Civil & Environmental Engineering

THERMAL INTEGRITY PROFILING FOR AUGERED CAST-IN-PLACE PILES - (IMPLEMENTATION PLAN)

BDV25-977-34

FINAL REPORT

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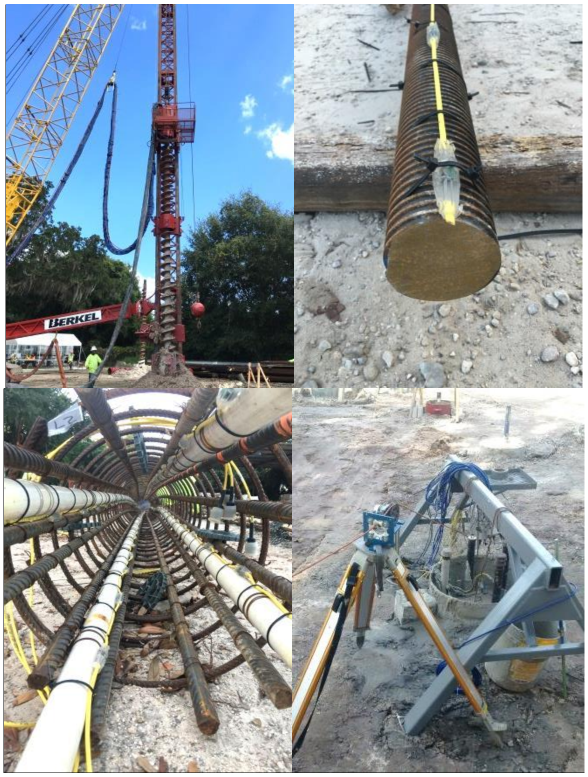

August 2017

Disclaimer

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fL	foot-Lamberts	3.426	candela/m^2	cd/m^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
kip	kilopound	4.45	kilonewtons	kN

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
^oC	Celsius	1.8C+32	Fahrenheit	^oF

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2
kN	kilonewtons	0.225	kilopound	kip

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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16. Abstract

This study was the second in a two-part research program focused on assessing the feasibility of using thermal integrity profiling (TIP) as a quality assurance tool for Augered Cast-In-Place (ACIP) piles. This was made possible by coordinating with the Deep Foundations Institute (DFI) ACIP pile project to demonstrate the strength of the piles in various loading conditions (i.e., tension, compression, and lateral loads), as well as overall pile integrity and the effectiveness of TIP for ACIP piles. In all, seven test piles were equipped with thermal integrity assessment devices. Both probe and thermal wire systems were used to collect data over an extended period of time, thereby providing a means to compare instrumentation methods, schemes, and analysis techniques. One of the seven piles was extracted to assess the validity of on-site inspection methods. The extracted pile was also used as a control for the thermal analysis comparison.

Results from thermal integrity profiling showed promising capabilities to verify the integrity and profile of the as-built piles. Analysis methods that were hypothesized in the original study were vetted and showed good agreement with the physically verified true pile size, shape, and integrity. These methods were further refined to minimize errors associated with simplistic linearization of the inverse hyperbolic tangent relationships.

Both probe and wire systems were shown to provide the same data; however, wire systems have the distinct advantage of reducing cage/reinforcement congestion. PVC access tubes were also shown to be better for small volumes of grout that can be vulnerable to heat sinking with steel tubes.

Like most new developments and the additional information provided for the contractor, thermal profiling has shown that single bar reinforcement is often eccentric and that tighter centralizer spacing would be beneficial. The shape of the pile predicted by thermal evaluation mimicked the actual pile closely, but accurate determination of grout volumes directly affects the thermal analysis results. As such, it is a critical factor in the entire ACIP pile quality assurance program, and improvements are needed in this determination.

17. Key Word
Auger-cast pile, thermal integrity test, quality assurance

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Executive Summary

The thermal integrity test has proven to be an effective method to evaluate the integrity of newly constructed drilled shafts (i.e., identifying anomalies, rebar cage alignment, concrete cover, etc.). However, very few auger-cast piles have been tested with this method as standard integrity access tubes are not typically installed. It was the goal of this research to explore the use of the thermal integrity technology for auger-cast piles. The research was performed in two phases; in the first phase, various instrumentation and analysis methods were explored, field data was collected, new equipment options were scrutinized, and numerical modeling was used to show areas of strength or weakness.

This study was the second in the two-part research program focused on assessing the feasibility of using thermal integrity profiling for ACIP piles. This was made possible by coordinating with the Deep Foundations Institute ACIP pile project to demonstrate the strength of the piles in various loading conditions (i.e., tension, compression, and lateral loads). In all, seven test piles were equipped with thermal integrity assessment devices. Both probe and thermal wire systems were used to collect data over an extended period of time, thereby providing a means to compare instrumentation methods, schemes and analysis techniques. One of the seven piles was extracted to assess the validity of on-site inspection methods. The extracted pile was also used as a control for the thermal analysis comparison.

Results from thermal integrity profiling of ACIP piles showed promising capabilities to test the as-built piles. Analysis methods that were hypothesized in the original study were vetted and showed good agreement with the true pile size and shape. These methods were further refined to minimize errors associated with simplistic linearization of the inverse hyperbolic tangent relationships.

Both probe and wire systems were shown to provide the same data; however, wire systems have the distinct advantage of reducing cage/reinforcement congestion. PVC access tubes were also shown to be better for small volumes of grout that can be vulnerable to heat sinking with steel tubes.

Like most new developments and the additional information provided for the contractor, thermal profiling has shown that centered single bar reinforcement is critical to TIP effectiveness and that tighter spacing would be beneficial. The shape of the pile predicted by thermal evaluation mimicked the actual pile closely, but accurate determination of grout volumes directly affects the thermal analysis results. As such, it is a critical factor in the entire ACIP pile quality assurance program, and improvements are needed in this determination.

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Chapter One: Introduction

1.1 Background

Augered Cast-In-Place (ACIP) piles are a subset of the larger category of cast-in-place deep foundations. In the U.S., cast-in-place deep foundations also include drilled shafts. As the name implies, cast-in-place deep foundation construction involves drilling a deep cylindrical hole in the ground and installing a fluid concrete or grout within the walls of the excavation wherein the walls are the "formwork." The dimensions of the as-built element are essentially defined by the shape taken on after drilling and the application of hydrostatic pressure from the fluid concrete or grout on the excavation walls.

Although similar at first glance, ACIP piles differ from drilled shafts both in construction processes and design capacity. Drilled shaft construction provides lateral stability to an open excavation via hydrostatic slurry pressure or mechanical bracing from a casing. Therein, the soil is methodically removed using repeated grabs, bites, or scoops with a relatively short drill tool (usually only 2 or 3 flights) or bucket. ACIP piles differ in that no slurry or casing is required to hold open the excavation; rather a continuous flight auger is used which maintains the stability and volume of the excavation via the soil that fills the auger flights. The sidewalls therefore push against the soil filled auger and are not free to collapse inward. The length of auger must extend to the deepest required tip elevation.

The net result of the significantly different auger configuration is that grout or concrete is pumped directly to the base of the excavation through the stem of the ACIP auger whereas drilled shafts place concrete through a separate and dedicated tremie pipe. Note that grout differs from concrete as it has no coarse aggregate and is easily pumped through smaller lines (e.g., drill stem). During grouting, the ACIP auger is extracted slowly enough such that the grout pumping rate can fill the entire theoretical volume plus a small over pour percentage. However, if the volume of the soil-laden auger is extracted faster than the inflowing grout it will result in a net negative pressure that will pull the soil walls in below the tip of the auger. As the auger tip reaches the surface it becomes more difficult to sustain grout pressure, and often, the contractor will reduce pumping rate to meet the theoretical volume per foot. Depending on the exact interaction between flow rate and extraction rate, severe necks in the cross-section and is a primary concern when using ACIP piles. Further, the most common configurations use a single central bar or a minimal reinforcing cage which have traditionally been too small to equip with integrity access tubes. This has made post-construction integrity evaluation limited.

The thermal integrity test has proven to be an effective method to evaluate the integrity of newly constructed drilled shafts (i.e., identifying anomalies, rebar cage alignment, concrete cover, etc.). However, very few auger-cast piles have been tested with this method as standard integrity access tubes are not typically installed. The disadvantage of auger-cast piles relative to piles or drilled shafts is that the final, as-built configuration of these foundation units is unknown. As such, their FDOT use has been limited to foundations for sound walls. If an improved quality assessment tool is developed to ascertain the final, as-built configuration (size, depth, diameter, concrete cover, etc.) of auger-cast piles, their use in other applications can be reevaluated. It is the goal of this research to explore the use of the thermal integrity technology for auger-cast piles.

This report is the second of two in a two-part program to evaluate the effectiveness of thermal integrity profiling applications in auger-cast-in place piles. The first phase (*BDV25-977-09, Thermal Integrity Profiling for Augered Cast-In-Place Piles*) followed a traditional research approach including: (1) a literature review of thermal integrity profiling and heat of hydration concepts, (2) numerical modeling, (3) feasibility of wheel-less gyroscopic inclination measurements for thermal probe systems, (4) field testing and (5) reporting.

1.2 Organization of the Report

This second-phase study entailed three basic tasks: thermal instrumentation and testing of several full scale piles, evaluation of the field collected data, and reporting. These tasks are fully discussed in the ensuing chapters: Chapter 2 and Chapter 3 cover the first two tasks, respectively; Chapter 4 provides an overview, discusses the pros and cons of the various analysis algorithms and includes recommendations.

Chapter Two: Instrumentation and Field Testing

Implementation of the recently concluded research project (BDV25-977-09) findings was conducted in cooperation with a Deep Foundations Institute (DFI) study entitled *“Verification of Installation and Performance of ACIP Piles.”* The overall scope of that study was multifaceted incorporating axial compression, pullout / tension, and lateral load tests as well as forms of verification testing. While verification can include a wide range of destructive and non-destructive test (NDT) methods, this program included on-board Automated Monitoring Equipment (AME), manual monitoring and field inspection, load testing and extraction of one of the installed piles (not used in load testing). NDT in the form of thermal integrity evaluation of all test piles formed the focus of this implementation plan.

2.1 Overview of DFI Study

The DFI study was planned to incorporate eighteen (18) auger-cast piles of various sizes of which seven (7) were slated for some form of testing. Figure 1 shows a plan view of the proposed pile layout at the test site in Okahumpka, Florida.

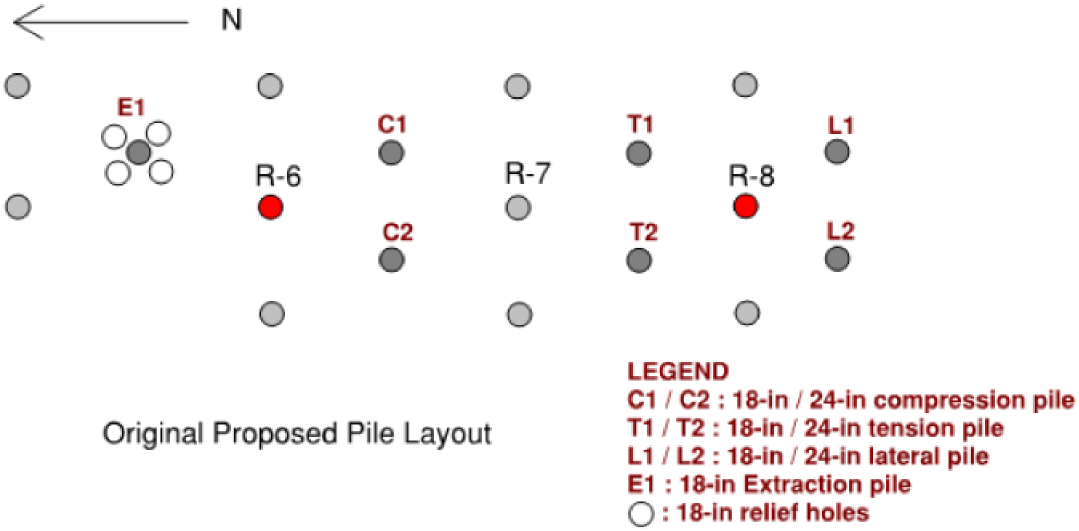


Figure 2.1 Original proposed DFI auger-cast test pile layout (DFI, 2017).

The remaining piles (shown in lighter grey) were reaction piles for the load frame(s) required to apply the axial or lateral loads. As shown, two piles were compression tests (C), two tension tests (T), two lateral load tests (L) and one was planned installed for the express purpose of being extracted (E). The extracted pile was to serve as a direct verification of the on-the-fly computer monitoring system which showed how much grout was placed at what depth and in that way made a prediction of the pile shape. This pile also served as the primary calibration tool for the thermal analysis options discussed as a result of the previous research project (discussed in Chapters 3 and 4).

2.2 Approach

A combination of thermal integrity methods were employed to evaluate the seven test piles. This allowed for a comparative analysis of results to assess the pros and cons of particular methods specific to their use in ACIP piles.

Reinforcement: Combinations of probe and wire methods were used in conjunction with both center bar and cage measurements. However, inherent with each load test type is a required (or preferred) reinforcement scheme. Tension tests required sufficient steel to resist up to 400-500 kips of anticipated load. This translated into a single 100-ksi threaded bar 3in in diameter. Compression load tests rely very little on the reinforcing scheme so more modest reinforcement schemes were used. The lateral load tests, by the nature of bending capacity performance (i.e., compression block vs. distance to tension steel), required a reinforcing cage sufficient to develop bending capacity without cracking at lower service load levels.

For the purpose of this implementation program, single bar reinforcing schemes were coupled with cage location measurements to compare the output results of each (and associated analysis algorithms). Comparisons of single wire versus four wire measurements were incorporated in five of the test piles. The extracted shaft incorporated a full cage with a center bar both of which extended full depth so that all analysis methods could be applied.

2.3 Soil Investigation

Prior to the onset of the instrumentation, construction and testing, subsurface site investigations were performed by the DFI team and showed loose soil conditions at depths below 55 ft. Figures 2.2 and 2.3 show a CPT sounding and SPT boring log, respectively. Complete details are included in Appendix E (DFI, 2017).

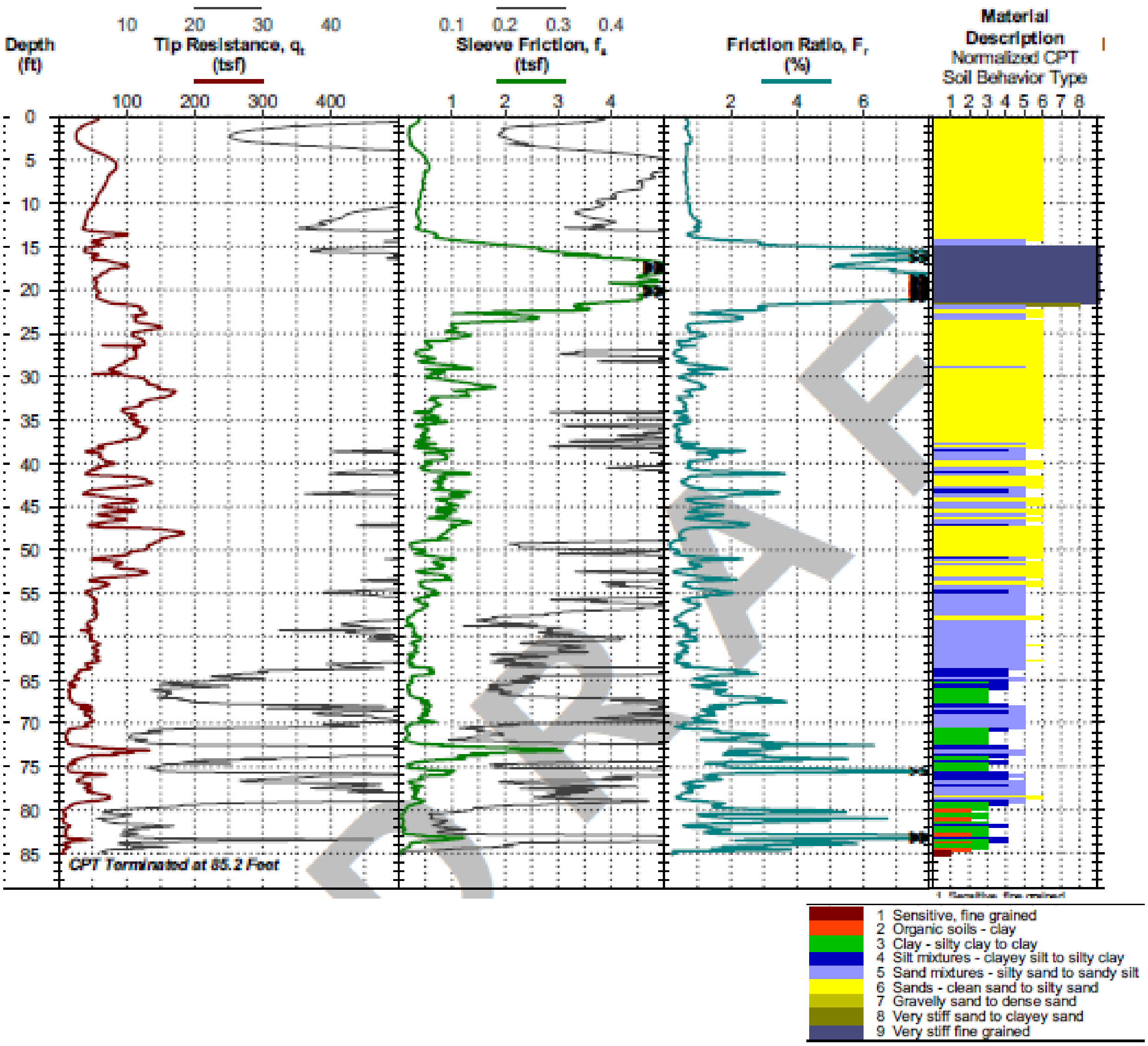
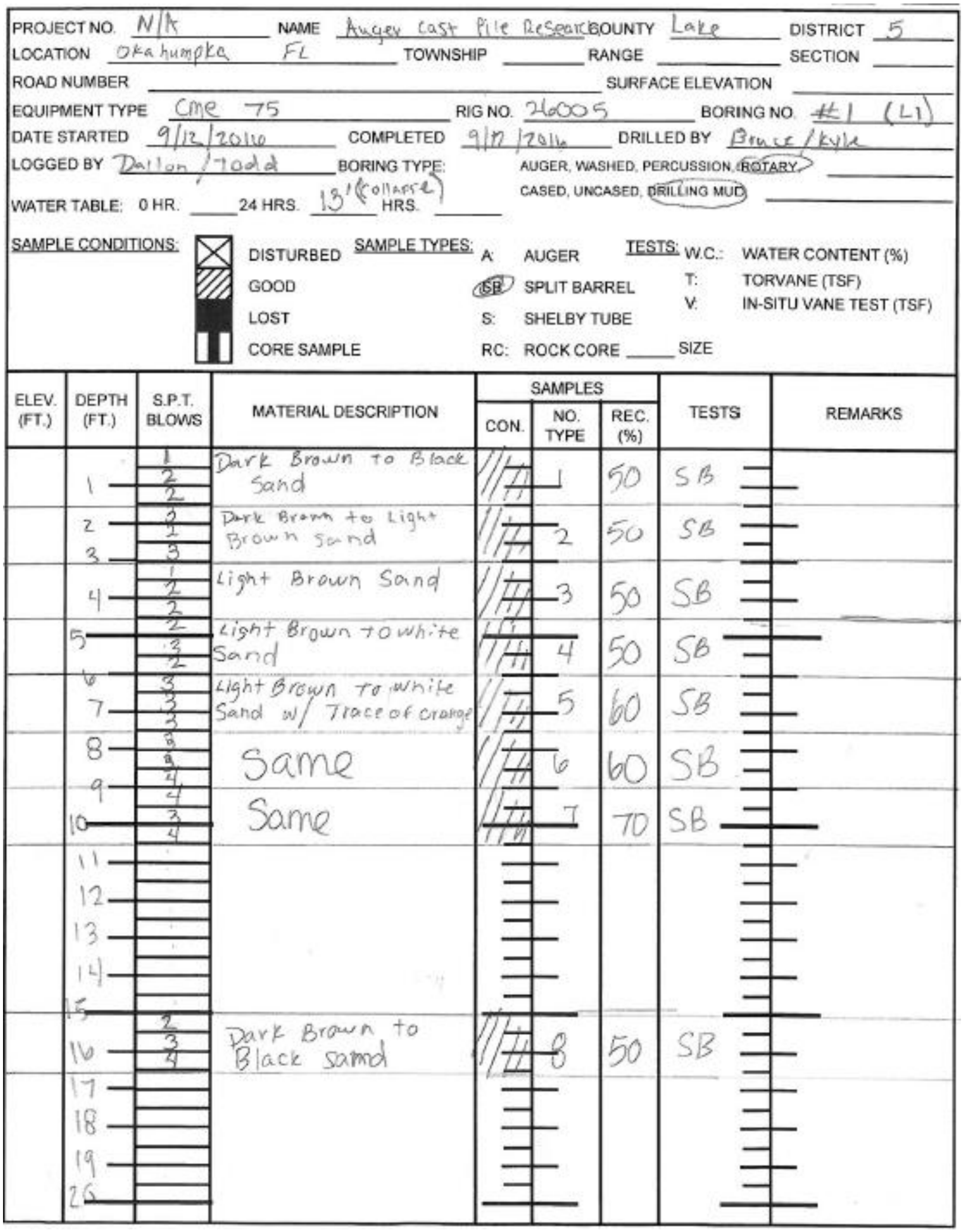


Figure 2.2 CPT sounding for initially proposed DFI test site (DFI, 2017).



PROJECT NO. N/A NAME Auger cast Pile Research COUNTY Lake DISTRICT 5
LOCATION Okahumpka FL TOWNSHIP RANGE SECTION
ROAD NUMBER SURFACE ELEVATION
EQUIPMENT TYPE Cme 75 RIG NO. 26005 BORING NO. #1 (L1)
DATE STARTED 9/12/2016 COMPLETED 9/12/2016 DRILLED BY Bruce / kyle
LOGGED BY Dallon / Todd BORING TYPE: AUGER, WASHED, PERCUSSION, [✓ ROTARY]
CASED, UNCASED, [✓ DRILLING MUD]
WATER TABLE: 0 HR. 24 HRS. 13' (collapse) HRS.

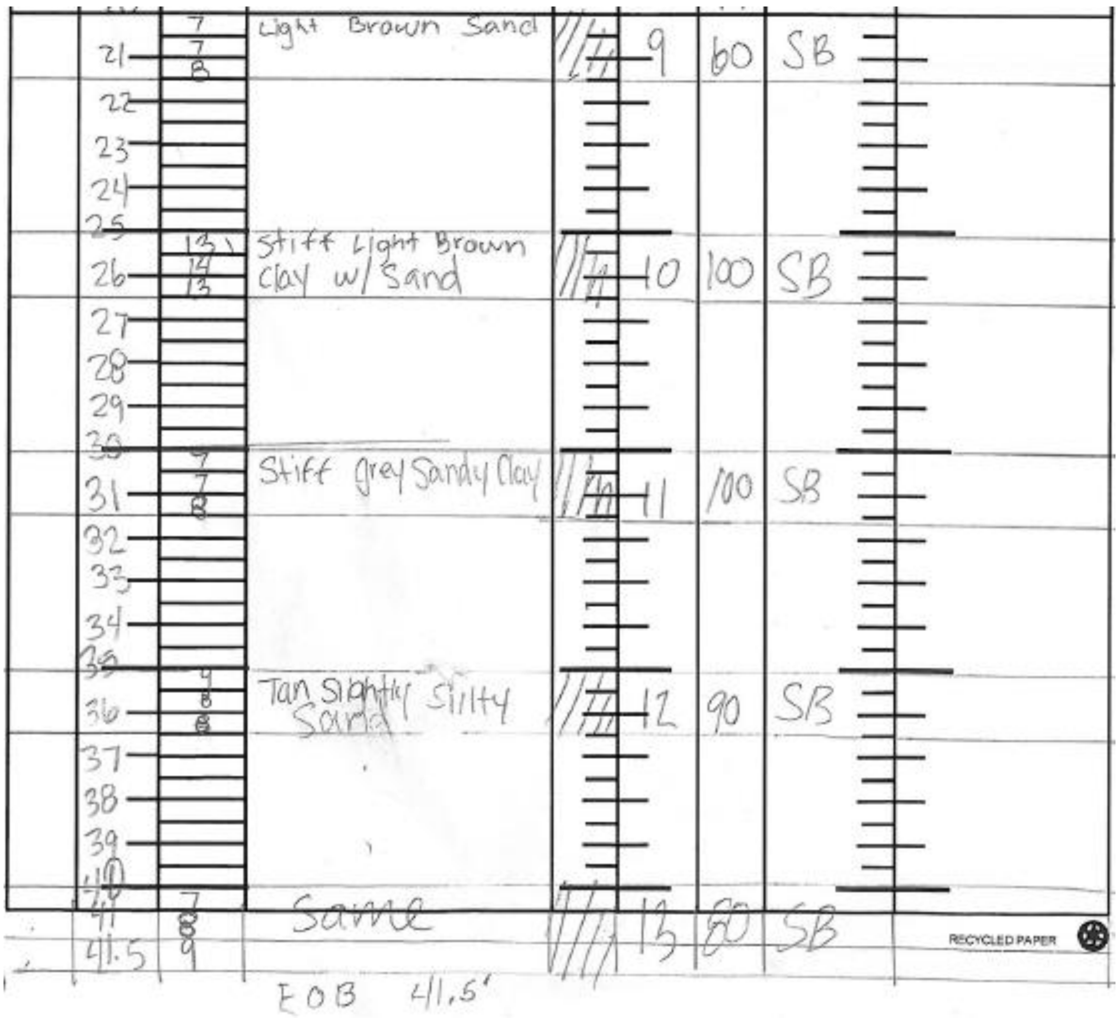
SAMPLE CONDITIONS:
☒ DISTURBED
▨ GOOD
■ LOST
CORE SAMPLE

SAMPLE TYPES:
A: AUGER
[✓ SB]: SPLIT BARREL
S: SHELBY TUBE
RC: ROCK CORE SIZE

TESTS:
W.C.: WATER CONTENT (%)
T: TORVANE (TSF)
V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	1	1 2 2	Dark Brown to Black Sand	▨	1	50	SB	
	2 3	3 1 3	Dark Brown to Light Brown sand	▨	2	50	SB	
	4	1 2 2	Light Brown Sand	▨	3	50	SB	
	5	2 3 2	Light Brown to white Sand	▨	4	50	SB	
	6 7	3 3 3	Light Brown to white Sand w/ Trace of orange	▨	5	60	SB	
	8 9	3 3 4	Same	▨	6	60	SB	
	10	4 3 4	Same	▨	7	70	SB	
	11 12 13 14							
	15 16	2 3 4	Dark Brown to Black sand	▨	8	50	SB	
	17 18 19 20							

Figure 2.3 SPT boring log data for DFI test site (DFI, 2017).



21	7 7 8	Light Brown Sand	9	60	SB
22					
23					
24					
25					
26	13 14 13	Stiff Light Brown clay w/ Sand	10	100	SB
27					
28					
29					
30					
31	9 7 8	Stiff grey Sandy Clay	11	100	SB
32					
33					
34					
35					
36	9 8 8	Tan Slightly Silty Sand	12	90	SB
37					
38					
39					
40					
41 41.5	7 8 9	Same	13	80	SB

EOB 41.5'

Figure 2.3 (continued) SPT boring log data for DFI test site (DFI, 2017).

Based on the findings of the site investigation and logistics, the test program was re-oriented 90 degrees counterclockwise as shown in Figure 2.4 and the final pile size and reinforcement scheme was established as shown in Table 2.1.

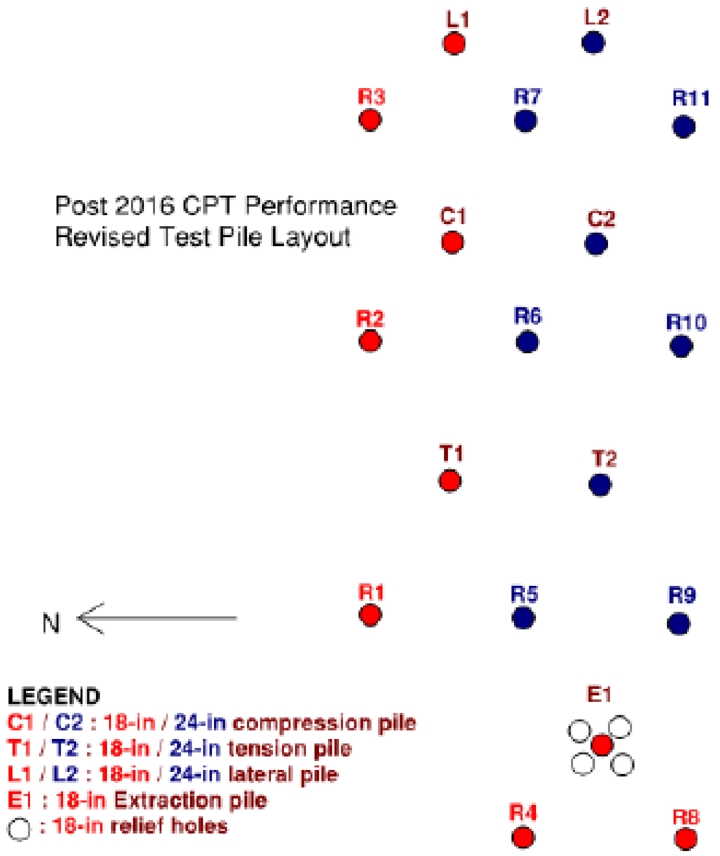


Figure 2.4 Final DFI augercast test pile layout (DFI, 2017).

Table 2.1. Test pile dimensions, reinforcement, and TIP instrumentation.

Pile	Diameter (in)	Length (ft)	Cage Length (ft)	Full Length Center Bar	Access Tubes	TIP Wires		TIP Probe
						Partial Length	Full Length	
E1	18	40	40	3” threaded	--	4	1	No
T1	18	60	--	3” threaded	--	--	1	No
C1	18	60	35	#11	--	4	1	No
L1	18	40	35	#11	--	4	1	No
T2	24	60	--	3” threaded	--	--	1	No
C2	24	60	35	#11	4 (Steel)	4	1	Partial Length
L2	24	40	35	#11	4 (PVC)	4	1	Partial Length

2.4 Instrumentation Installation

The reinforcing scheme in each pile (Table 2.1) defined how each pile reinforcement element was instrumented: plastic or steel access tubes and quantity and length of thermal wires. Upon arrival on-site, all cages were fully assembled and ready for installation of instrumentation. Instrumentation installation involved attaching access tubes and thermal wires and was performed in two visits due to hurricane warnings and evacuations affecting central and east Florida (Oct. 5 and 26, 2016).

Piles C2 and L2 were equipped with both access tubes and thermal wires. While the cages were not intended to extend full depth, the access tubes were slightly extended 1 ft below the bottom of cage for some additional information as there would be no interference with the bottom of the excavation. Access tubes were first installed to prevent damage to wires if installed before access tubes. Tubes were tied with steel tie wire at 2-ft intervals to provide a secure attachment. Wires were tied to the access tubes such that the sensors were all positioned 90 degrees counterclockwise from the inward direction of each tube. This aligned the radial distance from the center of pile to each wire sensor with the centerline distance of each access tube.

Piles C1, L2, and E1 were instrumented with only thermal wires where the same 90 degree counterclockwise orientation of the sensors was used relative to the vertical reinforcing steel bars. Sensors were secured with plastic wire ties where one tie was placed on the upper and lower side of the sensors (i.e., two ties per sensor or foot of wire length). Sensors were spaced at 1-ft intervals. The 24-in piles had twelve No. 8 bars and the 18-in piles had eight No. 8 bars, which made the installation of four wires conveniently spaced on multiples three bars for the 24-in piles and two bars for the 18-in piles. Excess wire length was bundled and attached to either the top of the access tubes or reinforcing bars (Figure 2.5). Figures 2.5 - 2.8 show each of the five reinforcing cages and the center bars that were instrumented with a single wire similarly secured with two ties per sensor.

Figure 2.5 Bottom end view of reinforcement cages for 24-in piles C2 (left) and L2 (right) instrumented with thermal wires and access tubes for thermal probe testing.

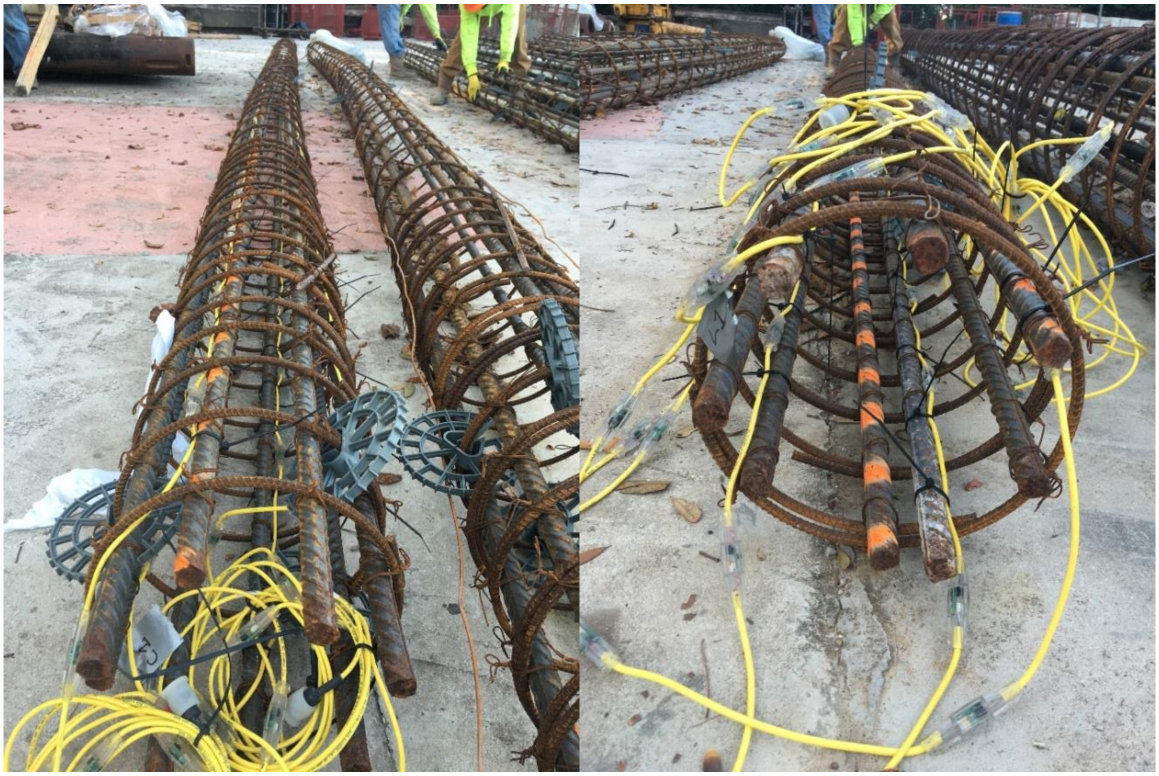


Figure 2.6 Top end of piles C1 (left) and L1 (right) reinforcement cages instrumented with thermal wires.

Figure 2.7 Pile E1 reinforcing cage with thermal wires attached.

Figure 2.8 3-in center bars (left) and #11 center bars (right) instrumented with thermal wires.

2.5 Pile Construction

While not the focus of this report, the construction of each test pile followed conventional ACIP pile construction practice where a full length continuous flight auger was slowly advanced into the ground while constantly spinning until the target depth of pile was reached. Grout was then pumped through the hollow stem central portion of the auger while slowly extracting. Several pump strokes of grout were initially placed prior to auger extraction. During extraction, the pump flow rate and extraction rate were kept as constant as possible to ensure uniform distribution of the grout. Upon complete extraction of the auger, the reinforcing steel was lowered down into the still-fluid grout. For piles with both center bars and cages, the center bar was installed first followed by the surrounding cage.

Pile installation records and the full construction process are reported elsewhere (DFI, 2017). However, selected components of the report are included in Appendices C, D, and E.

2.6 Thermal Testing

With two types of thermal systems installed on the reinforcing cages, two simultaneous testing efforts resulted using probe and thermal wire methods.

2.6.1 Probe Testing

Probe testing is usually only performed once, at a time that is near the peak temperature (ASTM 2014). At that time, the quality of the data is immediately evaluated by the testing engineer (or technician). If all profiles are clear and the data meaningful, then no more testing is required. However, for this study probe testing was performed on 6-hr intervals starting 6 hours after the piles were cast and continued up to 24 hours after casting. Each tube was profiled twice during each 6-hr interval/visit. Figures 2.9 - 2.11 show probe testing being performed at various stages of the curing/hydration process. For these tests an automated, reel-type system was used which frees the testing engineer to perform multiple field functions at once.

Figure 2.9 Automated reel and data collection system used for probe testing.

Figure 2.10 Overnight probe testing.

Figure 2.11 Probe testing pile C2 at approximately 24 hours after pile installation.

Per ASTM D7949, probe testing was performed by taking temperature measurements as the probe descended at a rate of 0.3 to 0.5 ft/sec. The initial position of the infrared viewing windows in the probe was always well above the top of pile to ensure capturing the transition from the cooler air environment to the warmer curing pile concrete. This clearly demarcates the top of pile location and serves as a reference for pile length. In this case access tubes were only partial length, so no analogous bottom of pile transition could be recorded. Figures 2.12 and 2.13 show thermal profiles from each of the piles that were equipped with access tubes for thermal probe testing.

Figure 2.14 shows the average temperature profiles from one of the piles over the duration of testing. Data from all tests and profiles are included in Appendix A.

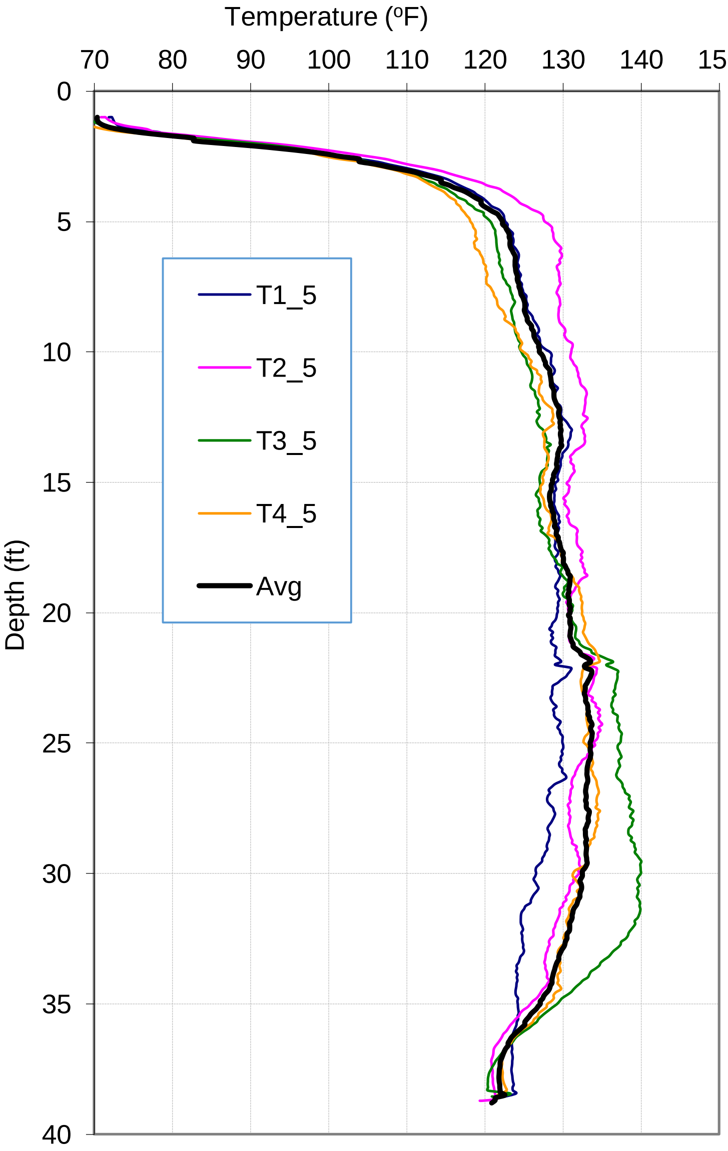


Figure **2.12** Temperature profile for pile C2 at peak temperature taken via probe system.

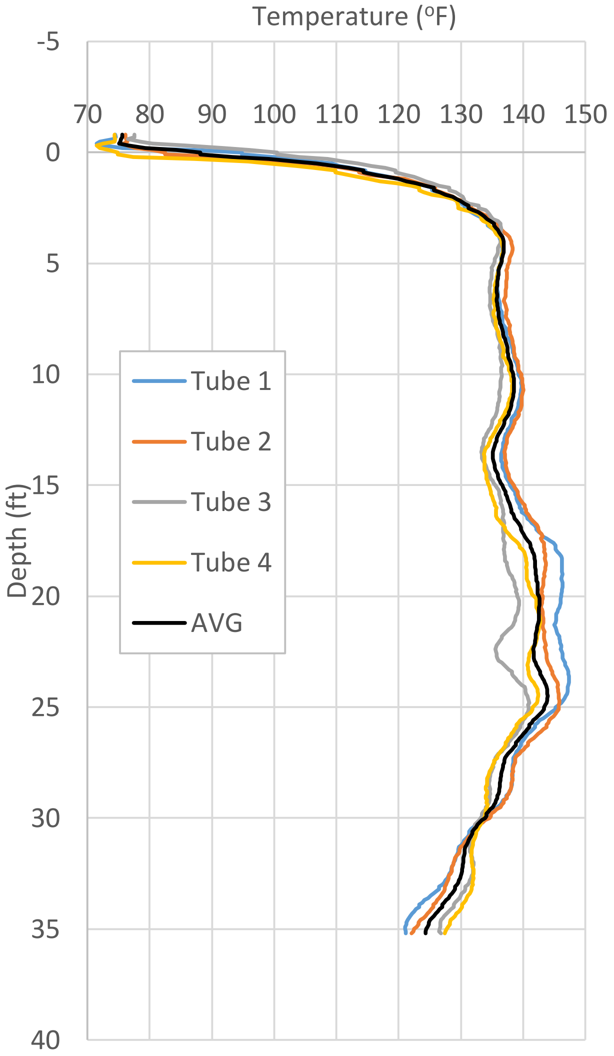


Figure 2.13 Temperature profile for pile L2 at peak temperature taken via probe system.

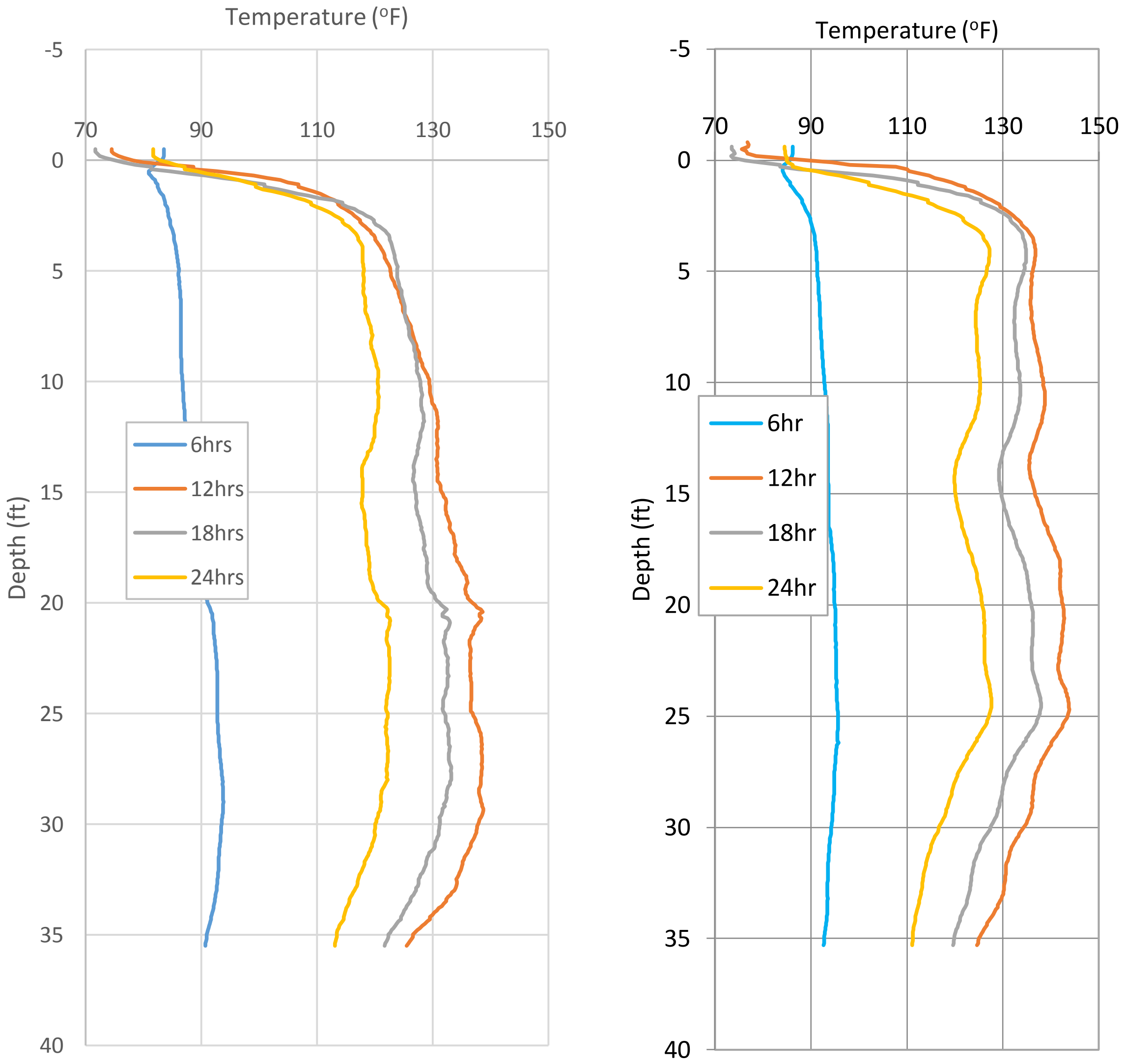


Figure 2.14 Pile C2 (left) and L2 (right) profiles from probe data taken on 6-hr intervals.

