December 13, 2013 J019907.01

Dr. Ronaldo Luna, PhD, P.E.
Missouri University of Science and Technology
130 Butler-Carlton Hall
1870 Minor Circle
Rolla, Missouri 65409-0300

Re: High-Strain Dynamic Pile Testing Report
Livingston County Test Pile
Evaluation of Pile Load Tests for use in Missouri LRFD Guidelines
Livingston County, Missouri
Addendum Number 1

Dear Dr. Luna:

This letter is prepared as an addendum to the referenced high-strain dynamic pile testing report.[1] The procedures, results and limitations contained in the original report remain unchanged and apply to this addendum.

It is our understanding that the Missouri University of Science and Technology (MS&T) performed a static load test on the test pile via the quick method on October 3, 2013. The static load test data was subsequently analyzed by MS&T and resulted in a 235-kip static capacity, which is much less than the estimated CAPWAP capacity performed on high-strain dynamic data collected at the beginning of the 7-day restrike (i.e. 475 to 485 kips). Therefore, an additional restrike of the test pile was requested and subsequently performed on October 24, 2013.

In preparation for static testing, approximately 9 inches of the pile was cutoff and the pile was filled with concrete. To facilitate high-strain dynamic testing of the resulting composite pile, the pile was redrilled and tapped approximately 28 inches below the pile top, the top of the pile was ground flush, and a steel plate was welded to the top of the pile.

The Delmag D19-42, open-ended diesel hammer was warmed up by striking a reaction pile with approximately 38 blows prior to restriking the test pile. The restrike test was performed by APAC-Missouri, Inc., dynamically monitored by an engineer from Geotechnology, Inc., and consisted of striking the test pile approximately 33 times and measuring the set per 10 blows.

[1] *High-Strain Dynamic Pile Testing Report, Livingston County Test Pile, Evaluation of Pile Load Tests for use in Missouri LRFD Guidelines, Livingston County, Missouri;* Prepared for the Missouri University of Science and Technology by Geotechnology Inc., Report Number J019907.01 and dated September 27, 2013.

Representative blows from data collected near the BOR were subsequently analyzed using CAPWAP. A summary of the CAPWAP results is presented in the following table.

CAPWAP RESULTS SUMMARY							
Test Pile Identifier	**Test Type**	**Blow Analyzed**	**Match Quality**	**Ultimate Capacity (kips)**			**JC***
				Total	**Shaft**	**Tip**	
Test Pile	Restrike	3	0.79	376.1	356.1	20.0	0.59
		4	0.86	355.5	336.4	19.1	0.51

* * * * *

If we can provide further information or services please contact the undersigned.

Very truly yours,

GEOTECHNOLOGY, INC.

