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

GRIP 2018

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Civil & Environmental Engineering

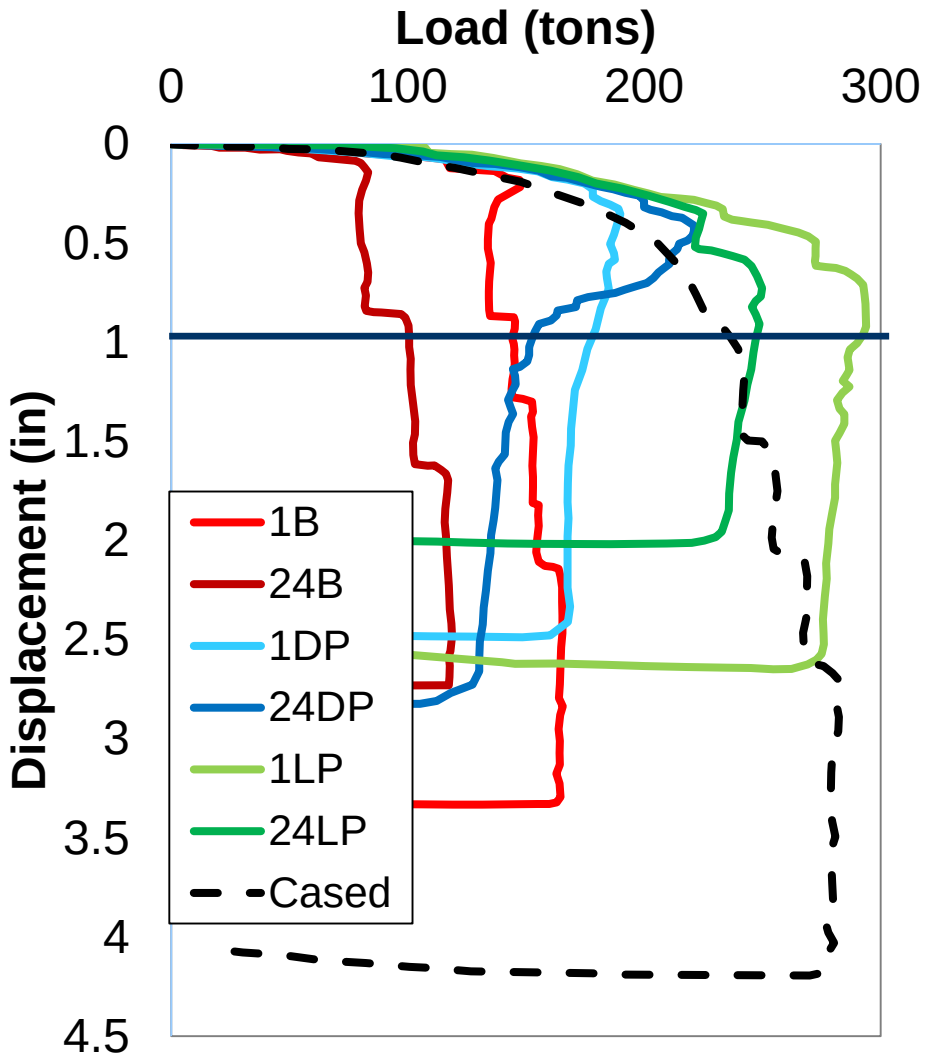
Problem Statement (recall)

- 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.

Time Exposure

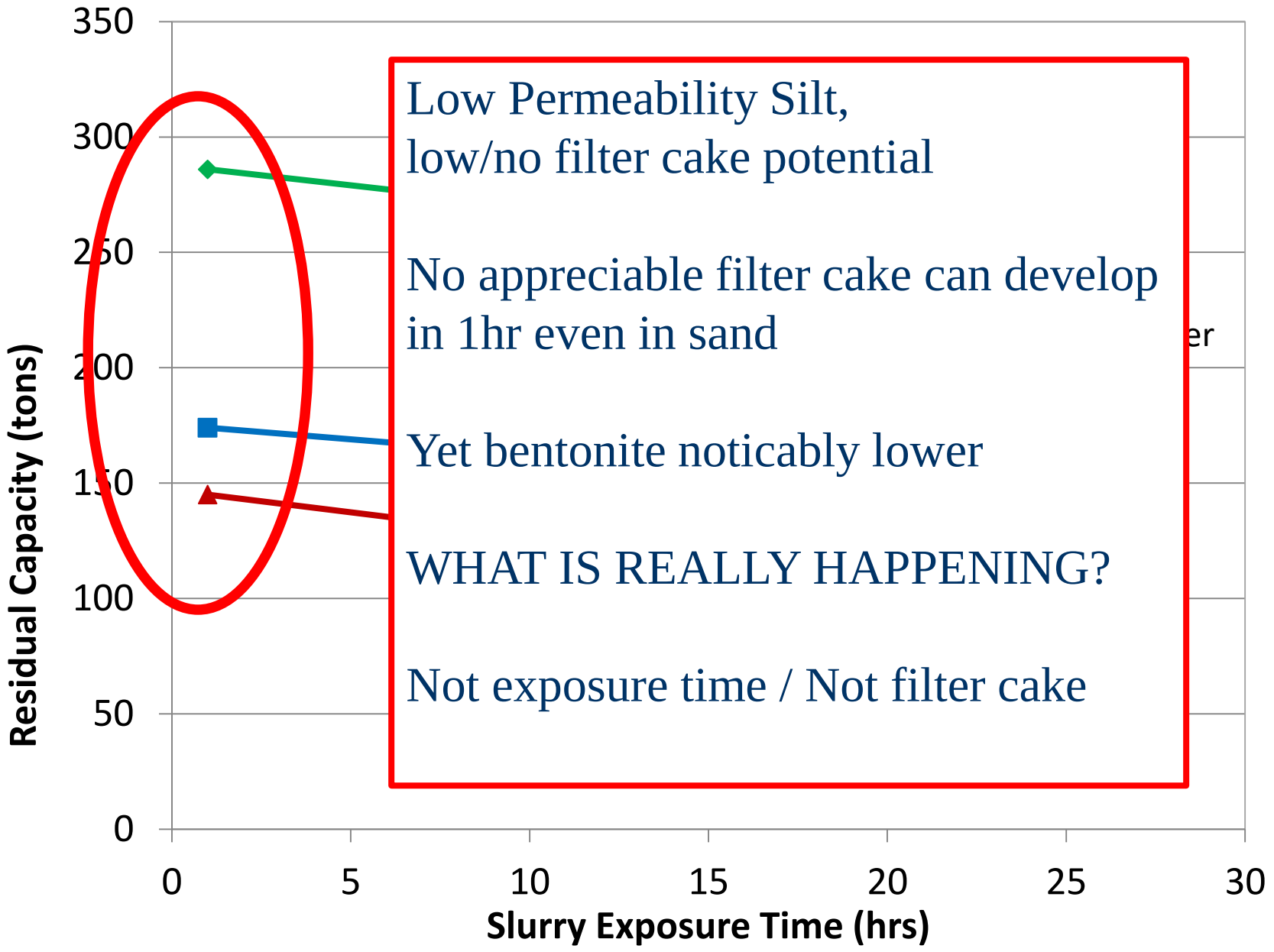
Effects of drilling slurries on Side Resistance (Brown, 2002)



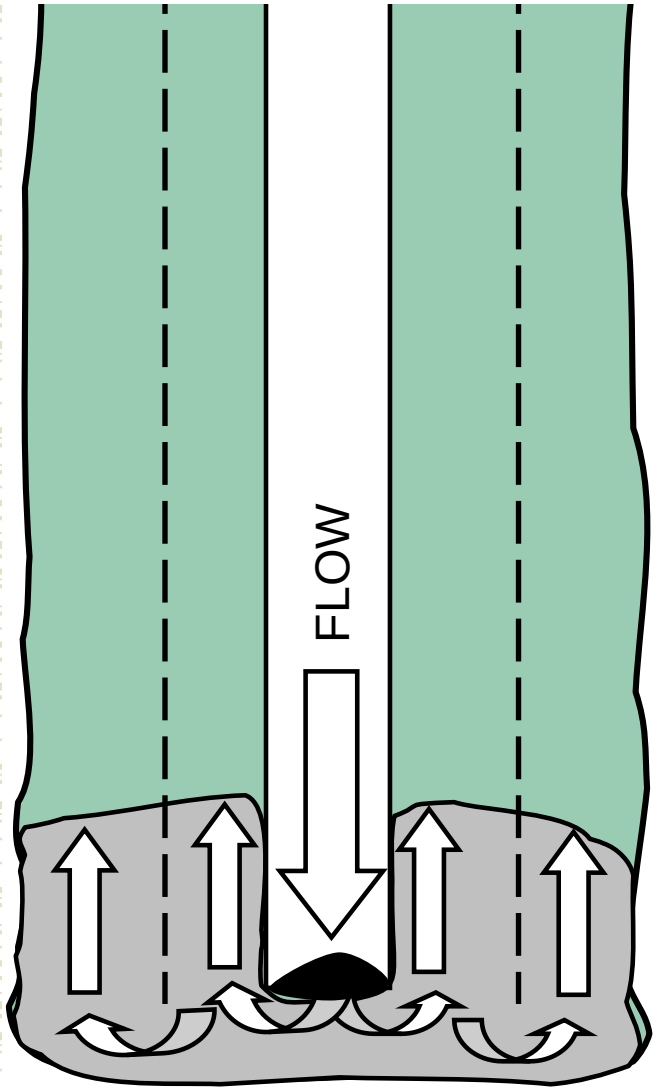
- Bentonite showed tremendous drop in capacity at 1hr
- Low permeability soil
- No time to form

