GRL Engineers, Inc.

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TRANSMITTAL

To: Mr. Kevin Weber	From: Al Ziai
Company: Lunda Construction Co.	No. of Sheets: 52
E-mail: kweber@lundaconstruction.com	Date: November 25, 2014

RE: Dynamic Testing Results – USH 10 over Little Lake Butte des Morts
Structure B-70-403 - Pier 21
Winnebago County, Wisconsin

On November 18, 2014, Pier 21 #1, Pier 21 #36, and Pier 21 #44 at the above structure were dynamically tested during initial driving. Project plans indicated the exterior row piles have a required driving resistance or ultimate capacity of 480 kips (240 tons) and the interior row piles have a required driving resistance or ultimate capacity of 400 kips (200 tons). The reference grade at the bottom of the footing excavations was reported to be at elevation EL 735.8. The piles have a required minimum tip elevation of EL 692.5. The HP 14 x 73 H-piles were equipped with driving shoes and were driven with an APE D30-42 hammer (number PD 0234) operated on fuel setting 4.

Pier 21 #1 was driven to a depth of 47.7 feet which corresponds to a pile tip elevation of EL 688.1. The reported pile set over the final ten blows of driving was 2 inches. The average hammer stroke over this increment was 8.7 feet. Pier 21 #36 was driven to a depth of 45.2 feet which corresponds to a pile tip elevation of EL 690.6. The reported pile set over the final ten blows was 4 inches. The average hammer stroke over this increment was 8.7 feet. Pier 21 #44 was driven to a depth of 47.1 feet which corresponds to a pile tip elevation of EL 688.7. The reported pile set over the final ten blows was 1⅜ inch. The average hammer stroke over this increment was 9.9 feet.

Restrike testing was performed on these three piles on November 19. Pier 21 #1 had a reported pile set of 1 inch for five blows at the beginning of the restrike at an average hammer stroke of 8.8 feet. Pier 21 #36 had a reported pile set of 1⅛ inch for five blows at the beginning of the restrike at an average hammer stroke of 8.8 feet. Pier 21 #44 had a reported pile set of no movement for five blows at the beginning of the restrike at an average hammer stroke of 9.5 feet.

Our driving recommendations have been prepared on a blows-per-inch basis. The criteria should be applied only after the minimum pile tip elevation is achieved. For the 480 and 400 kip piles driven with an APE D30-42 hammer (PD 0234) in Pier 21 of the USH 10 bridge over Little Lake Butte des Morts we recommend using the following criteria:

Field Observed Hammer Stroke (feet)	Exterior Piles (480 kips) Recommended Minimum Blow Count (blows per inch)	Interior Piles (400 kips) Recommended Minimum Blow Count (blows per inch)
7.0	8	4
7.5	7	4
8.0	6	4
8.5	5	4
9.0	5	3
9.5	5	3
10.0	5	3

We recommend the above blow counts at the required stroke be maintained for **three consecutive inches** of driving. We recommend terminating driving **if the blow counts exceed 10** blows over an increment of one inch or less at hammer strokes of 9.0 feet, after satisfying any minimum tip requirements. We anticipate the production piles will terminate at depths similar to those of the test piles.

These criteria should not be used for acceptance of piles under restrike and/or redrive conditions. After splicing or any other delays, we recommend not applying the criteria until a full foot of driving has occurred beyond the termination depth associated with the delay, unless the blow count exceeds 10 blows per inch.

Please call if you have any questions on these recommendations.

GRL Engineers, Inc.

Al Ziai

Travis Coleman, P.E.

Cc: Jeff Horsfall – jeffrey.horsfall@dot.wi.gov

Attachments:

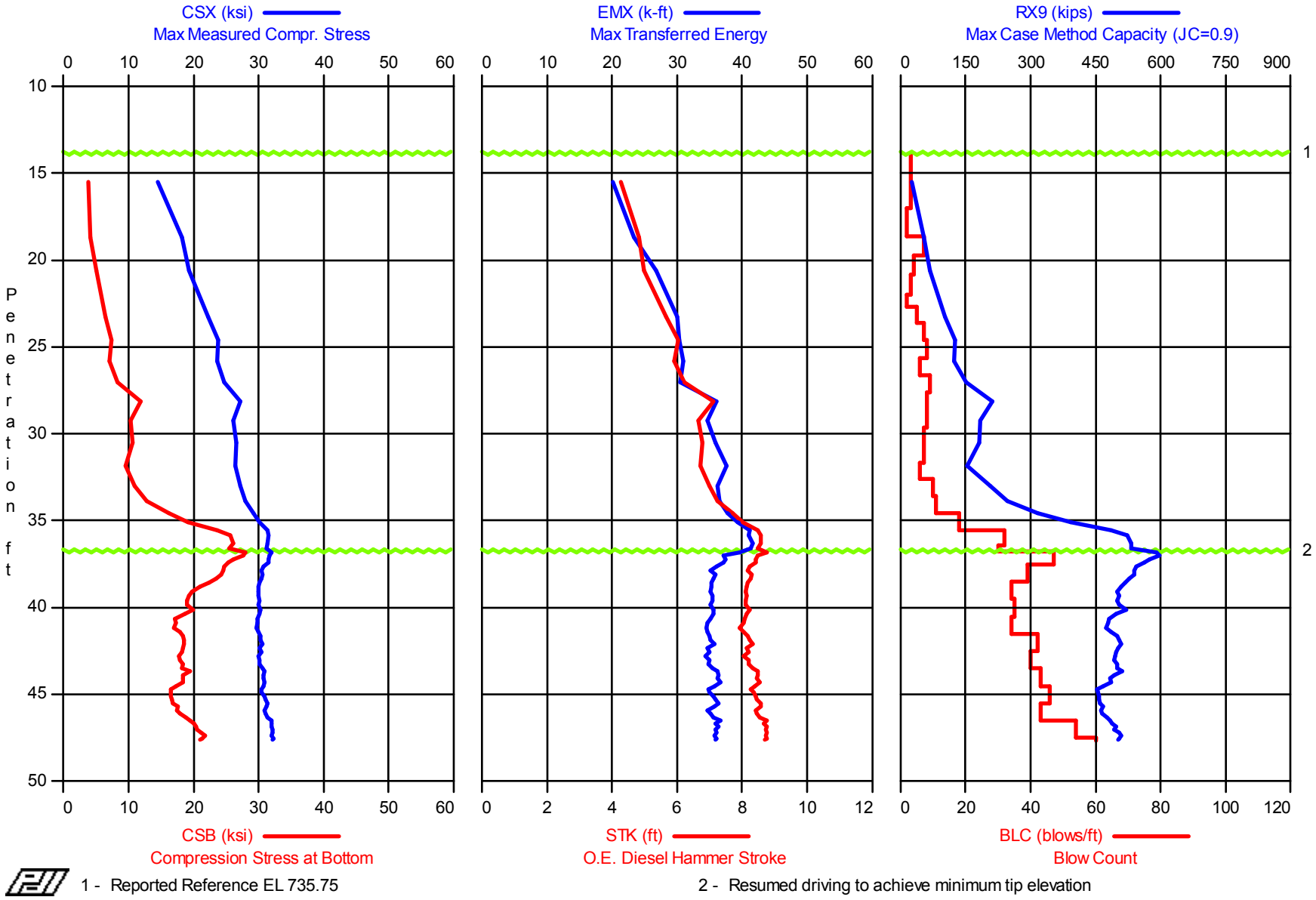
Dynamic Test Results - (pages 3 – 20)
CAPWAP Analysis Results - (pages 21 – 52)

GRL Engineers, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 24-Nov-2014

Test date: 18-Nov-2014

USH 10 over Little Lake Butte des Morts - Pier 21 #1
APE D30-42, HP 14 x 73



1 - Reported Reference EL 735.75

2 - Resumed driving to achieve minimum tip elevation

USH 10 over Little Lake Butte des Morts - Pier 21 #1
OP: MR

APE D30-42, HP 14 x 73
Test date: 18-Nov-2014

AR: 21.40 in^2
LE: 77.50 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 1.20

CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom
EMX: Max Transferred Energy

STK: O.E. Diesel Hammer Stroke
BPM: Blows per Minute
RX9: Max Case Method Capacity (JC=0.9)

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
7	11.50	3	AV1	9.4	2.9	9	3.5	61.5	0
			MAX	9.4	2.9	9	3.5	61.5	0
			MIN	9.4	2.9	9	3.5	61.5	0
7	13.50	3	AV1	23.6	4.9	38	6.3	46.7	33
			MAX	23.6	4.9	38	6.3	46.7	33
			MIN	23.6	4.9	38	6.3	46.7	33
9	14.50	3	AV1	13.1	3.5	17	3.6	60.7	0
			MAX	13.1	3.5	17	3.6	60.7	0
			MIN	13.1	3.5	17	3.6	60.7	0
12	15.50	3	AV2	9.7	3.1	15	3.4	62.9	16
			STD	2.4	0.4	5	0.4	3.2	13
			MAX	12.1	3.6	20	3.8	66.1	29
			MIN	7.3	2.7	11	3.0	59.7	3
15	16.50	3	AV3	16.2	4.1	22	4.5	54.7	47
			STD	1.0	0.1	2	0.2	1.1	7
			MAX	17.5	4.2	24	4.8	55.6	56
			MIN	15.1	4.0	20	4.4	53.2	39
17	17.50	2	AV2	14.9	3.8	20	4.3	56.2	35
			STD	0.9	0.2	1	0.1	0.8	1
			MAX	15.8	4.0	21	4.4	57.0	36
			MIN	14.0	3.6	19	4.2	55.4	34
19	18.50	2	AV2	17.1	4.1	27	4.6	54.2	37
			STD	1.6	0.3	4	0.3	1.9	1
			MAX	18.7	4.3	30	5.0	56.1	38
			MIN	15.4	3.8	23	4.3	52.3	36
26	19.50	7	AV7	19.0	4.3	22	4.9	52.7	63
			STD	1.4	0.2	4	0.4	1.8	11
			MAX	20.9	4.7	27	5.4	55.2	75
			MIN	16.9	3.9	17	4.5	50.5	42
30	20.50	4	AV4	17.4	4.8	22	4.6	54.6	68
			STD	3.0	0.5	7	0.6	3.4	6
			MAX	21.7	5.3	32	5.5	58.5	78
			MIN	14.1	4.2	15	3.9	49.9	64
33	21.50	3	AV3	21.7	5.4	33	5.5	49.9	63
			STD	0.6	0.2	3	0.2	0.7	8
			MAX	22.4	5.7	37	5.7	50.7	70
			MIN	20.9	5.3	30	5.3	49.1	52
35	22.50	2	AV2	22.1	5.7	38	5.6	49.6	65
			STD	0.5	0.1	1	0.1	0.6	4
			MAX	22.7	5.8	39	5.7	50.2	69
			MIN	21.6	5.6	36	5.4	49.0	61
40	23.50	5	AV5	22.2	6.3	30	5.7	49.3	103
			STD	0.6	0.3	1	0.2	0.7	3
			MAX	22.9	6.8	32	5.9	50.3	105
			MIN	21.4	6.1	28	5.4	48.4	97
47	24.50	7	AV7	23.3	7.2	29	5.9	48.2	122
			STD	1.1	0.4	3	0.3	1.2	7
			MAX	24.8	7.9	33	6.4	49.9	130
			MIN	21.8	6.6	25	5.5	46.6	111

USH 10 over Little Lake Butte des Morts - Pier 21 #1
OP: MR

APE D30-42, HP 14 x 73
Test date: 18-Nov-2014

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
55	25.50	8	AV8	23.7	7.1	30	6.0	48.1	126
			STD	0.5	0.2	1	0.1	0.6	3
			MAX	24.3	7.4	31	6.1	49.3	130
			MIN	22.5	6.9	27	5.7	47.4	122
61	26.50	6	AV6	23.4	7.0	31	5.9	48.5	123
			STD	0.5	0.2	1	0.1	0.6	3
			MAX	24.2	7.3	32	6.0	49.4	127
			MIN	22.6	6.7	30	5.6	47.8	119
70	27.50	9	AV9	24.7	8.3	30	6.2	47.1	152
			STD	0.7	1.3	1	0.2	0.7	27
			MAX	25.7	10.9	32	6.5	48.6	205
			MIN	23.3	7.0	27	5.8	46.1	129
78	28.50	8	AV8	27.1	12.0	36	7.1	44.3	213
			STD	0.6	0.4	2	0.2	0.6	7
			MAX	28.4	12.5	39	7.6	45.0	221
			MIN	26.3	11.3	33	6.9	42.9	202
86	29.50	8	AV8	26.2	10.1	34	6.7	45.6	184
			STD	0.7	0.5	1	0.2	0.7	13
			MAX	27.8	10.9	37	7.2	46.4	201
			MIN	25.6	9.3	34	6.4	43.9	163
93	30.50	7	AV7	26.8	11.1	36	6.9	45.0	193
			STD	0.4	0.2	1	0.1	0.3	3
			MAX	27.6	11.4	38	7.0	45.4	199
			MIN	26.4	11.0	34	6.7	44.4	188
100	31.50	7	AV7	26.3	9.5	36	6.7	45.6	157
			STD	0.5	0.5	1	0.2	0.5	13
			MAX	27.2	10.3	38	7.0	46.5	178
			MIN	25.4	8.8	35	6.4	44.6	136
106	32.50	6	AV6	26.6	9.8	38	6.8	45.3	157
			STD	0.5	0.3	1	0.1	0.5	11
			MAX	27.2	10.4	39	6.9	45.9	176
			MIN	25.8	9.4	36	6.6	44.7	145
116	33.50	10	AV10	27.2	11.1	36	7.0	44.5	210
			STD	0.4	1.0	1	0.1	0.4	24
			MAX	28.1	12.4	38	7.3	45.1	245
			MIN	26.6	9.8	34	6.8	43.6	173
127	34.50	11	AV11	28.2	13.6	37	7.4	43.5	258
			STD	0.5	1.1	1	0.2	0.5	21
			MAX	29.3	15.8	38	7.8	44.1	297
			MIN	27.6	12.3	36	7.1	42.4	218
145	35.50	18	AV18	30.0	18.8	39	8.0	41.8	382
			STD	0.7	2.0	1	0.2	0.6	46
			MAX	31.4	23.0	42	8.5	42.8	473
			MIN	28.8	15.6	37	7.6	40.5	292
174	36.42	32	AV24	31.4	25.5	41	8.6	40.4	522
			STD	0.4	0.9	1	0.1	0.3	12
			MAX	32.1	26.6	44	9.0	40.8	540
			MIN	30.8	23.5	40	8.4	39.4	491
184	36.75	30	AV10	31.3	25.6	41	8.5	40.6	532
			STD	0.2	0.6	1	0.1	0.2	8
			MAX	31.4	26.6	43	8.6	41.1	542
			MIN	30.6	24.5	39	8.3	40.4	519
219	37.50	47	AV35	31.7	26.8	38	8.5	40.5	582
			STD	0.6	1.5	1	0.2	0.6	24
			MAX	33.9	30.2	42	9.5	41.5	635
			MIN	30.6	24.2	35	8.1	38.5	543

