INFRASTRUCTURE
CONSULTING & ENGINEERING

May 23, 2023

Mr. Billy Hardwick
Senior Project Manager
Archer-United Joint Venture
billy.hardwick@uig.net

Re: **Report of Dynamic Pile Testing**
Bent 36 Pile 1&5
Bridge 35 – I-26 to I-20 Future Ramps and Ramp I-26WB to I-126 EB Bridge over Saluda River and CSX R.R.
Project ID: P039718
Lexington/Richland County, South Carolina

Dear Mr. Hardwick:

The attached results of dynamic pile testing for the subject piles and project includes measurements and analysis performed by Infrastructure Consulting & Engineering in accordance with ASTM D4945. Measurements were made with the Pile Dynamics, Inc. Model 8G and signal matching analysis was performed with CAPWAP version 2014. For further information on the test method please refer to the ASTM.

Also included are the production pile driving recommendations for Bent 36 of the subject project. The Geotechnical Engineer of Record should ultimately make final recommendations for foundation design and construction.

Thank you for the opportunity to provide these services.

Sincerely,
Infrastructure Consulting & Engineering (ICE), PLLC

Michael J Simpson, P.E. Digitally signed by Michael J Simpson, P.E. Date: 2023.05.23 21:27:13-04'00'

SOUTH CAROLINA LICENSED PROFESSIONAL ENGINEER No. 35396 MICHAEL JOEL SIMPSON

SOUTH CAROLINA INFRASTRUCTURE CONSULTING & ENGINEERING, PLLC No. 4470 CERTIFICATE OF AUTHORIZATION

Michael J. Simpson, P.E.
Geotechnical Testing Manager
Certified PDA Signatory "Advanced"
South Carolina Registration Number: 35396

Sally G. Thomson, P.E.
Geotechnical Designer
Certified PDA Signatory "Advanced"

Appendix A

Dynamic Pile Testing, Signal Matching Results, and Calibration WEAP

Bridge 35, Bent 36, Pile 1

Summary of Provided Project and Pile Driving Information

Project Description	I-26 to I-20 Future Ramps and Ramp I-26WB to I-126 EB Bridge over Saluda River and CSX R.R., Lexington/Richland County, South Carolina
Pile Driving Contractor	Archer United Joint Venture
Project ID	P039718
ICE Field Personnel	Sally G. Thomson, P.E.
ICE Responsible Engineer	Michael J. Simpson, P.E.

Bent Number	**Station**	**Pile Type**	**Pile Batter**	**Hammer Used**	**Pile Cushion Type and Thickness**
Bent 36	5424+25.76	HP14x89 with Pile Tip	Plumb	APE D30-52	N/A
Pile Number	**Total Pile Length (feet)**	**Pile Length Below Gages (feet)**	**Pile Splice Location(s) above Pile Tip (feet)**	**Initial Drive Test Date**	**Restrike Test Date**
1	55.0	52.7	N/A	5/4/23	N/A

Factored Design Load (kips)	**Geotechnical Resistance Factor**	**Nominal Resistance of Pile (kips)**	**Required Driving Resistance of Pile (kips)**	**Minimum Tip Elevation of Pile (feet)**
379	0.65	583	656	$^{+}$163.0

Installation Records Provided to ICE	Please Refer to SCDOT Pile Driving Logs
Project Information and Soil Borings Provided to ICE	Yes, Attached in Appendix D
Pile Driving Equipment Data Form Provided to ICE	APE D30-52 Data Hammer Sheet Attached in Appendix E
Strain and Accelerometer Calibrations Attached	Yes, Attached in Appendix F

Steel Acceptable Compression Driving Stress Limit (ksi)*	45
Steel Acceptable Tension Driving Stress Limit (ksi)*	45

*For steel piles based on Section 711.4.2.2 and a steel yield strength (Fy) of 50 ksi.

Approximate Reference Elevation (feet)	$^{+}$177.1
Approximate Ground/Mudline Elevation (feet)	$^{+}$176.1
Approximate Final Pile Penetration Below Reference at End of Initial Drive (feet)	9.8
Approximate Final Pile Tip Elevation at End of Initial Drive (feet)	$^{+}$167.3
Approximate Final Pile Penetration Below Reference at End of Restrike (feet)	N/A
Approximate Final Pile Tip Elevation at End of Restrike (feet)	N/A

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Additional Notes on Pile Installation

-Pile 1 was monitored with instrumentation for the entire initial drive.

-For additional detailed information on the hammer driving system, bridge plans, and soils information please refer to the project documents.

-The blows per foot of penetration for the pile was kept by the PDA operator on the PDA during the initial drive. A pile driving log was also maintained by a SCDOT representative.

Summary of Results

Dynamic Pile Testing Results (Detailed Results in Appendix A)

Location*	Capacity (kips)	Case Method	Max. Comp. Stress (ksi)	Avg. Comp. Stress (ksi)	Max. Comp. Stress at Pile Bottom (ksi)	Avg. Comp. Stress at Pile Bottom (ksi)	Avg. Transferred Energy (k-ft)	Avg. Stroke (feet)
EOD	1254	RAU	51.6	33.5	62.1	33.8	32.2	7.0

Signal Matching Analyses Results (Detailed Result in Appendix A)

Location*	R_{ult} (kips)	R_{side} / R_{end} (kips)	Equiv. BPF*	Stroke (ft)	EMX (k-ft)	Qs (in)	Qt (in)	Ss (sec/ft)	St (sec/ft)	MQN*
EOD (Blow 24)	1241	31 / 1210	240	9.1	41.8	0.10	0.14	0.15	0.03	4.95

*EOD – End of Drive; BPF – Blows per foot; MQN – Match Quality Number

Dynamic Pile Testing Interpretation and Commentary

The capacity listed in the Summary of Dynamic Pile Testing Results is based on the RAU (Auto Capacity End Bearing Piles) solution for the maximum value of the last increment of the initial drive. The summary plot and table attached for the dynamic pile testing results are based on the same capacity solution.

Signal matching analysis was performed for a blow (Blow 24) near the end of the initial drive. The signal matching mobilized capacity near the end of initial drive was above the required driving resistance of 656 kips for Bent 36.

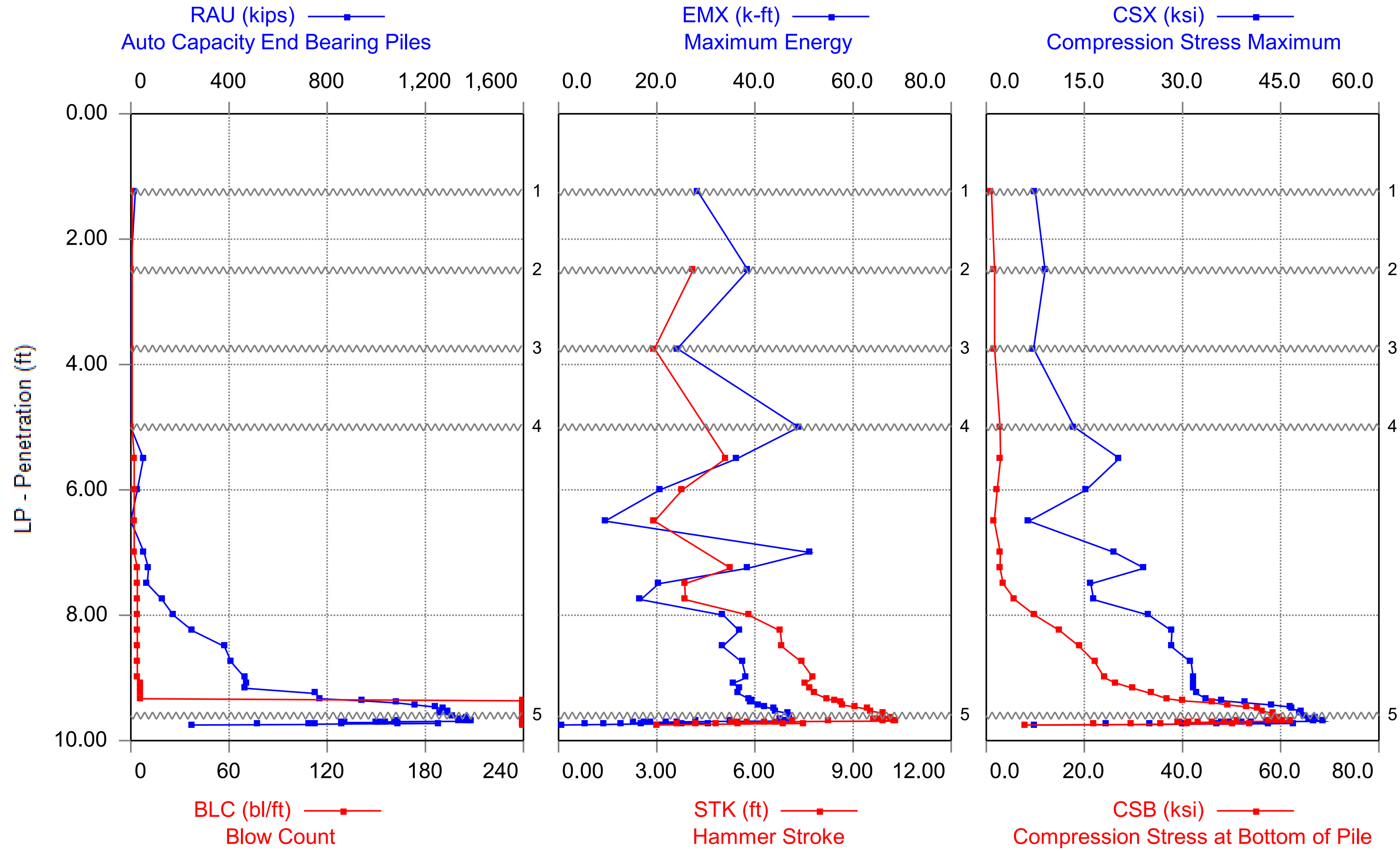
Compression pile driving stresses exceeded the acceptable limit for the pile tested during the last three increments of initial drive. Tension pile driving stresses were below the acceptable limit for the pile tested during initial drive. The pile tested did not show any signs of integrity problems below the gage locations based on the test results.

Pile Dynamics, Inc. - PDIPLOT2 Ver 2017.2.58.3 - Case Method & iCAP® Results

Printed: 23-May-2023

Test started: 04-May-2023

CCRP1 Bridge 35 Bent 36 - Pile 1



1 - Template Reference Elevation +177.1

2 - Ground Elevation +176.1

3 - Fuel Setting 1

4 - Fuel Setting 2 to fire hammer

5 - Hammer not shutting off

CCRP1 Bridge 35 Bent 36 - Pile 1 HP 14x89 w tips
OP: ICE Date: 04-May-2023

AR: 26.10 in² SP: 0.492 k/ft³
LE: 52.67 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.90

RAU: Auto Capacity End Bearing Piles
EMX: Maximum Energy
STK: Hammer Stroke
CSX: Compression Stress Maximum
CSB: Compression Stress at Bottom of Pile
TSX: Tension Stress Maximum - Full Record Search
DMX: Maximum Displacement
DFN: Final Displacement
BTA: Integrity Factor (1)

BL#	Depth	BLC	TYPE	RAU	EMX	STK	CSX	CSB	TSX	DMX	DFN	BTA
	ft	bl/ft		kips	k-ft	ft	ksi	ksi	ksi	in	in	(%)
4	5.00	1	AV4	5	35.1	3.52	9.3	1.8	1.5	15.10	15.00	90.5
			STD	8	9.6	0.59	2.5	0.6	1.1	0.16	0.00	11.1
			MAX	18	48.9	4.10	13.5	2.8	2.9	15.38	15.01	100.0
			@BL	1	4	2	4	4	4	1	3	1
8	7.00	2	AV4	33	29.5	3.95	15.4	2.4	7.4	7.26	6.00	94.8
			STD	22	15.8	0.90	5.5	0.5	3.2	1.36	0.00	5.3
			MAX	54	51.3	5.12	20.3	2.9	10.9	9.25	6.00	100.0
			@BL	8	8	5	5	5	5	8	7	5
12	8.00	4	AV4	110	27.4	4.70	20.4	5.5	9.8	3.87	3.00	100.0
			STD	44	9.0	0.86	4.2	2.8	2.7	1.40	0.00	0.0
			MAX	174	38.6	5.82	24.9	9.9	14.2	6.28	3.00	100.0
			@BL	12	9	12	12	12	9	9	11	9
16	9.00	4	AV4	377	36.5	7.21	29.9	20.1	5.9	3.00	3.00	100.0
			STD	78	1.8	0.42	1.6	3.4	1.2	0.00	0.00	0.0
			MAX	465	38.2	7.78	31.6	24.1	7.9	3.00	3.00	100.0
			@BL	16	16	16	16	16	13	16	16	13
20	9.33	6	AV4	617	37.0	7.81	32.3	31.7	8.3	1.88	1.88	100.0
			STD	146	1.1	0.26	0.8	3.9	0.6	0.00	0.00	0.0
			MAX	771	38.7	8.21	33.6	36.9	8.8	1.88	1.88	100.0
			@BL	20	20	20	20	20	20	19	19	17
30	9.67	240	AV10	1,227	43.6	9.34	45.8	53.7	11.7	0.95	0.04	100.0
			STD	125	2.9	0.58	4.4	6.2	2.1	0.04	0.01	0.0
			MAX	1,368	47.2	10.16	50.4	59.7	14.4	1.01	0.05	100.0
			@BL	29	28	29	29	29	29	27	27	21
40	9.71	240	AV10	1,240	36.0	8.44	47.0	54.9	11.7	0.78	0.04	100.0
			STD	154	11.2	1.72	4.5	6.6	2.1	0.15	0.01	0.0
			MAX	1,388	47.7	10.32	51.6	62.1	14.4	0.96	0.06	100.0
			@BL	33	34	34	35	35	35	35	38	31
50	9.75	240	AV10	820	15.2	5.17	31.6	36.0	6.5	0.48	0.04	100.0
			STD	271	8.4	1.29	11.3	12.7	2.9	0.19	0.01	0.0
			MAX	1,254	30.6	7.49	47.1	53.7	11.1	0.75	0.05	100.0
			@BL	44	44	44	44	44	44	44	50	41
			Average	749	32.2	6.96	33.5	33.8	8.6	2.93	2.33	98.8
			Std. Dev.	500	13.0	2.27	13.9	21.5	3.8	4.09	4.14	4.5
			Maximum	1,388	51.3	10.32	51.6	62.1	14.4	15.38	15.01	100.0
			@ Blow#	33	8	34	35	35	29	1	3	1