"filter cake"

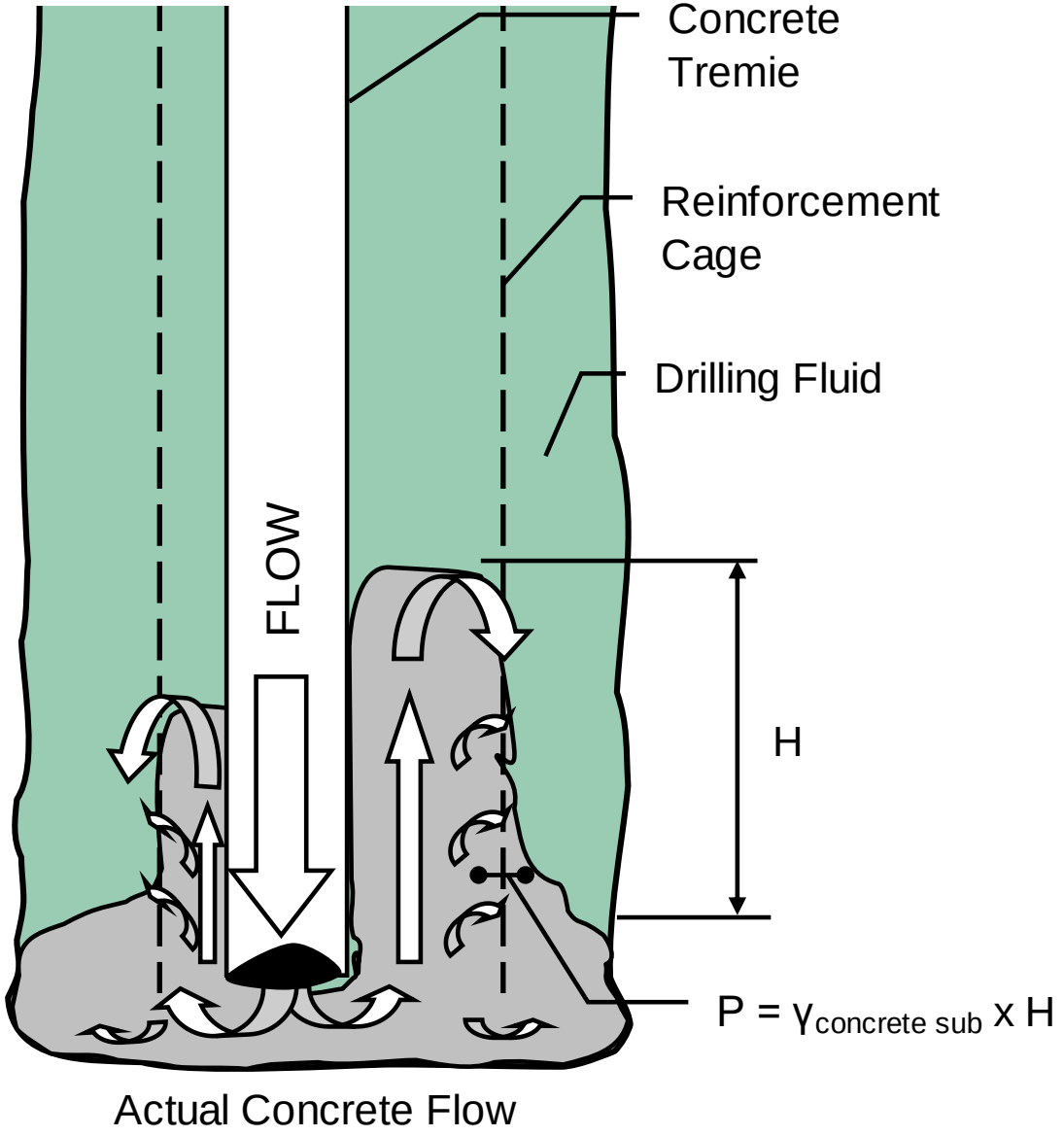
Brown, et al.


350
300
250
200
150
100
50
0
Residual Capacity (tons)
0
5
10
15
20
25
30
Slurry Exposure Time (hrs)
Low Permeability Silt,
low/no filter cake potential
No appreciable filter cake can develop in 1hr even in sand
Yet bentonite noticably lower
WHAT IS REALLY HAPPENING?
Not exposure time / Not filter cake

Concrete Flow in Drilled Shafts

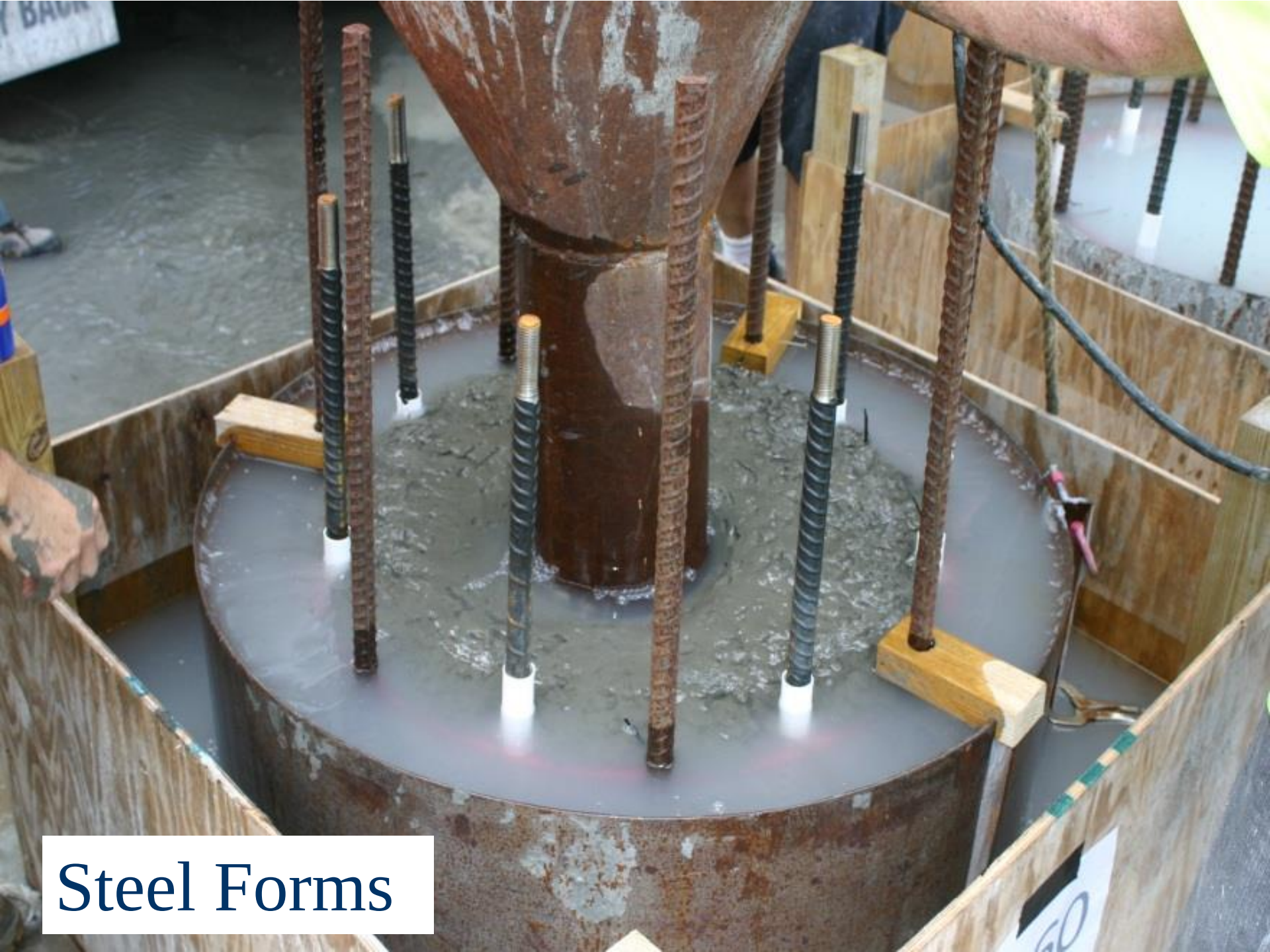


Idealized Concrete Flow



Actual Concrete Flow

Deese, G. and Mullins, G. (2005). " Factors Affecting Concrete Flow in Drilled Shaft Construction," ADSC GEO3, GEO Construction Quality Assurance / Quality Control Conference Proceedings, Bruce, D.A. and Cadden, A. W. (eds) pp. 144-155, November.

