

May 15, 2023

Mr. Billy Hardwick  
Senior Project Manager  
Archer-United Joint Venture  
[billy.hardwick@uig.net](mailto:billy.hardwick@uig.net)

**Re: Report of Dynamic Pile Testing**

Bent 2 Footing 5 Pile 37  
Bridge 42b – US 176 EB (Broad River Rd.) Bridge over I-20  
Project ID: P039719  
Richland County, South Carolina

Dear Mr. Hardwick:

The attached results of dynamic pile testing for the subject pile 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. The Geotechnical Engineer of Record should ultimately make final recommendations for foundation design and construction.

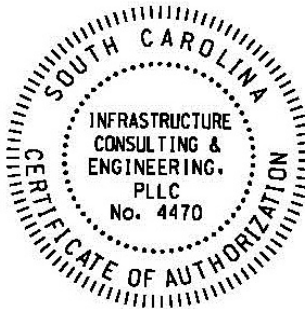
Also included are the production pile driving recommendations for Bent 2 Footings 3 to 5 of the subject project. The Geotechnical Engineer of Record should ultimately make final recommendations for foundation design and construction.

Thank you for the opportunity to provide these services.

Sincerely,  
Infrastructure Consulting & Engineering (ICE), PLLC



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



A handwritten signature in blue ink, appearing to read "Sally G. Thomson".

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

**Appendix A**

**Dynamic Pile Testing, Signal Matching Results, and  
Calibration WEAP**

**Bridge 42b, Bent 2, Footing 5, Pile 37**

## Summary of Provided Project and Pile Driving Information

Project Description		US 176 EB (Broad River Road) Bridge over I-20 Richland County, South Carolina			
Pile Driving Contractor		Archer United Joint Venture			
Project ID		P039719			
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 2	415+98.79	HP14x73 with Pile Tip	Plumb	ICE I-19v2	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
37	55.0	52.7	N/A	5/11/23	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)	
220	0.65	340	340	+270.0	
Installation Records Provided to ICE			Please Refer to SCDOT Pile Driving Logs		
Project Information and Soil Borings Provided to ICE			Yes, Attached in Appendix C		
Pile Driving Equipment Data Form Provided to ICE			ICE I-19v2 Data Hammer Sheet Attached in Appendix D		
Strain and Accelerometer Calibrations Attached			Yes, Attached in Appendix E		
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)					+301.8
Approximate Ground/Mudline Elevation (feet)					+300.8
Approximate Final Pile Penetration Below Reference at End of Initial Drive (feet)					48.5
Approximate Final Pile Tip Elevation at End of Initial Drive (feet)					+253.3
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

### Additional Notes on Pile Installation

- Pile 37 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	394	RX9	32.9	27.0	25.3	12.8	20.4	7.5

### Signal Matching Analyses Results (Detailed Result in Appendix A)

Location*	R <sub>ult</sub> (kips)	R <sub>side</sub> / R <sub>end</sub> (kips)	Equiv. BPF*	Stroke (ft)	EMX (k-ft)	Q <sub>s</sub> (in)	Q <sub>t</sub> (in)	S <sub>s</sub> (sec/ft)	S <sub>t</sub> (sec/ft)	MQN*
EOD (Blow 619)	396	265 / 131	107	8.3	20.7	0.25	0.10	0.23	0.02	3.16

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

### Dynamic Pile Testing Interpretation and Commentary

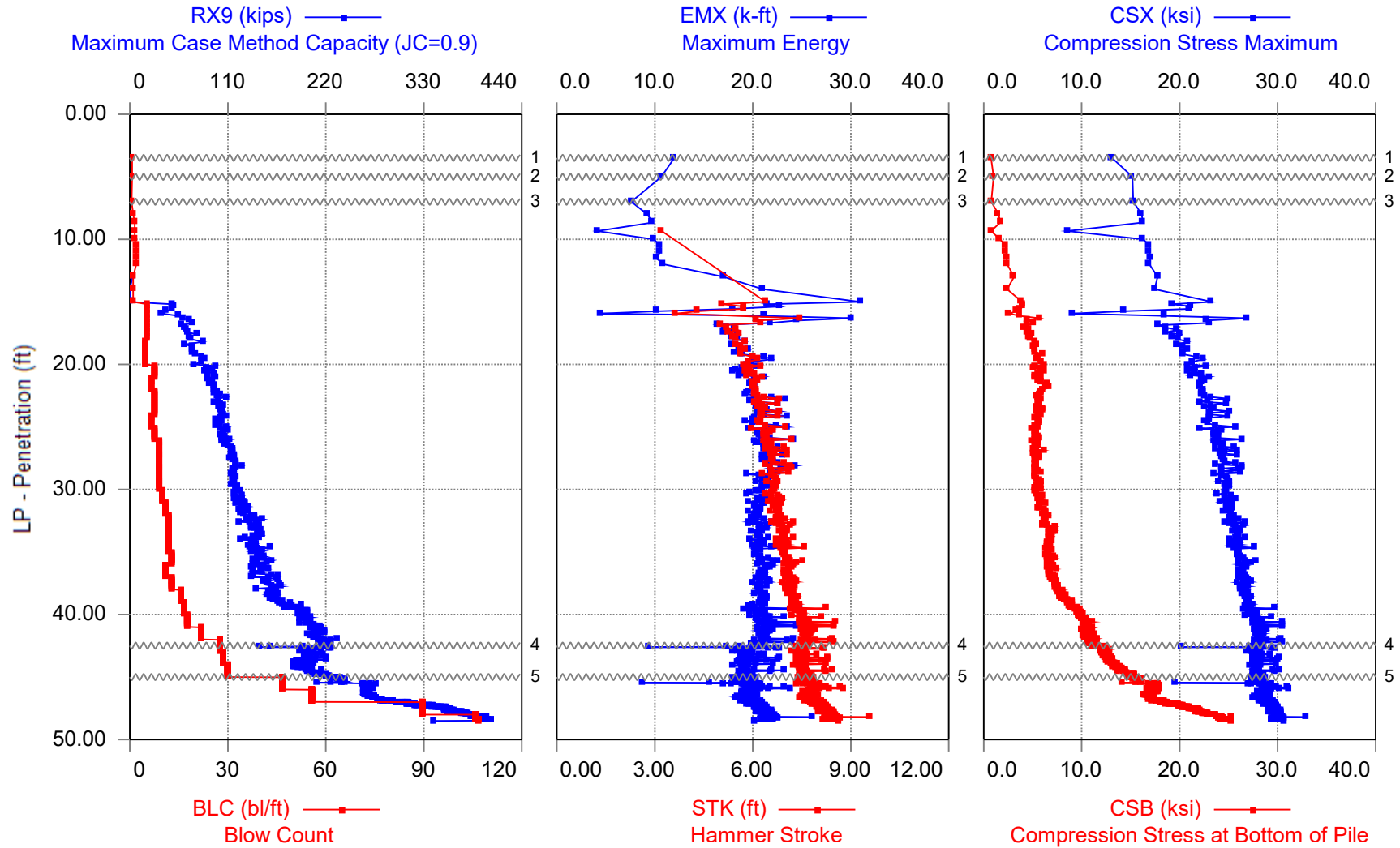
The capacity listed in the Summary of Dynamic Pile Testing Results is based on the RX9 (Maximum Case Method with J(c)=0.9) solution for the average value for the last increment of the initial drive. The summary plot and table attached for the dynamic pile testing results are based on the same capacity solution.

Signal matching analysis was performed for a blow (Blow 619) near the end of the initial drive. The signal matching ultimate capacity near the end of initial drive was above the required driving resistance of 340 kips for Bent 2.

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



CCRP2 Bridge 42b Bent 2 Ftg 5 - Pile 37



CCRP2 Bridge 42b Bent 2 Ftg 5 - Pile 37

HP 14x73 w tips

OP: ICE

Date: 11-May-2023

AR: 21.40 in<sup>2</sup>

SP: 0.492 k/ft<sup>3</sup>

LE: 52.67 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 0.90

RMX: Maximum Case Method Capacity (JC)

TSX: Tension Stress Maximum - Full Record Search

EMX: Maximum Energy

DMX: Maximum Displacement

STK: Hammer Stroke

DFN: Final Displacement

CSX: Compression Stress Maximum

BTA: Integrity Factor (1)