2.6.2 Thermal Wire Testing

Thermal wire testing has the inherent advantage to the field technician in that no planning is necessary to ensure thermal testing aligns with the anticipated peak temperature timeframe. Rather, data collectors (TAP units / **T**hermal **A**ccess **P**orts) are attached to the wires immediately after casting or as soon as access is granted and data is continuously taken up to and beyond the peak temperature occurrence. The disadvantage is that the quality of the data is not known until after retrieval of the TAP units and the data is downloaded. Figures 2.15 – 2.21 show the TAP units attached to each of the test piles.

Figure 2.15 Pile E1 with thermal wires and attached TAP units.

Figure 2.16 Pile L1 with thermal wires and attached TAP units.

Figure 2.17 Pile C1 with thermal wires and attached TAP units.

Figure 2.18 Pile T1 with thermal wires and attached TAP unit.

Figure 2.19 Pile L2 with thermal wires and attached TAP units.

Figure 2.20 Pile C2 with thermal wires and attached TAP units.

Figure 2.21 Pile T2 with thermal wires and attached TAP unit.

Due to the continuous data collection feature of thermal wire data, not only can thermal profiles be collected, but also time vs temperature relationships can be derived. Figures 2.22 and 2.23 show examples of thermal wire data collected from one of the test piles and the associated temperature trace from a selected elevation, respectively. All thermal profiles from wires and temperature traces from each pile are included in Appendix A.

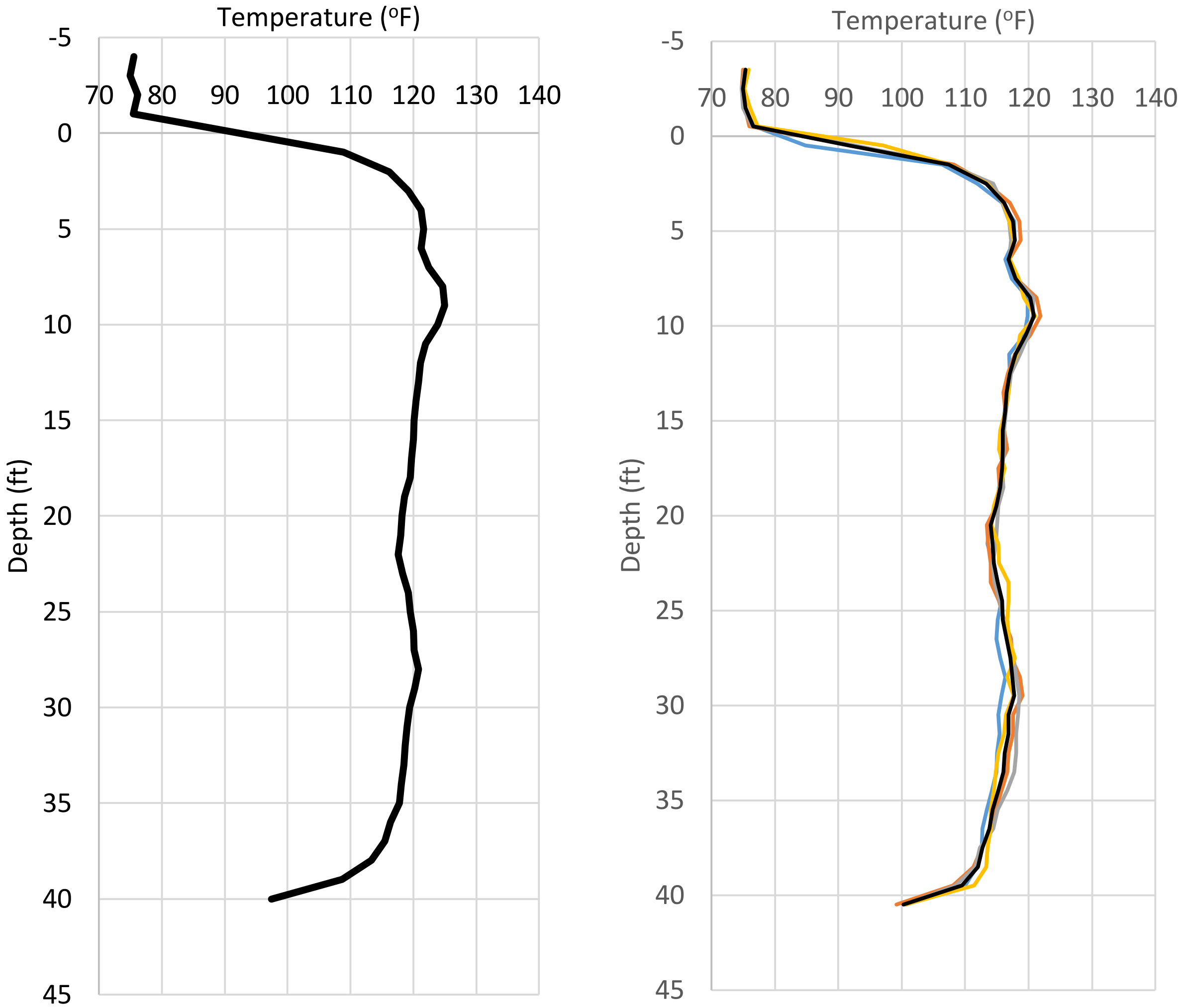


Figure 2.22 Pile E1 center bar thermal wire data (left); cage wire date (right) at 15 hours.

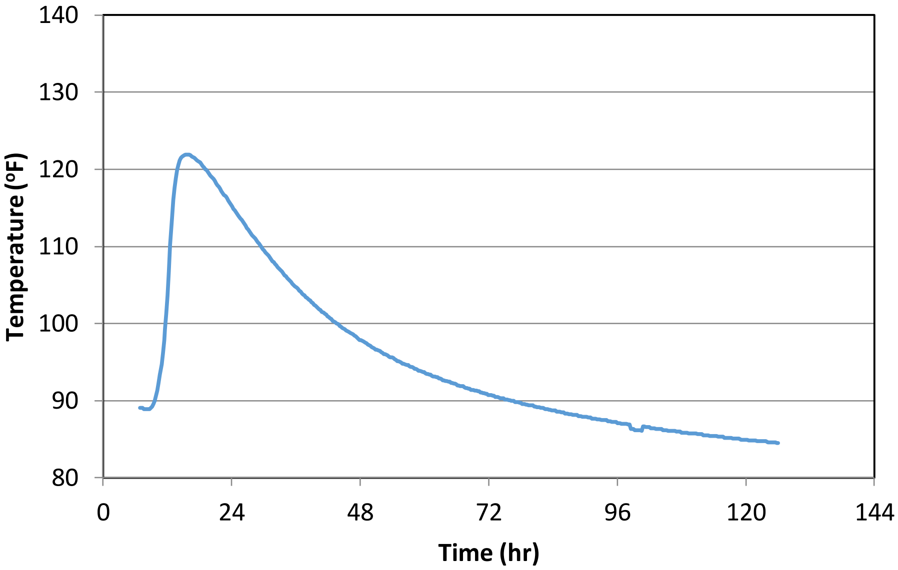


Figure 2.23 Temperature vs. time for pile E1 center bar wire from 10 ft below pile top.

2.7 Extraction and Physical Dimension Measurements

Only one of the test piles was extracted for evaluation of as-built dimensions. Four relief holes were drilled around pile E1 to reduce side shear, and the pile was removed using the central threaded bar. The pile was cleaned and measured via manual measurements. Two different teams measured the circumference on 1-ft intervals down the pile. These measurements were then converted to the equivalent diameter, which assumed the pile was circular in section and that there were no significant voids or bulges. Using a large-scale caliper, direct measurements of diameter were taken at 90 degree locations down the length of the pile (i.e., two measurements per depth location). The results of the actual diameter were then used to assess the true as-placed volume of the pile and then compared to the predicted volume per pump strokes from the automated installation recorder. These data are presented and discussed in Chapter 3. Figure 2.24 shows the extracted pile marked on 1-ft intervals from top to bottom.

Figure 2.24 Extracted pile shape from top to bottom (left to right and down).

Chapter Three: Results of Testing and Analysis Methods

Both thermal probe and wire systems were used to collect data over an extended period of time. The evaluation of the data focused on: measurement system (i.e., probe or wire), access tube material, measurement location (i.e., center vs cage), analysis techniques, grout volume determination, and required input parameters for thermal analyses when converting temperature to radius (or diameter). Note that radius predictions apply to local cage position measurements with multiple locations within the cross-section; single-location, center bar measurements can only produce an average diameter for the pile at that depth. Throughout this chapter, cage based radii predictions are compared to average radii (not diameter) from center bar data for clarity.

3.1 Measurement Systems

The choice of whether to use probe or wire systems revolves largely around the owner's (or contractor) testing strategies or philosophy. For sites where other test methods will be used that require access tubes, the probe system adds no additional cage preparation time as access tubes will already be available. However, a testing engineer or technician must be scheduled to arrive and perform probe profiling near the peak temperature (to ensure the highest possible definition of shaft dimensions is obtained). Thermal wire systems require similar cage preparation times when compared to access tube installation but if dual access tubes and wires are used, both the time of installation and overall system costs increase. Ideally, from a cost standpoint, replacing tubes with thermal wires would be about the same. Scheduling for wire systems has the advantage over probe systems as continuous data collection ensures the peak temperature profile is captured. So, in certain cases the thermal testing engineer or technician may not need to visit the site at all (when the contractor team has developed a level of installation and operation competence). Increased care should be observed when installing any wire-based instrumentation. However, even under close supervision of the wire installation and construction processes, the wires are vulnerable to damage. Likewise, data may not be collected if the storage units are not properly maintained (kept charged and safe from vandalism) or when wires are cut.

For this project, piles C2 and L2 where equipped with both access tubes and thermal wires. For both piles, four access tubes were installed where wires were attached to each tube such that they would lie along the same radial position as the center of the tubes (i.e. same radial distance from center). Both piles also had a center bar that was only instrumented with a wire so no direct comparison between center access tubes and wires could be made. Figures 3.1 and 3.2 show the thermal profiles for piles C2 and L2, respectively, measured using both the probe and wire methods. Recall the wires were tied along the side of the access tubes such that the wire position radius would be the same as the center of the tubes relative to the center of the cage. In some of the wire profiles sensor failures occurred; wire 1 on pile C2 experienced failures for all nodes below 5 ft, and wire 3 experienced failures for nodes at 32 and 33 ft.

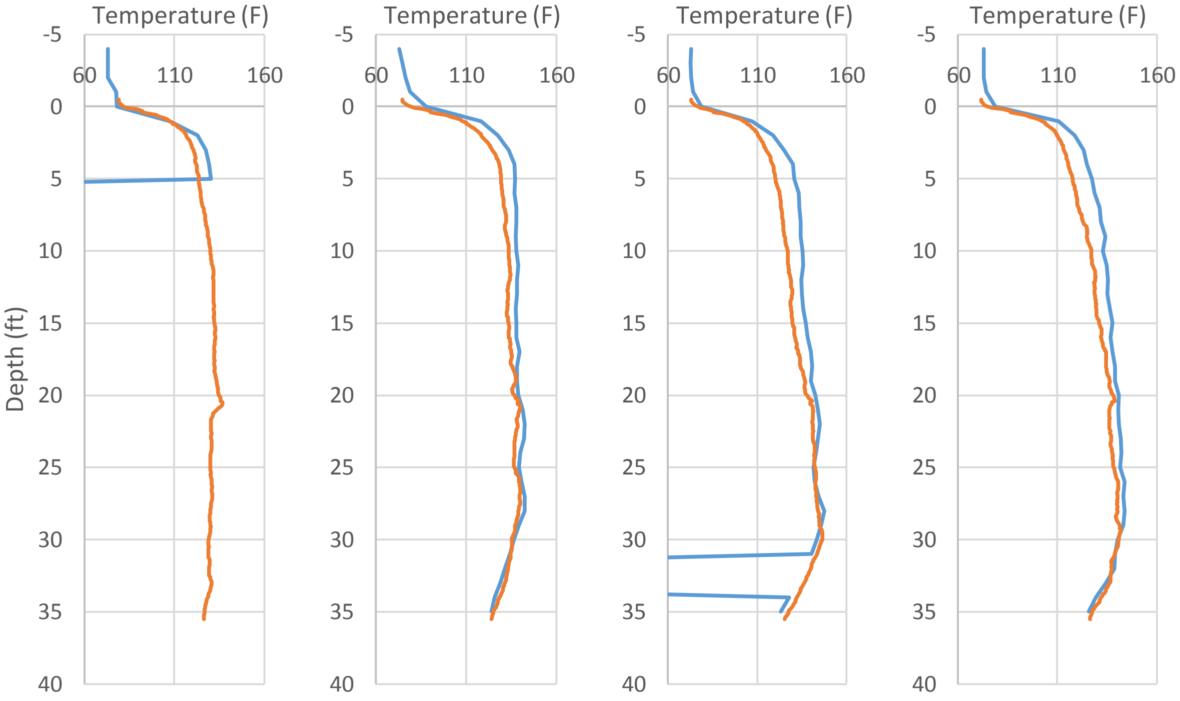


Figure 3.1 Pile C2, probe in steel (orange) and wire (blue) measured thermal profiles for each tube 1 – 4 (left to right) near peak temperature.

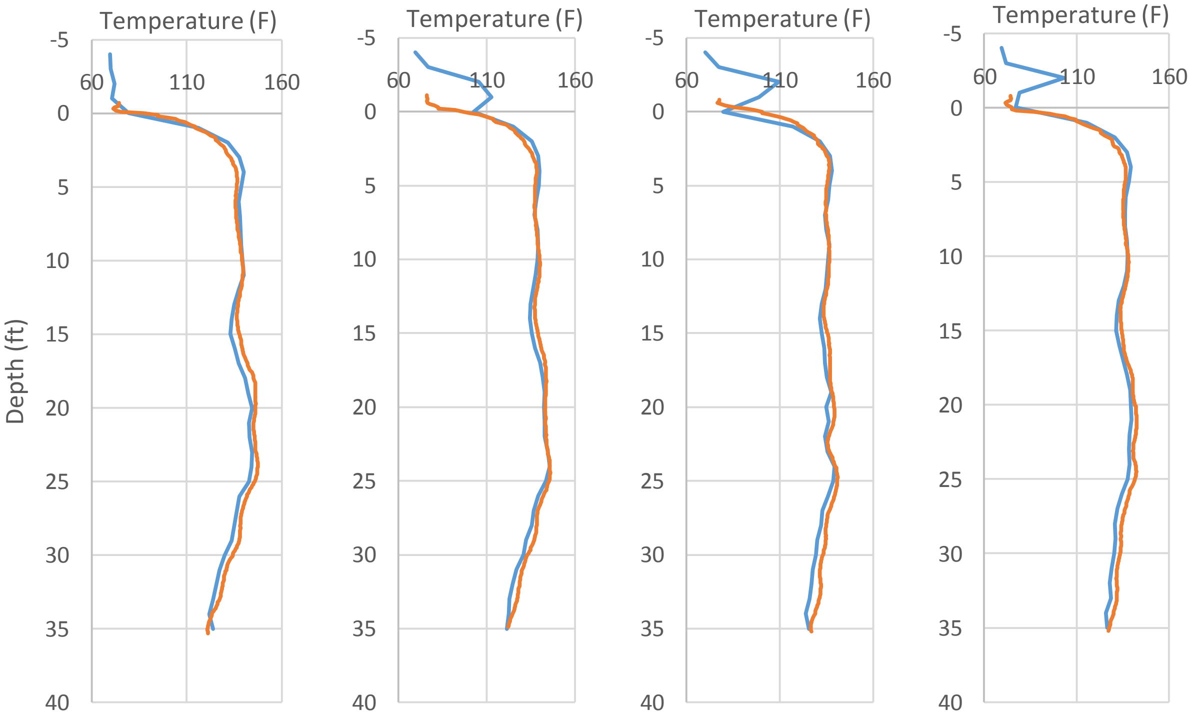


Figure 3.2 Pile L2, probe in PVC (orange) and wire (blue) measured thermal profiles for each tube 1 – 4 (left to right) near peak temperature.

While not usually performed via probe testing, thermal wire options provide temperature versus time information which is helpful in assessing the cementation material performance. For this project, however, both probe and wire systems were used to collect data over an extended period of time. The results indicated that both systems showed close agreement. Figure 3.3 shows an example temperature versus time response for pile C2 at a depth of 30 feet for both systems.

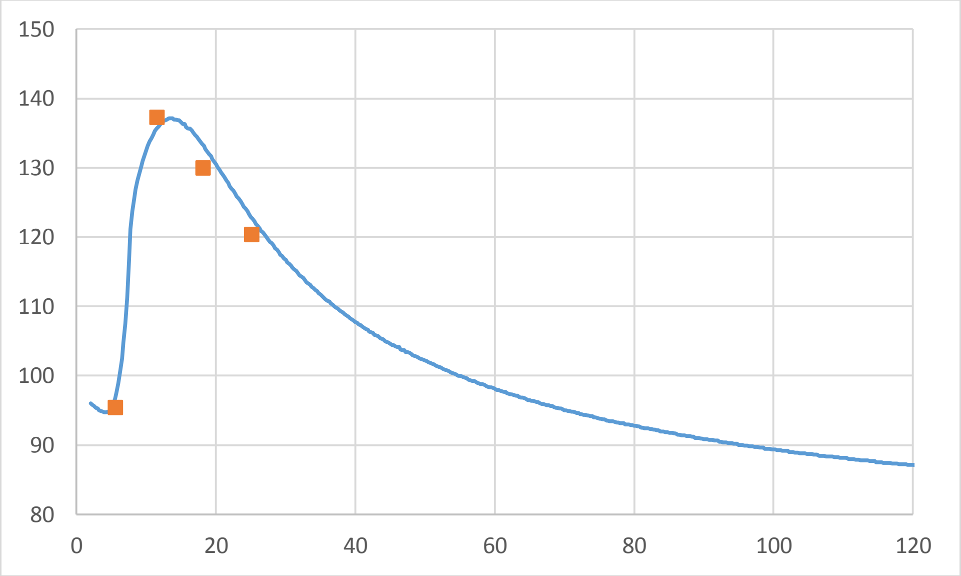


Figure 3.3 Pile C2 temperature vs. time from wire data (blue) and probe data (orange).

While Figure 3.3 shows the temperature versus time response at a depth of 30 ft, this type of plot can be produced for any depth where a measurement was taken. The most important aspect of these curves is the ability to denote the presence of a typical hydration response and if retarders are used, the performance of the admixture can be verified.

3.2 Access Tube Material

Probe testing can be performed in any preformed hole usually provided via plastic or metal access tubes. Whether to use plastic or metal is again an owner decision. Western state DOTs tend to be more willing to use PVC and cite no adverse effects. For those agencies added benefits from using PVC include less signal attenuation from gamma radiation based systems and increased ease in jetting out pockets of debris or anomalous formations. Southeastern state DOTs have a different experience base and prefer the use of steel access tubes. Nevertheless, both materials have about the same incidence of debonding failures which suggests other variables such as contractor practices may play a significant role. This is not the focus of this access tube material comparison.

Side-by-side testing of probe in steel access tubes and wire systems for larger drilled shafts has shown no adverse effects despite weather (time of year, cold or hot). However, for the smaller diameter piles tested here, there was a clear indication that the cooler fall weather influenced the upper portions of the probe measurements. Probe testing was performed using steel access tubes in pile C2 (Figure 3.1 above) and PVC access tubes in pile L2 (Figure 3.2). Both piles showed general agreement between the two methods except for slight discrepancies in the upper portion of pile C2 (steel tubes) where the probe measured slightly lower temperatures than the wires. This is not surprising given the surface area of four steel tubes compared to the small mass of energy-producing cement and the ability of the 2-ft exposed steel tubes to dissipate heat energy to the air. Recall early mass concrete assessments compared the dissipation shaft surface area to the overall shaft volume. Similarly, the surface area of the steel tubes increases the ability to locally lose heat to the surroundings. The low diffusivity PVC showed no effects. When only thermal integrity testing is used for a given site, installation of dry PVC tubes allows the contractor to skip the water-filling process, thereby reducing de-watering testing time, and lowering the overall cost of integrity testing.

3.3 Measurement Location

Five of the seven test piles were instrumented with both center bar and cage position temperature systems (two of which also included access tubes on the cage as noted above). Based on normal temperature distributions within a cylindrical hydrating foundation element, it is well understood that the centermost positions will be warmer than more peripheral positions closer to the surrounding cooler soil. This is especially true for smaller diameter ACIP piles, and for Pile E2 this phenomenon was clearly demonstrated where the center bar temperatures were consistently and uniformly warmer than the cage temperatures (Figure 3.4). However, for several other piles the average of cage-located measurements was consistently cooler near the surface (normal), but came to the same temperature as the center bar at depth. This showed that the center bar was not centered.

Piles C1 and C2 could not be used to produce reliable average profiles due to missing data from malfunctioning wire sensors; those comparative graphs were not prepared. However, the same basic trends can be seen in Figures A.3 and A.4 where the center bar was generally warmer than cage position measurements (Appendix A).

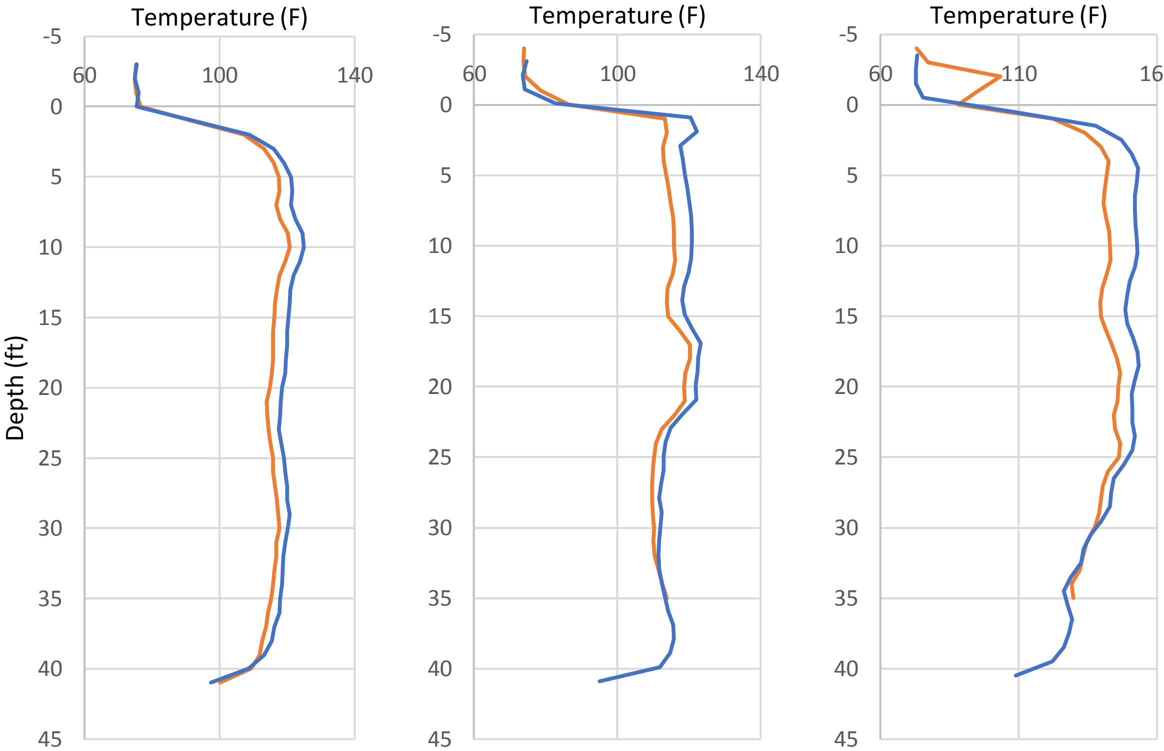


Figure 3.4 Pile E1 (left), L1 (center), and L2 (right) – average cage wire data (orange) compared with center bar wire data (blue).

Previous studies and projects have shown the value of at least four cage based temperature measurements in providing an indication of cage offset from concentricity with the excavation. For ACIP piles, the small cross section and construction process almost completely removes the possibility of full length cages for the proper assessment of the cage eccentricity and pile integrity. As a result, use of instrumented single center bars (with wires) has become widespread. The downside is the loss of valuable information. However, in the high bending moment regions beneath the pile cap, cages can be used even for small piles (e.g., 12-in cages used in this study).

Using the individual cage position temperature measurements the cage offset was qualitatively assessed to ascertain the relative location of the center bar. Figure 3.5 shows the complete profiles for piles L1 and L2 and indicates the center bar, which was well centered at the top of pile, gradually aligned with the cage at a depth of 15 and 20 ft, respectively, and was adjacent to the cage from that point to greater depths.

For Pile L1, the average cage measurement profile indicates a bulge from 15 to 25 ft. The center bar measurements reflect the same general shape, however, at one point the cage temperature exceeded the center bar temperature indicating that in the bulge region, the cage was positioned to the north and pushed the center bar out of the higher temperature core. Wire 3 (southern-most side of cage) at that depth was then the most centered sensor string. Below the bulge the cage measurements gradually converge to the same temperature (at 30 ft) indicating the cage is then centered. However, the center bar temperature at that depth is the same as the cage from that depth downward indicating the center bar is nestled into the cage (same radial position). Given a nominal cage OD of 12 in (ID of 11 in) and that the bar temperature is the same as the cage position measurements, the center bar can be located approximately 5.5 in off-center (the distance from the center of cage to the center of the main vertical reinforcement. *Note: where it seems unlikely to have the center bar colder than the cage at a given depth, it is actually reasonable provided that the average of all cage measurements is still cooler than the center bar measurement.*

For Pile L2, like Pile L1, the cage appears to have moved laterally where Wires 2 and 3 are warmer than the other cage temperatures and are the same as the center bar at 20 ft. At a depth of 30 ft all four cage wires are the same temperature indicating a perfectly centered cage, but because the center bar shares the same temperature as all cage temperatures, the center bar is touching the cage between Wires 2 and 3. With a nominal cage OD of 18 in (ID of 17 in) and given the bar temperature is the same as the cage position measurements, the center bar can be located 7.5 in off-center. *Note: wires were tied to the side of 2-in OD access tubes which slightly changed the radial position relative to L1 where wires were tied to the side of No. 8 main bars.*

The same review was applied to the remaining piles: C1, C2, and E1:

- Pile C1, the center bar and Wire 3 have the same temperature at 35 ft, so the center bar is part of the cage at that depth (Figure 3.6, left); cage offset cannot be evaluated due to missing opposite side measurements within the cage.
- Pile C2, the center bar has the same temperature as Wires 3 and 4 again showing the center bar to be nestled within the cage (Figures 3.6, right); as the average of Wires 2 and 4 (125 and 130^{o}F at 34 ft) is similar to the center bar, the center bar has moved closer to Wire 4, yet the cage, qualitatively, is fairly well centered.
- Pile E1, the cage is well centered throughout with a moderate amount of offset at a depth of 30 ft (115 to 118^{o}F variation). The average of all cage measurements is consistently several degrees less than the center bar indicating the bar is centered within the excavation and the cage movement into the higher temperature core explains why Wire 2 is almost as warm as the center bar. At the very bottom of the pile, the center bar becomes cooler than Wire 4 indicating center bar deviation from center.

Overall, the 18-in piles can be quickly identified relative to the 24-in piles due to the normal cage temperature (115^{o}F for 18-in or 140^{o}F for 24-in) and center bar temperatures (120^{o}F and 150^{o}F, respectively) which were 25 to 30^{o}F cooler.

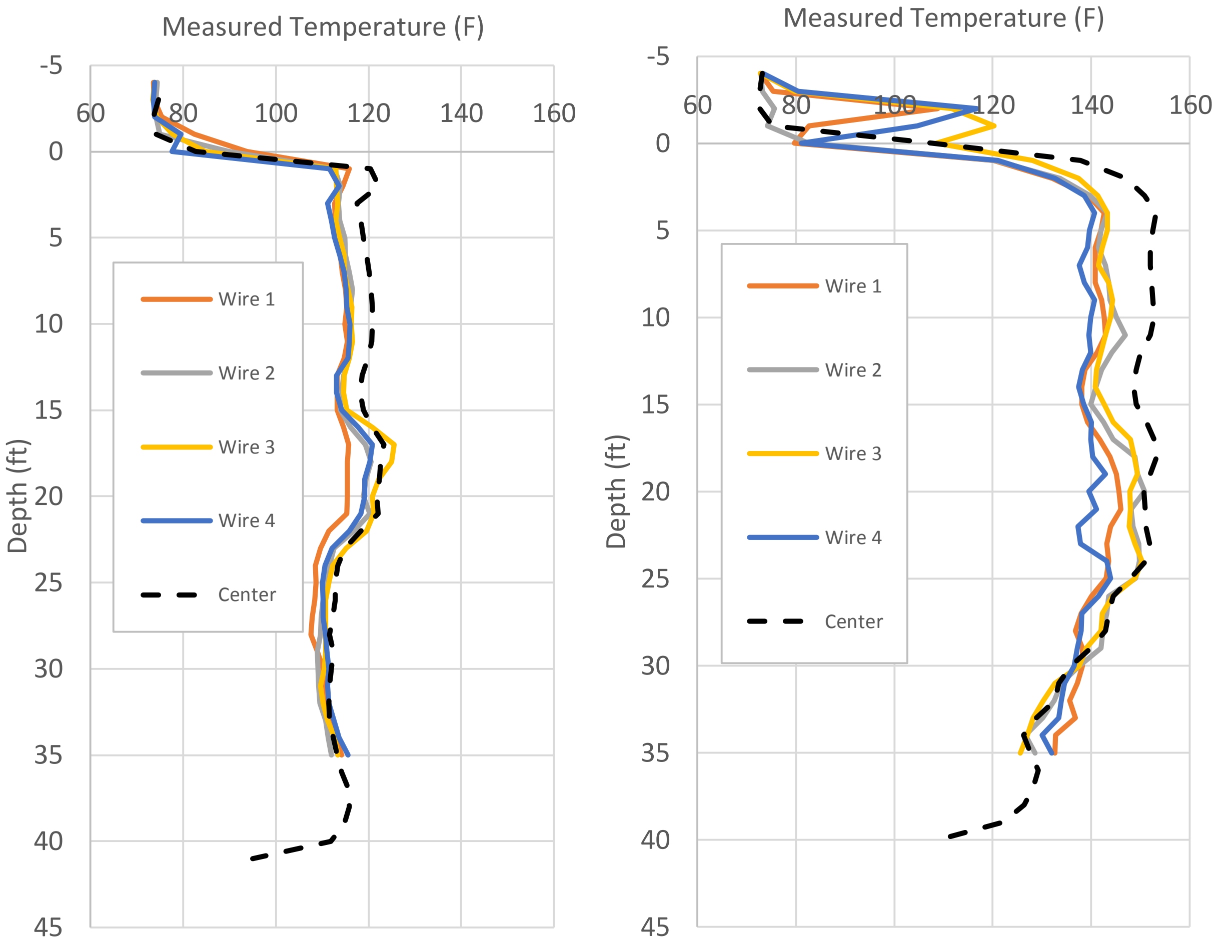


Figure 3.5 Pile L1 (left) center bar temperature aligns with cage from 15ft downward; Pile L2 (right) from 20ft downward.

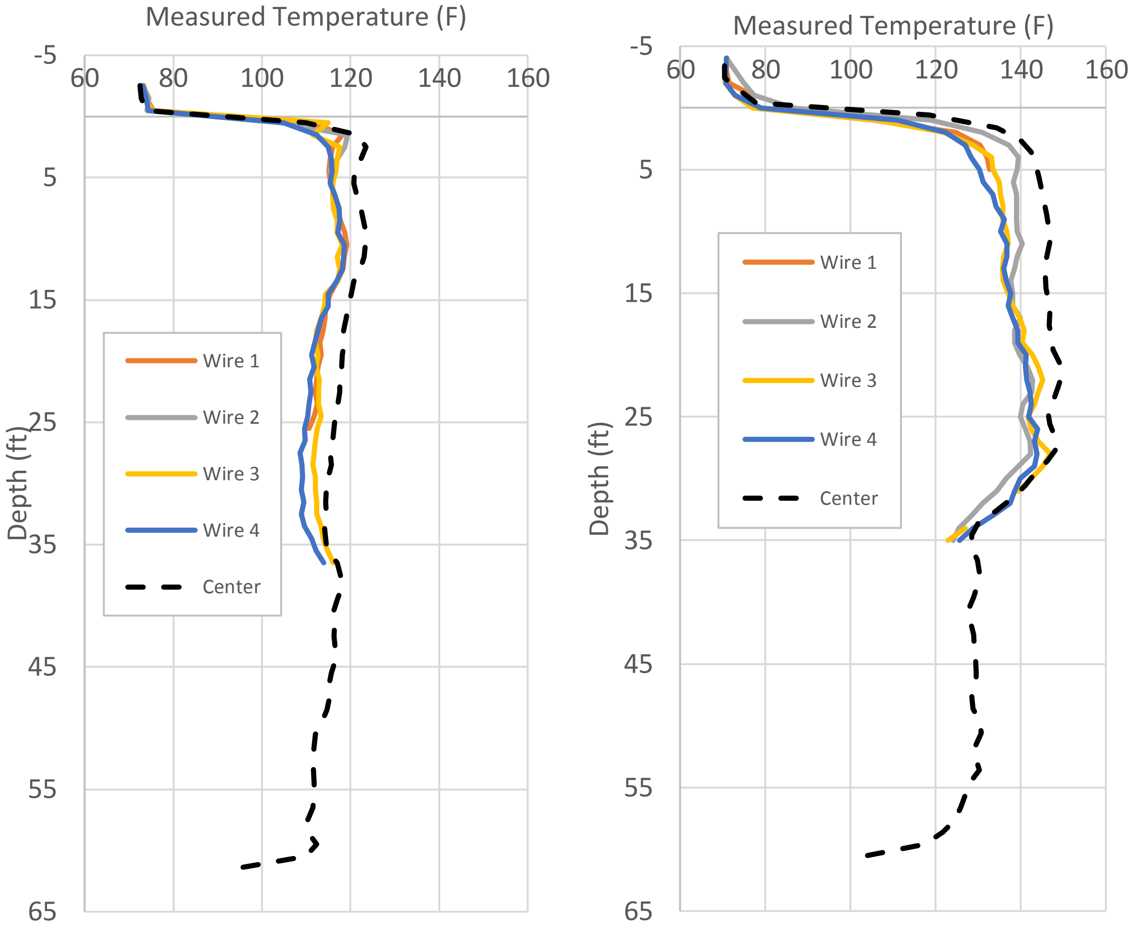


Figure 3.6 Center and cage measurements for Pile C1 (left) and C2 (right).

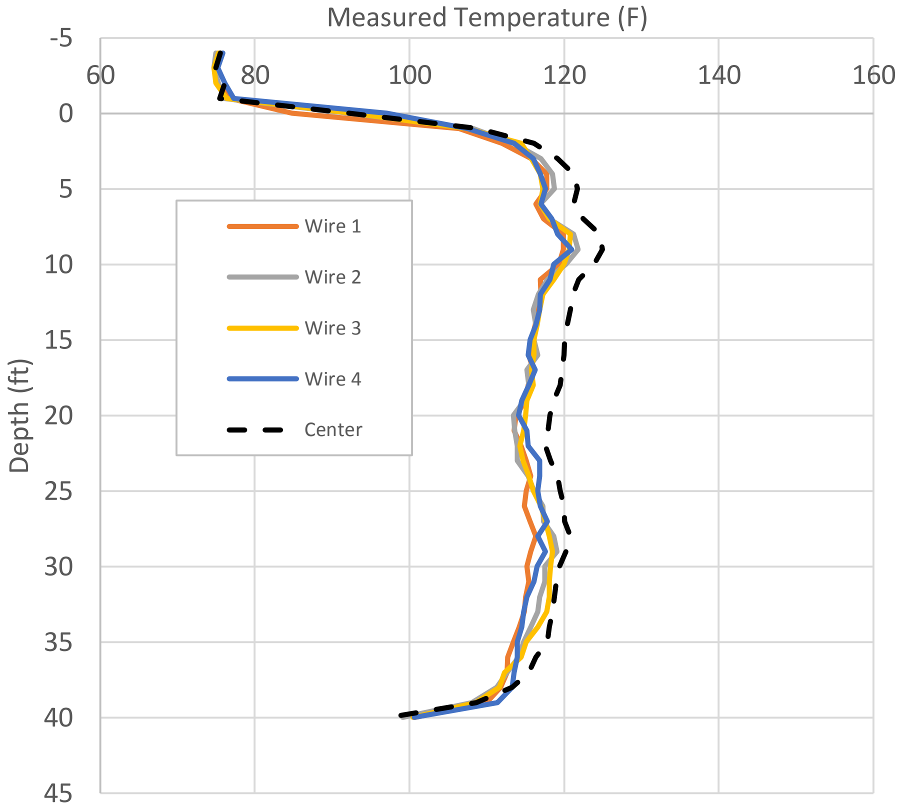


Figure 3.7 Center and cage measurements for Pile E1.

3.4 Analysis Techniques

Analysis of thermal profiles can be qualitative or quantitative whereby field observations of thermal profiles can quickly reveal the overall pile (or shaft) quality. As noted in Section 3.3, simple observations of cage-based measurements indicate the presence or absence of cage offsets and the basic shape of the foundation element. These reviews identify the limits of the concrete (or grout) in the form of length, and the relative temperature differences can be explained by changes in local radius relative to the rest of the profile (discussed above).

Quantitative evaluations can employ numerical modeling or simple concrete (or grout) volume distribution where the total placed volume is converted to local pile or shaft radii along the shaft length proportional to local temperature. Often, the total placed volume is known, but the final resting place and shape of the concrete mass is not. Thermal profiles locate the concrete. In essence, the average temperature profile is integrated over depth and the total “area under the curve” is equated to the total placed volume. This makes a simplistic assumption that a linear temperature-to-radius relationship can represent the actual shape of the temperature-to-radius equation which is best represented by an inverse hyperbolic tangent function. The hyperbolic function requires numerical modeling to precisely define, but input parameters for hydrating cementitious materials are at best estimates. Day to day changes in bulk materials can change the as-placed energy production and temperature rise. Therefore, models must be signal matched to field data until the input parameter selections produce the correct temperature profile.

Alternatively, simple field calibration of the hydration energy can be used where the average overall shaft or pile temperature is equated to the average shaft or pile radius. This is the method used for drilled shafts, but cage measurements on a shaft are considerably farther away from the center than in ACIP piles. This means that shaft cage measurements are in a strongly linear portion of the temperature / radius, bell curve (Figure 3.8).

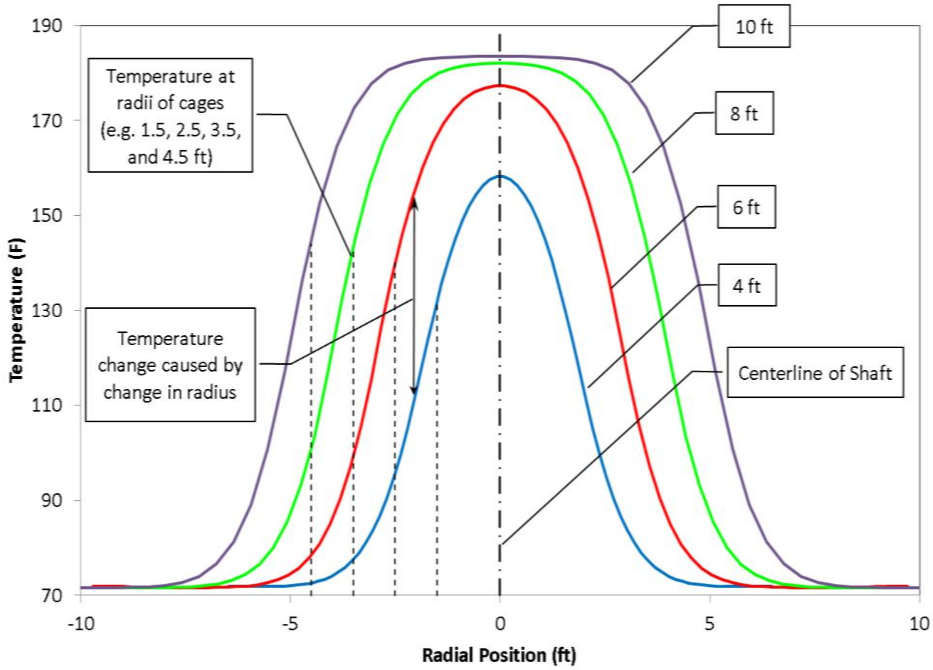


Figure 3.8 Typical temperature / radius plot or bell-curves (Part I, Figure 2.11; Mullins, 2012a).

The shape of the bell curve is similar to the temperature reduction that occurs at the top and bottom of the shaft (or pile) as the temperature profile transitions to the air or soil, respectively. The effect of radius increase or decreases also follows the same trends as shown in Figures 3.9 and 3.10. Figure 3.9 shows the overall effect of all shaft sizes and measurement locations, while Figure 3.10 shows a shaft specific temperature / radius (T-R) relationship where the measurement position within the foundation element is fixed dependent on the cage radius relative to the shaft radius. In both figures, the dashed black lines denote the T-R relationship at the location of the cage which is 6 in smaller than the shaft (which is the typical FDOT cover requirement). In other states, a smaller cover may be permissible or prescribed based on the shaft diameter.

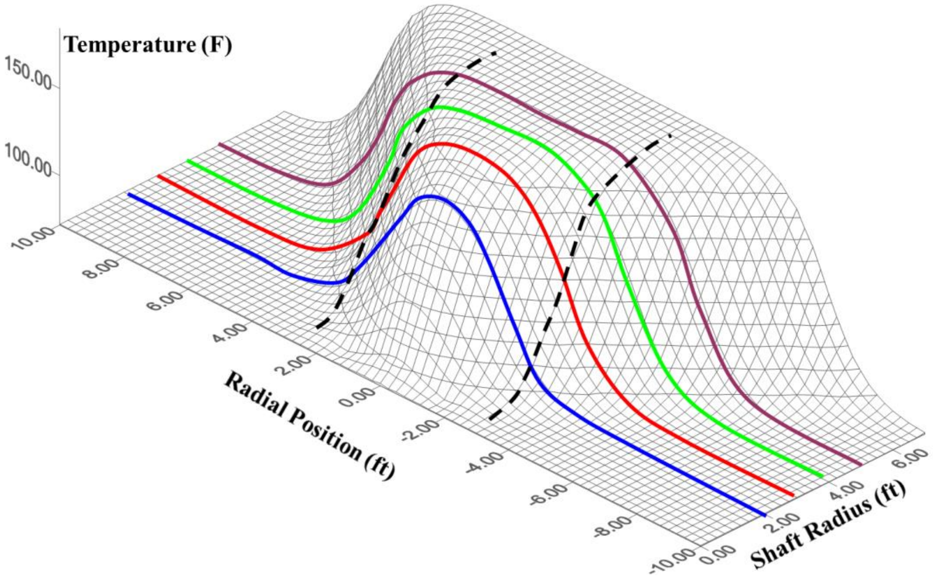


Figure 3.9 Relationship between cage position, shaft size, and temperature (Part I, Figure 2.12; Mullins, 2012a)

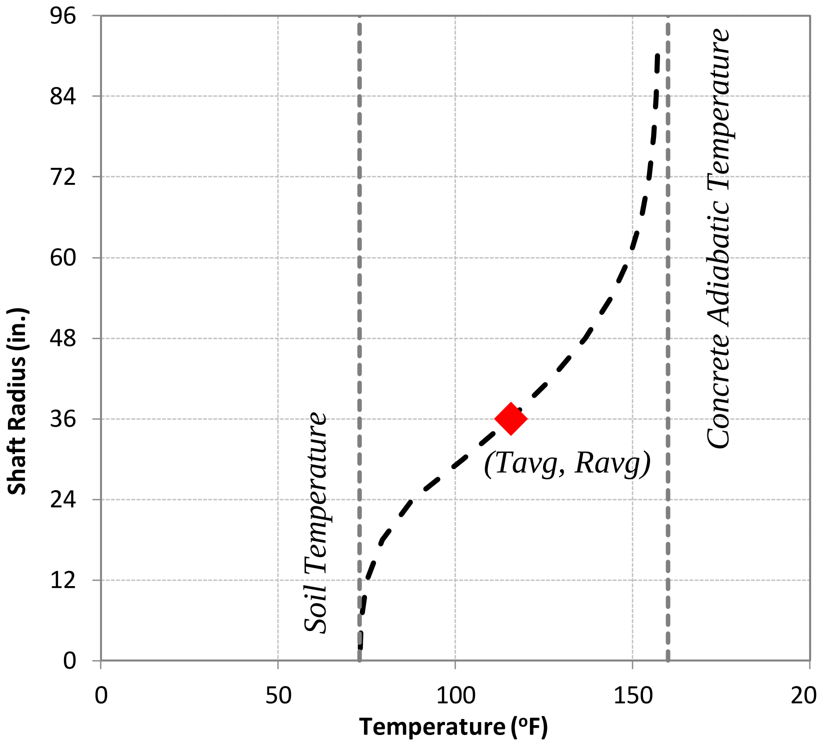


Figure 3.10 T – R relationship for a given cage position (Part I, Figure 2.13; Johnson, 2014).