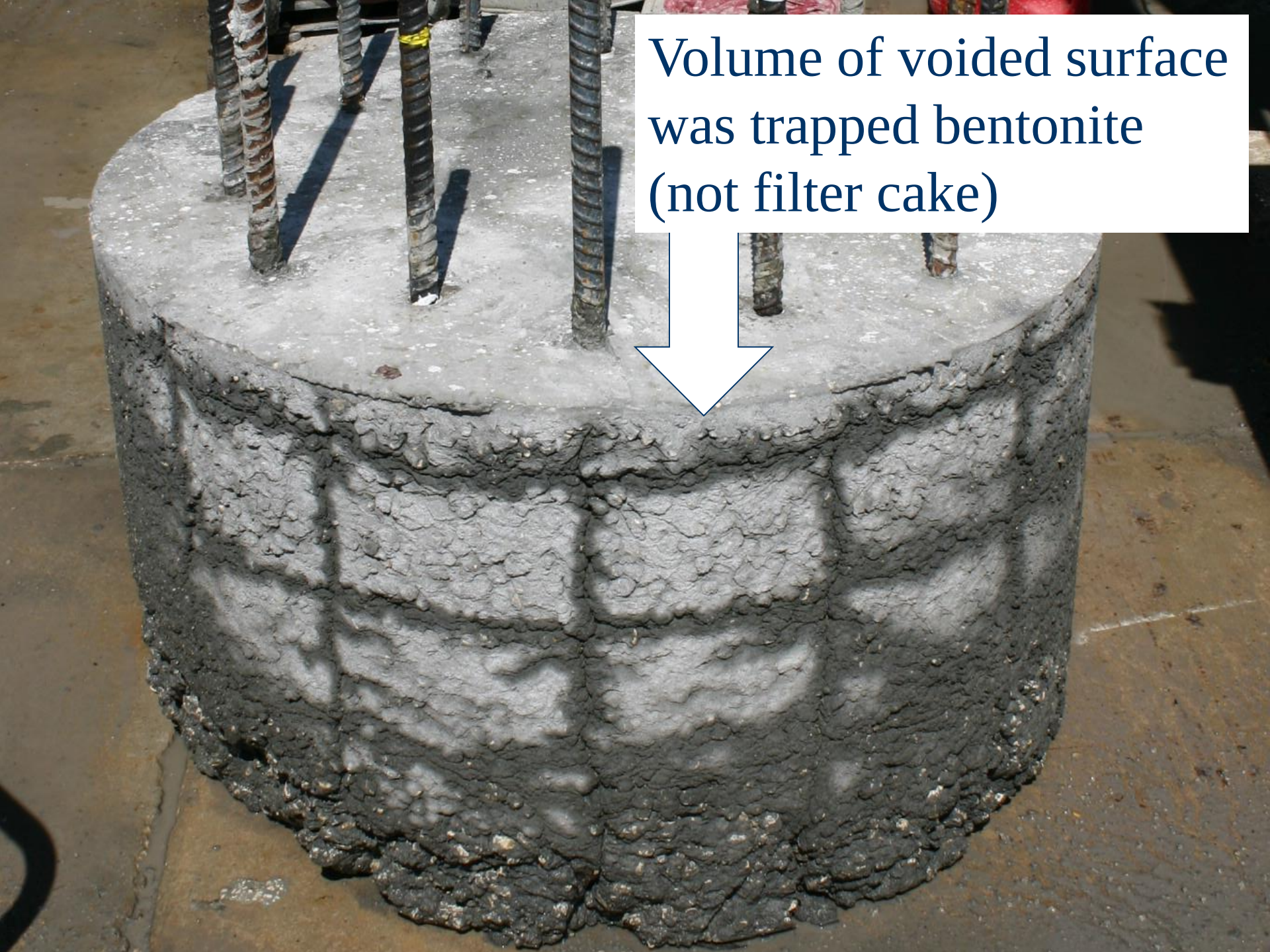


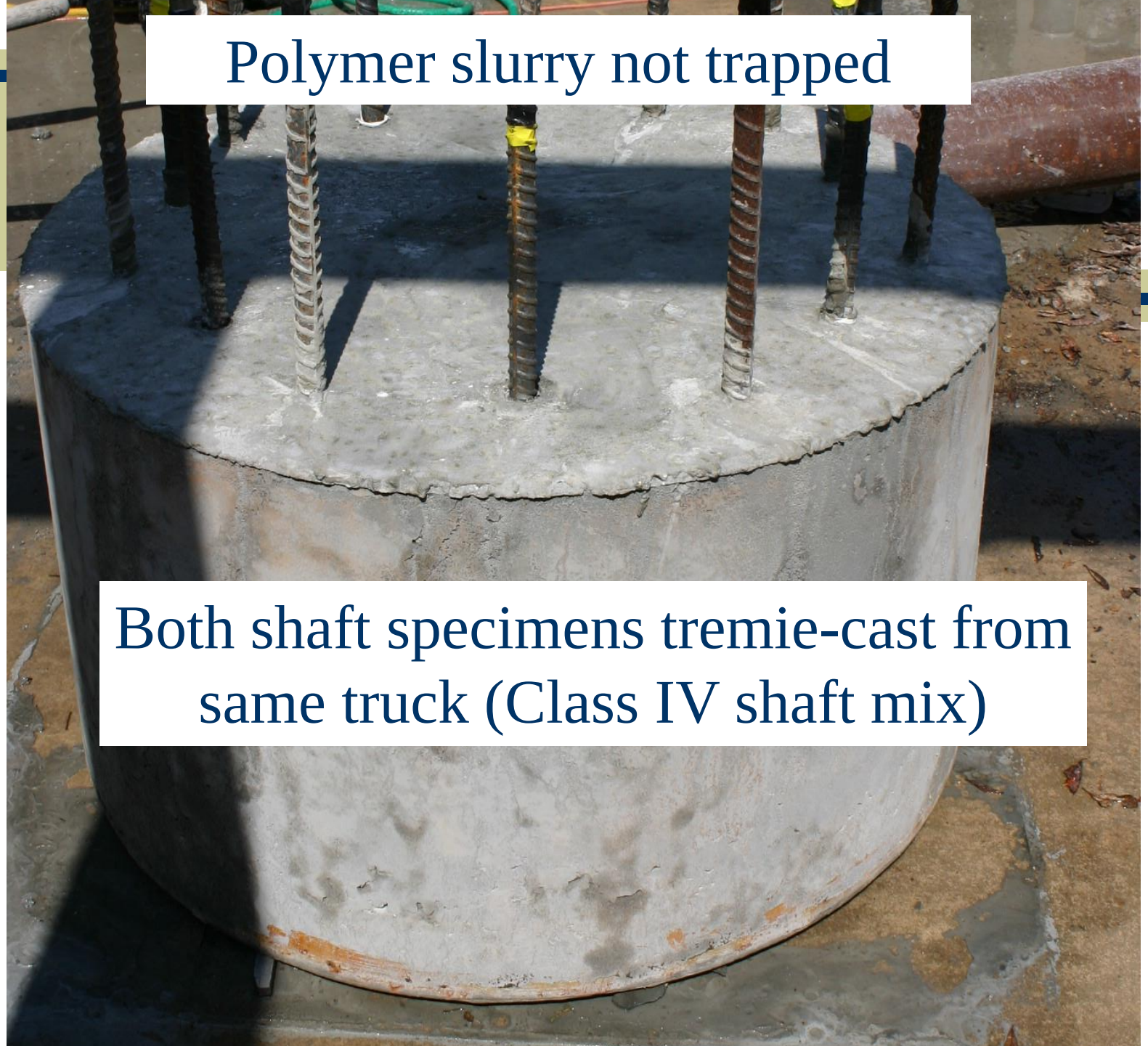
Steel Forms


Class IV Shaft Mix

SCC Shaft Mix


CAUTION
IF YOU CAN'T SEE MY
MIRRORS, I CAN'T SEE YOU.
PLEASE
AY BACK


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.