CSB: Compression Stress at Bottom of Pile

BL#	Depth ft	BLC bl/ft	TYPE	RMX kips	EMX k-ft	STK ft	CSX ksi	CSB ksi	TSX ksi	DMX in	DFN in	BTA (%)
2	5.00	1	AV2	0	11.3	**	14.1	0.9	9.5	18.00	18.00	95.0
			STD	0	0.7	**	1.1	0.1	1.0	0.00	0.00	5.0
			MAX	0	12.0	**	15.2	1.0	10.6	18.00	18.00	100.0
			@BL	1	1	**	2	2	2	1	1	1
3	7.00	1	AV1	0	7.6	**	15.3	0.8	10.5	24.01	24.01	100.0
			STD	0	0.0	**	0.0	0.0	0.0	0.00	0.00	0.0
			MAX	0	7.6	**	15.3	0.8	10.5	24.01	24.01	100.0
			@BL	3	3	**	3	3	3	3	3	3
4	8.00	1	AV1	0	9.2	**	16.1	1.5	10.9	12.00	12.00	90.0
			STD	0	0.0	**	0.0	0.0	0.0	0.00	0.00	0.0
			MAX	0	9.2	**	16.1	1.5	10.9	12.00	12.00	90.0
			@BL	4	4	**	4	4	4	4	4	4
7	10.00	2	AV3	0	7.9	3.21	13.7	1.4	9.2	8.09	8.00	100.0
			STD	0	2.7	0.00	3.6	0.4	2.5	0.12	0.00	0.0
			MAX	0	9.9	3.21	16.3	1.7	11.1	8.26	8.00	100.0
			@BL	5	7	6	7	5	5	5	7	5
9	11.00	2	AV2	0	10.6	**	16.9	2.3	11.2	6.00	6.00	100.0
			STD	0	0.0	**	0.0	0.0	0.2	0.00	0.00	0.0
			MAX	0	10.6	**	16.9	2.3	11.4	6.00	6.00	100.0
			@BL	8	8	**	8	9	8	9	9	8
11	12.00	2	AV2	0	10.5	**	17.0	2.4	10.9	6.00	6.00	100.0
			STD	0	0.4	**	0.0	0.0	0.1	0.00	0.00	0.0
			MAX	0	10.9	**	17.0	2.4	11.0	6.00	6.00	100.0
			@BL	10	11	**	10	11	11	10	10	10
12	13.00	1	AV1	3	17.0	**	17.8	3.1	11.9	12.01	12.01	100.0
			STD	0	0.0	**	0.0	0.0	0.0	0.00	0.00	0.0
			MAX	3	17.0	**	17.8	3.1	11.9	12.01	12.01	100.0
			@BL	12	12	**	12	12	12	12	12	12
14	15.00	1	AV2	0	26.0	6.40	20.4	3.2	11.5	12.00	12.00	100.0
			STD	0	5.0	0.00	2.9	0.8	0.6	0.00	0.00	0.0
			MAX	0	31.0	6.40	23.3	3.9	12.2	12.00	12.00	100.0
			@BL	13	14	14	14	14	14	13	13	13
30	18.00	5	AV16	58	18.6	5.45	19.4	4.3	9.5	3.21	2.25	100.0
			STD	11	5.5	0.83	3.8	0.7	2.6	0.92	0.00	0.0
			MAX	76	30.1	7.43	26.9	5.7	15.6	4.84	2.25	100.0
			@BL	28	21	21	21	21	21	15	19	15

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BL#	Depth ft	BLC bl/ft	TYPE	RMX kips	EMX k-ft	STK ft	CSX ksi	CSB ksi	TSX ksi	DMX in	DFN in	BTA (%)
35	19.00	5	AV5	71	18.7	5.66	20.4	5.3	9.3	2.44	2.40	100.0
			STD	6	0.6	0.10	0.4	0.1	0.4	0.05	0.00	0.0
			MAX	82	19.6	5.77	20.9	5.4	9.9	2.53	2.40	100.0
			@BL	31	34	34	34	32	31	31	34	31
40	20.00	5	AV5	79	20.3	5.88	21.3	5.9	9.2	2.42	2.40	100.0
			STD	5	1.1	0.18	0.7	0.3	0.6	0.03	0.00	0.0
			MAX	84	22.0	6.17	22.5	6.2	10.1	2.48	2.40	100.0
			@BL	38	38	38	38	40	38	38	38	36
48	21.00	8	AV8	92	19.2	5.99	21.8	5.5	9.0	2.05	1.50	100.0
			STD	4	1.0	0.19	0.8	0.4	0.6	0.07	0.00	0.0
			MAX	96	21.2	6.32	23.1	6.2	10.1	2.16	1.50	100.0
			@BL	48	48	48	48	44	41	41	47	41
55	22.00	7	AV7	92	20.1	6.07	22.2	6.2	8.8	2.04	1.71	100.0
			STD	2	0.2	0.04	0.2	0.4	0.2	0.03	0.00	0.0
			MAX	95	20.3	6.15	22.5	6.7	9.0	2.10	1.71	100.0
			@BL	53	50	50	50	54	50	49	53	49
63	23.00	8	AV8	100	20.5	6.22	22.9	5.7	8.6	1.96	1.50	100.0
			STD	4	1.4	0.24	0.9	0.2	0.6	0.09	0.00	0.0
			MAX	108	23.4	6.81	25.0	5.9	10.0	2.13	1.50	100.0
			@BL	60	61	61	61	61	61	61	59	56
71	24.00	8	AV8	103	21.3	6.42	23.6	5.8	8.8	1.96	1.50	100.0
			STD	2	0.9	0.23	0.8	0.2	0.8	0.05	0.00	0.0
			MAX	106	22.8	6.83	25.1	6.1	10.1	2.04	1.50	100.0
			@BL	71	69	69	69	67	69	64	71	64
78	25.00	7	AV7	103	21.3	6.43	23.7	5.5	8.7	1.94	1.71	100.0
			STD	5	1.7	0.30	1.1	0.2	1.0	0.12	0.00	0.0
			MAX	110	23.5	7.01	25.7	5.8	10.7	2.11	1.71	100.0
			@BL	78	78	78	78	76	78	72	75	72
86	26.00	8	AV8	106	21.4	6.49	24.0	5.4	8.6	1.89	1.50	100.0
			STD	4	1.3	0.32	1.1	0.2	0.9	0.06	0.00	0.0
			MAX	113	24.2	7.19	26.4	5.7	10.5	2.03	1.50	100.0
			@BL	86	86	86	86	85	86	86	86	79
95	27.00	9	AV9	111	21.4	6.61	24.4	5.4	8.6	1.79	1.33	100.0
			STD	4	1.0	0.25	0.8	0.3	0.6	0.04	0.01	0.0
			MAX	117	23.3	7.08	26.0	6.2	9.6	1.87	1.33	100.0
			@BL	94	94	94	94	94	94	94	88	87
104	28.00	9	AV9	117	21.7	6.67	24.7	5.4	8.2	1.73	1.33	100.0
			STD	2	0.7	0.19	0.7	0.2	0.7	0.04	0.00	0.0
			MAX	119	23.1	7.05	25.9	5.8	9.4	1.81	1.33	100.0
			@BL	102	97	97	97	100	97	97	103	96
113	29.00	9	AV9	118	22.1	6.81	25.2	5.4	8.4	1.72	1.33	100.0
			STD	3	1.4	0.32	1.0	0.2	1.0	0.09	0.01	0.0
			MAX	126	24.4	7.19	26.5	5.9	9.8	1.86	1.33	100.0

CCRP2 Bridge 42b Bent 2 Ftg 5 - Pile 37

HP 14x73 w tips

OP: ICE

Date: 11-May-2023

BL#	Depth ft	BLC bl/ft	TYPE @BL	RMX kips 105	EMX k-ft 105	STK ft 106	CSX ksi 106	CSB ksi 110	TSX ksi 110	DMX in 105	DFN in 108	BTA (%) 105
122	30.00	9	AV9	118	21.2	6.70	24.9	5.6	7.9	1.63	1.33	100.0
			STD	2	0.4	0.10	0.3	0.2	0.3	0.03	0.00	0.0
			MAX	121	21.6	6.80	25.2	5.9	8.4	1.67	1.33	100.0
			@BL	120	120	117	120	122	117	114	115	114
132	31.00	10	AV10	122	20.5	6.67	24.8	5.7	7.6	1.50	1.20	100.0
			STD	4	0.7	0.16	0.5	0.3	0.4	0.04	0.00	0.0
			MAX	128	21.5	6.95	25.7	6.1	8.1	1.55	1.20	100.0
			@BL	132	130	130	130	127	128	123	125	123
143	32.00	11	AV11	128	20.5	6.76	25.1	6.0	7.4	1.41	1.09	100.0
			STD	4	0.4	0.08	0.3	0.3	0.2	0.04	0.00	0.0
			MAX	134	21.1	6.86	25.4	6.4	7.7	1.46	1.09	100.0
			@BL	136	134	134	134	133	134	134	133	133
155	33.00	12	AV12	139	20.6	6.89	25.6	6.4	7.1	1.30	1.00	100.0
			STD	7	0.7	0.18	0.6	0.3	0.3	0.03	0.00	0.0
			MAX	149	22.0	7.25	26.7	7.3	7.8	1.38	1.00	100.0
			@BL	148	151	151	151	155	151	151	155	144
167	34.00	12	AV12	141	20.7	6.98	25.9	6.9	6.9	1.24	1.00	100.0
			STD	7	0.5	0.13	0.4	0.2	0.2	0.03	0.00	0.0
			MAX	148	21.7	7.24	26.8	7.4	7.4	1.30	1.00	100.0
			@BL	163	166	166	166	159	166	166	157	156
179	35.00	12	AV12	141	21.0	7.01	26.1	6.7	7.1	1.28	1.00	100.0
			STD	7	0.8	0.20	0.6	0.2	0.3	0.04	0.00	0.0
			MAX	159	23.4	7.58	27.8	7.0	7.8	1.38	1.00	100.0
			@BL	175	175	175	175	178	175	175	178	168
192	36.00	13	AV13	148	21.1	7.09	26.4	6.8	7.2	1.24	0.92	100.0
			STD	6	0.7	0.17	0.5	0.3	0.3	0.03	0.00	0.0
			MAX	160	22.6	7.53	27.8	7.3	7.7	1.28	0.92	100.0
			@BL	188	189	189	189	186	191	188	185	180
203	37.00	11	AV11	148	21.3	7.11	26.5	6.9	7.0	1.23	1.09	100.0
			STD	9	0.4	0.09	0.3	0.3	0.2	0.03	0.00	0.0
			MAX	166	22.1	7.26	26.9	7.4	7.4	1.29	1.09	100.0
			@BL	202	193	193	193	196	193	193	199	193
216	38.00	13	AV13	160	20.9	7.14	26.6	7.3	6.7	1.15	0.92	100.0
			STD	8	0.5	0.13	0.4	0.2	0.3	0.03	0.00	0.0
			MAX	171	21.8	7.38	27.3	7.6	7.2	1.19	0.92	100.0
			@BL	213	208	208	208	215	208	208	215	204
232	39.00	16	AV16	162	21.0	7.24	26.9	8.2	6.3	1.09	0.75	100.0
			STD	4	0.3	0.06	0.2	0.4	0.2	0.02	0.00	0.0
			MAX	171	21.5	7.38	27.3	9.1	6.8	1.14	0.75	100.0
			@BL	231	225	225	225	232	217	222	224	217
249	40.00	17	AV17	187	20.7	7.42	27.4	9.4	5.6	0.97	0.70	100.0