Knowing the actual relationship, simplistic linear T-R approximations have been employed to estimate the local shaft radius within the linear portion of the true hyperbolic T-R curve. For shafts this approach is known as the T_{zero} method. Therein, a line is defined using two points in the temperature / radius coordinate space: (0,0) and (T_{avg},R_{avg}). Modeling has shown that this approximation is valid for changes in radius up to 6 in. For changes in radius larger than 6 in, the T_{zero} method tends to under-predict the magnitude of variation. Nevertheless, as shafts can be rejected on the basis of only 1.5-in reductions, inaccuracies at radial reductions exceeding 6 in are not really an issue. In all cases, the method was designed to never over-predict the severity of actual radial reductions to eliminate false positives of problematic conditions. However, for shaft sizes greater than about 5 ft in diameter, the T_{zero} method is quite precise. For smaller diameters (3 to 5 ft), it slightly under-predicts the magnitude of shaft variation for a given change in temperature (i.e., bulges are larger than predicted and necks are smaller).

In the Part I report, center bar temperature measurements of ACIP piles were shown to be only mildly affected by diameter changes using the T_{soil} method and drastically underestimated true radial variations. Several alternate analysis methods were discussed for small piles with only center bar measurements; one did not require numerical modeling and is referred to in this report as the T_{soil} method. This method uses a modified version of the T_{zero} method where the linear T-R relationship is again defined using two points but the zero radius temperature value is defined by the local at-depth soil temperature: $(T_{soil},0)$ and (T_{avg},R_{avg}). As an example, Figure 3.11 shows the modeled inverse hyperbolic tangent T-R relationships for 2, 4, 8 and 12-ft diameter elements at the time of peak temperature. Recall, the T-R relationship is dependent on the location of measurement; the center of element and cage positions are shown as grey and black curves, respectively. The cage position relationships are fitted with the T_{zero} linear approximation passing through the T_{avg},R_{avg} point; the center of pile curves are fitted with the best linear relationship to represent the linear portion nearest the T_{avg},R_{avg} point. All elements were modeled with ACIP pile grout for comparison. The grout or concrete composition only affects the adiabatic core temperature and the rate at which it is achieved; it does not affect the hyperbolic T-R shape.

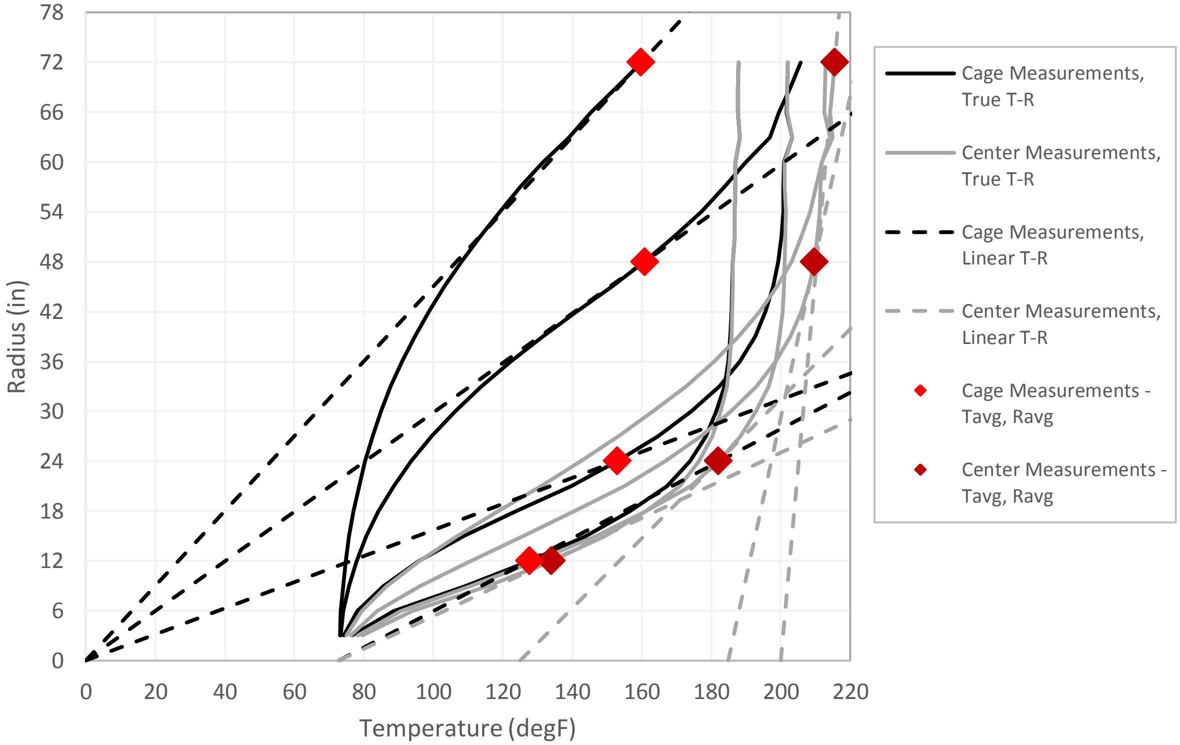


Figure 3.11 T-R relationships for varying foundation element sizes with both cage and center measurement locations.

Interestingly, as the diameter of the element decreases and approaches 2 ft, the average temperature from the cage and from the center bar become the similar due to close proximity (shown as light and dark red diamonds, respectively). This is due to the cover requirement that makes the cage quite small relative to the element diameter. Also, the best-fit T-intercept (x-axis intercept) for center location measurement ranges from 200^{o}F for 12-ft diameter to T_{soil} for 2-ft diameter. This is expected as elements of diameter greater than about 5 ft tend to plateau at the adiabatic temperature within the core, so a linearization produces a near flat and over-sensitive T-R relationship. When the same approach is applied to smaller diameter ACIP-sized elements, the T-R relationship for both the cage and center bar locations are well represented by the T_{soil} intercept (Figure 3.12).

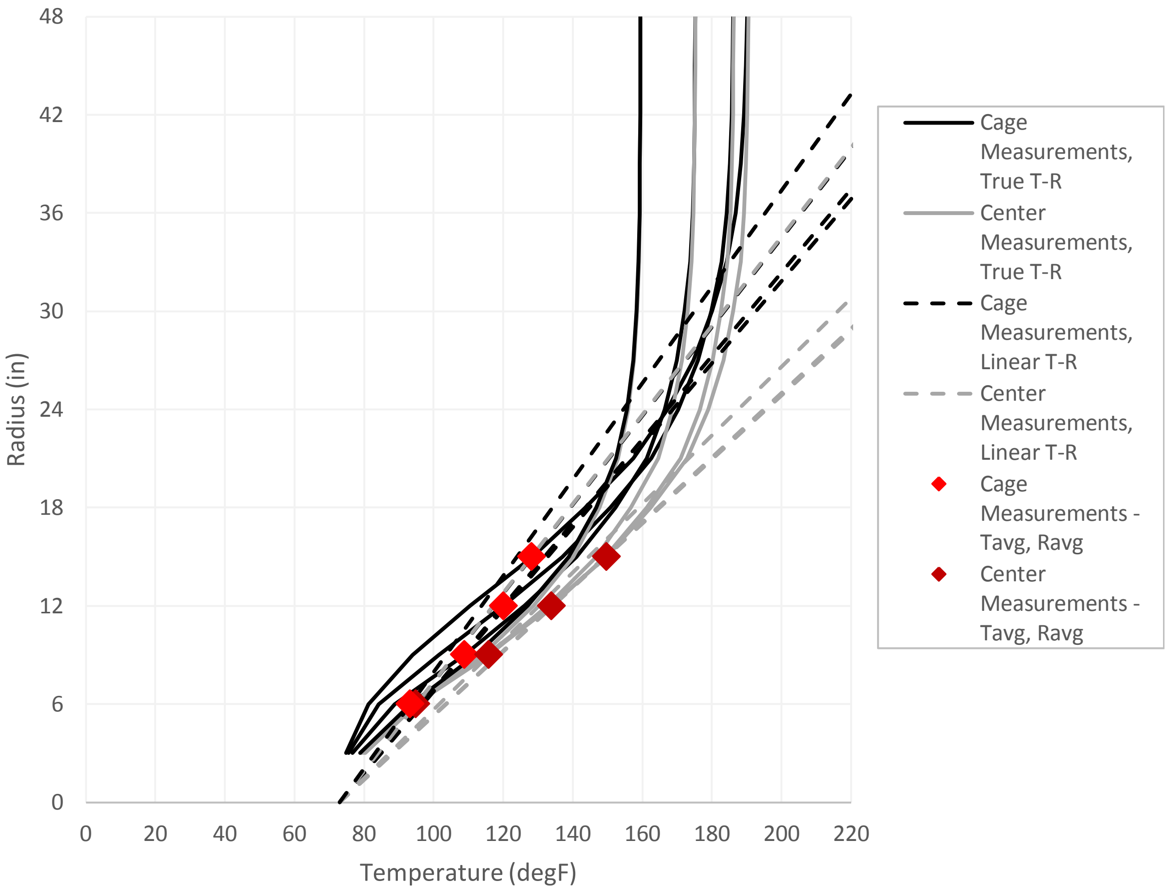


Figure 3.12 T-R relationships for smaller elements using T_{soil} method.

In a previous study, twelve 22-in diameter elements were instrumented with center bar measurements and then extracted for physical measurements (Mullins, 2012b; Mullins and Winters, 2014). At that time, the T_{zero} method was shown to be ineffective so advanced modeling techniques were used. Figure 3.13 shows the data from two of these shafts now regressed using the T_{soil} approach.

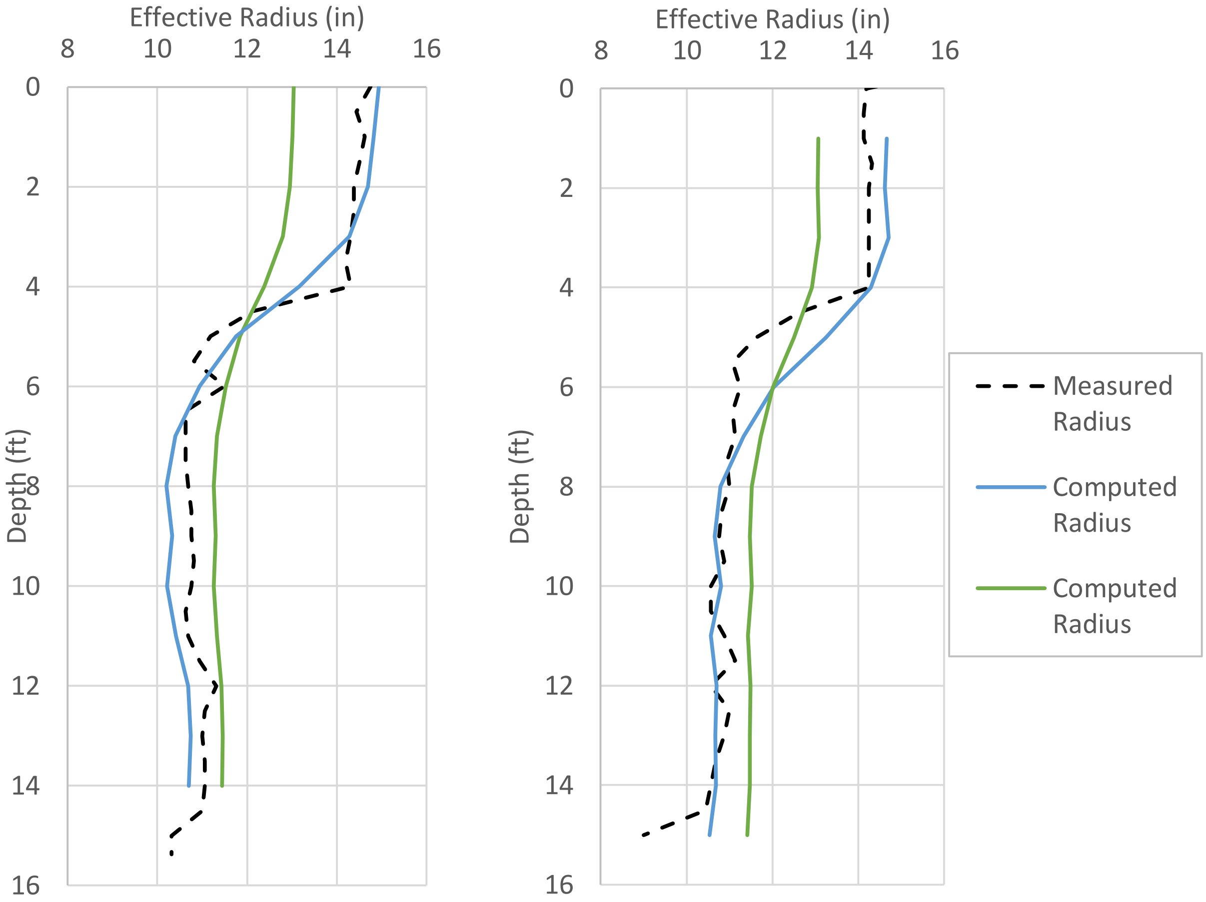


Figure 3.13 22-in diameter drilled shafts with center bar measurements analyzed using T_{zero} (green) and T_{soil} (blue) methods shown with post-extraction as-built dimensions.

The measured step in each shaft (black dotted lines) was caused by an oversized surface casing and resulted in the shaft diameter transitioning quickly to the smaller auger diameter. Similar to end of pile transitions to air or soil, sudden steps in the shaft appear in the temperature profiles as inverse hyperbolic tangent transitions from warmer to cooler (or vice versa). For top and toe profiles these transitions are adjusted to reflect the proximity to the known end of pile effects. For mid shaft steps no adjustments are presently employed. Review of this data reveals the possible need for this type of algorithm although the use would need to be selectively used. *Note: similar mid shaft profile transitions can occur from drastic changes in the surrounding environment (i.e. cased shaft extending from soil through water to air). In those cases the effects of the surroundings are removed; in this case the effect of transition would be emphasized.*

When considering changes in shaft diameter due to casing, it is clear that accurate field records are critical to ensure the proper vertical alignment of sensors. In the case of the Figure 3.13 left, the actual change in diameter aligns reasonably well with the recorded thermal transition. In Figure 3.13 right, the two transitions are offset by what must have been an erroneous field notation locating the top most sensors (datum). For both cases, however, the T_{soil} method correctly captured the magnitude of radius change associated with a significant dimensional variation. T_{zero} did not.

3.5 Grout Volume Determination

Before extraction of the auger several pump strokes are applied which build pressure in the system (soil and all lines) and establish a concrete head similar to tremie placed concrete. Traditionally, this volume of grout is discounted when assessing the actual placed volume. The auger is then extracted while continuously pumping grout and hence a volume/length of pile relationship can be used to estimate the local diameter (or radius). Once near the surface, the pressurized grout reaches the surface before the full extraction of the auger which is noted in the field records as the depth when grout return was observed at the surface. Thereafter, grout volume placed could be used to account for further soil expansion, replacement of the auger volume or overflow at the surface. Discounting this volume completely is not reasonable but a portion should be. These records can be collected manually (on 5-ft intervals or similar) or via automated on-board data collection systems (noted here as AME records).

Considering Pile E1, Figure 3.14 shows the predicted radius from manual and AME records where no attempt to correct for losses was imposed. At the bottom of pile, the initial pump strokes are registered as a significantly oversized pile when compared to the actual measured dimensions after extraction. Three different sets of manual measurements were taken to document the as-built dimensions; all are shown as the basis of comparison. Several aspects make the actual placed volume and distribution difficult: tendency of grout under pressure to flow up the sides of the soil filled auger, initial pump count to fill all lines and achieve pressure head, and volume lost at surface after grout return. Using several approaches the as-built pile shapes were estimated/computed for all other piles and presented in Appendix B.

The T-R analysis relies on an accurate estimate of the total volume of grout/concrete (and steel) that comprises the as-built pile. For drilled shafts, this is usually determined from the number of trucks used to pour a shaft (i.e., 9-10 CY increments). With ACIP pile construction however, pump strokes are counted and tallied over a given length of auger withdrawal (e.g., every 5 ft). Additionally, the use of automated monitoring equipment allows grout flow rate and auger withdrawal rate (along with other parameters) to be monitored continuously and thereby compute grout volumes at even higher resolution (smaller depth increments). The deceiving allure of this is that the exact distribution of grout should be able to be determined by combining these measurements throughout the entire auger withdrawal. Considering the Figure 3.14 results it is difficult to decide the volume to be discounted when the actual pile shape (and associated volume) is not available.

Using three possible placed volume values corresponding to total volume placed, total minus initial pump strokes and the actual volume from physical measurements of Pile E1, the thermal data collected was converted to radius profiles (Figure 3.15) using the T_{soil} method. The first two options overestimated the pile radius by 2 and 1 in, respectively. It is apparent that an additional amount of grout volume must be removed (the true waste), but the rationale for selecting this value is not apparent. Using the true volume from the measured pile dimensions, the effective radius profiles closely resemble the actual shape of the pile. The radii determined from manual or

AME-data largely did not align with the actual shape (Figure 3.14); but is understood that this measurement is not intended to predict the radial dimension as function of depth, rather it provides a mechanism to monitor grout volume vs extraction rate ratios consistent with good practice. For thermal analyses, actual in-hole grout volume is necessary.

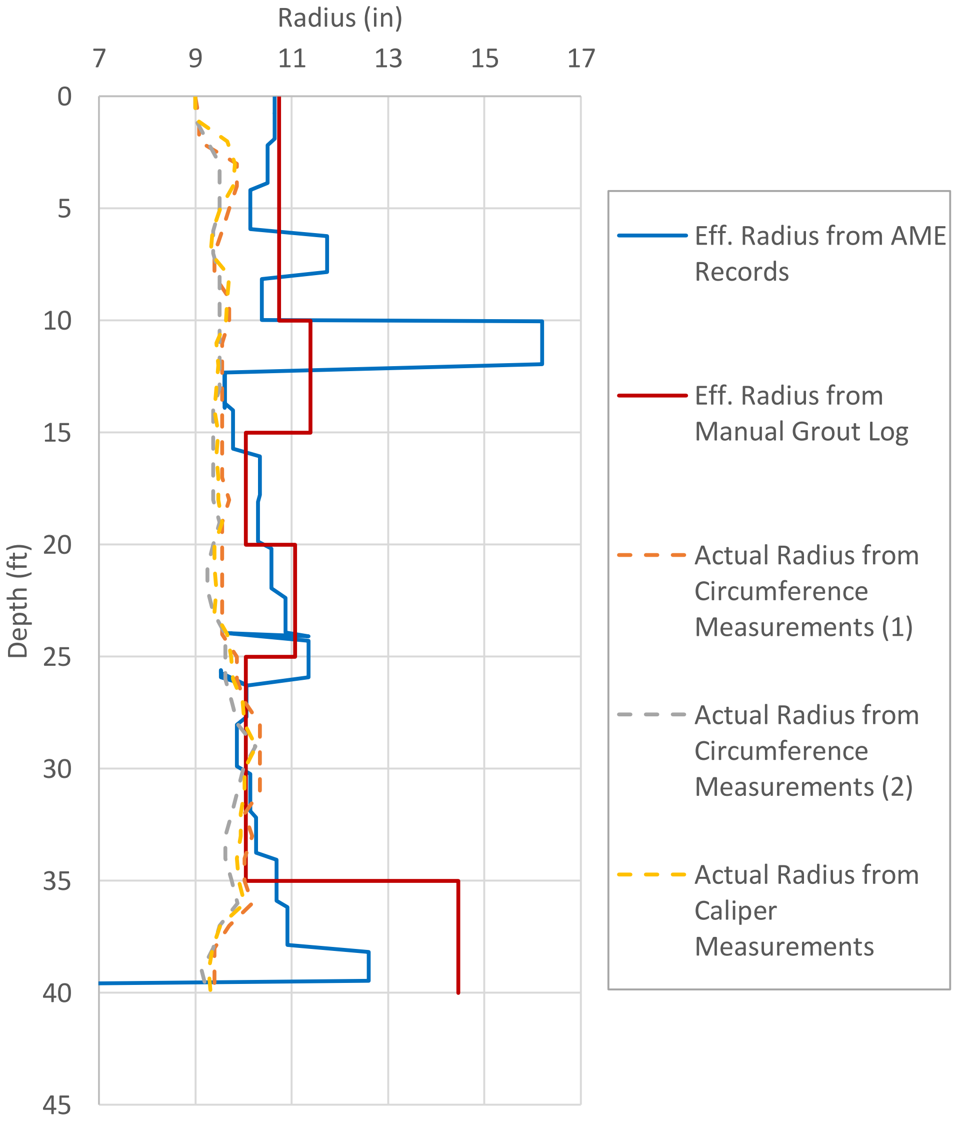


Figure 3.14 Radius computed from automated and manual grout log compared against actual radius measured after extraction for Pile E1.

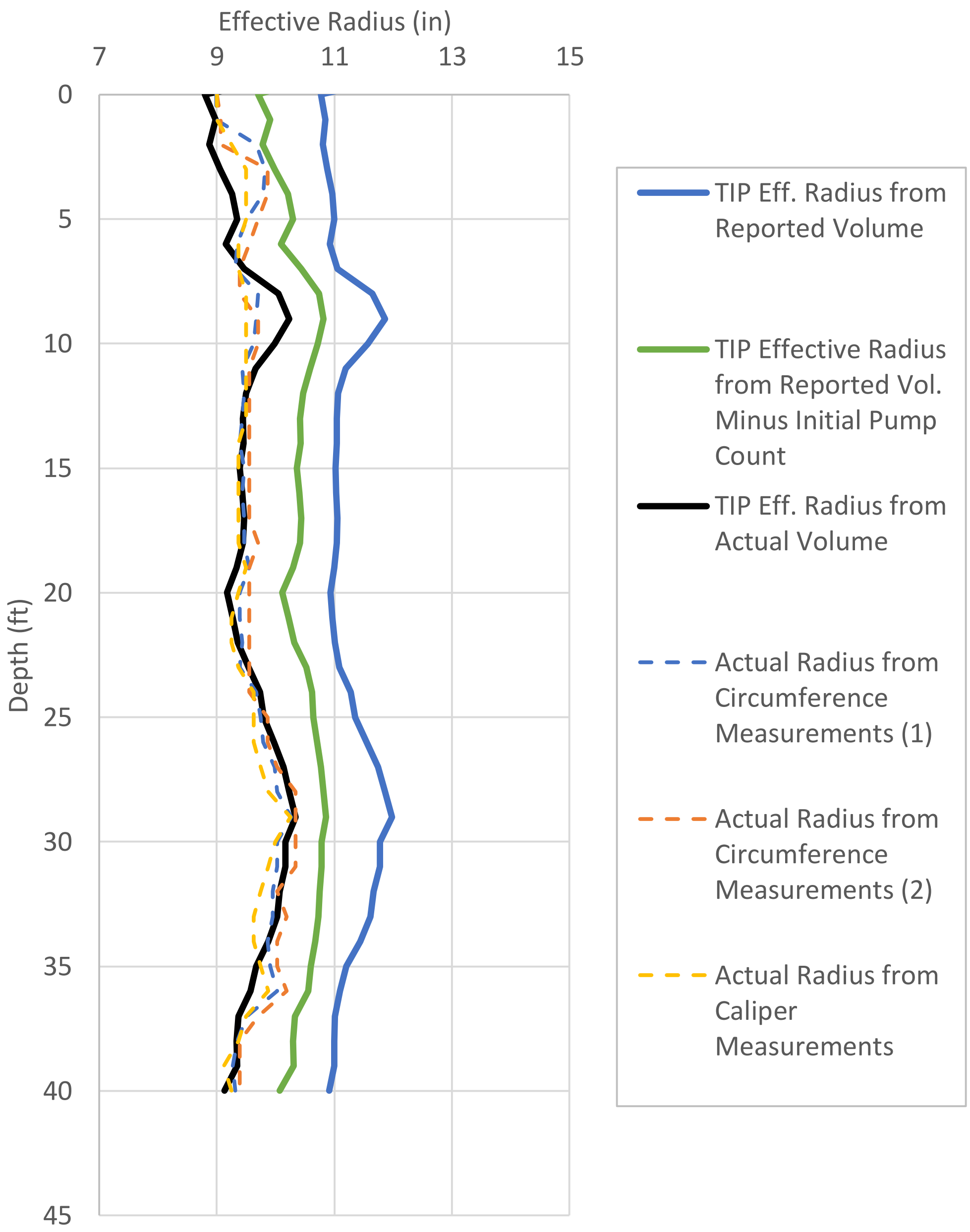


Figure 3.15 Effective radius from T_{soil} method compared to actual radius of Pile E1.

Using the information obtained from the Pile E1 analysis, the effective radius profiles for all other piles were prepared using both the reported grout volume and that minus initial pump count – Appendix B. The following observations were made:

- Piles L1, T1, L2, C2, T2 showed drastic radius reduction around 30 ft
- Pile C2 – mid-pile step corroborated by grout log (and AME)
- Subtraction of initial pump count on pile E1 resulted in 1 in larger radius than actual, but that pile had the deepest auger depth upon grout return.

- For other piles which had shallower depths at grout return, subtraction of initial pump count resulted in radii almost equal to that of auger size in the bottom portion, as all shafts except E1 and C1 exhibited significant mid-pile radius reductions.
- Only piles T2 and L2 had resulting radii less than the auger dimension (~1 to 1.5 inches less) in the bottom portion. For pile L2, this could be explained by AME records which show a relatively fast withdrawal rate near the base, without a corresponding increase in grout flow rate.
- For piles with only center bar measurements any temperature reduction trend (which could be due to misalignment) will affect the grout volume distribution (i.e., high temperature regions will overestimate radius and lower temperature regions will underestimate the radius).

3.6 Effective Radius Estimates

The effective radius was shown to be best estimated using the T_{soil} method and using both center bar and cage location measurement. For cage location temperature measurements, the T-R relationship is based on the average temperature profile and the average of that profile is compared to the average radius. The overall average cage temperature should be less than the average center bar temperature if the center bar is truly centered. This was the case for Pile E1. Therefore, the R/T slope (Eqn 3.1) is different for the two measurement locations although both locations were shown to be best represented by the T_{soil} method.

$$R_{effective} = \frac{R_{avg}}{(T_{avg} - T_{soil})} T_{measured} + \frac{R_{avg} T_{soil}}{T_{soil} - T_{avg}} \qquad \text{Eqn. (3.1)}$$

The net effect is the higher measured temperature at the center is balanced with a lower R/T slope compared to the cage R/T value such that temperature measurements from both locations produce the same effective radius profile. This is also true in shaft evaluations where two shafts of the same diameter that have different cage diameters / cover criteria; both produce the same effective radius profile using a shaft and time specific R/T value.

Using only the true volume (as determined from post-extraction measurements), the effective radius profiles were estimated for both thermal measurement locations from Pile E1, which showed close agreement with the post-extraction as-built pile measurements (Figure 3.16). The magnitude of variation between the two estimated shapes is on the same order as that observed by different physical measurements conducted by two different teams (DFI contractor and USF researchers) or by using two different measurement methods (diameter from taped circumference vs localized diameter from calipers).

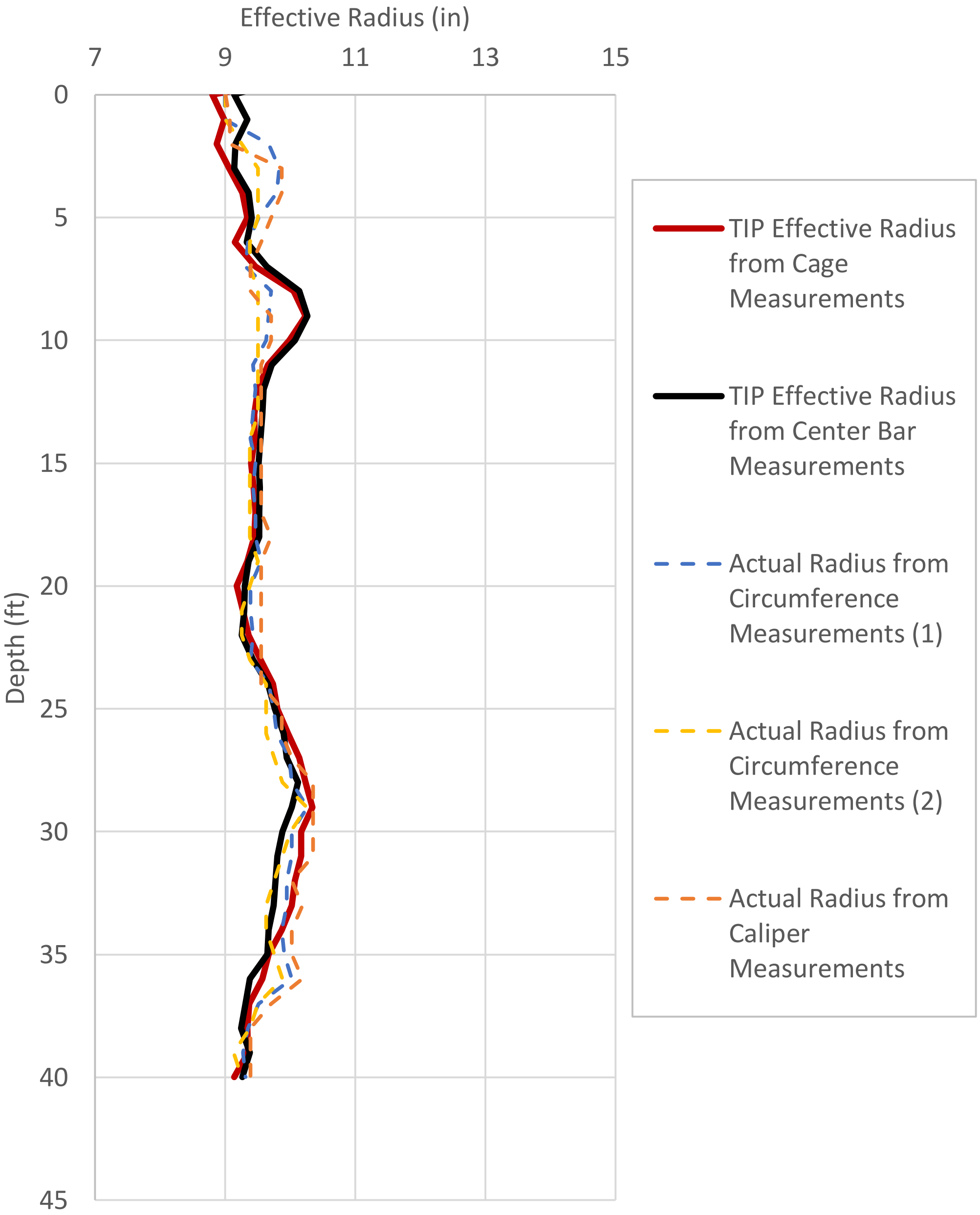


Figure 3.16 Pile E1 effective radius determined from cage measurements and center bar measurements compared to actual radius measured after extraction.

Chapter Four: Conclusions and Recommendations

This study was the second in a two-part research program focused on assessing the feasibility of using thermal integrity profiling for ACIP piles. This was made possible by coordinating with the Deep Foundations Institute ACIP pile project to demonstrate the strength of piles in various loading conditions (i.e., tension, compression and lateral loads). In all, seven test piles were equipped with thermal integrity assessment devices. Both probe and thermal wire systems were used to collect data over an extended period of time, thereby providing a means to compare instrumentation methods, schemes and analysis techniques. One of the seven piles was extracted to assess the validity of on-site inspection methods which was also used as a control for the thermal analysis comparison.

4.1 Instrumentation Methods and Schemes

Instrumentation, defined by the installation of sensors or measuring systems, for thermal integrity methods is dependent on the reinforcing steel configuration. Probe systems require access tubes, wire systems require a cage on which to attach the sensor strings. Commonly used single bar reinforcement in ACIP piles is not conducive to probe systems unless hollow reinforcement is used (a relatively new development). Regardless of method, both probe and wire systems showed close agreement with each other in this study.

Use of steel access tubes in small piles was shown to influence the near surface probe measurements in the small piles when in cool weather (e.g., 70^{o}F). When used in larger diameter foundations elements (e.g., 3-ft diameter or larger), no similar effects have been noted. The temperature measurements in PVC access tubes were unaffected.

Both center bar and cage position measurements were shown to be sensitive to the as-built radius variations for the small 18 and 24-in piles used for this study. Based on numerical modeling, center bar measurements are not a good option for piles (or shafts) large than 3 ft in diameter. This is due to the loss of sensitivity to peripheral changes in dimension.

Center bar installation can result in off-center placement which may or may not be detected via thermal wires. Use of cage based measurements (4 preferred) allows for full assessment of pile size and cage offset. While centralizers were used, mixed results were found in this study where both the center bar and cage showed centered and off-center results (Table 4.1). The degree of center bar eccentricity was such that full pile size determination could not be made by traditional temperature to radius conversions. Some correction for misalignment may be possible (discussed later). For this project, center bars (and cages) were well centered near the top of a pile where visual inspection could be used to adjust the final position. Table 4.1 provides a summary of the center bar and cage movements. For cages, the direction of movement can be determined; for center bars alone direction cannot be determined; when both center bar and cages are used then both movements can be determined.

Table 4.1 Summary of cage or center bar movement trends.

Pile	Center Bar Alignment	Cage Alignment
L1(18in)	Centered from 0-15ft Touching cage from 30-35ft on west side (up to 5in movement)	Centered from 0-15ft Bulge on south side from 15-22ft causes abnormal alignment determinations Centered from 23-35ft
L2 (24in)	Centered from 0-25ft Touching south east edge of cage from 20-35ft (up to 5in movement)	Centered from 0-15ft 15-25ft cage movement ≈1.5in North
C1 (18in)	Centered from 0 – 25ft Incomplete data but either cage has moved into center bar or vice versa. Center bar is touch cage on south side; Cage movement is more likely 35-60ft not enough information	Centered from 0-25ft Incomplete data below 25ft but cage shows signs of movement to the north 35-60ft no cage
C2 (24in)	Centered from 0-25ft Touching cage from 30 to 35ft on SW side (up to 6in movement) 35-60ft not enough information	Cage ≈2in off center to the West at 5ft Centered from15ft to 25ft 25-35ft ≈1in NE 35-60ft no cage
E1 (18in)	Centered 0-40ft (full depth)	Centered 0-20ft Less than 1in off center NE
T1 (18in)	Not enough information with only center bar data	No cage
T2 (24in)	Not enough information with only center bar data	No cage

While auger-cast piles are often reinforced with only a single center bar, their use on highway projects subjects them to AASHTO specifications which require a minimum reinforcement of 1% of the gross concrete area for concrete columns. For an 18-in pile with only a single center bar, this specification would require a #18 bar be used, the largest commonly available size. For a 24-in pile, this would not suffice. Therefore it is reasonable to suggest that the use of full rebar cages may become more commonplace on highway production piles and thermal measurements taken at cage location should then be considered as a viable option for integrity testing. At a minimum partial length cages can be implemented like that used for this study. This increases the verification capability in high bending moment regions beneath the pile cap.

Of the twenty seven wires installed for this study, four exhibited partial length failure around peak temperature times. Others went dead and came back multiple times, but were alive at peak hydration. No wires were completely unusable.

4.2 Grout Volume Determination

Thermal evaluation of ACIP piles (or shafts) can be both qualitative and quantitative. To transform qualitative insights to quantitative radius or cage offset values, the placed volume of grout (or concrete) is required. Unfortunately, this is a highly interpretative quantity. Where AME systems are not intended for radius determination, they provide accurate knowledge of the pumped grout. For the purposes of thermal data analysis only the in-hole grout volume is needed.

AME data including grout flow rate, volume, penetration rate, depth of auger, and grout pressure provide a means to better identify the as-built pile, but interpretation of the recorded data from different sensors can lead to different conclusions. Figure 4.1 shows the Pile E1 radius profiles predicted from manual pump stroke counts, grout factor per 2-ft interval, cumulative volume changes per 1-ft interval, and flow rate divided by extraction rate. The actual pile radius is also shown in which the average of the three measurement systems was used. In short, the predicted radius from placed volume does not under-estimate radius.

The total grout volume is directly proportional to the square of radius. The various methods of determining radius place excess volume at different locations along the length of the pile making a simple rule for the determination of the true waste volume difficult (e.g. initial pump strokes or some portion of the volume after return is observed). For example with Pile E1 the true volume of the pile was determined from manual measurements to be approximately 80 ft^3 and the overall pumped grout was 109 ft^3. By subtracting the volume from initial pump strokes (10 ft^3) and the entire volume after grout return was observed (34 ft^3), the pile volume would drop to 65 ft^3. Adding back the theoretical volume of the auger in the ground at the time return was noted (22 ft^3), the volume increases to 87 ft^3 which is 7 ft^3 too high (8.8%). This would increase the actual average pile radius (9.6 in) to a prediction of 10.4 in.

Determination of the true wasted grout volume is further complicated by the amount of grout that mixes with the ground water and becomes unrecognizable as clean grout return. It is conceivable that an overflow casing (or similar) could be used to better quantify the waste volume. No suggested configuration is provided herein.

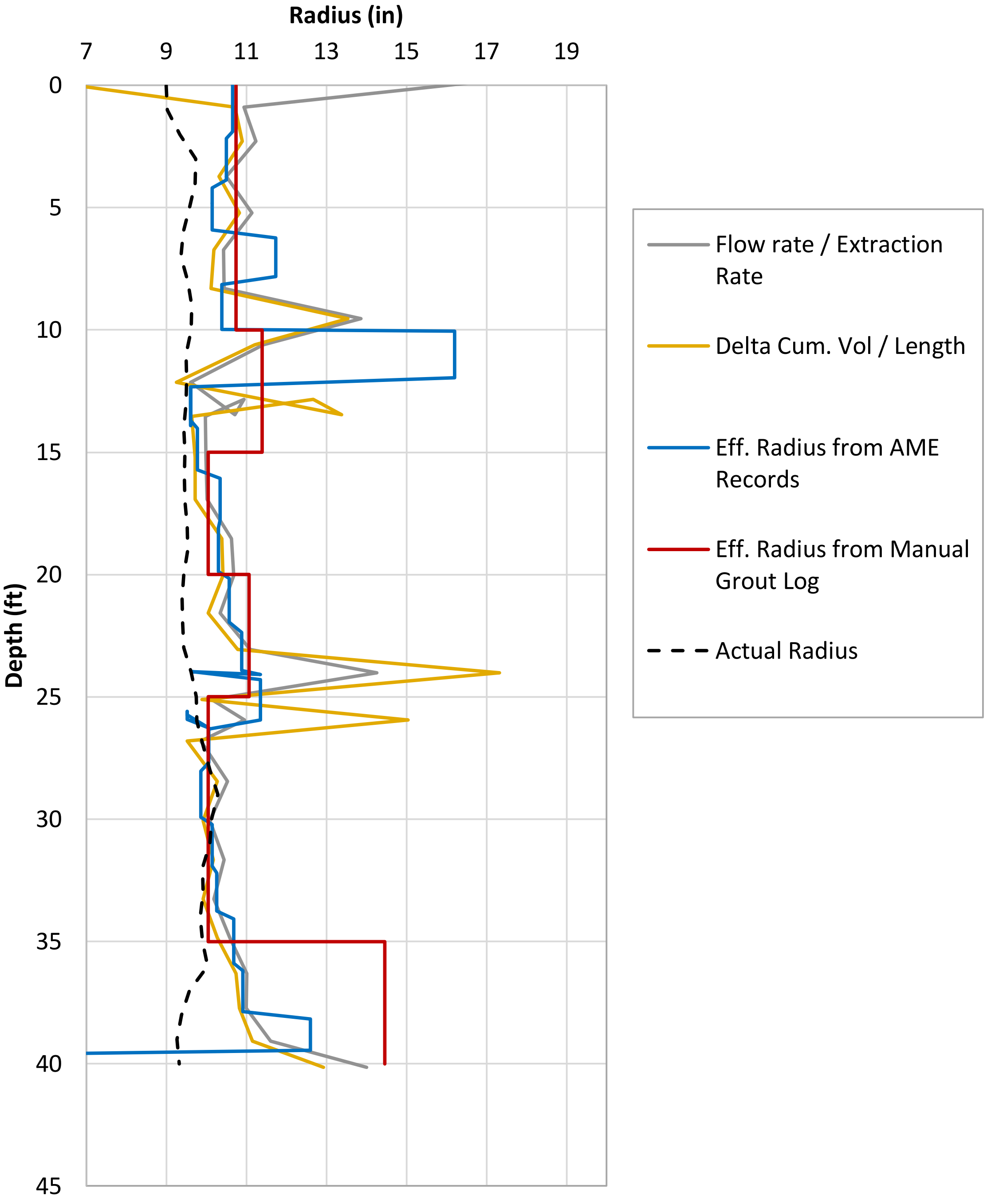


Figure 4.1 Radius predictions from grout volume measurements.

FDOT currently requires ACIP piles to be placed with at least 15% extra volume. This in part activates passive pressure along the side of piles and in cases like this could account for inaccurate grout return/waste assessment.

4.3 Analysis of ACIP Pile Thermal Profiles

Using accurate measurements of as-built piles (or shafts), the true volume was input into various radius prediction methods for thermal integrity data sets. The use of small cages in small piles or center bar instrumentation schemes places the measurement location at or near the top of the bell curve (i.e., radial temperature distribution, Figure 3.8). Traditional shaft evaluation algorithms that assume the location to be near the edge of shaft in the linear region are therefore not appropriate. Best fit projections from hyperbolic T-R curves show that shafts larger than 2 ft do not provide the same response as smaller piles when center bar measurements are used and are not recommended. Piles or shafts larger than 2 ft should use cage measurements for thermal analyses, which is not unreasonable for that size element.

The T_{zero} linearization of the hyperbolic T-R relationship was confirmed to be conservative for all diameters of foundation elements regardless of the measurement location. The T_{soil} method was shown to be a reasonable approximation for smaller elements for both center bar and cage position measurements. However, a slight over-prediction of radial variations results from its use. Figure 4.2 includes the model predicted best fit T-intercepts for cage based measurements in shafts greater than 2-ft diameter with no more than 6 in of cover, and for both center bar and cage measurements in piles 2-ft diameter or smaller. For ACIP piles, the simplistic T_{soil} method could be refined based on these model results to use $0.9T_{soil}$ as the intercept value. In general any intercept selected that is less than that shown results in conservative radius variation predictions.

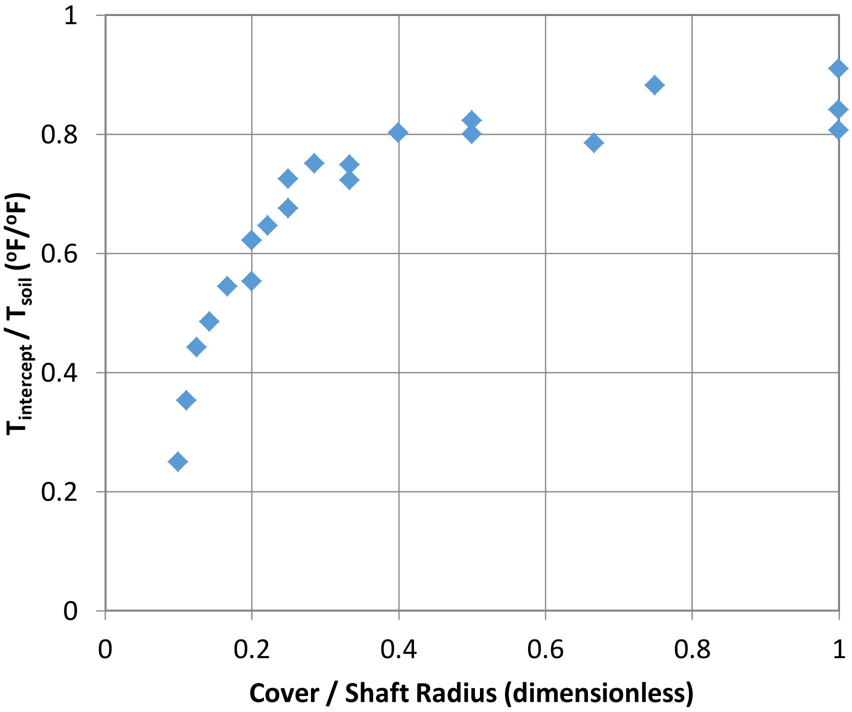


Figure 4.2 Intercept temperature as a function of measurement position.