USH 10 over Little Lake Butte des Morts - Pier 21 #1
OP: MR

APE D30-42, HP 14 x 73
Test date: 18-Nov-2014

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
258	38.50	39	AV39	30.5	24.1	36	8.2	41.2	536
			STD	0.4	0.8	1	0.1	0.3	10
			MAX	31.5	25.5	38	8.5	41.7	553
			MIN	29.9	22.5	34	8.0	40.5	517
292	39.50	34	AV34	30.0	20.4	35	8.1	41.4	507
			STD	0.5	1.1	1	0.2	0.4	9
			MAX	31.0	22.7	37	8.5	42.3	524
			MIN	28.9	18.7	33	7.8	40.5	491
327	40.50	35	AV35	30.1	19.1	35	8.1	41.4	506
			STD	0.4	0.9	1	0.2	0.4	15
			MAX	31.6	20.8	38	8.7	42.1	532
			MIN	29.3	17.1	33	7.9	40.2	478
361	41.50	34	AV34	29.8	17.3	35	8.0	41.7	479
			STD	0.4	0.4	1	0.2	0.4	7
			MAX	30.9	18.4	37	8.4	42.5	494
			MIN	28.9	16.7	33	7.7	40.8	464
403	42.50	42	AV40	30.3	18.4	35	8.2	41.3	503
			STD	0.4	0.3	1	0.2	0.4	6
			MAX	31.0	19.1	37	8.5	42.0	518
			MIN	29.5	17.9	33	7.9	40.5	486
443	43.50	40	AV40	30.2	18.1	35	8.2	41.3	497
			STD	0.3	0.4	1	0.1	0.3	6
			MAX	30.9	19.3	37	8.4	42.0	507
			MIN	29.5	17.4	33	7.9	40.7	486
486	44.50	43	AV43	30.8	18.5	36	8.5	40.6	491
			STD	0.4	0.7	1	0.1	0.3	13
			MAX	31.6	20.3	39	8.8	41.3	523
			MIN	30.1	17.1	34	8.2	39.9	465
532	45.50	46	AV46	30.8	16.6	35	8.4	40.8	458
			STD	0.5	0.3	1	0.2	0.4	5
			MAX	31.9	17.7	38	8.8	41.7	468
			MIN	29.9	15.9	33	8.0	39.8	447
575	46.50	43	AV43	31.2	17.9	35	8.5	40.5	468
			STD	0.5	0.7	1	0.2	0.4	7
			MAX	32.2	19.3	37	8.8	41.5	481
			MIN	29.9	16.6	32	8.1	39.9	454
629	47.50	54	AV54	32.1	20.7	36	8.7	40.0	497
			STD	0.5	0.8	1	0.2	0.4	10
			MAX	33.2	22.6	38	9.1	40.7	517
			MIN	31.2	19.3	34	8.4	39.2	472
639	47.67	60	AV10	32.2	21.1	36	8.7	40.0	504
			STD	0.4	0.4	1	0.2	0.3	6
			MAX	32.8	21.8	38	9.0	40.4	511
			MIN	31.6	20.4	35	8.6	39.4	492
			Average	29.4	17.9	35	7.9	42.3	430
			Std. Dev.	3.4	5.6	4	1.0	3.4	147
			Maximum	33.9	30.2	44	9.5	66.1	635
			Minimum	7.3	2.7	9	3.0	38.5	0

Total number of blows analyzed: 625

BL#	depth (ft)	Comments
7	13.83	Reported Reference EL 735.75
184	36.75	Resumed driving to achieve minimum tip elevation

Time Summary

Drive	8 minutes 17 seconds	2:50:30 PM - 2:58:47 PM (11/18/2014) BN 1 - 186
Stop	1 hour 48 minutes 35 seconds	2:58:47 PM - 4:47:22 PM
Drive	11 minutes 4 seconds	4:47:22 PM - 4:58:26 PM BN 187 - 640

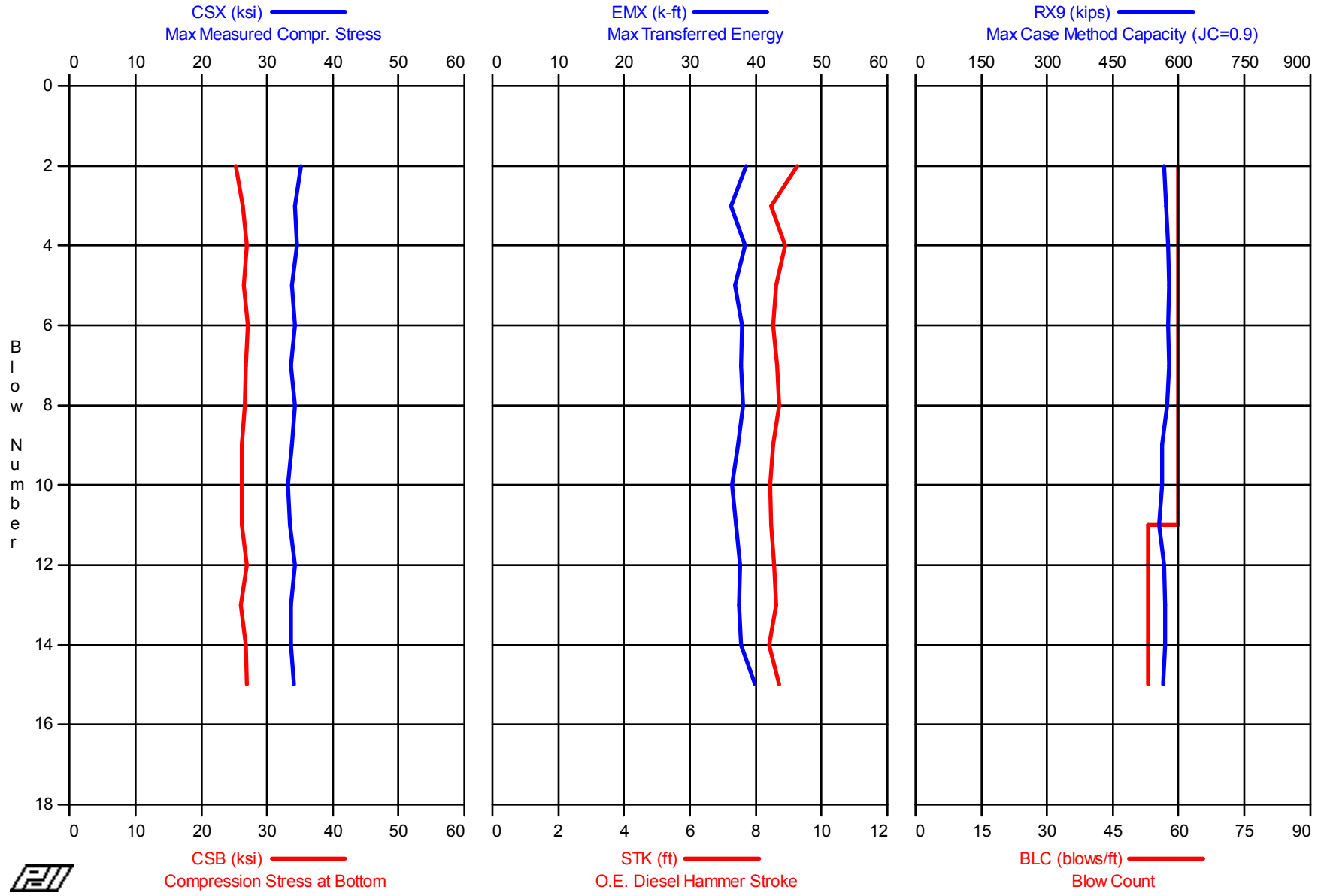
Total time [2:07:56] = (Driving [0:19:21] + Stop [1:48:35])

GRL Engineers, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 24-Nov-2014

Test date: 19-Nov-2014

USH 10 over Little Lake Butte des Morts - Pier 21 #1 Restrike
APE D30-42, HP 14 x 73



USH 10 over Little Lake Butte des Morts - Pier 21 #1 Restrike
OP: MR

APE D30-42, HP 14 x 73
Test date: 19-Nov-2014

AR: 21.40 in^2
LE: 51.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 1.20

CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom
EMX: Max Transferred Energy

STK: O.E. Diesel Hammer Stroke
BPM: Blows per Minute
RX9: Max Case Method Capacity (JC=0.9)

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
5	47.73	60	AV4	34.4	26.2	38	8.8	39.9	573
			STD	0.5	0.6	1	0.3	0.6	4
			MAX	35.2	27.0	39	9.3	40.6	578
			MIN	33.8	25.2	36	8.5	38.9	568
10	47.82	60	AV5	33.8	26.5	37	8.6	40.4	571
			STD	0.4	0.3	1	0.1	0.2	7
			MAX	34.2	27.0	38	8.7	40.7	579
			MIN	33.2	26.2	36	8.4	40.1	563
15	47.91	53	AV5	33.8	26.5	38	8.6	40.4	566
			STD	0.3	0.4	1	0.1	0.2	5
			MAX	34.2	26.9	40	8.7	40.8	570
			MIN	33.5	26.0	37	8.4	40.1	557
			Average	34.0	26.4	38	8.6	40.3	570
			Std. Dev.	0.5	0.5	1	0.2	0.5	6
			Maximum	35.2	27.0	40	9.3	40.8	579
			Minimum	33.2	25.2	36	8.4	38.9	557

Total number of blows analyzed: 14

Time Summary

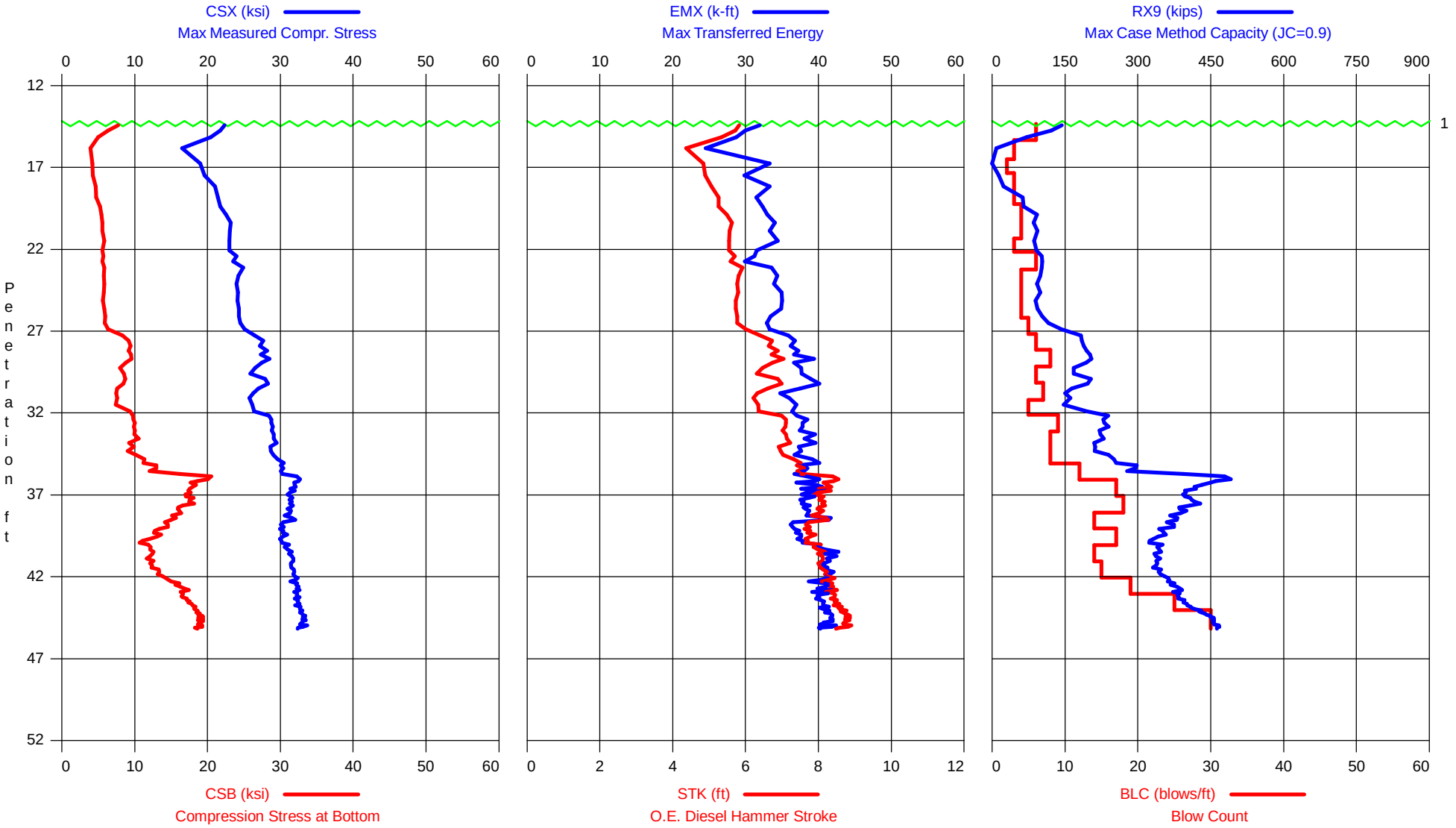
Drive 21 seconds 9:19:58 AM - 9:20:19 AM (11/19/2014) BN 1 - 15

GRL Engineers, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 25-Nov-2014

Test date: 18-Nov-2014

USH 10 over Little Lake Butte des Morts - Pier 21 #36
APE D30-42, HP 14 x 73



1 - Reference Elevation EL 735.75

USH 10 over Little Lake Butte des Morts - Pier 21 #36 APE D30-42, HP 14 x 73
OP: MR Test date: 18-Nov-2014

AR: 21.40 in^2 SP: 0.492 k/ft3
LE: 51.00 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 1.20

CSX: Max Measured Compr. Stress STK: O.E. Diesel Hammer Stroke
CSB: Compression Stress at Bottom BPM: Blows per Minute
EMX: Max Transferred Energy RX9: Max Case Method Capacity (JC=0.9)

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
7	12.00	6	AV1	21.5	7.8	31	5.5	50.0	145
			MAX	21.5	7.8	31	5.5	50.0	145
			MIN	21.5	7.8	31	5.5	50.0	145
7	13.00	6	AV1	23.2	7.6	33	6.1	47.4	142
			MAX	23.2	7.6	33	6.1	47.4	142
			MIN	23.2	7.6	33	6.1	47.4	142
7	14.00	6	AV1	22.9	6.7	32	6.1	47.7	128
			MAX	22.9	6.7	32	6.1	47.7	128
			MIN	22.9	6.7	32	6.1	47.7	128
11	15.00	6	AV2	20.2	5.6	27	5.3	51.0	104
			STD	0.4	0.4	1	0.1	0.4	13
			MAX	20.6	6.0	28	5.4	51.4	116
			MIN	19.8	5.3	26	5.2	50.5	91
14	16.00	3	AV3	18.0	4.2	27	4.7	53.8	23
			STD	2.5	0.4	3	0.6	2.9	21
			MAX	21.0	4.7	31	5.5	57.1	50
			MIN	14.8	3.6	23	4.1	50.0	0
16	17.00	2	AV2	19.0	4.2	33	4.8	53.1	0
			STD	0.4	0.0	1	0.2	1.0	0
			MAX	19.5	4.2	34	5.0	54.1	0
			MIN	18.6	4.1	33	4.6	52.1	0
19	18.00	3	AV3	19.9	4.3	31	4.9	52.7	21
			STD	0.6	0.1	1	0.2	0.9	10
			MAX	20.4	4.5	32	5.1	53.9	35
			MIN	19.0	4.2	29	4.7	51.8	10
22	19.00	3	AV3	21.5	4.8	32	5.2	51.2	46
			STD	0.7	0.1	2	0.1	0.6	26
			MAX	22.2	4.8	34	5.4	51.8	73
			MIN	20.6	4.6	29	5.1	50.3	11
26	20.00	4	AV4	22.1	5.4	33	5.4	50.5	79
			STD	0.9	0.1	1	0.2	0.9	14
			MAX	22.9	5.5	34	5.5	52.0	96
			MIN	20.7	5.2	31	5.1	49.8	61
30	21.00	4	AV4	23.1	5.6	34	5.6	49.6	89
			STD	0.2	0.1	1	0.1	0.3	6
			MAX	23.4	5.8	34	5.7	50.1	93
			MIN	22.8	5.4	33	5.5	49.3	79
33	22.00	3	AV3	23.1	5.8	34	5.5	49.8	85
			STD	0.5	0.0	0	0.1	0.4	2
			MAX	23.6	5.9	35	5.7	50.2	88
			MIN	22.4	5.8	34	5.4	49.3	84
39	23.00	6	AV6	23.8	5.6	31	5.7	49.2	102
			STD	0.8	0.2	1	0.2	0.6	4
			MAX	24.9	5.8	32	6.0	49.7	107
			MIN	22.6	5.3	29	5.6	48.1	97
43	24.00	4	AV4	24.4	5.9	35	5.8	48.6	97
			STD	0.6	0.2	1	0.1	0.6	4
			MAX	25.0	6.2	36	6.0	49.5	104
			MIN	23.5	5.7	33	5.6	47.9	93
47	25.00	4	AV4	23.9	5.7	34	5.7	49.0	94
			STD	0.3	0.1	1	0.1	0.4	6
			MAX	24.5	5.8	35	5.9	49.4	103
			MIN	23.6	5.5	33	5.6	48.4	87
51	26.00	4	AV4	24.4	5.8	35	5.8	48.8	92
			STD	0.1	0.2	0	0.0	0.2	3
			MAX	24.4	6.0	35	5.8	49.1	96
			MIN	24.2	5.5	34	5.7	48.6	89

