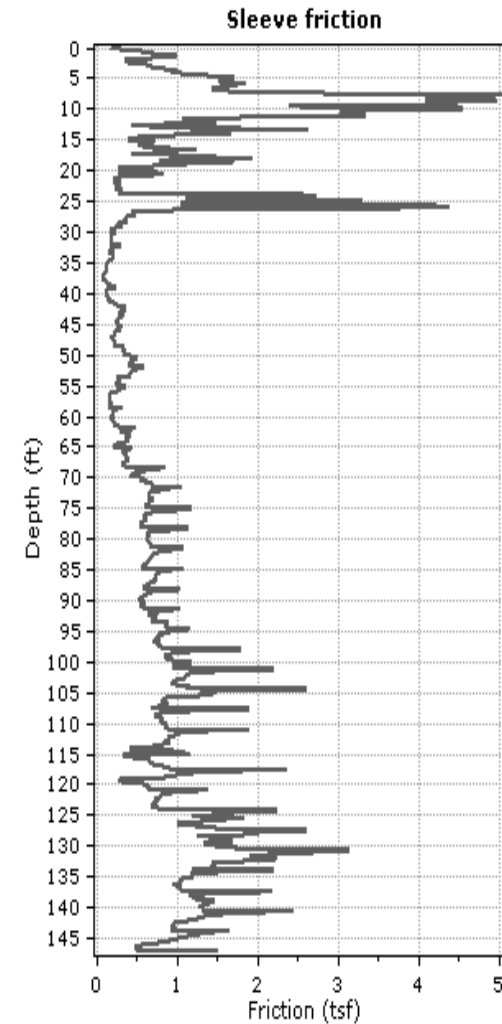
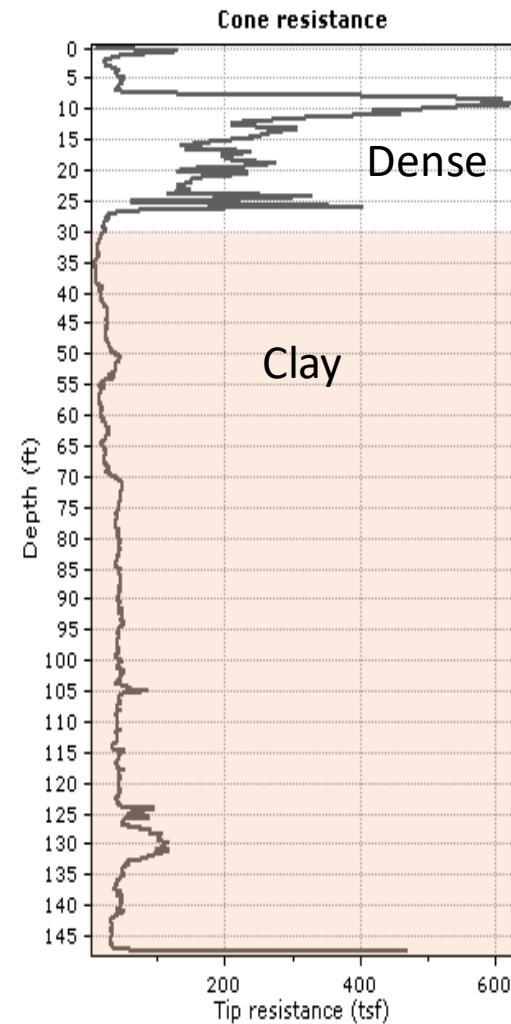


Displacement tooling (Berkel)

“Brittle” Clay Behavior and Drilled Displacement Piles (Confidential Site)

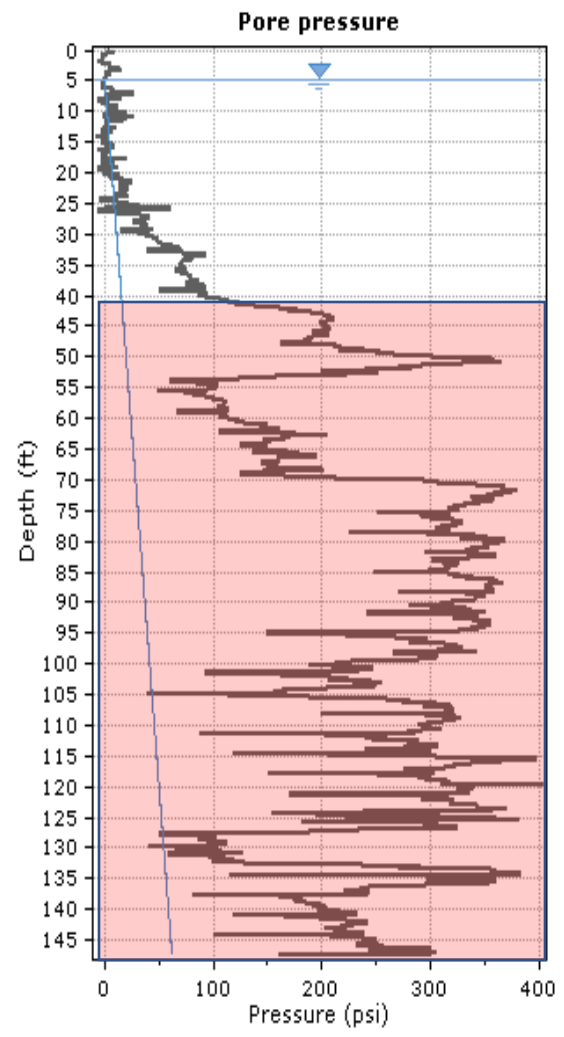


"Brittle" Clay Behavior and Drilled Displacement Piles (Confidential Site)



“Brittle” Clay Behavior and Drilled Displacement Piles (Confidential Site)