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HP 14x73 w tips

OP: ICE

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BL#	Depth ft	BLC bl/ft	TYPE	RMX kips	EMX k-ft	STK ft	CSX ksi	CSB ksi	TSX ksi	DMX in	DFN in	BTA (%)
			STD	10	1.2	0.23	0.7	0.4	0.4	0.06	0.00	0.0
			MAX	200	24.9	8.24	29.7	10.1	6.4	1.13	0.71	100.0
			@BL	244	241	241	241	249	241	241	241	233
267	41.00	18	AV18	200	21.8	7.74	28.4	10.3	5.4	0.94	0.66	100.0
			STD	6	1.5	0.39	1.1	0.4	0.6	0.04	0.00	0.0
			MAX	213	25.1	8.55	30.6	11.2	6.6	1.03	0.67	100.0
			@BL	267	260	260	260	260	264	260	267	250
289	42.00	22	AV22	211	21.3	7.71	28.3	10.6	5.0	0.88	0.54	100.0
			STD	7	0.8	0.19	0.5	0.4	0.3	0.02	0.00	0.0
			MAX	234	24.2	8.44	30.3	11.6	5.9	0.95	0.55	100.0
			@BL	288	288	288	288	288	288	288	274	268
317	43.00	28	AV28	210	20.1	7.70	28.1	11.6	4.0	0.77	0.42	100.0
			STD	19	2.6	0.33	1.8	0.7	1.1	0.11	0.01	0.0
			MAX	227	24.0	8.50	30.6	12.8	6.1	0.92	0.43	100.0
			@BL	300	295	295	295	311	295	295	317	290
346	44.00	29	AV29	202	19.8	7.61	28.2	12.8	3.0	0.68	0.41	100.0
			STD	9	1.2	0.29	0.8	0.4	0.4	0.04	0.00	0.0
			MAX	221	22.7	8.33	30.2	13.7	3.9	0.76	0.42	100.0
			@BL	330	330	330	330	344	330	335	324	318
376	45.00	30	AV30	203	19.6	7.64	28.1	14.3	2.0	0.63	0.40	100.0
			STD	12	1.0	0.25	0.7	0.6	0.5	0.03	0.00	0.0
			MAX	224	23.2	8.44	30.2	15.4	3.1	0.72	0.41	100.0
			@BL	374	360	360	360	371	360	360	357	347
423	46.00	47	AV47	252	19.5	7.82	28.4	16.6	0.8	0.58	0.25	100.0
			STD	17	2.1	0.29	1.6	0.9	0.3	0.04	0.00	0.0
			MAX	277	23.9	8.78	31.2	18.0	1.6	0.66	0.26	100.0
			@BL	403	419	419	419	411	380	419	399	377
479	47.00	56	AV56	273	19.6	7.78	28.6	17.3	0.6	0.57	0.21	100.0
			STD	8	0.6	0.15	0.4	0.4	0.1	0.01	0.00	0.0
			MAX	297	20.8	8.11	29.5	18.4	1.0	0.59	0.22	100.0
			@BL	479	479	479	479	479	474	432	449	424
569	48.00	90	AV90	346	21.0	8.20	29.7	20.8	1.7	0.58	0.13	100.0
			STD	23	0.6	0.16	0.4	1.4	0.4	0.01	0.00	0.0
			MAX	380	22.0	8.52	30.4	22.9	2.4	0.61	0.14	100.0
			@BL	567	556	565	556	569	568	540	568	480
612	48.41	106	AV43	390	21.9	8.46	30.2	24.0	2.5	0.59	0.11	100.0
			STD	6	0.7	0.20	0.5	0.5	0.1	0.01	0.00	0.0
			MAX	401	26.1	9.60	32.9	25.3	2.8	0.64	0.11	100.0
			@BL	591	591	591	591	591	606	591	591	570
622	48.50	107	AV10	394	21.2	8.34	29.9	24.6	3.0	0.58	0.11	100.0
			STD	18	0.5	0.14	0.4	0.3	0.4	0.02	0.00	0.0
			MAX	407	22.2	8.63	30.8	25.2	4.1	0.60	0.11	100.0
			@BL	621	614	622	622	622	622	621	621	613

CCRP2 Bridge 42b Bent 2 Ftg 5 - Pile 37

HP 14x73 w tips

OP: ICE

Date: 11-May-2023

BL#	Depth ft	BLC bl/ft	TYPE	RMX kips	EMX k-ft	STK ft	CSX ksi	CSB ksi	TSX ksi	DMX in	DFN in	BTA (%)
			Average	216	20.4	7.45	27.0	12.8	4.5	1.25	0.90	100.0
			Std. Dev.	101	2.3	0.79	3.2	6.6	3.1	1.81	1.84	0.6
			Maximum	407	31.0	9.60	32.9	25.3	15.6	24.01	24.01	100.0
			@ Blow#	621	14	591	591	591	21	3	3	1
Total number of blows analyzed: 622												

#### BL# Sensors

1-622 F2: [S868] 145.1 (1.00); F3: [P821] 145.1 (1.00); A1: [K12389] 483.2 (1.00);  
A4: [K12388] 451.0 (1.00)

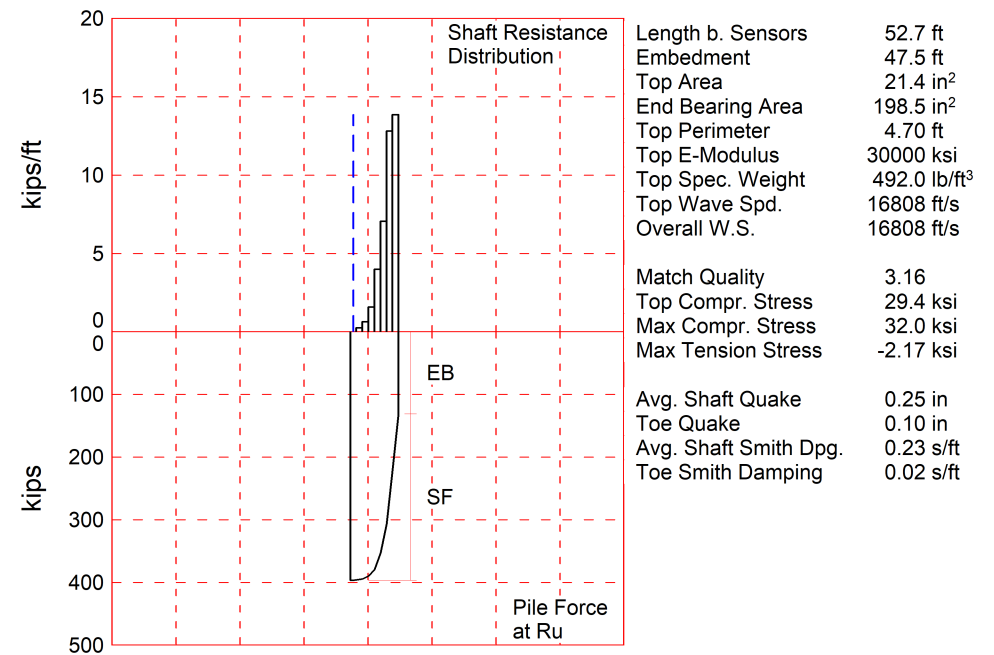
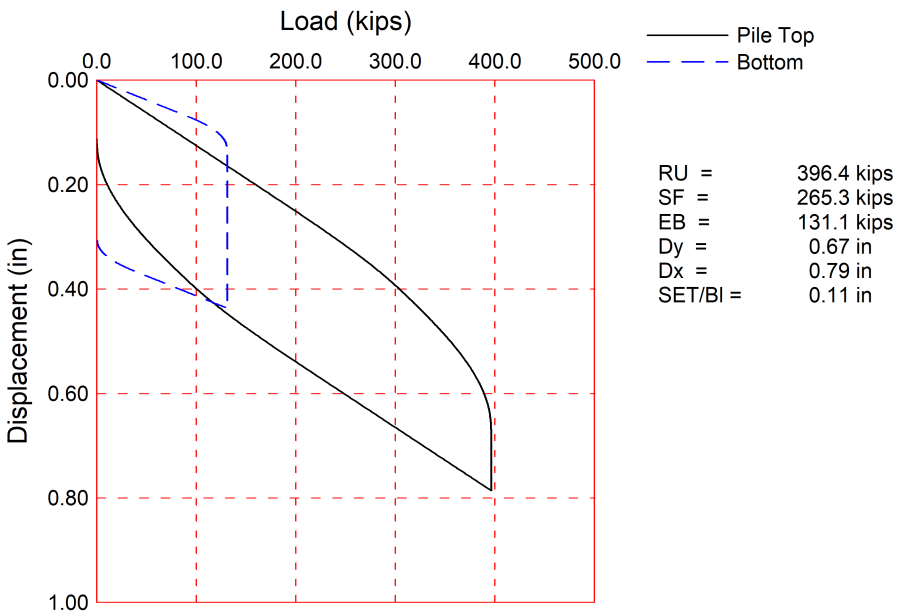
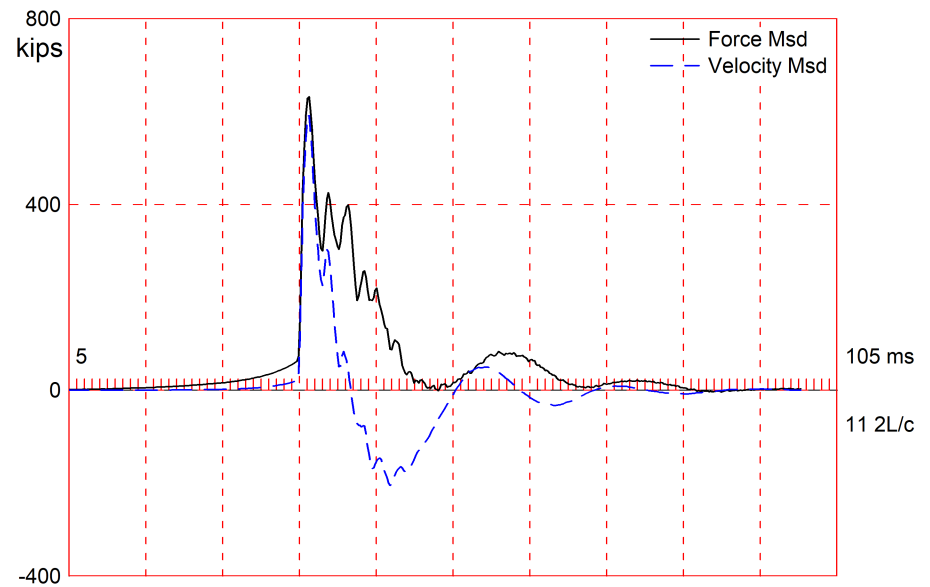
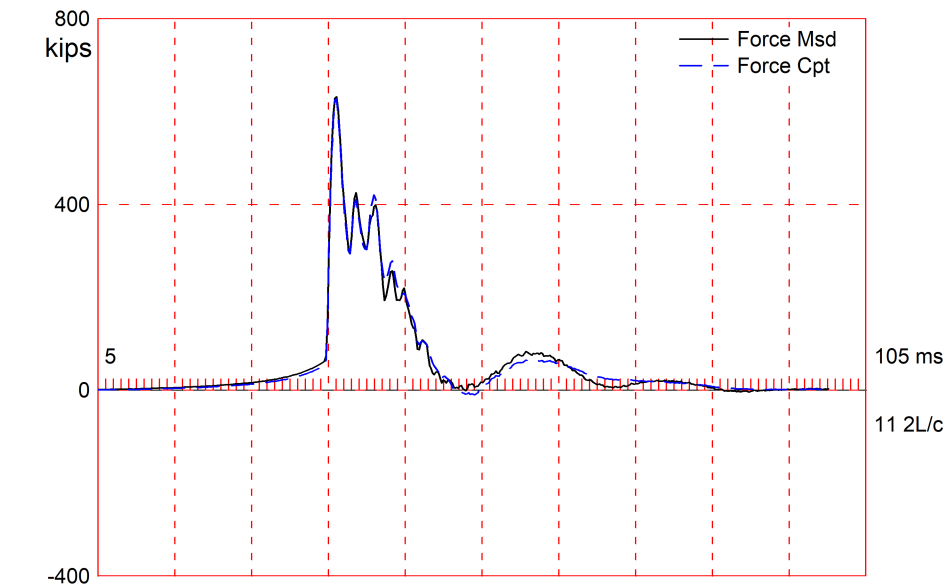
#### BL# Comments