USH 10 over Little Lake Butte des Morts - Pier 21 #36
OP: MR

APE D30-42, HP 14 x 73
Test date: 18-Nov-2014

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
56	27.00	5	AV5	24.7	6.1	33	5.9	48.5	126
			STD	0.4	0.2	1	0.1	0.5	16
			MAX	25.5	6.5	34	6.1	49.0	156
			MIN	24.2	5.8	32	5.7	47.6	106
62	28.00	6	AV6	27.1	9.0	36	6.6	45.9	185
			STD	0.7	0.6	1	0.2	0.7	4
			MAX	27.9	9.6	37	6.8	47.3	189
			MIN	25.9	7.8	35	6.2	45.1	178
70	29.00	8	AV8	27.9	9.3	37	6.8	45.0	198
			STD	0.6	0.5	1	0.2	0.5	6
			MAX	28.7	10.0	39	7.1	45.9	207
			MIN	26.8	8.4	35	6.6	44.3	187
76	30.00	6	AV6	26.8	8.4	38	6.6	46.0	180
			STD	0.8	0.4	1	0.2	0.8	18
			MAX	28.0	8.8	39	6.9	46.9	207
			MIN	25.8	7.8	36	6.3	44.7	155
83	31.00	7	AV7	27.0	7.8	37	6.6	45.9	168
			STD	1.0	0.5	2	0.3	1.1	20
			MAX	28.5	8.8	41	7.0	47.5	204
			MIN	25.6	7.4	34	6.1	44.4	148
88	32.00	5	AV5	26.2	8.2	37	6.3	46.7	170
			STD	0.6	1.7	2	0.1	0.5	32
			MAX	27.0	11.7	39	6.5	47.4	233
			MIN	25.3	7.1	34	6.1	46.0	147
97	33.00	9	AV9	28.7	9.9	38	7.1	44.3	234
			STD	0.3	0.4	1	0.1	0.3	7
			MAX	29.2	10.5	39	7.2	44.7	247
			MIN	28.3	9.2	37	6.9	43.8	222
105	34.00	8	AV8	29.1	10.0	39	7.1	44.2	219
			STD	0.3	0.5	1	0.1	0.3	11
			MAX	29.5	10.8	40	7.2	44.6	242
			MIN	28.8	9.0	37	7.0	43.8	204
113	35.00	8	AV8	29.2	10.2	38	7.1	44.1	230
			STD	0.8	0.9	2	0.3	0.8	18
			MAX	30.8	11.8	43	7.6	45.2	250
			MIN	28.4	8.7	35	6.8	42.8	201
125	36.00	12	AV12	30.7	15.1	38	7.7	42.6	355
			STD	1.0	3.8	2	0.5	1.1	93
			MAX	33.1	21.9	41	8.8	44.1	492
			MIN	29.3	11.5	34	7.1	39.9	276
142	37.00	17	AV17	31.8	17.9	39	8.2	41.3	425
			STD	0.6	0.9	2	0.2	0.6	29
			MAX	33.0	19.8	41	8.7	42.5	491
			MIN	30.5	16.3	37	7.7	40.2	384
160	38.00	18	AV18	31.4	17.0	38	8.1	41.5	404
			STD	0.3	0.9	1	0.1	0.3	15
			MAX	31.8	18.5	40	8.3	42.4	432
			MIN	30.5	15.2	37	7.8	41.1	378
174	39.00	14	AV14	30.9	15.1	38	7.9	42.0	375
			STD	0.8	0.8	2	0.3	0.7	13
			MAX	32.7	16.9	43	8.5	43.0	398
			MIN	30.0	14.1	35	7.5	40.6	359
191	40.00	17	AV17	30.3	12.3	38	7.7	42.4	341
			STD	0.5	1.0	1	0.2	0.4	14
			MAX	31.3	13.8	40	8.1	43.1	366
			MIN	29.5	10.6	36	7.5	41.5	316
205	41.00	14	AV14	31.3	12.2	41	8.0	41.7	342
			STD	0.5	0.4	1	0.1	0.3	9
			MAX	32.2	12.9	44	8.3	42.2	359
			MIN	30.4	11.6	40	7.8	41.0	328

USH 10 over Little Lake Butte des Morts - Pier 21 #36
OP: MR

APE D30-42, HP 14 x 73
Test date: 18-Nov-2014

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
220	42.00	15	AV15	31.7	12.9	41	8.1	41.5	343
			STD	0.4	0.6	1	0.2	0.4	8
			MAX	32.3	14.0	43	8.4	42.2	357
			MIN	30.8	12.1	39	7.8	40.9	326
239	43.00	19	AV19	32.2	15.9	41	8.3	40.9	374
			STD	0.5	1.0	1	0.2	0.4	11
			MAX	33.1	17.7	43	8.7	41.7	392
			MIN	31.2	13.9	38	8.0	40.2	357
264	44.00	25	AV25	32.4	17.4	40	8.5	40.6	396
			STD	0.4	0.7	1	0.1	0.3	12
			MAX	33.4	19.1	42	8.8	41.1	419
			MIN	31.8	16.3	39	8.3	39.9	376
294	45.00	30	AV30	33.1	18.9	41	8.8	40.0	448
			STD	0.5	0.5	1	0.2	0.4	12
			MAX	34.4	19.9	44	9.1	40.8	469
			MIN	32.0	18.2	39	8.4	39.2	422
299	45.17	30	AV5	32.7	18.7	41	8.7	40.2	465
			STD	0.4	0.5	1	0.2	0.3	6
			MAX	33.1	19.3	42	8.9	40.6	471
			MIN	32.1	18.2	39	8.5	39.7	455
			Average	29.5	12.9	38	7.5	43.5	301
			Std. Dev.	3.7	4.8	3	1.1	3.5	130
			Maximum	34.4	21.9	44	9.1	57.1	492
			Minimum	14.8	3.6	23	4.1	39.2	0

Total number of blows analyzed: 293

BL#	depth (ft)	Comments
7	14.33	Reference Elevation EL 735.75

Time Summary

Drive 6 minutes 54 seconds 3:42:32 PM - 3:49:26 PM (11/18/2014) BN 1 - 299

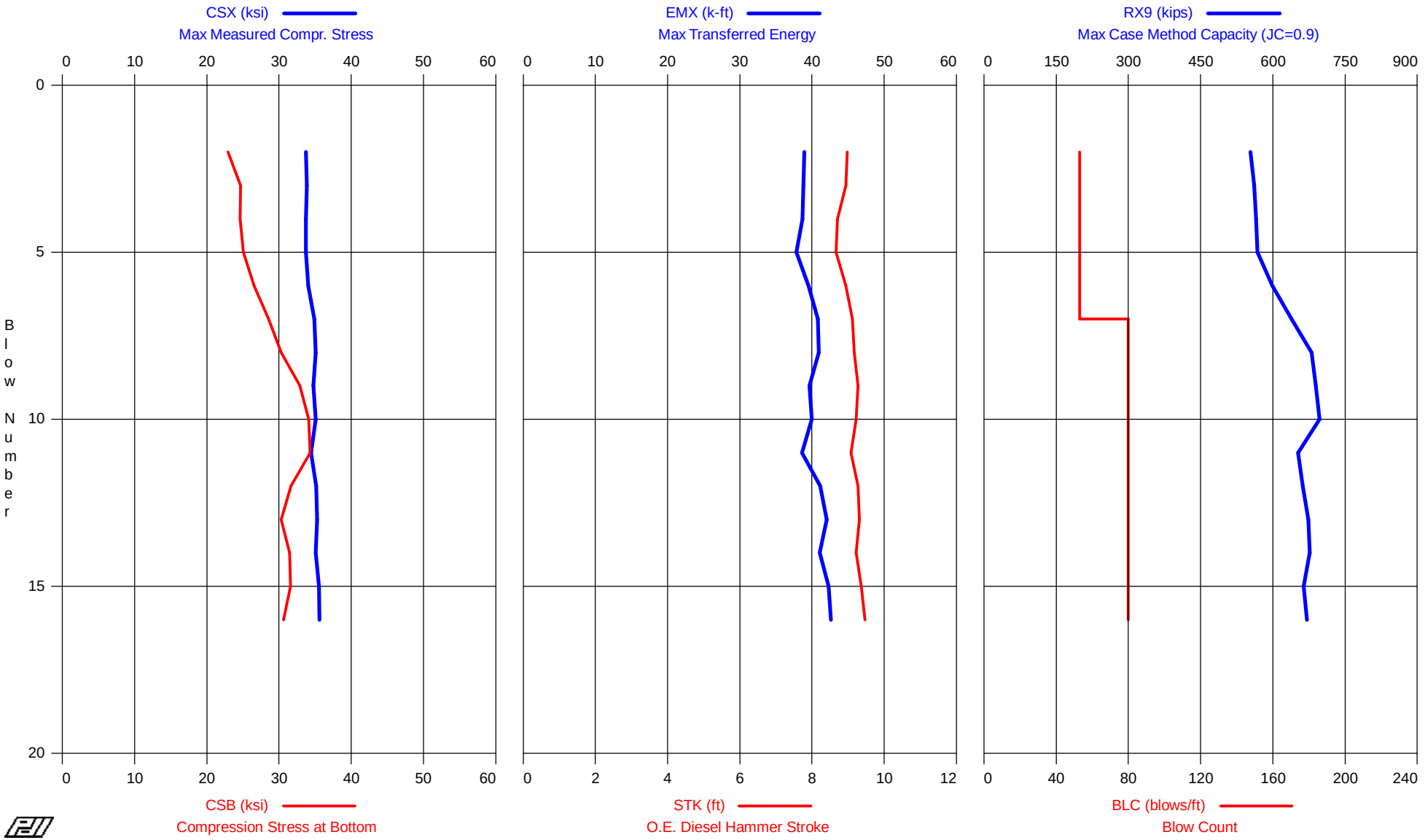
GRL Engineers, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 25-Nov-2014

Test date: 19-Nov-2014

USH 10 over LLBDM - Pier 21 #36 Restrike

APE D30-42, HP 14 x 73



USH 10 over LLBDM - Pier 21 #36 Restrike
OP: MR

APE D30-42, HP 14 x 73
Test date: 19-Nov-2014

AR: 21.40 in^2
LE: 51.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 1.20

CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom
STK: O.E. Diesel Hammer Stroke

EMX: Max Transferred Energy
BPM: Blows per Minute
RX9: Max Case Method Capacity (JC=0.9)

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	STK ft	EMX k-ft	BPM **	RX9 kips
6	45.25	53	AV5	33.8	24.8	8.8	39	40	570
			STD	0.1	1.1	0.1	1	0	15
			MAX	34.1	26.5	9.0	40	40	599
			MIN	33.7	22.9	8.7	38	40	554
11	45.32	80	AV5	34.9	32.0	9.2	40	39	671
			STD	0.2	2.3	0.1	1	0	22
			MAX	35.1	34.3	9.3	41	39	697
			MIN	34.4	28.5	9.1	39	39	638
16	45.38	80	AV5	35.3	31.1	9.3	42	39	669
			STD	0.2	0.5	0.1	1	0	6
			MAX	35.6	31.7	9.5	43	39	676
			MIN	35.0	30.3	9.2	41	39	662
			Average	34.7	29.3	9.1	40	39	637
			Std. Dev.	0.7	3.6	0.2	1	0	50
			Maximum	35.6	34.3	9.5	43	40	697
			Minimum	33.7	22.9	8.7	38	39	554

Total number of blows analyzed: 15

Time Summary

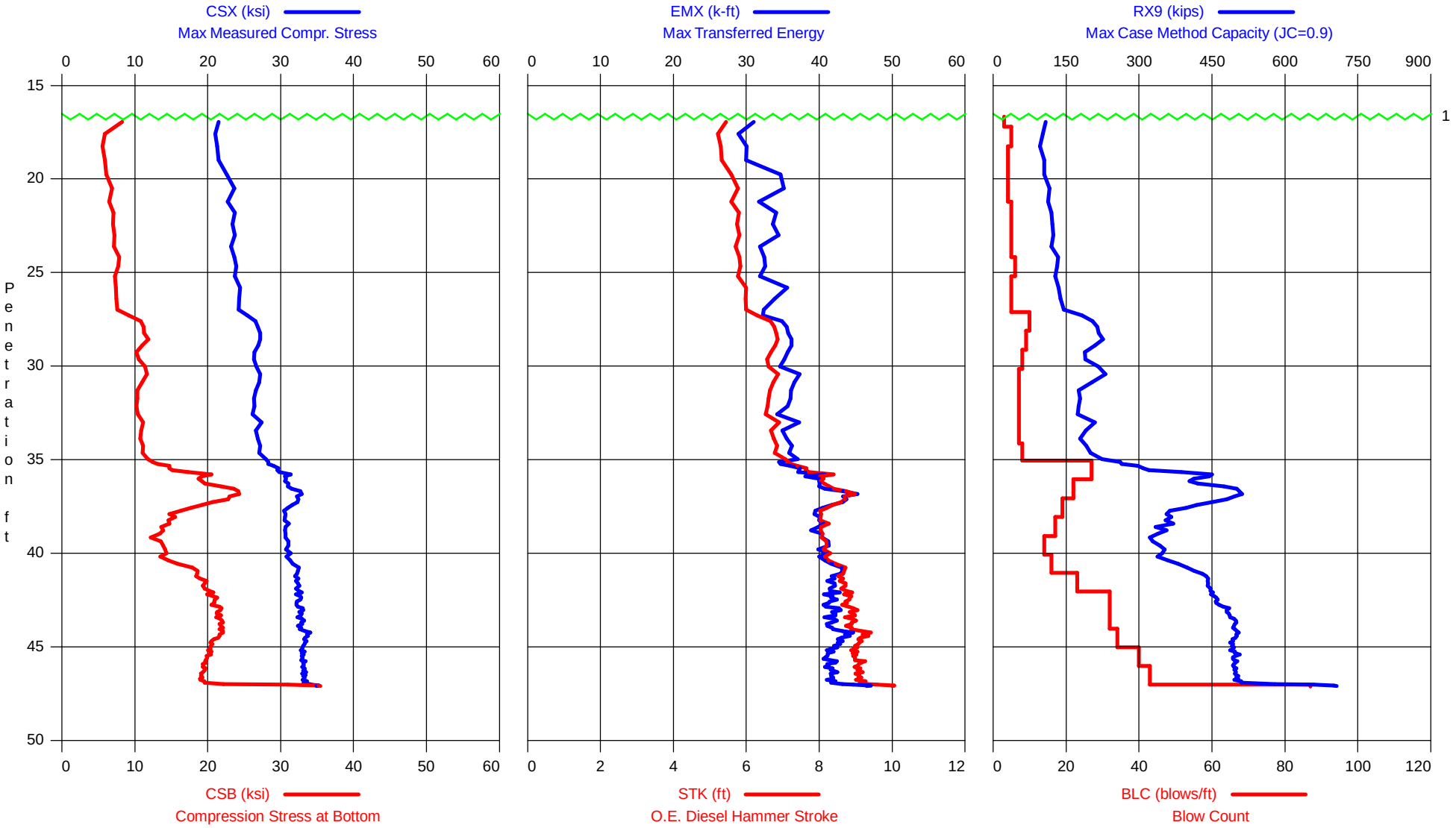
Drive 22 seconds 9:32:55 AM - 9:33:17 AM (11/19/2014) BN 2 - 16