Current Specification

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 1/2inches and the maximum depth is 3 inches. . .*

Research Approach

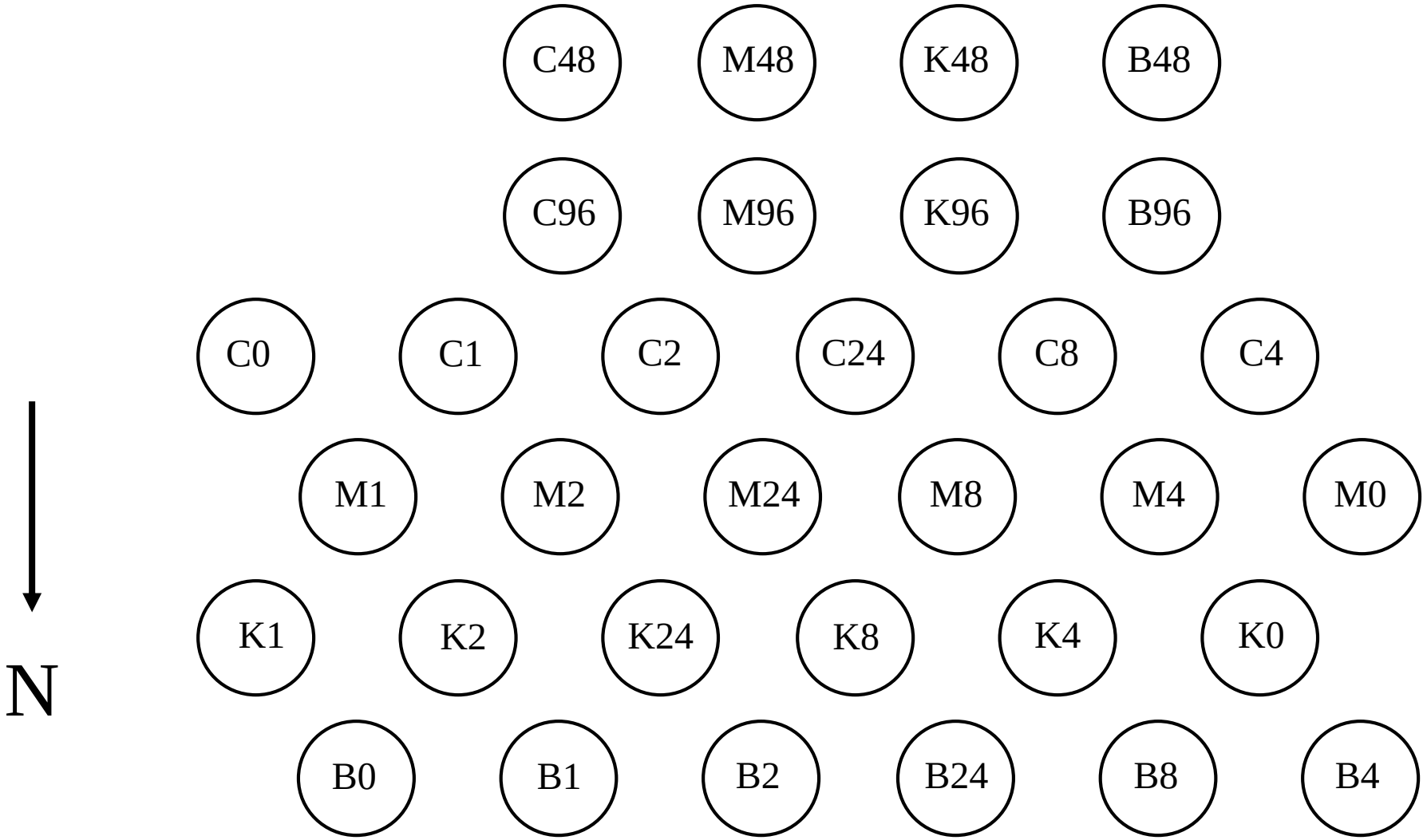
- Cast small and large scale shafts using three different polymer products
- Maintain open excavations with slurry prior to casting
- Perform pull out tests

- Small scale and full scale test program

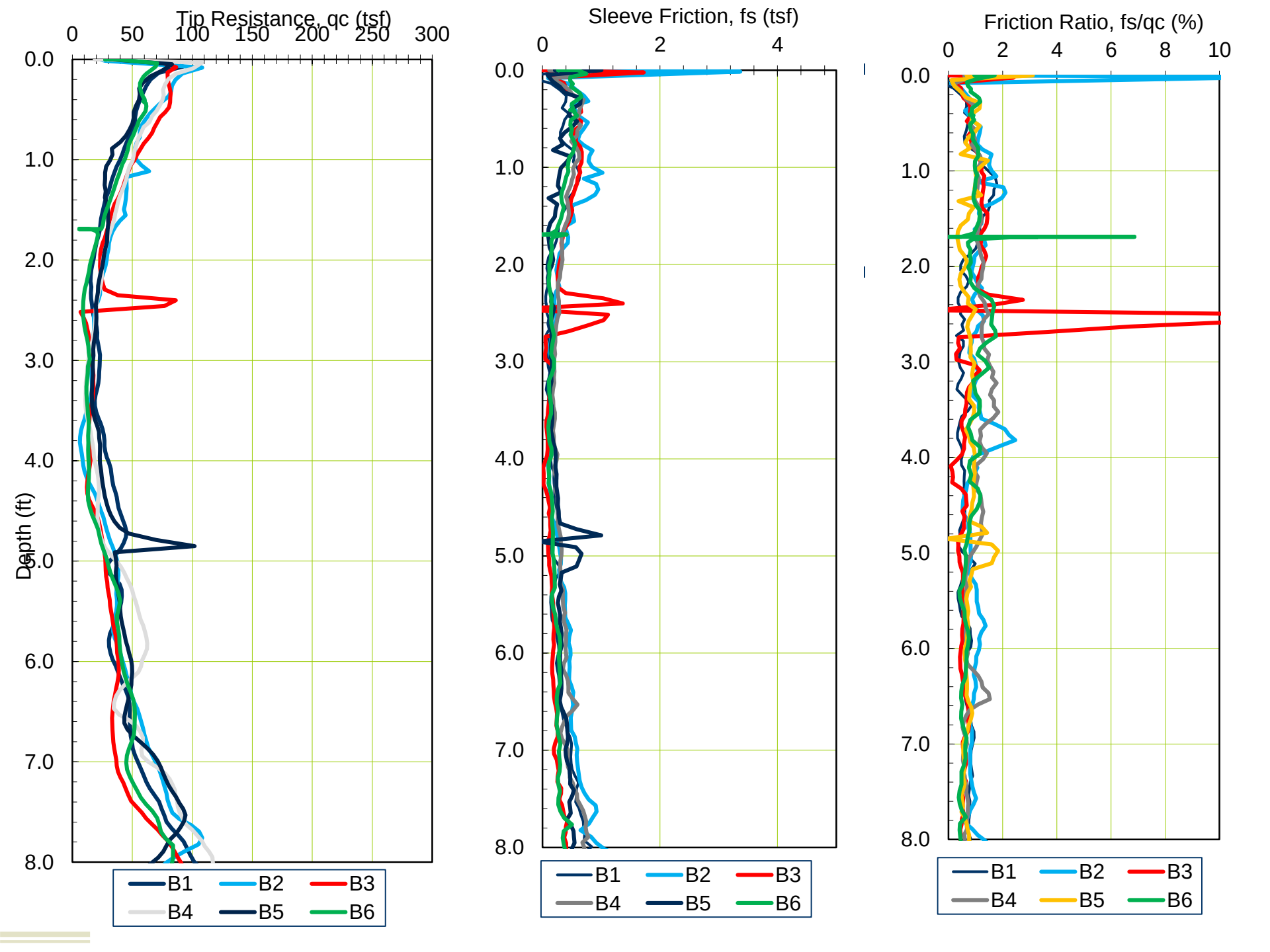
Small Scale Test Shaft Program

- 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

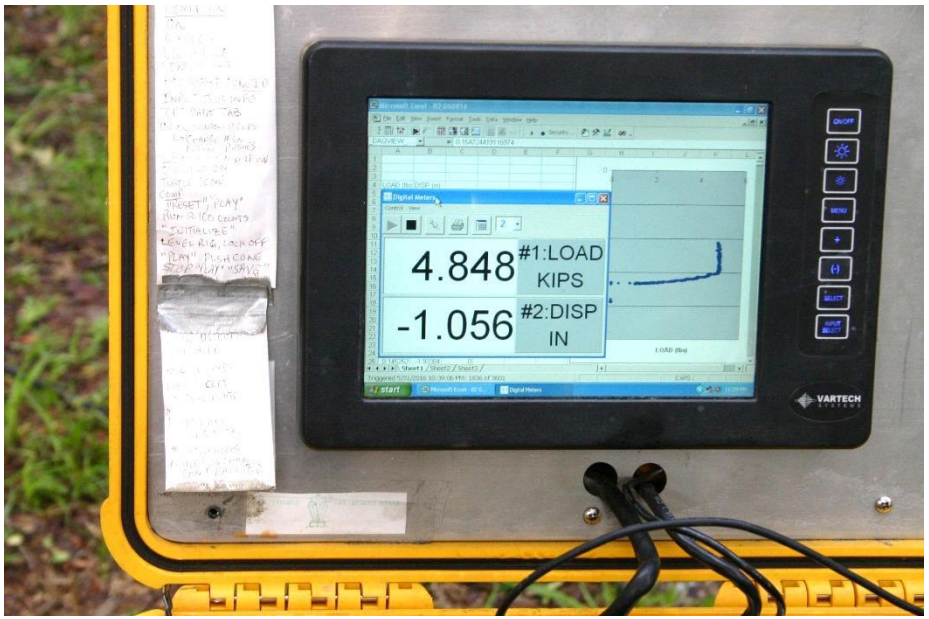

Tip Resistance, qc (tsf)
0
50
100
150
200
250
300
Depth (ft)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
B1
B2
B3
B4
B5
B6
Sleeve Friction, fs (tsf)
0
2
4
Friction Ratio, fs/qc (%)
0
2
4
6
8
10