1 Template Reference Elevation 301.8  
2 Ground Elevation 300.8  
3 Fuel Setting 2  
303 Pause to move template  
376 Pause to cut template

#### Time Summary

Drive 24 minutes 12 seconds 1:24 AM - 1:48 AM (5/11/2023) BN 1 - 305  
Stop 14 minutes 36 seconds 1:48 AM - 2:02 AM  
Drive 14 minutes 23 seconds 2:02 AM - 2:17 AM BN 306 - 622

Total time [00:53:13] = (Driving [00:38:36] + Stop [00:14:36])



---

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.

CCRP2 Bridge 42b Bent 2 Ftg 5 ; Pile: Pile 37  
 HP 14x73 w tips; Blow: 619  
 Infrastructure Consulting & Eng., PLLC

Test: 11-May-2023 02:17  
 CAPWAP (R) 2014-3  
 OP: ICE

# CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 396.4; along Shaft 265.3; at Toe 131.1 kips

Soil Sgmt 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
				396.4			
1	13.2	8.0	2.1	394.3	2.1	0.26	0.06
2	19.8	14.6	4.3	390.0	6.4	0.65	0.14
3	26.3	21.1	10.5	379.5	16.9	1.59	0.34
4	32.9	27.7	26.3	353.2	43.2	3.99	0.85
5	39.5	34.3	46.5	306.7	89.7	7.06	1.50
6	46.1	40.9	84.4	222.3	174.1	12.82	2.73
7	52.7	47.5	91.2	131.1	265.3	13.85	2.95
Avg. Shaft			37.9			5.59	1.19
Toe			131.1				95.10

## Soil Model Parameters/Extensions

		Shaft	Toe
Smith Damping Factor		0.23	0.02
Quake	(in)	0.25	0.10
Case Damping Factor		1.60	0.08
Damping Type		Viscous	Sm+Visc
Unloading Quake	(% of loading quake)	83	100
Reloading Level	(% of Ru)	100	100

CAPWAP match quality = 3.16 (Wave Up Match) ; RSA = 0  
 Observed: Final Set = 0.11 in; Blow Count = 107 b/ft  
 Computed: Final Set = 0.11 in; Blow Count = 107 b/ft  
 max. Top Comp. Stress = 29.4 ksi (T= 36.4 ms, max= 1.088 x Top)  
 max. Comp. Stress = 32.0 ksi (Z= 32.9 ft, T= 38.2 ms)  
 max. Tens. Stress = -2.17 ksi (Z= 32.9 ft, T= 51.9 ms)  
 max. Energy (EMX) = 20.7 kip-ft; max. Measured Top Displ. (DMX)= 0.57 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	3.3	628.7	-18.0	29.4	-0.84	20.7	15.6	0.59
2	6.6	631.7	-26.8	29.5	-1.25	20.4	15.5	0.57
3	9.9	634.9	-30.4	29.7	-1.42	20.1	15.4	0.55
4	13.2	640.4	-35.8	29.9	-1.67	19.8	15.2	0.52
5	16.5	637.4	-39.3	29.8	-1.84	19.1	15.1	0.50
6	19.8	648.6	-44.1	30.3	-2.06	18.7	14.8	0.48
7	23.0	642.9	-42.7	30.0	-2.00	17.9	14.6	0.45
8	26.3	666.6	-43.5	31.2	-2.03	17.5	14.0	0.43
9	29.6	648.0	-38.7	30.3	-1.81	16.2	13.5	0.41
10	32.9	683.9	-46.4	32.0	-2.17	15.9	12.7	0.39
11	36.2	627.7	-35.9	29.3	-1.68	13.8	11.9	0.37
12	39.5	674.2	-37.1	31.5	-1.73	13.5	10.7	0.34
13	42.8	564.0	-22.8	26.4	-1.07	10.6	9.8	0.33
14	46.1	550.3	-25.3	25.7	-1.18	10.4	10.2	0.31
15	49.4	342.1	-8.0	16.0	-0.38	6.6	10.1	0.29
16	52.7	380.3	-9.7	17.8	-0.45	2.8	9.3	0.28
Absolute	32.9			32.0			(T =	38.2 ms)
	32.9				-2.17		(T =	51.9 ms)

## CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	751.8	703.3	654.8	606.2	557.7	509.2	460.7	412.2	363.7	315.2
RX	751.8	703.3	654.8	606.2	557.7	509.2	460.7	430.8	413.6	396.4
RU	760.6	713.0	665.4	617.8	570.2	522.5	474.9	427.3	379.7	332.1
RAU =	208.2	(kips);	RA2 =	459.1	(kips)					

Current CAPWAP Ru = 396.4 (kips); Corresponding J(RP)= 0.73; J(RX) = 0.90

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
15.7	36.23	601.4	635.4	636.5	0.57	0.11	0.11	21.1	739.3	1313

## PILE PROFILE AND PILE MODEL

Depth ft	Area in <sup>2</sup>	E-Modulus ksi	Spec. Weight lb/ft <sup>3</sup>	Perim. ft
0.0	21.4	30000.0	492.000	4.70
52.7	21.4	30000.0	492.000	4.70

Toe Area 198.5 in<sup>2</sup>

Top Segment Length 3.29 ft, Top Impedance 38 kips/ft/s

Wave Speed: Pile Top 16807.9, Elastic 16807.9, Overall 16807.9 ft/s

CCRP2 Bridge 42b Bent 2 Ftg 5 ; Pile: Pile 37

Test: 11-May-2023 02:17

HP 14x73 w tips; Blow: 619

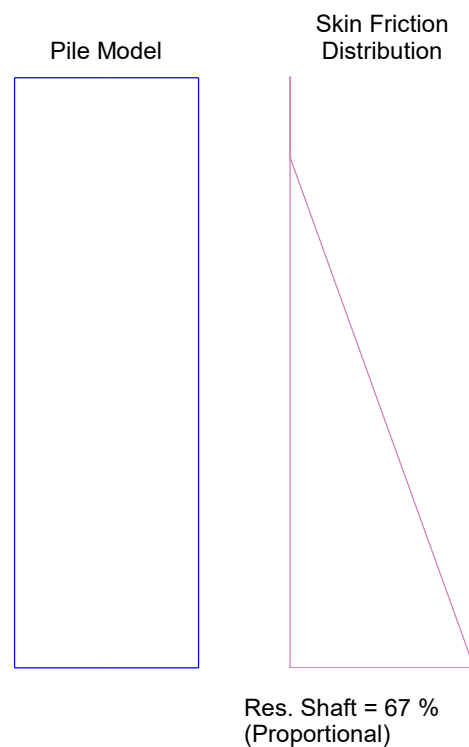
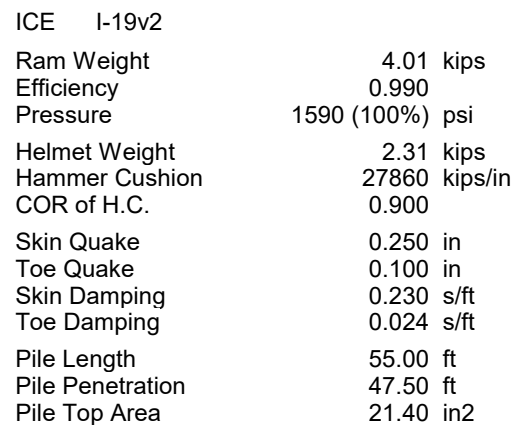
CAPWAP (R) 2014-3