Craig K. Kaibel, P.E.
Senior Project Manager

CKK/JAW:ckk/jab

Attachments: Appendix E – CAPWAP Results

Copies submitted: (3) hard copies

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12/13/2013

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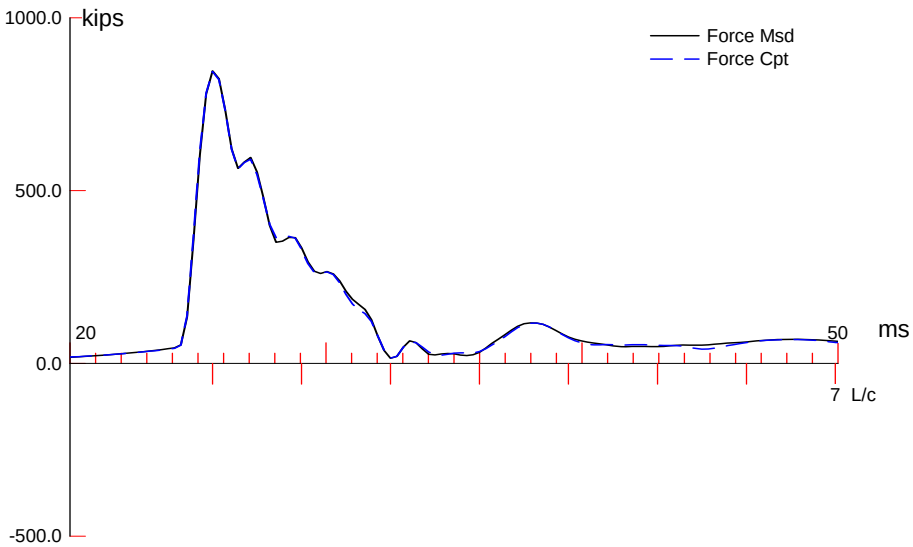
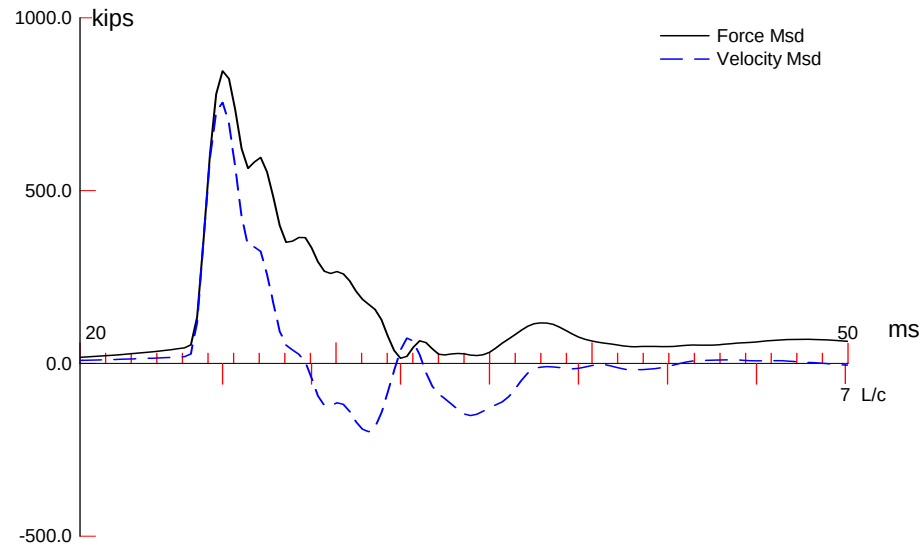
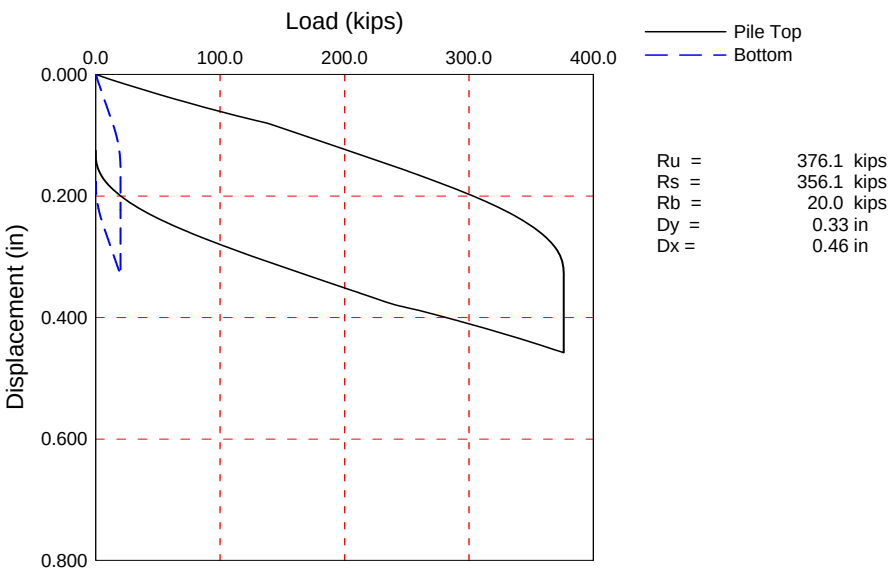
APPENDIX E