Total number of blows analyzed: 50

Hammer trying to shut off for last 22 blows

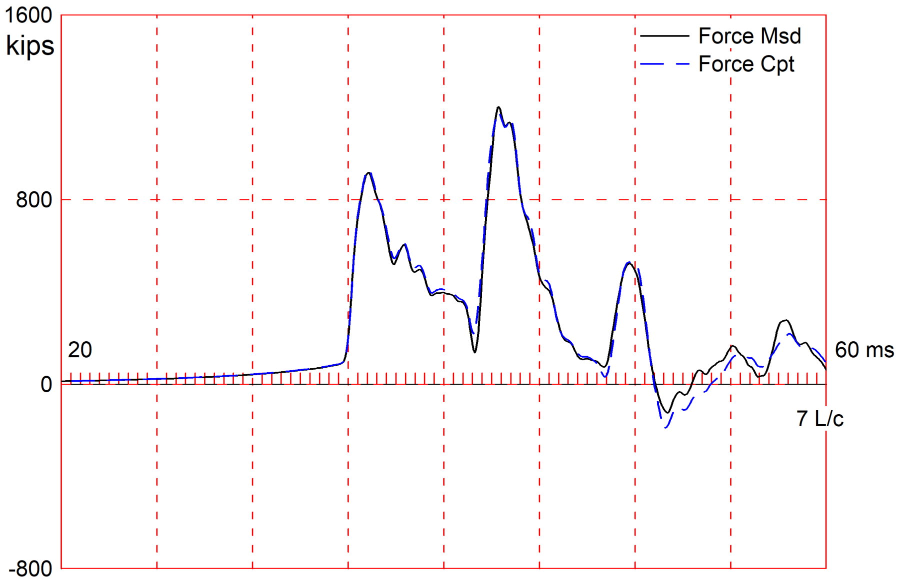
CCRP1 Bridge 35 Bent 36 - Pile 1 HP 14x89 w tips
OP: ICE Date: 04-May-2023

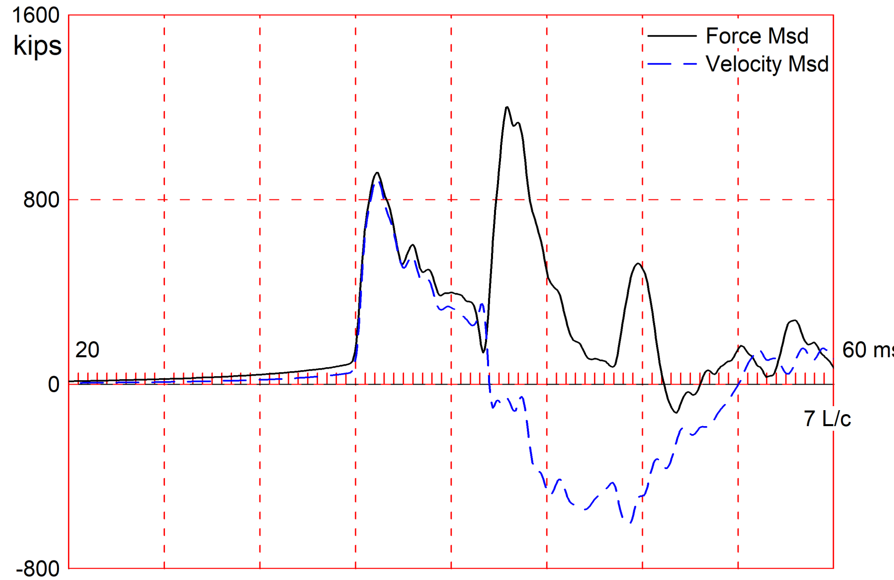
BL#	Sensors
1-50	F2: [P821] 145.1 (1.00); F4: [S868] 145.1 (1.00); A1: [K12389] 483.2 (1.00); A3: [K12388] 451.0 (1.00)

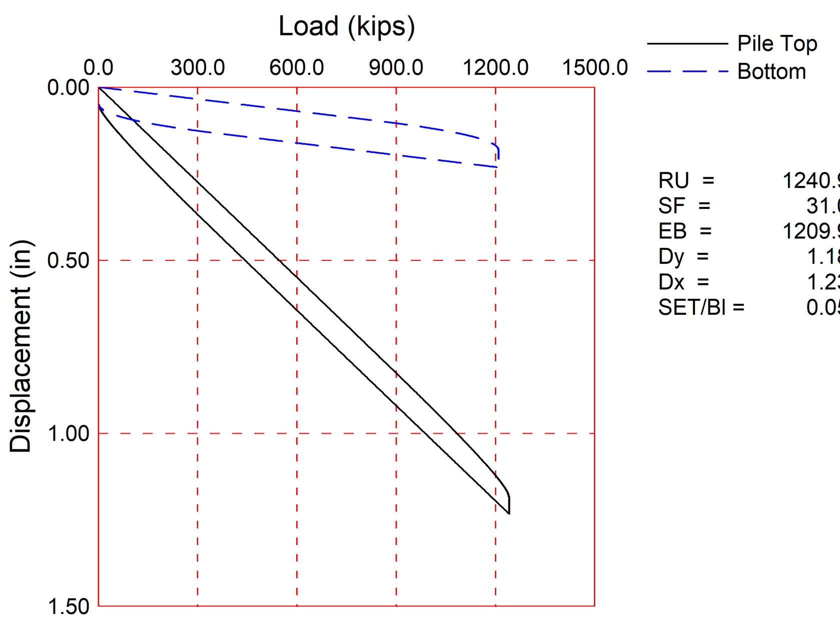
BL#	Comments
1	Template Reference Elevation +177.1
2	Ground Elevation +176.1
3	Fuel Setting 1
4	Fuel Setting 2 to fire hammer
28	Hammer not shutting off

Time Summary

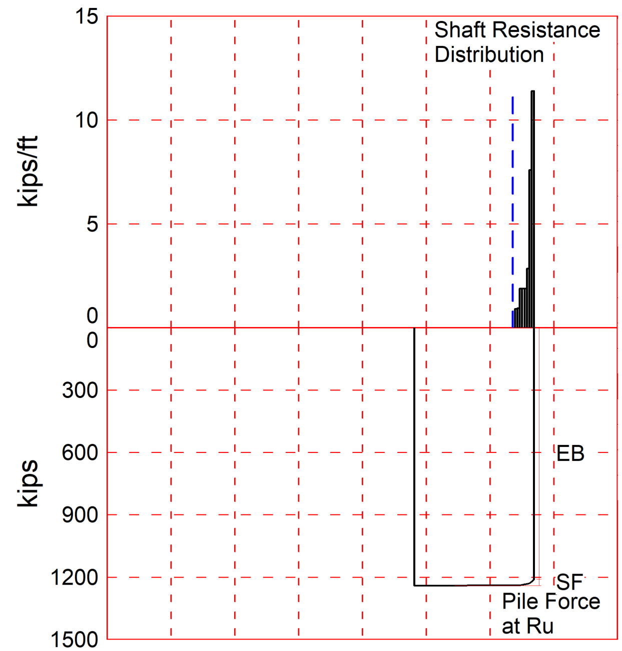
Drive 7 minutes 53 seconds 3:44 PM - 3:52 PM BN 1 - 50







RU	=	1240.9 kips
SF	=	31.0 kips
EB	=	1209.9 kips
Dy	=	1.18 in
Dx	=	1.23 in
SET/Bl	=	0.05 in



Length b. Sensors	52.7 ft
Embedment	8.5 ft
Top Area	26.1 in^2
End Bearing Area	203.2 in^2
Top Perimeter	4.75 ft
Top E-Modulus	30000 ksi
Top Spec. Weight	492.0 lb/ft^3
Top Wave Spd.	16808 ft/s
Overall W.S.	16808 ft/s
Match Quality	4.95
Top Compr. Stress	45.1 ksi
Max Compr. Stress	55.8 ksi
Max Tension Stress	-8.26 ksi
Avg. Shaft Quake	0.10 in
Toe Quake	0.14 in
Avg. Shaft Smith Dpg.	0.15 s/ft
Toe Smith Damping	0.03 s/ft

About the CAPWAP Results

The CAPWAP program performs a signal matching or reverse analysis based on measurements taken on a deep foundation under an impact load. The program is based on a one-dimensional mathematical model. Under certain conditions, the model only crudely approximates the often complex dynamic situations.

The CAPWAP analysis relies on the input of accurately measured dynamic data plus additional parameters describing pile and soil behavior. If the field measurements of force and velocity are incorrect or were taken under inappropriate conditions (e.g., at an inappropriate time or with too much or too little energy) or if the input pile model is incorrect, then the solution cannot represent the actual soil behavior.

Generally the CAPWAP analysis is used to estimate the axial compressive pile capacity and the soil resistance distribution. The long-term capacity is best evaluated with restrike tests since they incorporate soil strength changes (set-up gains or relaxation losses) that occur after installation. The calculated load settlement graph does not consider creep or long term consolidation settlements. When uplift is a controlling factor in the design, use of the CAPWAP results to assess uplift capacity should be made only after very careful analysis of only good measurement quality, and further used only with longer pile lengths and with nominally higher safety factors.

CAPWAP is also used to evaluate driving stresses along the length of the pile. However, it should be understood that the analysis is one dimensional and does not take into account bending effects or local contact stresses at the pile toe.

Furthermore, if the user of this software was not able to produce a solution with satisfactory signal “match quality” (MQ), then the associated CAPWAP results may be unreliable. There is no absolute scale for solution acceptability but solutions with MQ above 5 are generally considered less reliable than those with lower MQ values and every effort should be made to improve the analysis, for example, by getting help from other independent experts.

Considering the CAPWAP model limitations, the nature of the input parameters, the complexity of the analysis procedure, and the need for a responsible application of the results to actual construction projects, it is recommended that at least one static load test be performed on sites where little experience exists with dynamic behavior of the soil resistance or when the experience of the analyzing engineer with both program use and result application is limited.

Finally, the CAPWAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors. The CAPWAP results should be reviewed by the Engineer of Record with consideration of applicable geotechnical conditions including, but not limited to, group effects, potential settlement from underlying compressible layers, soil resistances provided from any layers unsuitable for long term support, as well as effective stress changes due to soil surcharges, excavation or change in water table elevation.

The CAPWAP analysis software is one of many means by which the capacity of a deep foundation can be assessed. The engineer performing the analysis is responsible for proper software application and the analysis results. Pile Dynamics accepts no liability whatsoever of any kind for the analysis solution and/or the application of the analysis result.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 1240.9; along Shaft 31.0; at Toe 1209.9 kips

Soil Sgmnt No.	Dist. Below Gages ft	Depth Below Grade ft	Ru kips	Force in Pile kips	Sum of Ru kips	Unit Resist. (Depth) kips/ft	Unit Resist. (Area) ksf
				1240.9			
1	45.3	1.1	1.0	1239.9	1.0	0.92	0.19
2	46.3	2.1	1.0	1238.9	2.0	0.95	0.20
3	47.4	3.2	2.0	1236.9	4.0	1.90	0.40
4	48.5	4.3	2.0	1234.9	6.0	1.90	0.40
5	49.5	5.3	2.0	1232.9	8.0	1.90	0.40
6	50.6	6.4	3.0	1229.9	11.0	2.85	0.60
7	51.6	7.4	8.0	1221.9	19.0	7.59	1.60
8	52.7	8.5	12.0	1209.9	31.0	11.39	2.40
Avg. Shaft			3.9			3.66	0.77
Toe			1209.9				857.28

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.15	0.03
Quake	(in)	0.10	0.14
Case Damping Factor		0.10	0.78
Damping Type		Smith	Sm+Visc
Unloading Quake	(% of loading quake)	100	30
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	0	

CAPWAP match quality = 4.95 (Wave Up Match) ; RSA = 0
Observed: Final Set = 0.05 in; Blow Count = 240 b/ft
Computed: Final Set = 0.04 in; Blow Count = 277 b/ft

max. Top Comp. Stress = 45.1 ksi (T= 43.0 ms, max= 1.235 x Top)
max. Comp. Stress = 55.8 ksi (Z= 52.7 ft, T= 39.4 ms)
max. Tens. Stress = -8.26 ksi (Z= 39.0 ft, T= 53.8 ms)
max. Energy (EMX) = 41.8 kip-ft; max. Measured Top Displ. (DMX)= 0.92 in

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	1.1	1178.3	-199.6	45.1	-7.65	41.8	18.8	0.88
2	2.1	1180.3	-207.1	45.2	-7.93	41.6	18.8	0.88
5	5.3	1188.3	-207.9	45.5	-7.96	41.1	18.8	0.85
8	8.4	1120.7	-197.9	42.9	-7.58	40.4	18.7	0.82
11	11.6	1122.6	-193.6	43.0	-7.42	39.6	18.7	0.79
14	14.7	1119.7	-190.9	42.9	-7.32	38.6	18.6	0.76
17	17.9	1049.6	-189.7	40.2	-7.27	37.5	18.6	0.72
20	21.1	1033.4	-192.0	39.6	-7.36	36.5	18.6	0.69
23	24.2	971.2	-193.2	37.2	-7.40	35.4	18.5	0.65
26	27.4	978.1	-193.5	37.5	-7.41	34.0	18.4	0.61
29	30.5	1067.3	-193.4	40.9	-7.41	32.1	18.4	0.57
32	33.7	1080.5	-200.6	41.4	-7.69	30.3	18.3	0.52
35	36.9	1159.4	-211.5	44.4	-8.11	27.9	18.3	0.47
38	40.0	1182.5	-210.5	45.3	-8.07	25.3	18.1	0.41
41	43.2	1188.1	-210.2	45.5	-8.05	23.0	19.2	0.36
44	46.3	1282.5	-208.4	49.1	-7.98	20.1	19.9	0.30
45	47.4	1324.1	-204.4	50.7	-7.83	19.0	19.4	0.28
46	48.5	1351.2	-199.7	51.8	-7.65	17.9	18.4	0.26
47	49.5	1377.0	-195.2	52.8	-7.48	16.8	17.3	0.24
48	50.6	1410.6	-191.6	54.0	-7.34	15.7	16.0	0.22
49	51.6	1444.5	-189.2	55.3	-7.25	15.2	14.5	0.20
50	52.7	1455.3	-188.4	55.8	-7.22	15.7	12.4	0.18
Absolute	52.7			55.8			(T =	39.4 ms)
	39.0				-8.26		(T =	53.8 ms)

CASE METHOD

J =	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
RP	1364.3	1274.1	1184.0	1093.9	1003.7					
RX	1440.8	1394.0	1354.4	1325.9	1297.9	1269.8	1241.8	1240.9	1240.9	1240.9
RU	1367.0	1277.4	1187.8	1098.2	1008.6					