Infrastructure Consulting & Eng., PLLC

OP: ICE

Pile Damping 1.00 %, Time Incr 0.196 ms, 2L/c 6.3 ms

Total volume: 7.827 ft<sup>3</sup>; Volume ratio considering added impedance: 1.000





ICE of Carolinas, PLLC  
Bridge 42b Bent 2 Pile 37 EOD CAL

15-May-2023  
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
396.0	28.82	0.56	107.0	8.29	20.69

**Appendix B**

**Pile Driving Criteria**

**Bent 2, Footings 3,4, and 5**

### Recommended Production Pile Driving Criteria

The recommended drive criteria for the up to 55.0 feet long HP 14x73 steel piles in Bent 2 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 ICE I-19v2 hammer driving system. A hammer helmet weight of 2.3 kips and a hammer cushion of 2.5 total inches of nylon, 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 2 Footings 3, 4 and 5

The up to 55.0 foot HP 14x73 steel piles at Bent 2 Footings 3, 4, and 5 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.

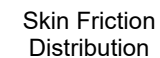
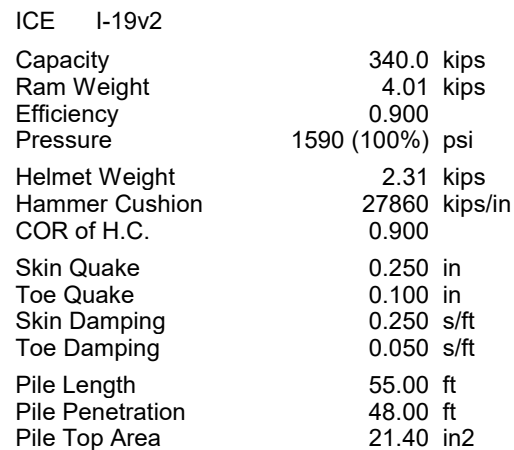
1. Practical refusal (20 blows per one inch or ½ inch in 10 blows with at least a stroke of 6.0 feet) is reached during driving.
2. The following maximum set per 10 blows is not exceeded (minimum blows per foot is met) for the respective stroke during driving:

Stroke (feet)	Maximum Set in inches per 10 blows	Minimum Blows Per Foot
6.5	¾	150
7.0	1	120
7.5	1-1/8	100
8.0	1-1/4	93
8.5 or greater	1-1/2	80

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.



Res. Shaft = 67 %  
(Proportional)

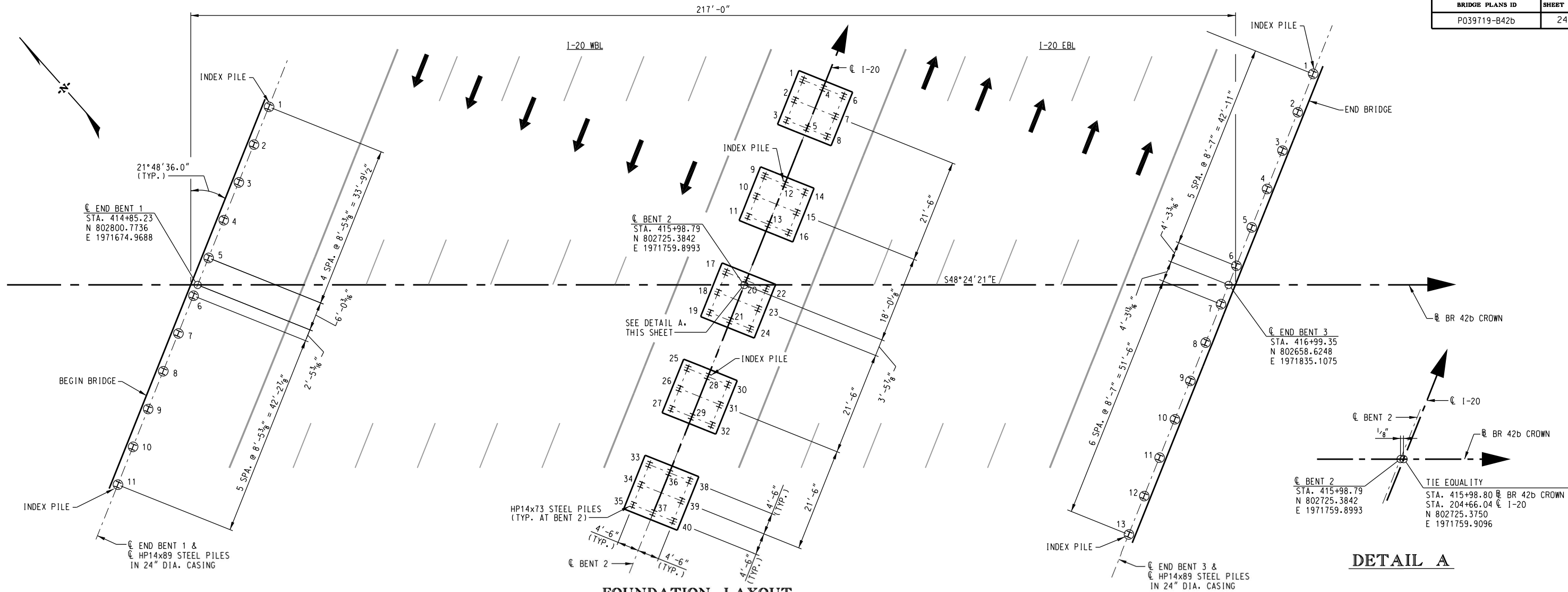
Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Set in/10 bl	Stroke ft	Energy kips-ft
340.0	19.38	0.36	0.4	5.50	11.18
340.0	21.02	0.32	0.6	6.00	12.70
340.0	22.57	0.30	0.8	6.50	14.20
340.0	24.01	0.28	1.0	7.00	15.66
340.0	25.38	0.26	1.2	7.50	17.11
340.0	26.68	0.24	1.3	8.00	18.54
340.0	27.93	0.23	1.5	8.50	19.96
340.0	29.11	0.22	1.6	9.00	21.37
340.0	30.29	0.21	1.8	9.50	22.82
340.0	31.38	0.20	1.9	10.00	24.18

## **Appendix C**

### **Project Information and Nearby Soil Borings**

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BRIDGE PLANS ID	SHEET NO.
P039719-B42b	24



### FOUNDATION LAYOUT

PILE BEARING TABLE			
BENT I.D.	E.B.1	I.B.2	E.B.3
PILE SECTION	HP 14X89	HP 14X73	HP 14X89
FACTORED DESIGN LOAD (TONS)	185	110	185
GEOTECHNICAL RESISTANCE FACTOR	0.65	0.65	0.65
NOMINAL RESISTANCE (TONS)	285	170	285
SETTLEMENT INDUCED UNFACTORED DOWNDRAW (TONS)	0	0	0
SETTLEMENT INDUCED FACTORED DOWNDRAW (TONS)	0	0	0
LIQUEFACTION INDUCED DOWNDRAW (TONS)	0	0	0
REQUIRED DRIVING RESISTANCE (TONS)	285	170	285
REQUIRED MINIMUM TIP ELEVATION TO ACHIEVE LATERAL STABILITY (FEET MSL)	280	270	280
ESTIMATED PILE TIP ELEVATION (FEET MSL)	235	255	250

Initially drive End Bent 1 and End Bent 3 piles to at least the required minimum tip elevation and no deeper than tip elevation 265 before MSE wall and bridge embankment construction.

Settlement monitoring is required at End Bent 1 and End Bent 3 during MSE wall and bridge embankment construction. Final End Bent pile driving to the required driving resistance shall begin at the direction of the Geotechnical Engineer of Record after sufficient foundation soil settlement has completed.

Method of controlling installation of piles and verifying their capacity: Capacity will be verified by Pile Driving Analyzer and CAPWAP analysis of index piles. A Pile Installation Chart developed from the analysis will be used to verify the capacity of production piles.

Perform Pile Driving Analyzer (PDA) testing on six (6) index piles. An index pile shall be the first production pile driven at each bent. Include an additional two feet of pile length in order 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.

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.

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, Interior Bent 2, & End Bent 3:

DRIVABILITY ANALYSIS			
BENT I.D.	E.B.1	I.B.2	E.B.3
Skin Quake (QS)	0.10 in	0.10 in	0.10 in
Toe Quake (QT)	0.10 in	0.10 in	0.10 in
Skin Damping (SD)	0.15 s/ft	0.15 s/ft	0.15 s/ft
Toe Damping (TD)	0.15 s/ft	0.15 s/ft	0.15 s/ft
% Skin Friction	30%	50%	30%
Distribution Shape Number	0	0	0
Pile Installation Chart	Proportional	Proportional	Proportional
Pile Penetration	60%	75%	60%
Hammer Energy Range	50-80 kip-ft	30-60 kip-ft	50-80 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 Request for Proposals.