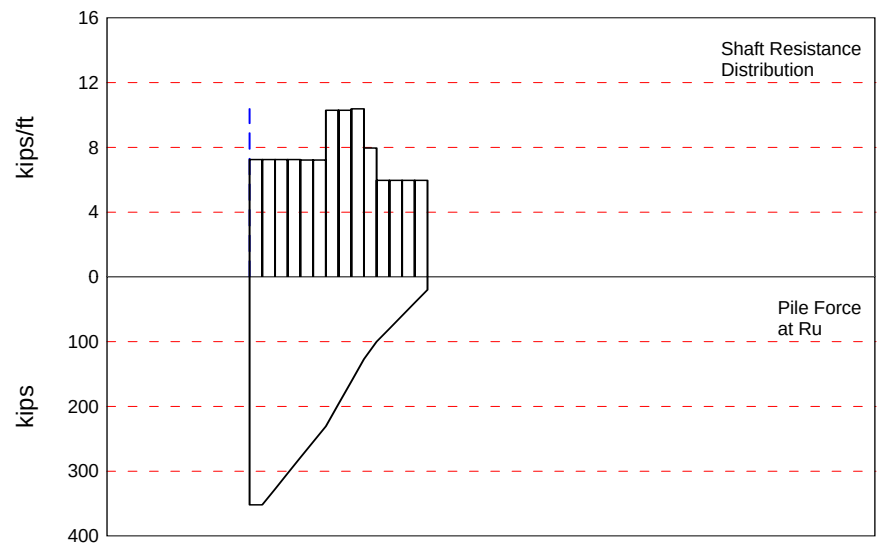
CAPWAP RESULTS







Ru =	376.1	kips
Rs =	356.1	kips
Rb =	20.0	kips
Dy =	0.33	in
Dx =	0.46	in



CAPWAP(R) 2006 Licensed to Geotechnology, Inc.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 376.1; along Shaft 356.1; at Toe 20.0 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	Smith Damping Factor s/ft
				376.1				
1	3.4	3.4	24.3	351.8	24.3	7.08	1.93	0.257
2	6.7	6.8	24.3	327.5	48.6	7.25	1.98	0.257
3	10.1	10.1	24.3	303.2	72.9	7.25	1.98	0.257
4	13.4	13.5	24.3	278.9	97.2	7.25	1.98	0.257
5	16.8	16.8	24.2	254.7	121.4	7.22	1.97	0.257
6	20.1	20.2	24.2	230.5	145.6	7.22	1.97	0.257
7	23.5	23.5	34.5	196.0	180.1	10.29	2.81	0.257
8	26.8	26.9	34.5	161.5	214.6	10.29	2.81	0.257
9	30.2	30.2	34.8	126.7	249.4	10.38	2.83	0.257
10	33.5	33.6	26.7	100.0	276.1	7.97	2.17	0.257
11	36.9	36.9	20.0	80.0	296.1	5.97	1.63	0.257
12	40.2	40.3	20.0	60.0	316.1	5.97	1.63	0.257
13	43.6	43.6	20.0	40.0	336.1	5.97	1.63	0.257
14	46.9	47.0	20.0	20.0	356.1	5.97	1.63	0.257
Avg. Shaft			25.4			7.58	2.07	0.257
Toe			20.0				18.71	0.245

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(in)	0.158	0.118
Case Damping Factor		1.330	0.071
Damping Type			Smith
Unloading Quake	(% of loading quake)	75	30
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	54	
Resistance Gap (included in Toe Quake)	(in)		0.078
Soil Plug Weight	(kips)		0.21

CAPWAP match quality = 0.79 (Wave Up Match) ; RSA = 0
Observed: final set = 0.125 in; blow count = 96 b/ft
Computed: final set = 0.104 in; blow count = 115 b/ft

max. Top Comp. Stress = 5.72 ksi (T= 26.1 ms, max= 1.000 x Top)
max. Comp. Stress = 5.72 ksi (Z= 3.4 ft, T= 26.1 ms)
max. Tens. Stress = -0.59 ksi (Z= 33.5 ft, T= 30.5 ms)
max. Energy (EMX) = 14.0 kip-ft; max. Measured Top Displ. (DMX)= 0.28 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	3.4	880.7	-17.7	5.72	-0.11	13.98	10.7	0.263
2	6.7	836.0	-46.9	5.43	-0.30	12.48	10.2	0.247
3	10.1	793.4	-63.2	5.15	-0.41	11.13	9.7	0.231
4	13.4	752.8	-50.3	4.89	-0.33	9.93	9.2	0.217
5	16.8	715.1	-26.6	4.64	-0.17	8.86	8.8	0.215
6	20.1	685.1	-53.9	4.45	-0.35	8.00	8.2	0.215
7	23.5	660.1	-52.7	4.29	-0.34	7.24	7.7	0.215
8	26.8	612.5	-38.0	3.98	-0.25	6.24	7.2	0.215
9	30.2	563.7	-78.8	3.66	-0.51	5.33	6.8	0.216
10	33.5	511.6	-91.1	3.32	-0.59	4.40	6.5	0.218
11	36.9	475.2	-47.3	3.09	-0.31	3.54	6.3	0.220
12	40.2	439.1	-49.1	2.85	-0.32	2.84	6.6	0.220
13	43.6	328.3	-31.4	2.13	-0.20	2.06	8.9	0.220
14	46.9	120.1	-14.2	0.78	-0.09	0.49	10.1	0.220
Absolute	3.4			5.72			(T =	26.1 ms)
	33.5				-0.59		(T =	30.5 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	829.6	752.4	675.2	598.1	520.9	443.7	366.5	289.3	212.1	134.9
RX	829.6	752.4	675.2	598.1	520.9	443.7	366.5	289.3	212.1	186.1
RU	1008.9	949.6	890.4	831.1	771.8	712.6	653.3	594.1	534.8	475.6