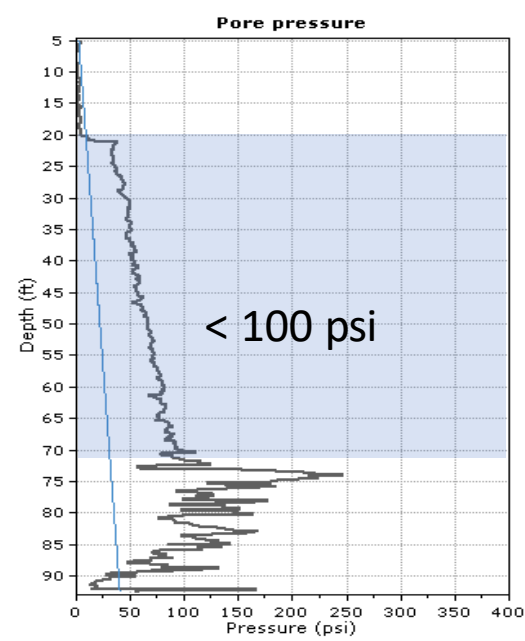
Subject site



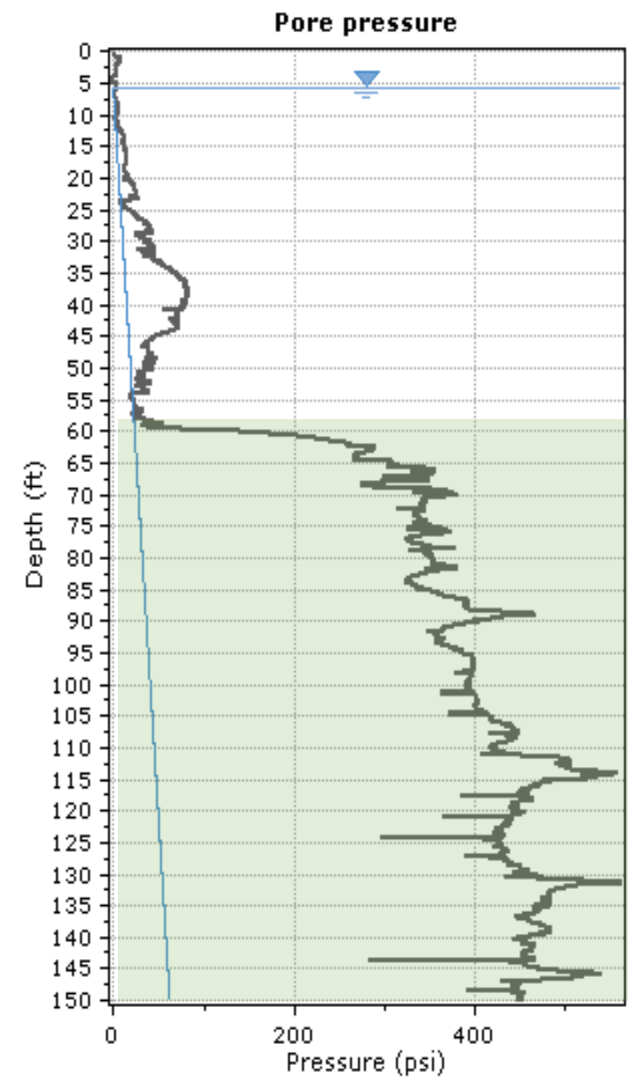
For comparison



Young Bay Mud

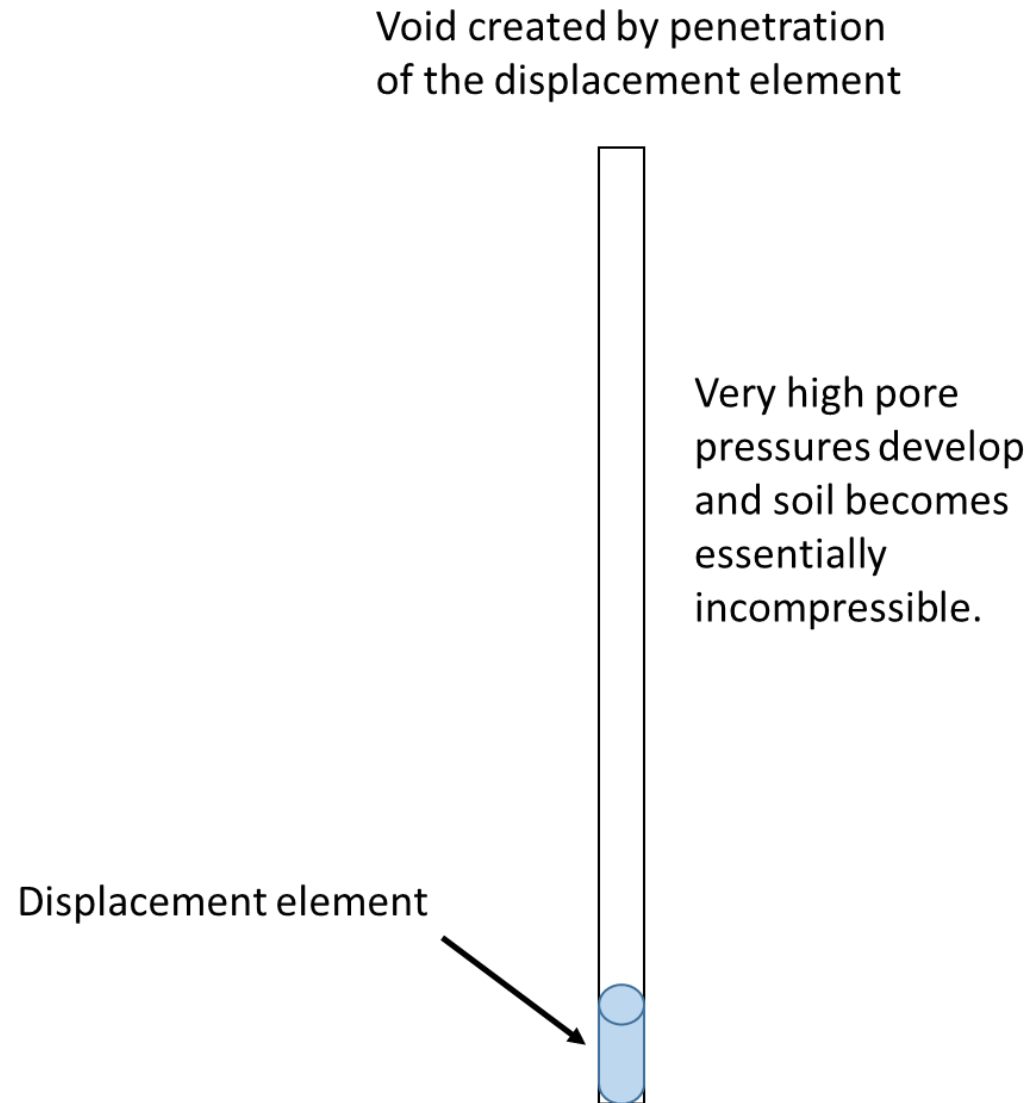


Cooper Marl

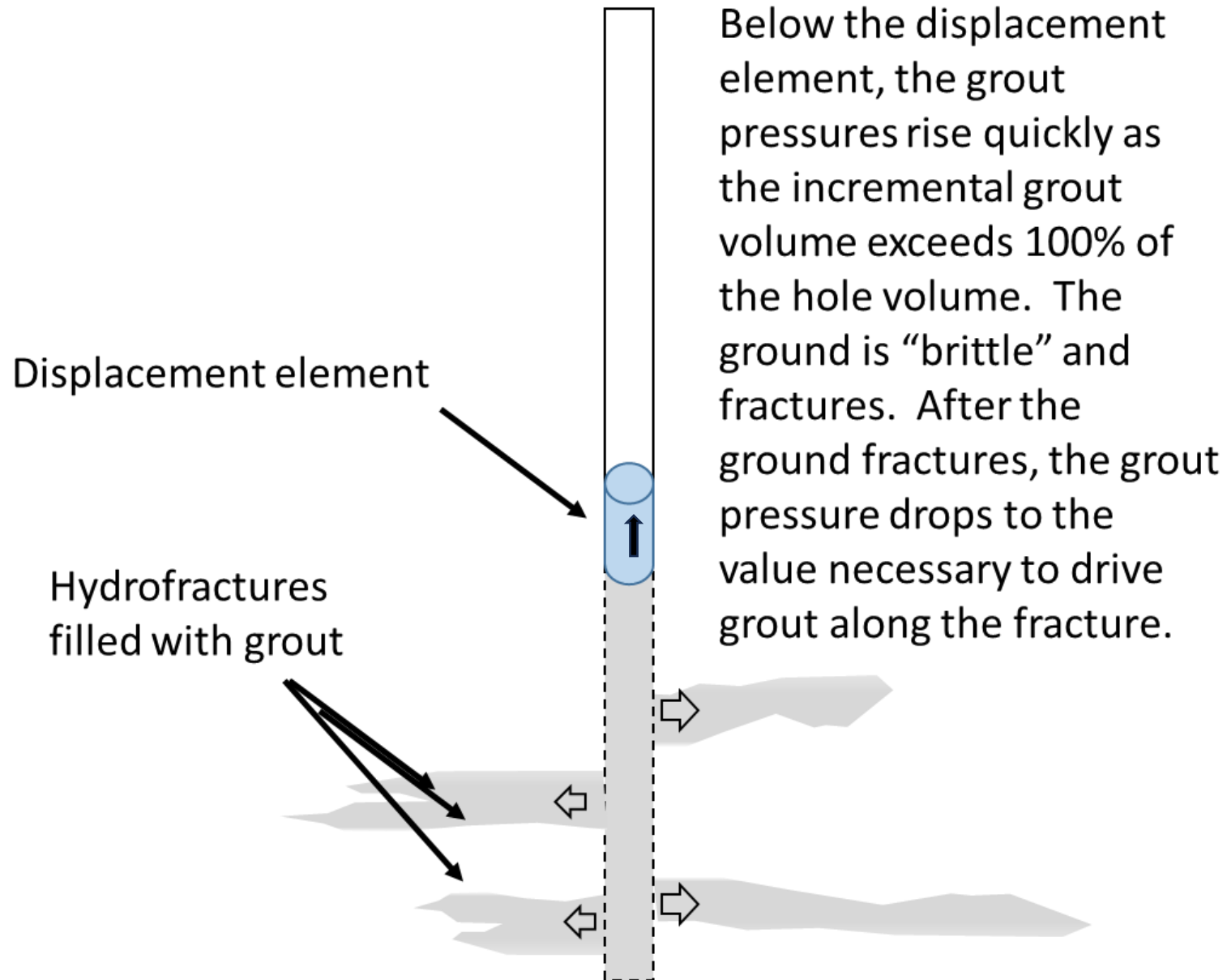


Cooper Marl data courtesy of Greg Canivan S&ME, Inc.

“Brittle” Clay Behavior and Drilled Displacement Piles (Confidential Site)