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

FINAL PLANS  
NOT FOR CONSTRUCTION

REV.			
REV.			
REV.			
REVIEWED	PLC	04-22	
QUAN.			
DR.	RMH	WRS	03-22
DES.	WRS	ALP	03-22
BY	CHK.	DATE	

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**INFRASTRUCTURE**  
CONSULTING & ENGINEERING

**SOUTH CAROLINA**  
**DEPARTMENT OF TRANSPORTATION**

**FOUNDATION LAYOUT**  
US 176 EB (BROAD RIVER RD.)  
BRIDGE OVER I-20

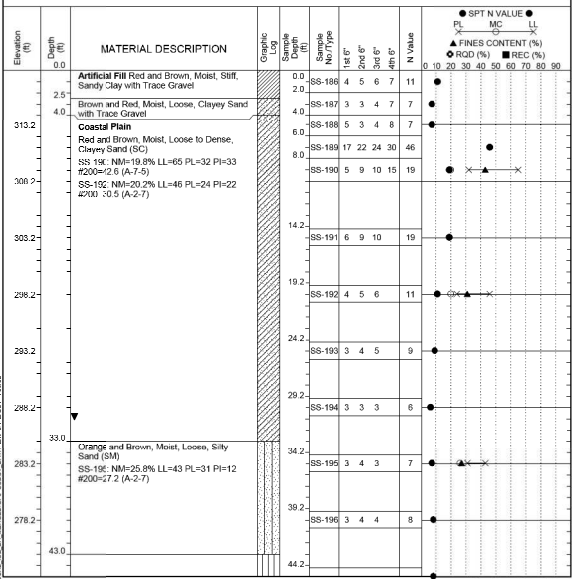
COUNTY RICHLAND ROUTE US 176



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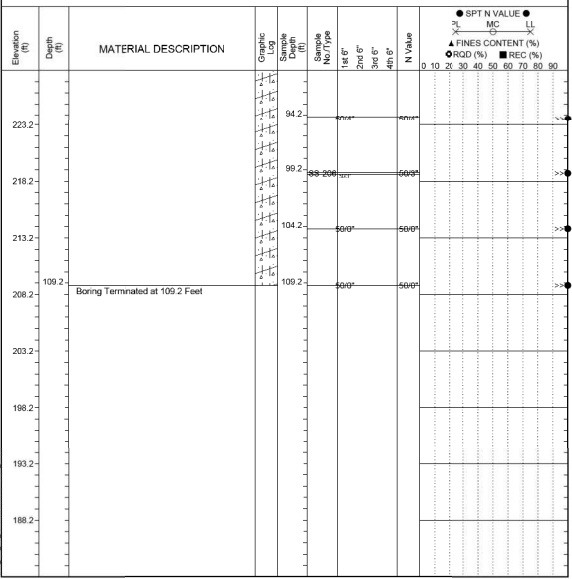
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Site Description: Carolina Crossroads Phase 2 - Bridge 42B Route: Broad River Rd.  
Eng./Geo.: M. Stanbury Boring Location: 203+85 Offset: 118 LT Alignment: I20CL  
Elev.: 1318.2 ft Latitude: 34.0397555 Longitude: -81.09362896 Date Started: 2/23/2022  
Total Depth: 109.2 ft Soil Depth: 109.2 ft Core Depth: N/A ft Date Completed: 2/23/2022  
Bore Hole Diameter (in): 2.25 Sampler Configuration: Liner Required: Y (N) Liner Used: Y (N)  
Drill Machine: D-50 #439 Drill Method: RW Hammer Type: Automatic Energy Ratio: 90.8%  
Core Size: N/A Driller: R. Cassell Groundwater: TOB N/A 24HR 31.1 ft



LEGEND  
SS - Split Spoon N2 - 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

INFRASTRUCTURE  
CONSULTING & ENGINEERING

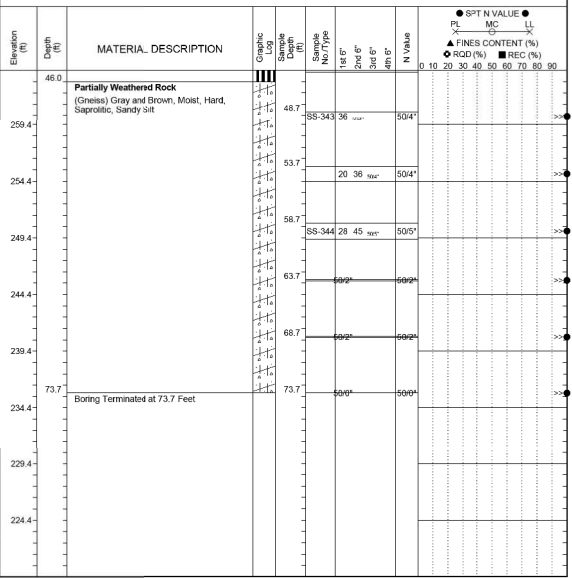
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Eng./Geo.: M. Stanbury Boring Location: 203+85 Offset: 118 LT Alignment: I20CL  
Elev.: 1318.2 ft Latitude: 34.0397555 Longitude: -81.09362896 Date Started: 2/23/2022  
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Core Size: N/A Driller: R. Cassell Groundwater: TOB N/A 24HR 31.1 ft



LEGEND  
SS - Split Spoon N2 - 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

INFRASTRUCTURE  
CONSULTING & ENGINEERING

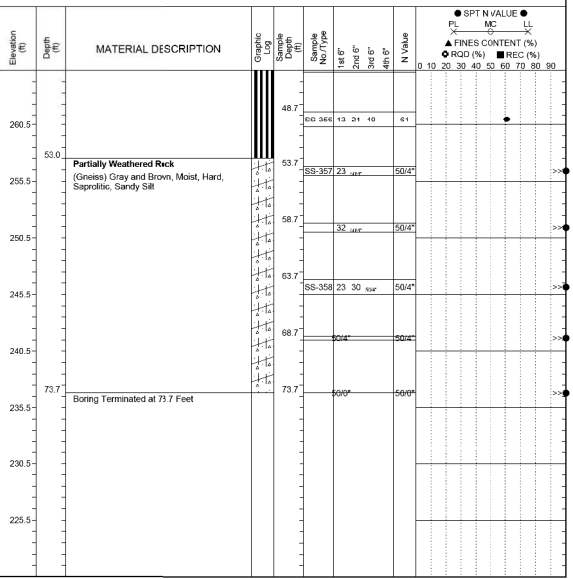
Project ID: P039719 County: Richland Boring No.: G-134  
Site Description: Carolina Crossroads Phase 2 - Bridge 42B Route: Broad River Rd.  
Eng./Geo.: M. Stanbury Boring Location: 204+13 Offset: 4 RT Alignment: I20CL  
Elev.: 1309.4 ft Latitude: 34.03963447 Longitude: -81.09336881 Date Started: 3/14/2022  
Total Depth: 73.7 ft Soil Depth: 73.7 ft Core Depth: N/A ft Date Completed: 3/14/2022  
Bore Hole Diameter (in): 2.25 Sampler Configuration: Liner Required: Y (N) Liner Used: Y (N)  
Drill Machine: D-50 #439 Drill Method: RW Hammer Type: Automatic Energy Ratio: 90.8%  
Core Size: N/A Driller: R. Cassell Groundwater: TOB N/A 24HR FIAD



LEGEND  
SS - Split Spoon N2 - 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

INFRASTRUCTURE  
CONSULTING & ENGINEERING

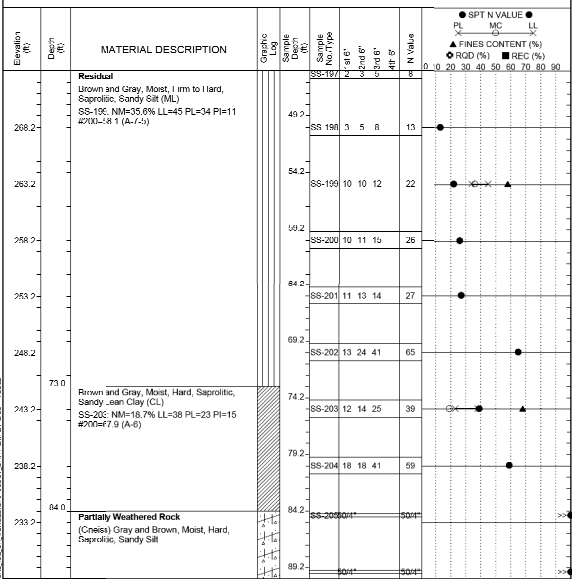
Project ID: P039719 County: Richland Boring No.: G-135  
Site Description: Carolina Crossroads Phase 2 - Bridge 42B Route: Broad River Rd.  
Eng./Geo.: M. Stanbury Boring Location: 204+97 Offset: 4 RT Alignment: I20CL  
Elev.: 1310.5 ft Latitude: 34.03963447 Longitude: -81.09312144 Date Started: 3/15/2022  
Total Depth: 73.7 ft Soil Depth: 73.7 ft Core Depth: N/A ft Date Completed: 3/15/2022  
Bore Hole Diameter (in): 2.25 Sampler Configuration: Liner Required: Y (N) Liner Used: Y (N)  
Drill Machine: D-50 #439 Drill Method: RW Hammer Type: Automatic Energy Ratio: 90.8%  
Core Size: N/A Driller: R. Cassell Groundwater: TOB N/A 24HR FIAD



LEGEND  
SS - Split Spoon N2 - 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