GRL Engineers, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 25-Nov-2014

Test date: 18-Nov-2014

USH 10 over Little Lake Butte des Morts - Pier 21 #44
APE D30-42, HP 14 x 73



1 - Reference Elevation EL 735.75

USH 10 over Little Lake Butte des Morts - Pier 21 #44 APE D30-42, HP 14 x 73
OP: MR Test date: 18-Nov-2014

AR: 21.40 in^2 SP: 0.492 k/ft3
LE: 77.50 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 1.20

CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom
EMX: Max Transferred Energy
STK: O.E. Diesel Hammer Stroke
BPM: Blows per Minute
RX9: Max Case Method Capacity (JC=0.9)

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
13	12.00	3	AV1	18.2	7.9	22	4.4	55.3	106
			MAX	18.2	7.9	22	4.4	55.3	106
			MIN	18.2	7.9	22	4.4	55.3	106
13	13.00	3	AV1	21.9	8.2	34	5.6	49.7	99
			MAX	21.9	8.2	34	5.6	49.7	99
			MIN	21.9	8.2	34	5.6	49.7	99
13	14.00	3	AV1	24.5	8.7	37	6.3	46.7	118
			MAX	24.5	8.7	37	6.3	46.7	118
			MIN	24.5	8.7	37	6.3	46.7	118
13	15.00	3	AV1	21.8	6.5	31	5.4	50.4	107
			MAX	21.8	6.5	31	5.4	50.4	107
			MIN	21.8	6.5	31	5.4	50.4	107
13	16.00	3	AV1	20.5	5.7	28	5.1	51.8	103
			MAX	20.5	5.7	28	5.1	51.8	103
			MIN	20.5	5.7	28	5.1	51.8	103
14	17.00	3	AV1	20.7	5.4	28	5.2	51.4	97
			MAX	20.7	5.4	28	5.2	51.4	97
			MIN	20.7	5.4	28	5.2	51.4	97
19	18.00	5	AV1	21.4	5.4	28	5.4	50.5	101
			MAX	21.4	5.4	28	5.4	50.5	101
			MIN	21.4	5.4	28	5.4	50.5	101
23	19.00	4	AV4	21.2	5.7	30	5.3	51.0	99
			STD	0.6	0.3	1	0.2	0.8	7
			MAX	22.0	6.1	32	5.5	52.2	108
			MIN	20.4	5.2	29	5.0	49.9	89
27	20.00	4	AV4	22.4	6.2	34	5.5	49.8	106
			STD	0.4	0.2	2	0.1	0.4	6
			MAX	23.0	6.3	36	5.7	50.4	110
			MIN	22.0	5.9	31	5.4	49.3	96
31	21.00	4	AV4	23.6	6.9	35	5.8	48.9	115
			STD	0.5	0.3	2	0.1	0.5	2
			MAX	24.1	7.3	37	5.9	49.7	117
			MIN	22.8	6.6	33	5.6	48.4	112
36	22.00	5	AV5	23.2	6.8	33	5.7	49.2	117
			STD	0.8	0.4	2	0.2	0.7	4
			MAX	24.0	7.4	35	5.9	50.5	122
			MIN	21.6	6.3	31	5.4	48.3	112
41	23.00	5	AV5	23.5	7.0	34	5.8	48.8	123
			STD	0.7	0.2	2	0.2	0.7	6
			MAX	24.4	7.2	37	6.0	49.5	129
			MIN	22.7	6.7	30	5.6	48.0	112
46	24.00	5	AV5	23.2	7.2	32	5.7	49.2	122
			STD	0.8	0.3	2	0.2	0.8	4
			MAX	24.5	7.7	35	6.0	50.1	130
			MIN	22.2	6.7	29	5.5	47.8	119
52	25.00	6	AV6	24.0	7.8	33	5.9	48.5	132
			STD	0.3	0.5	1	0.1	0.4	2
			MAX	24.5	8.5	34	6.0	49.2	136
			MIN	23.5	7.3	32	5.7	48.0	129
57	26.00	5	AV5	24.1	7.3	34	5.9	48.4	132
			STD	0.6	0.2	2	0.2	0.6	6
			MAX	24.9	7.6	36	6.1	49.4	136
			MIN	23.1	7.0	30	5.6	47.6	120

USH 10 over Little Lake Butte des Morts - Pier 21 #44
OP: MR

APE D30-42, HP 14 x 73
Test date: 18-Nov-2014

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
62	27.00	5	AV5	24.2	7.5	33	6.0	48.1	139
			STD	0.3	0.1	1	0.1	0.5	2
			MAX	24.5	7.7	34	6.1	48.9	141
			MIN	23.7	7.4	31	5.8	47.5	135
72	28.00	10	AV10	26.1	10.1	34	6.5	46.1	196
			STD	0.8	1.3	2	0.3	0.9	20
			MAX	27.2	11.4	38	6.9	47.5	221
			MIN	24.5	7.6	31	6.1	44.9	160
81	29.00	9	AV9	27.1	11.4	36	6.8	45.1	217
			STD	0.4	0.4	1	0.1	0.4	8
			MAX	27.9	12.3	38	7.0	45.7	232
			MIN	26.7	10.8	34	6.6	44.5	205
89	30.00	8	AV8	26.4	10.6	35	6.6	45.7	194
			STD	0.7	0.4	1	0.2	0.6	9
			MAX	27.5	11.3	37	6.9	46.5	213
			MIN	25.6	10.1	33	6.4	45.0	183
96	31.00	7	AV7	27.0	11.4	37	6.8	45.3	219
			STD	0.9	0.4	2	0.3	0.9	16
			MAX	28.6	11.8	39	7.2	46.4	237
			MIN	26.0	10.8	33	6.4	43.8	195
103	32.00	7	AV7	26.6	10.4	36	6.7	45.6	178
			STD	0.5	0.2	1	0.1	0.5	3
			MAX	27.2	10.5	37	6.9	46.2	181
			MIN	25.9	10.1	35	6.5	44.9	173
110	33.00	7	AV7	26.4	10.6	35	6.6	45.8	186
			STD	0.8	0.5	2	0.3	0.9	21
			MAX	28.4	11.6	40	7.2	46.7	223
			MIN	25.7	10.1	33	6.3	43.9	166
117	34.00	7	AV7	26.9	10.8	36	6.8	45.3	186
			STD	0.7	0.3	2	0.2	0.6	10
			MAX	27.7	11.2	39	7.0	46.4	202
			MIN	25.6	10.3	33	6.4	44.6	171
125	35.00	8	AV8	27.4	11.3	37	6.9	44.9	200
			STD	0.7	0.4	2	0.2	0.6	9
			MAX	29.1	11.9	41	7.4	45.5	215
			MIN	26.6	10.6	35	6.7	43.4	189
152	36.00	27	AV27	29.6	16.0	37	7.7	42.7	343
			STD	1.2	2.9	2	0.4	1.2	74
			MAX	31.9	21.0	43	8.7	44.8	465
			MIN	27.4	11.7	33	6.9	40.0	247
174	37.00	22	AV22	31.6	22.1	42	8.4	40.7	470
			STD	1.0	2.2	2	0.4	0.8	43
			MAX	33.3	25.2	46	9.2	42.3	521
			MIN	30.1	18.5	38	7.8	39.0	401
193	38.00	19	AV19	31.4	18.4	41	8.3	41.0	410
			STD	1.0	2.7	2	0.3	0.8	44
			MAX	33.3	23.1	45	8.9	42.7	483
			MIN	29.5	14.4	37	7.6	39.7	346
210	39.00	17	AV17	30.7	14.2	40	8.1	41.5	352
			STD	0.5	0.8	1	0.2	0.5	17
			MAX	31.7	15.7	43	8.4	42.8	376
			MIN	29.4	12.9	37	7.6	40.8	315
224	40.00	14	AV14	31.0	13.6	41	8.2	41.3	339
			STD	0.5	0.9	1	0.2	0.5	17
			MAX	31.8	14.9	43	8.5	42.1	370
			MIN	30.2	11.7	39	7.9	40.6	314
240	41.00	16	AV16	31.7	16.0	42	8.4	40.7	376
			STD	0.7	2.0	1	0.2	0.6	28
			MAX	33.0	18.9	44	8.8	41.7	417
			MIN	30.4	12.9	40	8.0	39.9	334

USH 10 over Little Lake Butte des Morts - Pier 21 #44
APE D30-42, HP 14 x 73
OP: MR
Test date: 18-Nov-2014

BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
263	42.00	23	AV23	32.3	19.3	42	8.6	40.2	441
			STD	0.4	0.7	1	0.1	0.3	6
			MAX	33.0	21.0	44	8.9	40.8	452
			MIN	31.6	17.8	40	8.4	39.7	424
295	43.00	32	AV32	32.5	21.0	42	8.8	39.9	462
			STD	0.5	0.7	1	0.2	0.3	11
			MAX	33.4	22.7	44	9.1	40.6	490
			MIN	31.7	19.8	39	8.5	39.3	443
327	44.00	32	AV32	32.8	21.7	42	8.9	39.7	491
			STD	0.5	0.5	1	0.2	0.3	8
			MAX	33.8	22.5	44	9.2	40.7	509
			MIN	31.7	20.6	39	8.4	39.1	472
361	45.00	34	AV34	33.4	21.2	43	9.1	39.2	496
			STD	0.5	0.7	1	0.2	0.4	7
			MAX	34.6	22.8	46	9.6	40.3	512
			MIN	32.0	20.0	41	8.6	38.2	483
401	46.00	40	AV40	33.0	20.0	41	9.0	39.4	496
			STD	0.4	0.5	1	0.2	0.3	6
			MAX	34.0	21.0	44	9.5	40.2	520
			MIN	32.0	19.2	39	8.7	38.5	484
444	47.00	43	AV43	33.3	19.5	42	9.1	39.2	506
			STD	0.4	1.0	1	0.2	0.3	22
			MAX	34.2	24.7	43	9.4	39.9	614
			MIN	32.4	18.6	40	8.8	38.6	490
453	47.10	87	AV9	34.8	33.9	46	9.9	37.7	689
			STD	0.6	2.2	1	0.2	0.5	22
			MAX	35.5	36.0	47	10.2	38.7	709
			MIN	33.7	29.4	44	9.4	37.1	650
			Average	30.4	16.9	40	8.1	42.0	381
			Std. Dev.	3.5	5.7	4	1.2	3.4	145
			Maximum	35.5	36.0	47	10.2	55.3	709
			Minimum	18.2	5.2	22	4.4	37.1	89

Total number of blows analyzed: 441

BL#	depth (ft)	Comments
13	16.67	Reference Elevation EL 735.75

Time Summary

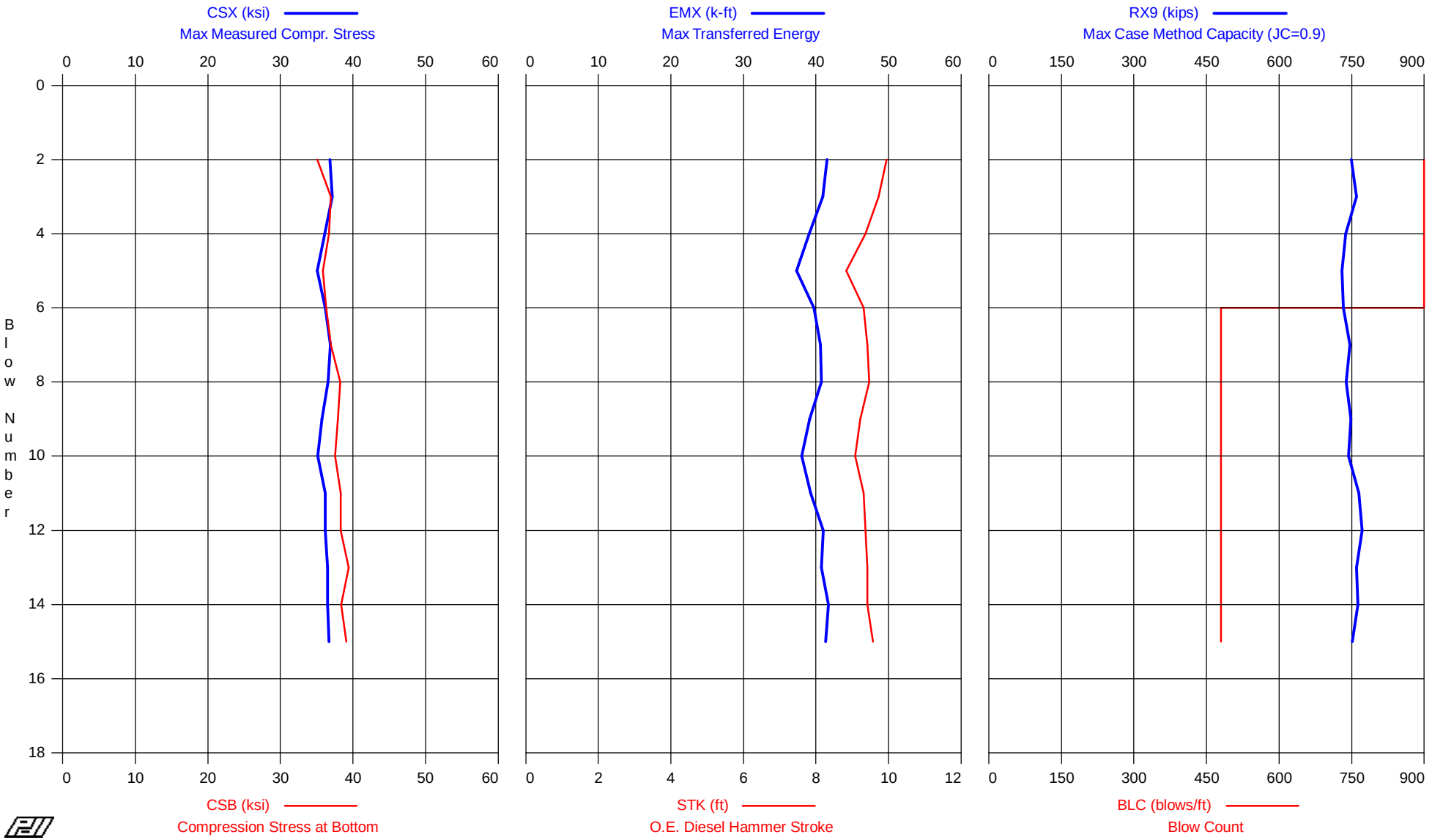
Drive 11 minutes 18 seconds 4:12:33 PM - 4:23:51 PM (11/18/2014) BN 1 - 454