RAU = 1240.9 (kips); RA2 = 1240.9 (kips)

Current CAPWAP Ru = 1240.9 (kips); Corresponding J(RP)= 0.27; matches RX20 within 5%

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS	KEB
ft/s	ms	kips	kips	kips	in	in	in	kip-ft	kips	kips/in
19.2	36.10	893.1	921.8	1213.3	0.92	0.04	0.05	42.1	1038.3	8642

PILE PROFILE AND PILE MODEL

Depth	Area	E-Modulus	Spec. Weight	Perim.
ft	in^2	ksi	lb/ft^3	ft
0.0	26.1	30000.0	492.000	4.75
52.7	26.1	30000.0	492.000	4.75

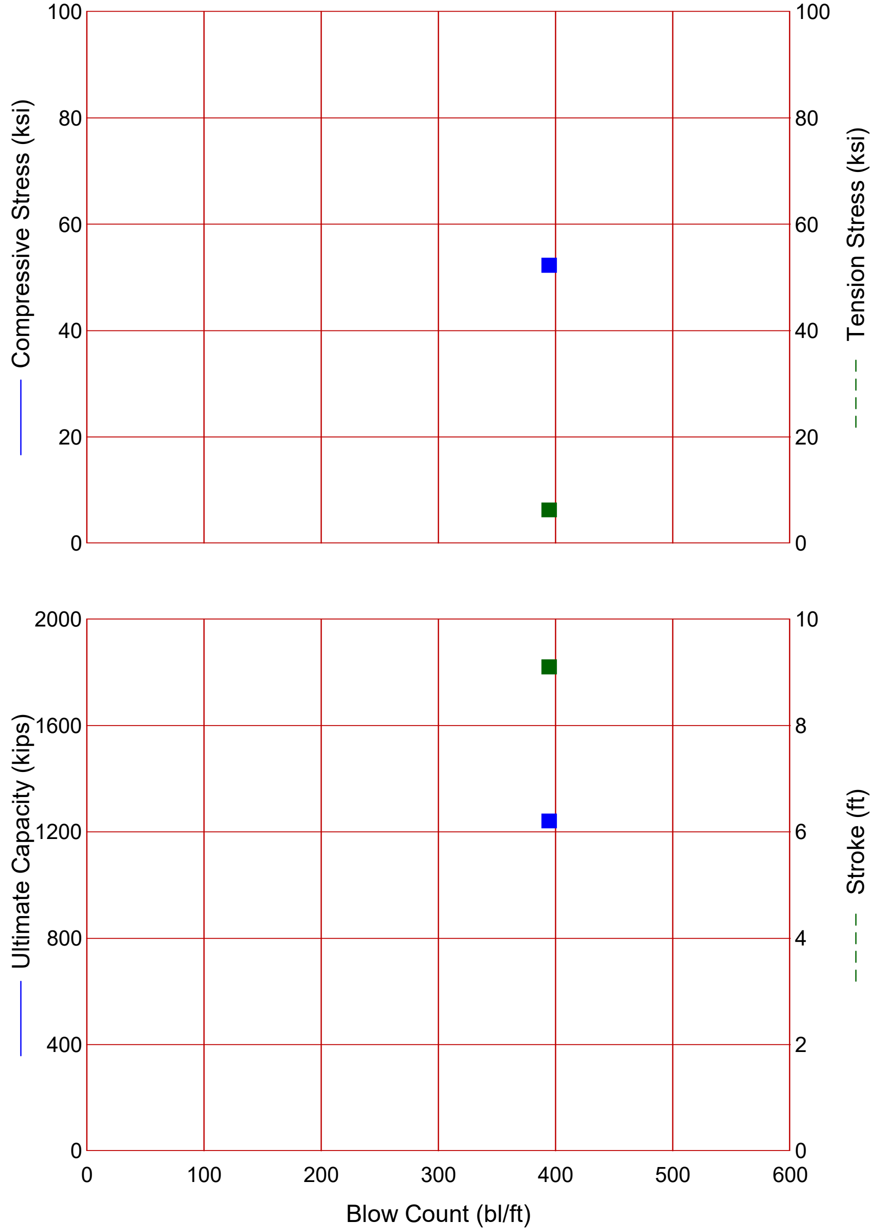
Toe Area 203.2 in^2

Top Segment Length 1.05 ft, Top Impedance 47 kips/ft/s

Wave Speed: Pile Top 16807.9, Elastic 16807.9, Overall 16807.9 ft/s
Pile Damping 1.00 %, Time Incr 0.063 ms, 2L/c 6.3 ms
Total volume: 9.546 ft^3; Volume ratio considering added impedance: 1.000

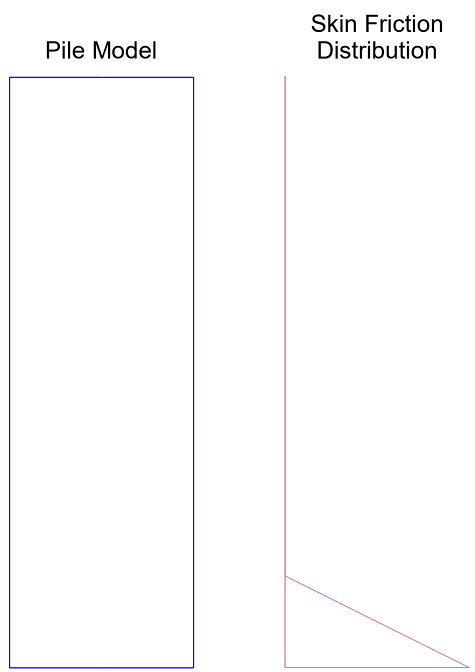
ICE of Carolinas, PLLC
CCR 1 Bridge 35 BT36 PI 1 EOD CAL

23-May-2023
GRLWEAP Version 2010



APE D 30-52

Ram Weight	6.62	kips
Efficiency	0.990	
Pressure	1638 (115%)	psi
Helmet Weight	2.65	kips
Hammer Cushion	45372	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.140	in
Skin Damping	0.150	s/ft
Toe Damping	0.030	s/ft
Pile Length	55.00	ft
Pile Penetration	8.50	ft
Pile Top Area	26.10	in2



Res. Shaft = 2 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
1241.0	52.27	6.25	394.8	9.10	41.76

Appendix B

Dynamic Pile Testing, Signal Matching Results, and Calibration WEAP

Bridge 35, Bent 36, Pile 5

INFRASTRUCTURE CONSULTING & ENGINEERING

Summary of Provided Project and Pile Driving Information

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Project ID	P039718
ICE Field Personnel	Sally G. Thomson, P.E.
ICE Responsible Engineer	Michael J. Simpson, P.E.

Bent Number	**Station**	**Pile Type**	**Pile Batter**	**Hammer Used**	**Pile Cushion Type and Thickness**
Bent 36	5424+25.76	HP14x89 with Pile Tip	Plumb	APE D30-52	N/A
Pile Number	**Total Pile Length (feet)**	**Pile Length Below Gages (feet)**	**Pile Splice Location(s) above Pile Tip (feet)**	**Initial Drive Test Date**	**Restrike Test Date**
5	55.0	52.7	N/A	5/5/23	N/A

Factored Design Load (kips)	**Geotechnical Resistance Factor**	**Nominal Resistance of Pile (kips)**	**Required Driving Resistance of Pile (kips)**	**Minimum Tip Elevation of Pile (feet)**
379	0.65	583	656	+163.0

Installation Records Provided to ICE	Please Refer to SCDOT Pile Driving Logs
Project Information and Soil Borings Provided to ICE	Yes, Attached in Appendix D
Pile Driving Equipment Data Form Provided to ICE	APE D30-52 Data Hammer Sheet Attached in Appendix E
Strain and Accelerometer Calibrations Attached	Yes, Attached in Appendix F

Steel Acceptable Compression Driving Stress Limit (ksi)*	45
Steel Acceptable Tension Driving Stress Limit (ksi)*	45

*For steel piles based on Section 711.4.2.2 and a steel yield strength (Fy) of 50 ksi.

Approximate Reference Elevation (feet)	+177.1
Approximate Ground/Mudline Elevation (feet)	+176.1
Approximate Final Pile Penetration Below Reference at End of Initial Drive (feet)	13.3
Approximate Final Pile Tip Elevation at End of Initial Drive (feet)	+163.8
Approximate Final Pile Penetration Below Reference at End of Restrike (feet)	N/A
Approximate Final Pile Tip Elevation at End of Restrike (feet)	N/A

INFRASTRUCTURE CONSULTING & ENGINEERING

Additional Notes on Pile Installation
-Pile 5 was monitored with instrumentation for the entire initial drive. -For additional detailed information on the hammer driving system, bridge plans, and soils information please refer to the project documents. -The blows per foot of penetration for the pile was kept by the PDA operator on the PDA during the initial drive. A pile driving log was also maintained by a SCDOT representative.

Summary of Results

Dynamic Pile Testing Results (Detailed Results in Appendix A)

Location*	Capacity (kips)	Case Method	Max. Comp. Stress (ksi)	Avg. Comp. Stress (ksi)	Max. Comp. Stress at Pile Bottom (ksi)	Avg. Comp. Stress at Pile Bottom (ksi)	Avg. Transferred Energy (k-ft)	Avg. Stroke (feet)
EOD	898	RAU	38.5	26.8	44.6	21.5	29.4	6.2

Signal Matching Analyses Results (Detailed Result in Appendix A)

Location*	R_{ult} (kips)	R_{side} / R_{end} (kips)	Equiv. BPF*	Stroke (ft)	EMX (k-ft)	Qs (in)	Qt (in)	Ss (sec/ft)	St (sec/ft)	MQN*
EOD (Blow 44)	672	35 / 637	139	7.5	34.1	0.04	0.33	0.06	0.06	4.76

*EOD – End of Drive; BPF – Blows per foot; MQN – Match Quality Number

Dynamic Pile Testing Interpretation and Commentary

The capacity listed in the Summary of Dynamic Pile Testing Results is based on the RAU (Auto Capacity End Bearing Piles) solution for the average of the last increment of the initial drive. The summary plot and table attached for the dynamic pile testing results are based on the same capacity solution.

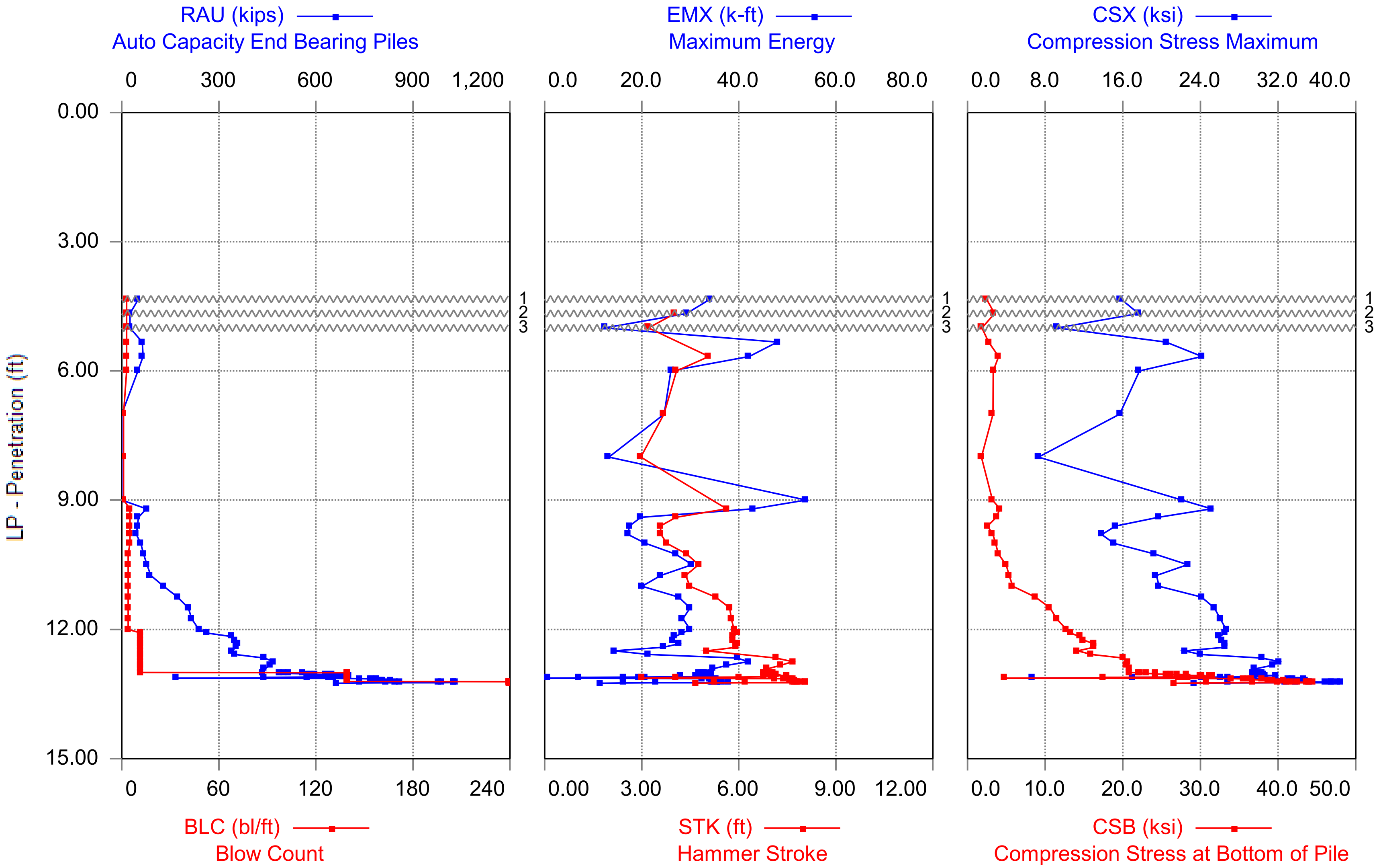
Signal matching analysis was performed for a blow (Blow 44) near the end of the initial drive. The signal matching mobilized capacity near the end of initial drive was above the required driving resistance of 656 kips for Bent 36.

Compression and tension pile driving stresses were below the acceptable limit for the pile tested during initial drive. The pile tested did not show any signs of integrity problems below the gage locations based on the test results.