Using a shaft and site specific intercept temperature from Figure 4.2, Eqn 3.1 can be rewritten in a more generic format (Eqn 4.1) where the intercept temperature is denoted as T_{int}.

$$R_{effective} = \frac{R_{avg}}{(T_{avg} - T_{int})} T_{measured} + \frac{R_{avg}T_{int}}{T_{int} - T_{avg}} \qquad \text{Eqn. (4.1)}$$

The radial temperature distribution of ACIP piles changes only moderately around the top of the bell curve (Figure 4.3). In that region (i.e. ±2 in or ±0.3°F), lateral center bar movement has little effect on the measured temperature and therefore the predicted radius.

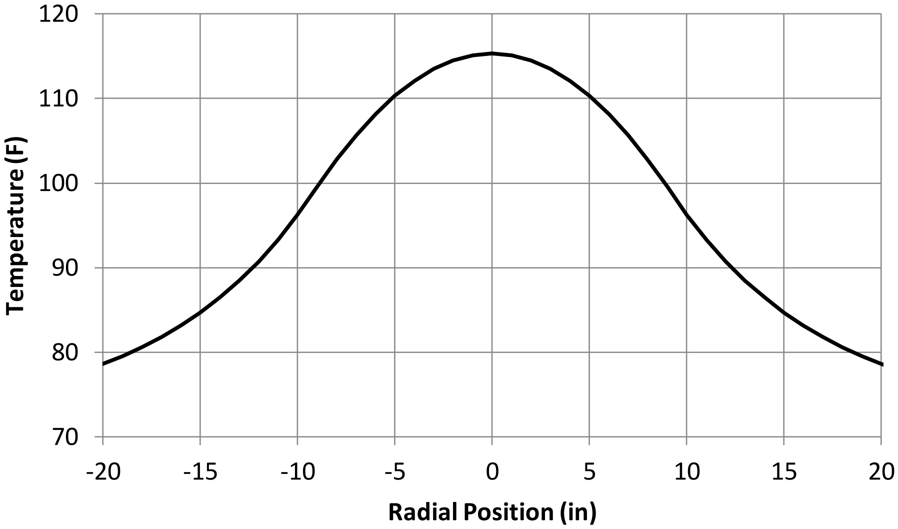


Figure 4.3 Radial temperature distribution in 18-in ACIP pile (12 hrs).

However, piles tested in this study were confirmed to have moved up to 5.5 in for 18-in and 7.5 in for 24-in diameters. This translated into potential radius prediction errors of 1 to 2 in based on the observed R/T slope of 0.25 in/°F. These errors create both under and over predictions as the integrated temperature vs depth curve is equated to the placed volume; where one region of the pile under-predicts radius from low temperature, higher temperature regions must over-predict to balance the overall volume. These types of errors are preventable via use of more centralizers to ensure the center bar reinforcement remains centered. In this case, centralizers were spaced approximately every 10 feet (Figure 4.4).

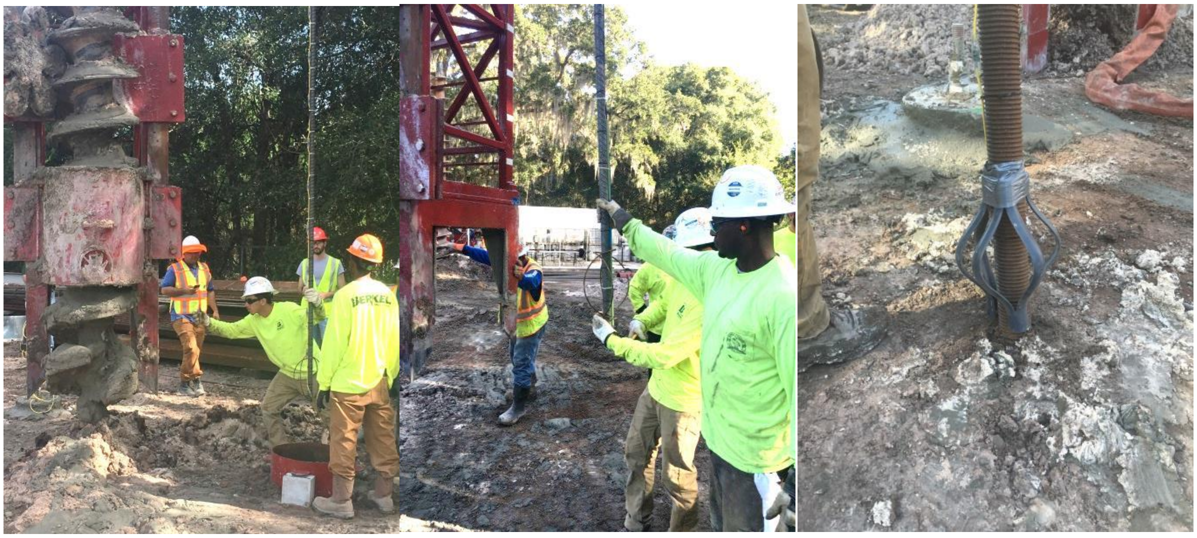


Figure 4.4 Number 8 bar with small and widely spaced centralizers ≈10 ft (left).

4.4 Summary

Results from thermal integrity profiling of ACIP piles showed promising capabilities to evaluate the as-built piles. Analysis methods that were hypothesized in the original study were vetted and showed good agreement with the true pile size and shape. These methods were further refined to minimize errors associated with simplistic linearization of the inverse hyperbolic tangent relationships.

Both probe and wire systems were shown to provide the similar results, however, wire systems have the distinct advantage of reducing cage/reinforcement congestion. PVC access tubes were also shown to be better for small volumes of grout in piles that can be vulnerable to heat sinking with steel tubes.

Like most new developments and the additional information provided for the contractor, thermal profiling has shown that centered single bar reinforcement is central to TIP effectiveness and that tighter spacing would be beneficial. The shape of the pile predicted by thermal evaluation mimicked the actual pile closely but accurate determination of grout volume directly affects the thermal analysis results. As such, it is the critical factor in the entire ACIP pile quality assurance program, and improvements are needed in this determination.

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Appendix A

TIP Data

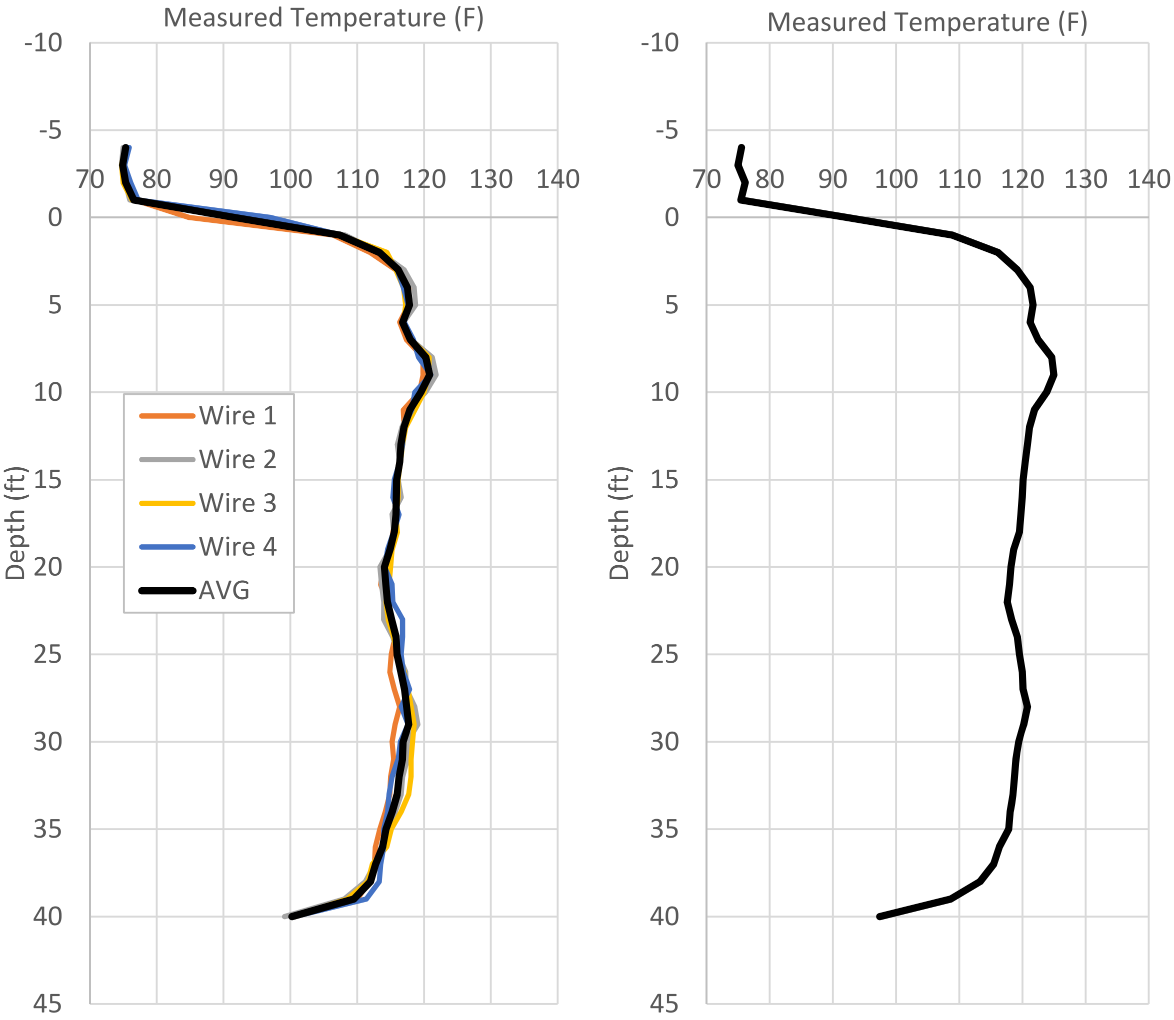

Figure A.1 TIP wire data for pile E1, at cage location (left) and center bar location (right).

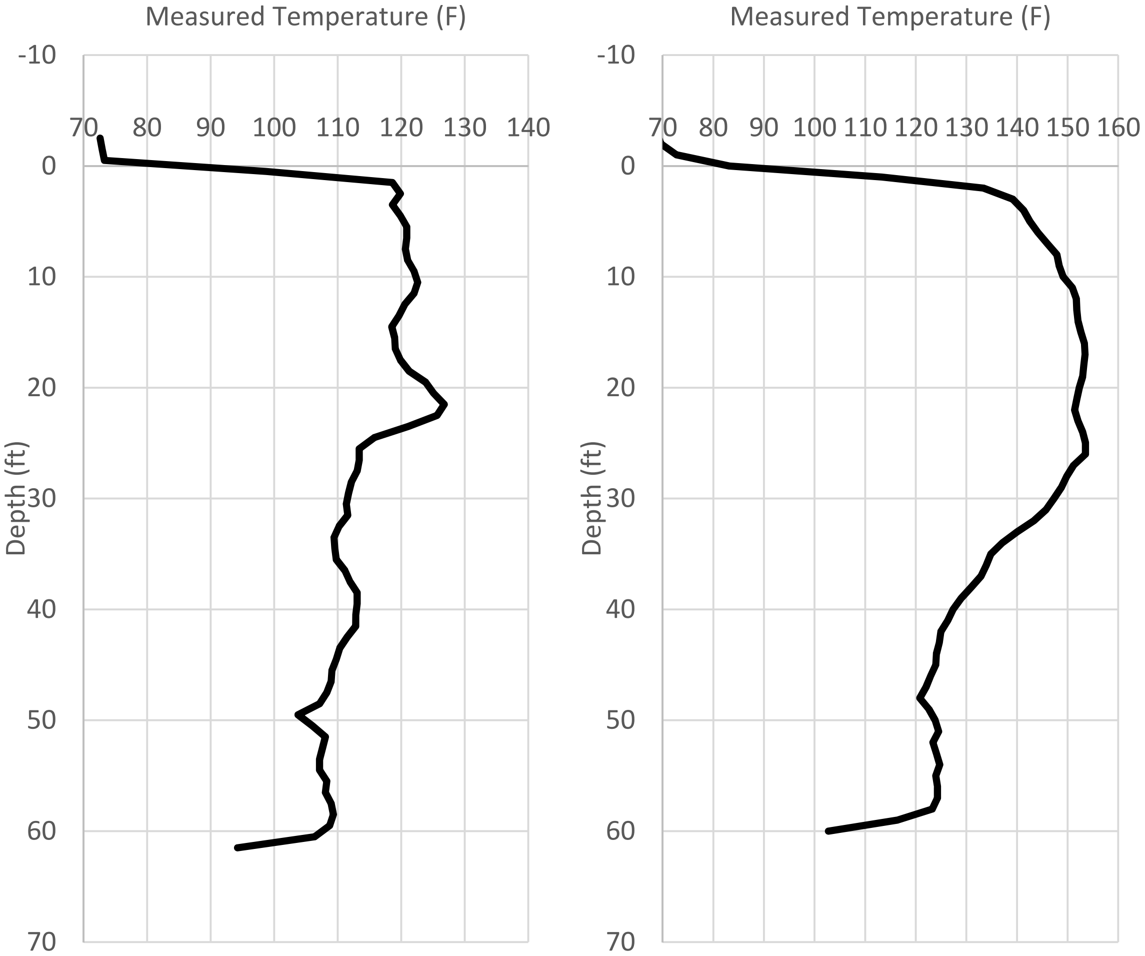

Figure A.2 TIP wire data for piles T1 (left) and T2 (right), at center bar location.

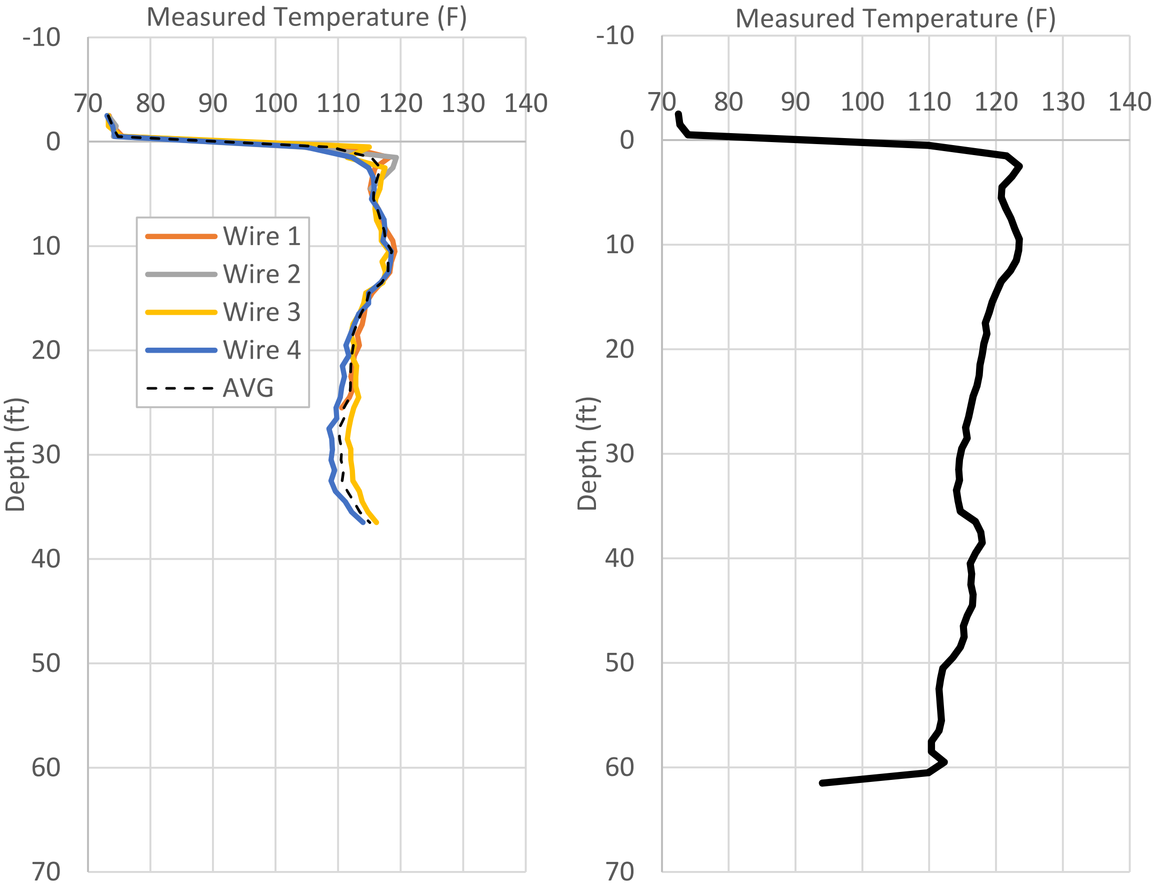

Figure A.3 TIP wire data for pile C1, at cage location (left) and center bar location (right).

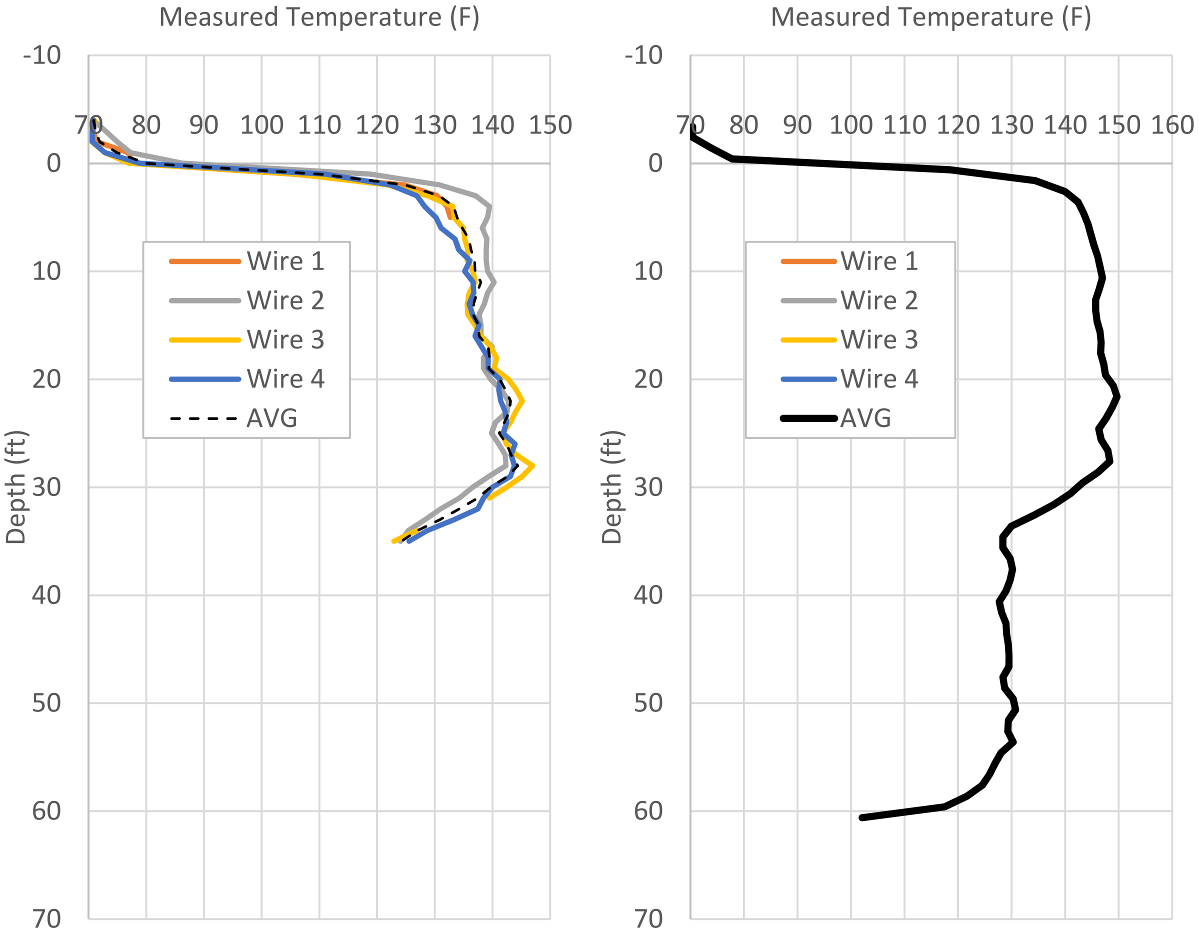

Figure A.4 TIP wire data for pile C2, at cage location (left) and center bar location (right).

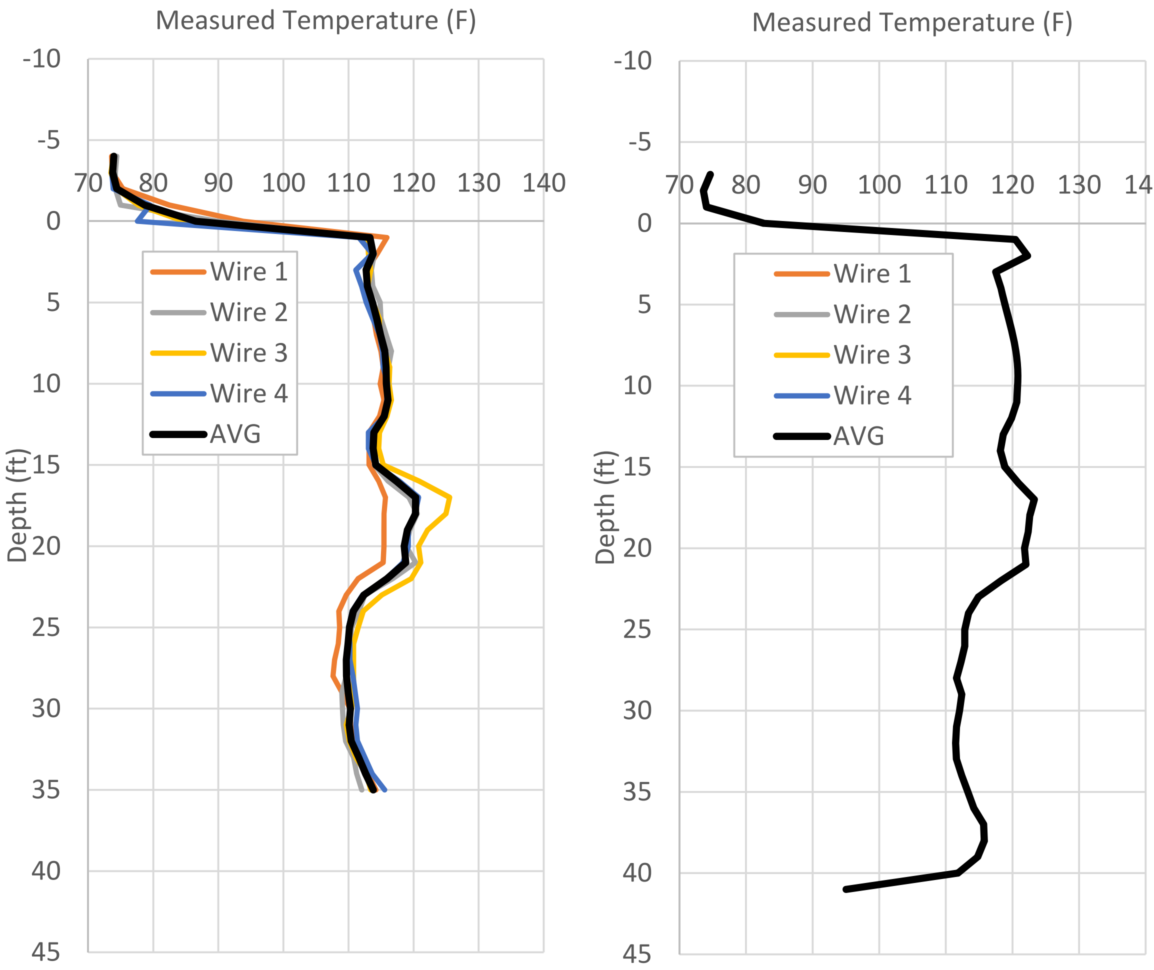

Figure A.5 TIP wire data for pile L1, at cage location (left) and center bar location (right).

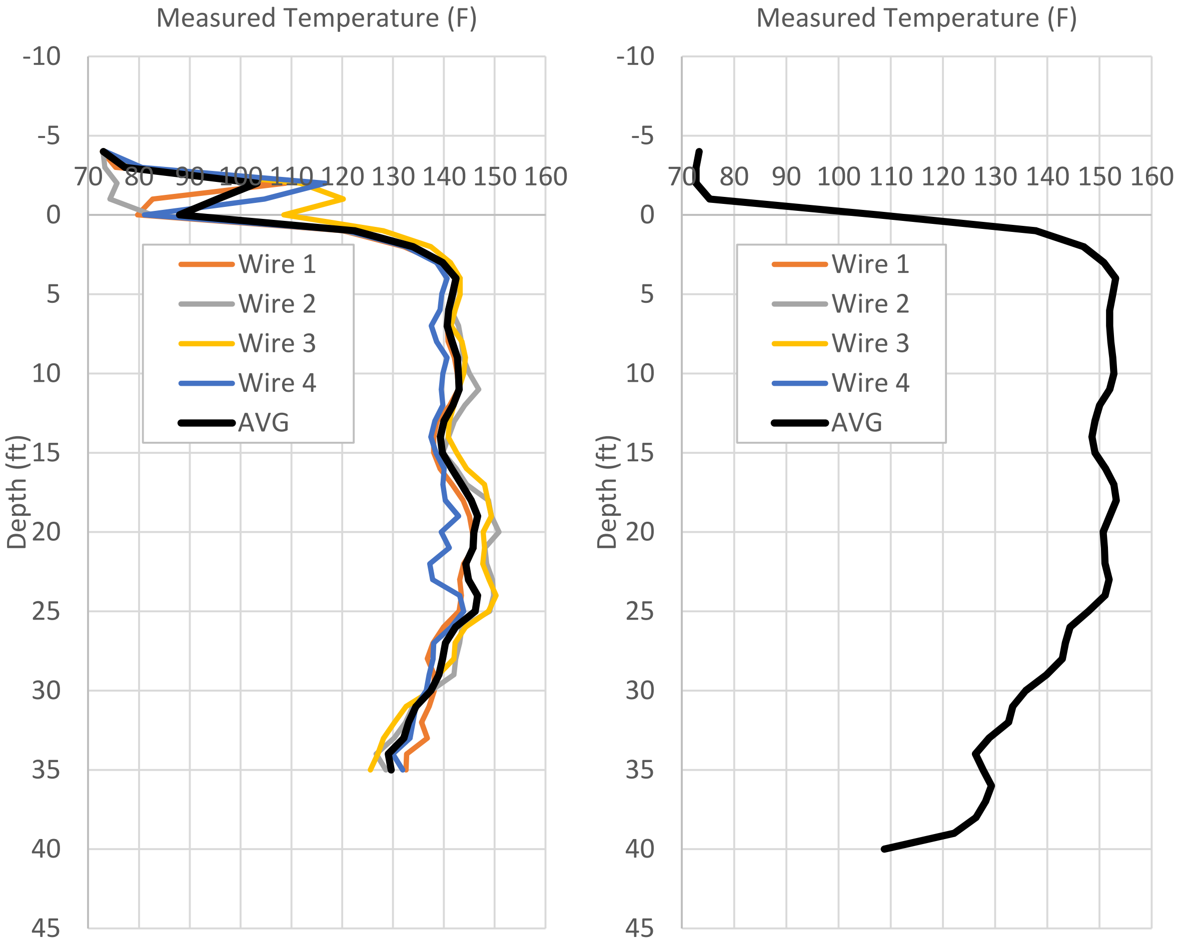

Figure A.6 TIP wire data for pile L2, at cage location (left) and center bar location (right).

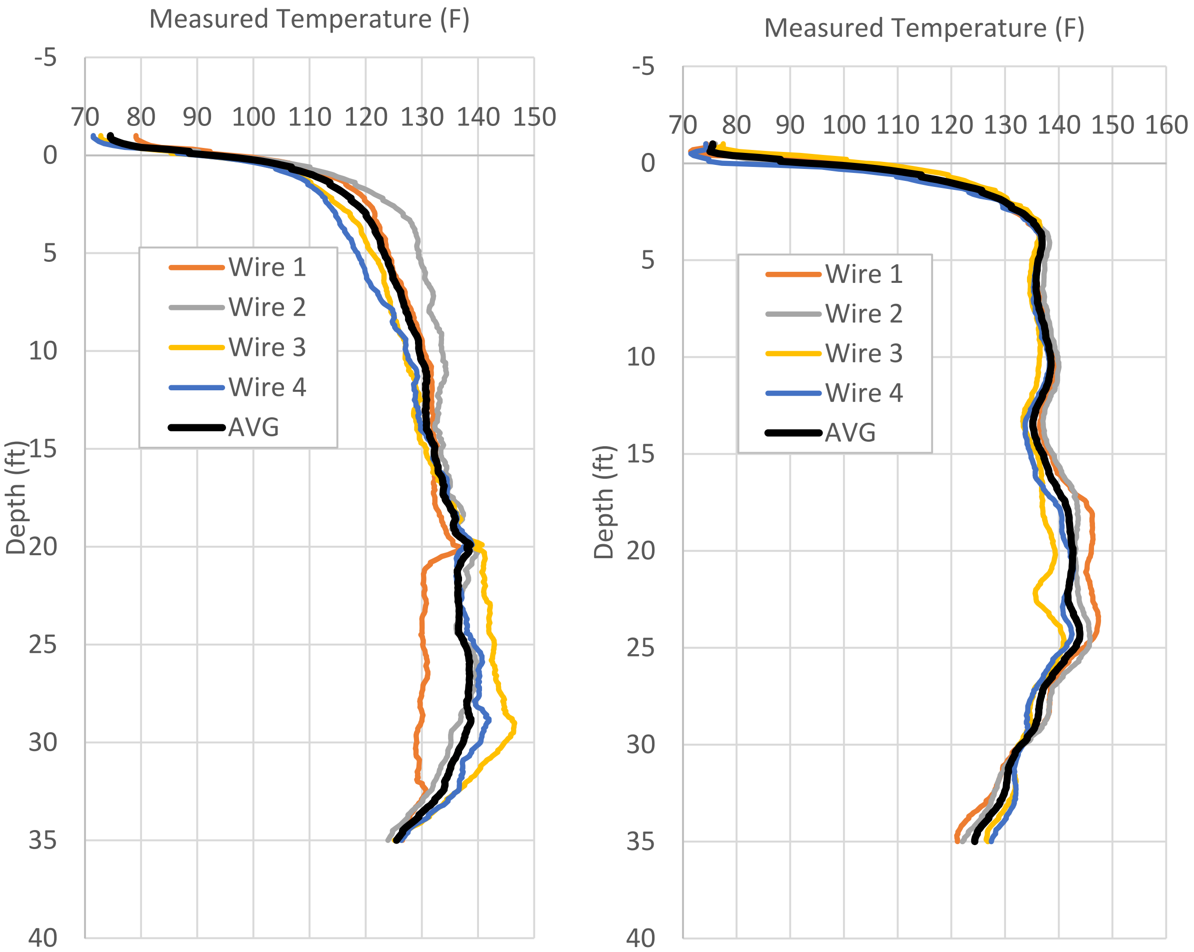

Figure A.7 TIP probe data for piles C2 (left) and L2 (right), at cage location.

Appendix B

TIP Effective Radius Profiles

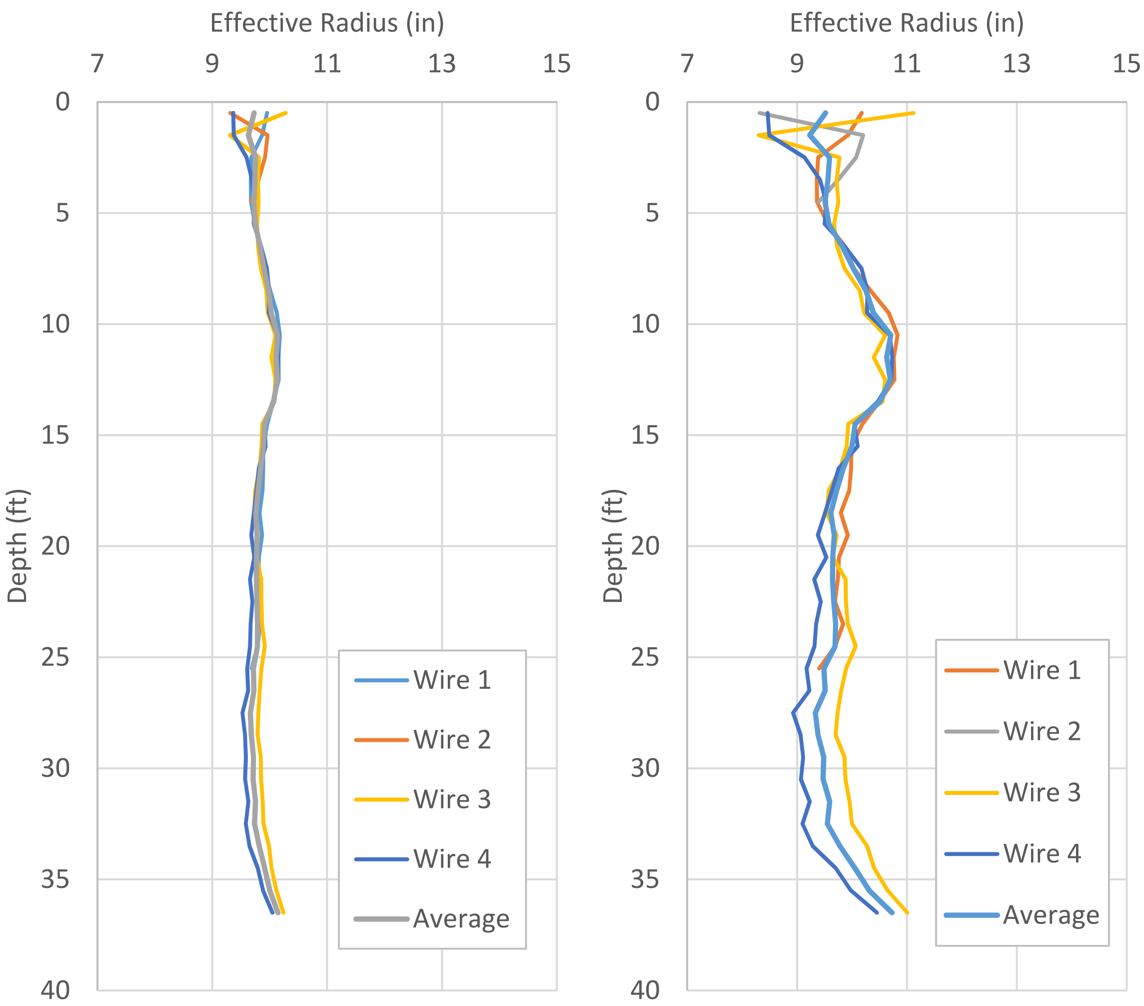

Figure B.1 Pile C1 effective radius from cage wire data, using T0 method (left) and Tsoil method (right).

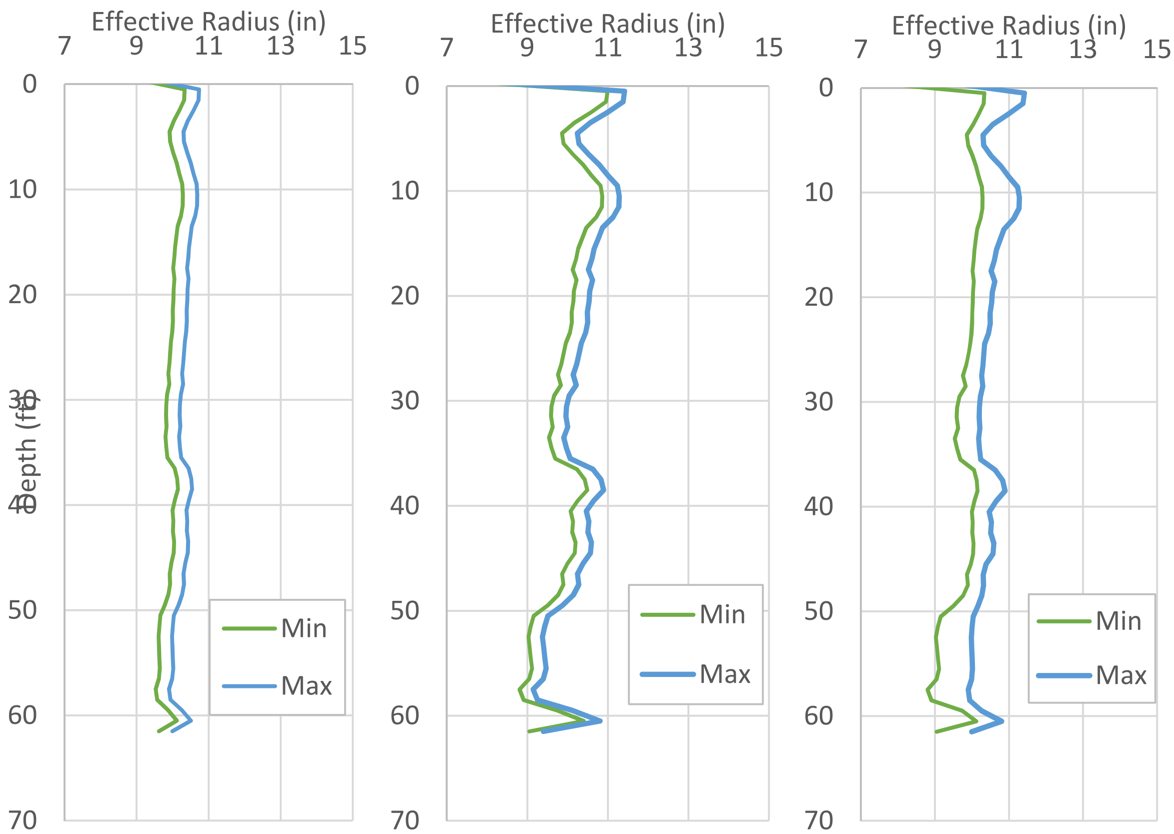

Figure B.2 Pile C1 effective radius from center bar wire data using actual reported grout volume (max) and reported volume grout less initial pump count (min) – T0 method (left), Tsoil method (center), min/max from all combinations (right).

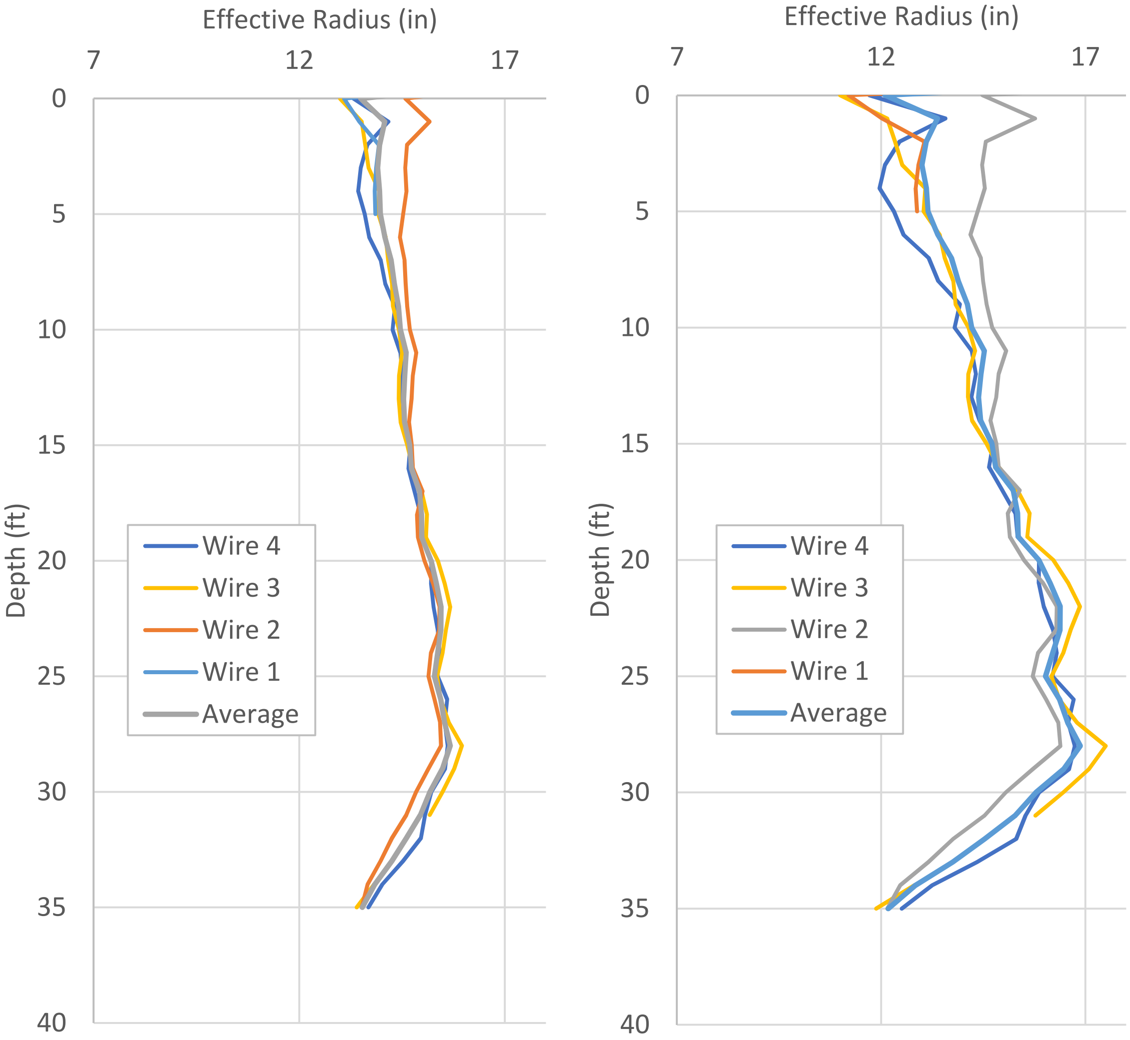

Figure B.3 Pile C2 effective radius from cage wire data using reported grout volume over given partial length, T0 method (left), Tsoil method (right).

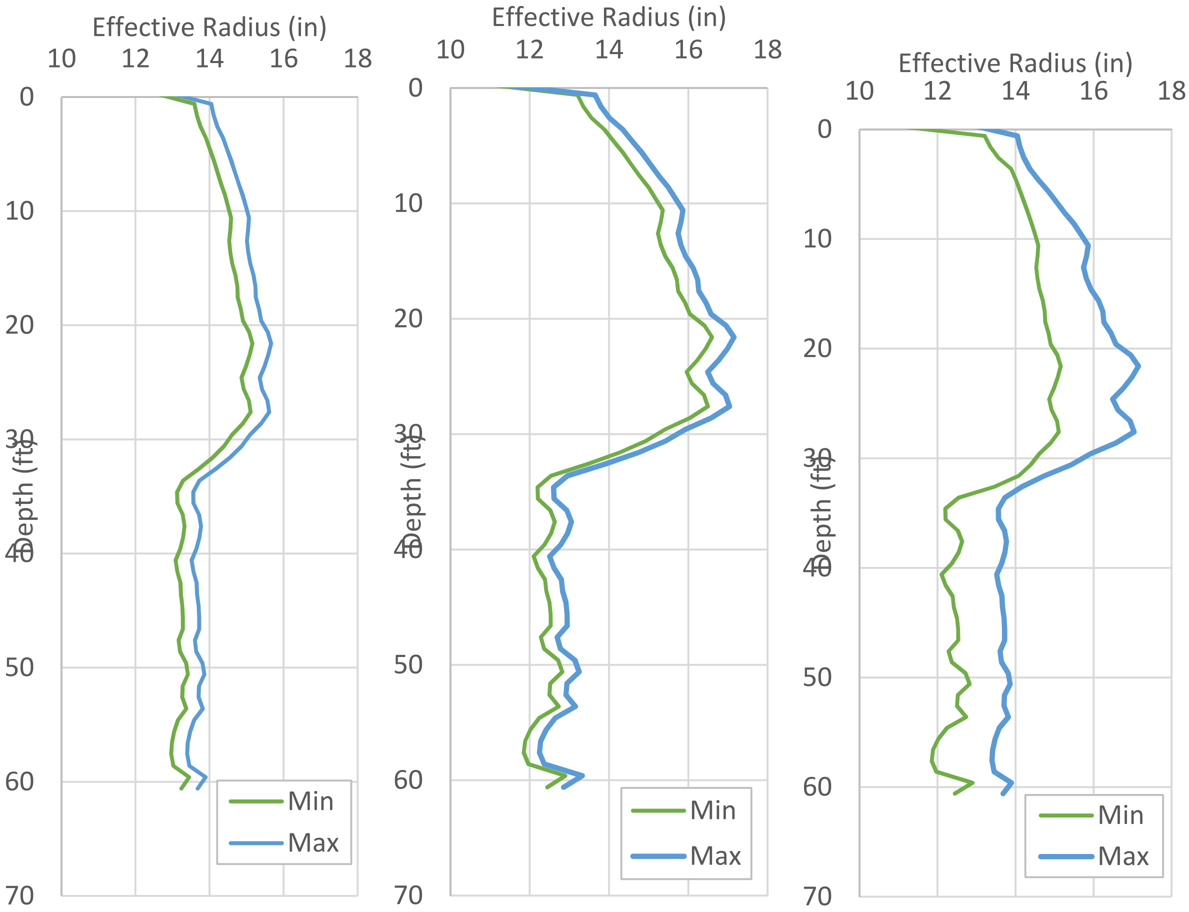

Figure B.4 Pile C2 effective radius from center bar wire data using actual reported grout volume (max) and reported volume grout less initial pump count (min) – T0 method (left), Tsoil method (center), min/max from all combinations (right).