“Brittle” Clay Behavior and Drilled Displacement Piles



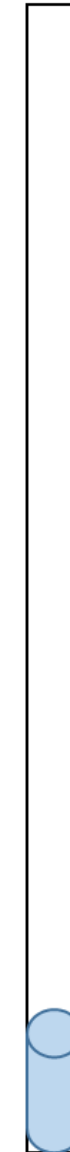
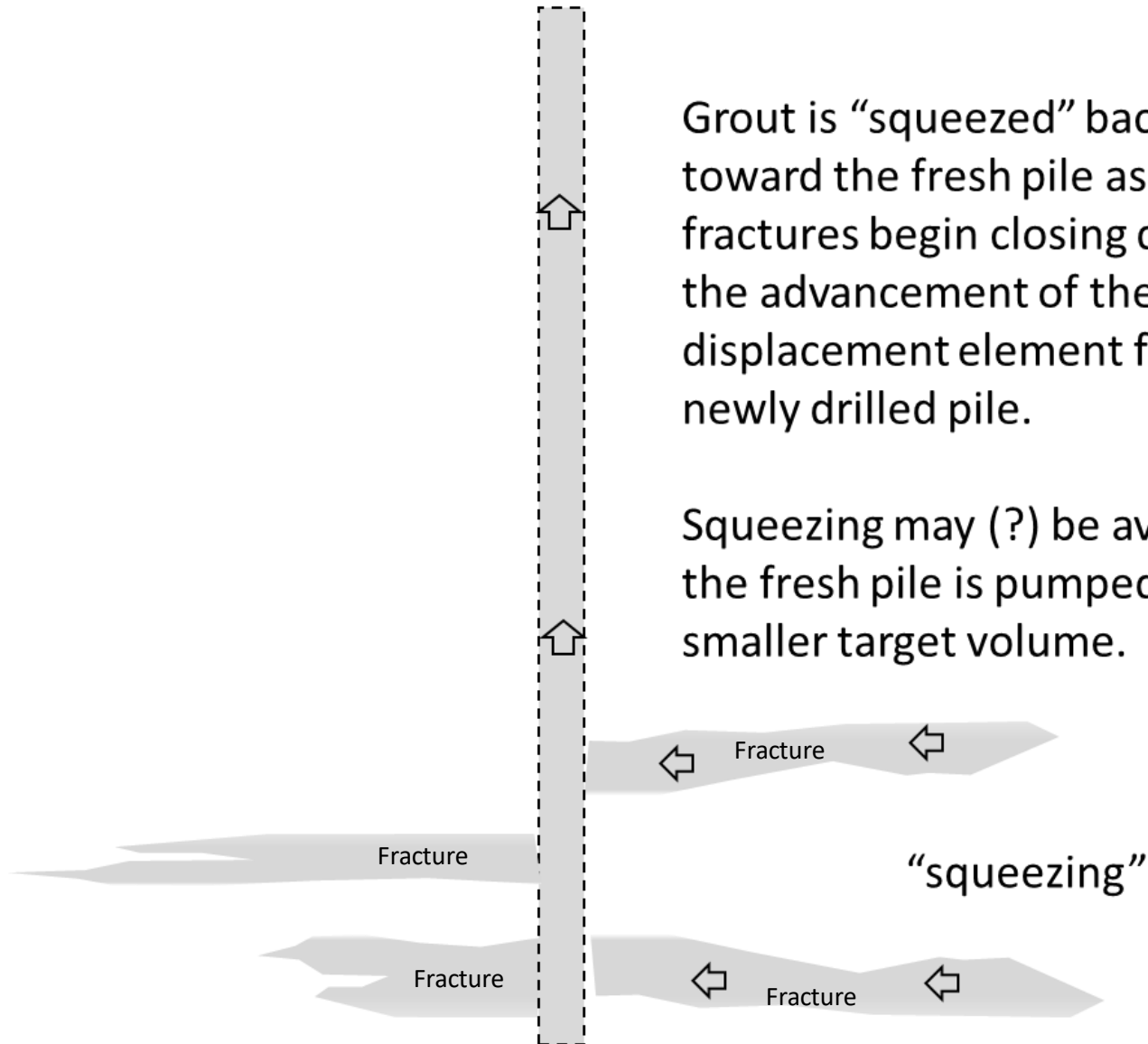
“Brittle” Clay Behavior and Drilled Displacement Piles

Fresh pile

Newly “drilled” pile

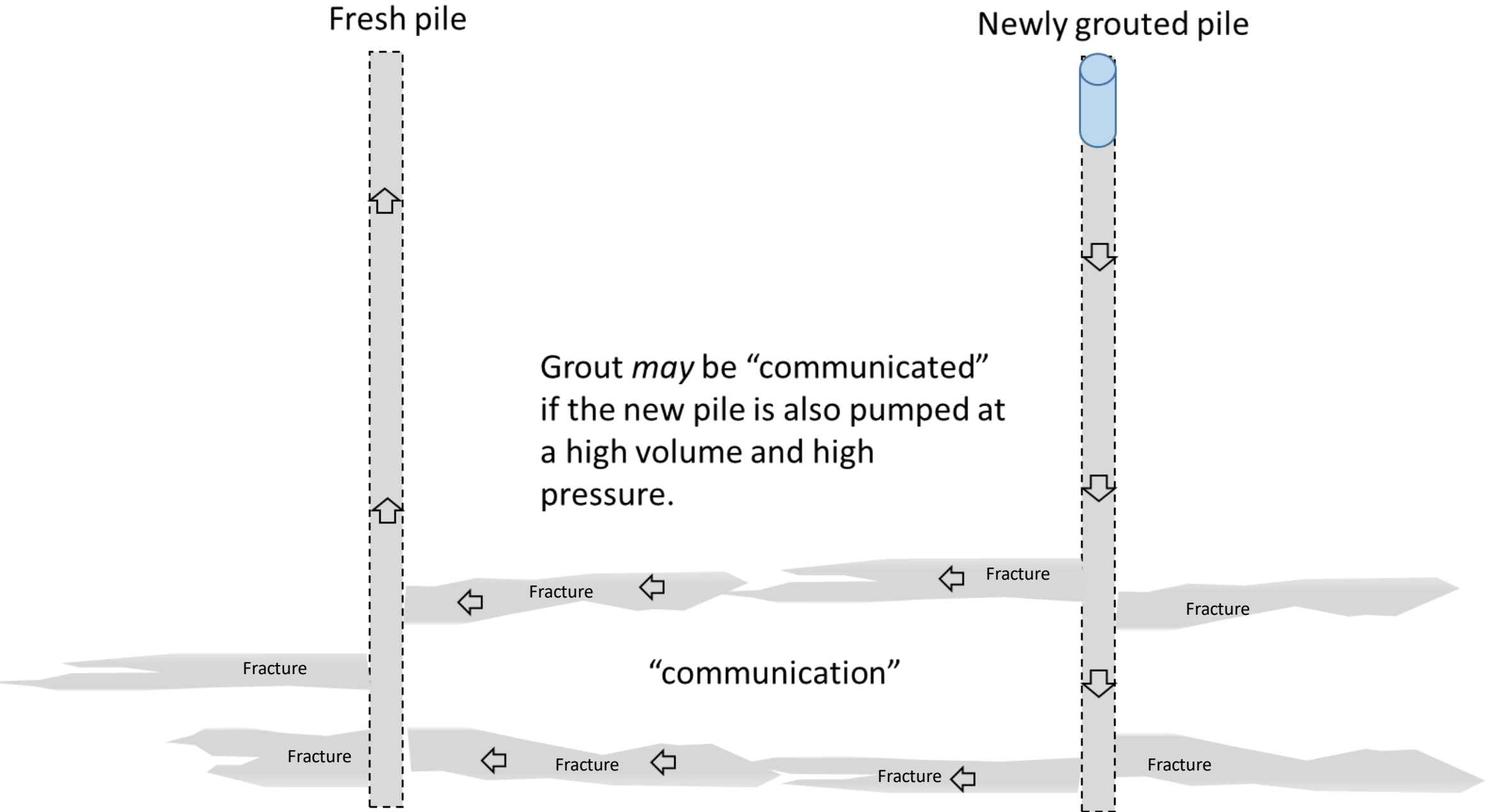
Grout is “squeezed” back toward the fresh pile as the fractures begin closing due to the advancement of the displacement element for a newly drilled pile.

Squeezing may (?) be avoided if the fresh pile is pumped at a smaller target volume.