RAU = 154.7 (kips); RA2 = 391.3 (kips)

Current CAPWAP Ru = 376.1 (kips); Corresponding J(RP)= 0.59; J(RX) = 0.59

VMX ft/s	VFN ft/s	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips
11.22	0.00	771.8	846.4	846.4	0.282	0.116	0.125	14.2	838.7

Peak Velocity Time = 25.82 ms.

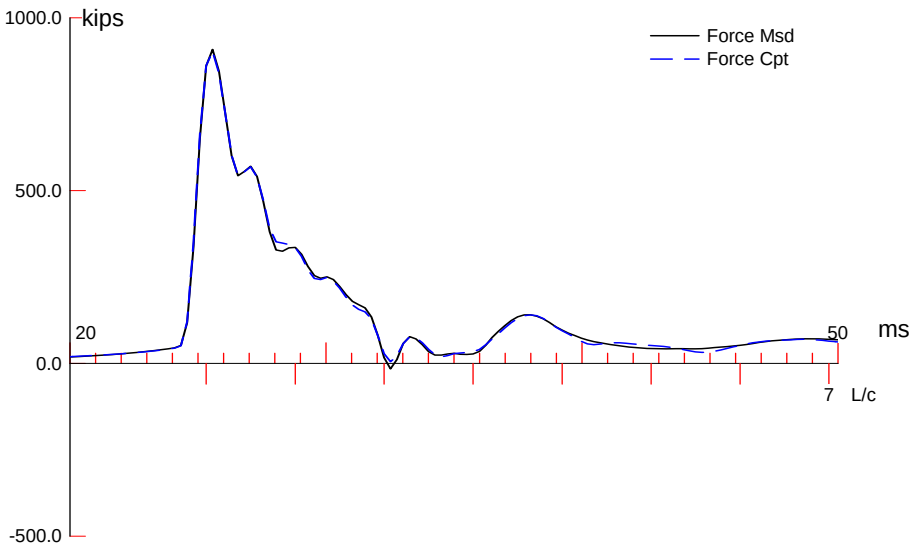
PILE PROFILE AND PILE MODEL

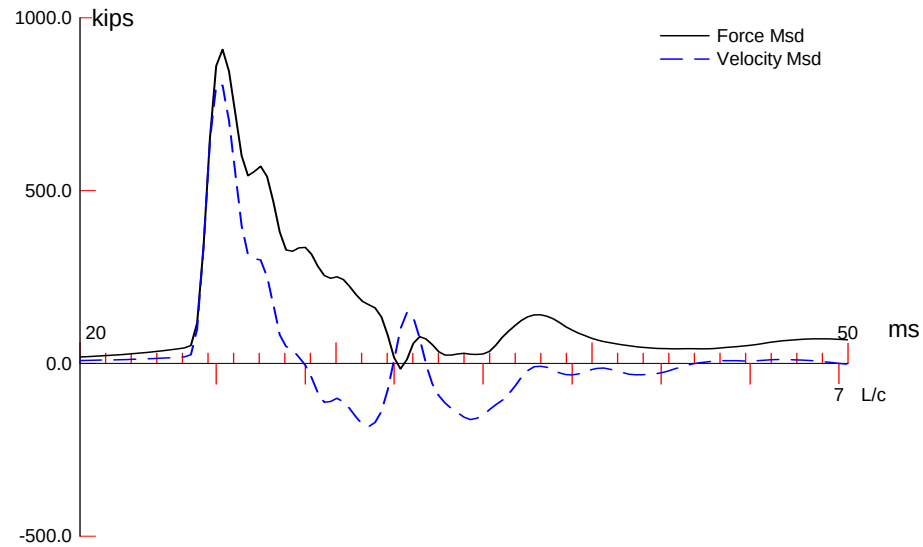
Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.00	153.94	5899.0	150.000	3.665
46.92	153.94	5899.0	150.000	3.665