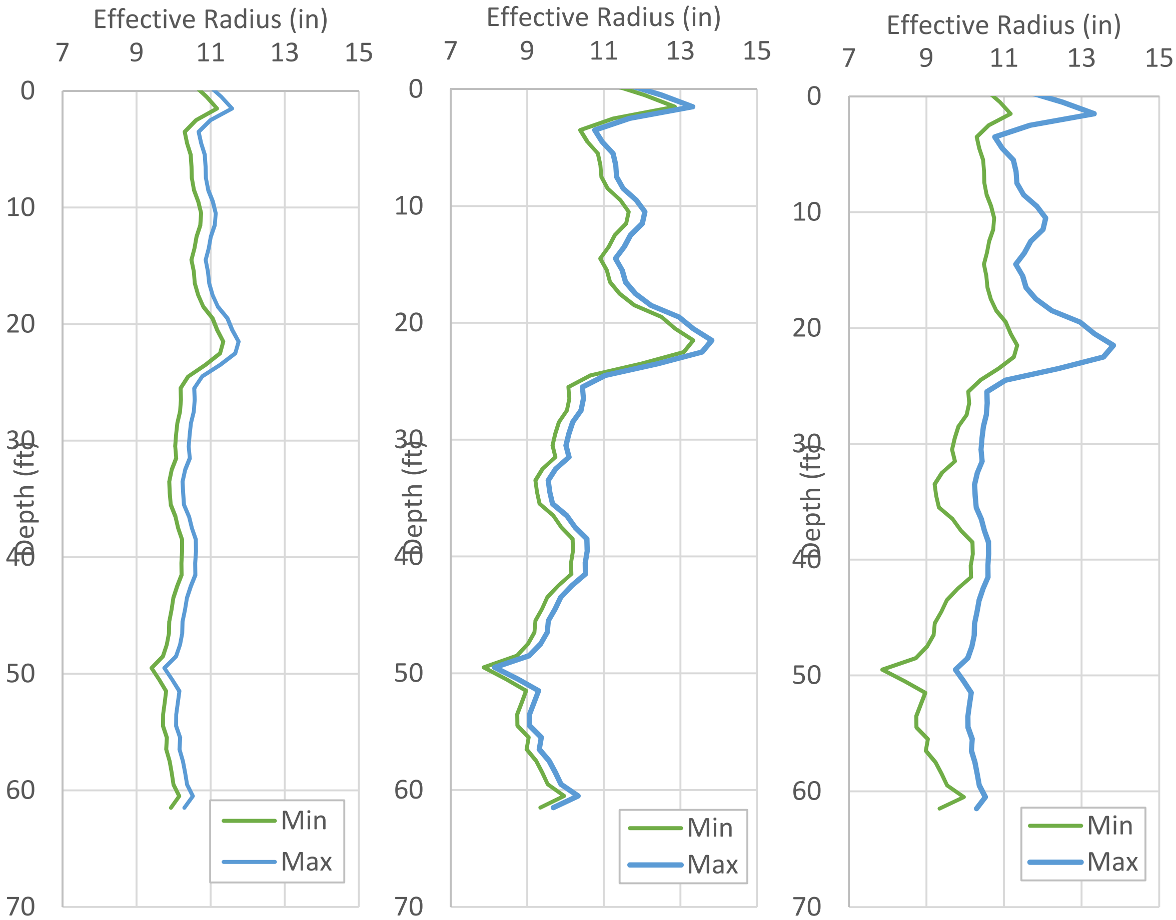

Figure B.5 Pile T1 effective radius from center bar wire data using actual reported grout volume (max) and reported volume grout less initial pump count (min) – T0 method (left), Tsoil method (center), min/max from all combinations (right).

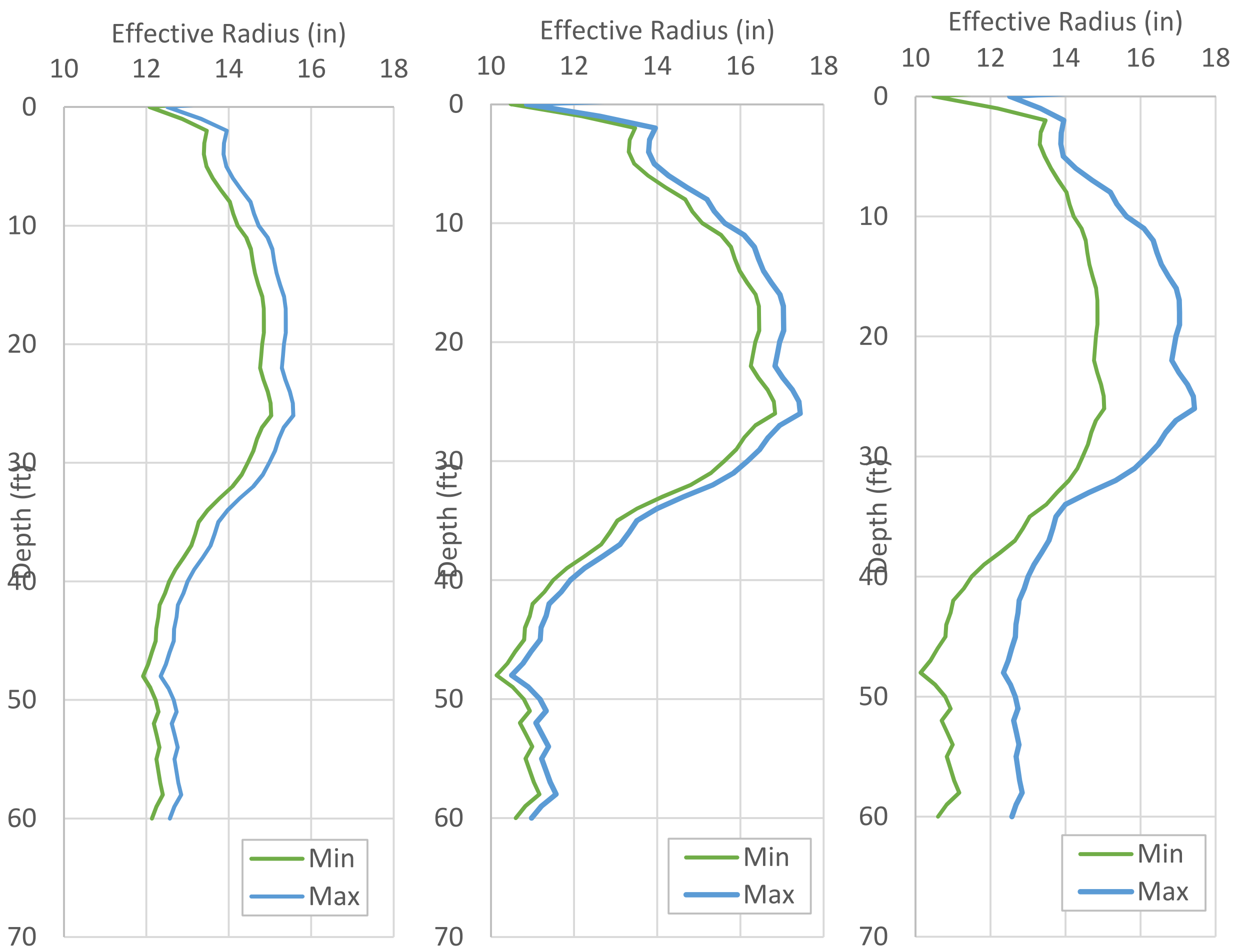

Figure B.6 Pile T2 effective radius from center bar wire data using actual reported grout volume (max) and reported volume grout less initial pump count (min) – T0 method (left), Tsoil method (center), min/max from all combinations (right).

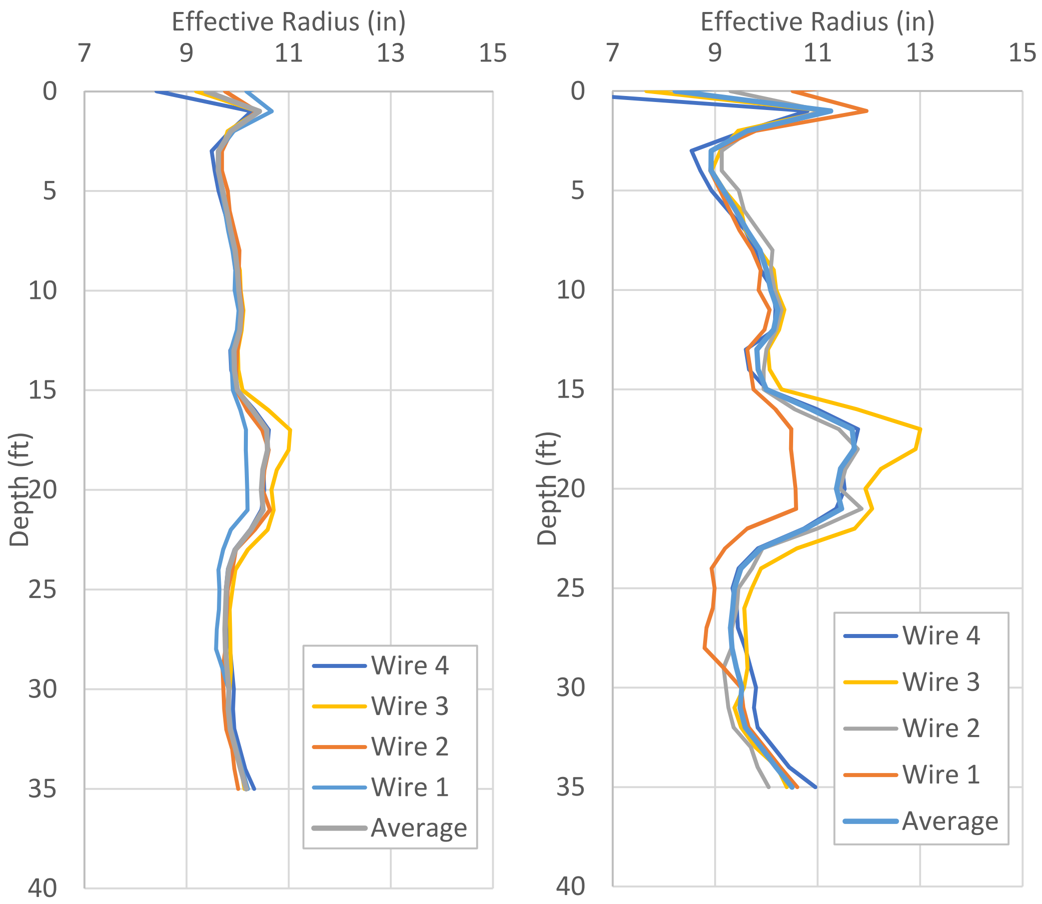

Figure B.7 Pile L1 effective radius from cage wire data using reported grout volume over given partial length, T0 method (left), Tsoil method (right).

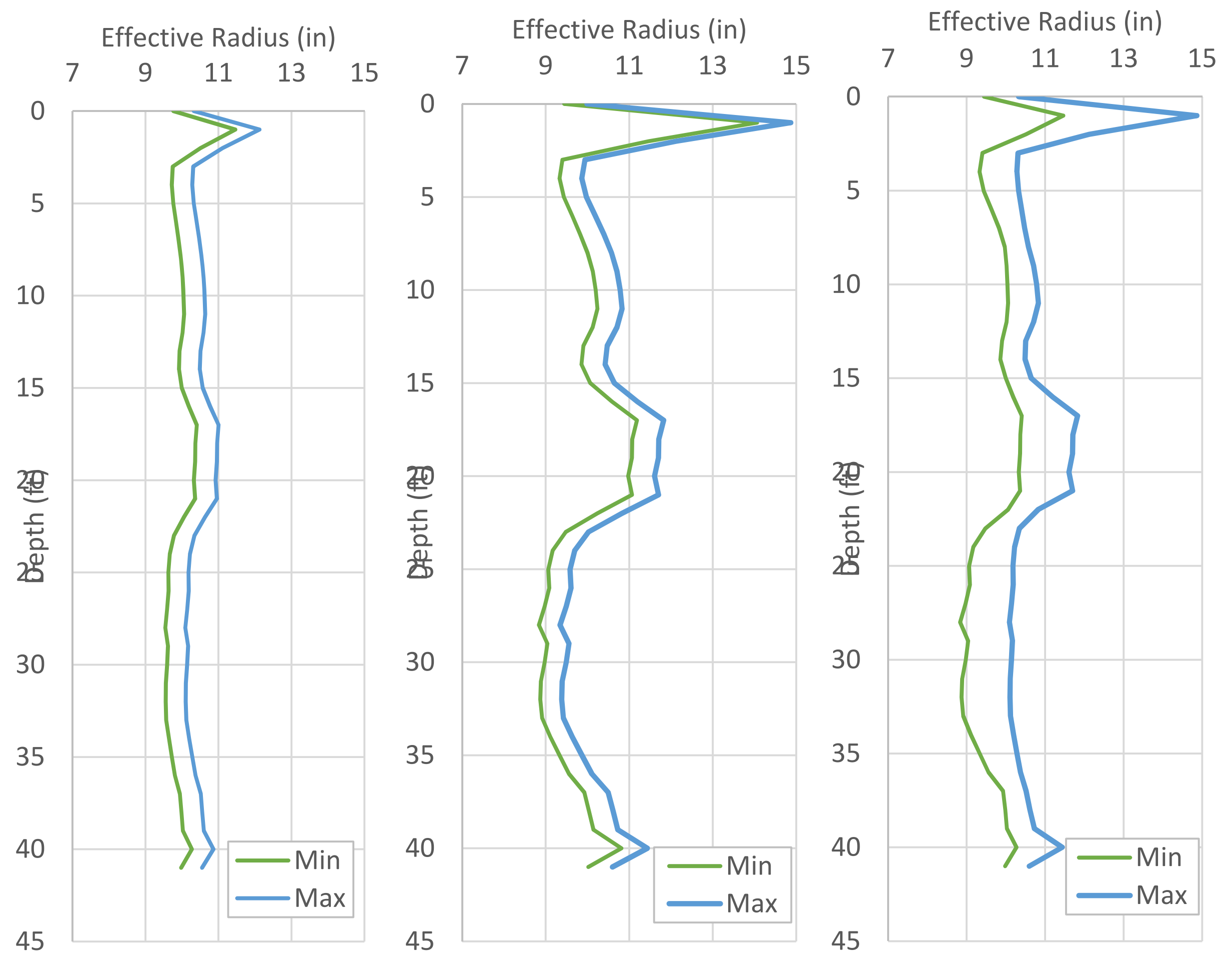

Figure B.8 Pile L1 effective radius from center bar wire data using actual reported grout volume (max) and reported volume grout less initial pump count (min) – T0 method (left), Tsoil method (center), min/max from all combinations (right).

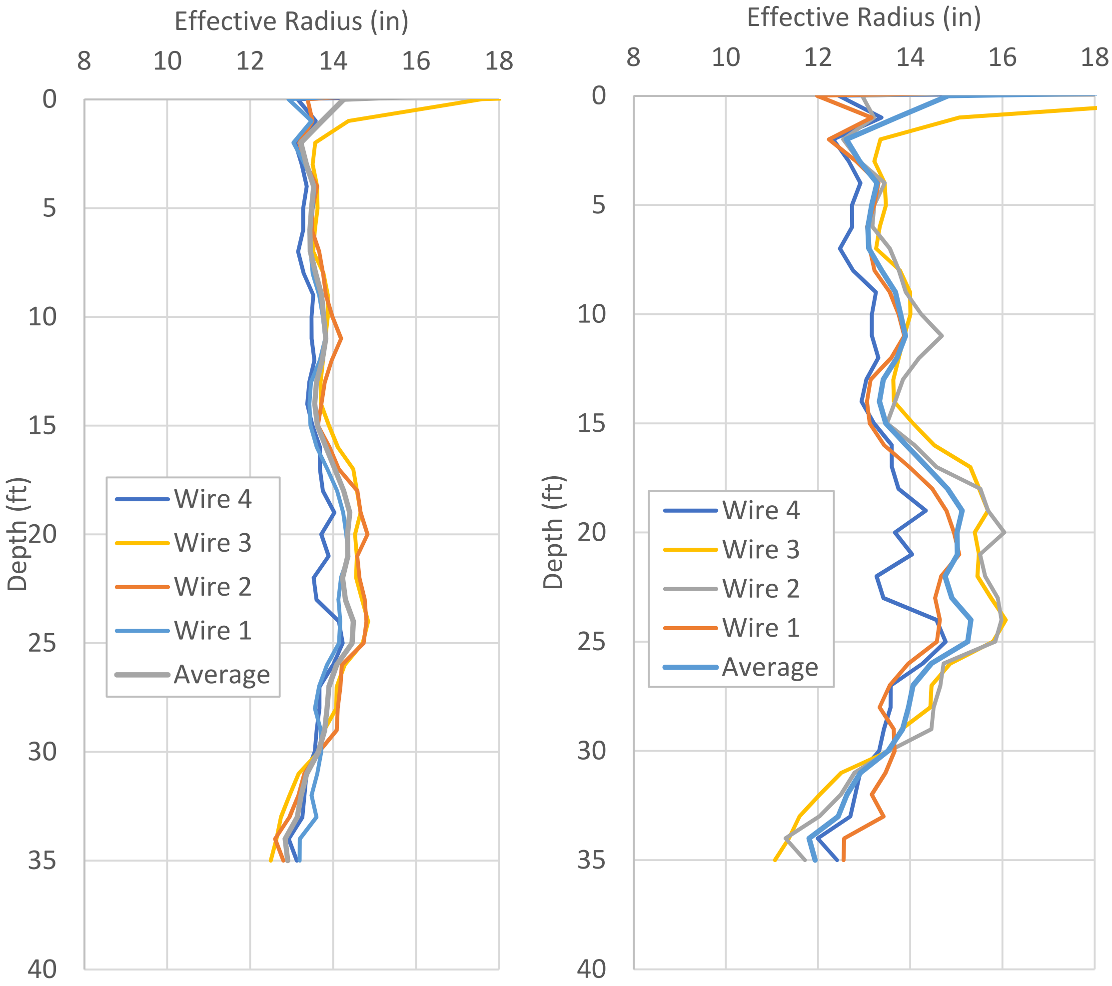

Figure B.9 Pile L2 effective radius from cage wire data using reported grout volume over given partial length, T0 method (left), Tsoil method (right).

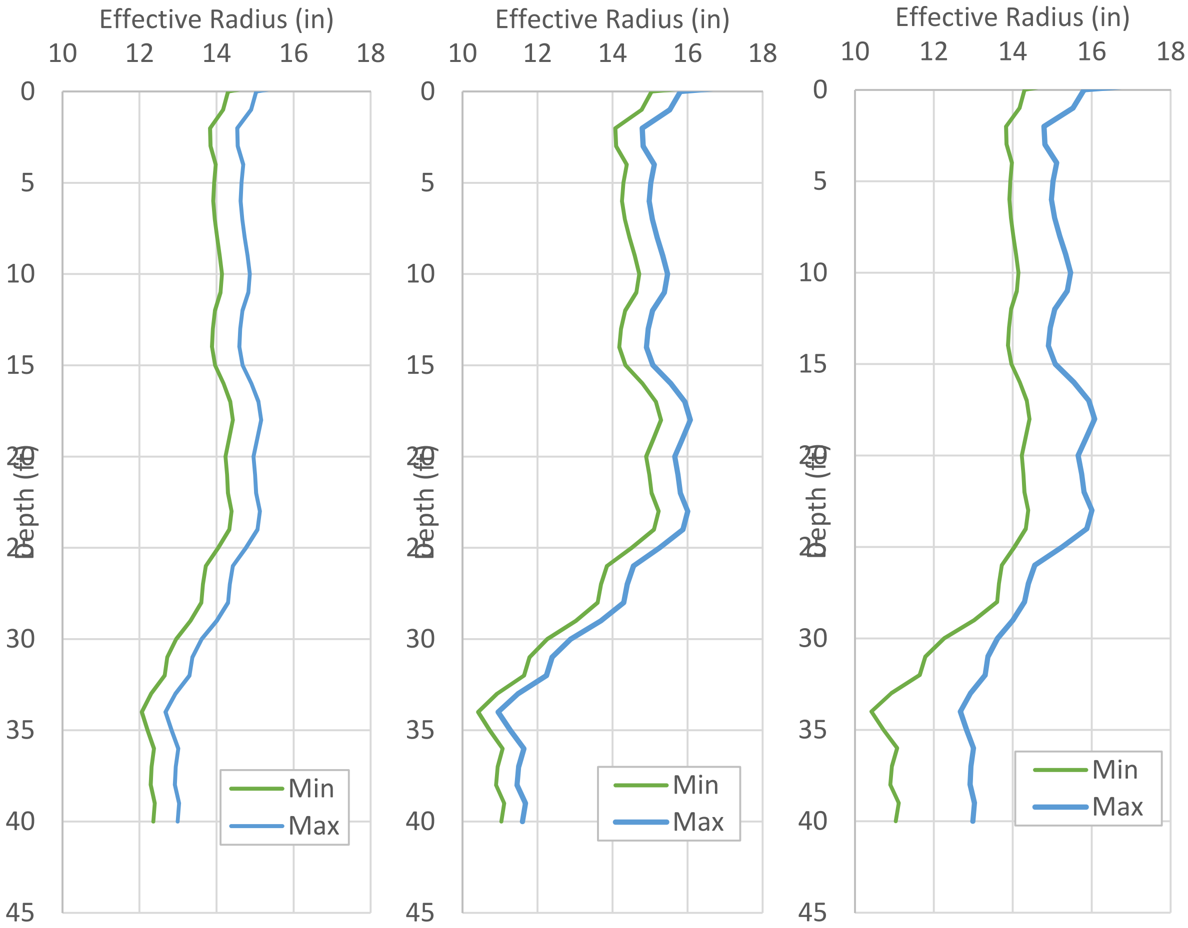

Figure B.10 Pile L2 effective radius from center bar wire data using actual reported grout volume (max) and reported volume grout less initial pump count (min) – T0 method (left), Tsoil method (center), min/max from all combinations (right).

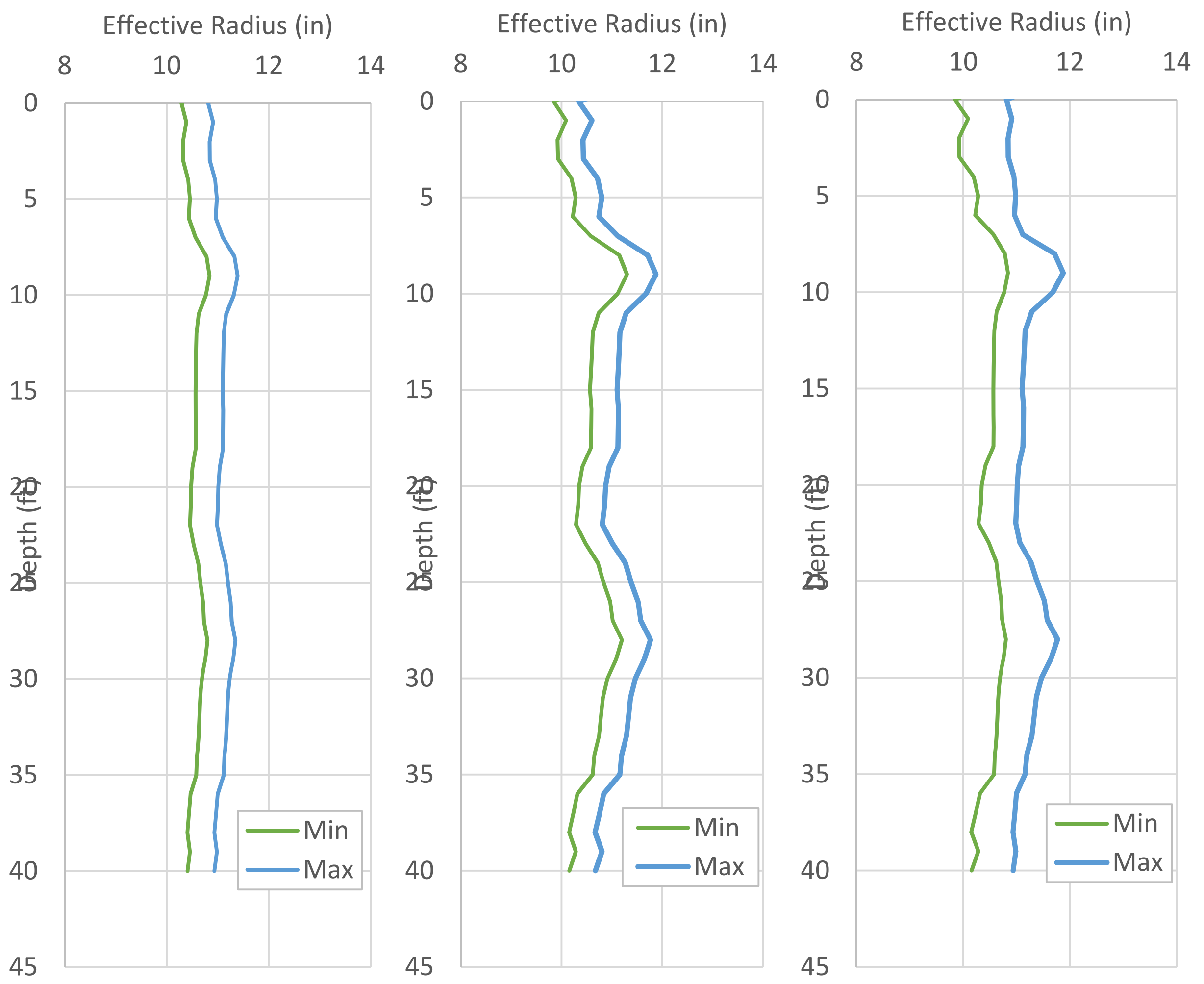

Figure B.11 Pile E1 effective radius from center bar wire data using actual reported grout volume (max) and reported volume grout less initial pump count (min) – T0 method (left), Tsoil method (center), min/max from all combinations (right).

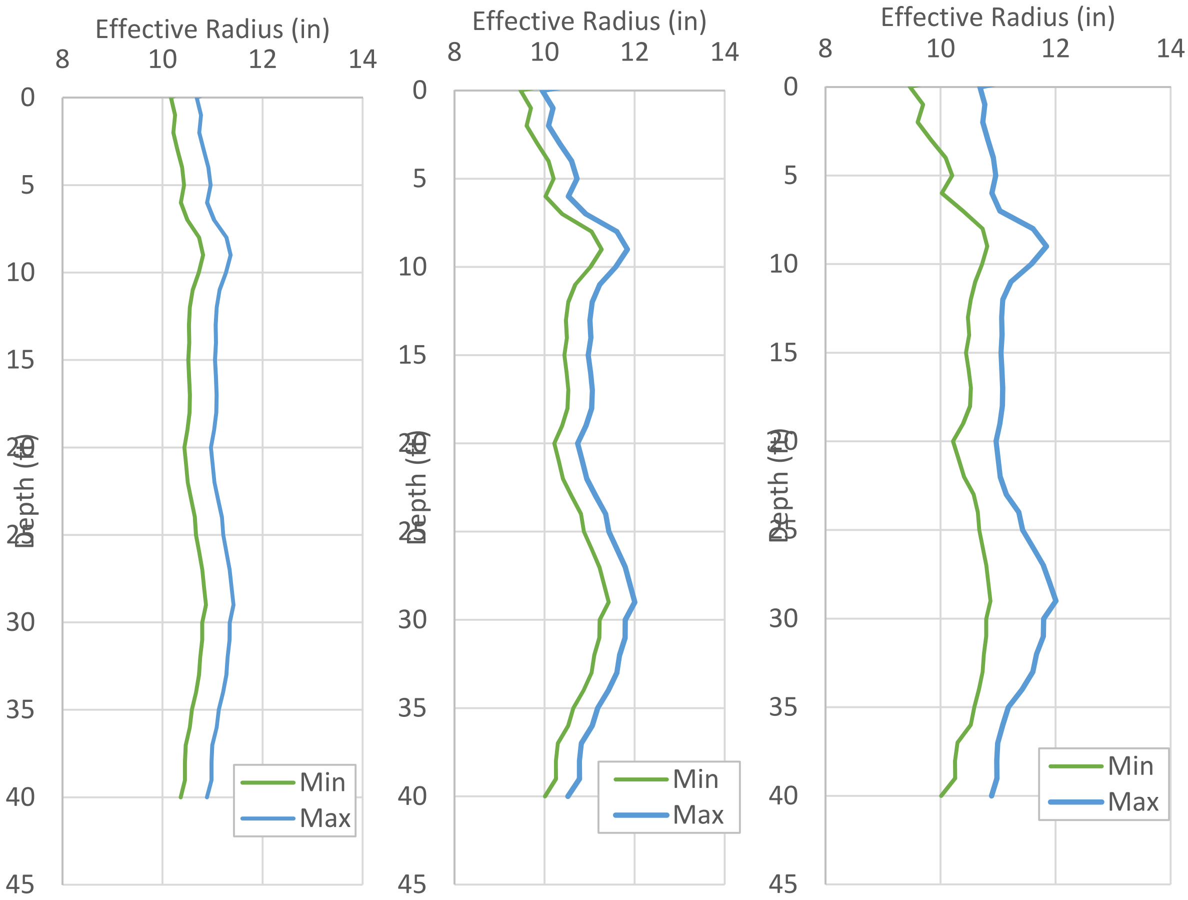

Figure B.12 Pile E1 effective radius from cage wire data using actual reported grout volume (max) and reported volume grout less initial pump count (min) – T0 method (left), Tsoil method (center), min/max from all combinations (right).

Appendix C

Boring Logs

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

FORM 675-020-12
MATERIALS
08/99

SHEET 1 OF 2

PROJECT NO. N/A NAME Auger Cast Pile Research COUNTY Lake DISTRICT 5
LOCATION Okahumpka FL TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE Cme 75 RIG NO. 26005 BORING NO. #1 (L1)
DATE STARTED 9/12/2016 COMPLETED 9/17/2016 DRILLED BY Bruce/Kyle
LOGGED BY Dallon/Todd BORING TYPE: AUGER, WASHED, PERCUSSION, [✓ ROTARY]
CASED, UNCASED, [✓ DRILLING MUD]
WATER TABLE: 0 HR. ______ 24 HRS. 13' (collapse) HRS. ______

SAMPLE CONDITIONS:
☒ DISTURBED
▨ GOOD
■ LOST
▯ CORE SAMPLE

SAMPLE TYPES:
A: AUGER
[✓ SB:] SPLIT BARREL
S: SHELBY TUBE
RC: ROCK CORE ______ SIZE

TESTS:
W.C.: WATER CONTENT (%)
T: TORVANE (TSF)
V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	1	1 2 2	Dark Brown to Black Sand	▨	1	50	SB	
	2 3	3 2 3	Dark Brown to Light Brown sand	▨	2	50	SB	
	4	1 2 2	Light Brown Sand	▨	3	50	SB	
	5	2 3 2	Light Brown to white Sand	▨	4	50	SB	
	6 7	3 3 3	Light Brown to white Sand w/ Trace of orange	▨	5	60	SB	
	8 9	3 3 4	Same	▨	6	60	SB	
	10	4 3 4	Same	▨	7	70	SB	
	11 12 13 14							
	15 16	2 3 4	Dark Brown to Black sand	▨	8	50	SB	
	17 18 19 20							

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08/99

FIELD BORING LOG

SHEET 2 OF 2

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER Same SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #1 (L1)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:
- ☒ DISTURBED
- ▨ GOOD
- ■ LOST
- ◫ CORE SAMPLE

SAMPLE TYPES:
- A: AUGER
- SB: SPLIT BARREL
- S: SHELBY TUBE
- RC: ROCK CORE ______ SIZE

TESTS:
- W.C.: WATER CONTENT (%)
- T: TORVANE (TSF)
- V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	20							
	21	7 7 8	Light Brown Sand	▨	9	60	SB	
	22							
	23							
	24							
	25							
	26	13 14 13	Stiff Light Brown Clay w/ Sand	▨	10	100	SB	
	27							
	28							
	29							
	30							
	31	7 7 8	Stiff Grey Sandy Clay	▨	11	100	SB	
	32							
	33							
	34							
	35							
	36	9 8 8	Tan Slightly Silty Sand	▨	12	90	SB	
	37							
	38							
	39							
	40							
	41	7 8	Same	▨	13	80	SB	
	41.5	9						

EOB 41.5'

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FIELD BORING LOG

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SHEET 1 OF 4

PROJECT NO. N/A NAME Auger Cast Pile Research COUNTY Lake DISTRICT 5
LOCATION Okahumpka FL TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE CME 75 RIG NO. 26005 BORING NO. #2 (C-1)
DATE STARTED 9/12/2016 COMPLETED 9/13/2016 DRILLED BY Bruce /Kyle
LOGGED BY Dalton / Todd BORING TYPE: AUGER, WASHED, PERCUSSION, [✓ ROTARY], CASED, UNCASED, [✓ DRILLING MUD],
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:
- ☒ DISTURBED
- ▨ GOOD
- ■ LOST
- ▥ CORE SAMPLE

SAMPLE TYPES:
- A: AUGER
- [✓ SB]: SPLIT BARREL
- S: SHELBY TUBE
- RC: ROCK CORE ______ SIZE

TESTS:
- W.C.: WATER CONTENT (%)
- T: TORVANE (TSF)
- V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	0							
	1							
	2 3	1 1	Dark Brown to Black Sand	▨	1	30	SB	
	4	3 2 2	Light Brown to Brown Sand	▨	2	40	SB	
	5 6	1 2 4	Light tan Sand	▨	3	60	SB	
	7	4 5 5	Light tan Sand Trace of orange	▨	4	70	SB	
	8 9	4 4 4	Same	▨	5	50	SB	
	10	5 3 4	Same	▨	6	70	SB	
	11 12	3 3 3	Same	▨	7	60	SB	
	13	3 3 3	Light tan Sand	▨	8	60	SB	
	14 15	1 2 1	Dark Brown to Grey Sand	▨	9	70	SB	Water Table 15'
	16							
	17							
	18 19	5 5 6	Tan Sand	▨	10	70	SB	
	20							

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FIELD BORING LOG

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SHEET 2 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #2 (C-1)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:		SAMPLE TYPES:		TESTS:	
☒	DISTURBED	A:	AUGER	W.C.:	WATER CONTENT (%)
▨	GOOD	SB:	SPLIT BARREL	T:	TORVANE (TSF)
■	LOST	S:	SHELBY TUBE	V:	IN-SITU VANE TEST (TSF)
▥	CORE SAMPLE	RC:	ROCK CORE ______ SIZE		

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	20 21 22	6 5 6	sand - traces of silt (?)	■	1	0		Sample fell out of spoon
	23 24	4 8 6	SAME	■	2	0		SAME
	25 26 27	9 8 7	Tan Silty Sand w/ trace orange	▨	11	80	SB	
	28 29	3 6 7	Tan Silty Sand	▨	12	80	SB	
	30 31 32	7 7 8	Same	▨	13	80	SB	
	33 34	8 7 8	Same	▨	14	70	SB	
	35 36 37	8 7 7	Tan Slightly Silty Sand	▨	15	70	SB	
	38 39 40	7 7 8	Same	▨	16	70	SB	

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FIELD BORING LOG

SHEET 3 OF 4

PROJECT NO. ____ NAME ____ COUNTY ____ DISTRICT ____
LOCATION ____ TOWNSHIP ____ RANGE ____ SECTION ____
ROAD NUMBER ____ SURFACE ELEVATION ____
EQUIPMENT TYPE ____ RIG NO. ____ BORING NO. #2 (C+1)
DATE STARTED ____ COMPLETED ____ DRILLED BY ____
LOGGED BY ____ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ____
WATER TABLE: 0 HR. ____ 24 HRS. ____ HRS. ____

SAMPLE CONDITIONS:
☒ DISTURBED
▨ GOOD
■ LOST
◫ CORE SAMPLE

SAMPLE TYPES:
A: AUGER
SB: SPLIT BARREL
S: SHELBY TUBE
RC: ROCK CORE ____ SIZE

TESTS:
W.C.: WATER CONTENT (%)
T: TORVANE (TSF)
V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES			TESTS	REMARKS
				CON.	NO. TYPE	REC. (%)		
	40 41 42	5 6 7	Tan slightly Silty Sand	▨	17	70	SB	
	43 44	5 6 6	Same	▨	18	70	SB	
	45 46 47	6 6 5	Slightly Silty tan Sand	▨	19	80	SB	
	48 49	5 5 5	Tan Slightly Silty Sand	▨	20	70	SB	* lost First 20% of Sample From Tip of Spoon
	50 51 52	3 4 3	Same	▨	21	70	SB	
	53 54	5 7 7	Tan Sand with Slight Trace of Silt	▨	22	60	SB	* lost First 20% of Sample From Tip of Spoon
	55 56 57	5 3 6	Same	▨	23	90	SB	
	58 59 60	8 6 5	Same	▨	24	80	SB	

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FIELD BORING LOG

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SHEET 4 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #2 (C-1)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______

Same

WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:		SAMPLE TYPES:		TESTS:	
☒	DISTURBED	A:	AUGER	W.C.:	WATER CONTENT (%)
▨	GOOD	SB:	SPLIT BARREL	T:	TORVANE (TSF)
■	LOST	S:	SHELBY TUBE	V:	IN-SITU VANE TEST (TSF)
▯	CORE SAMPLE	RC:	ROCK CORE ______ SIZE		

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES			TESTS	REMARKS
				CON.	NO. TYPE	REC. (%)		
	60							
	61	5 9 9	Same	▨	25	70	SB	
	62							
	63 64	5 7 8	Same	▨	26	60	SB	
	65							
	66	6 8 8	Same	▨	27	60	SB	
	67							
	68 69	6 5 8	Same	▨	28	60	SB	
	70							
	71 71.5	6 7 8	Same	▨	29	70	SB	
			EOB 71.5'					

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FIELD BORING LOG

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MATERIALS
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SHEET 1 OF 4

PROJECT NO. ______ NAME Auger cast Pile Research COUNTY Lake DISTRICT 5
LOCATION Okahumpka, FL. TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE CME 75 RIG NO. 26005 BORING NO. #3 (T-1)
DATE STARTED 9/13/2016 COMPLETED 9/13/2016 DRILLED BY Bruce / kyle
LOGGED BY Dalton / Todd BORING TYPE: AUGER, WASHED, PERCUSSION, [✓ ROTARY], CASED, UNCASED, [✓ DRILLING MUD],
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:
- ☒ DISTURBED
- ▨ GOOD
- ■ LOST
- ▥ CORE SAMPLE

SAMPLE TYPES:
- A: AUGER
- [✓ SB:] SPLIT BARREL
- S: SHELBY TUBE
- RC: ROCK CORE ______ SIZE

TESTS:
- W.C.: WATER CONTENT (%)
- T: TORVANE (TSF)
- V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	1		Dug Down					
	2 3	2 3 3	DARK GREY SAND	▨	1	50	SB	
	4	2 2 3	TAN SAND	▨	2	70	SB	
	5 6	2 3 4	LIGHT TAN SAND	▨	3	70	SB	
	7	3 4 5	SAME/SLIGHTLY SILTY	▨	4	75	SB	
	8 9	4 3 5	LIGHT TAN TO BROWN SOME SILT	▨	5	70	SB	
	10	4 4 4	Tan Sand	▨	6	70	SB	
	11 12	3 3 3	Tan Sand w/Trace orange Sand	▨	7	70	SB	
	13	3 3 2	Tan Sand	▨	8	60	SB	
	14 15	1 2 2	Tan Sand	▨	9	95	SB	
	16	1 1 3	Braun to tan Sand	▨	10	25	SB	
	17							
	18							
	19							
	20							

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SHEET 2 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE Same RIG NO. ______ BORING NO. #3 (T-1)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:		SAMPLE TYPES:		TESTS:	
☒	DISTURBED	A:	AUGER	W.C.:	WATER CONTENT (%)
▨	GOOD	SB:	SPLIT BARREL	T:	TORVANE (TSF)
■	LOST	S:	SHELBY TUBE	V:	IN-SITU VANE TEST (TSF)
▥	CORE SAMPLE	RC:	ROCK CORE ______ SIZE		

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	20							
	21	3 3 3	Tan Sand Slight trace of silt	▨	11	40	SB	
	22							
	23							
	24							
	25							
	26	5 7 9	Silty tan sand w/ Trace orange sand	▨	12	60	SB	
	27							
	28							
	29							
	30							
	31	7 7 8	Same	▨	13	80	SB	
	32							
	33							
	34							
	35							
	36	5 6 6	Same	▨	14	70	SB	
	37							
	38							
	39							
	40							

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SHEET 3 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______

LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______

ROAD NUMBER ______ Same SURFACE ELEVATION ______

EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #3 (T-1)

DATE STARTED ______ COMPLETED ______ DRILLED BY ______

LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______

WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:		SAMPLE TYPES:		TESTS:	
☒	DISTURBED	A:	AUGER	W.C.:	WATER CONTENT (%)
▨	GOOD	SB:	SPLIT BARREL	T:	TORVANE (TSF)
■	LOST	S:	SHELBY TUBE	V:	IN-SITU VANE TEST (TSF)
◫	CORE SAMPLE	RC:	ROCK CORE ______ SIZE		

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	40							
	41	1 4 4	Same	▨	15	50	SB	
	42							
	43							
	44							
	45							
	46	6 9 8	Same	▨	16	60	SB	
	47							
	48							
	49							
	50							
	51	6 7 7	Tan sand w/ Trace of Silt	▨	17	70	SB	
	52							
	53							
	54							
	55							
	56	3 3 5	Light tan Sand w/ trace of silt	▨	18	60	SB	
	57							
	58							
	59							
	60							

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FIELD BORING LOG

SHEET 4 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER Same SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #3 (T-1)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:
☒ DISTURBED
▨ GOOD
■ LOST
▯ CORE SAMPLE

SAMPLE TYPES:
A: AUGER
SB: SPLIT BARREL
S: SHELBY TUBE
RC: ROCK CORE ______ SIZE

TESTS:
W.C.: WATER CONTENT (%)
T: TORVANE (TSF)
V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	60 61	4 5 9	Same	▨	19	60	SB	
	62							
	63							
	64							
	65 66	7 9 7	Tan Silty Sand	▨	20	60	SB	# Sample 20
	67							
	68							
	69							
	70 71 71.5	4 6 6	Same EOB 71.5'	▨	21	60	SB	

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STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

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SHEET 1 OF 2

PROJECT NO. ______ NAME Auger Cast Pile Research COUNTY Lake DISTRICT 5
LOCATION Okahumpka, FL TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE CME 75 RIG NO. 26005 BORING NO. #4 (L-2)
DATE STARTED 9/13/2016 COMPLETED ______ DRILLED BY Bruce/kyle
LOGGED BY Dalton/todd BORING TYPE: AUGER, WASHED, PERCUSSION, [✓ ROTARY], CASED, UNCASED, [✓ DRILLING MUD],
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:		SAMPLE TYPES:		TESTS:	
☒	DISTURBED	A:	AUGER	W.C.:	WATER CONTENT (%)
▨	GOOD	[✓ SB:]	SPLIT BARREL	T:	TORVANE (TSF)
■	LOST	S:	SHELBY TUBE	V:	IN-SITU VANE TEST (TSF)
◫	CORE SAMPLE	RC:	ROCK CORE ______ SIZE		

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES			TESTS	REMARKS
				CON.	NO. TYPE	REC. (%)		
	0 1 2		Dug Down					
	3	1 1 2	Brown Sand	▨	1	60	SB	
	4 5	1 1 1	Tan to Brown Sand	▨	2	40	SB	
	6	2 2 4	Light tan Sand w/ Trace orange sand	▨	3	50	SB	
	7 8	3 3 4	Same	▨	4	60	SB	
	9	3 4 4	Same	▨	5	60	SB	
	10 11	3 4 3	Same	▨	6	60	SB	
	12	3 4 3	Brown to light tan Sand w/ Trace orange sand	▨	7	60	SB	
	13 14 15							
	16	1 1 2	Dark Brown Sand	▨	8	30	SB	
	17 18 19 20							* material is Real soft (WOH?)