INFRASTRUCTURE  
CONSULTING & ENGINEERING

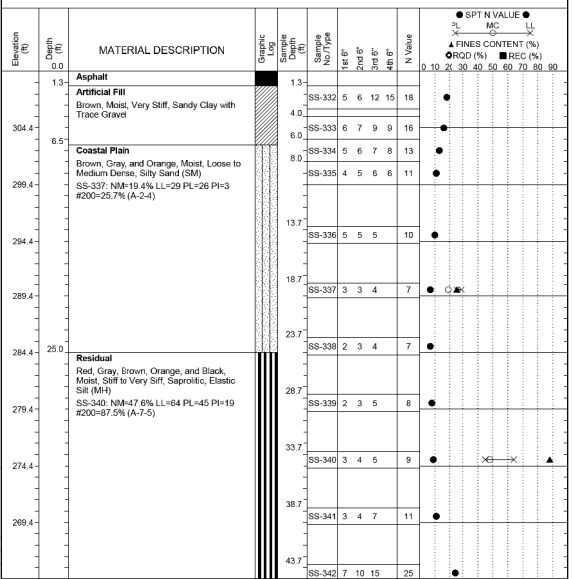
Project ID: P039719 County: Richland Boring No.: G-131  
Site Description: Carolina Crossroads Phase 2 - Bridge 42B Route: Broad River Rd.  
Eng./Geo.: M. Stanbury Boring Location: 203+85 Offset: 118 LT Alignment: I20CL  
Elev.: 1318.2 ft Latitude: 34.0397555 Longitude: -81.09362896 Date Started: 2/23/2022  
Total Depth: 109.2 ft Soil Depth: 109.2 ft Core Depth: N/A ft Date Completed: 2/23/2022  
Bore Hole Diameter (in): 2.25 Sampler Configuration: Liner Required: Y (N) Liner Used: Y (N)  
Drill Machine: D-50 #439 Drill Method: RW Hammer Type: Automatic Energy Ratio: 90.8%  
Core Size: N/A Driller: R. Cassell Groundwater: TOB N/A 24HR 31.1 ft



LEGEND  
SS - Split Spoon N2 - 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

INFRASTRUCTURE  
CONSULTING & ENGINEERING

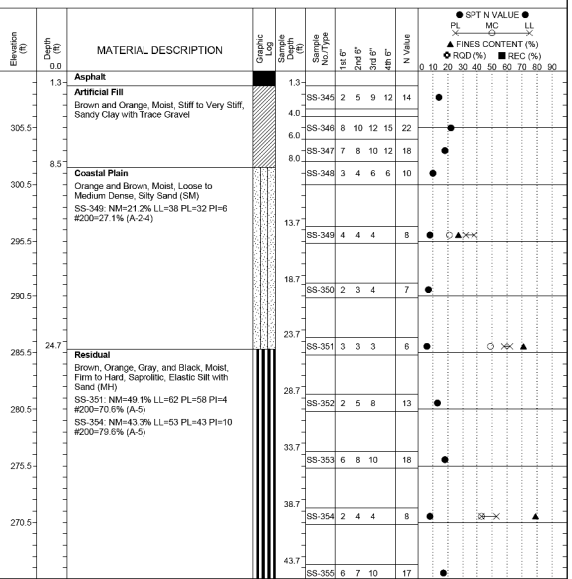
Project ID: P039719 County: Richland Boring No.: G-134  
Site Description: Carolina Crossroads Phase 2 - Bridge 42B Route: Broad River Rd.  
Eng./Geo.: M. Stanbury Boring Location: 204+13 Offset: 4 RT Alignment: I20CL  
Elev.: 1309.4 ft Latitude: 34.03963447 Longitude: -81.09336881 Date Started: 3/14/2022  
Total Depth: 73.7 ft Soil Depth: 73.7 ft Core Depth: N/A ft Date Completed: 3/14/2022  
Bore Hole Diameter (in): 2.25 Sampler Configuration: Liner Required: Y (N) Liner Used: Y (N)  
Drill Machine: D-50 #439 Drill Method: RW Hammer Type: Automatic Energy Ratio: 90.8%  
Core Size: N/A Driller: R. Cassell Groundwater: TOB N/A 24HR FIAD



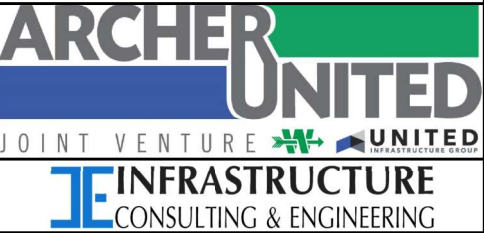
LEGEND  
SS - Split Spoon N2 - Rock Core, 1-7/8" HSA - Hollow Stem Auger RW - Rotary Wash  
UD - Undisturbed Sample CU - Cuttings CFA - Continuous Flight Augers RC - Rock Core  
AWG - Rock Core, 1-1/8" CT - Continuous Tube DC - Driving Casing

INFRASTRUCTURE  
CONSULTING & ENGINEERING

Project ID: P039719 County: Richland Boring No.: G-135  
Site Description: Carolina Crossroads Phase 2 - Bridge 42B Route: Broad River Rd.  
Eng./Geo.: M. Stanbury Boring Location: 204+97 Offset: 4 RT Alignment: I20CL  
Elev.: 1310.5 ft Latitude: 34.03963447 Longitude: -81.09312144 Date Started: 3/15/2022  
Total Depth: 73.7 ft Soil Depth: 73.7 ft Core Depth: N/A ft Date Completed: 3/15/2022  
Bore Hole Diameter (in): 2.25 Sampler Configuration: Liner Required: Y (N) Liner Used: Y (N)  
Drill Machine: D-50 #439 Drill Method: RW Hammer Type: Automatic Energy Ratio: 90.8%  
Core Size: N/A Driller: R. Cassell Groundwater: TOB N/A 24HR FIAD



LEGEND  
SS - Split Spoon N2 - 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



SOUTH CAROLINA  
DEPARTMENT OF TRANSPORTATION  
BORING LOGS (3)  
US 176 EB (BROAD RIVER RD.)  
BRIDGE OVER I-20  
COUNTY RICHLAND ROUTE US 176

FOR INFORMATION ONLY

REV.			
REV.			
REV.			
REVIEWED	PLC	04-22	
QUAN.			
DR.	BFS	WRS	04-22
DES.			
BY	CHK.	DATE	

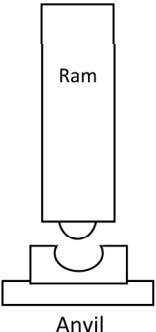


## **Appendix D**


### **Pile Driving Hammer Information**

County:	Richland County	Bridge Plans ID:	P039719-B42b		
Route:	US 176 EB (Broad River Road) Bridge Over I-20				
Description:	Carolina Crossroads Phase 2 Bridge 42B				
Contractor:	Archer United Joint Venture				

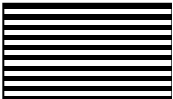
  

	<b>Hammer</b>	Manufacturer:	ICE		Model:	I-19
		Type:	Single Act Diesel		Serial No.	TBD
		Rated Energy (k-ft)	46.17	at	11.5	Length of stroke (ft)
		Lead Size (in):	26			
		Modifications:	None			
		<b>Note:</b> Attach any hammer modification specifications. Manufacturer's Specifications may be required if hammer is not found in Wave Equation database.				
		Date of Last Maintenance:	TBD			
		Type of Maintenance:	TBD			
		Performed By:	TBD			

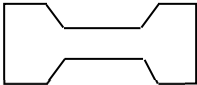
  

	<b>Striker Plate</b>	Weight (kips):	0.46		
		Diameter (in):	22.5	Thickness (in):	4


  

	<b>Hammer Cushion</b>	Description:				
		Material Description		No. of Layers	Modulus of Elasticity (ksi)	Thickness (in)
		1	MC-904 Blue Nylon	1	175	2
		2				
		Area (sq. in):	398	Total Thickness (in)	2.5	
		Coefficient of Restitution:	0.90			


  

	<b>Pile Cap (Helmet)</b>	Dimension:	DCB-1HD Drive Cap & DCH-1 Cap Insert		
		Pile Cap Weight (kips):	1.065		
		Inserts Weight (kips):	0.78		

	<b>Pile Cushion</b>	Material:	N/A			
		Thickness (in.):	N/A	Area (sq. in):	N/A	
		Modulus of Elasticity (ksi):	N/A			
		Coefficient of Restitution:	N/A			

	<b>Pile</b>	Pile Type/Size & Pile Point:	HP 14x73 14x73 Welded Reinf. Pile Tips			
		Total Pile & Point Length (ft):	EB 2 -47.3	Exposed Pile Point Length (ft):	N/A	
		Pile Cross-Sectional Area (sq.in):	21.4 on 14x79			
		Pipe Pile Wall Thickness (in):	N/A			
		Pile Tip Description:	Welded Reinf. Tip			
		Splice Description:	Bevel Butt per SCDOT Spec. Section 711.4.10.1			
		Splice Location From Pile Top (ft):	N/A			
		Concrete Pile Strength, $f'_c$ (psi):	N/A			
		Steel Pile Yield Strength, $F_y$ (ksi):	50			

<b>Note:</b> Within 30 calendar days after award of contract or no later than 30 days before driving the first pile, submit form and Pile Installation Plan to the Geotechnical Design Engineer, with copy to the Bridge Construction Engineer and RCE.				
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SCDOT – Design-Build Section Geotechnical Design Engineer P.O. Box 191 Columbia, SC 29202-0191 Telephone (803) 737-0766 FAX (803) 737-9868	Submitted By:	Engelbert Ocampo		
	Title:	Project Engineer		
	Telephone No.	(954)-901-5736	Date:	12/06/2022

# **Appendix E**

## **Instrumentation Calibrations**

# Accelerometer Calibration Certificate

## Pile Dynamics, Inc.



Calibrated by Pile Dynamics, Inc.  
Calibration performed on **OCT 22 2021**

Serial No: K12388      Temperature: 22.6 °C

Model: PR      Humidity: 44%

Calibrated on: Channel 3 on 8G 5161 LE

### PDA CALIBRATION FACTOR

**451.0 mv/5000g**

(90.2  $\mu$ v/g)