Pile Dynamics, Inc. - PDIPLOT2 Ver 2017.2.58.3 - Case Method & iCAP® Results

Printed: 22-May-2023 Test started: 05-May-2023

CCRP1 Bridge 35 Bent 36 - Pile 5



1 - Template Reference El. +177.1

2 - Ground Elevation +176.1

3 - Fuel Setting 1

CCRP1 Bridge 35 Bent 36 - Pile 5 HP 14x89 w tips
OP: ICE Date: 05-May-2023

AR: 26.10 in² SP: 0.492 k/ft³
LE: 52.67 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.90

RAU: Auto Capacity End Bearing Piles
EMX: Maximum Energy
STK: Hammer Stroke
CSX: Compression Stress Maximum
CSB: Compression Stress at Bottom of Pile
TSX: Tension Stress Maximum - Full Record Search
DMX: Maximum Displacement
DFN: Final Displacement
BTA: Integrity Factor (1)

BL#	Depth	BLC	TYPE	RAU	EMX	STK	CSX	CSB	TSX	DMX	DFN	BTA
	ft	bl/ft		kips	k-ft	ft	ksi	ksi	ksi	in	in	(%)
3	5.00	3	AV3	34	25.2	3.62	14.2	2.6	6.4	7.51	4.00	89.0
			STD	13	9.3	0.41	3.6	0.7	2.1	2.90	0.00	0.8
			MAX	52	34.1	4.03	17.6	3.5	8.2	11.14	4.00	90.0
			@BL	1	1	2	2	2	2	1	3	3
6	6.00	3	AV3	60	38.7	4.58	20.8	3.4	9.6	7.27	4.00	92.7
			STD	7	9.3	0.50	2.6	0.5	2.0	2.53	0.00	5.2
			MAX	66	47.9	5.08	24.2	4.0	12.3	10.60	4.00	100.0
			@BL	5	4	5	5	5	5	4	5	6
9	9.00	1	AV3	0	30.6	3.33	15.0	2.8	6.0	12.01	12.01	96.0
			STD	0	17.1	0.36	6.1	0.7	3.2	0.00	0.00	5.7
			MAX	0	53.9	3.69	22.1	3.3	9.7	12.01	12.01	100.0
			@BL	7	9	7	9	7	9	8	8	8
14	10.00	5	AV5	56	23.7	4.13	17.8	3.5	7.8	3.78	2.40	93.0
			STD	11	9.8	0.77	4.2	0.5	3.4	1.27	0.00	5.8
			MAX	76	43.0	5.63	25.1	4.2	14.0	6.30	2.40	100.0
			@BL	10	10	10	10	10	10	10	11	12
18	11.00	4	AV4	91	25.4	4.50	20.3	5.0	7.9	3.18	2.98	100.0
			STD	23	3.8	0.16	1.4	0.7	1.3	0.19	0.03	0.0
			MAX	129	30.4	4.76	22.7	5.8	9.9	3.40	3.00	100.0
			@BL	18	16	16	16	18	16	15	17	15
22	12.00	4	AV4	208	29.0	5.66	25.6	10.9	6.0	3.00	3.00	100.0
			STD	24	1.0	0.22	0.9	1.5	1.0	0.00	0.00	0.0
			MAX	239	30.0	5.86	26.7	12.8	7.5	3.00	3.00	100.0
			@BL	22	22	22	22	22	19	21	21	19
34	13.00	12	AV12	384	29.7	6.39	27.6	17.4	3.3	1.04	1.00	100.0
			STD	60	7.7	0.77	2.9	2.9	0.6	0.07	0.00	0.0
			MAX	470	41.9	7.67	32.2	21.0	4.7	1.18	1.00	100.0
			@BL	31	31	31	31	34	23	31	32	23
63	13.21	139	AV29	650	30.0	6.94	29.8	29.7	5.5	0.80	0.08	100.0
			STD	141	8.6	1.04	5.7	7.7	1.9	0.19	0.00	0.0
			MAX	829	36.0	7.74	34.9	40.7	8.1	0.97	0.09	100.0
			@BL	61	63	61	60	63	60	38	45	35
73	13.25	240	AV10	898	30.2	7.12	34.1	39.2	6.9	0.74	0.05	100.0
			STD	126	9.1	1.19	4.9	5.7	2.0	0.17	0.01	0.0
			MAX	1,034	37.8	8.09	38.5	44.6	8.6	0.88	0.05	100.0
			@BL	68	68	68	68	70	69	69	64	64
			Average	468	29.4	6.17	26.8	21.5	5.8	2.29	1.52	98.6

CCRP1 Bridge 35 Bent 36 - Pile 5
OP: ICE
HP 14x89 w tips
Date: 05-May-2023

BL#	Depth	BLC	TYPE	RAU	EMX	STK	CSX	CSB	TSX	DMX	DFN	BTA
	ft	bl/ft		kips	k-ft	ft	ksi	ksi	ksi	in	in	(%)
			Std. Dev.	312	9.2	1.48	7.3	13.7	2.5	2.91	2.54	3.7
			Maximum	1,034	53.9	8.09	38.5	44.6	14.0	12.01	12.01	100.0
			@ Blow#	68	9	68	68	70	10	8	8	6

Total number of blows analyzed: 73

BL# Sensors

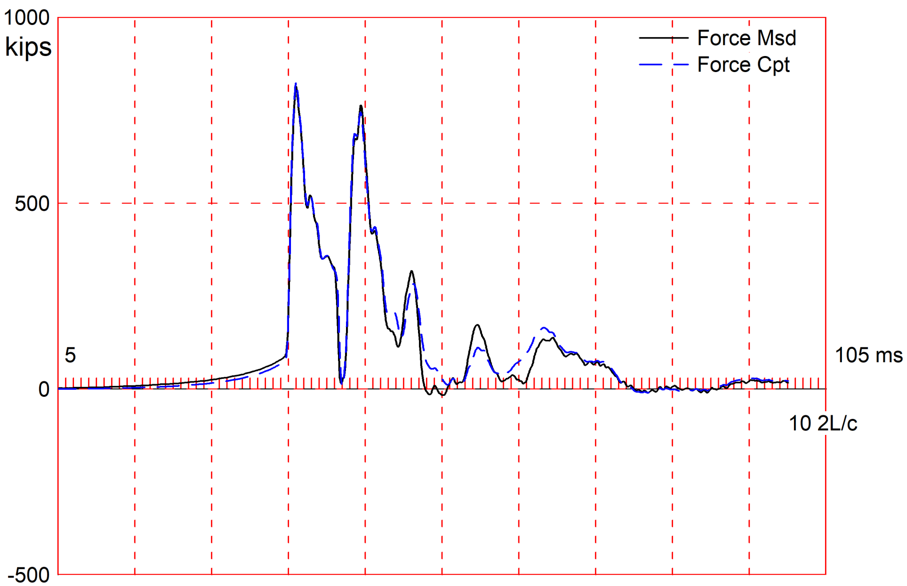
1-73 F2: [P821] 145.1 (1.00); F4: [S868] 145.1 (1.00); A1: [K12389] 483.2 (1.00);
A3: [K12388] 451.0 (1.00)

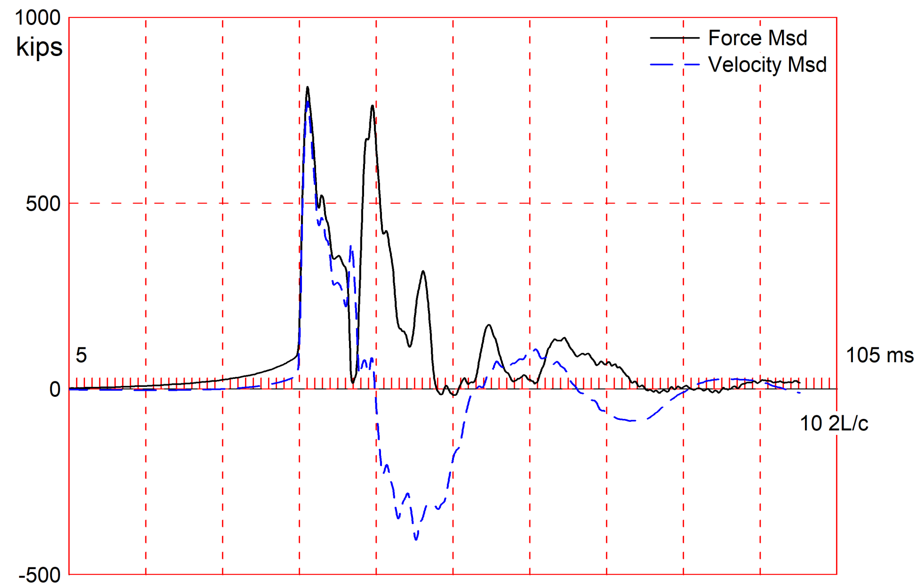
BL# Comments

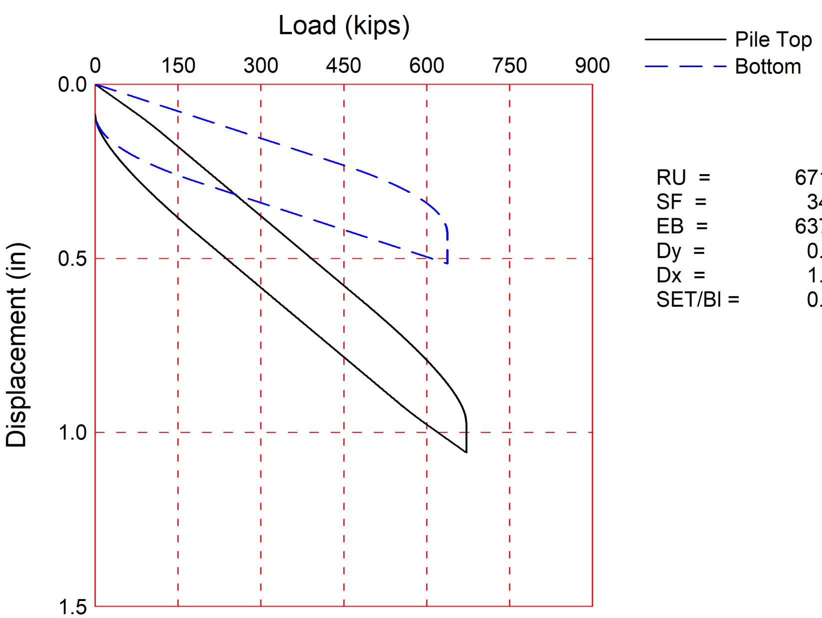
1 Template Reference El. +177.1
2 Ground Elevation +176.1
3 Fuel Setting 1

Time Summary

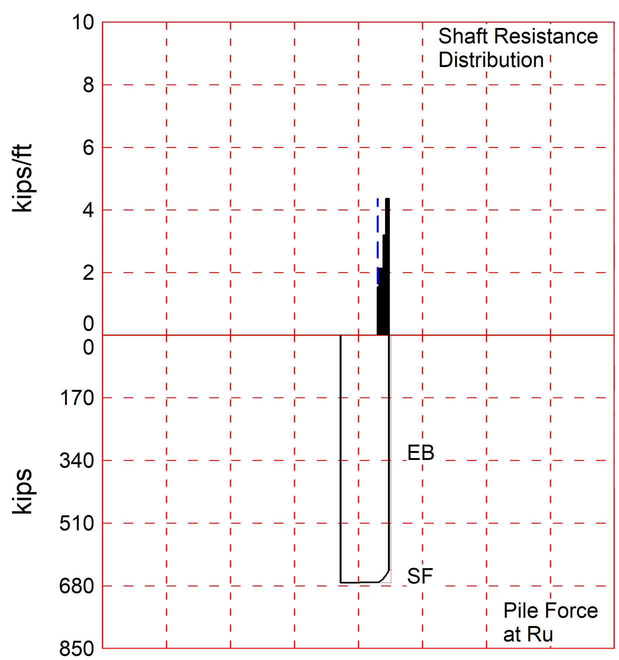
Drive 6 minutes 29 seconds 8:37 AM - 8:43 AM BN 1 - 73







RU	=	671.6 kips
SF	=	34.4 kips
EB	=	637.2 kips
Dy	=	0.97 in
Dx	=	1.06 in
SET/Bl	=	0.09 in



Length b. Sensors	52.7 ft
Embedment	12.1 ft
Top Area	26.1 in^2
End Bearing Area	203.2 in^2
Top Perimeter	4.75 ft
Top E-Modulus	30000 ksi
Top Spec. Weight	492.0 lb/ft^3
Top Wave Spd.	16808 ft/s
Overall W.S.	16721 ft/s
Match Quality	4.76
Top Compr. Stress	31.7 ksi
Max Compr. Stress	33.8 ksi
Max Tension Stress	-6.30 ksi
Avg. Shaft Quake	0.04 in
Toe Quake	0.33 in
Avg. Shaft Smith Dpg.	0.06 s/ft
Toe Smith Damping	0.06 s/ft

About the CAPWAP Results

The CAPWAP program performs a signal matching or reverse analysis based on measurements taken on a deep foundation under an impact load. The program is based on a one-dimensional mathematical model. Under certain conditions, the model only crudely approximates the often complex dynamic situations.

The CAPWAP analysis relies on the input of accurately measured dynamic data plus additional parameters describing pile and soil behavior. If the field measurements of force and velocity are incorrect or were taken under inappropriate conditions (e.g., at an inappropriate time or with too much or too little energy) or if the input pile model is incorrect, then the solution cannot represent the actual soil behavior.

Generally the CAPWAP analysis is used to estimate the axial compressive pile capacity and the soil resistance distribution. The long-term capacity is best evaluated with restrike tests since they incorporate soil strength changes (set-up gains or relaxation losses) that occur after installation. The calculated load settlement graph does not consider creep or long term consolidation settlements. When uplift is a controlling factor in the design, use of the CAPWAP results to assess uplift capacity should be made only after very careful analysis of only good measurement quality, and further used only with longer pile lengths and with nominally higher safety factors.

CAPWAP is also used to evaluate driving stresses along the length of the pile. However, it should be understood that the analysis is one dimensional and does not take into account bending effects or local contact stresses at the pile toe.

Furthermore, if the user of this software was not able to produce a solution with satisfactory signal "match quality" (MQ), then the associated CAPWAP results may be unreliable. There is no absolute scale for solution acceptability but solutions with MQ above 5 are generally considered less reliable than those with lower MQ values and every effort should be made to improve the analysis, for example, by getting help from other independent experts.

Considering the CAPWAP model limitations, the nature of the input parameters, the complexity of the analysis procedure, and the need for a responsible application of the results to actual construction projects, it is recommended that at least one static load test be performed on sites where little experience exists with dynamic behavior of the soil resistance or when the experience of the analyzing engineer with both program use and result application is limited.