GRL Engineers, Inc. - Case Method & iCAP® Results

PDIPLOT Ver. 2014.1 - Printed: 25-Nov-2014

Test date: 19-Nov-2014

USH 10 over Little Lake Butte des Morts - Pier 21 #44 Restrike
APE D30-42, HP 14 x 73



USH 10 over Little Lake Butte des Morts - Pier 21 #44 Restrike APE D30-42, HP 14 x 73
OP: MR Test date: 19-Nov-2014

AR: 21.40 in^2 SP: 0.492 k/ft3
LE: 52.00 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 1.20

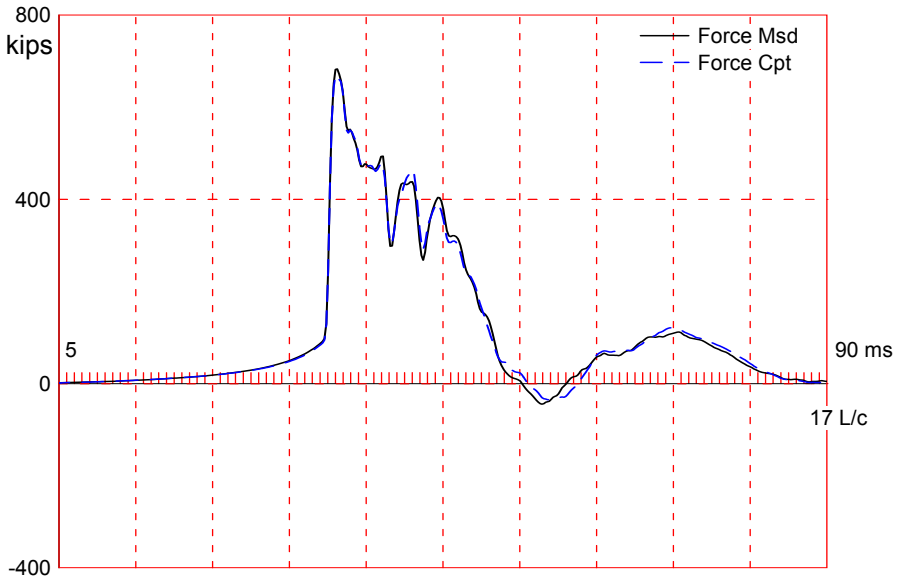
CSX: Max Measured Compr. Stress STK: O.E. Diesel Hammer Stroke
CSB: Compression Stress at Bottom BPM: Blows per Minute
EMX: Max Transferred Energy RX9: Max Case Method Capacity (JC=0.9)

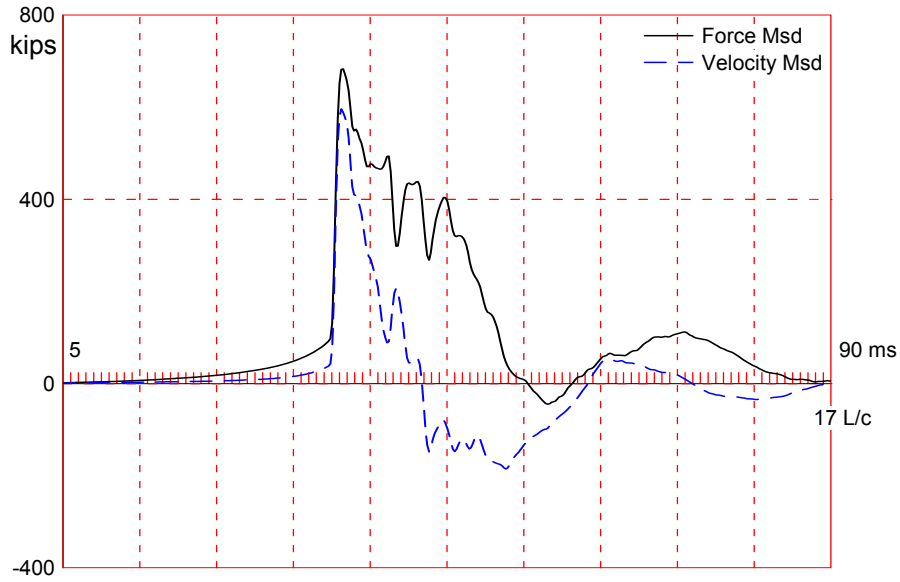
BL# end	depth ft	BLC bl/ft	TYPE	CSX ksi	CSB ksi	EMX k-ft	STK ft	BPM **	RX9 kips
5	47.09	960	AV4	36.3	36.1	40	9.5	38.5	745
			STD	0.8	0.7	2	0.4	0.8	11
			MAX	37.2	36.9	42	9.9	39.8	760
			MIN	35.0	35.1	37	8.8	37.6	730
10	47.10	480	AV5	36.1	37.4	40	9.3	38.8	742
			STD	0.6	0.7	1	0.1	0.3	5
			MAX	36.9	38.3	41	9.5	39.3	749
			MIN	35.2	36.3	38	9.1	38.5	733
15	47.11	480	AV5	36.4	38.7	41	9.4	38.6	762
			STD	0.2	0.5	1	0.1	0.2	7
			MAX	36.7	39.4	42	9.6	38.8	772
			MIN	36.2	38.3	39	9.3	38.3	751
			Average	36.3	37.5	40	9.4	38.7	750
			Std. Dev.	0.6	1.2	1	0.3	0.5	12
			Maximum	37.2	39.4	42	9.9	39.8	772
			Minimum	35.0	35.1	37	8.8	37.6	730

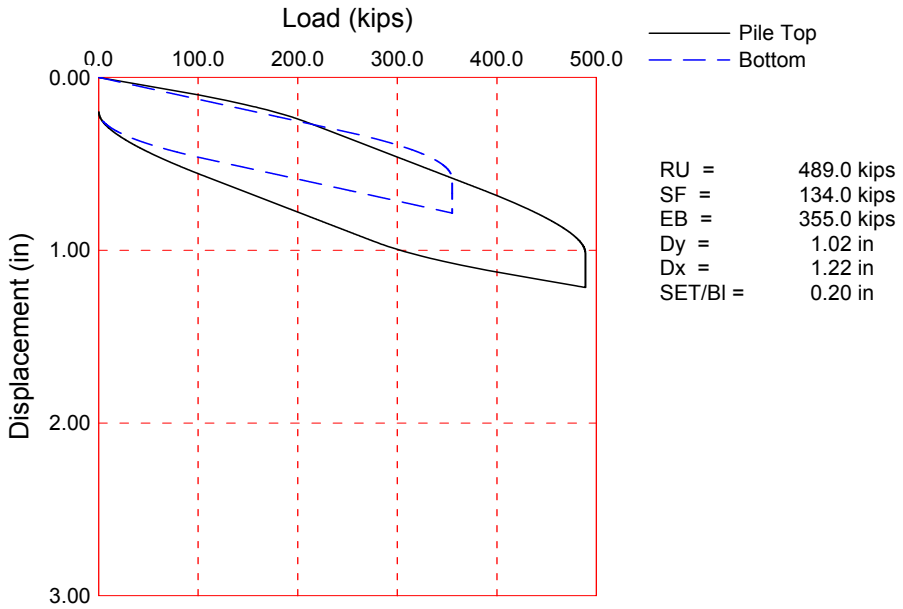
Total number of blows analyzed: 14

Time Summary

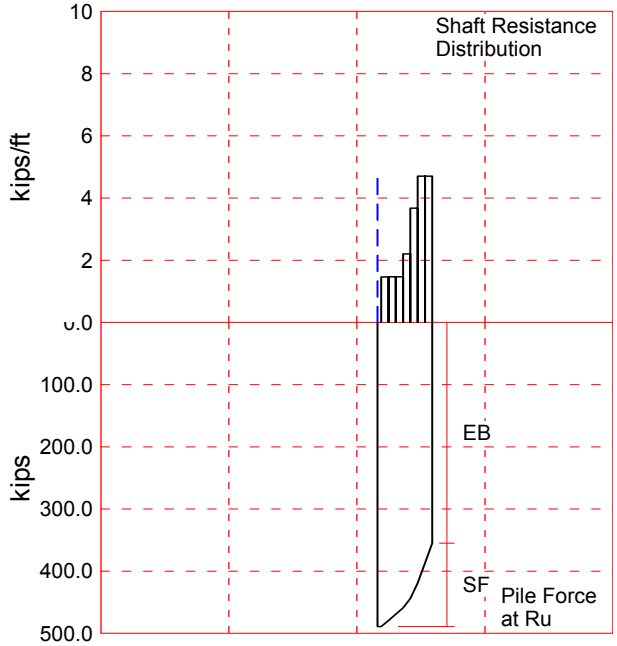
Drive 22 seconds 9:41:32 AM - 9:41:54 AM (11/19/2014) BN 1 - 15







RU =	489.0 kips
SF =	134.0 kips
EB =	355.0 kips
Dy =	1.02 in
Dx =	1.22 in
SET/Bl =	0.20 in



Length b. Sensors	51.0 ft
Embedment	47.6 ft
Top Area	21.4 in^2
End Bearing Area	198.5 in^2
Top Perimeter	4.70 ft
Top E-Modulus	29992 ksi
Top Spec. Weight	492.0 lb/ft^3
Top Wave Spd.	16808 ft/s
Overall W.S.	16808 ft/s
Match Quality	2.76
Top Compr. Stress	31.7 ksi
Max Compr. Stress	32.8 ksi
Max Tension Stress	-3.00 ksi
Avg. Shaft Quake	0.08 in
Toe Quake	0.45 in
Avg. Shaft Smith Dpg.	0.27 s/ft
Toe Smith Damping	0.09 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

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 489.0; along Shaft 134.0; at Toe 355.0 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
				489.0			
1	10.2	6.8	10.0	479.0	10.0	1.46	0.31
2	17.0	13.6	10.0	469.0	20.0	1.47	0.31
3	23.8	20.4	10.0	459.0	30.0	1.47	0.31
4	30.6	27.2	15.0	444.0	45.0	2.21	0.47
5	37.4	34.0	25.0	419.0	70.0	3.68	0.78
6	44.2	40.8	32.0	387.0	102.0	4.71	1.00
7	51.0	47.6	32.0	355.0	134.0	4.71	1.00
Avg. Shaft			19.1			2.81	0.60
Toe			355.0				257.53

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.27	0.09
Quake	(in)	0.08	0.45
Case Damping Factor		0.95	0.84
Damping Type		Viscous	Smith
Unloading Quake	(% of loading quake)	100	31
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	7	
Resistance Gap (included in Toe Quake)	(in)		0.06
Soil Plug Weight	(kips)	0.200	0.050

CAPWAP match quality = 2.76 (Wave Up Match) ; RSA = 0
Observed: Final Set = 0.20 in; Blow Count = 60 b/ft
Computed: Final Set = 0.20 in; Blow Count = 60 b/ft
Transducer F3(F590) CAL: 95.0; RF: 0.95; F4(F607) CAL: 93.6; RF: 0.95
A3(K2253) CAL: 325; RF: 1.05; A4(K2524) CAL: 360; RF: 1.05

max. Top Comp. Stress = 31.7 ksi (T= 36.2 ms, max= 1.033 x Top)
max. Comp. Stress = 32.8 ksi (Z= 10.2 ft, T= 36.6 ms)
max. Tens. Stress = -3.00 ksi (Z= 23.8 ft, T= 60.1 ms)
max. Energy (EMX) = 34.6 kip-ft; max. Measured Top Displ. (DMX)= 0.87 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	678.9	-41.2	31.7	-1.92	34.6	15.8	0.85
2	6.8	689.2	-47.3	32.2	-2.21	34.0	15.4	0.82
3	10.2	701.0	-52.4	32.8	-2.45	33.4	15.2	0.79
4	13.6	661.2	-55.3	30.9	-2.59	30.7	14.8	0.76
5	17.0	672.6	-60.0	31.4	-2.80	30.1	14.6	0.73
6	20.4	634.7	-61.2	29.7	-2.86	27.6	14.3	0.70
7	23.8	649.6	-64.1	30.3	-3.00	27.1	14.0	0.67
8	27.2	619.5	-59.5	28.9	-2.78	24.8	13.5	0.64
9	30.6	644.9	-60.6	30.1	-2.83	24.2	13.1	0.61
10	34.0	620.5	-53.8	29.0	-2.51	21.4	12.4	0.59
11	37.4	646.2	-53.3	30.2	-2.49	20.8	11.6	0.56
12	40.8	567.2	-39.2	26.5	-1.83	17.0	12.1	0.53
13	44.2	556.9	-38.3	26.0	-1.79	16.5	13.6	0.50
14	47.6	424.5	-20.2	19.8	-0.95	12.2	14.3	0.48
15	51.0	439.5	-18.7	20.5	-0.87	8.7	14.3	0.45
Absolute	10.2			32.8			(T =	36.6 ms)
	23.8				-3.00		(T =	60.1 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	683.9	563.7	443.5	323.4	203.2					
RX	734.5	645.5	564.8	511.4	502.7	494.9	487.3	480.7	476.4	472.9
RU	683.9	563.7	443.5	323.4	203.2					

RAU = 309.9 (kips); RA2 = 571.5 (kips)

Current CAPWAP Ru = 489.0 (kips); Corresponding J(RP)= 0.32; J(RX) = 1.16

VMX ft/s	TVP ms	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips	KEB kips/in
15.7	35.80	600.4	684.3	688.1	0.87	0.20	0.20	35.3	790.8	910

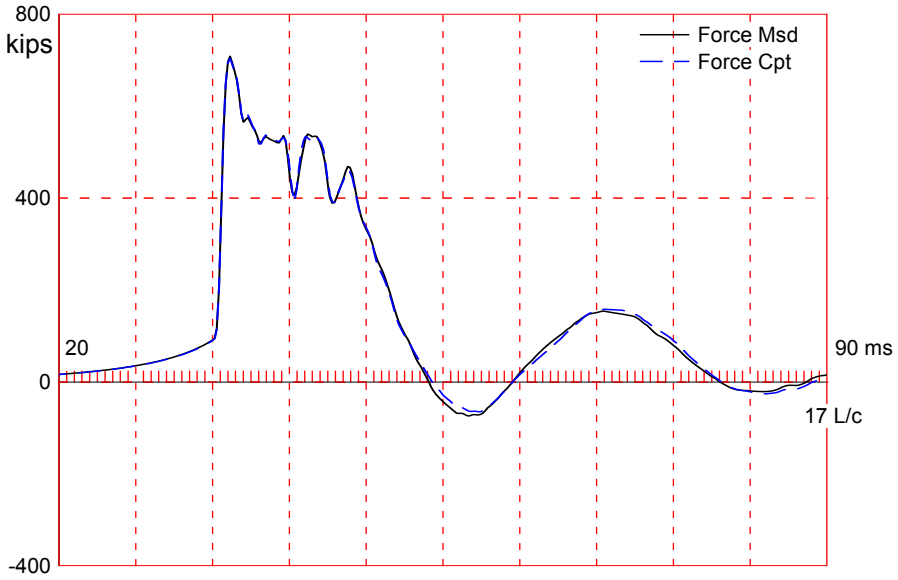
PILE PROFILE AND PILE MODEL

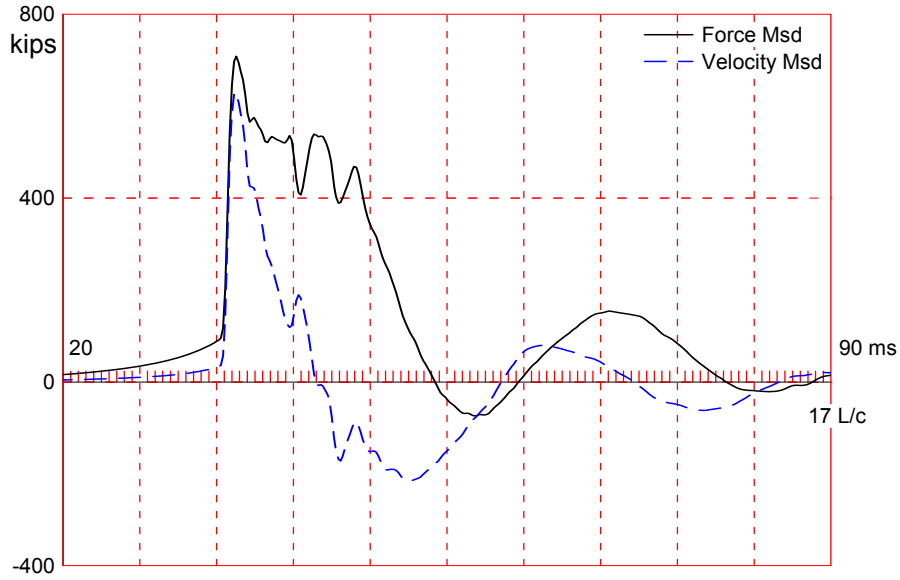
Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.0	21.4	29992.2	492.000	4.70
51.0	21.4	29992.2	492.000	4.70