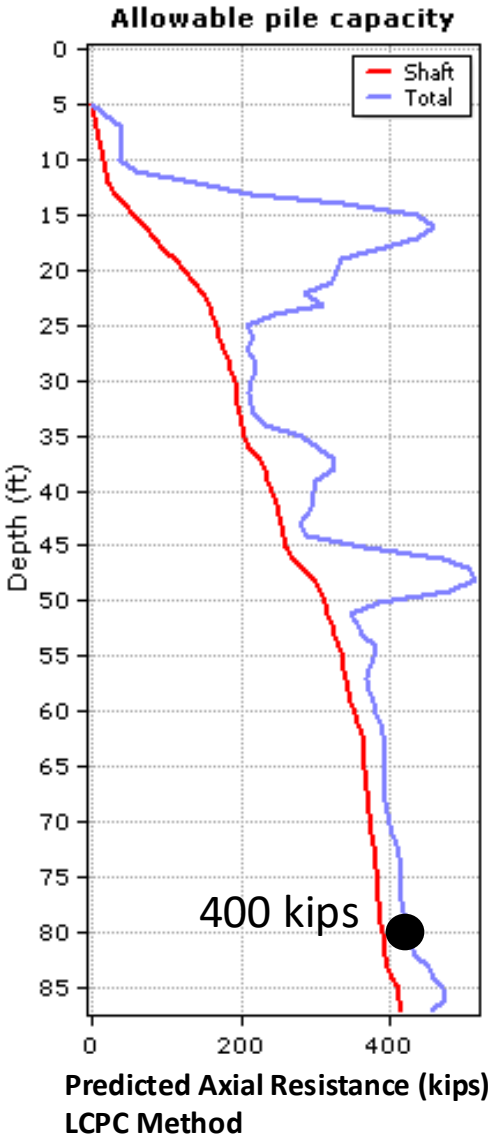
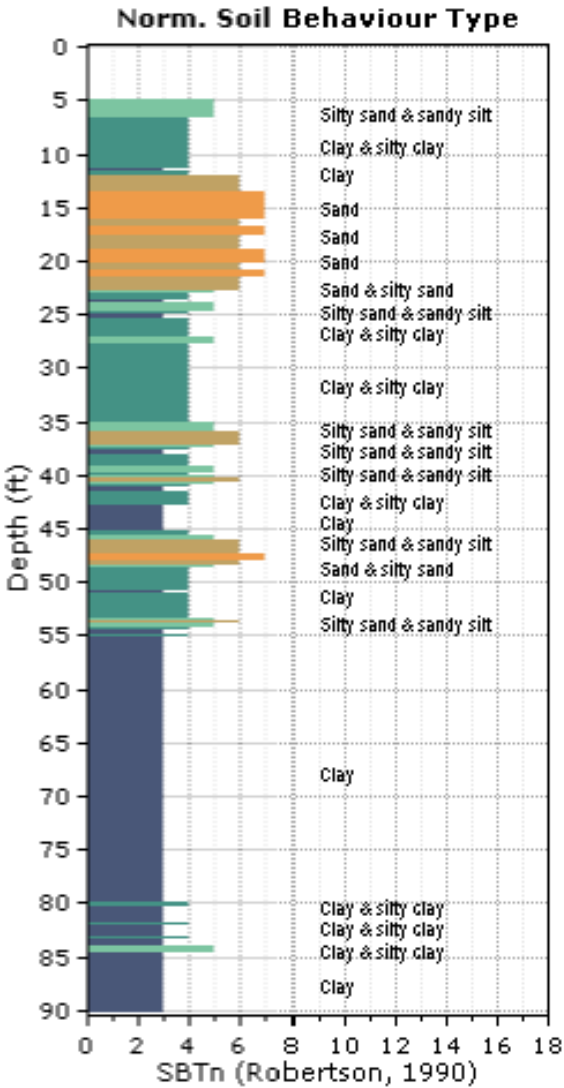
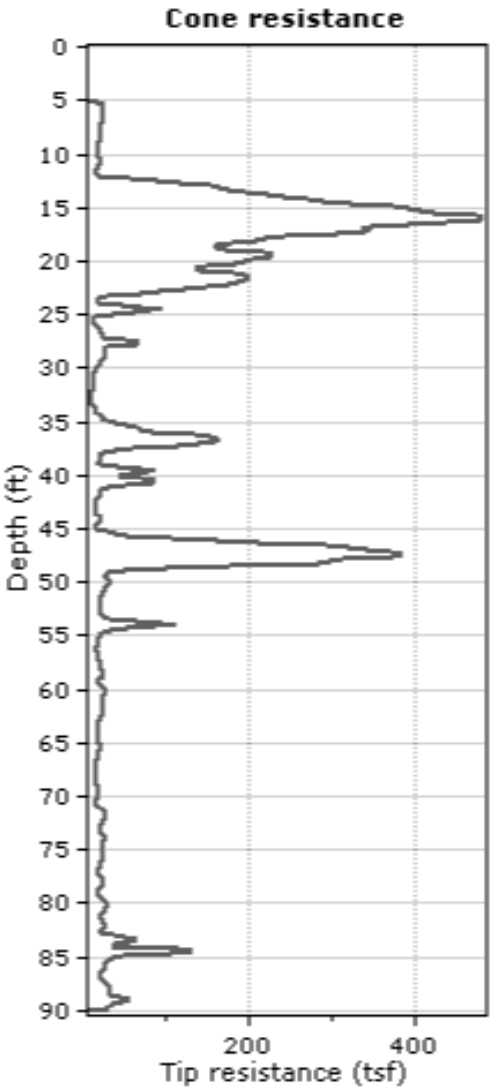
Displacement element

“Brittle” Clay Behavior and Drilled Displacement Piles



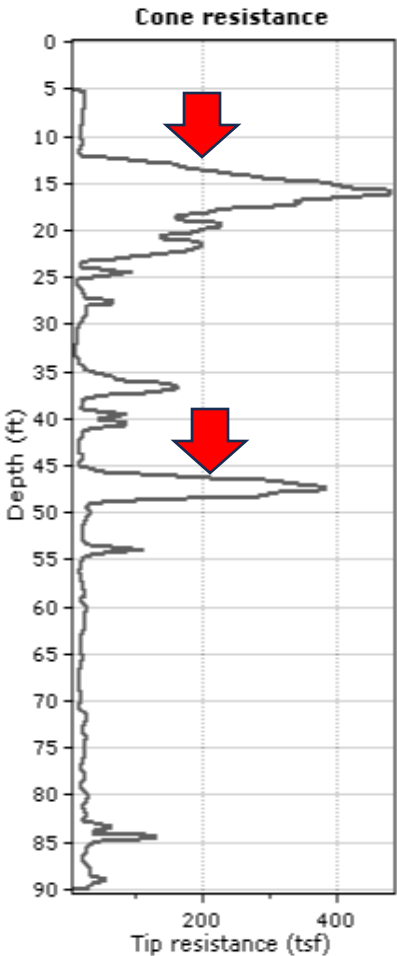
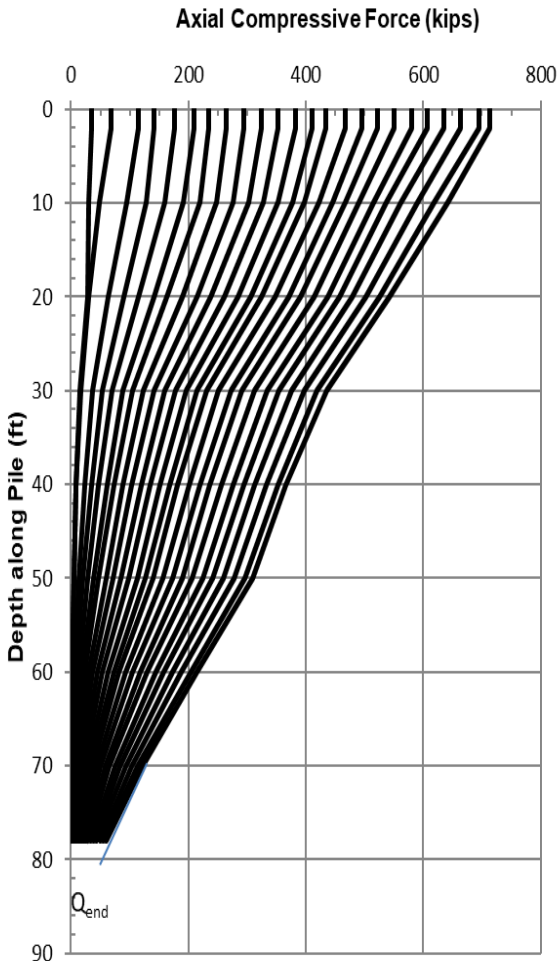
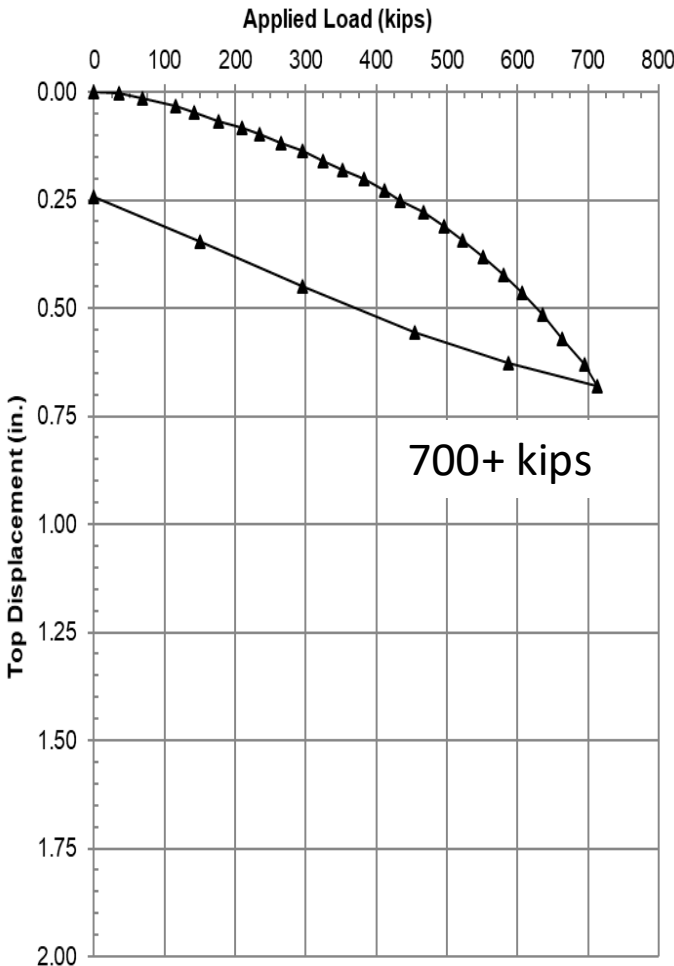
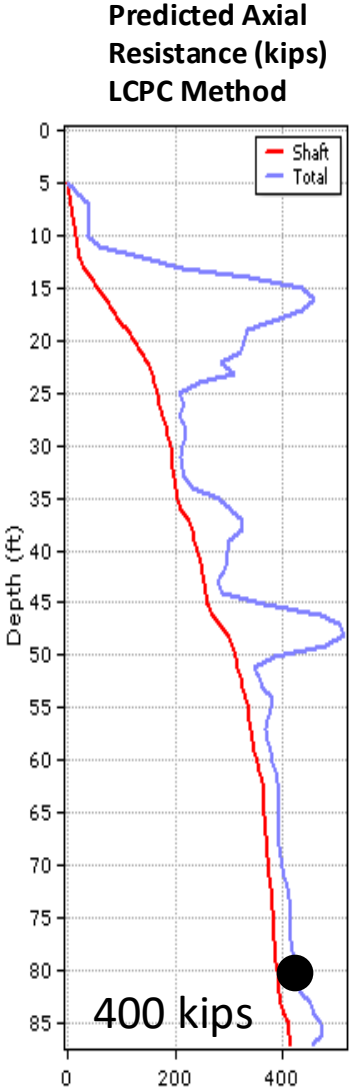
What is good in most circumstances may not good in all circumstances