Finally, the CAPWAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors. The CAPWAP results should be reviewed by the Engineer of Record with consideration of applicable geotechnical conditions including, but not limited to, group effects, potential settlement from underlying compressible layers, soil resistances provided from any layers unsuitable for long term support, as well as effective stress changes due to soil surcharges, excavation or change in water table elevation.

The CAPWAP analysis software is one of many means by which the capacity of a deep foundation can be assessed. The engineer performing the analysis is responsible for proper software application and the analysis results. Pile Dynamics accepts no liability whatsoever of any kind for the analysis solution and/or the application of the analysis result.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 671.6; along Shaft 34.4; at Toe 637.2 kips

Soil Sgmnt No.	Dist. Below Gages ft	Depth Below Grade ft	Ru kips	Force in Pile kips	Sum of Ru kips	Unit Resist. (Depth) kips/ft	Unit Resist. (Area) ksf	Quake in
				671.6				
1	41.3	0.7	1.1	670.5	1.1	1.55	0.33	0.04
2	42.3	1.7	1.1	669.4	2.2	1.07	0.22	0.04
3	43.4	2.8	2.2	667.2	4.4	2.13	0.45	0.04
4	44.4	3.8	2.2	665.0	6.6	2.13	0.45	0.04
5	45.4	4.8	2.2	662.8	8.8	2.13	0.45	0.04
6	46.5	5.9	2.2	660.6	11.0	2.13	0.45	0.04
7	47.5	6.9	3.3	657.3	14.3	3.20	0.67	0.04
8	48.5	7.9	3.3	654.0	17.6	3.20	0.67	0.04
9	49.6	9.0	3.3	650.7	20.9	3.20	0.67	0.04
10	50.6	10.0	4.5	646.2	25.4	4.36	0.92	0.04
11	51.6	11.0	4.5	641.7	29.9	4.36	0.92	0.04
12	52.7	12.1	4.5	637.2	34.4	4.36	0.92	0.04
Avg. Shaft			2.9			2.85	0.60	0.04
Toe			637.2				451.49	0.33

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.06	0.06
Case Damping Factor		0.05	0.82
Damping Type		Viscous	Sm+Visc
Unloading Quake	(% of loading quake)	30	88
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	79	
Soil Plug Weight	(kips)	0.196	

CAPWAP match quality = 4.76 (Wave Up Match) ; RSA = 0
Observed: Final Set = 0.09 in; Blow Count = 139 b/ft
Computed: Final Set = 0.09 in; Blow Count = 131 b/ft
Transducer F2 (P821) CAL: 145.1; RF: 1.00; F4 (S868) CAL: 145.1; RF: 1.00
A1 (K12389) CAL: 483; RF: 1.00; A3 (K12388) CAL: 451; RF: 1.00

max. Top Comp. Stress = 31.7 ksi (T= 36.1 ms, max= 1.067 x Top)
max. Comp. Stress = 33.8 ksi (Z= 52.7 ft, T= 40.0 ms)
max. Tens. Stress = -6.30 ksi (Z= 44.4 ft, T= 56.3 ms)
max. Energy (EMX) = 34.1 kip-ft; max. Measured Top Displ. (DMX)= 0.85 in

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	1.0	827.4	-10.7	31.7	-0.41	34.1	16.3	0.87
2	2.1	827.7	-11.3	31.7	-0.43	33.8	16.3	0.86
5	5.2	828.7	-19.2	31.8	-0.73	32.9	16.3	0.83
8	8.3	829.5	-39.1	31.8	-1.50	32.3	16.3	0.82
11	11.4	830.3	-56.3	31.8	-2.16	32.0	16.3	0.80
14	14.5	831.1	-69.2	31.8	-2.65	31.5	16.2	0.78
17	17.6	832.1	-81.2	31.9	-3.11	30.9	16.2	0.75
20	20.7	833.7	-97.2	31.9	-3.72	30.3	16.2	0.72
23	23.8	835.5	-115.5	32.0	-4.42	29.6	16.1	0.69
26	26.9	837.2	-132.7	32.1	-5.09	28.8	16.1	0.66
29	29.9	838.6	-146.0	32.1	-5.60	28.0	16.0	0.63
32	33.0	839.9	-154.4	32.2	-5.92	27.1	16.0	0.60
35	36.1	842.7	-159.4	32.3	-6.11	26.3	15.9	0.57
38	39.2	847.2	-162.0	32.5	-6.21	25.4	15.8	0.54
41	42.3	844.2	-162.4	32.3	-6.22	24.5	17.9	0.51
44	45.4	801.7	-164.1	30.7	-6.29	23.3	19.8	0.48
47	48.5	802.4	-158.0	30.7	-6.05	21.9	20.4	0.45
48	49.6	801.7	-153.8	30.7	-5.89	21.4	20.0	0.44
49	50.6	832.4	-149.8	31.9	-5.74	21.0	19.3	0.43
50	51.6	858.7	-144.9	32.9	-5.55	20.4	18.4	0.42
51	52.7	882.5	-140.2	33.8	-5.37	20.1	17.3	0.41
Absolute	52.7			33.8			(T =	40.0 ms)
	44.4				-6.30		(T =	56.3 ms)

CASE METHOD

J =	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
RP	725.4	552.5	379.5	206.6	33.6					
RX	827.8	788.2	757.9	736.3	716.9	697.6	684.3	678.6	675.4	673.2
RU	725.4	552.5	379.5	206.6	33.6					

RAU = 671.6 (kips); RA2 = 718.7 (kips)

Current CAPWAP Ru = 671.6 (kips); Corresponding J(RP)= 0.06; J(RX) = 2.00

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS	KEB
ft/s	ms	kips	kips	kips	in	in	in	kip-ft	kips	kips/in
16.6	36.07	775.4	814.7	815.6	0.85	0.08	0.09	34.3	877.4	1931

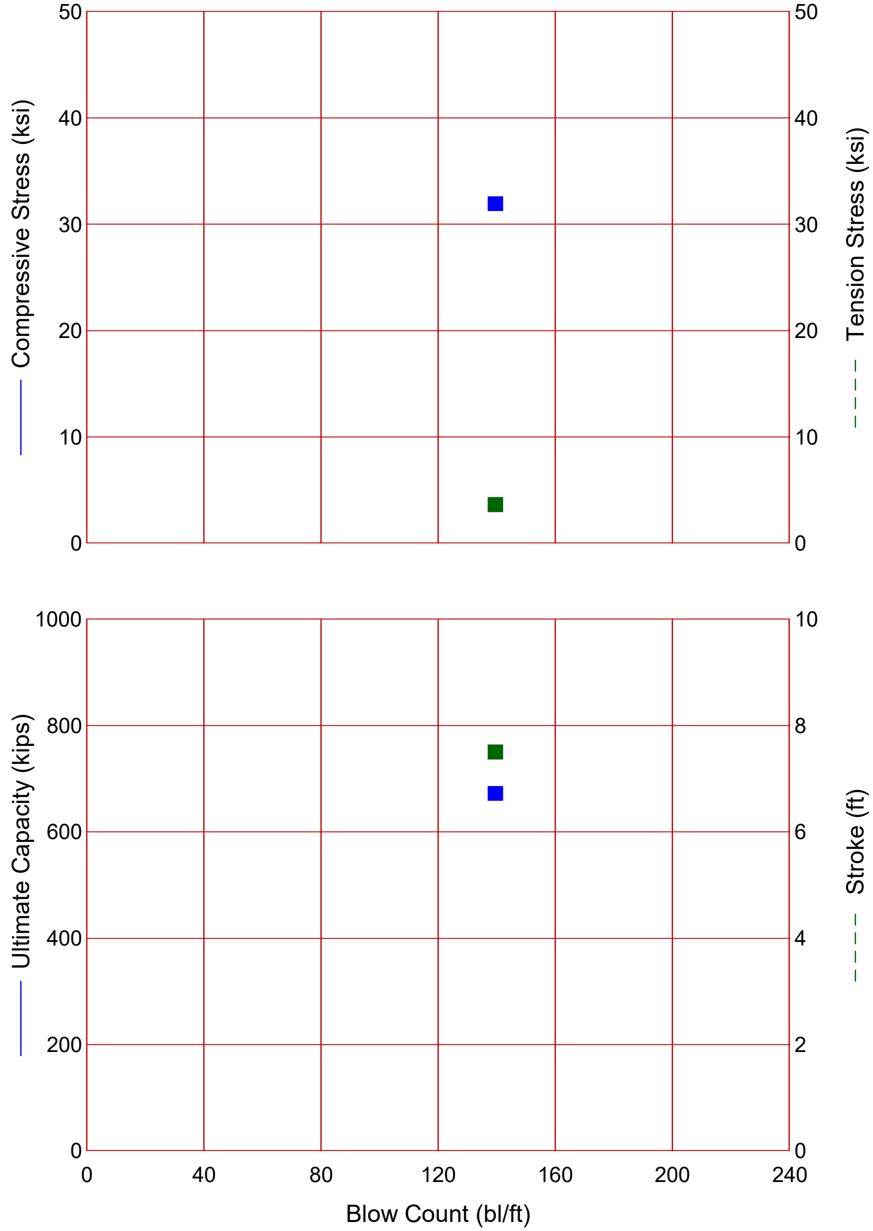
PILE PROFILE AND PILE MODEL

Depth	Area	E-Modulus	Spec. Weight	Perim.
ft	in^2	ksi	lb/ft^3	ft
0.0	26.1	30000.0	492.000	4.75
52.7	26.1	30000.0	492.000	4.75

Toe Area 203.2 in^2

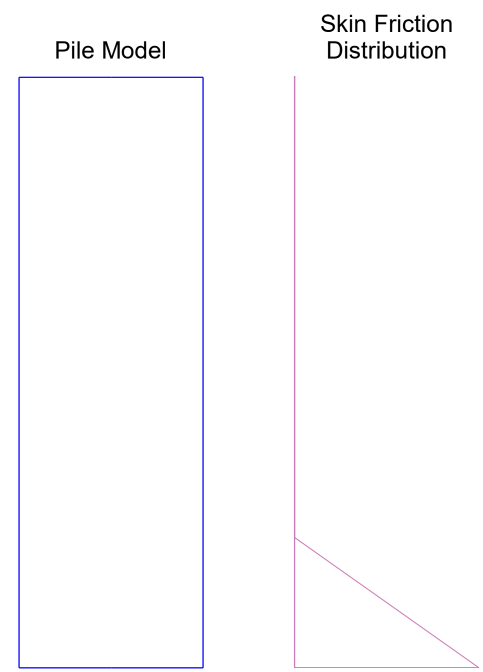
Segmnt Number	Dist. B.G.	Impedance	Imped. Change	Tension Slack	Tension Eff.	Compression Slack	Compression Eff.	Perim.	Wave Speed	Soil Plug
	ft	kips/ft/s	%	in		in		ft	ft/s	kips
1	1.0	46.59	0.00	0.00	0.000	-0.00	0.000	4.75	16720.6	0.000
2	2.1	46.59	0.00	0.00	0.000	-0.00	0.000	4.75	16720.6	0.004
51	52.7	46.59	0.00	0.00	0.000	-0.00	0.000	4.75	16720.6	0.004

Wave Speed: Pile Top 16807.9, Elastic 16807.9, Overall 16720.6 ft/s
Pile Damping 1.00 %, Time Incr 0.062 ms, 2L/c 6.3 ms
Total volume: 9.546 ft^3; Volume ratio considering added impedance: 1.000



APE D 30-52

Ram Weight	6.62	kips
Efficiency	0.990	
Pressure	1453 (102%)	psi
Helmet Weight	2.65	kips
Hammer Cushion	45372	kips/in
COR of H.C.	0.800	
Skin Quake	0.040	in
Toe Quake	0.330	in
Skin Damping	0.060	s/ft
Toe Damping	0.060	s/ft
Pile Length	55.00	ft
Pile Penetration	12.10	ft
Pile Top Area	26.10	in2



Res. Shaft = 5 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
672.0	31.91	3.62	139.6	7.50	34.01

Appendix C

Pile Driving Criteria

Bent 36

INFRASTRUCTURE CONSULTING & ENGINEERING

Recommended Production Pile Driving Criteria

The recommended drive criteria for the up to 55-feet long HP 14x89 steel piles in Bent 36 is based on the wave equation analysis and the dynamic testing results. Please see the attached wave equation outputs for additional information.

The driving criteria also only apply to piles driven with the APE D30-52 hammer driving system. A hammer helmet weight of 2.7 kips and a hammer cushion of 2.5 total inches of micarta and aluminum, based on the project pile installation plan, was used to develop the production pile driving criteria. A change in the hammer driving system, installation procedures, and/or pile type would require re-analysis and likely would warrant modifications to the driving criteria. ICE should be notified immediately should any changes occur.