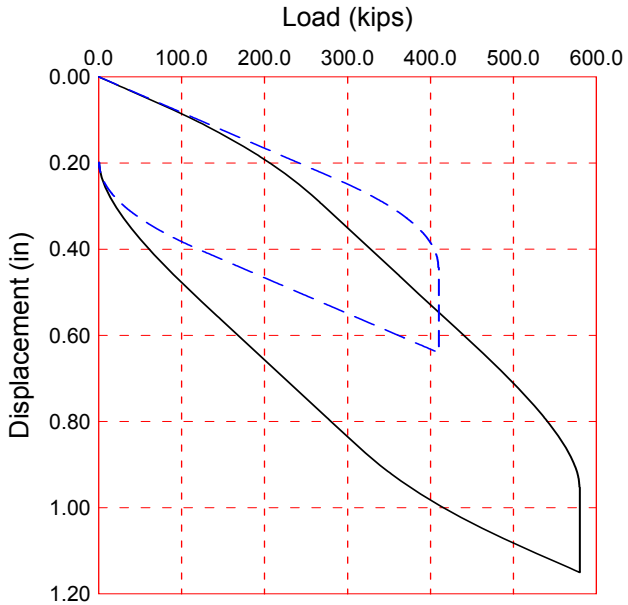
Toe Area 198.5 in^2

Segmnt Number	Dist. B.G. ft	Impedance kips/ft/s	Imped. Change %	Slack in	Tension Eff.	Slack in	Compression Eff.	Perim. ft	Wave Speed ft/s	Soil Plug kips
1	3.4	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16807.9	0.000
13	44.2	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16807.9	0.040
14	47.6	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16807.9	0.060
15	51.0	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16807.9	0.100

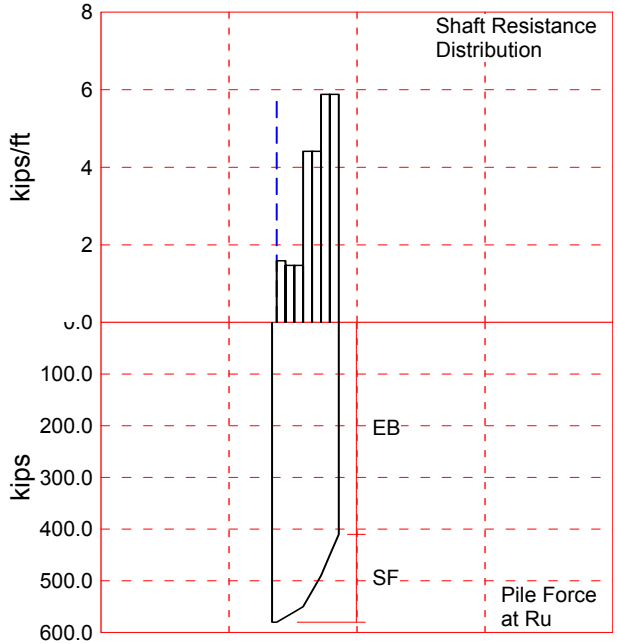
Wave Speed: Pile Top 16807.9, Elastic 16807.9, Overall 16807.9 ft/s
Pile Damping 1.00 %, Time Incr 0.202 ms, 2L/c 6.1 ms
Total volume: 7.579 ft^3; Volume ratio considering added impedance: 1.000







RU =	580.0 kips
SF =	170.0 kips
EB =	410.0 kips
Dy =	0.95 in
Dx =	1.15 in
SET/BI =	0.20 in



Length b. Sensors	51.0 ft
Embedment	47.1 ft
Top Area	21.4 in^2
End Bearing Area	198.5 in^2
Top Perimeter	4.70 ft
Top E-Modulus	29992 ksi
Top Spec. Weight	492.0 lb/ft^3
Top Wave Spd.	16808 ft/s
Overall W.S.	16808 ft/s
Match Quality	1.72
Top Compr. Stress	33.4 ksi
Max Compr. Stress	34.6 ksi
Max Tension Stress	-3.83 ksi
Avg. Shaft Quake	0.07 in
Toe Quake	0.34 in
Avg. Shaft Smith Dpg.	0.29 s/ft
Toe Smith Damping	0.12 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: 580.0; along Shaft 170.0; at Toe 410.0 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
				580.0			
1	10.2	6.3	10.0	570.0	10.0	1.59	0.34
2	17.0	13.1	10.0	560.0	20.0	1.47	0.31
3	23.8	19.9	10.0	550.0	30.0	1.47	0.31
4	30.6	26.7	30.0	520.0	60.0	4.41	0.94
5	37.4	33.5	30.0	490.0	90.0	4.41	0.94
6	44.2	40.3	40.0	450.0	130.0	5.88	1.25
7	51.0	47.1	40.0	410.0	170.0	5.88	1.25
Avg. Shaft			24.3			3.61	0.77
Toe			410.0				297.43

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.29	0.12
Quake	(in)	0.07	0.34
Case Damping Factor		1.29	1.29
Damping Type		Viscous	Sm+Visc
Unloading Quake	(% of loading quake)	100	98
Resistance Gap (included in Toe Quake)	(in)		0.09
Soil Plug Weight	(kips)		0.066

CAPWAP match quality = 1.72 (Wave Up Match) ; RSA = 0
Observed: Final Set = 0.20 in; Blow Count = 60 b/ft
Computed: Final Set = 0.20 in; Blow Count = 61 b/ft

Transducer F3(F590) CAL: 95.0; RF: 1.00; F4(F607) CAL: 93.6; RF: 1.00
A3(K2253) CAL: 325; RF: 1.14; A4(K2524) CAL: 360; RF: 1.14

max. Top Comp. Stress = 33.4 ksi (T= 36.0 ms, max= 1.035 x Top)
max. Comp. Stress = 34.6 ksi (Z= 10.2 ft, T= 36.4 ms)
max. Tens. Stress = -3.83 ksi (Z= 10.2 ft, T= 58.3 ms)
max. Energy (EMX) = 36.0 kip-ft; max. Measured Top Displ. (DMX)= 0.84 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	715.4	-70.5	33.4	-3.29	36.0	16.3	0.81
2	6.8	728.0	-76.3	34.0	-3.56	35.2	16.0	0.77
3	10.2	740.4	-82.1	34.6	-3.83	34.4	15.6	0.74
4	13.6	697.7	-72.7	32.6	-3.40	31.4	15.3	0.70
5	17.0	709.7	-78.0	33.2	-3.64	30.6	15.0	0.67
6	20.4	670.1	-69.1	31.3	-3.23	27.8	14.6	0.63
7	23.8	697.6	-73.4	32.6	-3.43	27.0	14.1	0.60
8	27.2	676.6	-63.0	31.6	-2.95	24.6	13.2	0.56
9	30.6	701.2	-67.8	32.8	-3.17	23.8	12.6	0.53
10	34.0	596.6	-32.4	27.9	-1.51	19.0	11.8	0.49
11	37.4	626.7	-35.6	29.3	-1.66	18.3	11.1	0.46
12	40.8	528.0	-2.9	24.7	-0.13	14.2	11.6	0.43
13	44.2	528.5	-5.1	24.7	-0.24	13.6	12.8	0.40
14	47.6	480.7	0.0	22.5	0.00	9.2	13.6	0.37
15	51.0	487.3	0.0	22.8	0.00	6.0	13.8	0.34
Absolute	10.2			34.6			(T =	36.4 ms)
	10.2				-3.83		(T =	58.3 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	801.3	746.3	691.2	636.2	581.2	526.1	471.1	416.1	361.0	306.0
RX	827.4	788.9	753.5	718.4	687.2	658.9	633.4	610.4	587.4	574.8
RU	801.3	746.3	691.2	636.2	581.2	526.1	471.1	416.1	361.0	306.0

RAU = 346.1 (kips); RA2 = 722.0 (kips)

Current CAPWAP Ru = 580.0 (kips); Corresponding J(RP)= 0.40; J(RX) = 0.86

VMX ft/s	TVP ms	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips	KEB kips/in
16.7	35.80	637.4	714.2	714.2	0.84	0.20	0.20	37.0	851.9	1640

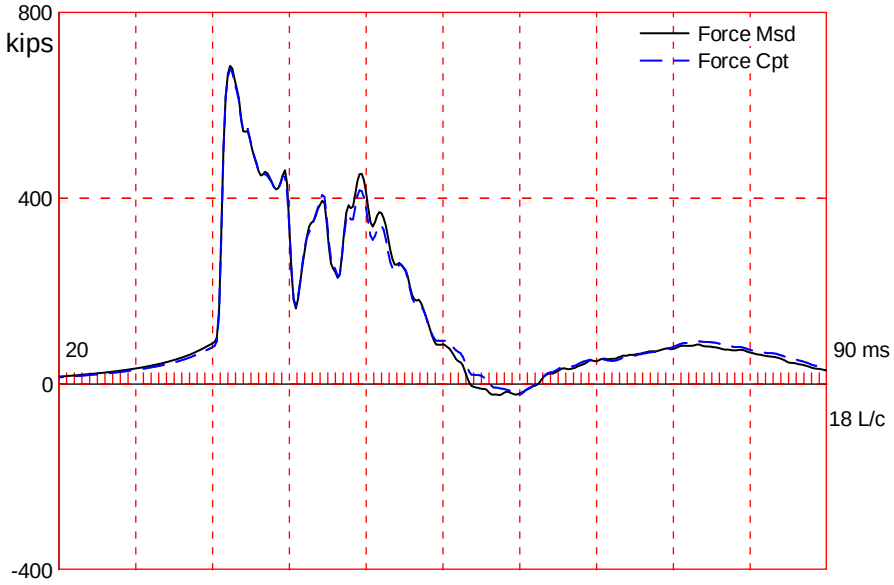
PILE PROFILE AND PILE MODEL

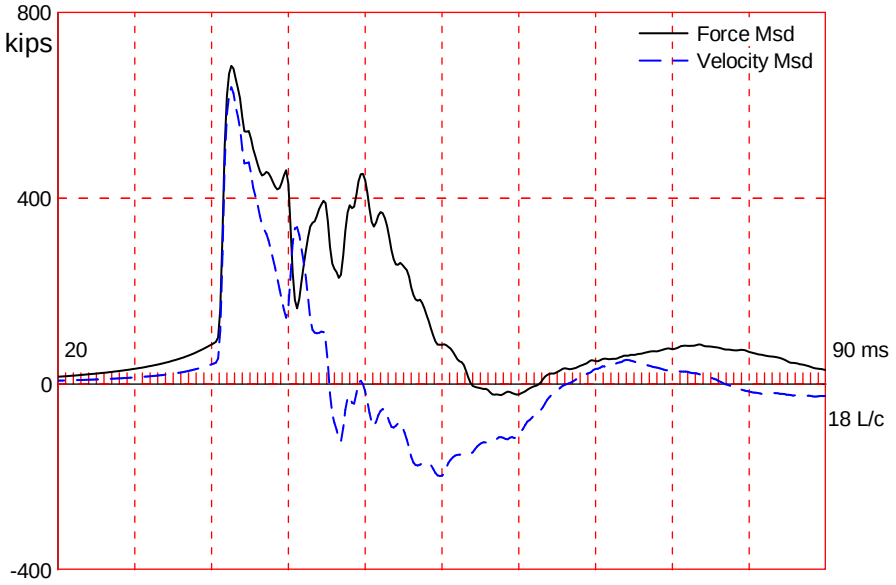
Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.0	21.4	29992.2	492.000	4.70
51.0	21.4	29992.2	492.000	4.70

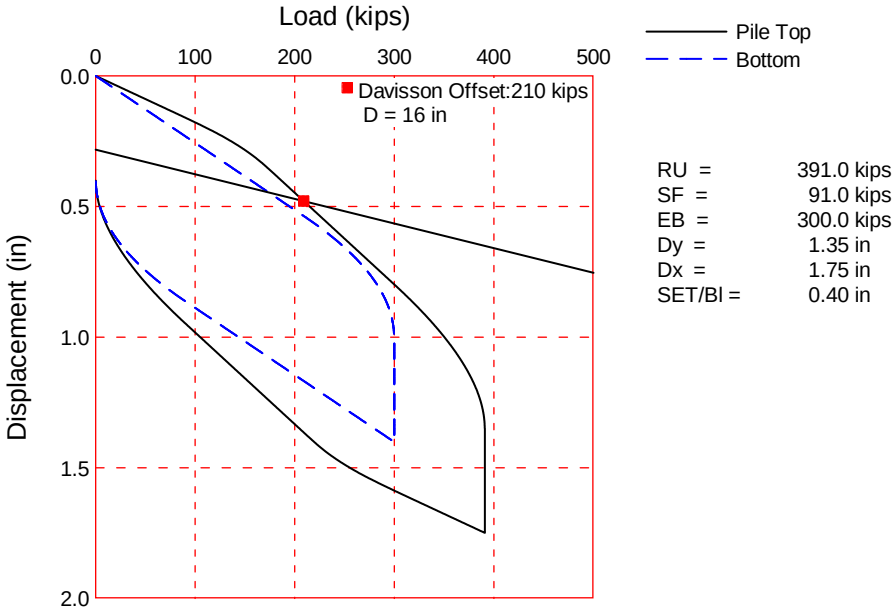
Toe Area 198.5 in^2

Top Segment Length 3.40 ft, Top Impedance 38 kips/ft/s

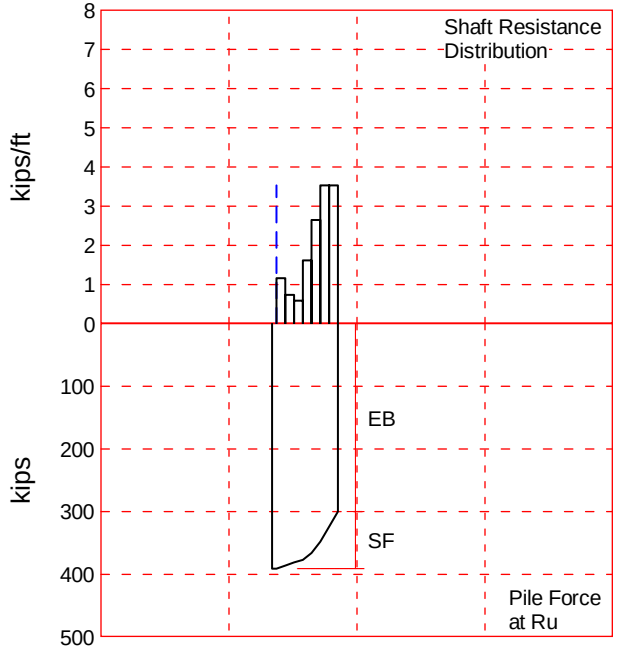
Wave Speed: Pile Top 16807.9, Elastic 16807.9, Overall 16807.9 ft/s
Pile Damping 1.00 %, Time Incr 0.202 ms, 2L/c 6.1 ms
Total volume: 7.579 ft^3; Volume ratio considering added impedance: 1.000