Effect of Discrete Layering



Effect of Discrete Layering

16" Omega Pile



Limitations exist in every analysis.

Ground Response to Retesting CFA Piles

Recently placed pile
under zero top load

First load test

Unloaded pile

Reloaded pile

Timeline

@ 1 to 2 weeks

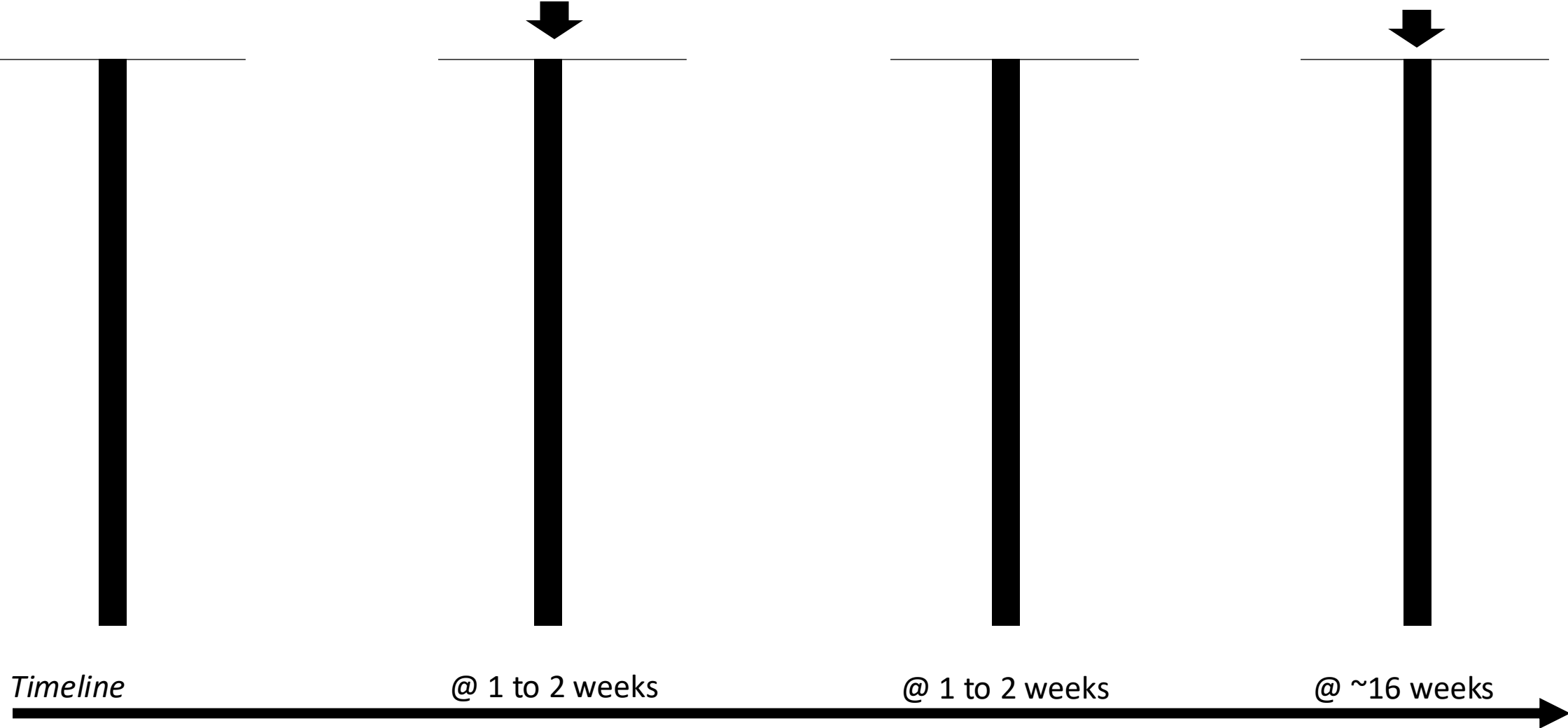
@ 1 to 2 weeks

@ ~16 weeks

Install

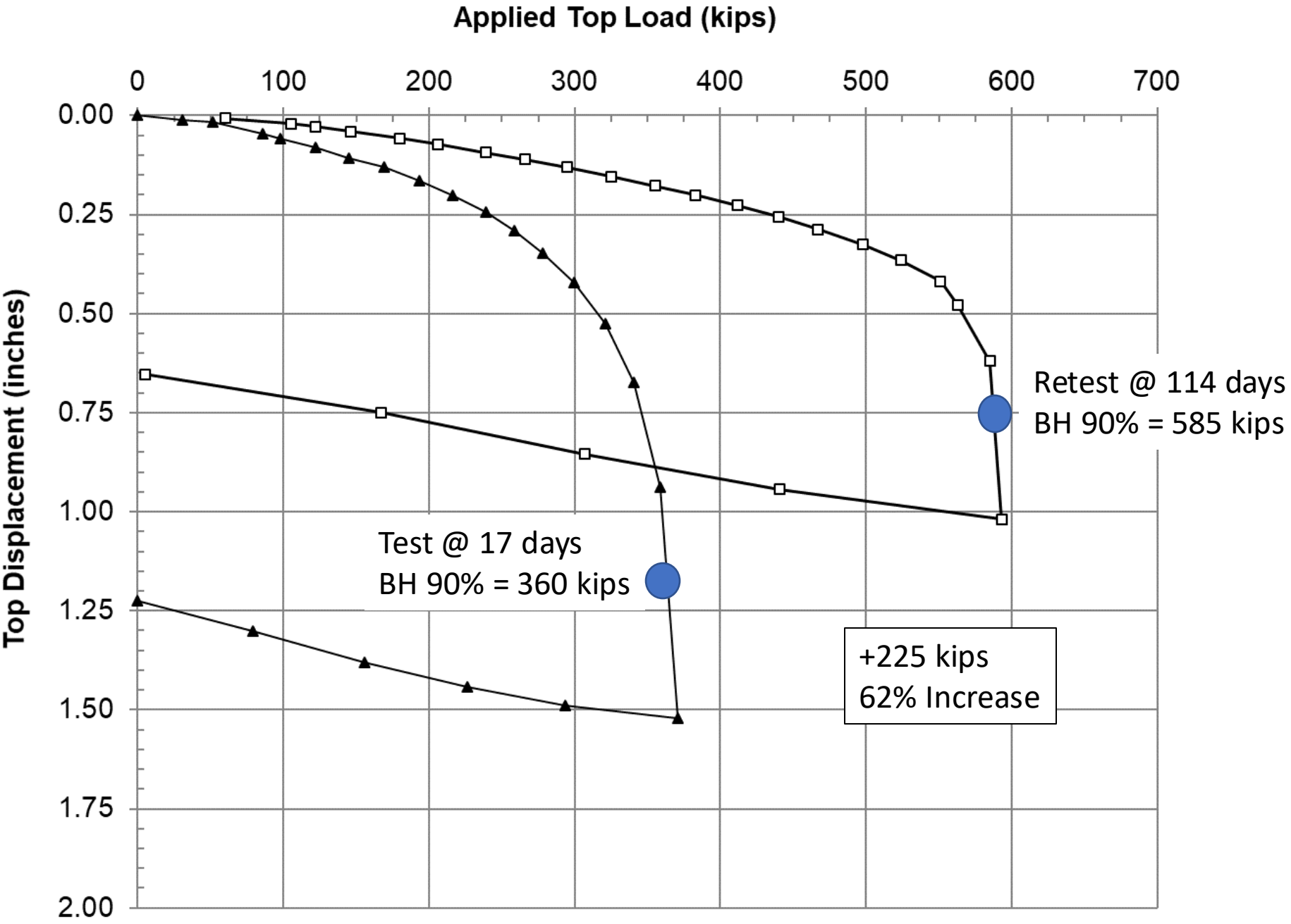
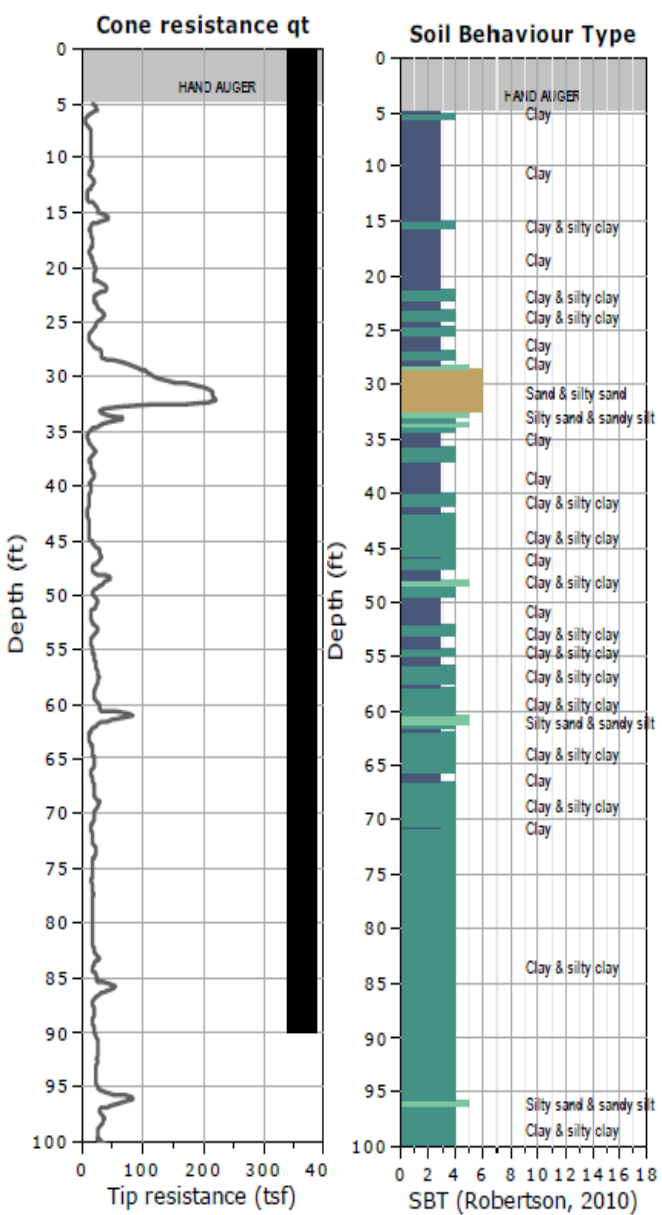
Top down test per ASTM D1143
Quick Method in a typical timeframe