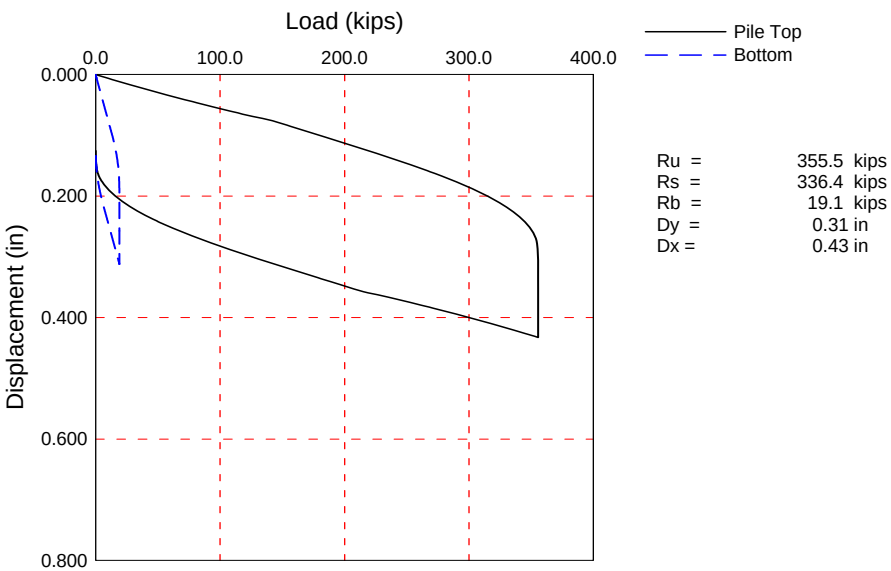
Toe Area 1.069 ft^2

Top Segment Length 3.35 ft, Top Impedance 67.28 kips/ft/s

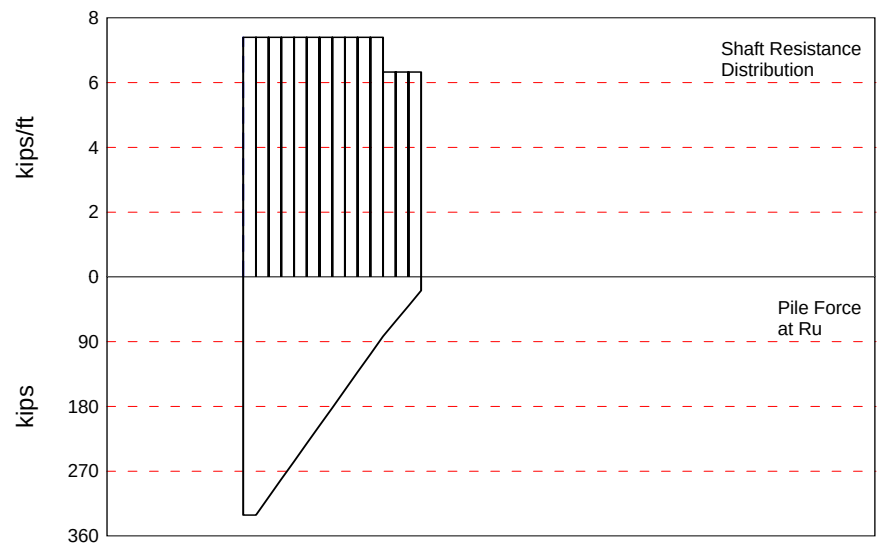
Pile Damping 2.0 %, Time Incr 0.248 ms, Wave Speed 13500.0 ft/s, 2L/c 7.0 ms