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FIELD BORING LOG

SHEET 2 OF 2

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE Same RIG NO. ______ BORING NO. #4 (L-2)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:		SAMPLE TYPES:		TESTS:	
☒	DISTURBED	A:	AUGER	W.C.:	WATER CONTENT (%)
▨	GOOD	SB:	SPLIT BARREL	T:	TORVANE (TSF)
■	LOST	S:	SHELBY TUBE	V:	IN-SITU VANE TEST (TSF)
▯	CORE SAMPLE	RC:	ROCK CORE ______ SIZE		

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	20							
	21	1 1 3	Light Brown to Brown Sand	▨	9	30	SB	
	22							
	23							
	24							
	25							
	26	6 7 9	Light Brown Sand	▨	10	30	SB	
	27							
	28							
	29							
	30							
	31	8 9 11	Brown Slightly Silty Sand	▨	11	50	SB	
	32							
	33							
	34							
	35							
	36	5 6 7	Silty Brown Sand	▨	12	50	SB	
	37							
	38							
	39							
	40							
	41 41.5	6 9 11	Green to Grey Clay	▨	13	95	SB	

EOB 41.5'

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STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

FORM 675-020-12
MATERIALS
08/99

SHEET 1 OF 4

PROJECT NO. ______ NAME Auger cast Pile Research COUNTY Lake DISTRICT 5
LOCATION Okahumpka, FL TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE CME-75 RIG NO. 26005 BORING NO. #5 (C-2)
DATE STARTED 9/14/2016 COMPLETED 9/14/2016 DRILLED BY Bruce/Kyle
LOGGED BY Dalton/Todd BORING TYPE: AUGER, WASHED, PERCUSSION, [✓ ROTARY], CASED, UNCASED, [✓ DRILLING MUD],
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:
- ☒ DISTURBED
- ▨ GOOD
- ■ LOST
- ▥ CORE SAMPLE

SAMPLE TYPES:
- A: AUGER
- [✓ SB:] SPLIT BARREL
- S: SHELBY TUBE
- RC: ROCK CORE ______ SIZE

TESTS:
- W.C.: WATER CONTENT (%)
- T: TORVANE (TSF)
- V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES			TESTS	REMARKS
				CON.	NO. TYPE	REC. (%)		
	1 2		Dug Down					
	3	1 2 2	Dark Brown Sand	▨	1	30	SB	
	4 5	2 2 2	Brown to Dark Brown Sand	▨	2	30	SB	
	6	3 3 3	Tan to Brown Sand	▨	3	40	SB	
	7 8	2 3 4	Same	▨	4	40	SB	
	9	4 5 4	Same	▨	5	50	SB	
	10 11	4 3 3	Tan Sand W/ trace of orange Sand	▨	6	50	SB	
	12	4 4 3	Tan Sand	▨	7	60	SB	
	13 14 15							
	16	1 2 3	Brown Sand	▨	8	30	SB	
	17 18 19 20							

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STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FORM 675-020-12
MATERIALS
08/99

FIELD BORING LOG

SHEET 2 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #5 (C-2)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAME

SAMPLE CONDITIONS:
☒ DISTURBED
▨ GOOD
■ LOST
▯ CORE SAMPLE

SAMPLE TYPES:
A: AUGER
SB: SPLIT BARREL
S: SHELBY TUBE
RC: ROCK CORE ______ SIZE

TESTS:
W.C.: WATER CONTENT (%)
T: TORVANE (TSF)
V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	20	3 5 4	Brown Slightly Silty Sand	▨	9	50	SB	
	21							
	22							
	23							
	24							
	25	4 5 7	tan Sand w/ Trace of Silt	▨	10	50	SB	
	26							
	27							
	28							
	29							
	30	4 7 8	Tan Sand	▨	11	50	SB	
	31							
	32							
	33							
	34							
	35	8 8 7	Slightly Silty Brown Sand	▨	12	40	SB	
	36							
	37							
	38							
	39							
	40							

RECYCLED PAPER

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

FORM 675-020-12
MATERIALS
08/99

SHEET 3 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #5 (C-2)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

Same

SAMPLE CONDITIONS:		SAMPLE TYPES:		TESTS:	
☒	DISTURBED	A:	AUGER	W.C.:	WATER CONTENT (%)
▨	GOOD	SB:	SPLIT BARREL	T:	TORVANE (TSF)
■	LOST	S:	SHELBY TUBE	V:	IN-SITU VANE TEST (TSF)
▥	CORE SAMPLE	RC:	ROCK CORE ______ SIZE		

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	40	5	grey to green Sandy Clay	▨				
	41	8 8			13	60	SB	
	42							
	43							
	44							
	45	4						
	46	7 10	SAME		14	60	SB	
	47							
	48							
	49							
	50	8	Tan Slightly Silty Sand	▨				
	51	10 8			15	50	SB	
	52							
	53							
	54							
	55	6		▨				
	56	5 5	Same		16	60	SB	
	57							
	58							
	59							
	60							

RECYCLED PAPER

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

FORM 675-020-12
MATERIALS
08/99

SHEET 4 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #5 (C-2)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:
☒ DISTURBED
▨ GOOD
■ LOST
▥ CORE SAMPLE

SAMPLE TYPES:
A: AUGER
SB: SPLIT BARREL
S: SHELBY TUBE
RC: ROCK CORE ______ SIZE

TESTS:
W.C.: WATER CONTENT (%)
T: TORVANE (TSF)
V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES			TESTS	REMARKS
				CON.	NO. TYPE	REC. (%)		
	60 61	4 4 5	Same	▨	17	60	SB	
	62							
	63							
	64							
	65 66	3 5 5	Same	▨	18	50	SB	
	67							
	68							
	69							
	70 71 71.5	5 7 8	Same	▨	19	50	SB	

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

FORM 675-020-12
MATERIALS
08/99

SHEET 1 OF 4

PROJECT NO. ____ NAME Auger cast Pile Research COUNTY Lake DISTRICT 5
LOCATION okahumpka, FL TOWNSHIP ____ RANGE ____ SECTION ____
ROAD NUMBER ____ SURFACE ELEVATION ____
EQUIPMENT TYPE CME - 75 RIG NO. 26005 BORING NO. #6 (T-2)
DATE STARTED 9/14/2016 COMPLETED 9/14/2016 DRILLED BY Bruce / Kyle
LOGGED BY Todd / Dalton BORING TYPE: AUGER, WASHED, PERCUSSION, [✓ ROTARY,] CASED, UNCASED, [✓ DRILLING MUD,]
WATER TABLE: 0 HR. ____ 24 HRS. ____ HRS. ____

SAMPLE CONDITIONS:

- ☒ DISTURBED
- ▨ GOOD
- ■ LOST
- ◫ CORE SAMPLE

SAMPLE TYPES:

- A: AUGER
- [✓ SB:] SPLIT BARREL
- S: SHELBY TUBE
- RC: ROCK CORE ____ SIZE

TESTS:

- W.C.: WATER CONTENT (%)
- T: TORVANE (TSF)
- V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES			TESTS	REMARKS
				CON.	NO. TYPE	REC. (%)		
	0 1		Dug Down					
	2 3	2 3 3	Dark Brown Sand	▨	1	20	SB	
	4 5	2 2 3	tan to Brown Sand	▨	2	30	SB	
	6	2 4 3	Same	▨	3	40	SB	
	7 8	2 2 2	Brown to Dark Brown sand	▨	4	50	SB	
	9	2 3 2	Dark Brown Sand	▨	5	50	SB	
	10 11	2 2 2	Same	▨	6	50		
	12 13 14 15							
	16	1 2 2	Brown to Dark Brown Sand	▨	7	20	SB	
	17 18 19 20							

RECYCLED PAPER

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

FORM 675-020-12
MATERIALS
08/99

SHEET 2 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE Same RIG NO. ______ BORING NO. #6(T-2)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:		SAMPLE TYPES:		TESTS:	
☒	DISTURBED	A:	AUGER	W.C.:	WATER CONTENT (%)
▨	GOOD	SB:	SPLIT BARREL	T:	TORVANE (TSF)
■	LOST	S:	SHELBY TUBE	V:	IN-SITU VANE TEST (TSF)
▮	CORE SAMPLE	RC:	ROCK CORE ______ SIZE		

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES			TESTS	REMARKS
				CON.	NO. TYPE	REC. (%)		
	20	2 3 5	Brown Slightly Silty Sand	▨	8	40	SB	
	21							
	22							
	23							
	24							
	25	4 6 5	Same	▨	9	50	SB	
	26							
	27							
	28							
	29							
	30	5 7 8	Slightly Silty Tan Sand	▨	10	46	SB	
	31							
	32							
	33							
	34							
	35	4 5 6	Light Brown Slightly Silty Sand	▨	11	50	SB	
	36							
	37							
	38							
	39							
	40							

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STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

FORM 675-020-12
MATERIALS
08/99

SHEET 3 OF 4

PROJECT NO. ______ NAME Auger cast pile COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER Same SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #6 (T-2)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:		SAMPLE TYPES:		TESTS:	
☒	DISTURBED	A:	AUGER	W.C.:	WATER CONTENT (%)
▨	GOOD	SB:	SPLIT BARREL	T:	TORVANE (TSF)
■	LOST	S:	SHELBY TUBE	V:	IN-SITU VANE TEST (TSF)
▮	CORE SAMPLE	RC:	ROCK CORE ______ SIZE		

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	40	6 7 7	Same	▨	12	30	SB	
	41							
	42							
	43							
	44							
	45	5 7 8	grey to green clay	▨	13	60	SB	
	46							
	47							
	48							
	49							
	50	5 6 8	Same	▨	14	60	SB	
	51							
	52							
	53							
	54							
	55	7 9 11	Slightly Silt tan Sand	▨	15	50	SB	
	56							
	57							
	58							
	59							
	60							

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FORM 675-020-12
MATERIALS
08/99

FIELD BORING LOG

SHEET 4 OF 4

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER Same SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. #16 (T-2)
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS:
☒ DISTURBED
▨ GOOD
■ LOST
▥ CORE SAMPLE

SAMPLE TYPES:
A: AUGER
SB: SPLIT BARREL
S: SHELBY TUBE
RC: ROCK CORE ______ SIZE

TESTS:
W.C.: WATER CONTENT (%)
T: TORVANE (TSF)
V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	60	6						
	61	7 7	Slightly silty tan sand	////	16	60	SB	
	62							
	63							
	64							
	65	5						
	66	5 8	Same	////	17	50	SB	
	67							
	68							
	69							
	70	3						
	71 71.5	4 6	Same EOB 71.5'	////	18	70	SB	

RECYCLED PAPER

Appendix D

Manual Grout Logs

Florida Department of Transportation

Auger Cast-In-Place Pile Installation Record

Worksheet

Pile Number / ID: **C1**

700-011-03
Construction
01/16

Page: 1

PROJECT:

FP ID Number:	86 166	Pile Number / ID:	C1
Project Descr.:	DFI Research Project	Pile Location:	Okahumpka FL
Contractor:	DFI ACIP Pile Committee	Installation Date:	10/27/16
Structure No./ID:	Test Area	Inspector (s):	Clay Davis

Comments:
18" Compression Test

THEORETICAL: calculated OGF Vol. & Strokes				THEOR.
Segment / Incr. Length (ft)	OGF (%)	VOL. (cu ft)	PUMP STROKES	100% Vol. (cu ft)
1 ft INCREMENT:	115	2.03	3	1.77
5 ft *SEGMENT(s):		10.16	13	8.84
5 ft Top SEGMENT:	105	9.28	12	8.84
PILE Vol. & Stroke TOTALS:		121.05	155	106.03

	Segment Length (ft):	5.00
OGF	Reduced OGF (Top 5 ft Segment only):	1.05
OGF	Overgrout Factor OGF (Below 5 ft depth):	1.15
Head	Min. Req'd Grout Head (ft):	5.00
Head	Theor. Initial Pump Count (strokes):	12
	Pressure Gage Location (descr.):	
	Grout Design Strength (psi):	6000

Design Capacity: 220 tons

PUMP CALIBRATION	
VOLUME of Container (cu ft):	5.50
STROKES to Fill Cont. (strokes):	7
PUMP CAL (cu ft/stroke):	0.79

* Qty of (11) full 115%-OGF, 5-ft segments, in this 60-ft pile [below the top (1) 5-ft Reduced OGF segment]

INSTALLATION DATA

PLAN	Plan Top Elev. (ft, NGVD):		141.00
	Plan Length (ft):		60.00
	Plan Tip Elev. (ft, NGVD):		81.00
	Plan Dia. (ft):		1.50
DRILLING	GSE (ft, NGVD):		140.00
	Drilling START (time):		9:45 AM
	Auger Rate (rpf):		
	Drilling FINISH (time):		9:52 AM
	Drilling TIME (min.):		7
	Actual Pile Dia. (ft):		1.50
	Actual Pile Top Elev. (ft, NGVD):		141.00
	Overburden Length (above Plan Top) (ft):		n/a
	Actual Pile Length (below Pile Top)(ft):		60.00
	Actual Tip Elev. (ft, NGVD):		81.00
GROUT	Plant No.:	1 or 2 Concr. Trucks:	2
	T2 Start Depth (ft):	**2nd Truck**	**1st Truck**
	Delivery Ticket No.:	41401202	41401201
	Batch (time):	8:23 AM	8:20 AM
	Arrive (time):	9:16 AM	8:43 AM
	Flow Cone Test (sec):	15	18
	Grout Temp. (ºF):		
	Grout Cylinders LOT (ID):	Sample 4	
	Placement START (time):	9:54 AM	9:52 AM
	Starting Pressure (psi):	185	185
	Actual **Initial Pump Count** (strokes):		13
	Auger Depth @ **Grout Return** (ft):		10.0
	Truck Empty (time):		9:54 AM
	Placement FINISH (time):	9:55 AM	9:54 AM
	Placement TIME (min.):	1	2
	Mixer TIME (min.):		94
STEEL	Reinf. Condition Satisfactory? (Y or N):		Y
	Reinf. Placement START (time):		9:55 AM
	Reinf. Placement FINISH (time):		10:05 AM
	Reinf. Comments:	#11 Centerbar - 8x#8 Cage x 35 ft	
TEST	Check **GROUT STRENGTH TESTING** Results	2nd Truck	1st Truck
	Does the Grout Meet the Minimum Required Stength? (Y or N) :	6650	

Comments:

FEEDBACK

Actual Pile Length (ft) & Segment Length (ft) input complete.
Table rows for the Pile & Segment Lengths input complete.
Table input of the table PUMP COUNT data, for the bottom/1st lift is complete.
Actual Pile Diameter = Plan Pile Diameter, meets 455 spec.
Flow Cone Test, FAILED (Consistency < 21 sec)
Note: ACTUAL initial pump count OK, > or = THEORETICAL (Min. Req'd Grout Head)
Actual Grout volume placed is OK. All incr. segments are > or = the min. Theoretical OGF volume req'd.
Grout Return > or = the 'Min. Req'd Grout Head' (5 ft) input above.
Reinforcement Placement Time, 10 min, meets 455 spec limit (< or = 30 min).
Follow-up to verify the Grout meets the Minimum Required Strength.

Type of PUMP COUNT input = 'INCREMENTAL' : I

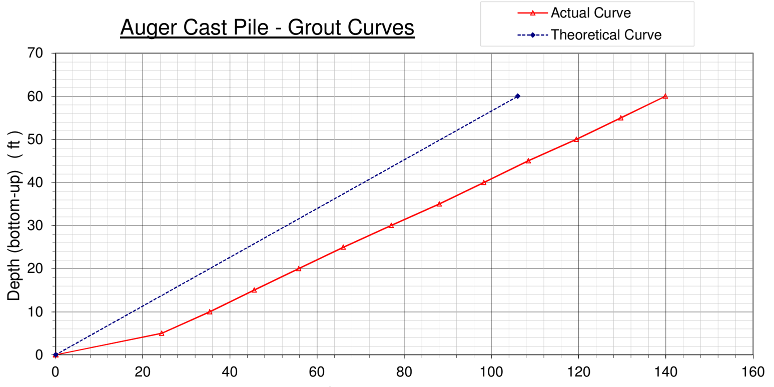
DRILLING & GROUTING TABLE

DEPTH (ft)			SEGMENT	SOIL	GROUT	PUMP COUNT		GROUT VOLUMES			
								INCREMENTAL			ACCRUED
Below Top	-	Top of Segment	EL (ft, NGVD)	Cond. S, M, or H	Pressure (psi)	INCR. (Per 5 ft)	ACCRUED (SUM)	Theor. (cu ft)	Actual (cu ft)	% Theor.	Actual (cu ft)
0		(Pile TOP)	141.00	Soil Cond.: Start input at Pile TOP, Grout Pump Count: start input at Pile BOTTOM.							
5	-	0	136.00		185	13	178	8.84	10.21	116 %	139.86
10	-	5	131.00		185	13	165	8.84	10.21	116 %	129.64
15	-	10	126.00		185	14	152	8.84	11.00	124 %	119.43
20	-	15	121.00		185	13	138	8.84	10.21	116 %	108.43
25	-	20	116.00		185	13	125	8.84	10.21	116 %	98.21
30	-	25	111.00		185	14	112	8.84	11.00	124 %	88.00
35	-	30	106.00		185	14	98	8.84	11.00	124 %	77.00
40	-	35	101.00		185	13	84	8.84	10.21	116 %	66.00
45	-	40	96.00		185	13	71	8.84	10.21	116 %	55.79
50	-	45	91.00		185	13	58	8.84	10.21	116 %	45.57
55	-	50	86.00		185	14	45	8.84	11.00	124 %	35.36
60	-	55	81.00		185	31	31	8.84	24.36	276 %	24.36
	-										
	-										
	-										
	-										
	-										
	-										
	-										
	-										
Pile BOTTOM @ depth = 60 ft						178		106.03		132 %	139.86
						Total Pump Strokes		Total Theor. Vol. (cf)		Actual/Theor. (%)	Actual (cf)

GROUT VOLUME PLACEMENT RESULTS

SEGMENT Descr.	VOLUMES (cu ft)		% THEORETICAL			ACCEPTANCE	
	Actual Placed	Theor. Vol.	OGF %	% Theor. Actual/Theor	% Over	Min. % Placed	P/F
TOP 5-ft	10.21	8.84	105	116 %	11 %	116 %	Pass
BELOW 5-ft	129.64	97.19	115	133 %	18 %	116 %	Pass
Total Pile	139.86	106.03	114	132 %	Pile Pass/Fail:		Pass

FINAL ACEPTANCE	Pile Not Yet Accepted
Accepted or Rejected ? (input "A" or "R"):	
Pile Acceped or Rejected (date):	
Comments:	



Florida Department of Transportation

Auger Cast-In-Place Pile Installation Record

Worksheet

Pile Number / ID: **C2**

700-011-03
Construction
01/16

Page: 1

PROJECT:

FP ID Number:	86 166
Project Descr.:	DFI Research Project
Contractor:	DFI ACIP Pile Committee
Structure No./ID:	Test Area

Comments:
24" Compression Test

Pile Number / ID:	C2
Pile Location:	Okahumpka FL
Installation Date:	10/27/16
Inspector (s):	Clay Davis

THEORETICAL: calculated OGF Vol. & Strokes				THEOR.
Segment / Incr. Length (ft)	OGF (%)	VOL. (cu ft)	PUMP STROKES	100% Vol. (cu ft)
1 ft INCREMENT:		3.61	5	3.14
	115			
5 ft *SEGMENT(s):		18.06	23	15.71
5 ft Top SEGMENT:	105	16.49	21	15.71
PILE Vol. & Stroke TOTALS:		215.20	274	188.50

	Segment Length (ft):	5.00
OGF	Reduced OGF (Top 5 ft Segment only):	1.05
OGF	Overgrout Factor OGF (Below 5 ft depth):	1.15
Head	Min. Req'd Grout Head (ft):	5.00
Head	Theor. Initial Pump Count (strokes):	20
	Pressure Gage Location (descr.):	
	Grout Design Strength (psi):	6000

Design Capacity: 285 tons

PUMP CALIBRATION	
VOLUME of Container (cu ft):	5.50
STROKES to Fill Cont. (strokes):	7
PUMP CAL (cu ft/stroke):	0.79

* Qty of (11) full 115%-OGF, 5-ft segments, in this 60-ft pile [below the top (1) 5-ft Reduced OGF segment]

INSTALLATION DATA

PLAN	Plan Top Elev. (ft, NGVD):	141.00
	Plan Length (ft):	60.00
	Plan Tip Elev. (ft, NGVD):	81.00
	Plan Dia. (ft):	2.00
DRILLING	GSE (ft, NGVD):	140.00
	Drilling START (time):	12:07 PM
	Auger Rate (rpf):	
	Drilling FINISH (time):	12:14 PM
	Drilling TIME (min.):	7
	Actual Pile Dia. (ft):	2.00
	Actual Pile Top Elev. (ft, NGVD):	141.00
	Overburden Length (above Plan Top) (ft):	n/a
	Actual Pile Length (below Pile Top)(ft):	60.00
	Actual Tip Elev. (ft, NGVD):	81.00

GROUT	Plant No.:	1 or 2 Concr. Trucks:	2
	T2 Start Depth (ft):	**2nd Truck**	**1st Truck**
	Delivery Ticket No.:	41401209	41401206
	Batch (time):	10:40 AM	9:48 AM
	Arrive (time):	11:20 AM	10:11 AM
	Flow Cone Test (sec):	15	17
	Grout Temp. (ºF):		
	Grout Cylinders LOT (ID):	Sample 7	
	Placement START (time):	12:20 PM	12:14 PM
	Starting Pressure (psi):	185	185
	Actual **Initial Pump Count** (strokes):		22
	Auger Depth @ **Grout Return** (ft):		8.0
	Truck Empty (time):		12:20 PM
	Placement FINISH (time):	12:22 PM	12:20 PM
	Placement TIME (min.):	2	6
	Mixer TIME (min.):		152
STEEL	Reinf. Condition Satisfactory? (Y or N):		Y
	Reinf. Placement START (time):		12:22 PM
	Reinf. Placement FINISH (time):		12:35 PM
	Reinf. Comments:	#11 Centerbar - 12x#8 Cage x 35 ft	
TEST	Check **GROUT STRENGTH TESTING** Results		
	Does the Grout Meet the Minimum Required Stength? (Y or N) :	2nd Truck	1st Truck
		6070	

Comments:

FEEDBACK

Actual Pile Length (ft) & Segment Length (ft) input complete.

Table rows for the Pile & Segment Lengths input complete.

Table input of the table PUMP COUNT data, for the bottom/1st lift is complete.

Actual Pile Diameter = Plan Pile Diameter, meets 455 spec.

Flow Cone Test, FAILED (Consistency < 21 sec)

Note: ACTUAL initial pump count OK, > or = THEORETICAL (Min. Req'd Grout Head)

Actual Grout volume placed is OK. All incr. segments are > or = the min. Theoretical OGF volume req'd.

Grout Return > or = the 'Min. Req'd Grout Head' (5 ft) input above.

Reinforcement Placement Time, 13 min, meets 455 spec limit (< or = 30 min).

Follow-up to verify the Grout meets the Minimum Required Strength.

DRILLING & GROUTING TABLE

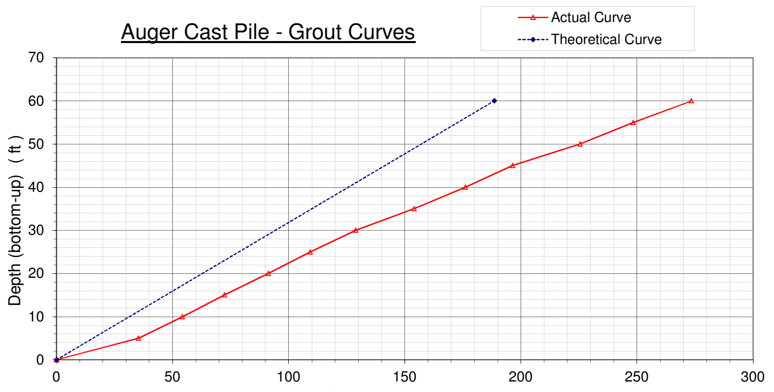
Type of PUMP COUNT input = 'INCREMENTAL' : I

DEPTH (ft)			SEGMENT	SOIL	GROUT	PUMP COUNT		GROUT VOLUMES INCREMENTAL			ACCRUED
Below Top	-	Top of Segment	EL (ft, NGVD)	Cond. S, M, or H	Pressure (psi)	INCR. (Per 5 ft)	ACCRUED (SUM)	Theor. (cu ft)	Actual (cu ft)	% Theor.	Actual (cu ft)
0		(Pile TOP)	141.00	Soil Cond.: Start input at Pile TOP, Grout Pump Count: start input at Pile BOTTOM.							
5	-	0	136.00		185	32	348	15.71	25.14	160 %	273.43
10	-	5	131.00		185	29	316	15.71	22.79	145 %	248.29
15	-	10	126.00		185	37	287	15.71	29.07	185 %	225.50
20	-	15	121.00		185	26	250	15.71	20.43	130 %	196.43
25	-	20	116.00		185	28	224	15.71	22.00	140 %	176.00
30	-	25	111.00		185	32	196	15.71	25.14	160 %	154.00
35	-	30	106.00		185	25	164	15.71	19.64	125 %	128.86
40	-	35	101.00		185	23	139	15.71	18.07	115 %	109.21
45	-	40	96.00		185	24	116	15.71	18.86	120 %	91.14
50	-	45	91.00		185	23	92	15.71	18.07	115 %	72.29
55	-	50	86.00		185	24	69	15.71	18.86	120 %	54.21
60	-	55	81.00		185	45	45	15.71	35.36	225 %	35.36
	-										
	-										
	-										
	-										
	-										
	-										
	-										
	-										
Pile BOTTOM @ depth = 60 ft						348		188.50		145 %	273.43
						Total Pump Strokes		Total Theor. Vol. (cf)		Actual/Theor. (%)	Actual (cf)

GROUT VOLUME PLACEMENT RESULTS

SEGMENT Descr.	VOLUMES (cu ft)		% THEORETICAL			ACCEPTANCE	
	Actual Placed	Theor. Vol.	OGF %	% Theor. Actual/Theor	% Over	Min. % Placed	P/F
TOP 5-ft	25.14	15.71	105	160 %	55 %	160 %	Pass
BELOW 5-ft	248.29	172.79	115	144 %	29 %	115 %	Pass
Total Pile	273.43	188.50	114	145 %		Pile Pass/Fail:	Pass

FINAL ACEPTANCE	Pile Not Yet Accepted
Accepted or Rejected ? (input "A" or "R"):	
Pile Acceped or Rejected (date):	
Comments:	



Florida Department of Transportation

Auger Cast-In-Place Pile Installation Record

Worksheet

Pile Number / ID: **T1**

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PROJECT:

FP ID Number:	86 166
Project Descr.:	DFI Research Project
Contractor:	DFI ACIP Pile Committee
Structure No./ID:	Test Area

Comments:
18" Tension Test

Pile Number / ID:	T1
Pile Location:	Okahumpka FL
Installation Date:	10/27/16
Inspector (s):	Clay Davis

THEORETICAL: calculated OGF Vol. & Strokes				THEOR.
Segment / Incr. Length (ft)	OGF (%)	VOL. (cu ft)	PUMP STROKES	100% Vol. (cu ft)
1 ft INCREMENT:		2.03	3	1.77
	115			
5 ft *SEGMENT(s):		10.16	13	8.84
5 ft Top SEGMENT:	105	9.28	12	8.84
PILE Vol. & Stroke TOTALS:		121.05	155	106.03

	Segment Length (ft):	5.00
OGF	Reduced OGF (Top 5 ft Segment only):	1.05
OGF	Overgrout Factor OGF (Below 5 ft depth):	1.15
Head	Min. Req'd Grout Head (ft):	5.00
Head	Theor. Initial Pump Count (strokes):	12
	Pressure Gage Location (descr.):	
	Grout Design Strength (psi):	6000

PUMP CALIBRATION	
VOLUME of Container (cu ft):	5.50
STROKES to Fill Cont. (strokes):	7
PUMP CAL (cu ft/stroke):	0.79

Design Capacity: 205 tons

* Qty of (11) full 115%-OGF, 5-ft segments, in this 60-ft pile [below the top (1) 5-ft Reduced OGF segment]

INSTALLATION DATA

PLAN	Plan Top Elev. (ft, NGVD):	141.00
PLAN	Plan Length (ft):	60.00
PLAN	Plan Tip Elev. (ft, NGVD):	81.00
PLAN	Plan Dia. (ft):	1.50
DRILLING	GSE (ft, NGVD):	140.00
DRILLING	Drilling START (time):	10:19 AM
DRILLING	Auger Rate (rpf):	
DRILLING	Drilling FINISH (time):	10:28 AM
DRILLING	Drilling TIME (min.):	9
DRILLING	Actual Pile Dia. (ft):	1.50
DRILLING	Actual Pile Top Elev. (ft, NGVD):	141.00
DRILLING	Overburden Length (above Plan Top) (ft):	n/a
DRILLING	Actual Pile Length (below Pile Top)(ft):	60.00
DRILLING	Actual Tip Elev. (ft, NGVD):	81.00

GROUT	Plant No.:		1 or 2 Concr. Trucks:	1
GROUT				**1st Truck**
GROUT	Delivery Ticket No.:			41401202
GROUT	Batch (time):			8:23 AM
GROUT	Arrive (time):			9:16 AM
GROUT	Flow Cone Test (sec):			15
GROUT	Grout Temp. (ºF):			
GROUT	Grout Cylinders LOT (ID):			Sample 5
GROUT	Placement START (time):			10:28 AM
GROUT	Starting Pressure (psi):			185
GROUT	Actual **Initial Pump Count** (strokes):			13
GROUT	Auger Depth @ **Grout Return** (ft):			5.0
GROUT	Truck Empty (time):			10:32 AM
GROUT	Placement FINISH (time):			10:32 AM
GROUT	Placement TIME (min.):			4
GROUT	Mixer TIME (min.):			129
STEEL	Reinf. Condition Satisfactory? (Y or N):			Y
STEEL	Reinf. Placement START (time):			10:32 AM
STEEL	Reinf. Placement FINISH (time):			10:37 AM
STEEL	Reinf. Comments:			3" Centerbar

Check **GROUT STRENGTH TESTING** Results

TEST		1st Truck
TEST	Does the Grout Meet the Minimum Required Stength? (Y or N) :	6910

Comments:

FEEDBACK

- Actual Pile Length (ft) & Segment Length (ft) input complete.
- Table rows for the Pile & Segment Lengths input complete.
- Table input of the table PUMP COUNT data, for the bottom/1st lift is complete.
- Actual Pile Diameter = Plan Pile Diameter, meets 455 spec.
- Flow Cone Test, FAILED (Consistency < 21 sec)
- Note: ACTUAL initial pump count OK, > or = THEORETICAL (Min. Req'd Grout Head)
- Actual Grout volume placed is OK. All incr. segments are > or = the min. Theoretical OGF volume req'd.
- Grout Return > or = the 'Min. Req'd Grout Head' (5 ft) input above.
- Reinforcement Placement Time, 5 min, meets 455 spec limit (< or = 30 min).
- Grout meets the Minimum required Strength.

Type of PUMP COUNT input = 'INCREMENTAL' : I

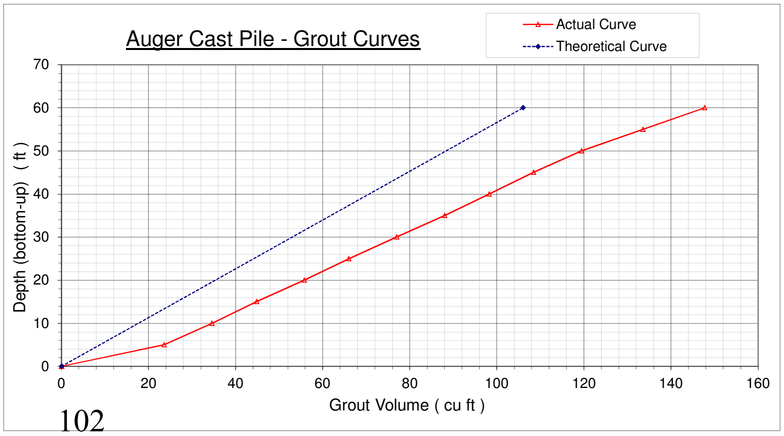
DRILLING & GROUTING TABLE

DEPTH (ft)			SEGMENT	SOIL	GROUT	PUMP COUNT		GROUT VOLUMES INCREMENTAL			ACCRUED
Below Top	-	Top of Segment	EL (ft, NGVD)	Cond. S, M, or H	Pressure (psi)	INCR. (Per 5 ft)	ACCRUED (SUM)	Theor. (cu ft)	Actual (cu ft)	% Theor.	Actual (cu ft)
0		(Pile TOP)	141.00	Soil Cond.: Start input at Pile TOP, Grout Pump Count: start input at Pile BOTTOM.							
5	-	0	136.00		185	18	188	8.84	14.14	160 %	147.71
10	-	5	131.00		185	18	170	8.84	14.14	160 %	133.57
15	-	10	126.00		185	14	152	8.84	11.00	124 %	119.43
20	-	15	121.00		185	13	138	8.84	10.21	116 %	108.43
25	-	20	116.00		185	13	125	8.84	10.21	116 %	98.21
30	-	25	111.00		185	14	112	8.84	11.00	124 %	88.00
35	-	30	106.00		185	14	98	8.84	11.00	124 %	77.00
40	-	35	101.00		185	13	84	8.84	10.21	116 %	66.00
45	-	40	96.00		185	14	71	8.84	11.00	124 %	55.79
50	-	45	91.00		185	13	57	8.84	10.21	116 %	44.79
55	-	50	86.00		185	14	44	8.84	11.00	124 %	34.57
60	-	55	81.00		185	30	30	8.84	23.57	267 %	23.57
	-										
	-										
	-										
	-										
	-										
	-										
	-										
	-										
Pile BOTTOM @ depth = 60 ft						188		106.03		139 %	147.71
						Total Pump Strokes		Total Theor. Vol. (cf)		Actual/Theor. (%)	Actual (cf)

GROUT VOLUME PLACEMENT RESULTS

SEGMENT Descr.	VOLUMES (cu ft)		% THEORETICAL			ACCEPTANCE	
	Actual Placed	Theor. Vol.	OGF %	% Theor. Actual/Theor	% Over	Min. % Placed	P/F
TOP 5-ft	14.14	8.84	105	160 %	55 %	160 %	Pass
BELOW 5-ft	133.57	97.19	115	137 %	22 %	116 %	Pass
Total Pile	147.71	106.03	114	139 %		Pile Pass/Fail:	Pass

FINAL ACEPTANCE	Pile Not Yet Accepted
Accepted or Rejected ? (input "A" or "R"):	
Pile Acceped or Rejected (date):	
Comments:	



Florida Department of Transportation

Auger Cast-In-Place Pile Installation Record

Worksheet

Pile Number / ID: **T2**

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PROJECT:

FP ID Number:	86 166
Project Descr.:	DFI Research Project
Contractor:	DFI ACIP Pile Committee
Structure No./ID:	Test Area

Comments:
24" Tension Test

Pile Number / ID:	T2
Pile Location:	Okahumpka FL
Installation Date:	10/27/16
Inspector (s):	Clay Davis

THEORETICAL: calculated OGF Vol. & Strokes				THEOR.
Segment / Incr. Length (ft)	OGF (%)	VOL. (cu ft)	PUMP STROKES	100% Vol. (cu ft)
1 ft INCREMENT:		3.61	5	3.14
	115			
5 ft *SEGMENT(s):		18.06	23	15.71
5 ft Top SEGMENT:	105	16.49	21	15.71
PILE Vol. & Stroke TOTALS:		215.20	274	188.50

	Segment Length (ft):	5.00
OGF	Reduced OGF (Top 5 ft Segment only):	1.05
OGF	Overgrout Factor OGF (Below 5 ft depth):	1.15
Head	Min. Req'd Grout Head (ft):	5.00
Head	Theor. Initial Pump Count (strokes):	20
	Pressure Gage Location (descr.):	
	Grout Design Strength (psi):	6000

Design Capacity: 265 tons

PUMP CALIBRATION	
VOLUME of Container (cu ft):	5.50
STROKES to Fill Cont. (strokes):	7
PUMP CAL (cu ft/stroke):	0.79

* Qty of (11) full 115%-OGF, 5-ft segments, in this 60-ft pile [below the top (1) 5-ft Reduced OGF segment]

INSTALLATION DATA

PLAN	Plan Top Elev. (ft, NGVD):	141.00
	Plan Length (ft):	60.00
	Plan Tip Elev. (ft, NGVD):	81.00
	Plan Dia. (ft):	2.00
DRILLING	GSE (ft, NGVD):	140.00
	Drilling START (time):	12:35 PM
	Auger Rate (rpf):	
	Drilling FINISH (time):	12:43 PM
	Drilling TIME (min.):	8
	Actual Pile Dia. (ft):	2.00
	Actual Pile Top Elev. (ft, NGVD):	141.00
	Overburden Length (above Plan Top) (ft):	n/a
	Actual Pile Length (below Pile Top)(ft):	60.00
	Actual Tip Elev. (ft, NGVD):	81.00

GROUT	Plant No.:	1 or 2 Concr. Trucks:	2
	T2 Start Depth (ft):	**2nd Truck**	**1st Truck**
	Delivery Ticket No.:	41401211	41401209
	Batch (time):	11:16 AM	10:40 AM
	Arrive (time):	11:52 AM	11:20 AM
	Flow Cone Test (sec):	15	15
	Grout Temp. (ºF):		
	Grout Cylinders LOT (ID):	Sample 8	
	Placement START (time):	12:47 PM	12:43 PM
	Starting Pressure (psi):	185	185
	Actual **Initial Pump Count** (strokes):		22
	Auger Depth @ **Grout Return** (ft):		5.0
	Truck Empty (time):		12:47 PM
	Placement FINISH (time):	12:50 PM	12:47 PM
	Placement TIME (min.):	3	4
	Mixer TIME (min.):		127
STEEL	Reinf. Condition Satisfactory? (Y or N):		Y
	Reinf. Placement START (time):		12:22 PM
	Reinf. Placement FINISH (time):		12:35 PM
	Reinf. Comments:	3" Centerbar	
TEST	Check **GROUT STRENGTH TESTING** Results		
	Does the Grout Meet the Minimum Required Stength? (Y or N) :	2nd Truck	1st Truck
		5800	

Comments:

FEEDBACK

Actual Pile Length (ft) & Segment Length (ft) input complete.
Table rows for the Pile & Segment Lengths input complete.
Table input of the table PUMP COUNT data, for the bottom/1st lift is complete.
Actual Pile Diameter = Plan Pile Diameter, meets 455 spec.
Flow Cone Test, FAILED (Consistency < 21 sec)
Note: ACTUAL initial pump count OK, > or = THEORETICAL (Min. Req'd Grout Head)
Actual Grout volume placed is OK. All incr. segments are > or = the min. Theoretical OGF volume req'd.
Grout Return > or = the 'Min. Req'd Grout Head' (5 ft) input above.
Reinforcement Placement Time, -15 min, meets 455 spec limit (< or = 30 min).
Follow-up to verify the Grout meets the Minimum Required Strength.

Type of PUMP COUNT input = 'INCREMENTAL' : I

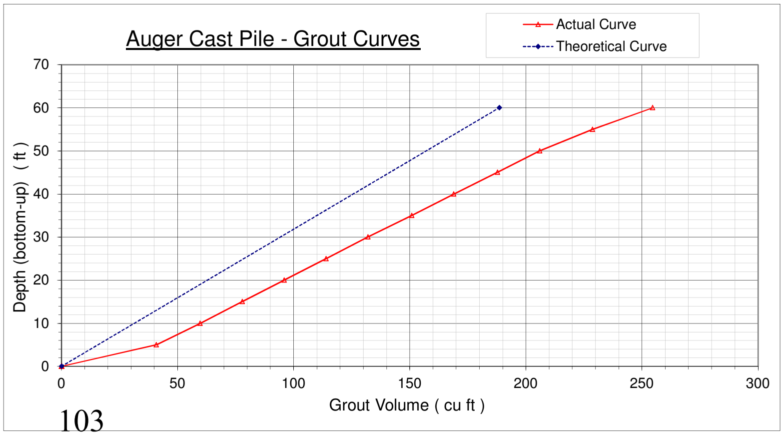
DRILLING & GROUTING TABLE

DEPTH (ft)			SEGMENT	SOIL	GROUT	PUMP COUNT		GROUT VOLUMES			
								INCREMENTAL			ACCRUED
Below Top	-	Top of Segment	EL (ft, NGVD)	Cond. S, M, or H	Pressure (psi)	INCR. (Per 5 ft)	ACCRUED (SUM)	Theor. (cu ft)	Actual (cu ft)	% Theor.	Actual (cu ft)
0		(Pile TOP)	141.00	Soil Cond.: Start input at Pile TOP, Grout Pump Count: start input at Pile BOTTOM.							
5	-	0	136.00		185	33	324	15.71	25.93	165 %	254.57
10	-	5	131.00		185	29	291	15.71	22.79	145 %	228.64
15	-	10	126.00		185	23	262	15.71	18.07	115 %	205.86
20	-	15	121.00		185	24	239	15.71	18.86	120 %	187.79
25	-	20	116.00		185	23	215	15.71	18.07	115 %	168.93
30	-	25	111.00		185	24	192	15.71	18.86	120 %	150.86
35	-	30	106.00		185	23	168	15.71	18.07	115 %	132.00
40	-	35	101.00		185	23	145	15.71	18.07	115 %	113.93
45	-	40	96.00		185	23	122	15.71	18.07	115 %	95.86
50	-	45	91.00		185	23	99	15.71	18.07	115 %	77.79
55	-	50	86.00		185	24	76	15.71	18.86	120 %	59.71
60	-	55	81.00		185	52	52	15.71	40.86	260 %	40.86
	-										
	-										
	-										
	-										
	-										
	-										
	-										
	-										
Pile BOTTOM @ depth = 60 ft							324	188.50		135 %	254.57
							Total Pump Strokes	Total Theor. Vol. (cf)		Actual/Theor. (%)	Actual (cf)

GROUT VOLUME PLACEMENT RESULTS

SEGMENT Descr.	VOLUMES (cu ft)		% THEORETICAL			ACCEPTANCE	
	Actual Placed	Theor. Vol.	OGF %	% Theor. Actual/Theor	% Over	Min. % Placed	P/F
TOP 5-ft	25.93	15.71	105	165 %	60 %	165 %	Pass
BELOW 5-ft	228.64	172.79	115	132 %	17 %	115 %	Pass
Total Pile	254.57	188.50	114	135 %		Pile Pass/Fail:	Pass

FINAL ACEPTANCE	Pile Not Yet Accepted
Accepted or **R**ejected ? (input "A" or "R"):	
Pile Acceped or Rejected (date):	
Comments:	



Florida Department of Transportation

Auger Cast-In-Place Pile Installation Record

Worksheet

Pile Number / ID:
L2

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PROJECT:

FP ID Number:	86 166
Project Descr.:	DFI Research Project
Contractor:	DFI ACIP Pile Committee
Structure No./ID:	Test Area

Comments:
24" Lateral Test

Pile Number / ID:	L2
Pile Location:	Okahumpka FL
Installation Date:	10/27/16
Inspector (s):	Clay Davis

THEORETICAL: calculated OGF Vol. & Strokes				THEOR.
Segment / Incr. Length (ft)	OGF (%)	VOL. (cu ft)	PUMP STROKES	100% Vol. (cu ft)
1 ft INCREMENT:		3.61	5	3.14
	115			
5 ft *SEGMENT(s):		18.06	24	15.71
5 ft Top SEGMENT:	105	16.49	22	15.71
PILE Vol. & Stroke TOTALS:		142.94	186	125.66

	Segment Length (ft):	5.00
OGF	Reduced OGF (Top 5 ft Segment only):	1.05
OGF	Overgrout Factor OGF (Below 5 ft depth):	1.15
Head	Min. Req'd Grout Head (ft):	5.00
Head	Theor. Initial Pump Count (strokes):	21
	Pressure Gage Location (descr.):	
	Grout Design Strength (psi):	6000

Design Capacity: 30 tons

PUMP CALIBRATION	
VOLUME of Container (cu ft):	6.15
STROKES to Fill Cont. (strokes):	8
PUMP CAL (cu ft/stroke):	0.77

* Qty of (7) full 115%-OGF, 5-ft segments, in this 40-ft pile [below the top (1) 5-ft Reduced OGF segment]

INSTALLATION DATA

PLAN	Plan Top Elev. (ft, NGVD):	141.00
	Plan Length (ft):	40.00
	Plan Tip Elev. (ft, NGVD):	101.00
	Plan Dia. (ft):	2.00
DRILLING	GSE (ft, NGVD):	140.00
	Drilling START (time):	11:40 AM
	Auger Rate (rpf):	
	Drilling FINISH (time):	11:45 AM
	Drilling TIME (min.):	5
	Actual Pile Dia. (ft):	2.00
	Actual Pile Top Elev. (ft, NGVD):	141.00
	Overburden Length (above Plan Top) (ft):	n/a
	Actual Pile Length (below Pile Top)(ft):	40.00
	Actual Tip Elev. (ft, NGVD):	101.00
	Plant No.:	1 or 2 Concr. Trucks: 1
		1st Truck
GROUT	Delivery Ticket No.:	41401206
	Batch (time):	9:48 AM
	Arrive (time):	10:11 AM
	Flow Cone Test (sec):	17
	Grout Temp. (ºF):	
	Grout Cylinders LOT (ID):	Sample 6
	Placement START (time):	11:45 AM
	Starting Pressure (psi):	185
	Actual **Initial Pump Count** (strokes):	22
	Auger Depth @ **Grout Return** (ft):	5.0
	Truck Empty (time):	
	Placement FINISH (time):	11:50 AM
	Placement TIME (min.):	5
	Mixer TIME (min.):	
STEEL	Reinf. Condition Satisfactory? (Y or N):	Y
	Reinf. Placement START (time):	11:50 AM
	Reinf. Placement FINISH (time):	12:05 AM
	Reinf. Comments:	#11 Centerbar - 12x#8 Cage x 35 ft
TEST	Check **GROUT STRENGTH TESTING** Results	1st Truck
	Does the Grout Meet the Minimum Required Stength? (Y or N) :	6220

Comments:

FEEDBACK

Actual Pile Length (ft) & Segment Length (ft) input complete.
Table rows for the Pile & Segment Lengths input complete.
Table input of the table PUMP COUNT data, for the bottom/1st lift is complete.
Actual Pile Diameter = Plan Pile Diameter, meets 455 spec.
Flow Cone Test, FAILED (Consistency < 21 sec)
Note: ACTUAL initial pump count OK, > or = THEORETICAL (Min. Req'd Grout Head)
Actual Grout volume placed is OK. All incr. segments are > or = the min. Theoretical OGF volume req'd.
Grout Return > or = the 'Min. Req'd Grout Head' (5 ft) input above.
Reinforcement Placement Time, -705 min, meets 455 spec limit (< or = 30 min).
Grout meets the Minimum required Strength.