Unloaded at the end
of the top down test.



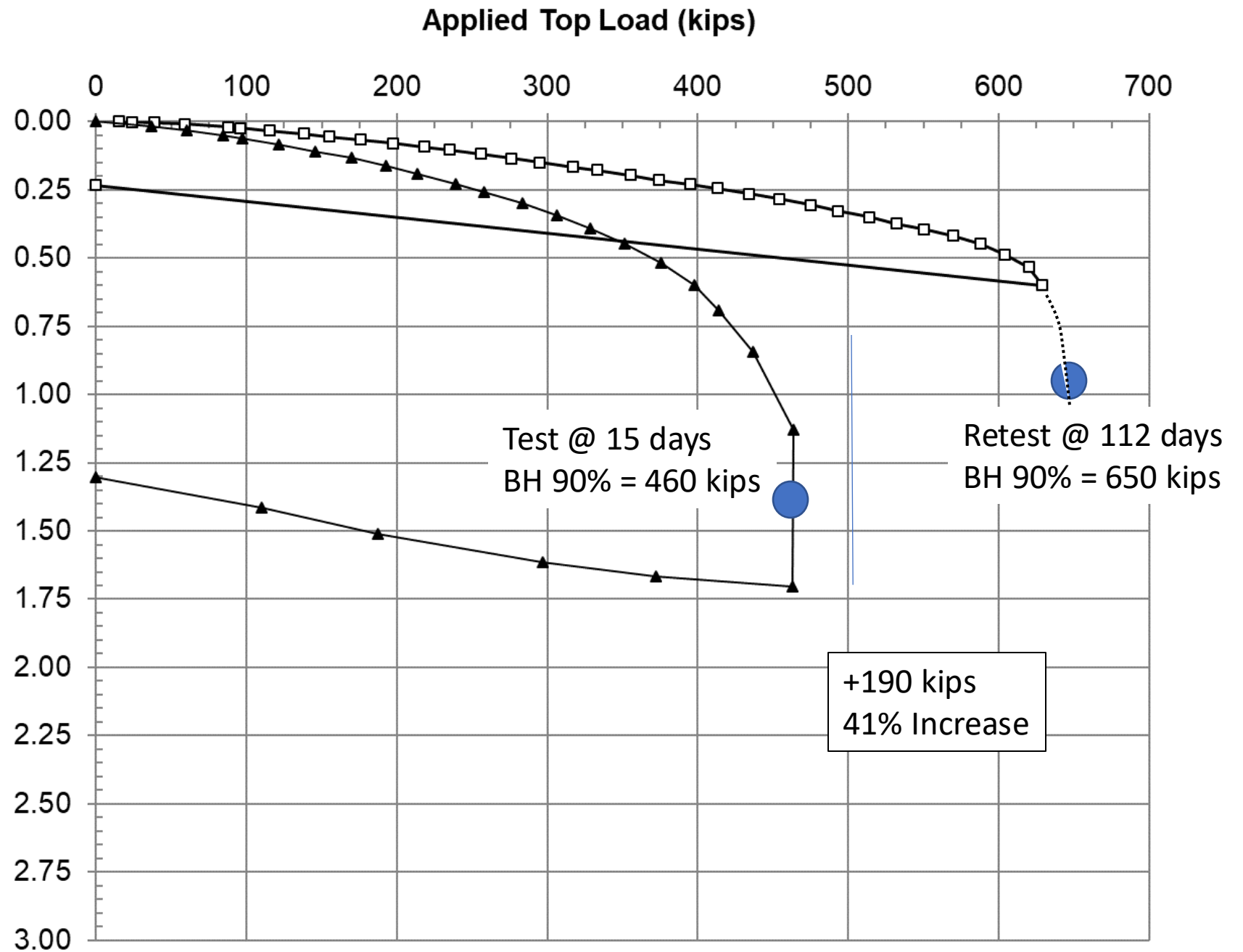
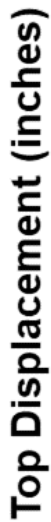
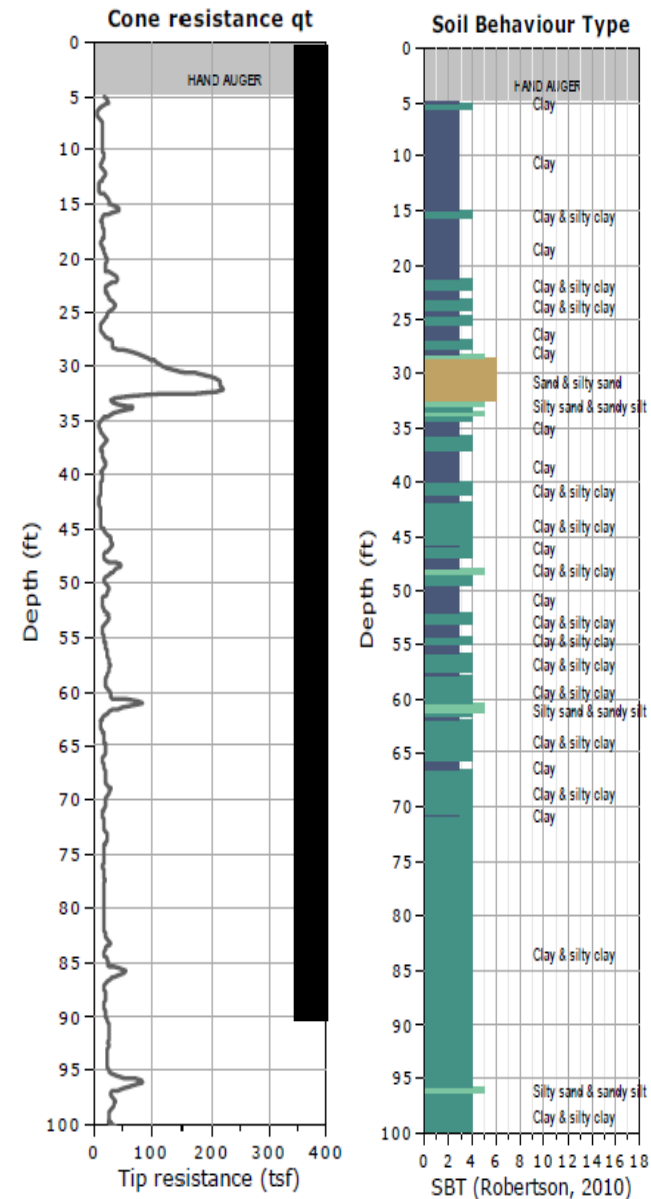
Retesting CFA Piles