Excavation

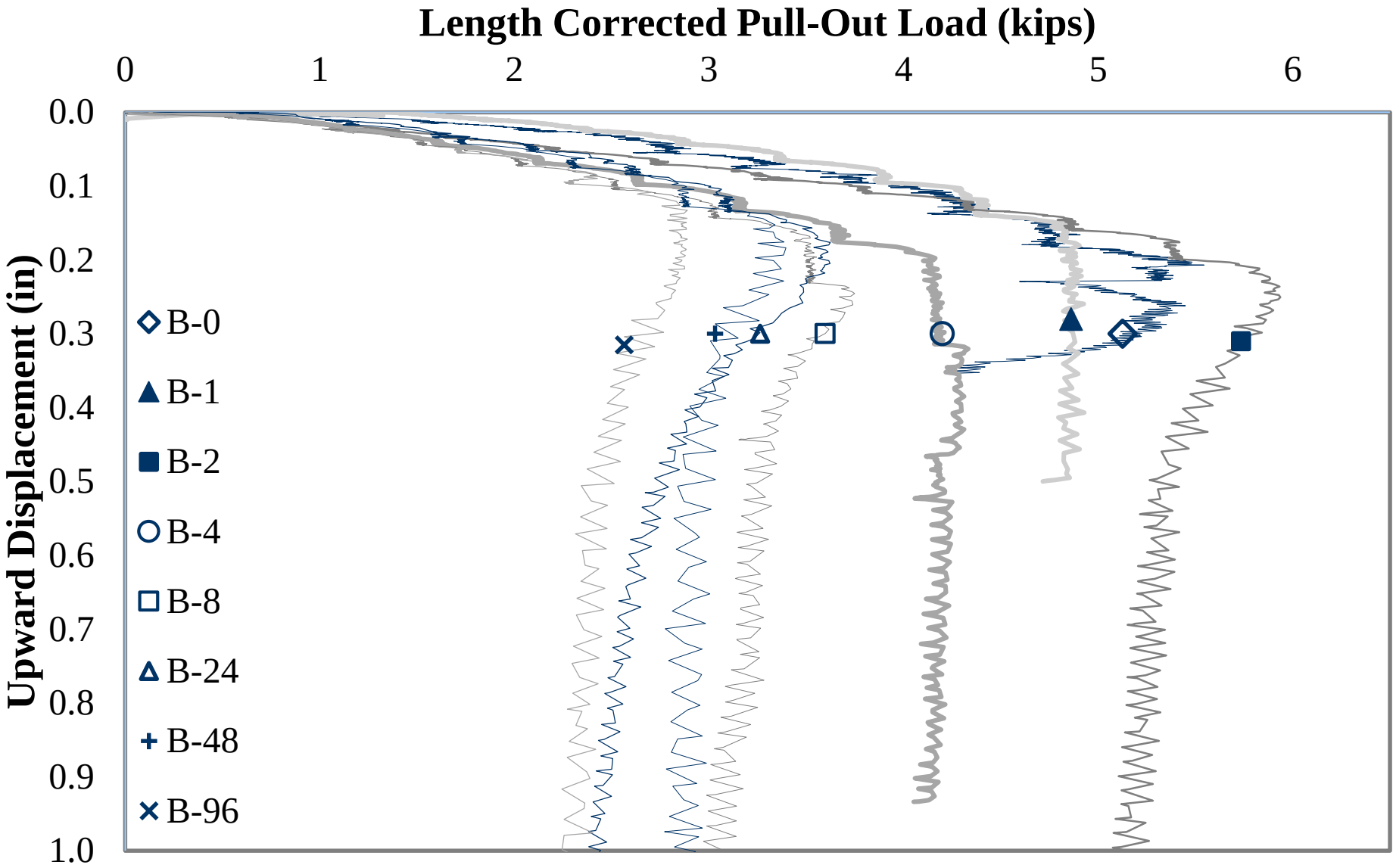
Concreting

Static Load Test

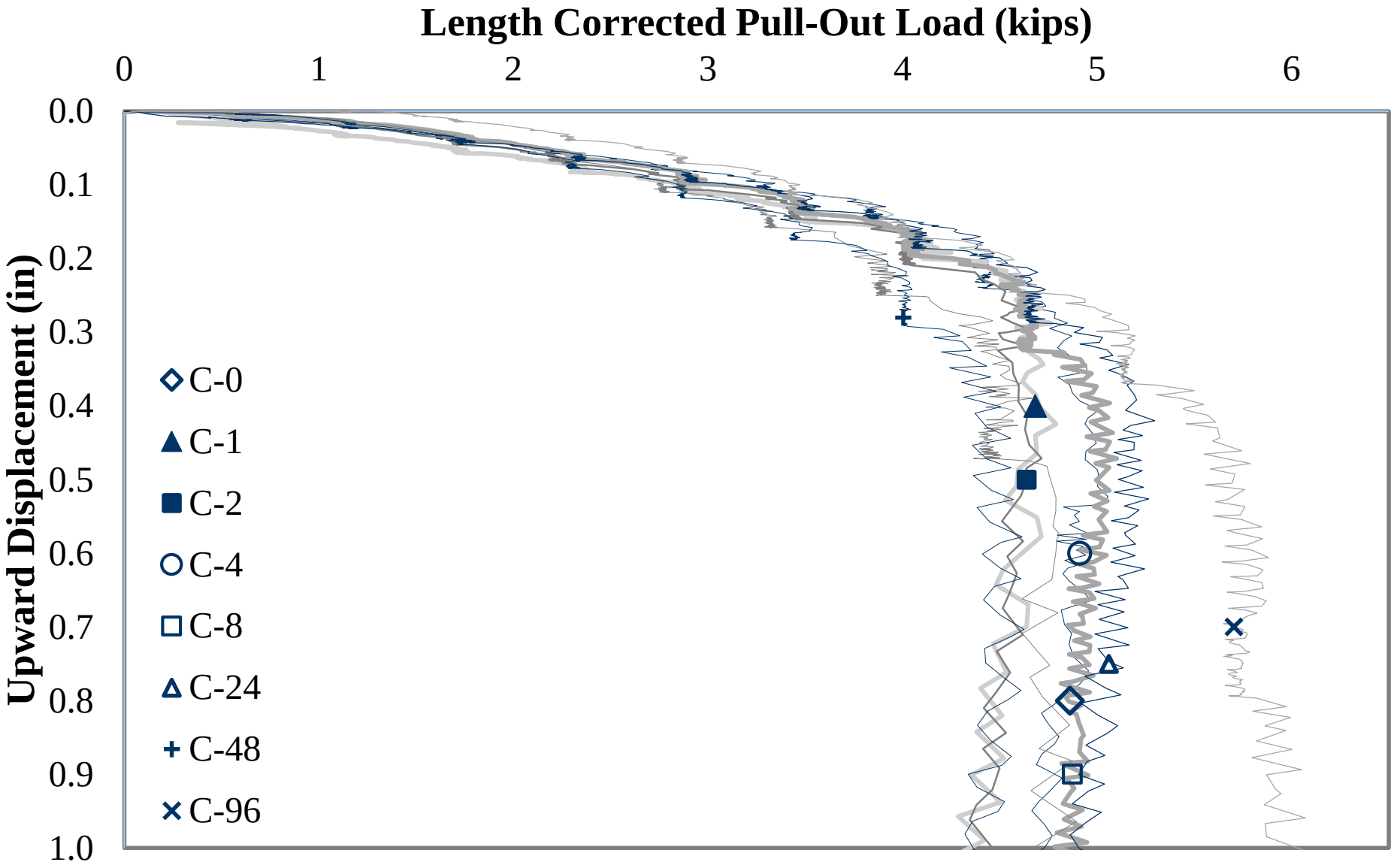
- Modified Quick Test
- Load Increments of 500lbs
- Max. Displacement of 4in