RU =	391.0 kips
SF =	91.0 kips
EB =	300.0 kips
Dy =	1.35 in
Dx =	1.75 in
SET/Bl =	0.40 in



Length b. Sensors	51.0 ft
Embedment	45.1 ft
Top Area	21.4 in^2
End Bearing Area	198.5 in^2
Top Perimeter	4.70 ft
Top E-Modulus	29992 ksi
Top Spec. Weight	492.0 lb/ft^3
Top Wave Spd.	16808 ft/s
Overall W.S.	17000 ft/s
Match Quality	2.38
Top Compr. Stress	31.9 ksi
Max Compr. Stress	32.4 ksi
Max Tension Stress	-1.68 ksi
Avg. Shaft Quake	0.17 in
Toe Quake	0.77 in
Avg. Shaft Smith Dpg.	0.26 s/ft
Toe Smith Damping	0.12 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

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 391.0; along Shaft 91.0; at Toe 300.0 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
				391.0			
1	10.2	4.3	5.0	386.0	5.0	1.16	0.25
2	17.0	11.1	5.0	381.0	10.0	0.74	0.16
3	23.8	17.9	4.0	377.0	14.0	0.59	0.13
4	30.6	24.7	11.0	366.0	25.0	1.62	0.34
5	37.4	31.5	18.0	348.0	43.0	2.65	0.56
6	44.2	38.3	24.0	324.0	67.0	3.53	0.75
7	51.0	45.1	24.0	300.0	91.0	3.53	0.75
Avg. Shaft			13.0			2.02	0.43
Toe			300.0				217.63

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.26	0.12
Quake	(in)	0.17	0.77
Case Damping Factor		0.62	0.94
Damping Type		Viscous	Smith
Unloading Quake	(% of loading quake)	55	81
Reloading Level	(% of Ru)	100	100
Resistance Gap (included in Toe Quake)	(in)		0.15
Soil Plug Weight	(kips)	0.160	0.029

CAPWAP match quality = 2.38 (Wave Up Match) ; RSA = 0
Observed: Final Set = 0.40 in; Blow Count = 30 b/ft
Computed: Final Set = 0.41 in; Blow Count = 29 b/ft
Transducer F3(F590) CAL: 95.0; RF: 0.98; F4(F607) CAL: 93.6; RF: 0.98
A3(K2253) CAL: 325; RF: 1.13; A4(K2524) CAL: 360; RF: 1.13

max. Top Comp. Stress = 31.9 ksi (T= 36.0 ms, max= 1.017 x Top)
max. Comp. Stress = 32.4 ksi (Z= 10.2 ft, T= 36.4 ms)
max. Tens. Stress = -1.68 ksi (Z= 10.2 ft, T= 62.4 ms)
max. Energy (EMX) = 39.4 kip-ft; max. Measured Top Displ. (DMX)= 1.09 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	683.2	-30.0	31.9	-1.40	39.4	16.8	1.09
2	6.8	689.4	-33.7	32.2	-1.57	39.1	16.6	1.07
3	10.2	694.6	-35.9	32.4	-1.68	38.7	16.5	1.05
4	13.6	674.4	-28.5	31.5	-1.33	36.9	16.3	1.03
5	17.0	678.9	-28.1	31.7	-1.31	36.6	16.2	1.00
6	20.4	657.9	-21.1	30.7	-0.99	34.8	16.0	0.98
7	23.8	666.3	-24.6	31.1	-1.15	34.5	15.8	0.96
8	27.2	657.7	-21.3	30.7	-1.00	33.0	15.5	0.93
9	30.6	674.1	-23.5	31.5	-1.10	32.6	15.1	0.91
10	34.0	637.4	-8.0	29.8	-0.37	29.6	15.1	0.89
11	37.4	677.1	-10.4	31.6	-0.48	29.2	15.6	0.86
12	40.8	626.3	0.0	29.3	0.00	24.8	16.6	0.84
13	44.2	607.4	0.0	28.4	0.00	24.4	18.2	0.82
14	47.6	429.8	0.0	20.1	0.00	18.9	19.4	0.80
15	51.0	423.7	-0.0	19.8	-0.00	14.0	18.9	0.78
Absolute	10.2			32.4			(T = 36.4 ms)	
	10.2				-1.68		(T = 62.4 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	576.1	424.4	272.7	121.0	0.0					
RX	636.7	556.7	476.8	466.6	461.1	456.5	452.0	447.5	443.3	439.5
RU	576.1	424.4	272.7	121.0	0.0					

RAU = 318.8 (kips); RA2 = 517.5 (kips)

Current CAPWAP Ru = 391.0 (kips); Corresponding J(RP)= 0.24;

RMX requires higher damping; see PDA-W

VMX ft/s	TVP ms	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips	KEB kips/in
16.9	35.80	647.1	687.6	687.6	1.09	0.40	0.40	39.8	640.5	484

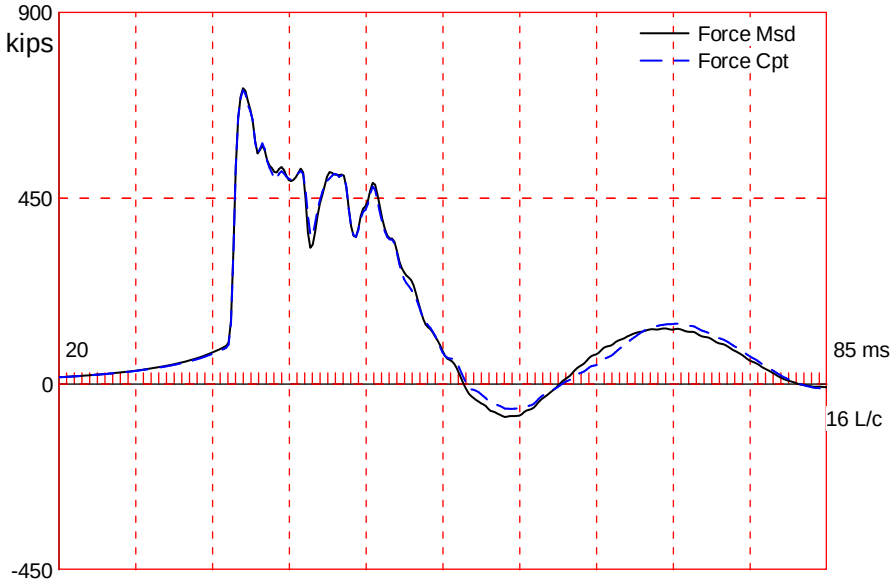
PILE PROFILE AND PILE MODEL

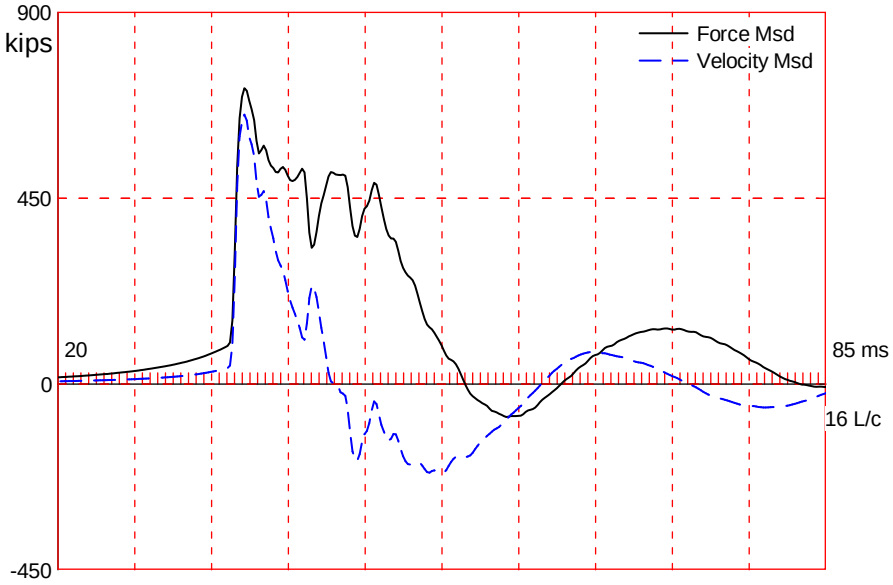
Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.0	21.4	29992.2	492.000	4.70
51.0	21.4	29992.2	492.000	4.70

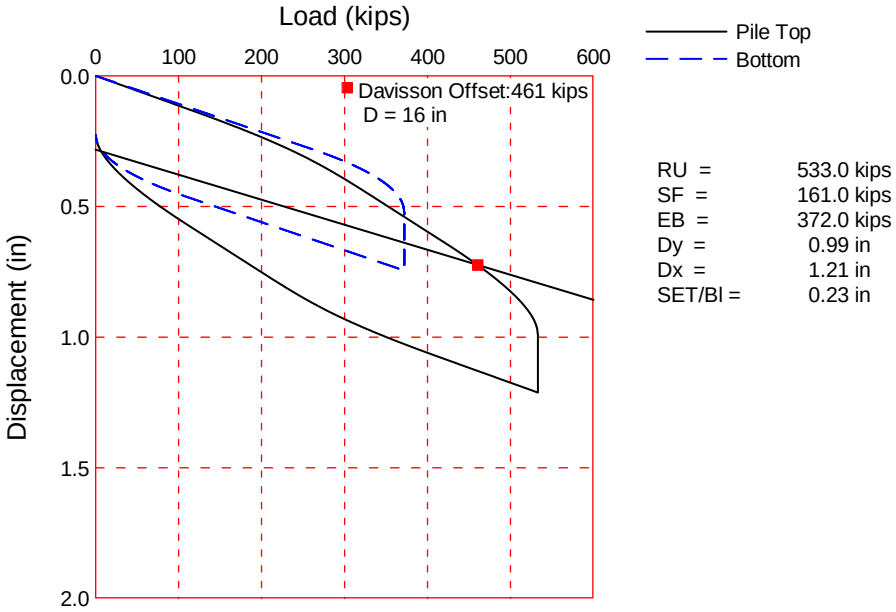
Toe Area 198.5 in^2

Segmnt Number	Dist. B.G. ft	Impedance kips/ft/s	Imped. Change %	Slack in	Tension Eff.	Slack in	Compression Eff.	Perim. ft	Wave Speed ft/s	Soil Plug kips
1	3.4	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	17000.0	0.000
14	47.6	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	17000.0	0.080
15	51.0	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	17000.0	0.080

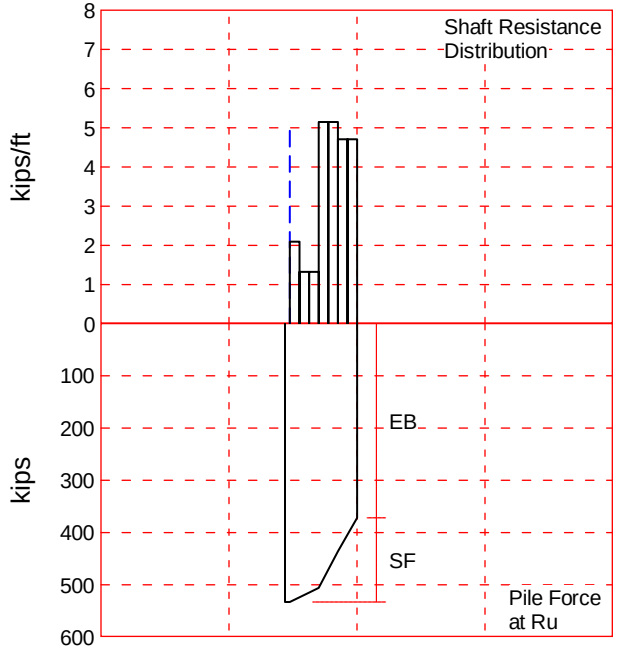
Wave Speed: Pile Top 16807.9, Elastic 16807.9, Overall 17000.0 ft/s
Pile Damping 1.00 %, Time Incr 0.200 ms, 2L/c 6.0 ms
Total volume: 7.579 ft^3; Volume ratio considering added impedance: 1.000







RU =	533.0 kips
SF =	161.0 kips
EB =	372.0 kips
Dy =	0.99 in
Dx =	1.21 in
SET/BI =	0.23 in



Length b. Sensors	51.0 ft
Embedment	45.1 ft
Top Area	21.4 in^2
End Bearing Area	198.5 in^2
Top Perimeter	4.70 ft
Top E-Modulus	29992 ksi
Top Spec. Weight	492.0 lb/ft^3
Top Wave Spd.	16808 ft/s
Overall W.S.	16721 ft/s
Match Quality	2.88
Top Compr. Stress	33.5 ksi
Max Compr. Stress	34.4 ksi
Max Tension Stress	-3.71 ksi
Avg. Shaft Quake	0.14 in
Toe Quake	0.40 in
Avg. Shaft Smith Dpg.	0.20 s/ft
Toe Smith Damping	0.10 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.

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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.

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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

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 533.0; along Shaft 161.0; at Toe 372.0 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
				533.0			
1	10.2	4.3	9.0	524.0	9.0	2.09	0.45
2	17.0	11.1	9.0	515.0	18.0	1.32	0.28
3	23.8	17.9	9.0	506.0	27.0	1.32	0.28
4	30.6	24.7	35.0	471.0	62.0	5.15	1.10
5	37.4	31.5	35.0	436.0	97.0	5.15	1.10
6	44.2	38.3	32.0	404.0	129.0	4.71	1.00
7	51.0	45.1	32.0	372.0	161.0	4.71	1.00
Avg. Shaft			23.0			3.57	0.76
Toe			372.0				269.86

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.20	0.10
Quake	(in)	0.14	0.40
Case Damping Factor		0.86	0.98
Damping Type		Viscous	Smith
Unloading Quake	(% of loading quake)	54	74
Reloading Level	(% of Ru)	100	100
Resistance Gap (included in Toe Quake) (in)			0.05

CAPWAP match quality = 2.88 (Wave Up Match) ; RSA = 0
Observed: Final Set = 0.23 in; Blow Count = 53 b/ft
Computed: Final Set = 0.26 in; Blow Count = 47 b/ft
Transducer F3(F590) CAL: 95.0; RF: 1.00; F4(F607) CAL: 93.6; RF: 1.00
A3(K2253) CAL: 325; RF: 1.13; A4(K2524) CAL: 360; RF: 1.13

max. Top Comp. Stress = 33.5 ksi (T= 36.0 ms, max= 1.025 x Top)
max. Comp. Stress = 34.4 ksi (Z= 10.2 ft, T= 36.4 ms)
max. Tens. Stress = -3.71 ksi (Z= 17.0 ft, T= 59.0 ms)
max. Energy (EMX) = 37.9 kip-ft; max. Measured Top Displ. (DMX)= 0.91 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	717.8	-67.7	33.5	-3.16	37.9	17.1	0.88
2	6.8	727.9	-73.3	34.0	-3.42	37.1	16.8	0.85
3	10.2	735.8	-79.0	34.4	-3.69	36.4	16.6	0.82
4	13.6	706.4	-73.3	33.0	-3.42	33.9	16.3	0.78
5	17.0	714.3	-79.4	33.4	-3.71	33.1	16.1	0.75
6	20.4	685.8	-70.6	32.0	-3.30	30.8	15.8	0.72
7	23.8	714.2	-73.0	33.4	-3.41	30.1	15.3	0.68
8	27.2	702.6	-63.1	32.8	-2.95	28.0	14.5	0.65
9	30.6	731.9	-67.9	34.2	-3.17	27.3	13.8	0.62
10	34.0	627.5	-30.6	29.3	-1.43	22.2	13.0	0.58
11	37.4	665.4	-35.7	31.1	-1.67	21.6	12.4	0.55
12	40.8	574.1	-0.5	26.8	-0.02	17.2	13.4	0.53
13	44.2	557.6	-5.3	26.0	-0.25	16.7	14.4	0.50
14	47.6	486.2	0.0	22.7	0.00	13.1	15.2	0.47
15	51.0	511.6	-0.0	23.9	-0.00	10.5	14.3	0.45
Absolute	10.2			34.4			(T =	36.4 ms)
	17.0				-3.71		(T =	59.0 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	781.3	660.3	539.3	418.4	297.4					
RX	811.5	730.9	671.5	615.3	575.8	549.7	535.2	524.2	521.1	517.9
RU	781.3	660.3	539.3	418.4	297.4					