Bent 36

The up to 55-foot HP 14x89 steel piles at Bent 36 may be stopped if one of the following conditions is met, provided pile rebound is less than ¼ inch per blow and the minimum tip elevation or minimum penetration requirements in the project plans and/or specifications are met. **To keep the pile stresses below the acceptable limit during driving, the hammer should be set on Fuel Setting 1 only and the maximum stroke should not exceed 8.0 feet.**

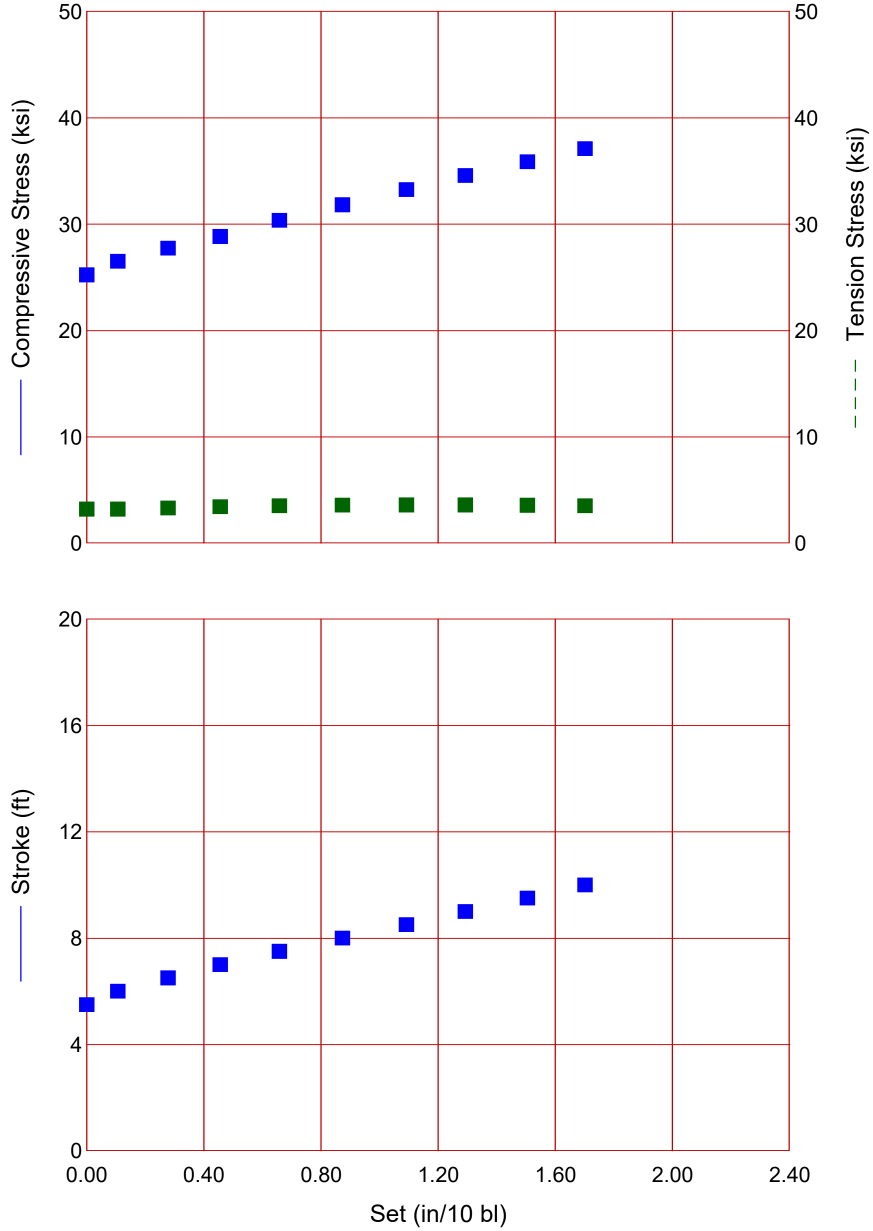
1. Practical refusal (20 blows per one inch or ½ inch in 10 blows with at least a stroke of 7.0 feet) is reached during driving.
2. The following maximum set per 10 blows is not exceeded for the respective stroke during driving:

Stroke (feet)	Maximum Set in inches per 10 blows	Minimum Blows Per Foot
7.5	5/8	171
8.0 or greater	7/8	134

Piles not meeting the above requirements should be brought to the Engineer's attention and may require additional testing and/or driving to meet the requirements.

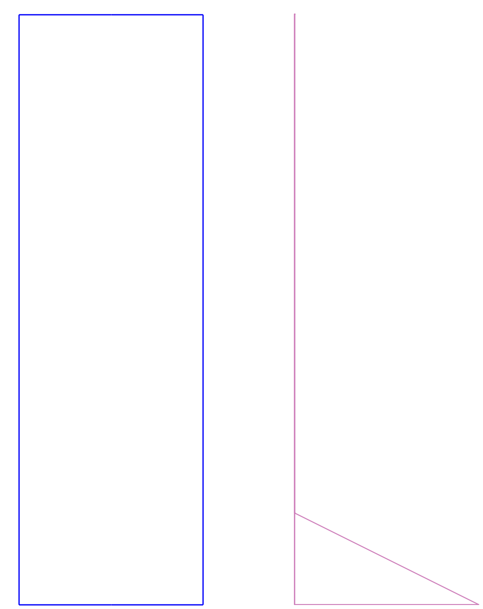
Limitations

This report presents test measurements made by ICE. Interpretations were made based upon the measurements made by ICE with the latest techniques available and currently accepted standards of care recognized by Geotechnical Engineering professionals. The Geotechnical Engineer of Record should ultimately make final recommendations for foundation design and construction.



APE D 30-52

Capacity	656.0	kips
Ram Weight	6.62	kips
Efficiency	0.900	
Pressure	1425 (100%)	psi
Helmet Weight	2.65	kips
Hammer Cushion	45372	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.330	in
Skin Damping	0.150	s/ft
Toe Damping	0.060	s/ft
Pile Length	55.00	ft
Pile Penetration	8.50	ft
Pile Top Area	26.10	in2



Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Set in/10 bl	Stroke ft	Energy kips-ft
656.0	25.23	3.20	0.0	5.50	22.24
656.0	26.51	3.21	0.1	6.00	24.55
656.0	27.73	3.32	0.3	6.50	26.87
656.0	28.83	3.43	0.5	7.00	29.12
656.0	30.36	3.51	0.7	7.50	31.49
656.0	31.82	3.58	0.9	8.00	33.89
656.0	33.24	3.60	1.1	8.50	36.27
656.0	34.57	3.59	1.3	9.00	38.54
656.0	35.86	3.56	1.5	9.50	40.91
656.0	37.10	3.50	1.7	10.00	43.17

Appendix D

Project Information and Nearby Soil Borings

BRIDGE PLANS ID	SHEET NO.
P039718-B35	62

FOUNDATION LAYOUT

Geotechnical Notes for End Bents 1 and 36:

BENT I.D.	END BENT 1	END BENT 36
PILE SECTION	HP14X117	HP14X89
CONTROLLING LIMIT STATE	Extreme Event 1	Strength
FACTORED DESIGN LOAD (KIPS)	830	379
GEOTECHNICAL RESISTANCE FACTOR	1.0	0.65
NOMINAL RESISTANCE (KIPS)	830	583
LIQUEFACTION INDUCED DOWNDRAG (KIPS)	0	0
SETTLEMENT INDUCED UNFACTORED DOWNDRAG (KIPS)	0	23
SETTLEMENT INDUCED FACTORED DOWNDRAG (KIPS)	0	32
REQUIRED DRIVING RESISTANCE (KIPS)	830	656
REQUIRED MINIMUM TIP ELEVATION TO ACHIEVE LATERAL STABILITY (FEET MSL)	150	163
ESTIMATED PILE TIP ELEVATION (FEET MSL)	131	162

Method of controlling installation of piles and verifying their resistance: Resistance and stresses will be verified by Pile Driving Analyzer (PDA) and CAPWAP analysis of index pile(s) during driving. A Pile Installation Chart developed from the analysis will be used to verify the resistance of production piles.

Perform Pile Driving Analyzer (PDA) testing on two (2) index piles per bent. An index pile shall be the first pile driven at each required bent location. Include an additional two feet of (HP14x117 or HP14x89) length to accommodate the initial PDA testing. If a CAPWAP analysis determines that capacity has not been achieved, restrike one of the production piles. Perform the restrike on the production pile exhibiting the least blows per foot. On initial drive, piles shall be stopped at the highest allowable finished grade on the plans to accommodate a restrike while remaining within an allowable plan finished grade elevation. Perform PDA testing during the restrike. The Geotechnical Engineer of Record will determine the time between initial driving and any required restrikes.

Each pile is to be installed in one continuous operation. Include details of any anticipated temporary driving discontinuances including anticipated time intervals in the Pile Installation Plan.

Reinforced pile tips are required to penetrate partially weathered rock. Install the reinforced pile tips in accordance with the manufacturer's installation recommendations.

The top of partially weathered rock elevation may vary across each bent and result in varying pile lengths. Practical refusal of a pile is defined as 20 blows per inch.

If required minimum tip elevation cannot be achieved by driving alone, predrill pile locations at End Bent 36 to an elevation no lower than 163 feet with equipment that will result in a maximum predrilling diameter of 20". For predrilling for piles, see section 711.4.5.2 of the standard specifications.

Reference the Standard Specifications for Highway Construction for Driven Pile Foundations, Section 711. Notes included in these plans are in addition to the requirements of the Standard Specifications.

The following estimated parameters were used for performing a drivability analysis for End Bent 1 and End Bent 36:

BENT I.D.	END BENT 1	END BENT 36
SKIN QUAKE (QS)	0.10 in	0.10 in
TOE QUAKE (QT)	0.10 in	0.10 in
SKIN DAMPING (SD)	0.20 s/ft	0.20 s/ft
TOE DAMPING (TD)	0.15 s/ft	0.15 s/ft
% SKIN FRICTION	28%	7%
DISTRIBUTION SHAPE NO.	0	0
PILE INSTALLATION CHART	Proportional	Proportional
PILE PENETRATION	97%	24%
HAMMER ENERGY RANGE	95-140 kip-ft	60-80 kip-ft

Note: GRLWEAP 2010-7 WAS USED TO PERFORM THE WAVE EQUATION ANALYSIS

A pile hammer having the rated energy as indicated above is considered suitable for driven pile installation. However, final hammer approval is based on a wave equation analysis that accurately reflects the Contractor's proposed driving system.

The Contractor shall retain a geotechnical engineering firm to perform the pre-construction condition assessment and Earth-borne Vibration Monitoring in accordance with the RFP.

SCDOT Supplemental Technical Specification SC-M-713 (01/19) shall apply to the project.

Temporary Shoring Notes:

Designer shall determine appropriate water level and consider all unbalanced water forces in design. Design shall accommodate live loading. Use the following soil strength parameters for determining earth pressure coefficients.

Temporary Shoring Wall Soil Design Parameters

	Elevation Top/Bottom	Stress State	Internal Friction, φ (deg)	Cohesion, c (psf)
Existing Embankment	190	Total	15	500
	166	Effective	32	150
Alluvial	166	Total	0	500
	157	Effective	29	0
Residual	157	Total	0	3500
	140	Effective	0	3500
PWR	140	Total	0	8000
	120	Effective	0	8000

Geotechnical Notes for End Bent 10:

BENT I.D.	END BENT 10
PILE SECTION	HP14X117
CONTROLLING LIMIT STATE	Extreme Event 1
FACTORED DESIGN LOAD (KIPS)	870
GEOTECHNICAL RESISTANCE FACTOR	1.0
NOMINAL RESISTANCE (KIPS)	870
RESISTANCE FROM DESIGN FLOOD SCOURABLE SOILS (KIPS)	0
RESISTANCE FROM LIQUEFIABLE SOILS (KIPS)	0
REQUIRED RESISTANCE (KIPS)	870
REQUIRED MINIMUM TIP ELEVATION TO ACHIEVE CRITICAL PENETRATION (FEET MSL)	157
ESTIMATED PILE TIP ELEVATION (FEET MSL)	157

The estimated drilled pile tip elevation for End Bent 10 is controlled by lateral stability. The top of rock elevation may be variable across the bent location and may result in varying pile lengths. Regardless of the rock elevation, extend the drilled piles at least 20 feet below bottom of cap including a minimum 10 foot rock socket.

At End Bent 10 prior to concreting and backfilling, remove (pump) any accumulation of water from the excavation. If the hole is a wet hole, concreting using wet construction method may be required as specified in Section 712 (Drilled Shafts and Drilled Pile Foundations) of the Standard Specifications for Highway Construction. After installation of the pile, concrete the HP 14x117 piling at End Bent 10 in the bottom 10 feet of the socket using Class 4000DS concrete.

Concrete and backfill at End Bent 10 prior to drilling any adjacent piles within a 20-foot radius.

Reference the Standard Specifications for Highway Construction for Driven Pile Foundations (Section 711) and Drilled Shafts and Drilled Pile Foundations (Section 712). Notes included in these plans are in addition to the requirements of the Standard Specifications.

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JOINT VENTURE
INFRASTRUCTURE CONSULTING & ENGINEERING

SOUTH CAROLINA No. 29964 DAVID K. YODER
SOUTH CAROLINA INFRASTRUCTURE CONSULTING & ENGINEERING, PLLC No. 4470 CERTIFICATE OF AUTHORIZATION

David Yoder 2022.06.20 11:27:53-04'00'

REV.	DKY	06-20-22
	RFC PLANS	
REV.		
REV.		
REVIEWED	J. FELKEL	
QUAN.		
DR.	BFS DKY	01-22
DES.	DKY ALP	01-22
	BY CHK.	DATE

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

FOUNDATION LAYOUT (1)
I-26 TO I-20 FUTURE RAMPS AND RAMP I-26 WB TO I-126 EB BRIDGE OVER SALUDA RIVER AND CSX R.R.

COUNTY: LEXINGTON/RICHLAND | ROUTE: I-26

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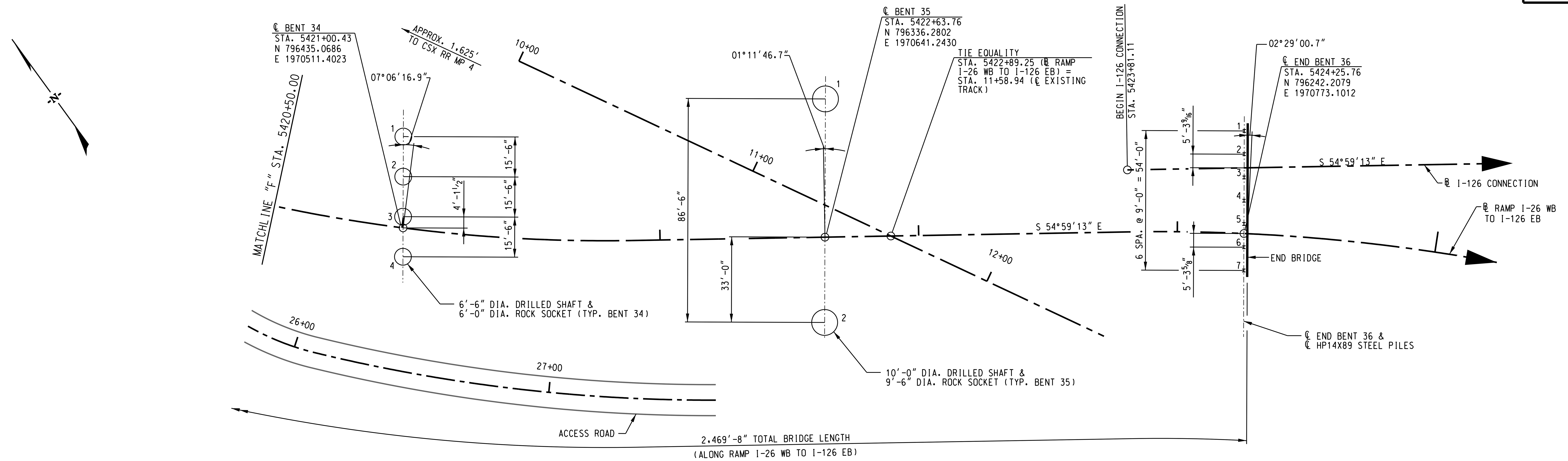