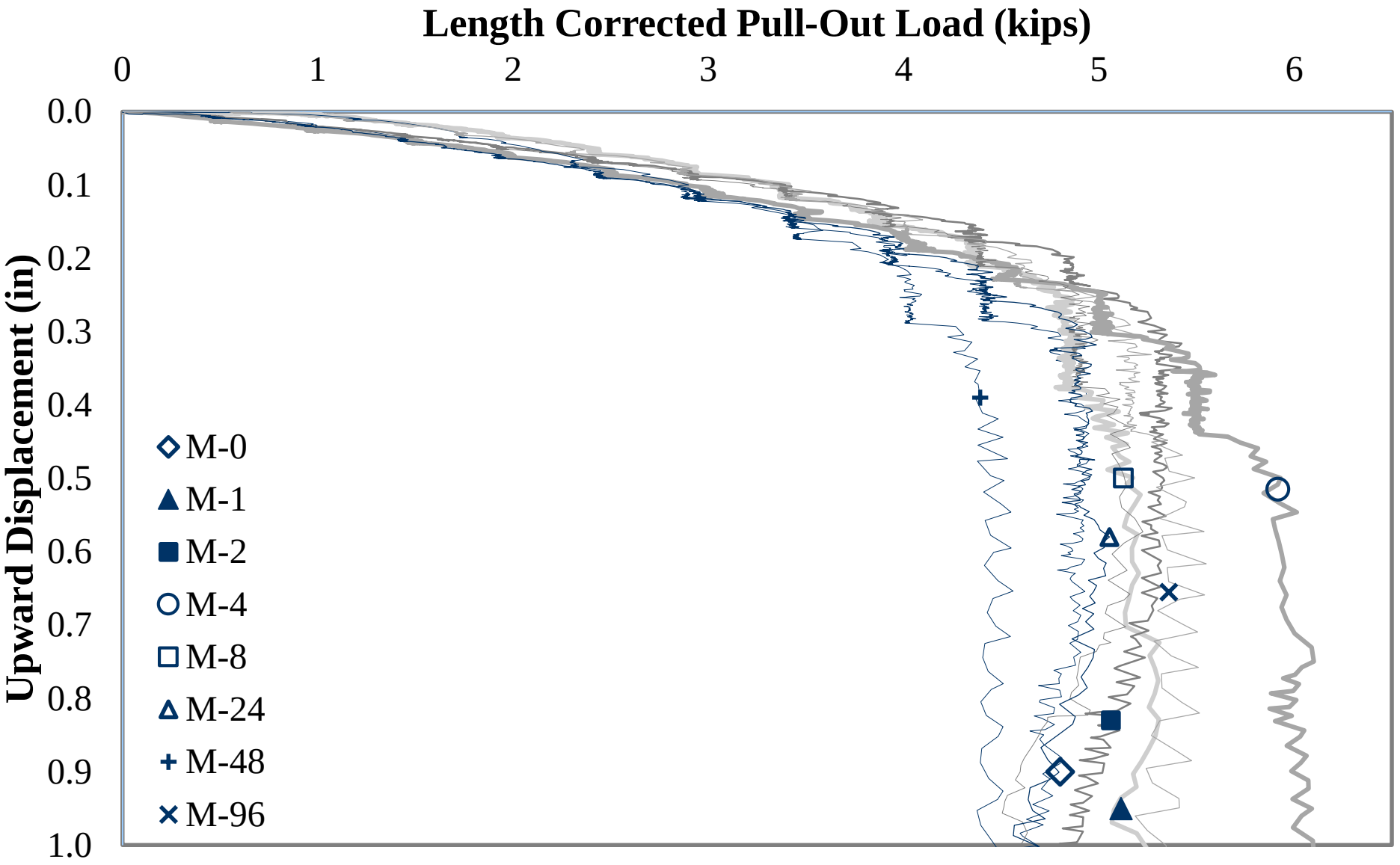
Bentonite Load Tests



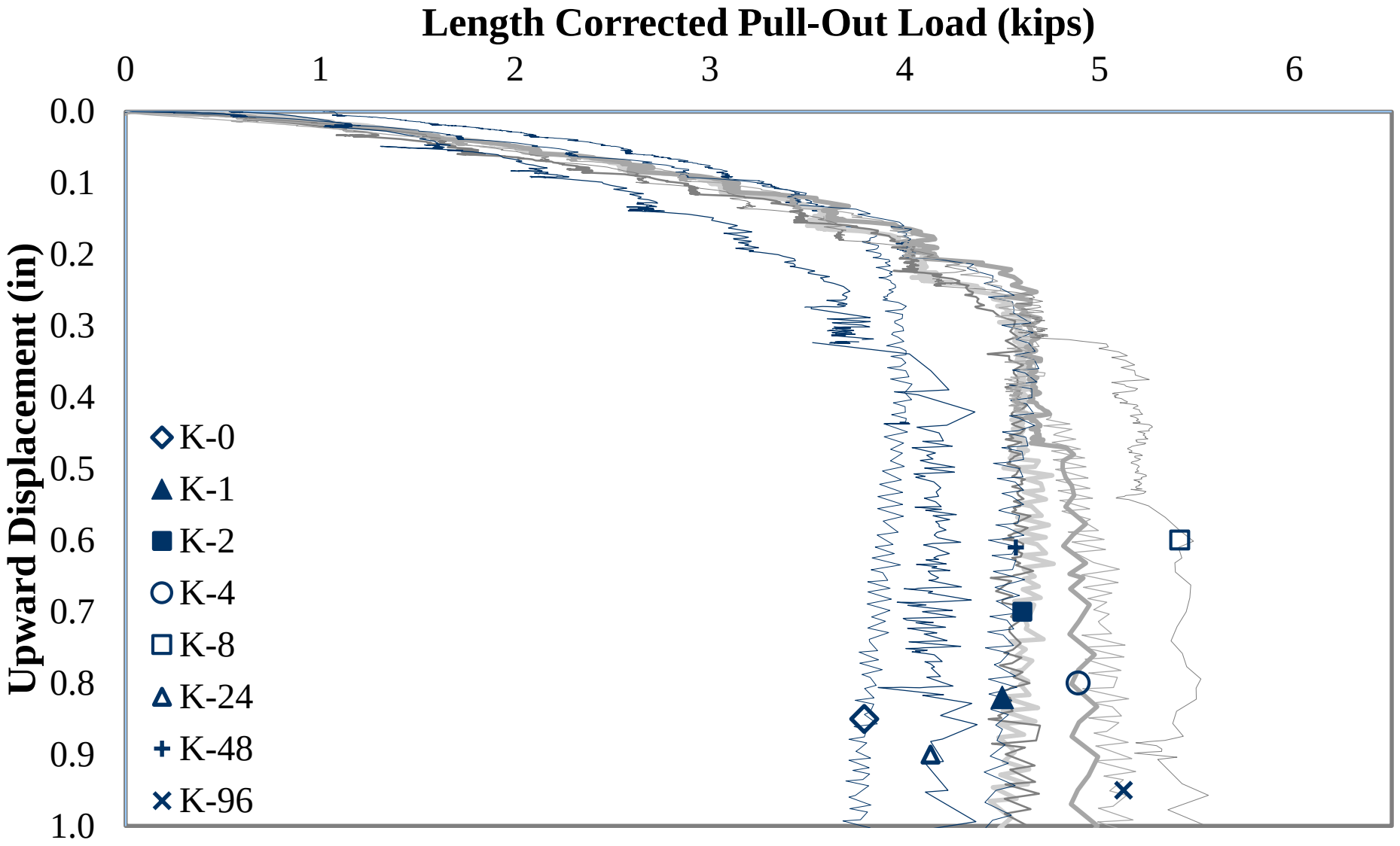
Cetco Polymer Load Tests



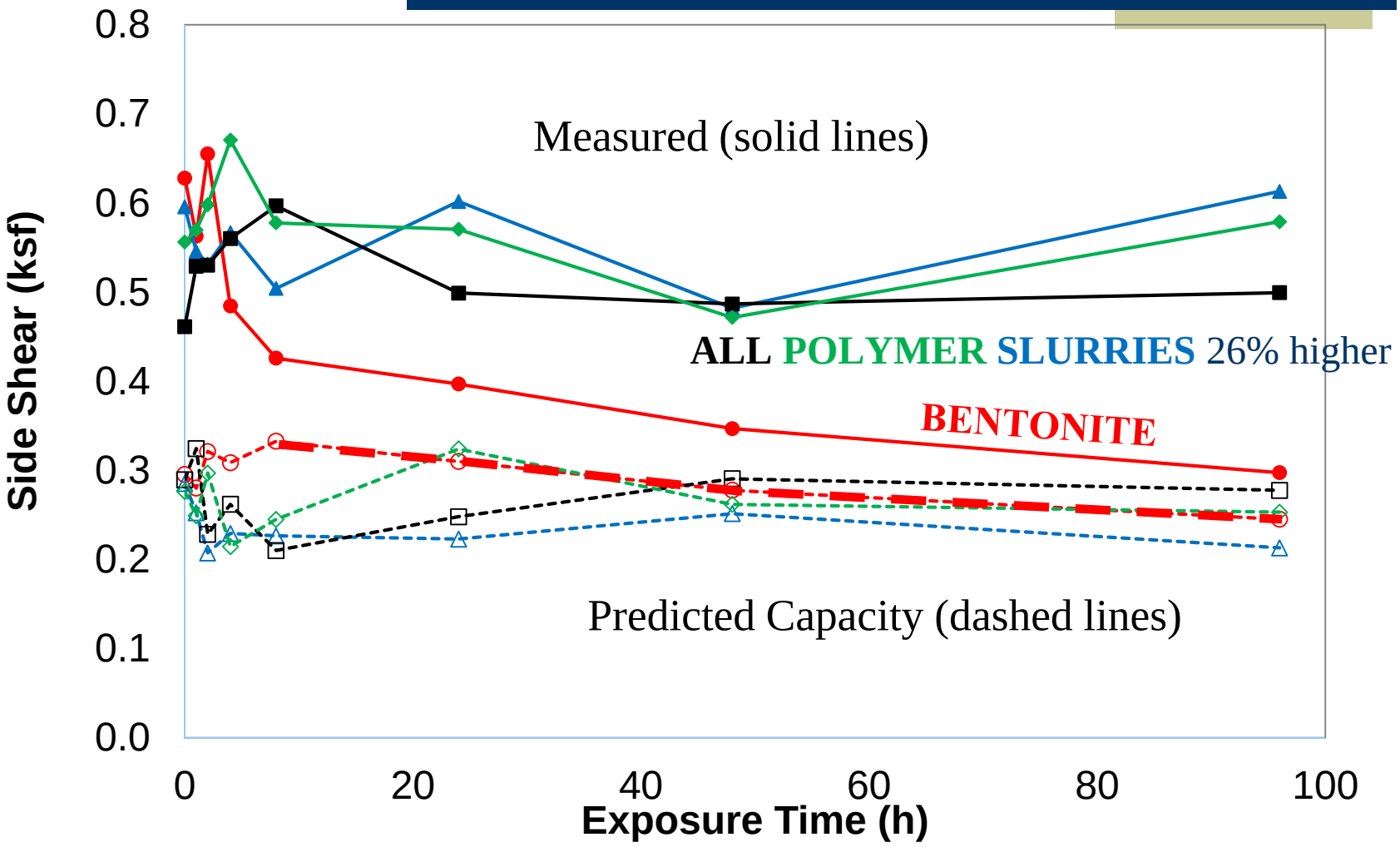