DRILLING & GROUTING TABLE

Type of PUMP COUNT input = 'INCREMENTAL' : I

DEPTH (ft)			SEGMENT	SOIL	GROUT	PUMP COUNT		GROUT VOLUMES INCREMENTAL			ACCRUED
Below Top	-	Top of Segment	EL (ft, NGVD)	Cond. (S, M, or H)	Pressure (psi)	INCR. (Per 5 ft)	ACCRUED (SUM)	Theor. (cu ft)	Actual (cu ft)	% Theor.	Actual (cu ft)
0		(Pile TOP)	141.00	Soil Cond.: Start input at Pile TOP, Grout Pump Count: start input at Pile BOTTOM.							
5	-	0	136.00		185	32	232	15.71	24.60	157 %	178.35
10	-	5	131.00		185	32	200	15.71	24.60	157 %	153.75
15	-	10	126.00		185	27	168	15.71	20.76	132 %	129.15
20	-	15	121.00		185	25	141	15.71	19.22	122 %	108.39
25	-	20	116.00		185	24	116	15.71	18.45	117 %	89.18
30	-	25	111.00		185	24	92	15.71	18.45	117 %	70.73
35	-	30	106.00		185	24	68	15.71	18.45	117 %	52.28
40	-	35	101.00		185	44	44	15.71	33.83	215 %	33.83
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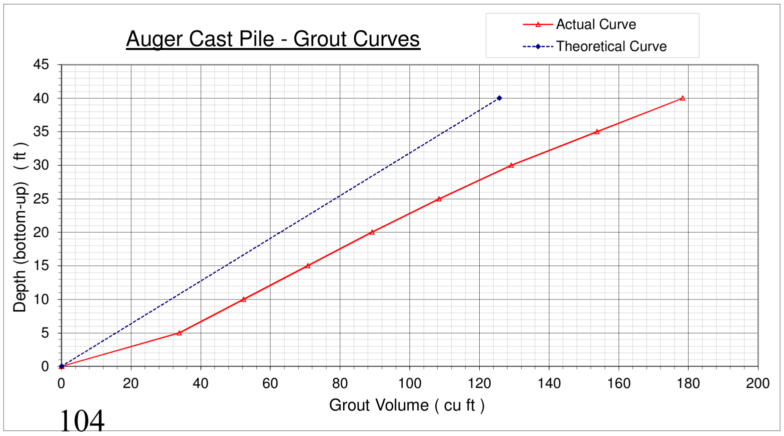
Pile BOTTOM @ depth = 40 ft						232		125.66		142 %	178.35
						Total Pump Strokes		Total Theor. Vol. (cf)		Actual/Theor. (%)	Actual (cf)

GROUT VOLUME PLACEMENT RESULTS

SEGMENT Descr.	VOLUMES (cu ft)		% THEORETICAL			ACCEPTANCE	
	Actual Placed	Theor. Vol.	OGF %	% Theor. Actual/Theor	% Over	Min. % Placed	P/F
TOP 5-ft	24.60	15.71	105	157 %	52 %	157 %	Pass
BELOW 5-ft	153.75	109.96	115	140 %	25 %	117 %	Pass
Total Pile	178.35	125.66	114	142 %		Pile Pass/Fail:	Pass

FINAL ACEPTANCE	Pile Not Yet Accepted
Accepted or Rejected ? (input "A" or "R"):	
Pile Accepted or Rejected (date):	
Comments:	



Florida Department of Transportation

Auger Cast-In-Place Pile Installation Record

Worksheet

Pile Number / ID: **L1**

700-011-03
Construction
01/16

Page: 1

PROJECT:

FP ID Number:	86 166	Comments: 18" Lateral Test	Pile Number / ID:	L1
Project Descr.:	DFI Research Project		Pile Location:	Okahumpka FL
Contractor:	DFI ACIP Pile Committee		Installation Date:	10/27/16
Structure No./ID:	Test Area		Inspector (s):	Clay Davis

THEORETICAL: calculated OGF Vol. & Strokes				THEOR.
Segment / Incr. Length (ft)	OGF (%)	VOL. (cu ft)	PUMP STROKES	100% Vol. (cu ft)
1 ft INCREMENT:		2.03	3	1.77
	115			
5 ft *SEGMENT(s):		10.16	13	8.84
5 ft Top SEGMENT:	105	9.28	12	8.84
PILE Vol. & Stroke TOTALS:		80.41	103	70.69

	Segment Length (ft):	5.00
OGF	Reduced OGF (Top 5 ft Segment only):	1.05
OGF	Overgrout Factor OGF (Below 5 ft depth):	1.15
Head	Min. Req'd Grout Head (ft):	5.00
Head	Theor. Initial Pump Count (strokes):	12
	Pressure Gage Location (descr.):	
	Grout Design Strength (psi):	6000

Design Capacity: 15 tons

PUMP CALIBRATION	
VOLUME of Container (cu ft):	5.50
STROKES to Fill Cont. (strokes):	7
PUMP CAL (cu ft/stroke):	0.79

* Qty of (7) full 115%-OGF, 5-ft segments, in this 40-ft pile [below the top (1) 5-ft Reduced OGF segment]

INSTALLATION DATA

PLAN	Plan Top Elev. (ft, NGVD):	141.00
	Plan Length (ft):	40.00
	Plan Tip Elev. (ft, NGVD):	101.00
	Plan Dia. (ft):	1.50
DRILLING	GSE (ft, NGVD):	140.00
	Drilling START (time):	9:20 AM
	Auger Rate (rpf):	
	Drilling FINISH (time):	9:26 AM
	Drilling TIME (min.):	6
	Actual Pile Dia. (ft):	1.50
	Actual Pile Top Elev. (ft, NGVD):	141.00
	Overburden Length (above Plan Top) (ft):	n/a
	Actual Pile Length (below Pile Top)(ft):	40.00
	Actual Tip Elev. (ft, NGVD):	101.00
GROUT	Plant No.: 1 or 2 Concr. Trucks:	1
		1st Truck
	Delivery Ticket No.:	41401201
	Batch (time):	8:20 AM
	Arrive (time):	8:43 AM
	Flow Cone Test (sec):	18
	Grout Temp. (ºF):	
	Grout Cylinders LOT (ID):	Sample 3
	Placement START (time):	9:26 AM
	Starting Pressure (psi):	185
	Actual **Initial Pump Count** (strokes):	13
	Auger Depth @ **Grout Return** (ft):	8.0
	Truck Empty (time):	
	Placement FINISH (time):	9:29 AM
	Placement TIME (min.):	3
	Mixer TIME (min.):	
STEEL	Reinf. Condition Satisfactory? (Y or N):	Y
	Reinf. Placement START (time):	9:29 AM
	Reinf. Placement FINISH (time):	9:36 AM
	Reinf. Comments:	#11 Centerbar - 8x#8 Cage x 35 ft
TEST	Check **GROUT STRENGTH TESTING** Results	
		1st Truck
	Does the Grout Meet the Minimum Required Stength? (Y or N) :	6750

Comments:

FEEDBACK

Actual Pile Length (ft) & Segment Length (ft) input complete.
Table rows for the Pile & Segment Lengths input complete.
Table input of the table PUMP COUNT data, for the bottom/1st lift is complete.
Actual Pile Diameter = Plan Pile Diameter, meets 455 spec.
Flow Cone Test, FAILED (Consistency < 21 sec)
Note: ACTUAL initial pump count OK, > or = THEORETICAL (Min. Req'd Grout Head)
Actual Grout volume placed is OK. All incr. segments are > or = the min. Theoretical OGF volume req'd.
Grout Return > or = the 'Min. Req'd Grout Head' (5 ft) input above.
Reinforcement Placement Time, 7 min, meets 455 spec limit (< or = 30 min).
Grout meets the Minimum required Strength.

Type of PUMP COUNT input = 'INCREMENTAL' : I

DRILLING & GROUTING TABLE

DEPTH (ft)			SEGMENT	SOIL	GROUT	PUMP COUNT		GROUT VOLUMES			
								INCREMENTAL			ACCRUED
Below Top	-	Top of Segment	EL (ft, NGVD)	Cond. S, M, or H	Pressure (psi)	INCR. (Per 5 ft)	ACCRUED (SUM)	Theor. (cu ft)	Actual (cu ft)	Actual % Theor.	Actual (cu ft)
0		(Pile TOP)	141.00	Soil Cond.: Start input at Pile TOP, Grout Pump Count: start input at Pile BOTTOM.							
5	-	0	136.00		185	13	123	8.84	10.21	116 %	96.64
10	-	5	131.00		185	14	110	8.84	11.00	124 %	86.43
15	-	10	126.00		185	14	96	8.84	11.00	124 %	75.43
20	-	15	121.00		185	14	82	8.84	11.00	124 %	64.43
25	-	20	116.00		185	14	68	8.84	11.00	124 %	53.43
30	-	25	111.00		185	14	54	8.84	11.00	124 %	42.43
35	-	30	106.00		185	14	40	8.84	11.00	124 %	31.43
40	-	35	101.00		185	26	26	8.84	20.43	231 %	20.43
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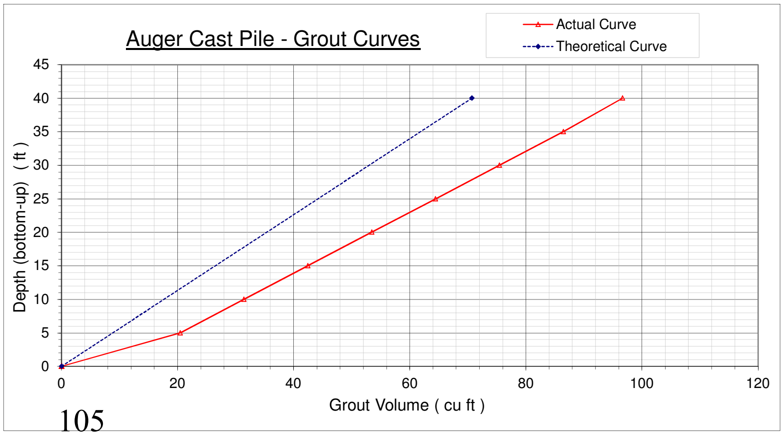
	-										
Pile BOTTOM @ depth = 40 ft						123		70.69		137 %	96.64
						Total Pump Strokes		Total Theor. Vol. (cf)		Actual/Theor. (%)	Actual (cf)

GROUT VOLUME PLACEMENT RESULTS

SEGMENT Descr.	VOLUMES (cu ft)		% THEORETICAL			ACCEPTANCE	
	Actual Placed	Theor. Vol.	OGF %	% Theor. Actual/Theor	% Over	Min. % Placed	P/F
TOP 5-ft	10.21	8.84	105	116 %	11 %	116 %	Pass
BELOW 5-ft	86.43	61.85	115	140 %	25 %	124 %	Pass
Total Pile	96.64	70.69	114	137 %	Pile Pass/Fail:		Pass

FINAL ACEPTANCE	Pile Not Yet Accepted
Accepted or **R**ejected ? (input "A" or "R"):	
Pile Acceped or Rejected (date):	
Comments:	


Auger Cast Pile - Grout Curves

Florida Department of Transportation

Auger Cast-In-Place Pile Installation Record

Worksheet

Pile Number / ID: **E1**

700-011-03
Construction
01/16

Page: 1

PROJECT:

FP ID Number:	86 166
Project Descr.:	DFI Research Project
Contractor:	DFI ACIP Pile Committee
Structure No./ID:	Test Area

Comments:
Extraction Pile

Pile Number / ID:	E1
Pile Location:	Okahumpka FL
Installation Date:	10/27/16
Inspector (s):	Clay Davis

THEORETICAL: calculated OGF Vol. & Strokes				THEOR.
Segment / Incr. Length (ft)	OGF (%)	VOL. (cu ft)	PUMP STROKES	100% Vol. (cu ft)
1 ft INCREMENT:		2.03	3	1.77
	115			
5 ft *SEGMENT(s):		10.16	13	8.84
5 ft Top SEGMENT:	105	9.28	12	8.84
PILE Vol. & Stroke TOTALS:		80.41	103	70.69

	Segment Length (ft):	5.00
OGF	Reduced OGF (Top 5 ft Segment only):	1.05
OGF	Overgrout Factor OGF (Below 5 ft depth):	1.15
Head	Min. Req'd Grout Head (ft):	5.00
Head	Theor. Initial Pump Count (strokes):	12
	Pressure Gage Location (descr.):	
	Grout Design Strength (psi):	6000

Design Capacity:

PUMP CALIBRATION	
VOLUME of Container (cu ft):	5.50
STROKES to Fill Cont. (strokes):	7
PUMP CAL (cu ft/stroke):	0.79

* Qty of (7) full 115%-OGF, 5-ft segments, in this 40-ft pile [below the top (1) 5-ft Reduced OGF segment]

INSTALLATION DATA

PLAN	Plan Top Elev. (ft, NGVD):		141.00
PLAN	Plan Length (ft):		40.00
PLAN	Plan Tip Elev. (ft, NGVD):		101.00
PLAN	Plan Dia. (ft):		1.50
DRILLING	GSE (ft, NGVD):		140.00
DRILLING	Drilling START (time):		9:00 AM
DRILLING	Auger Rate (rpf):		
DRILLING	Drilling FINISH (time):		9:04 AM
DRILLING	Drilling TIME (min.):		4
DRILLING	Actual Pile Dia. (ft):		1.50
DRILLING	Actual Pile Top Elev. (ft, NGVD):		141.00
DRILLING	Overburden Length (above Plan Top) (ft):		n/a
DRILLING	Actual Pile Length (below Pile Top)(ft):		40.00
DRILLING	Actual Tip Elev. (ft, NGVD):		101.00
GROUT	Plant No.:	1 or 2 Concr. Trucks:	2
GROUT	T2 Start Depth (ft):	**2nd Truck**	**1st Truck**
GROUT	Delivery Ticket No.:	41401201	41401199
GROUT	Batch (time):	8:20 AM	8:00 AM
GROUT	Arrive (time):	8:43 AM	8:25 AM
GROUT	Flow Cone Test (sec):	18	15
GROUT	Grout Temp. (ºF):		
GROUT	Grout Cylinders LOT (ID):	Sample 2	
GROUT	Placement START (time):	9:06 AM	9:04 AM
GROUT	Starting Pressure (psi):	185	185
GROUT	Actual **Initial Pump Count** (strokes):		13
GROUT	Auger Depth @ **Grout Return** (ft):		13.0
GROUT	Truck Empty (time):		9:06 AM
GROUT	Placement FINISH (time):	9:07 AM	9:06 AM
GROUT	Placement TIME (min.):	1	2
GROUT	Mixer TIME (min.):		66
STEEL	Reinf. Condition Satisfactory? (Y or N):		Y
STEEL	Reinf. Placement START (time):		9:07 AM
STEEL	Reinf. Placement FINISH (time):		9:14 AM
STEEL	Reinf. Comments:	3" Centerbar	

TEST	Check **GROUT STRENGTH TESTING** Results		
TEST	Does the Grout Meet the Minimum Required Stength? (Y or N) :	2nd Truck	1st Truck
TEST		6430	

Comments:

FEEDBACK

Actual Pile Length (ft) & Segment Length (ft) input complete.
Table rows for the Pile & Segment Lengths input complete.
Table input of the table PUMP COUNT data, for the bottom/1st lift is complete.
Actual Pile Diameter = Plan Pile Diameter, meets 455 spec.
Flow Cone Test, FAILED (Consistency < 21 sec)
Note: ACTUAL initial pump count OK, > or = THEORETICAL (Min. Req'd Grout Head)
Actual Grout volume placed is OK. All incr. segments are > or = the min. Theoretical OGF volume req'd.
Grout Return > or = the 'Min. Req'd Grout Head' (5 ft) input above.
Reinforcement Placement Time, 7 min, meets 455 spec limit (< or = 30 min).
Follow-up to verify the Grout meets the Minimum Required Strength.

DRILLING & GROUTING TABLE

Type of PUMP COUNT input = 'INCREMENTAL' : I

DEPTH (ft)			SEGMENT	SOIL	GROUT	PUMP COUNT		GROUT VOLUMES			
								INCREMENTAL			ACCRUED
Below Top	-	Top of Segment	EL (ft, NGVD)	Cond. S, M, or H	Pressure (psi)	INCR. (Per 5 ft)	ACCRUED (SUM)	Theor. (cu ft)	Actual (cu ft)	% Theor.	Actual (cu ft)
0		(Pile TOP)	141.00	Soil Cond.: Start input at Pile TOP, Grout Pump Count: start input at Pile BOTTOM.							
5	-	0	136.00		185	16	138	8.84	12.57	142 %	108.43
10	-	5	131.00		185	16	122	8.84	12.57	142 %	95.86
15	-	10	126.00		185	18	106	8.84	14.14	160 %	83.29
20	-	15	121.00		185	14	88	8.84	11.00	124 %	69.14
25	-	20	116.00		185	17	74	8.84	13.36	151 %	58.14
30	-	25	111.00		185	14	57	8.84	11.00	124 %	44.79
35	-	30	106.00		185	14	43	8.84	11.00	124 %	33.79
40	-	35	101.00		185	29	29	8.84	22.79	258 %	22.79
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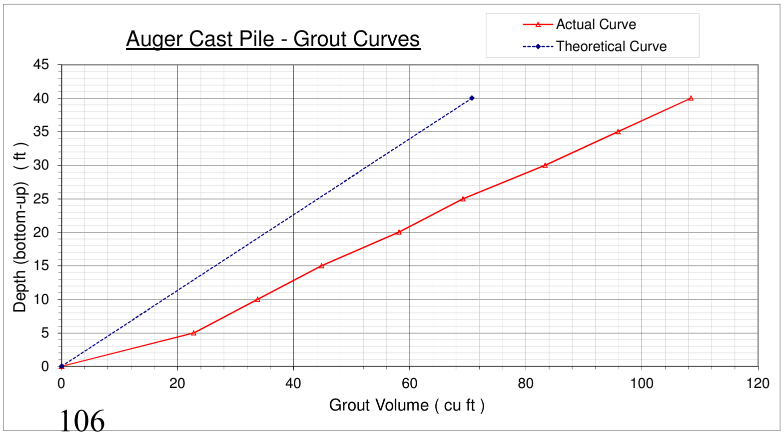
	-										
	-										
	-										
	-										
	-										
Pile BOTTOM @ depth = 40 ft						138		70.69		153 %	108.43
						Total Pump Strokes		Total Theor. Vol. (cf)		Actual/Theor. (%)	Actual (cf)

GROUT VOLUME PLACEMENT RESULTS

SEGMENT Descr.	VOLUMES (cu ft)		% THEORETICAL			ACCEPTANCE	
	Actual Placed	Theor. Vol.	OGF %	% Theor. Actual/Theor	% Over	Min. % Placed	P/F
TOP 5-ft	12.57	8.84	105	142 %	37 %	142 %	Pass
BELOW 5-ft	95.86	61.85	115	155 %	40 %	124 %	Pass
Total Pile	108.43	70.69	114	153 %	Pile Pass/Fail:		Pass

FINAL ACEPTANCE	Pile Not Yet Accepted
Accepted or Rejected ? (input "A" or "R"):	
Pile Acceped or Rejected (date):	
Comments:	



Appendix E

Automated Monitoring Equipment (AME) Grout Logs

DFI ACIP PILE COMMITTEE

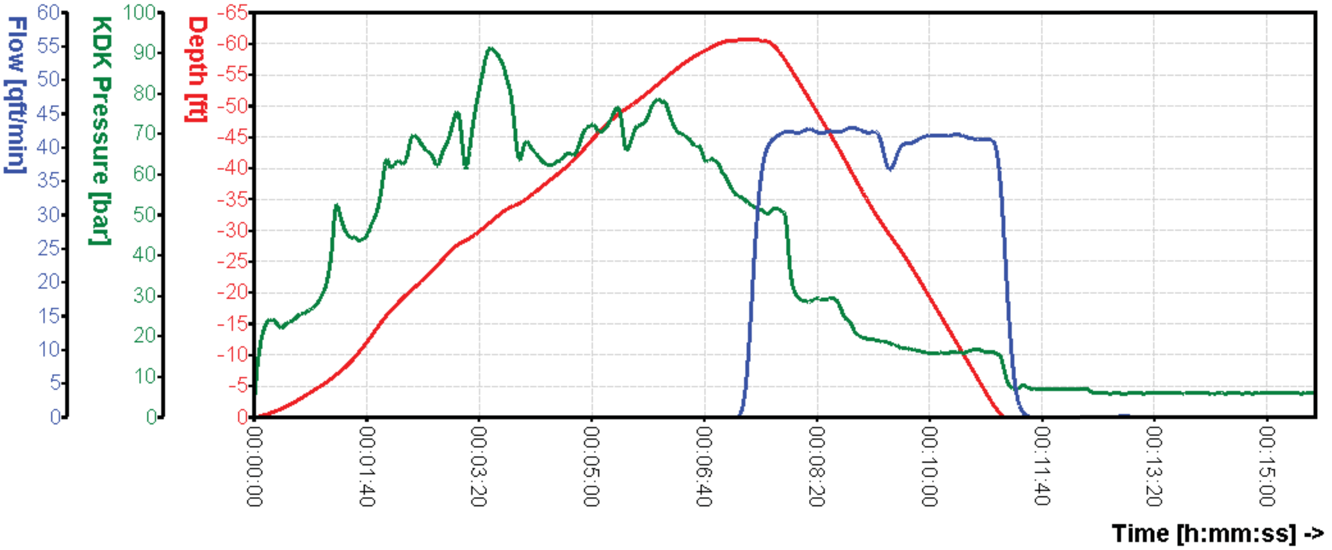
Job Site Data:

Project: 2016 Research Project
Location: Okahumpka FL
Machine No.: APG
Client: DFI ACIP Pile Committee
Project No.: 86 166

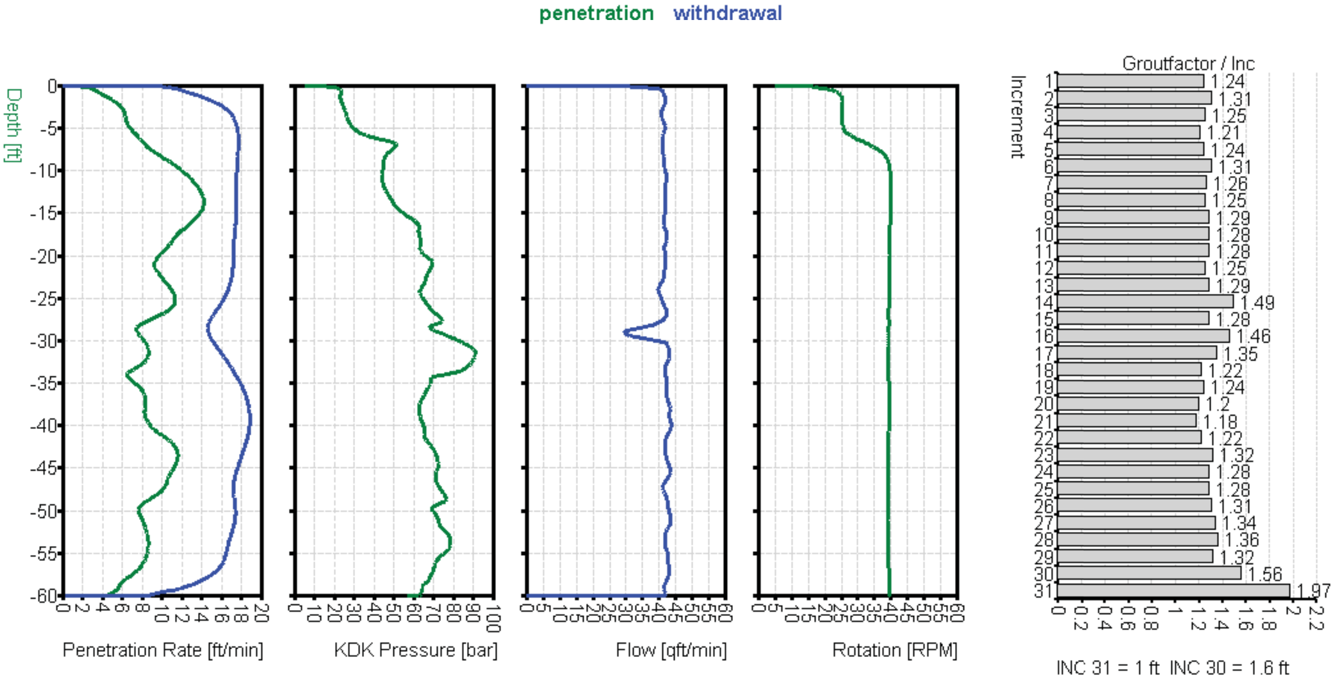
Data for Pile No: c1

Date:	10/27/2016	Pile Length:	60.6 ft
Start Time:	9:44:45 AM	Pile Diameter:	18 in
End Time:	10:00:26 AM	Theoretical Volume:	107.1 ft³
Total Time:	00:15:41		
Drilling Time:	00:06:58	Volume of Grout:	141.9 ft³
Grouting Time:	00:04:00	Grout Factor:	133 %

Parameter vs. Time



Parameter vs. Depth



INC 31 = 1 ft INC 30 = 1.6 ft
INC 29 - 1 = 2 ft

DFI ACIP PILE COMMITTEE

Job Site Data:

Project: 2016 Research Project

Location: Okahumpka FL
Machine No.: APG
Client: DFI ACIP Pile Committee
Project No.: 86 166

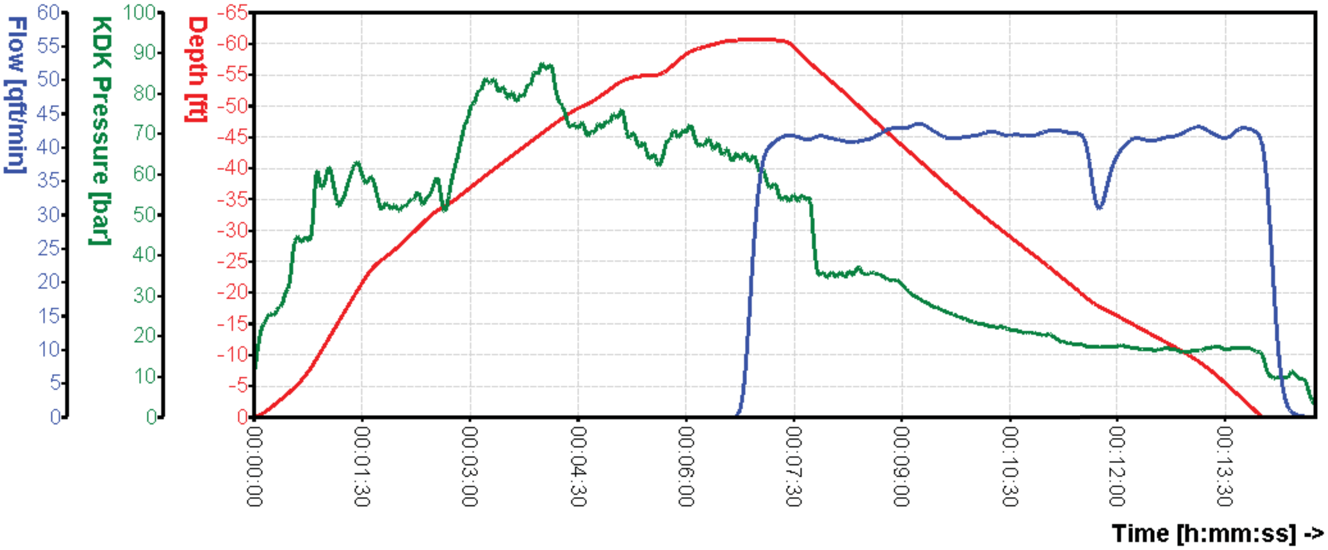
Data for Pile No: C2

Date: 10/27/2016
Start Time: 12:06:10 PM
End Time: 12:20:53 PM
Total Time: 00:14:43
Drilling Time: 00:06:33
Grouting Time: 00:07:23

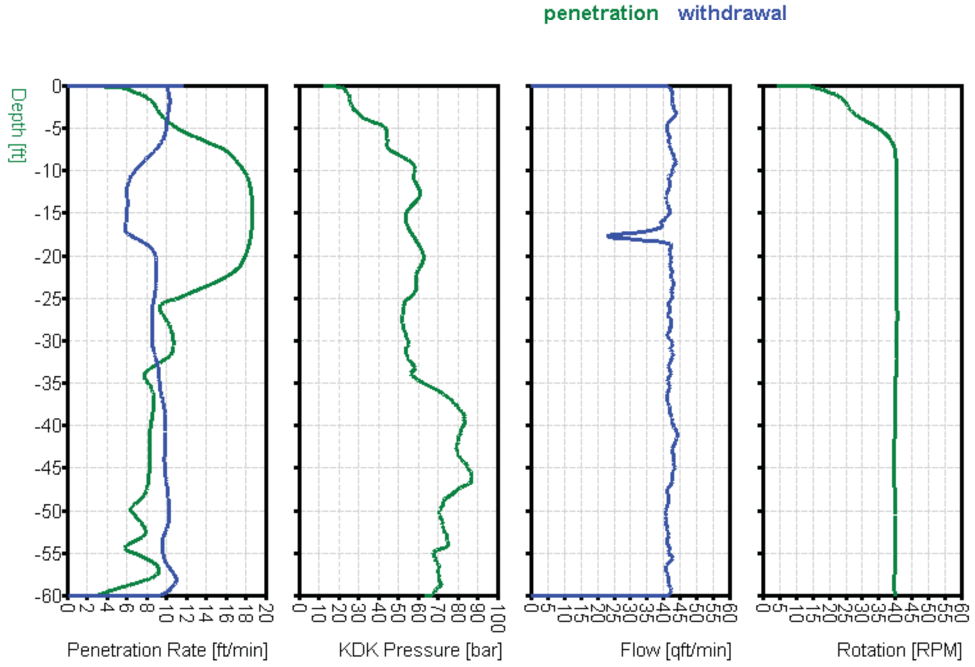
Pile Length: 60.6 ft
Pile Diameter: 24 in
Theoretical Volume: 190.4 ft³

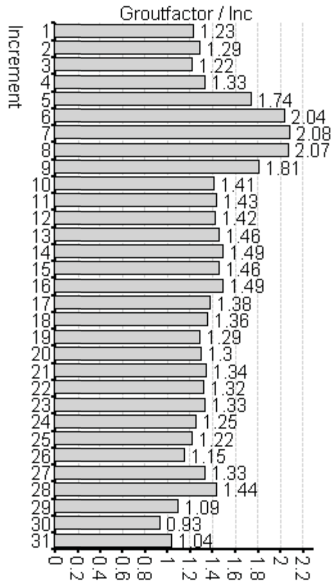
Volume of Grout: 272.4 ft³
Grout Factor: 143 %

Parameter vs. Time



Parameter vs. Depth





INC 31 = 1 ft INC 30 = 1.62 ft
INC 29 - 1 = 2 ft

DFI ACIP PILE COMMITTEE

Job Site Data:

Project: 2016 Research Project

Location: Okahumpka FL
Machine No.: APG
Client: DFI ACIP Pile Committee
Project No.: 86 166

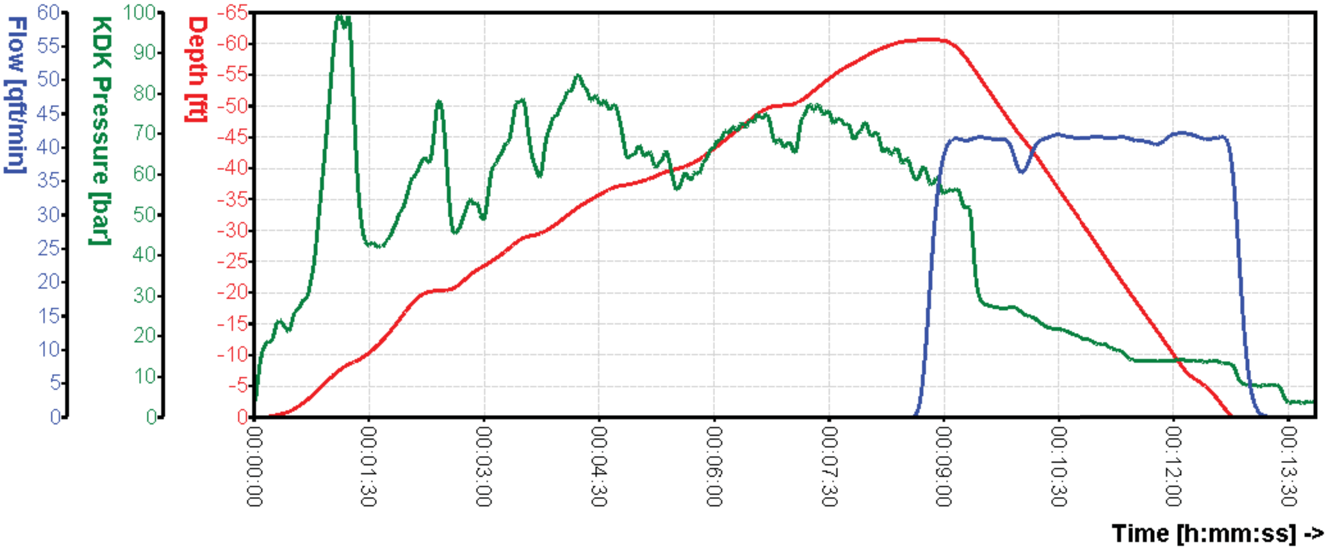
Data for Pile No: T1

Date: 10/27/2016
Start Time: 10:19:40 AM
End Time: 10:33:29 AM
Total Time: 00:13:49
Drilling Time: 00:08:30
Grouting Time: 00:04:08

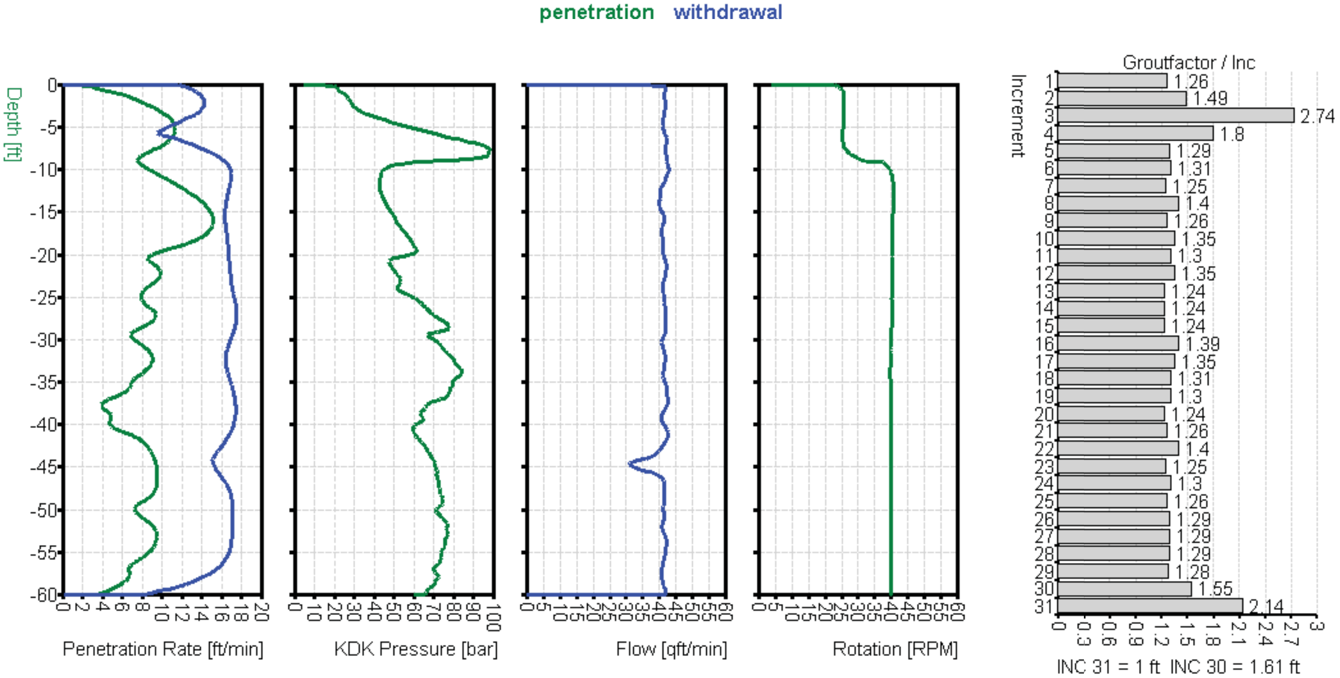
Pile Length: 60.6 ft
Pile Diameter: 18 in
Theoretical Volume: 107.1 ft³

Volume of Grout: 150.7 ft³
Grout Factor: 141 %

Parameter vs. Time



Parameter vs. Depth



INC 31 = 1 ft INC 30 = 1.61 ft
INC 29 - 1 = 2 ft

DFI ACIP PILE COMMITTEE

Job Site Data:

Project: 2016 Research Project

Location: Okahumpka FL
Machine No.: APG
Client: DFI ACIP Pile Committee
Project No.: 86 166

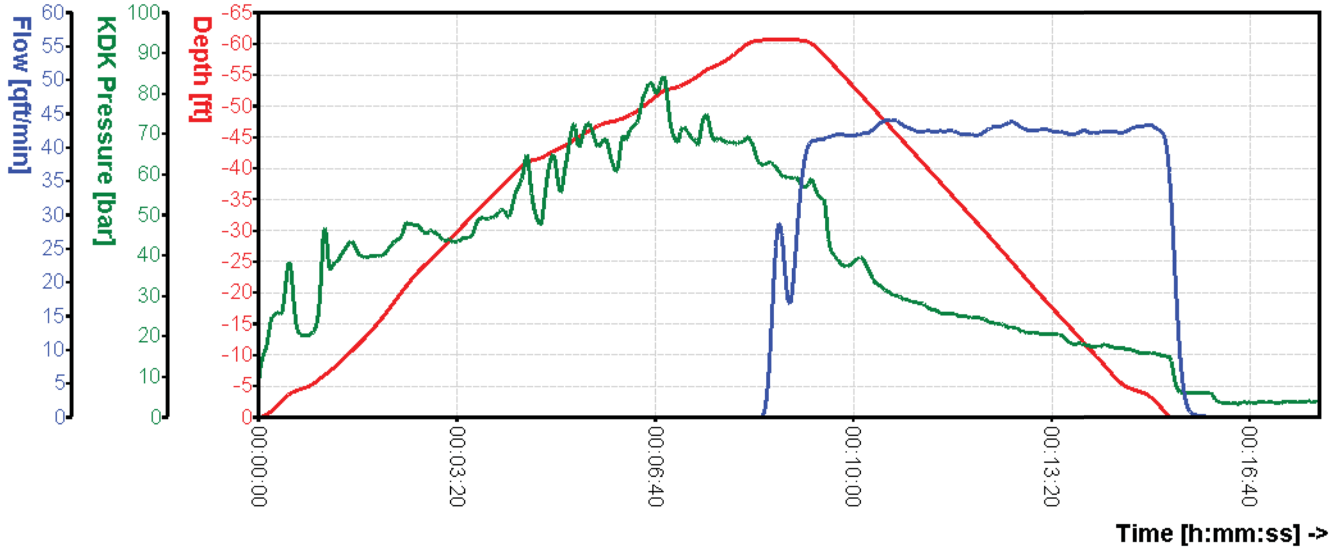
Data for Pile No: T2

Date: 10/27/2016
Start Time: 12:34:56 PM
End Time: 12:52:44 PM
Total Time: 00:17:48
Drilling Time: 00:08:15
Grouting Time: 00:06:59

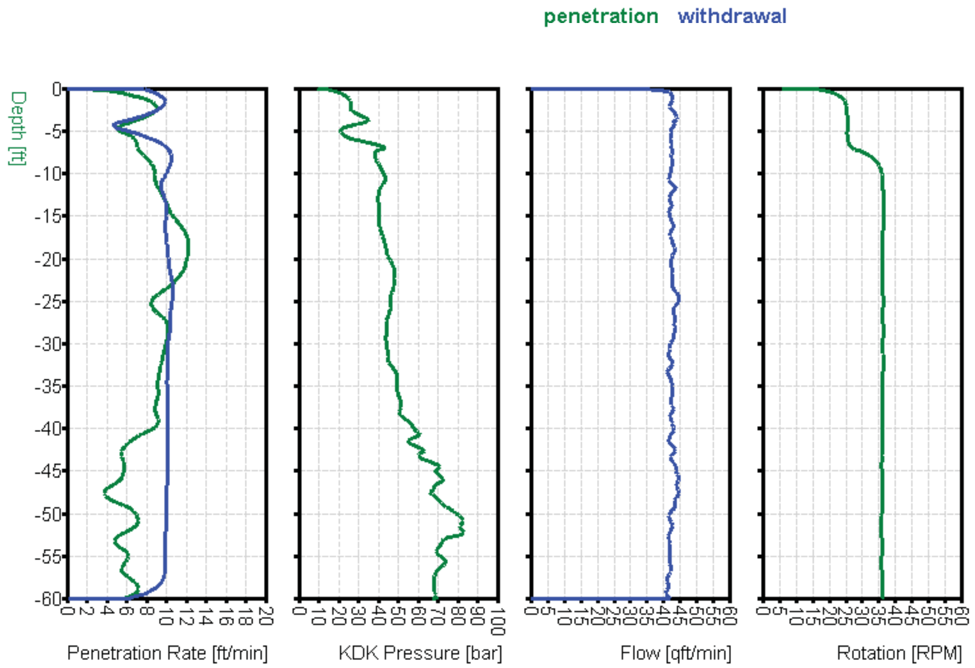
Pile Length: 60.6 ft
Pile Diameter: 24 in
Theoretical Volume: 190.5 ft³

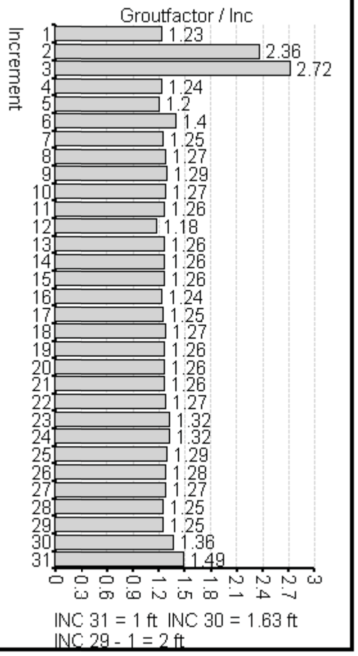
Volume of Grout: 257.3 ft³
Grout Factor: 135 %