16-inch CFA Pile



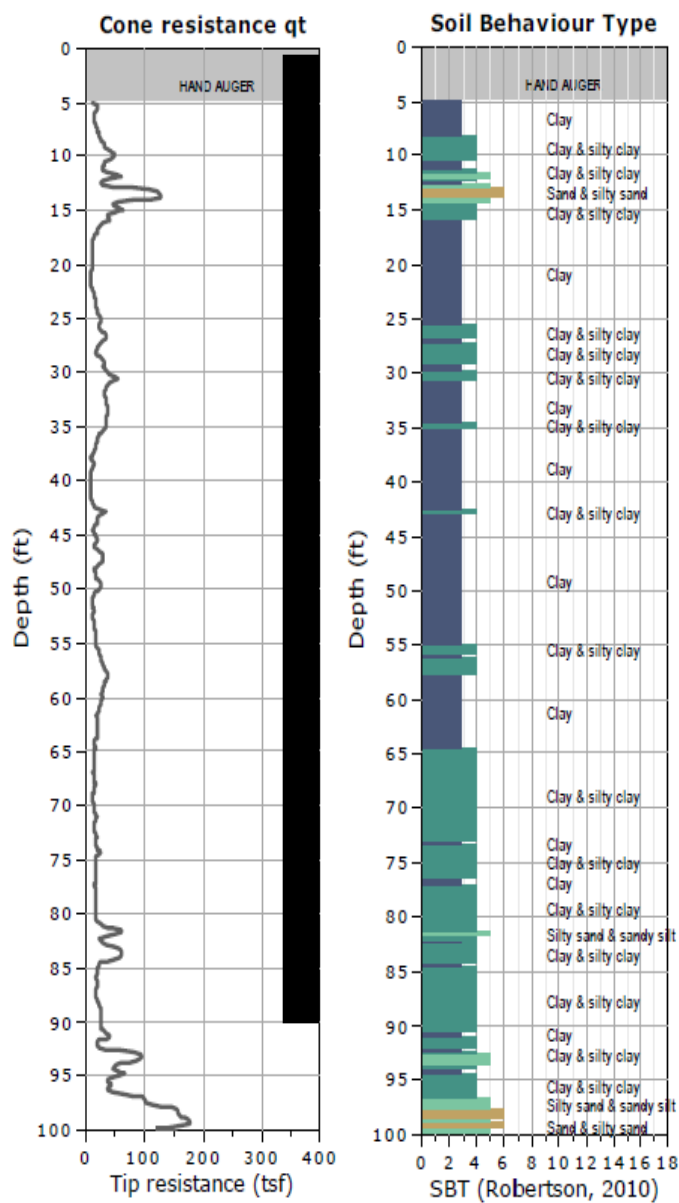
Retesting CFA Piles

16-inch CFA Pile

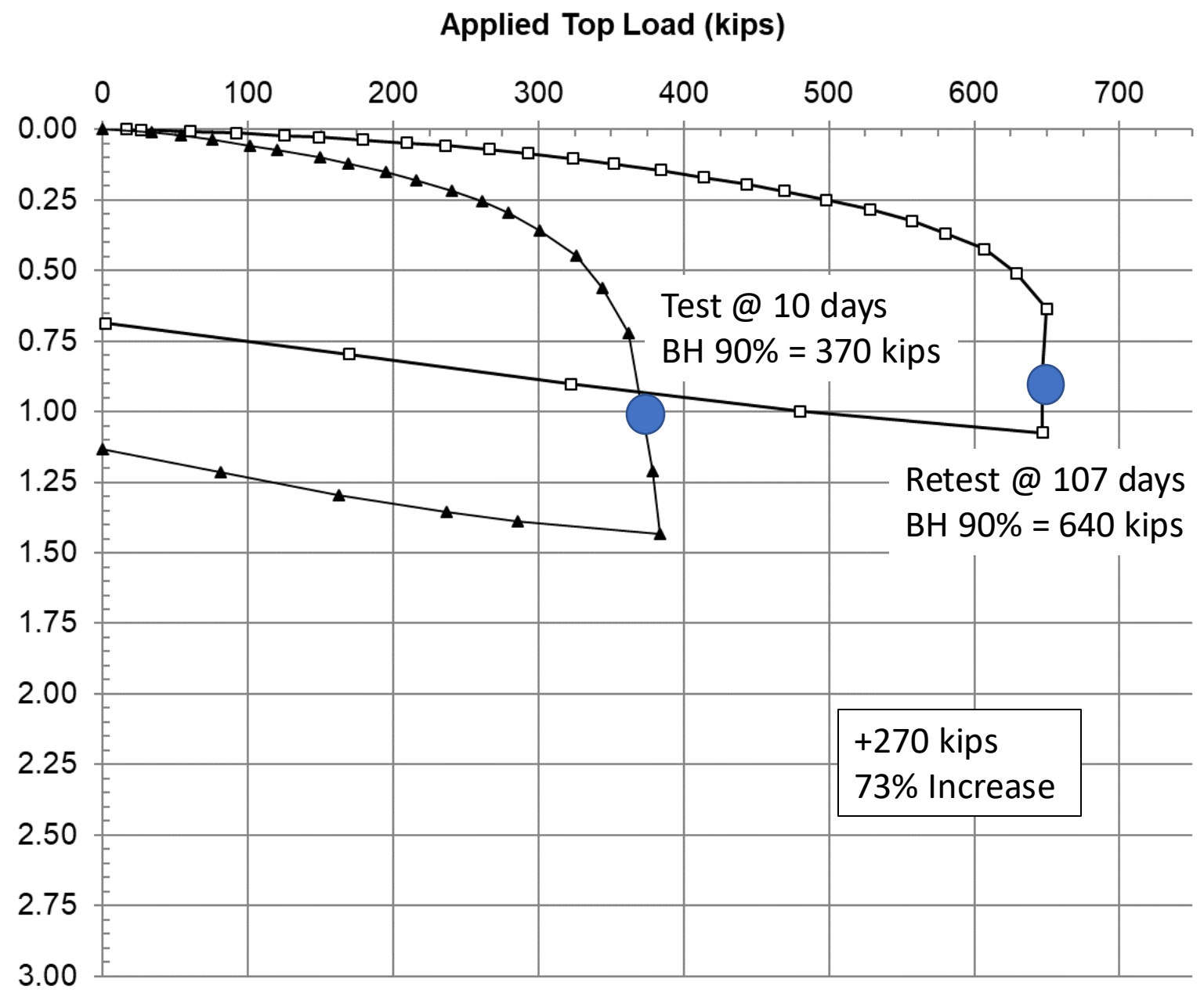


Retesting CFA Piles

16-inch CFA Pile

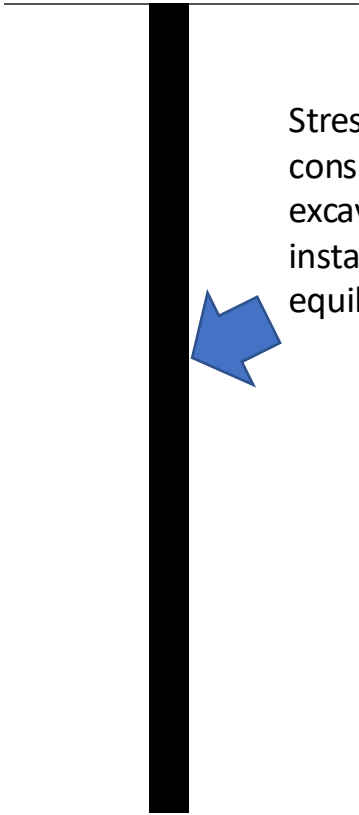


Top Displacement (inches)



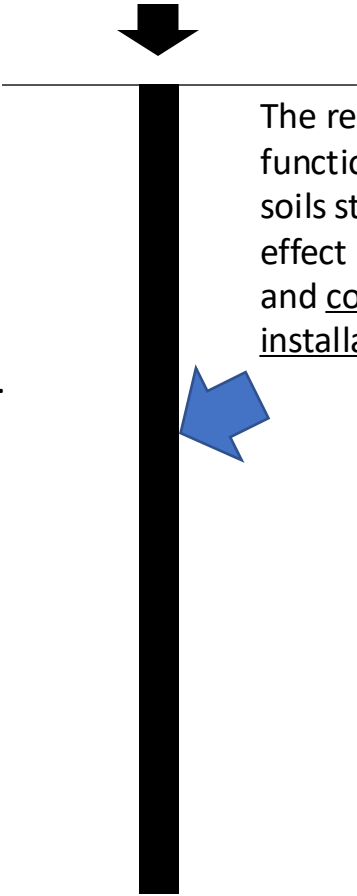
Ground Response to Retesting CFA Piles

Recently placed pile
under zero top load



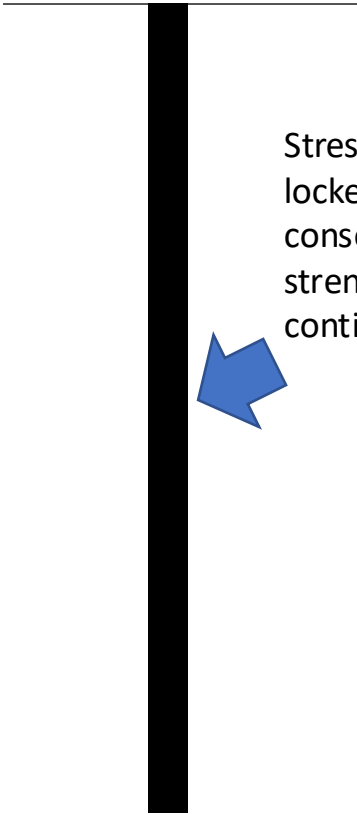
Stress changes and consolidation due to excavation and pile installation. Reaching equilibrium takes time.