Matrix Polymer Load Tests



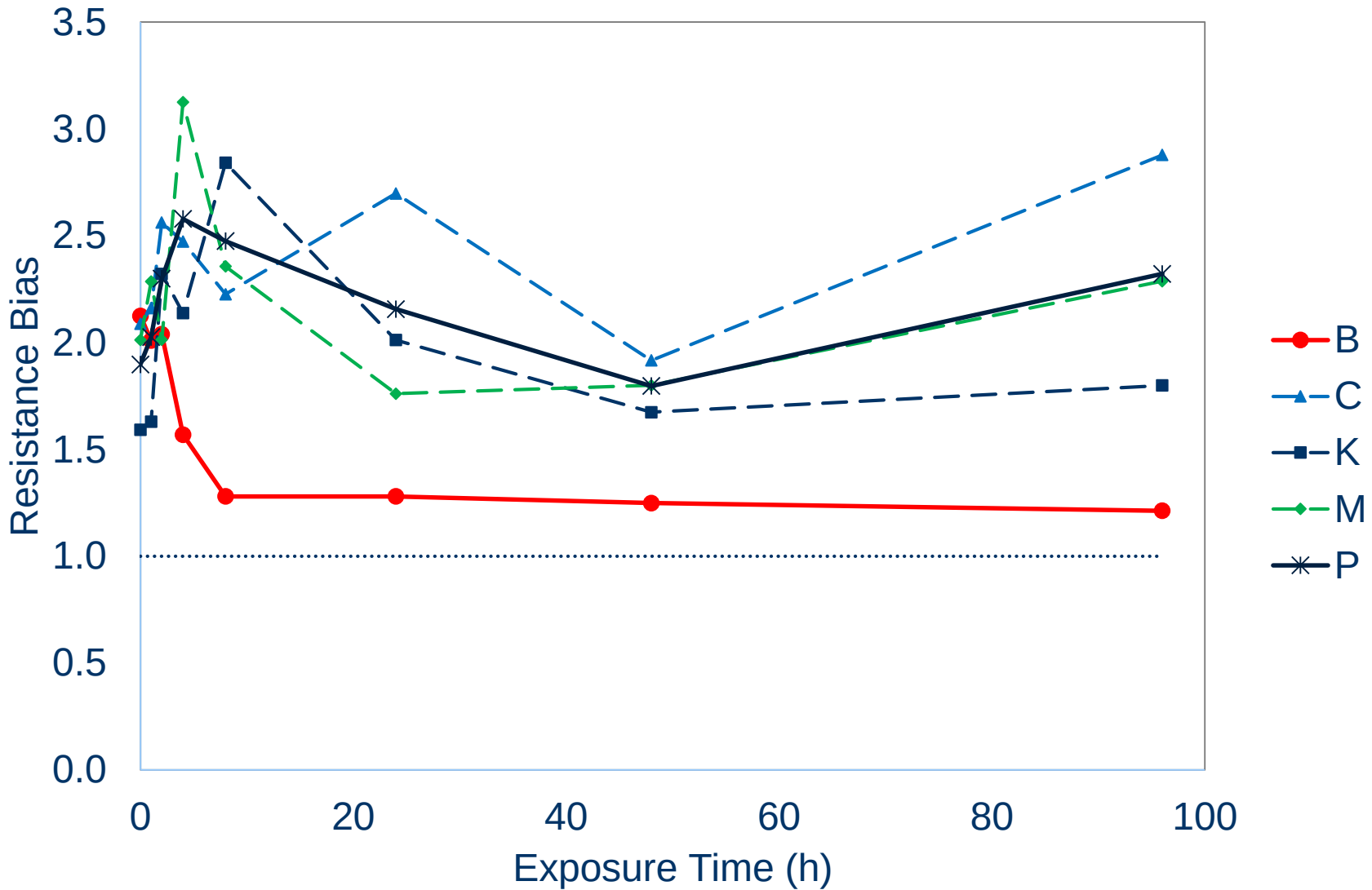
KBI Polymer Load Tests



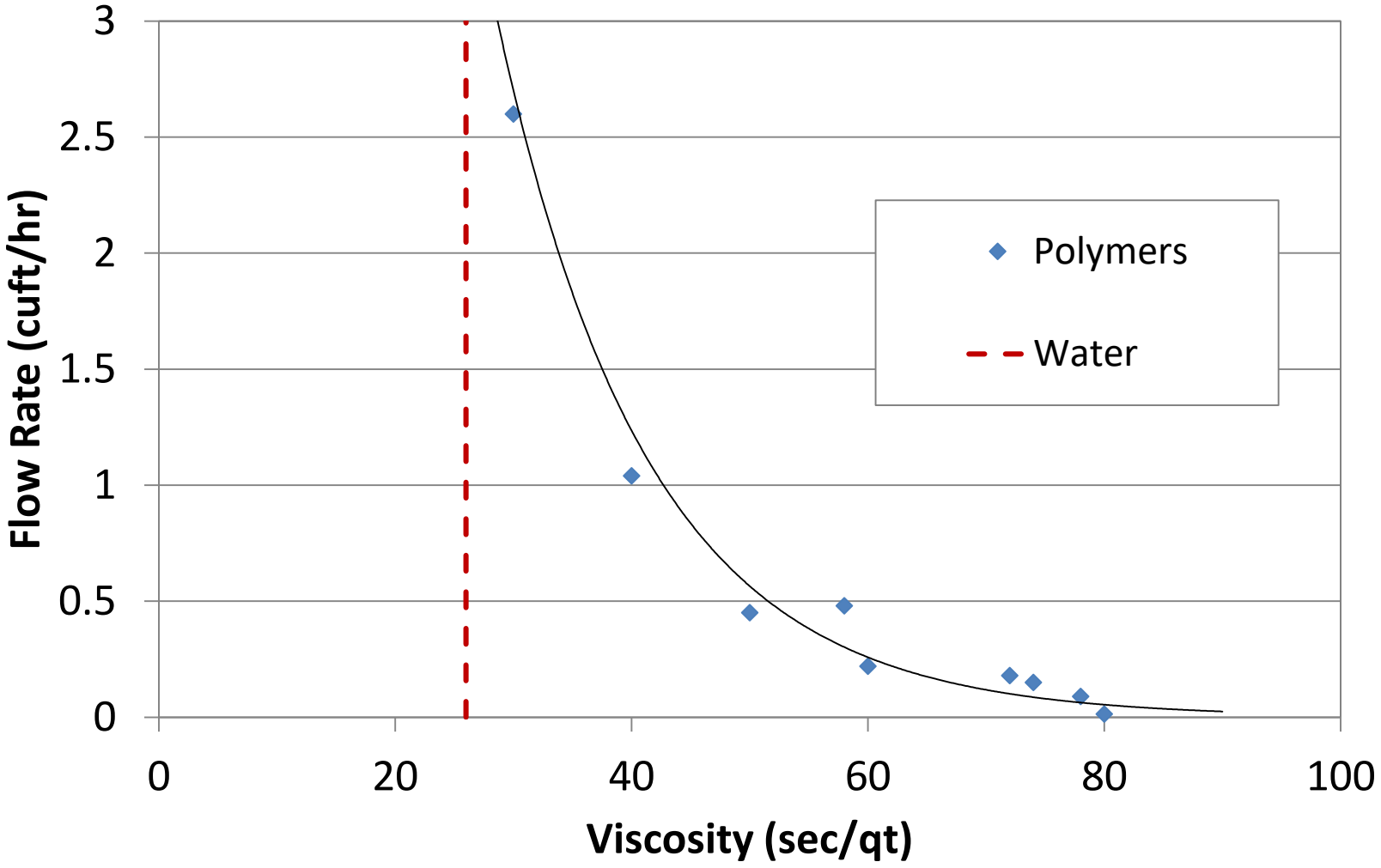
Slurry Exposure Results
(32 small-scale shafts)