R<sup>2</sup>: 0.999955 [Chip programmed]

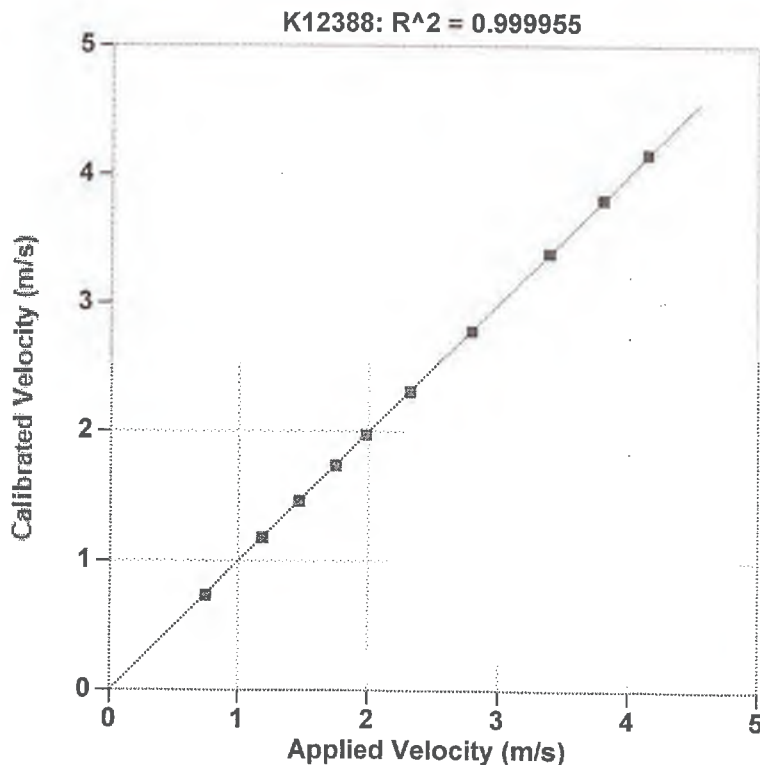
Operator: William Johnson

Ref Acc 1: 69132!      Cal on: 09Feb2021  
960 g's/volt

Ref Acc 2: 69096!      Cal on: 27Jan2021  
978 g's/volt

  
Signed

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



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 22 2021

Serial No: K12389 Temperature: 22.8 °C

Model: PR Humidity: 44%

Calibrated on: Channel 3 on 8G 5161 LE

### PDA CALIBRATION FACTOR

483.2 mv/5000g

(96.6  $\mu$ v/g)

R<sup>2</sup>: 0.999989 [Chip programmed]

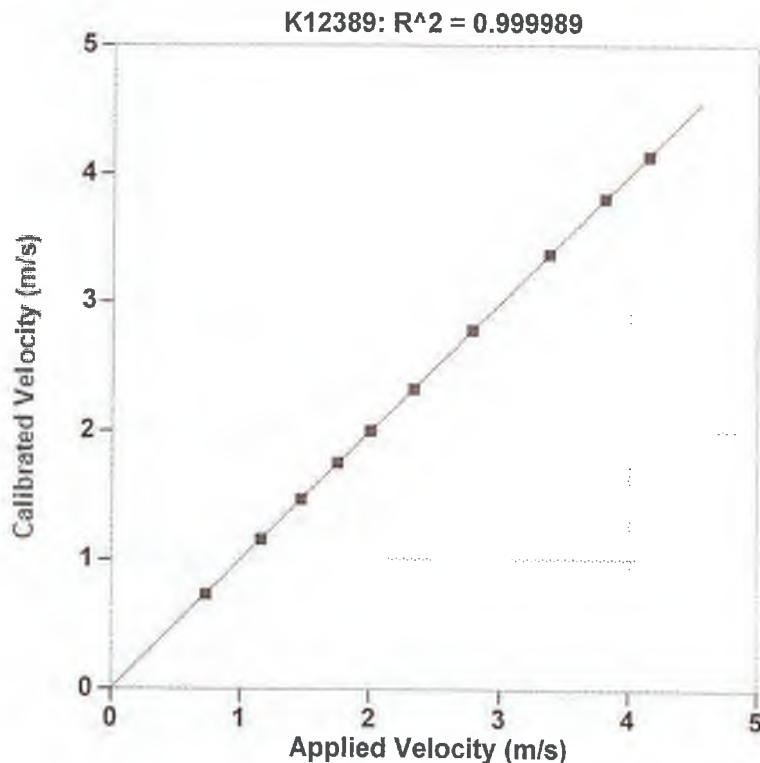
Operator: William Johnson

Ref Acc 1: 69132! Cal on: 09Feb2021  
960 g's/volt

Ref Acc 2: 69096! Cal on: 27Jan2021  
978 g's/volt

  
Signed

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



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



# Certificate of Calibration

Transducer Model: PDI Transducer

**Pile Dynamics, Inc.**

Serial Number: P821

PDI Gage Factor: 145.1 me/V

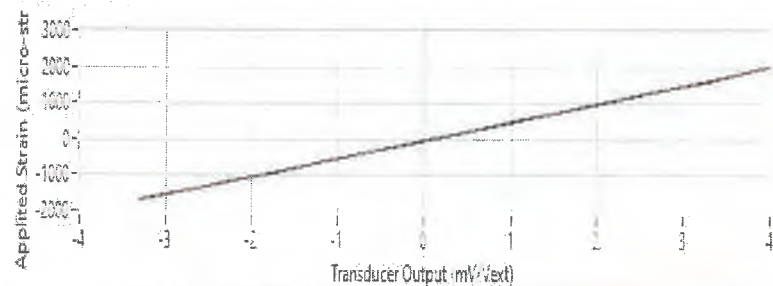
General Gage Factor: 503.9 me/mV/V<sub>ext</sub>

Initial Offset Voltage: 0.006 mV/V<sub>ext</sub>

Table 1: Representative Calibration Data

Applied Strain (micro-str)	Transducer Output (mV)	Applied Strain (micro-str)	Transducer Output (mV)
-41.039	-0.142	203.401	0.142
-171.916	-0.148	512.711	0.134
-351.274	-0.152	812.045	0.145
-559.238	-0.155	1103.000	0.152
-812.912	-0.142	1485.817	0.159
-1091.002	-0.141	1791.421	0.153
-1421.538	-0.155	2071.554	0.156
-1703.504	-0.143	1988.843	0.159
-1991.421	-0.153	1632.851	0.134
-1581.549	-0.135	1308.034	0.145
-1351.519	-0.155	891.103	0.135
-1054.545	-0.151	591.373	0.140
-728.603	-0.155	210.751	0.135
-392.011	-0.135	158.580	0.134
-24.157	-0.011	21.451	0.144
-55.231	-0.039	42.723	0.143

Calibration Curve



Mean Linear Correlation Coefficient (LCC): 0.999973

LCC Standard Deviation: 1.354270E-6

Calibrated By: DIC

Signature:

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

Temperature (Degrees C): 24.2



## Certificate of Calibration

Transducer Model: PDI Transducer

**Pile Dynamics, Inc.**

Serial Number: S868

PDI Gage Factor: 145.1 meV

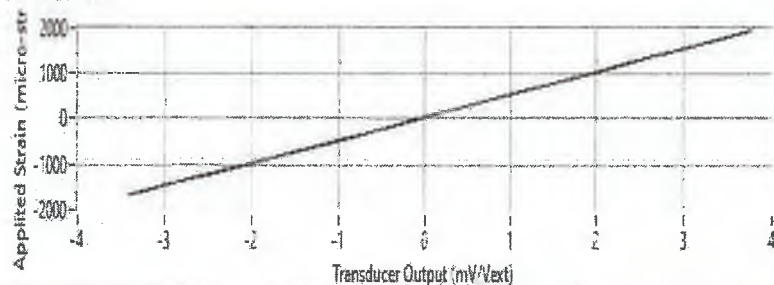
General Gage Factor: 503.9 meV/V<sub>ext</sub>

Initial Offset Voltage: -0.058 mV/V<sub>ext</sub>

Table 1: Representative Calibration Data

Applied Strain (micro-strain)	Transducer Output (mV/V <sub>ext</sub> )	Applied Strain (micro-strain)	Transducer Output (mV/V <sub>ext</sub> )
17.468	-0.059	166.844	0.227
138.739	-0.384	451.162	0.797
218.764	-0.705	757.082	1.404
468.733	-1.425	1070.886	2.038
712.547	-2.193	1386.164	2.657
956.488	-2.914	1695.848	3.273
1211.171	-3.686	1952.867	3.789
1462.474	-4.507	1899.336	3.660
1676.877	-5.409	1574.565	3.030
1851.690	-6.280	1251.079	2.388
1987.028	-7.124	945.467	1.751
1100.823	-0.890	663.516	1.233
881.345	-1.752	408.059	0.711
582.470	-2.623	164.516	0.204
303.691	-3.706	17.691	-0.287
19.718	-4.980	17.211	-0.288

Calibration Curve



Mean Linear Correlation Coefficient (LCC): 0.999993

LCC Standard Deviation: 1.772938E-6

Calibrated By: DJC

Signature:

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

Temperature (Degrees C): 25.2

Page 1 of 1

## Specifications

### PDI Automated Strain Transducer Calibration System (PDI - ASTCS)

ASTCS Serial Number:	PDI CAL 2015-02
ASTCS Software Version Number:	3.001
ASTCS Independent 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 F**

**PDA Proficiency Certifications**





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](http://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. 3139





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](http://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