Parameter vs. Time



Parameter vs. Depth





INC 31 = 1 ft INC 30 = 1.63 ft
INC 29 - 1 = 2 ft

DFI ACIP PILE COMMITTEE

Job Site Data:

Project: 2016 Research Project

Location: Okahumpka FL
Machine No.: APG
Client: DFI ACIP Pile Committee
Project No.: 86 166

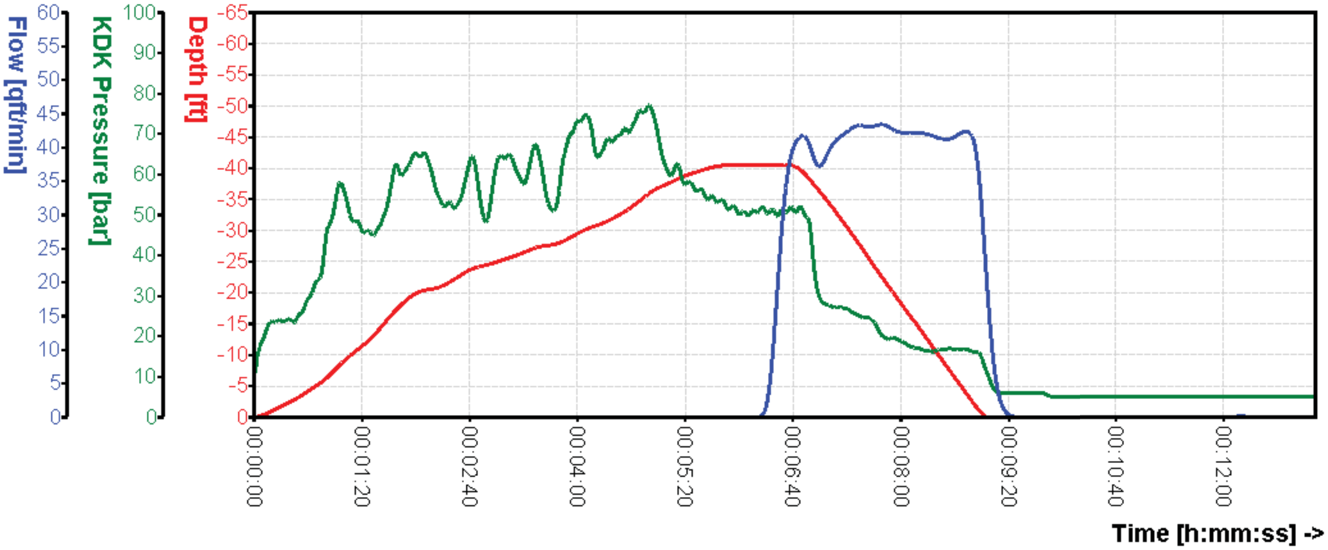
Data for Pile No: I1

Date: 10/27/2016
Start Time: 9:20:44 AM
End Time: 9:33:50 AM
Total Time: 00:13:06
Drilling Time: 00:05:53
Grouting Time: 00:03:04

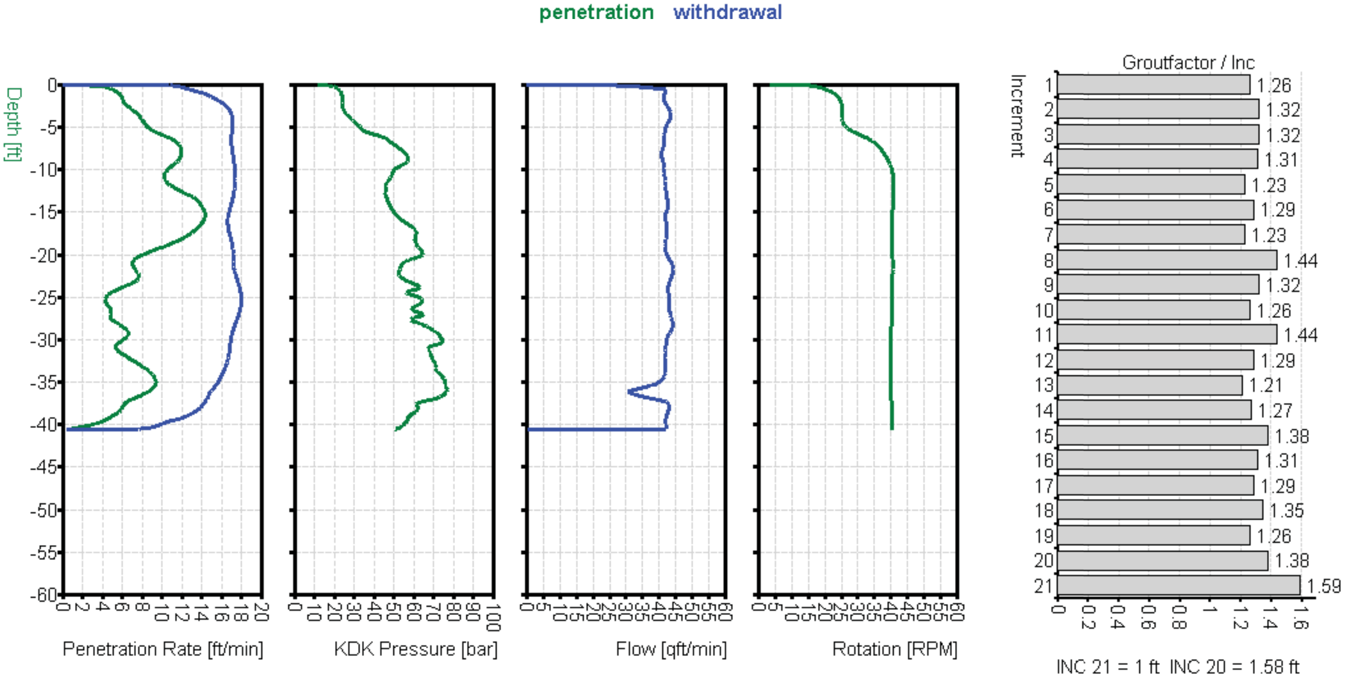
Pile Length: 40.6 ft
Pile Diameter: 18 in
Theoretical Volume: 71.7 ft³

Volume of Grout: 95.6 ft³
Grout Factor: 133 %

Parameter vs. Time



Parameter vs. Depth



INC 21 = 1 ft INC 20 = 1.58 ft
INC 19 - 1 = 2 ft

DFI ACIP PILE COMMITTEE

Job Site Data:

Project: 2016 Research Project

Location: Okahumpka FL
Machine No.: APG
Client: DFI ACIP Pile Committee
Project No.: 86 166

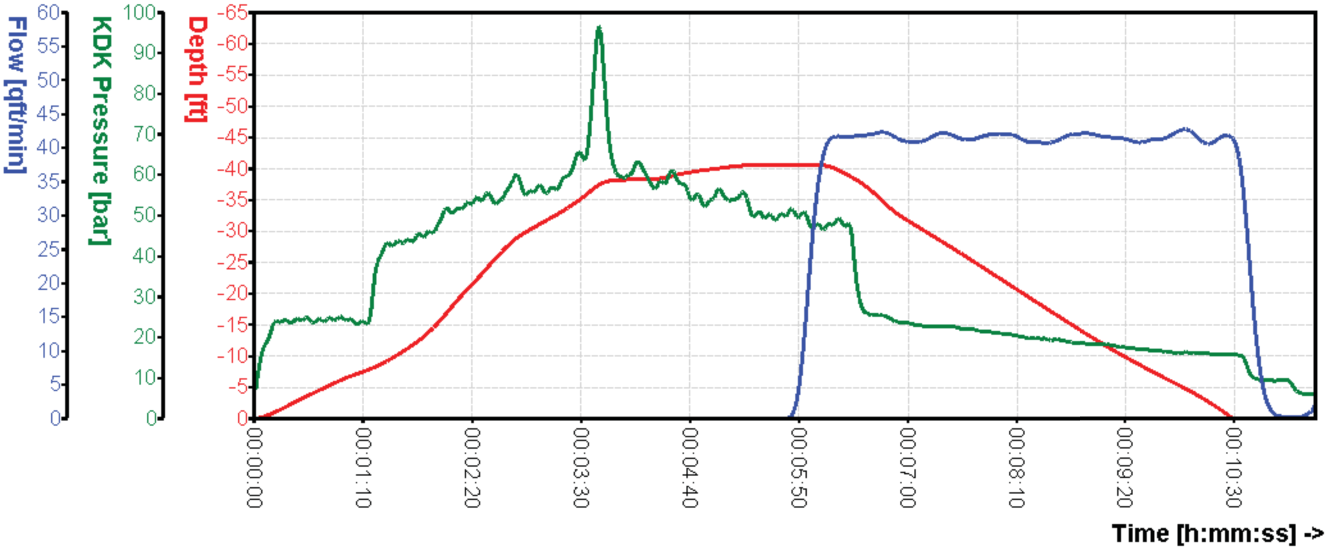
Data for Pile No: L2

Date: 10/27/2016
Start Time: 11:39:31 AM
End Time: 11:50:52 AM
Total Time: 00:11:21
Drilling Time: 00:05:32
Grouting Time: 00:04:50

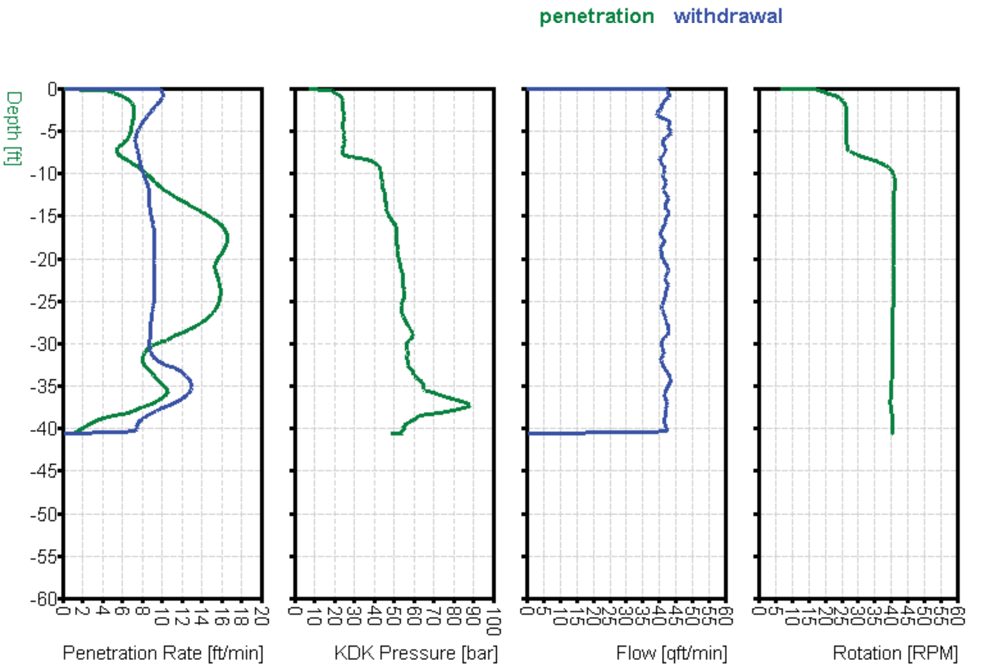
Pile Length: 40.6 ft
Pile Diameter: 24 in
Theoretical Volume: 127.5 ft³

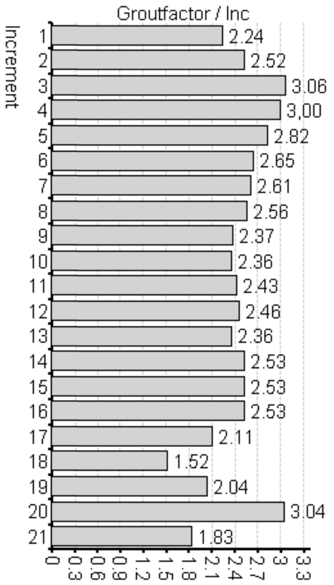
Volume of Grout: 178.3 ft³
Grout Factor: 140 %

Parameter vs. Time



Parameter vs. Depth





INC 21 = 1 ft INC 20 = 1.6 ft
INC 19 - 1 = 2 ft

DFI ACIP PILE COMMITTEE

Job Site Data:

Project: 2016 Research Project

Location: Okahumpka FL
Machine No.: APG
Client: DFI ACIP Pile Committee
Project No.: 86 166

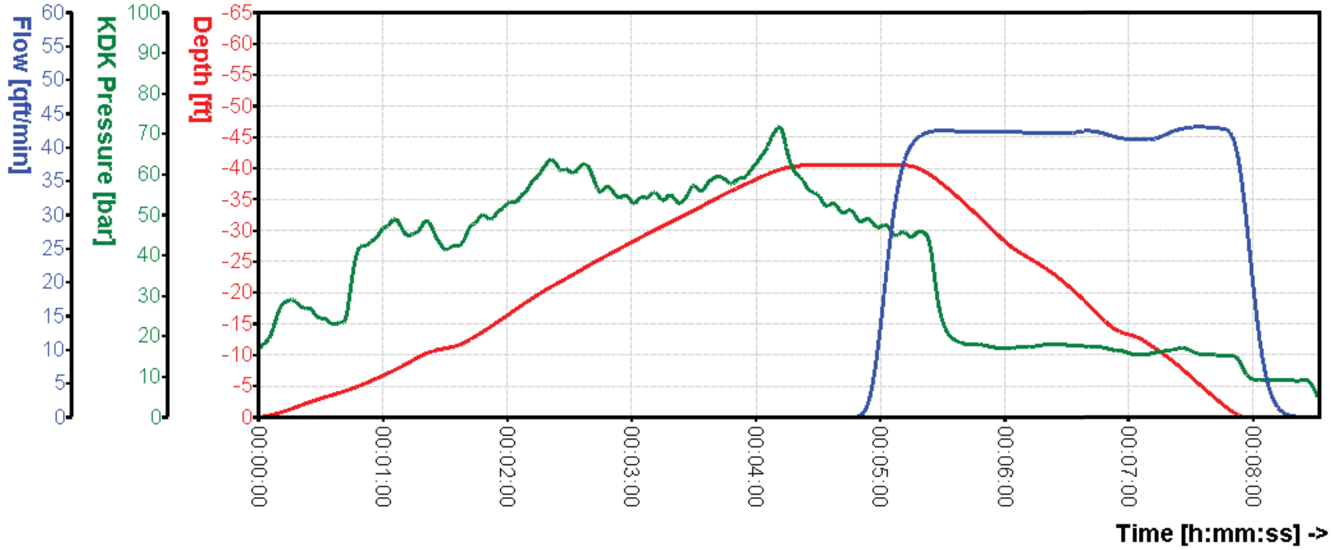
Data for Pile No: e1

Date: 10/27/2016
Start Time: 9:00:14 AM
End Time: 9:08:45 AM
Total Time: 00:08:31
Drilling Time: 00:04:25
Grouting Time: 00:03:26

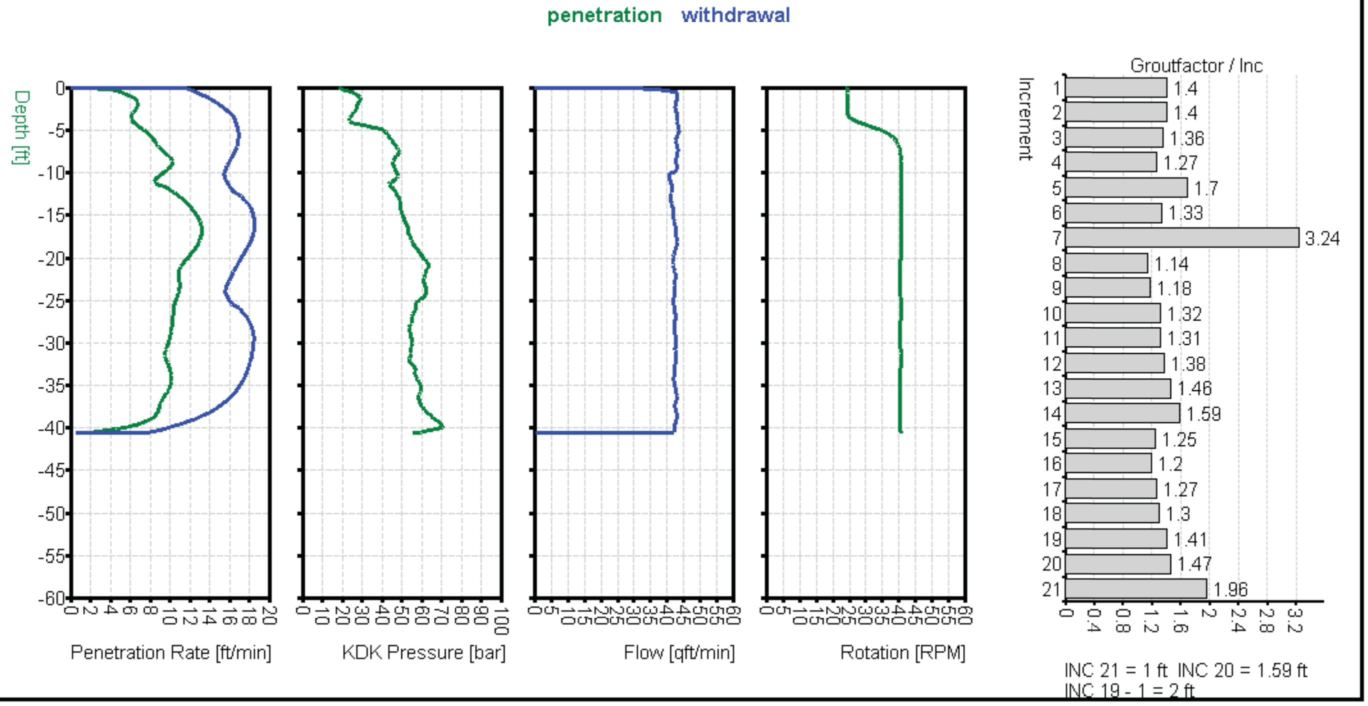
Pile Length: 40.6 ft
Pile Diameter: 18 in
Theoretical Volume: 71.7 ft³

Volume of Grout: 109.2 ft³
Grout Factor: 152 %

Parameter vs. Time



Parameter vs. Depth



INC 21 = 1 ft INC 20 = 1.59 ft
INC 19 - 1 = 2 ft

Appendix F

Computed Radius Profiles from Automated Monitoring Equipment (AME) Data, Manual Grout Logs, and TIP Data

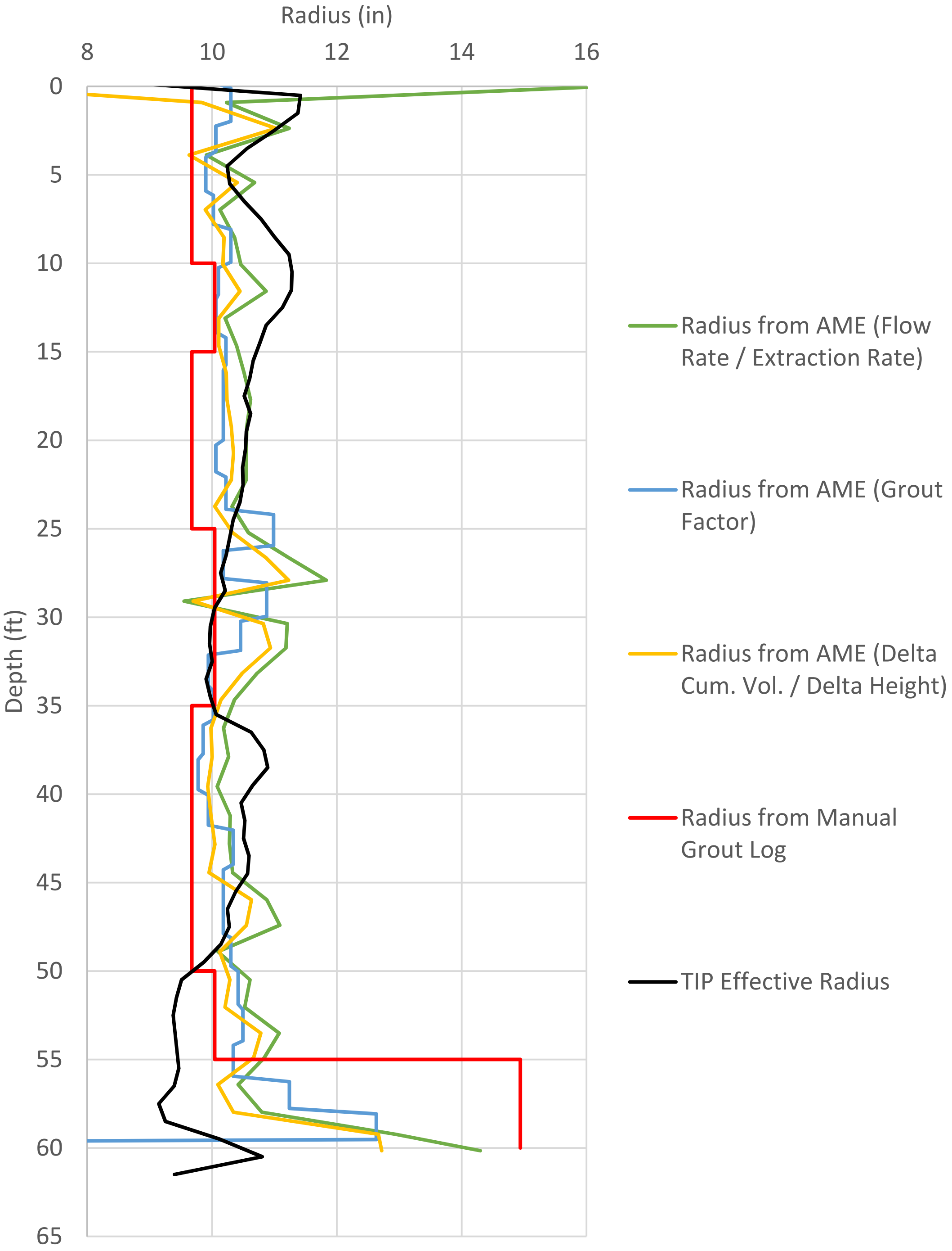


Figure F.1 Pile C1 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

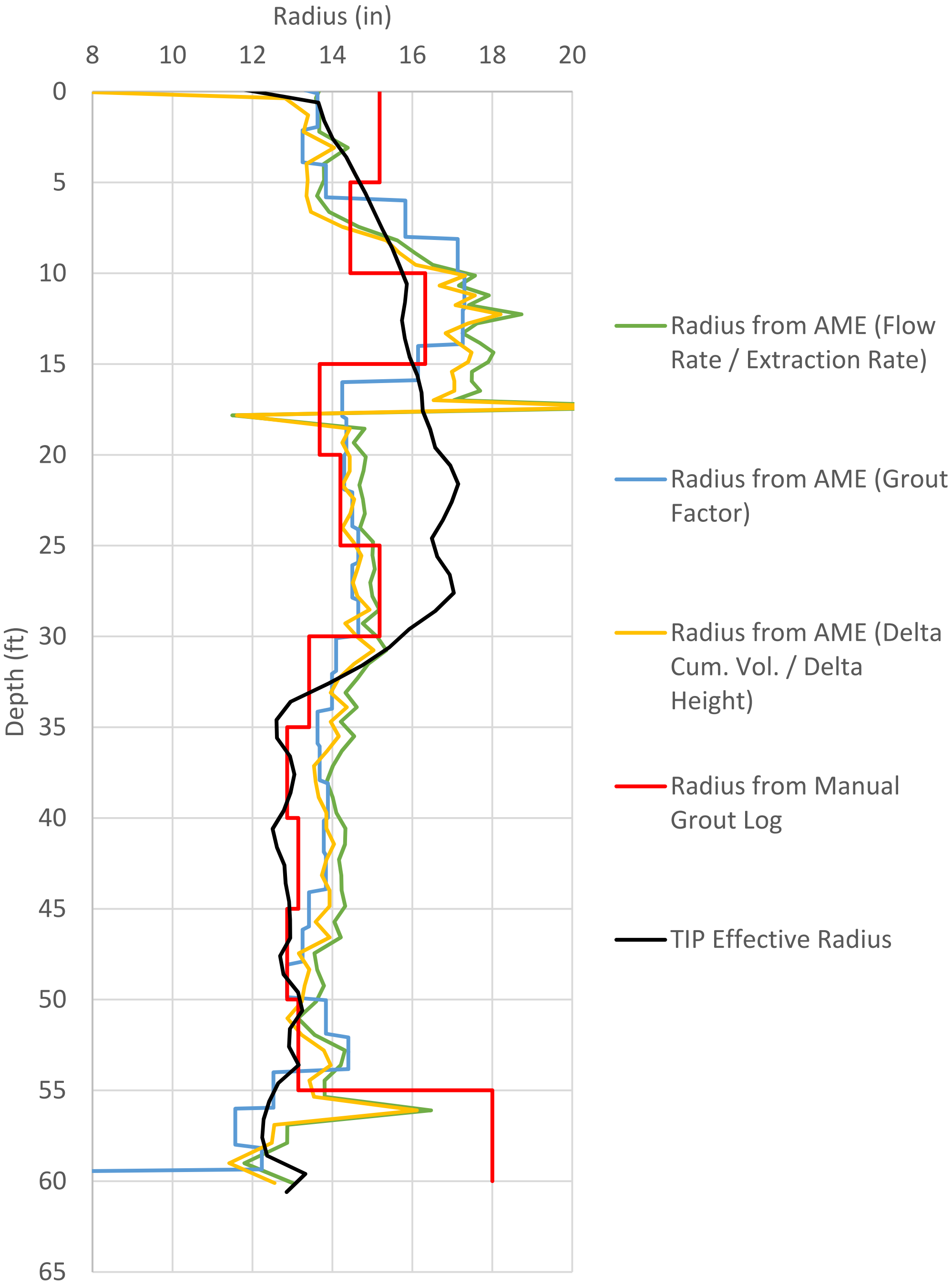


Figure F.2 Pile C2 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

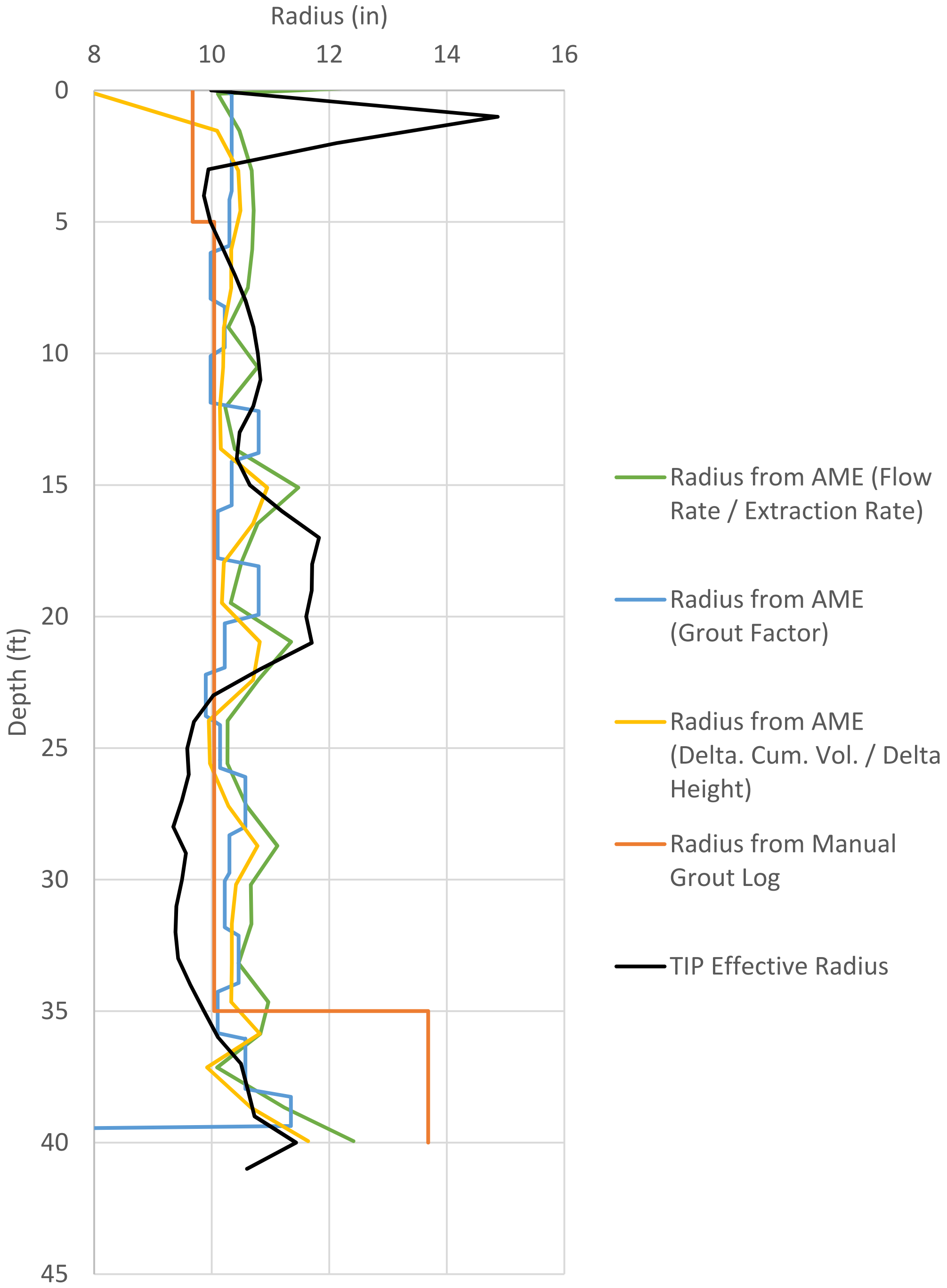


Figure F.3 Pile L1 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

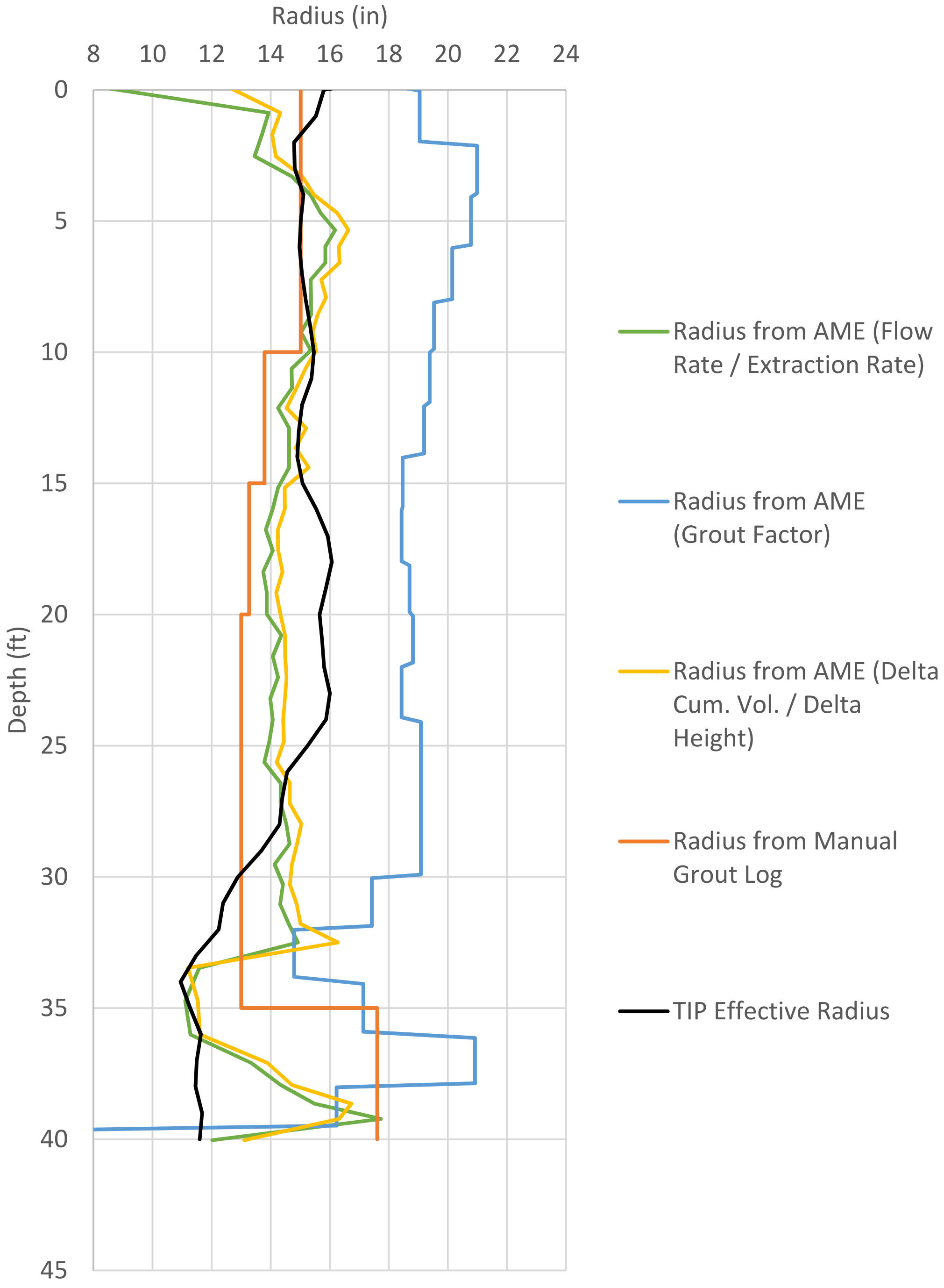


Figure F.4 Pile L2 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

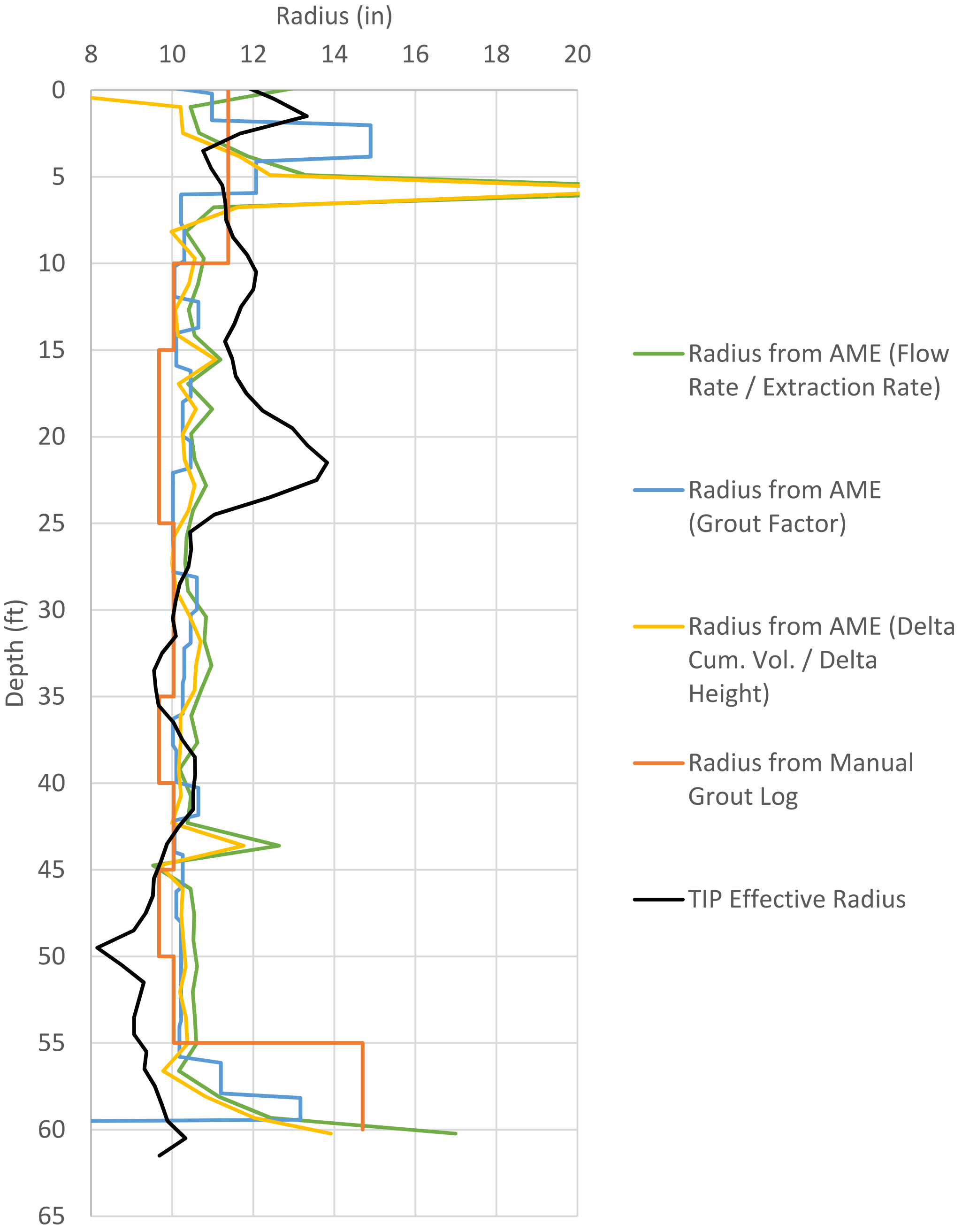


Figure F.5 Pile T1 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

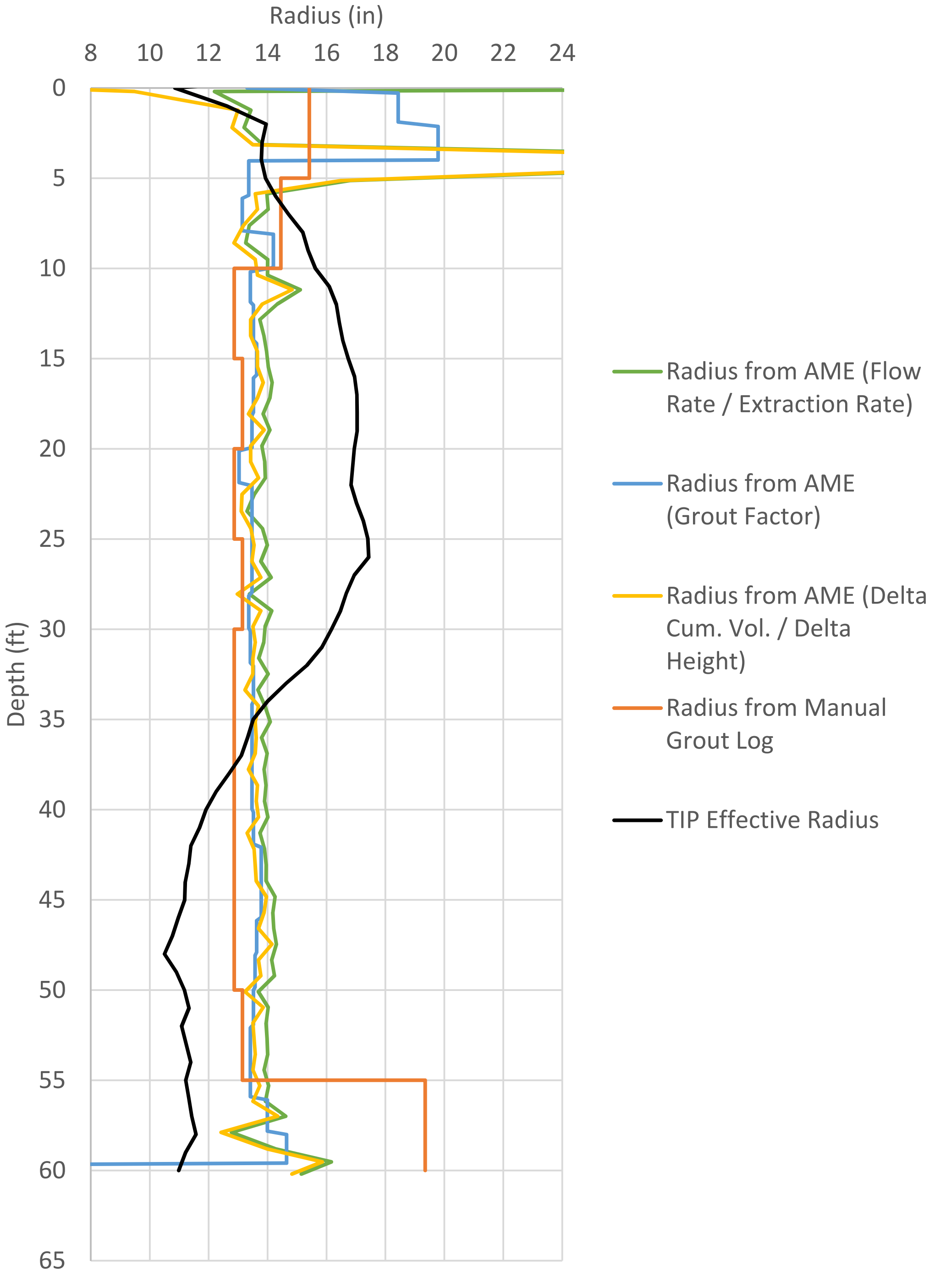


Figure F.6 Pile T2 Computed Radius from AME Data, Manual Grout Log, and TIP Data.

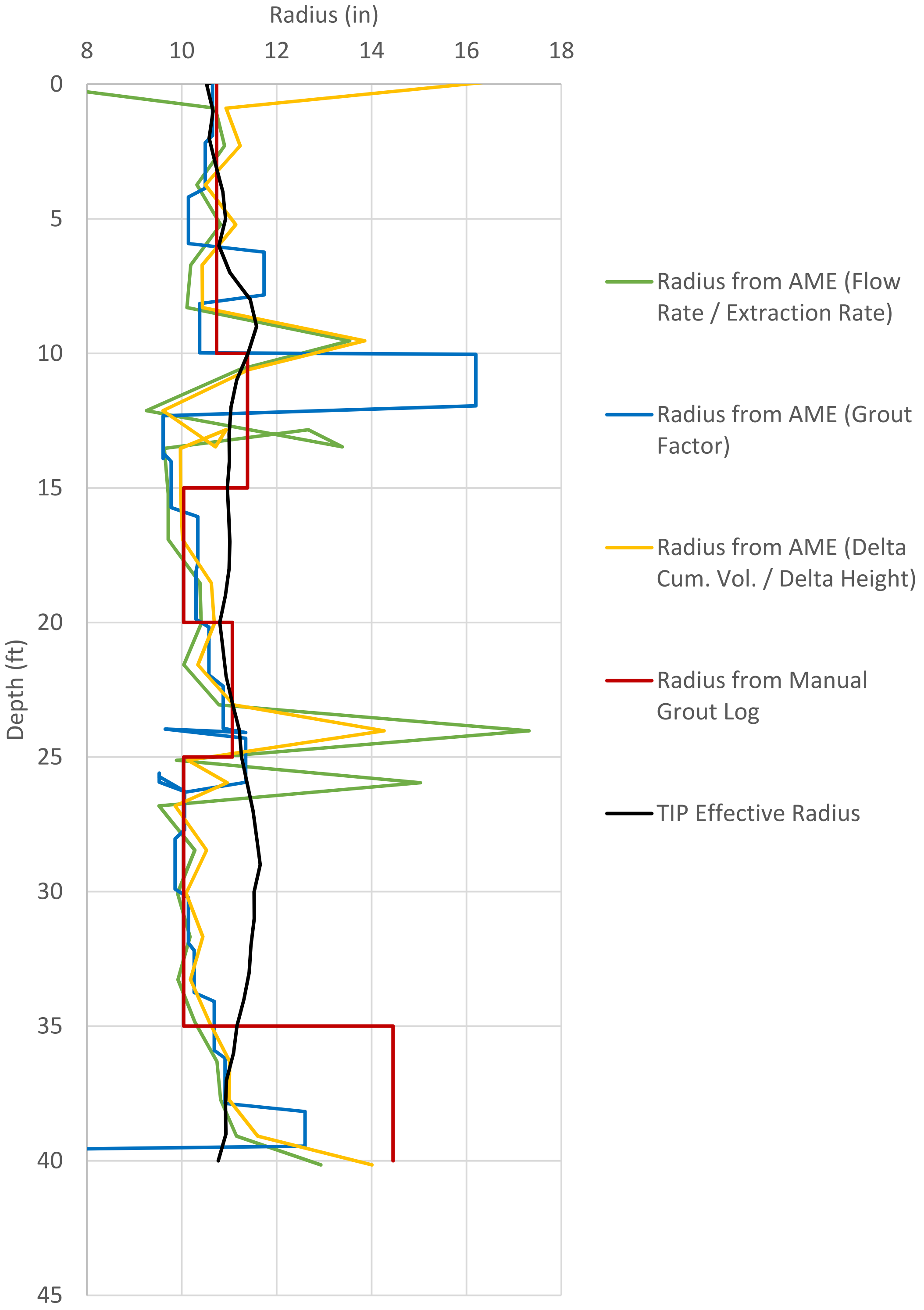


Figure F.7 Pile E1 Computed Radius from AME Data, Manual Grout Log, and TIP Data.