FOUNDATION LAYOUT

Boring No.	Recovery (%)	RQD (%)	Core Number	Depth (feet)	Compressive Strength (psi)
IB23-1	99	92	NQ-4	25.9	8670
IB23-1	97	87	NQ-7	40.9	11535
IB23-2	97	42	NQ-2	16.2	5047
IB23-2	100	72	NQ-6	36.2	11239
IB24-1	98	40	NQ-3	29.5	11765
IB24-1	96	58	NQ-6	44.5	12717
IB24-2	94	48	NQ-4	40.2	2190
IB24-2	94	48	RS-1_1	43.5	708
IB24-2	100	80	NQ-7	55	16709
IB25-1	100	30	NQ-2	20.5	10778
IB25-1	100	96	NQ-5	35.5	11255
IB25-2	100	68	NQ-2	16	23986
IB25-2	100	88	NQ-5	31	18365
IB26-1	100	90	NQ-1	5.3	23477
IB26-1	100	98	NQ-6	25.7	26372
IB26-2	100	100	NQ-2	10.9	10740
IB26-2	100	100	NQ-4	20.9	23438
IB27-1	100	84	NQ-2	5.8	35132
IB27-1	90	70	NQ-6	25.8	35727
IB27-2	94	86	NQ-2	10.4	19790
IB27-2	100	84	NQ-3	15.4	24904
IB28-1	100	90	NQ-1	6.3	32323
IB28-1	95	65	NQ-4	20.5	3442
IB28-1	100	70	NQ-5	25.5	20383
IB28-2	100	38	NQ-1	5.6	22097
IB28-2	100	100	NQ-4	20.9	31647
IB29-1	100	60	NQ-2	11.2	8787
IB29-1	100	64	NQ-4	21.2	12076
IB29-2B	96	90	NQ-2	10.8	26576
IB29-2B	96	90	NQ-5	25.8	22180

Boring No.	Recovery (%)	RQD (%)	Core Number	Depth (feet)	Compressive Strength (psi)
IB30-1	92	76	NQ-2	10.2	23615
IB30-1	100	62	NQ-3	15.2	27241
IB30-3	100	96	NQ-2	5.3	28051
IB30-3	100	100	NQ-4	15.3	32455
IB31-1	94	88	NQ-3	16	8911
IB31-1	100	92	NQ-4	21	1030
IB31-1	100	92	RS-2_1	25.6	24942
IB31-3	98	46	NQ-2	10.6	24034
IB31-3	96	82	NQ-4	20.6	23186
IB32-1	98	90	NQ-2	11.1	28393
IB32-1	99	76	NQ-5	26.1	32292
IB32-3	100	94	NQ-2	10.7	23065
IB32-3	100	88	NQ-4	20.7	13948
IB33-1	92	92	NQ-2	10	23909
IB33-1	94	82	NQ-4	20	29092
IB33-3	100	98	NQ-2	10.6	35782
IB33-3	100	100	NQ-4	20.6	25534
IB34-1	100	100	NQ-2	15.6	24578
IB34-1	100	64	NQ-4	25.6	9872
IB34-4	100	87	NQ-1	6.2	20957
IB34-4	100	87	NQ-3	16	30807
IB35-1	100	100	NQ-2	20.6	28776
IB35-1	100	100	NQ-3	25.6	17395
IB35-1	100	72	NQ-5	35.6	15667
IB35-1	100	100	NQ-6	40.6	18354
IB35-2	100	100	NQ-1	15.3	27600
IB35-2	100	100	NQ-3	25.3	21895
IB35-2	100	100	NQ-4	30.3	25099
IB35-2	100	100	NQ-6	40.3	23814

SOUTH CAROLINA PROFESSIONAL ENGINEER No. 29964 DAVID K. YODER

SOUTH CAROLINA INFRASTRUCTURE CONSULTING & ENGINEERING, PLLC No. 4470 CERTIFICATE OF AUTHORIZATION

David Yoder 2022.06.20 17:42:30-04'00'

REV.	DKY	06-20-22	RFC PLANS
REV.			
REV.			
REVIEWED	J. FELKEL		
QUAN.			
DR.	BFS	DKY	01-22
DES.	DKY	ALP	01-22
	BY	CHK.	DATE

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INFRASTRUCTURE CONSULTING & ENGINEERING

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

FOUNDATION LAYOUT (7)

I-26 TO I-20 FUTURE RAMPS AND RAMP I-26 WB TO I-126 EB BRIDGE OVER SALUDA RIVER AND CSX R.R.

COUNTY: LEXINGTON/RICHLAND — ROUTE: I-26

BRIDGE PLANS ID	SHEET NO.
P039718-B35	50

INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	County:	Richland	Boring No.:	EB36-1
Site Description:	Carolina Crossroads Phase 1 - Bridge 35			Route:	Bridge 35
Eng./Geo.: NM	Boring Location: 5424+26.74	Offset:	40.2 LT	Alignment:	I26RC_BD
Elev.: 177.6 ft	Latitude: 34.02186823	Longitude:	-81.09637078	Date Started:	11/10/2021
Total Depth: 25.9 ft	Soil Depth: 9.8 ft	Core Depth:	16.1 ft	Date Completed:	11/11/2021
Bore Hole Diameter (in): 2.25	Sampler Configuration	Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine: D-50 #0435	Drill Method: Casing w/ Adv	Hammer Type:	Automatic	Energy Ratio:	84%
Core Size: NQ2	Driller: M. Morgan	Groundwater:	TOB NM	24HR	5.0 ft

Elevation (ft)	Depth (ft)	Material Description	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	0.0	**Coastal Plain** Brown and Gray, Dry to Moist, Loose to Medium Dense, Clayey SAND (SC) SS-3055: NM=12.9% LL=37 PL=16 PI=21 #200=39.3% (A-6)	0.0–2.0	SS-3052	2	2	6	6	8
			2.0–4.0	SS-3053	5	6	10	11	16
172.6			4.0–6.0	SS-3054	9	14	16	12	30
			6.0–8.0	SS-3055	8	12	14	16	26
	8.5	**Partially Weathered Rock** Granite, Sampled as Gray, Very Dense, Silty Sand	8.0	SS-3056	7	50/4"			50/4"
167.6	9.8		9.8		50/0"				50/0"
	10.9	**Rock** Granite, Gray, Excellent, Fresh, Very Strong, Very Hard REC=100% RQD=100% GSI=80-90	9.8–10.9	NQ-1					
162.6	15.9	Granite, Gray, Excellent, Fresh, Very Strong, Very Hard REC=100% RQD=100% GSI=80-90 RS-1: 28045.0 psi	10.9–15.9	NQ-2					
157.6	20.9	Granite, Gray, Excellent, Fresh, Very Strong, Very Hard REC=100% RQD=100% GSI=80-90	15.9–20.9	NQ-3					
152.6	25.9	Granite, Gray, Excellent, Fresh, Very Strong, Very Hard REC=100% RQD=100% GSI=80-90	20.9–25.9	NQ-4					
147.6		Boring Terminated at 25.9 Feet							
142.6									
137.6									

● SPT N VALUE ● PL MC LL ▲ FINES CONTENT (%) ✿ RQD (%) ■ REC (%) 0 10 20 30 40 50 60 70 80 90

LEGEND

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT CCR1_ICE_BRIDGE_35_BH.GPJ SCDOT_DATATEMPLATE.GDT 2/24/22

INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	County:	Richland	Boring No.:	EB36-EMBK
Site Description:	Carolina Crossroads Phase 1 - Bridge 35			Route:	Bridge 35
Eng./Geo.: MS & NM	Boring Location: 5425+03.01	Offset:	16.7 RT	Alignment:	I26RC_BD
Elev.: 178.9 ft	Latitude: 34.02161034	Longitude:	-81.0963054	Date Started:	11/10/2021
Total Depth: 13 ft	Soil Depth: 13.0 ft	Core Depth:	NA ft	Date Completed:	11/10/2021
Bore Hole Diameter (in): 2.25	Sampler Configuration	Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine: D-50 #0439	Drill Method: HSA	Hammer Type:	Automatic	Energy Ratio:	91%
Core Size: NA	Driller: R. Cassell	Groundwater:	TOB 11.9 ft	24HR	7.6 ft

Elevation (ft)	Depth (ft)	Material Description	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	0.0	**Coastal Plain** Brown, Moist, Loose, Silty SAND (SM) SS-2196: NM=5.1% LL=NP PL=NP PI=NP #200=29.9% (A-2-4)	0.0–2.0	SS-2196	2	2	2	3	4
	3.5	Brown, Gray, and Orange, Moist to Wet, Loose to Medium Dense, Clayey SAND (SC) SS-2199: NM=14.8% LL=29 PL=17 PI=12 #200=25.2% (A-2-6) ST-2: 5.0-7.0 Feet	2.0–4.0	SS-2197	5	5	2	4	7
173.9			4.0–6.0	SS-2198	5	3	2	1	5
			6.0–8.0	SS-2199	2	3	5	4	8
168.9			8.0	SS-2200	2	11	10	7	21
	13.0	Boring Terminated at 13.0 Feet	13.0		50/0"				50/0"
163.9									
158.9									
153.9									
148.9									
143.9									
138.9									

● SPT N VALUE ● PL MC LL ▲ FINES CONTENT (%) ✿ RQD (%) ■ REC (%) 0 10 20 30 40 50 60 70 80 90

LEGEND

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT CCR1_ICE_BRIDGE_35_BH.GPJ SCDOT_DATATEMPLATE.GDT 2/24/22

INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	County:	Richland	Boring No.:	EB36-2
Site Description:	Carolina Crossroads Phase 1 - Bridge 35			Route:	Bridge 35
Eng./Geo.: NM	Boring Location: 5424+27.23	Offset:	13.2 RT	Alignment:	I26RC_BD
Elev.: 178.7 ft	Latitude: 34.02175444	Longitude:	-81.09648	Date Started:	11/10/2021
Total Depth: 36.1 ft	Soil Depth: 17.7 ft	Core Depth:	18.4 ft	Date Completed:	11/10/2021
Bore Hole Diameter (in): 2.25	Sampler Configuration	Liner Required:	Y (N)	Liner Used:	Y (N)
Drill Machine: D-50 #0435	Drill Method: Casing w/ Adv	Hammer Type:	Automatic	Energy Ratio:	84%
Core Size: NQ2	Driller: M. Morgan	Groundwater:	TOB NM	24HR	5.0 ft

Elevation (ft)	Depth (ft)	Material Description	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	0.0	**Artificial Fill** Brown, Moist, Stiff, Clayey Silt	0.0–2.0	SS-3046	5	7	6	3	13
	2.0	**Coastal Plain** Tan, Dry to Moist, Stiff to Very Stiff, Sandy Lean CLAY (CL) SS-3047: NM=15.3% LL=30 PL=19 PI=11 #200=52.3% (A-6)	2.0–4.0	SS-3047	2	2	8	10	10
173.7	6.0		4.0–6.0	SS-3048	8	8	10	12	18
	8.0	Tan and Gray, Moist, Dense, Clayey Sand	6.0–8.0	SS-3049	10	16	16	12	32
168.7		Tan and Gray, Moist, Stiff, Fat CLAY with Sand (CH) SS-3050: NM=24.7% LL=50 PL=21 PI=29 #200=75.3% (A-7-6) ST-1: 8.0-10.0 Feet ST-2: 10.0-11.4 Feet	8.0–10.0	SS-3050	4	5	7	9	12
			10.0	SS-3051	4	5	10		15
163.7	14.0	**Partially Weathered Rock** Granite, Sampled as Gray, Very Dense, Silty Sand	14.6		50/1"				50/1"
	17.7		17.7		50/0"				50/0"
158.7	21.1	**Rock** Granite, Gray, Excellent, Fresh, Very Strong, Very Hard REC=100% RQD=100% GSI=80-90 RS-1: 28892.0 psi	17.7–21.1	NQ-1					
153.7	26.1	Granite, Gray, Excellent, Fresh, Very Strong, Very Hard REC=100% RQD=100% GSI=80-90	21.1–26.1	NQ-2					
148.7	31.1	Granite, Gray, Excellent, Fresh, Very Strong, Very Hard REC=100% RQD=100% GSI=80-90	26.1–31.1	NQ-3					
143.7	36.1	Granite, Gray, Excellent, Fresh, Very Strong, Very Hard REC=100% RQD=100% GSI=80-90	31.1–36.1	NQ-4					
		Boring Terminated at 36.1 Feet							
138.7									

● SPT N VALUE ● PL MC LL ▲ FINES CONTENT (%) ✿ RQD (%) ■ REC (%) 0 10 20 30 40 50 60 70 80 90

LEGEND

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SC_DOT CCR1_ICE_BRIDGE_35_BH.GPJ SCDOT_DATATEMPLATE.GDT 2/24/22

ARCHER UNITED JOINT VENTURE UNITED INFRASTRUCTURE GROUP

INFRASTRUCTURE CONSULTING & ENGINEERING

FOR INFORMATION ONLY

	BY	CHK.	DATE
REV.	DKY		06-20-22
	RFC PLANS		
REV.			
REV.			
REVIEWED	J. FELKEL		
QUAN.			
DR.	BFS	DKY	01-22
DES.	DKY	CSB	01-22

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

BORING LOGS (23)

I-26 TO I-20 FUTURE RAMPS AND RAMP I-26 WB TO I-126 EB BRIDGE OVER SALUDA RIVER AND CSX R.R.

COUNTY: LEXINGTON/RICHLAND ROUTE: I-26

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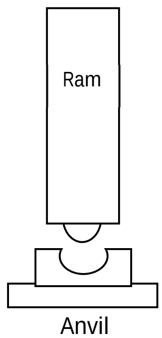
Appendix E

Pile Driving Hammer Information

County:	Richland	Bridge Plans ID:	P039718
Route:	S-2963 Road Colonial Life Blvd. Ramp B Bridge		
Description:	Carolina Crossroads Phase 1 Bridge 35 End Bent 36		
Contractor:	Archer United		



Hammer

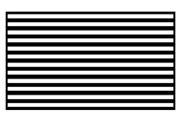
Manufacturer:	APE	Model:	D-30
Type:	Single Act Diesel	Serial No.	TBD
Rated Energy (k-ft)	74.419 at 11.25	Length of stroke (ft)	
Lead Size (in):	26		
Modifications:	None		

Note: Attach any hammer modification specifications. Manufacturer's Specifications may be required if hammer is not found in Wave Equation database.