Measured / Predicted



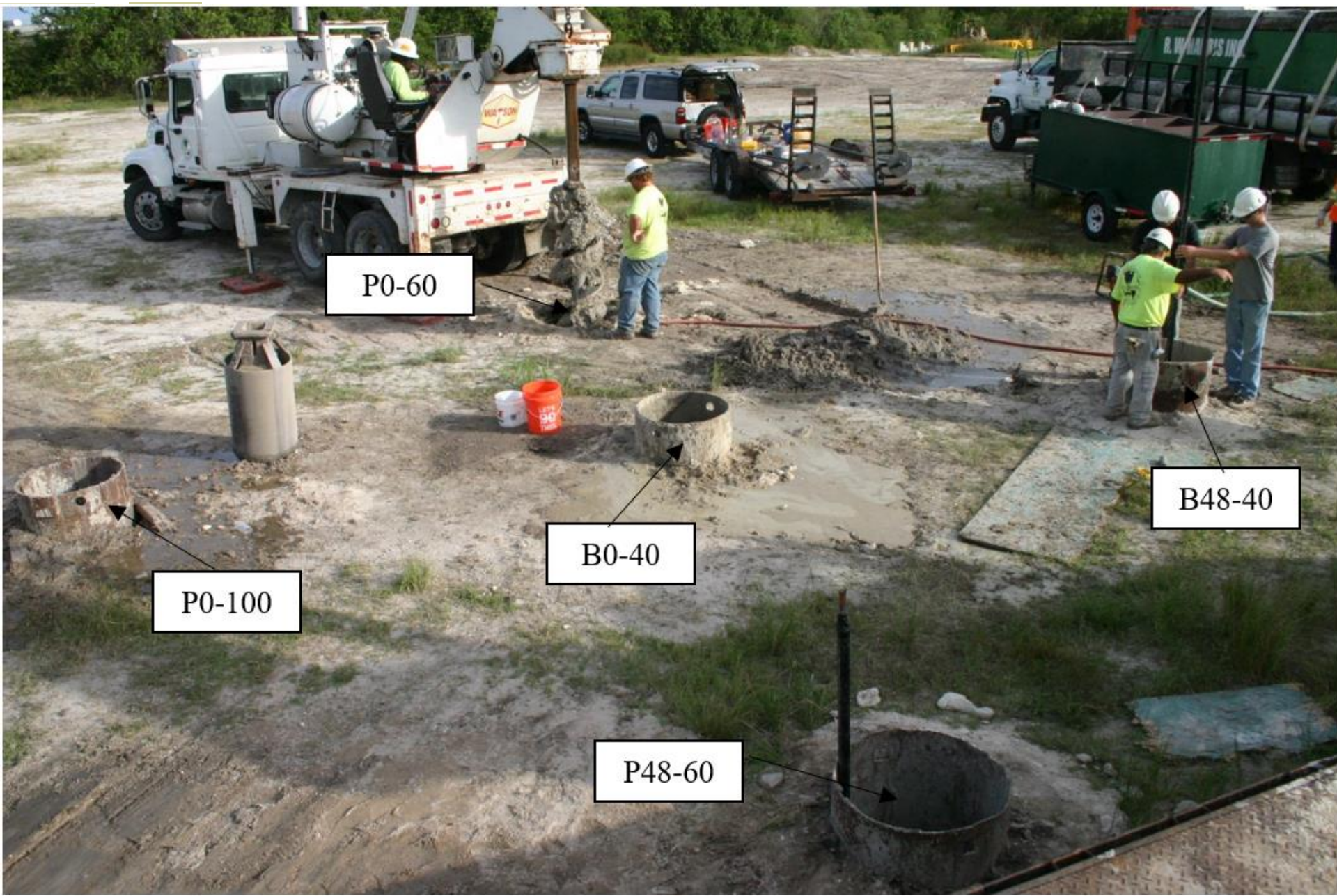
Viscosity vs Excavation Stability



Full-scale testing

Shaft ID	Slurry Type	Exposure Time (hr)	Target Viscosity (sec/qt)
B48-40	Bentonite	48	40
P48-60	Polymer	48	60
B0-40	Bentonite	0	40
P0-60	Polymer	0	60
P0-100	Polymer	0	>100

Excavation staged over two day period

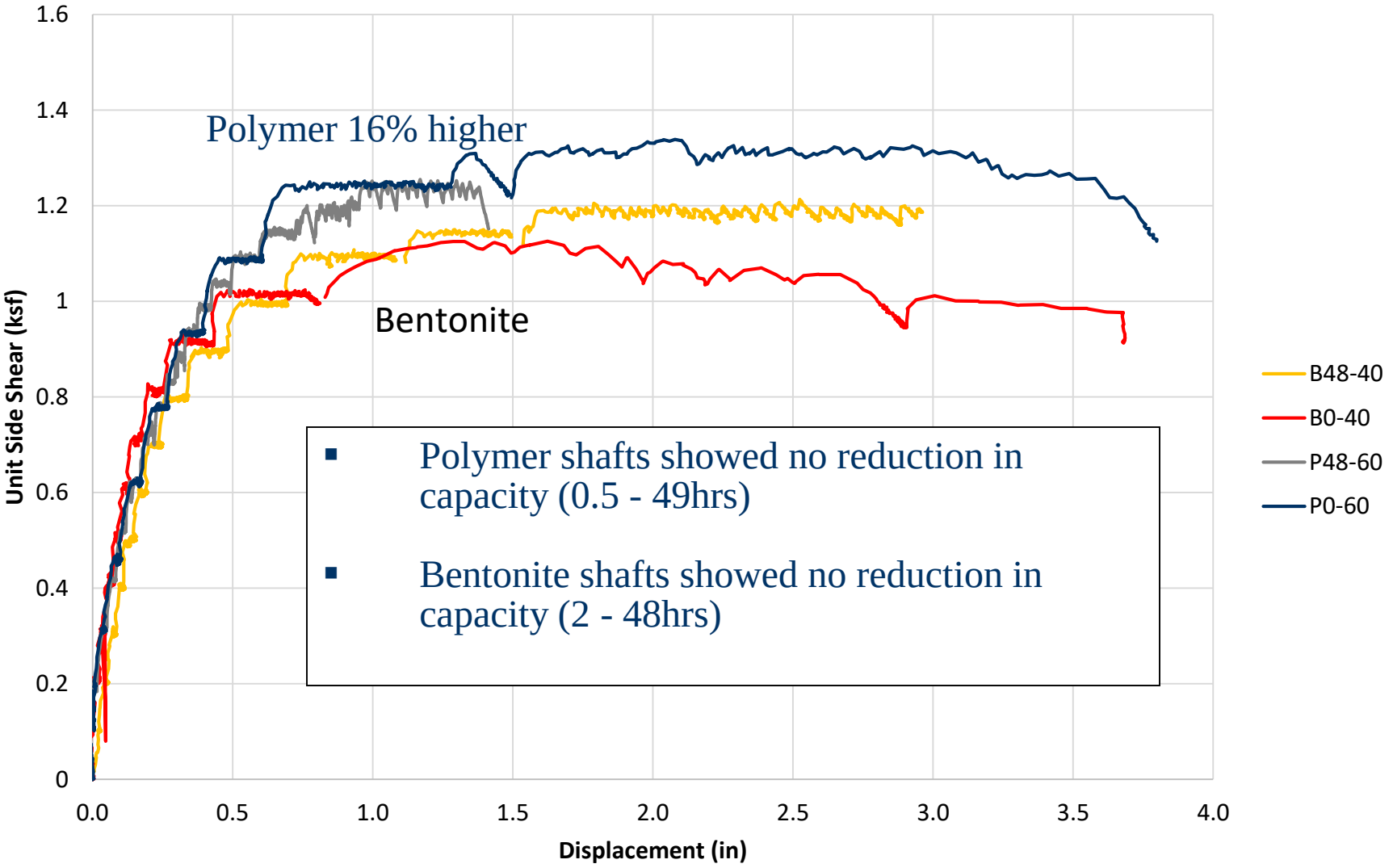


Concreting all conducted within 2hrs

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)

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.