Ru =	355.5	kips
Rs =	336.4	kips
Rb =	19.1	kips
Dy =	0.31	in
Dx =	0.43	in



CAPWAP(R) 2006 Licensed to Geotechnology, Inc.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 355.5; along Shaft 336.4; at Toe 19.1 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	Smith Damping Factor s/ft
				355.5				
1	3.4	2.9	24.8	330.7	24.8	8.46	2.31	0.248
2	6.7	6.3	24.8	305.9	49.6	7.40	2.02	0.248
3	10.1	9.6	24.8	281.1	74.4	7.40	2.02	0.248
4	13.4	13.0	24.8	256.3	99.2	7.40	2.02	0.248
5	16.8	16.3	24.8	231.5	124.0	7.40	2.02	0.248
6	20.1	19.7	24.8	206.7	148.8	7.40	2.02	0.248
7	23.5	23.0	24.8	181.9	173.6	7.40	2.02	0.248
8	26.8	26.4	24.8	157.1	198.4	7.40	2.02	0.248
9	30.2	29.7	24.8	132.3	223.2	7.40	2.02	0.248
10	33.5	33.1	24.8	107.5	248.0	7.40	2.02	0.248
11	36.9	36.4	24.8	82.7	272.8	7.40	2.02	0.248
12	40.2	39.8	21.2	61.5	294.0	6.33	1.73	0.248
13	43.6	43.1	21.2	40.3	315.2	6.33	1.73	0.248
14	46.9	46.5	21.2	19.1	336.4	6.33	1.73	0.248
Avg. Shaft			24.0			7.23	1.97	0.248
Toe			19.1				17.87	0.247

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(in)	0.129	0.143
Case Damping Factor		1.242	0.070
Damping Type			Smith
Unloading Quake	(% of loading quake)	97	30
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	76	
Resistance Gap (included in Toe Quake)	(in)		0.100
Soil Plug Weight	(kips)		0.25

CAPWAP match quality = 0.86 (Wave Up Match) ; RSA = 0
Observed: final set = 0.125 in; blow count = 96 b/ft
Computed: final set = 0.105 in; blow count = 114 b/ft

max. Top Comp. Stress = 6.12 ksi (T= 26.1 ms, max= 1.000 x Top)
max. Comp. Stress = 6.12 ksi (Z= 3.4 ft, T= 26.1 ms)
max. Tens. Stress = -0.74 ksi (Z= 30.2 ft, T= 30.8 ms)
max. Energy (EMX) = 14.5 kip-ft; max. Measured Top Displ. (DMX)= 0.28 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	3.4	941.7	-43.2	6.12	-0.28	14.50	11.5	0.260
2	6.7	893.5	-77.3	5.80	-0.50	12.98	10.9	0.246
3	10.1	847.6	-96.1	5.50	-0.62	11.61	10.4	0.232
4	13.4	804.0	-88.0	5.22	-0.57	10.37	9.9	0.220
5	16.8	762.4	-74.9	4.95	-0.49	9.26	9.4	0.222
6	20.1	722.9	-101.8	4.69	-0.66	8.30	8.9	0.224
7	23.5	685.1	-105.5	4.45	-0.69	7.46	8.5	0.224
8	26.8	649.0	-89.7	4.21	-0.58	6.66	8.1	0.225
9	30.2	614.4	-113.4	3.99	-0.74	5.91	7.7	0.226
10	33.5	580.9	-109.5	3.77	-0.71	5.11	7.3	0.227
11	36.9	546.8	-57.1	3.55	-0.37	4.20	7.0	0.228
12	40.2	503.5	-93.3	3.27	-0.61	3.39	6.9	0.229
13	43.6	402.9	-77.9	2.62	-0.51	2.44	9.4	0.228
14	46.9	160.5	-17.4	1.04	-0.11	0.39	11.3	0.228
Absolute	3.4			6.12			(T =	26.1 ms)
	30.2				-0.74		(T =	30.8 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	829.6	736.7	643.8	550.9	458.0	365.1	272.2	179.3	86.4	0.0
RX	829.6	736.7	643.8	550.9	458.0	365.1	280.3	242.1	208.8	199.6
RU	969.6	890.7	811.8	732.9	654.0	575.1	496.2	417.3	338.4	259.5

RAU = 173.7 (kips); RA2 = 435.6 (kips)

Current CAPWAP Ru = 355.5 (kips); Corresponding J(RP)= 0.51; J(RX) = 0.51

VMX ft/s	VFN ft/s	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips
12.44	0.00	837.2	921.4	926.1	0.282	0.122	0.125	15.0	887.6

Peak Velocity Time = 25.57 ms.

PILE PROFILE AND PILE MODEL

Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.00	153.94	5899.0	150.000	3.665
46.92	153.94	5899.0	150.000	3.665

Toe Area 1.069 ft^2

Top Segment Length 3.35 ft, Top Impedance 67.28 kips/ft/s

Pile Damping 2.0 %, Time Incr 0.248 ms, Wave Speed 13500.0 ft/s, 2L/c 7.0 ms