Date of Last Maintenance:	TBD
Type of Maintenance:	TBD
Performed By:	TBD

Striker Plate

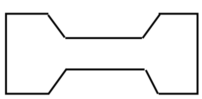
Weight (kips):	.628		
Diameter (in):	22.5	Thickness (in):	6



Hammer Cushion

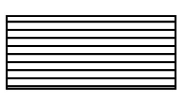
Description:

Material Description	No. of Layers	Modulus of Elasticity (ksi)	Thickness (in)
1 Micarata	1	____	1
2 Aluminum	3	285	.5
Area (sq. in): 398		Total Thickness (in)	3.5
Coefficient of Restitution: .8			



Pile Cap (Helmet)

Dimension:	DB-26
Pile Cap Weight (kips):	1.076
Inserts Weight (kips):	.948



Pile Cushion

Material:	N/A		
Thickness (in.)	N/A	Area (sq. in):	N/A
Modulus of Elasticity (ksi):	N/A		
Coefficient of Restitution:	N/A		

Pile

Pile Type/Size & Pile Point:	HP 14X89 14X89 Reinf. Pile Tips		
Total Pile & Point Length (ft):	BR35 EB36 – 48	Exposed Pile Point Length (ft):	N/A
Pile Cross-Sectional Area (sq.in):	26.1		
Pipe Pile Wall Thickness (in):	N/A		
Pile Tip Description:	Welded Reinf. Tip		
Splice Description:	Bevel butt weld per SCDOT Specs		
Splice Location From Pile Top (ft):	N/A		
Concrete Pile Strength, f'c (psi):	N/A		
Steel Pile Yield Strength, Fy (ksi):	50		

Appendix F

Instrumentation Calibrations

Accelerometer Calibration Certificate
Pile Dynamics, Inc.

Calibrated by Pile Dynamics, Inc.
Calibration performed on OCT 2 2 2021

Serial No:	K12388	**Temperature:**	22.6 °C
Model:	PR	**Humidity:**	44%
Calibrated on:	Channel 3 on 8G 5161 LE		
Ref Acc 1:	69132! 960 g's/volt	**Cal on:**	09Feb2021
Ref Acc 2:	69096! 978 g's/volt	**Cal on:**	27Jan2021

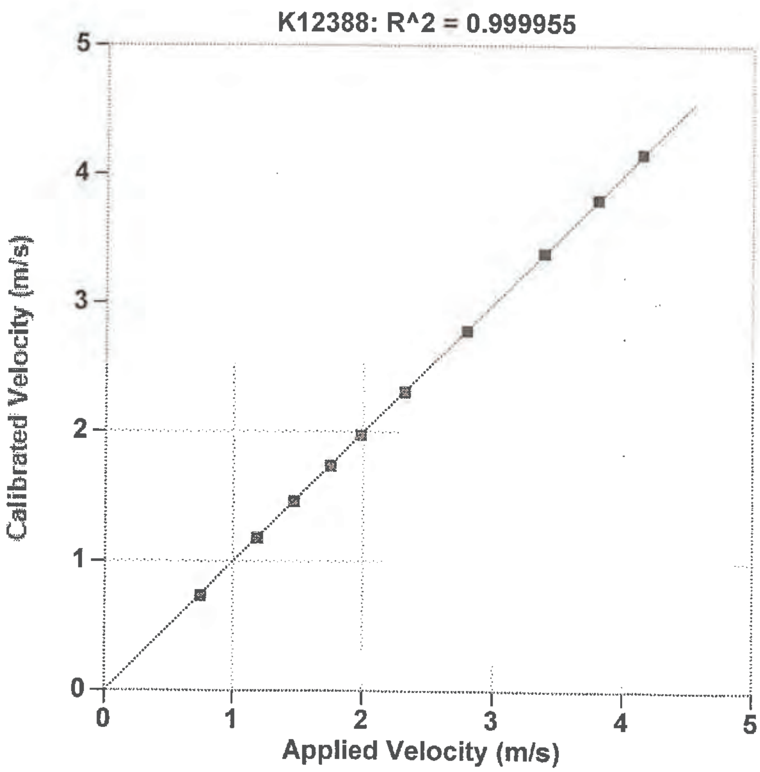
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).

PDA CALIBRATION FACTOR

451.0 mv/5000g
(90.2 µv/g)
R^2: 0.999955 [Chip programmed]

Operator: William Johnson

Signed



Reference Velocity m/s	S/N K12388 Velocity m/s
0.741	0.734
1.184	1.178
1.464	1.459
1.744	1.739
1.980	1.976
2.319	2.306
2.790	2.783
3.384	3.388
3.798	3.805
4.147	4.158

Maximum Acceleration: 919 g's

Accelerometer Calibration Certificate
Pile Dynamics, Inc.

Calibrated by Pile Dynamics, Inc.
Calibration performed on OCT 2 2 2021

Serial No:	K12389	**Temperature:**	22.8 °C
Model:	PR	**Humidity:**	44%
Calibrated on:	Channel 3 on 8G 5161 LE		

Ref Acc 1:	69132! 960 g's/volt	**Cal on:**	09Feb2021
Ref Acc 2:	69096! 978 g's/volt	**Cal on:**	27Jan2021

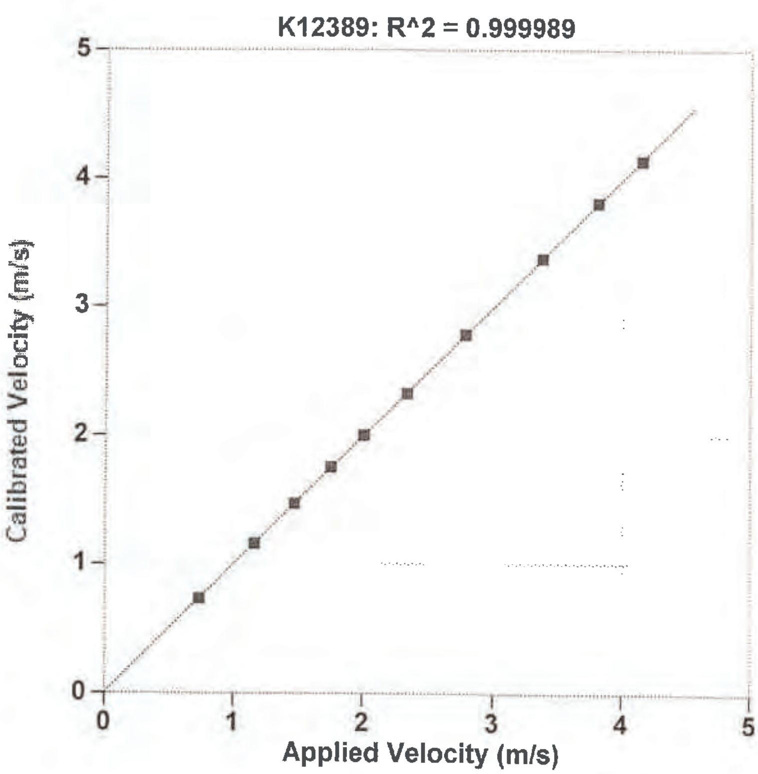
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).

PDA CALIBRATION FACTOR

483.2 mv/5000g
(96.6 µv/g)
R^2: 0.999989 [Chip programmed]

Operator: William Johnson

Signed



Reference Velocity m/s	S/N K12389 Velocity m/s
0.730	0.728
1.158	1.158
1.470	1.471
1.748	1.755
2.001	2.004
2.330	2.326
2.780	2.782
3.372	3.373
3.803	3.807
4.144	4.137

Maximum Acceleration: 914 g's

Pile Dynamics, Inc.

Certificate of Calibration

Transducer Model: PDI Transducer

Serial Number: P821

PDI Gage Factor: 145.1 me/V

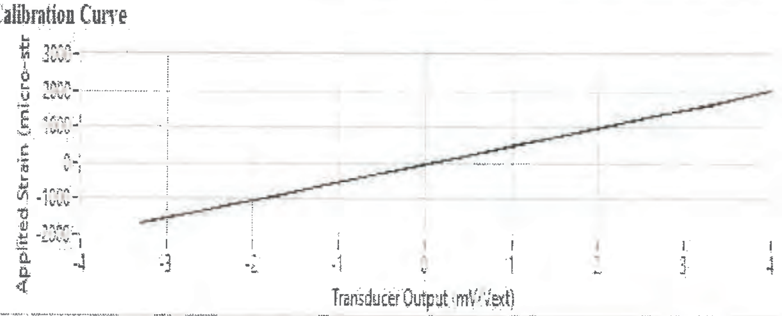
General Gage Factor: 503.9 **me**/mV/Vext

Initial Offset Voltage 0.006 mV/Vext

Table 1 Representative Calibration Data

Applied Strain (microstrain)	Transducer Output (mV/Vext)	Applied Strain (microstrain)	Transducer Output (mV/Vext)
-41.039	-0.142	223.451	0.442
-101.915	-0.195	522.711	1.034
-351.374	-0.725	812.046	1.645
-659.231	-1.235	1120.332	2.252
-903.922	-1.740	1453.617	2.653
-1151.032	-2.242	1751.421	3.563
-1421.536	-2.733	2007.584	3.996
-1625.524	-3.162	1896.853	3.909
-1597.427	-3.313	1620.651	3.234
-1565.939	-3.135	1306.004	2.646
-1332.909	-2.455	995.220	2.023
-1084.845	-2.092	591.373	1.420
-725.522	-1.550	416.251	0.835
-536.002	-1.135	156.662	0.354
-274.157	-0.517	41.451	0.145
-55.234	-0.139	40.088	0.143

Calibration Curve



Mean Linear Correlation Coefficient (LCC): 0.999973

LCC Standard Deviation: 1.354270E-6

Calibrated By: DJC

Signature:

Date and Time: 9/9/2021 8:53 AM

Temperature (Degrees C): 24.2

Certificate of Calibration

Pile Dynamics, Inc.

Transducer Model: PDI Transducer

Serial Number: S868

PDI Gage Factor: 145.1 me/V

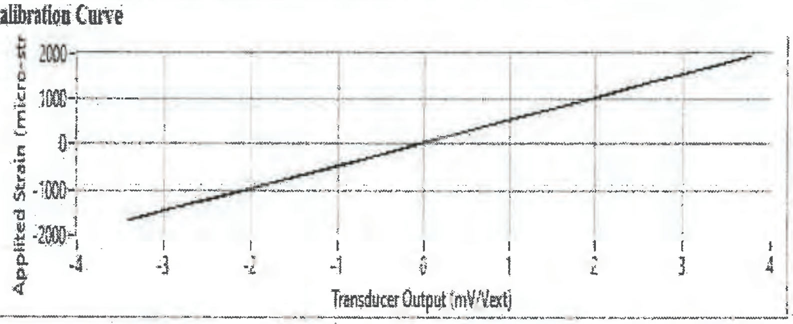
General Gage Factor: 503.9 me/mV/V_{ext}

Initial Offset Voltage: -0.058 mV/V_{ext}

Table 1: Representative Calibration Data

Applied Strain (micro-strain)	Transducer Output (mV/Vext)	Applied Strain (micro-strain)	Transducer Output (mV/Vext)
17.468	-0.059	166.544	0.227
-136.739	-0.384	451.152	0.797
-418.764	-0.925	757.082	1.404
-668.733	-1.425	1070.586	2.039
-912.547	-1.918	1386.164	2.657
-1166.456	-2.414	1696.846	3.275
-1411.174	-2.898	1952.857	3.769
-1620.474	-3.307	1899.336	3.660
-1676.877	-3.409	1574.566	3.030
-1601.650	-3.280	1252.019	2.389
-1367.028	-2.824	945.463	1.751
-1100.823	-2.290	663.515	1.225
-831.346	-1.752	408.053	0.711
-562.670	-1.223	164.516	0.224
-303.681	-0.706	17.561	-0.057
-29.713	-0.160	17.211	-0.058

Calibration Curve



Mean Linear Correlation Coefficient (LCC): 0.999993

LCC Standard Deviation: 1.772938E-6

Calibrated By: DJC

Signature: DJC

Date and Time: 2/10/2021 7:16 AM

Temperature (Degrees C): 25.2

Specifications

PDI Automated Strain Transducer Calibration System (PDI - ASTCS)

ASTCS Serial Number:	PDI CAL 2015-02
ASTCS Software Version Number:	3.001
ASTCS Independant Verification Date:	9 22 2015 1:48 PM
Transducer Gage Length:	3 inches (76.2 mm)
Full Scale Displacement Range:	+/- 0.0075 (inches)
Method for Applying Displacement:	Precision Stepper Motor Connected to Linear Stage
Excitation Voltage for Calibration:	2.5 VDC
Displacement Measurements:	Dual Precision LVDTs, Output Averaged
Displacement Certification:	NIST 274437-07
Linearity Verification Technique:	Linear Correlation Coefficient < 0.9996
Repeatability Verification Technique	Standard Deviation < 0.5% of mean

ASTCS System Check

Reference Strain Transducer:	B5580
Reference General Gage Factor:	529.70 micro-strain/mv/V
LVDT #1 Sensitivity (inches/volt):	0.0079
LVDT #2 Sensitivity (inches/volt):	0.0081
System Temperature Status	Passed
Date/Time of Last System Check	9 22 2015 1:48 PM

PDI Strain Transducer Connections

Black	Excitation +
Green	Excitation -
Red	Signal +
White	Signal -
Grey BARE	Shield

NIST Reference:

PDI certifies the above PDI-ASTCS instrument meets or exceeds published specifications and has been verified using standards and instruments whose accuracies are traceable to the National Institute of Standards and Technology (NIST), an accepted value of a natural physical constant or a ratio calibration technique. The calibration of this instrument was performed in accordance with the PDI Quality Assurance program. Measurements and information provided on this report are valid at the time of calibration only.

Appendix G

PDA Proficiency Certifications

PDCA
PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

This documents that

Sally Thomson
Infrastructure Consulting Engineering

has on August 11, 2021 achieved the rank of

ADVANCED

on the **Dynamic Measurement and Analysis Proficiency Test.**

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. ***It is recommended*** **that Individuals at the Advanced level seek Master or Expert levels through additional study within six years of the date of this document.**

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. **This certificate can be verified at www.PDAproficiencytest.com.** The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate.

Frank T. Peters, Executive Director
Pile Driving Contractors Association

SEAL
OHIO

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 3139

PDCA
PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

This documents that

Michael Simpson
Infrastructure Consulting & Engineering

has on August 25, 2021 achieved the rank of

ADVANCED

on the **Dynamic Measurement and Analysis Proficiency Test**.

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. ***It is recommended*** **that Individuals at the Advanced level seek Master or Expert levels through additional study within six years of the date of this document.**

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. **This certificate can be verified at www.PDAproficiencytest.com.** The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate.

Frank T. Peters, Executive Director
Pile Driving Contractors Association

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 3149