First load test



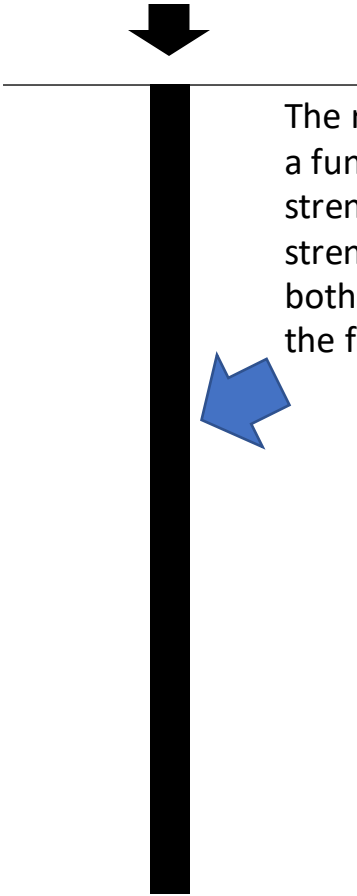
The resistances are a function of the in situ soils strength plus the effect of stress changes and consolidation from installation.

Unloaded pile



Stresses remain locked in pile and consolidation and strength gain continue.

Reloaded pile



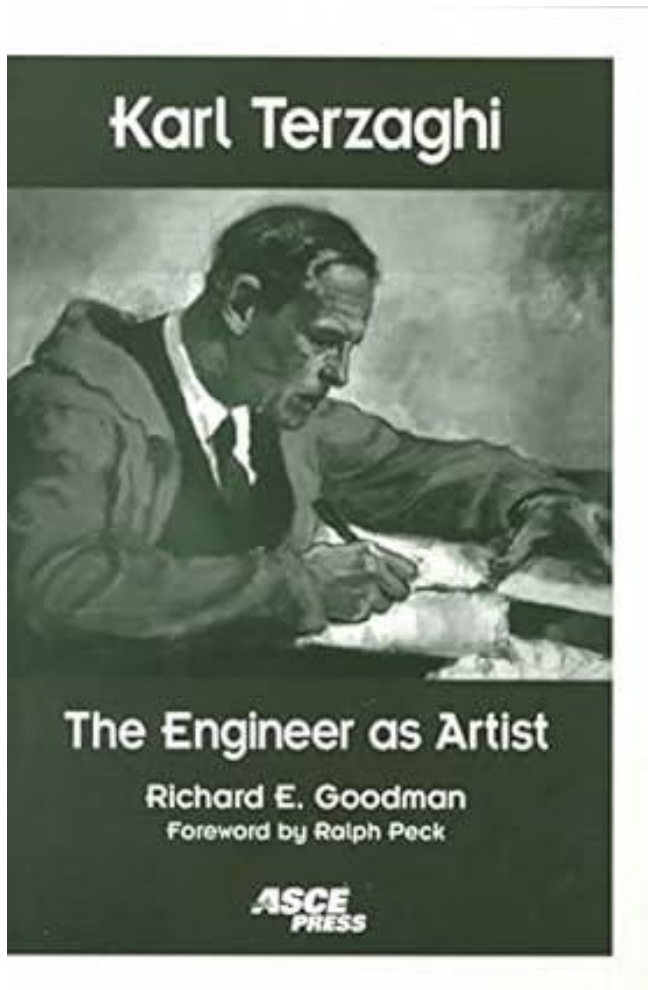
The resistances are a function of in situ strength plus strength gain from both installation and the first load test.

Ground Response to Retesting CFA Piles

*Even for things that we historically think are “**black or white**” – like pile resistance – may not be so.*

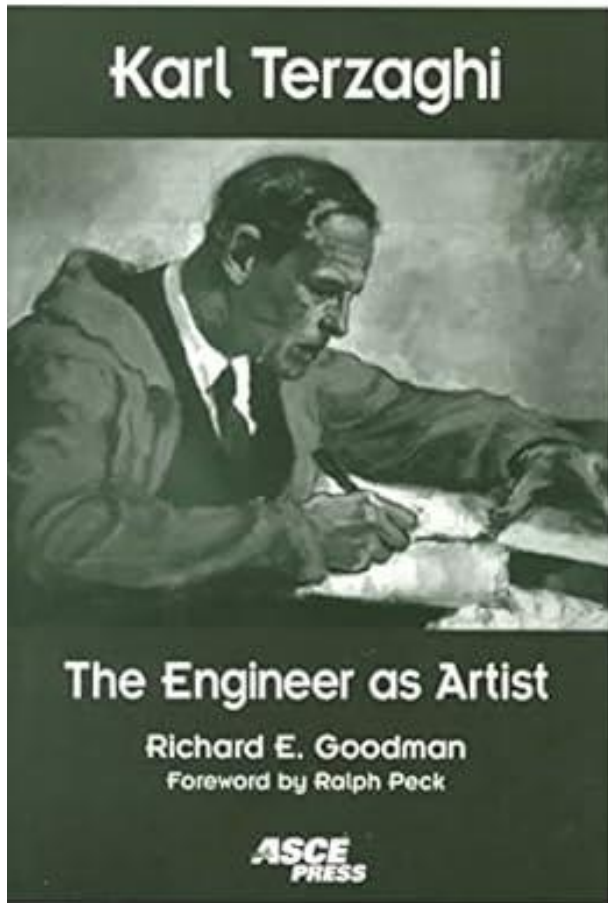
“It is wrong to faithfully apply the Rules without considering whether the results are correct”

—from Karl Terzaghi: The Engineer as Artist.



“It is wrong to faithfully apply the Rules without considering whether the results are correct”

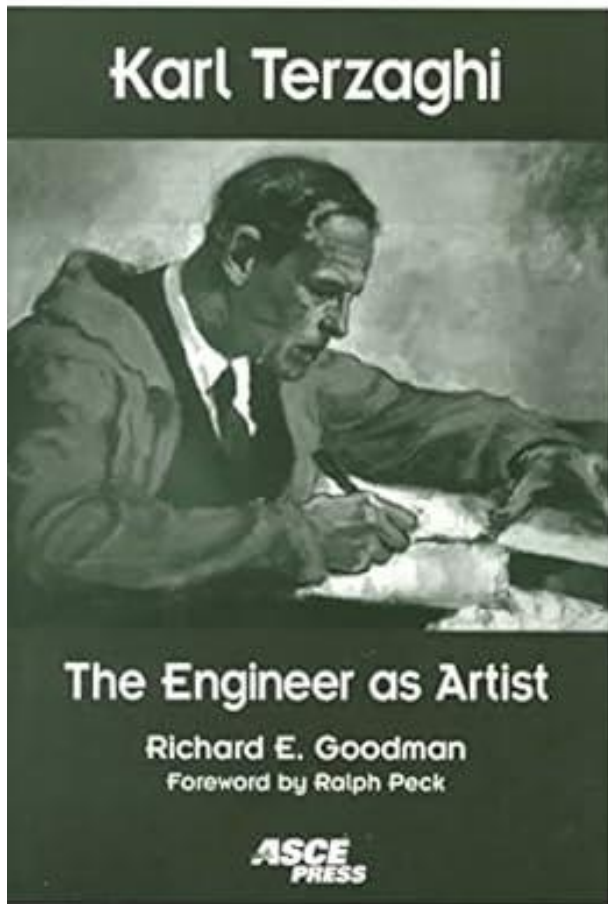
—from Karl Terzaghi: The Engineer as Artist.



- The Rules are not synonymous with ground behavior.

“It is wrong to faithfully apply the Rules without considering whether the results are correct”

—from Karl Terzaghi: The Engineer as Artist.



- The Rules are not synonymous with ground behavior.
- “Artists” recognize the Rules and their limitations. They
..... do not apply the Rules blindly and
.....do embrace actual ground behavior when it conflicts with the Rules.