RAU = 365.5 (kips); RA2 = 695.8 (kips)

Current CAPWAP Ru = 533.0 (kips); Corresponding J(RP)= 0.41; J(RX) = 1.23

VMX ft/s	TVP ms	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips	KEB kips/in
17.3	35.79	661.2	725.0	725.0	0.91	0.23	0.23	38.7	818.1	1063

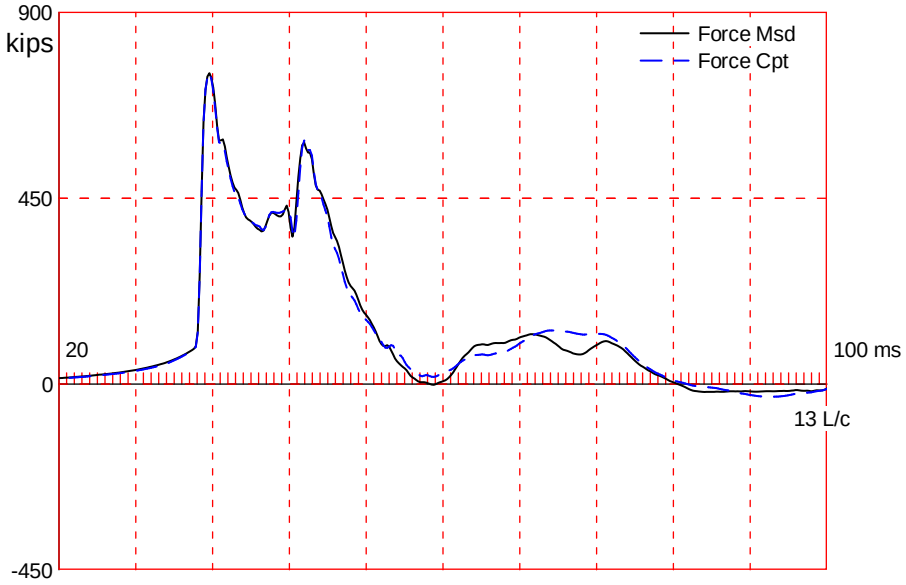
PILE PROFILE AND PILE MODEL

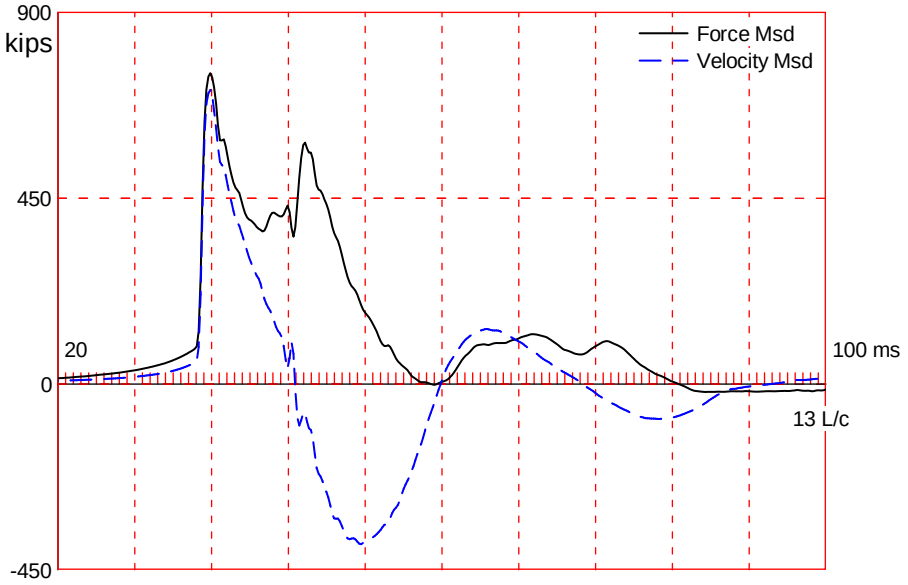
Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.0	21.4	29992.2	492.000	4.70
51.0	21.4	29992.2	492.000	4.70

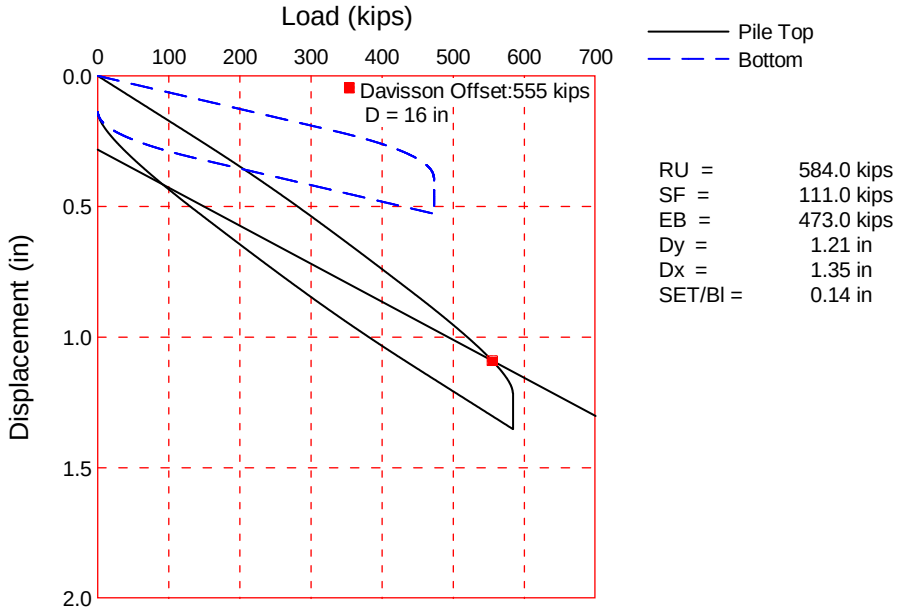
Toe Area 198.5 in^2

Segmnt Number	Dist. B.G. ft	Impedance kips/ft/s	Imped. Change %	Slack in	Tension Eff.	Slack in	Compression Eff.	Perim. ft	Wave Speed ft/s	Soil Plug kips
1	3.4	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16721.3	0.000
14	47.6	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16721.3	0.060
15	51.0	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16721.3	0.060

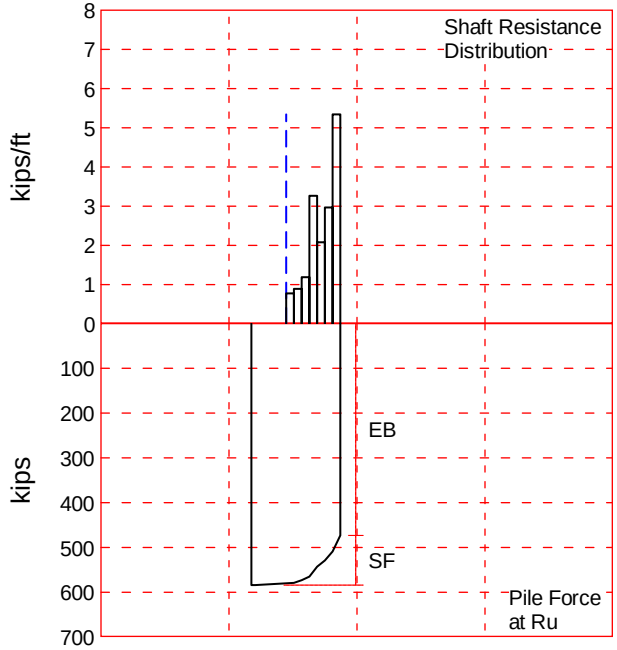
Wave Speed: Pile Top 16807.9, Elastic 16807.9, Overall 16721.3 ft/s
Pile Damping 1.00 %, Time Incr 0.203 ms, 2L/c 6.1 ms
Total volume: 7.579 ft^3; Volume ratio considering added impedance: 1.000







RU =	584.0 kips
SF =	111.0 kips
EB =	473.0 kips
Dy =	1.21 in
Dx =	1.35 in
SET/Bl =	0.14 in



Length b. Sensors	77.5 ft
Embedment	46.9 ft
Top Area	21.4 in^2
End Bearing Area	198.5 in^2
Top Perimeter	4.70 ft
Top E-Modulus	29992 ksi
Top Spec. Weight	492.0 lb/ft^3
Top Wave Spd.	16808 ft/s
Overall W.S.	16721 ft/s
Match Quality	3.78
Top Compr. Stress	35.2 ksi
Max Compr. Stress	36.8 ksi
Max Tension Stress	-5.40 ksi
Avg. Shaft Quake	0.16 in
Toe Quake	0.30 in
Avg. Shaft Smith Dpg.	0.29 s/ft
Toe Smith Damping	0.21 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

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 584.0; along Shaft 111.0; at Toe 473.0 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
				584.0			
1	37.1	6.5	5.0	579.0	5.0	0.77	0.16
2	43.8	13.2	6.0	573.0	11.0	0.89	0.19
3	50.5	19.9	8.0	565.0	19.0	1.19	0.25
4	57.3	26.7	22.0	543.0	41.0	3.26	0.69
5	64.0	33.4	14.0	529.0	55.0	2.08	0.44
6	70.8	40.2	20.0	509.0	75.0	2.97	0.63
7	77.5	46.9	36.0	473.0	111.0	5.34	1.14
Avg. Shaft			15.9			2.37	0.50
Toe			473.0				343.13

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.29	0.21
Quake	(in)	0.16	0.30
Case Damping Factor		0.84	2.60
Damping Type		Viscous	Sm+Visc
Unloading Quake	(% of loading quake)	100	96
Reloading Level	(% of Ru)	100	100
Resistance Gap (included in Toe Quake)	(in)		0.02

CAPWAP match quality = 3.78 (Wave Up Match) ; RSA = 0
Observed: Final Set = 0.14 in; Blow Count = 87 b/ft
Computed: Final Set = 0.10 in; Blow Count = 116 b/ft
Transducer F3(F590) CAL: 95.0; RF: 0.97; F4(F607) CAL: 93.6; RF: 0.97
A3(K2253) CAL: 325; RF: 1.12; A4(K2524) CAL: 360; RF: 1.12

max. Top Comp. Stress = 35.2 ksi (T= 36.1 ms, max= 1.046 x Top)
max. Comp. Stress = 36.8 ksi (Z= 77.5 ft, T= 40.9 ms)
max. Tens. Stress = -5.40 ksi (Z= 50.5 ft, T= 59.8 ms)
max. Energy (EMX) = 46.9 kip-ft; max. Measured Top Displ. (DMX)= 1.17 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	752.4	-31.1	35.2	-1.45	46.9	18.7	1.16
2	6.7	753.4	-31.9	35.2	-1.49	46.3	18.6	1.13
4	13.5	755.5	-38.0	35.3	-1.78	45.0	18.6	1.06
5	16.8	756.7	-49.6	35.4	-2.32	44.3	18.5	1.03
6	20.2	758.1	-59.9	35.4	-2.80	43.5	18.5	1.00
7	23.6	759.5	-70.7	35.5	-3.30	42.7	18.4	0.96
8	27.0	761.7	-79.7	35.6	-3.72	41.8	18.4	0.92
9	30.3	769.3	-89.6	35.9	-4.19	40.9	18.2	0.89
10	33.7	777.3	-98.8	36.3	-4.62	40.0	18.0	0.85
11	37.1	786.8	-106.7	36.8	-4.99	39.0	17.7	0.81
12	40.4	765.5	-105.2	35.8	-4.91	36.6	17.5	0.77
13	43.8	777.4	-112.3	36.3	-5.25	35.5	17.1	0.73
14	47.2	755.8	-109.5	35.3	-5.12	32.9	16.8	0.69
15	50.5	784.6	-115.5	36.7	-5.40	31.7	16.2	0.64
16	53.9	760.9	-108.6	35.5	-5.08	28.9	15.5	0.60
17	57.3	779.0	-115.2	36.4	-5.38	27.6	15.0	0.56
18	60.7	703.9	-88.7	32.9	-4.14	22.9	14.5	0.51
19	64.0	724.2	-93.8	33.8	-4.38	21.7	13.9	0.47
20	67.4	727.0	-78.3	34.0	-3.66	18.8	13.0	0.43
21	70.8	754.7	-81.6	35.3	-3.81	17.9	13.6	0.40
22	74.1	725.1	-62.9	33.9	-2.94	15.2	13.5	0.36
23	77.5	787.4	-67.6	36.8	-3.16	12.8	11.5	0.33
Absolute	77.5			36.8			(T =	40.9 ms)
	50.5				-5.40		(T =	59.8 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	1051.2	967.0	882.7	798.5	714.2					
RX	1051.2	967.0	884.3	802.6	724.0	698.1	688.7	680.9	673.7	667.2
RU	1064.0	982.3	900.6	818.9	737.2					

RAU = 638.8 (kips); RA2 = 776.6 (kips)

Current CAPWAP Ru = 584.0 (kips);

Case Method matching requires higher damping factor

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
18.8	35.87	717.0	755.4	757.1	1.17	0.14	0.14	47.6	875.3	1689

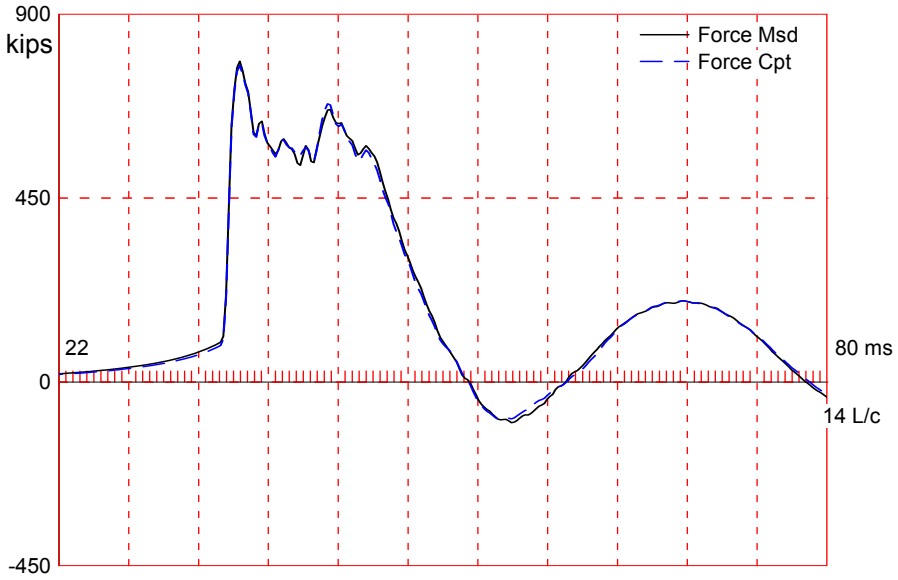
PILE PROFILE AND PILE MODEL

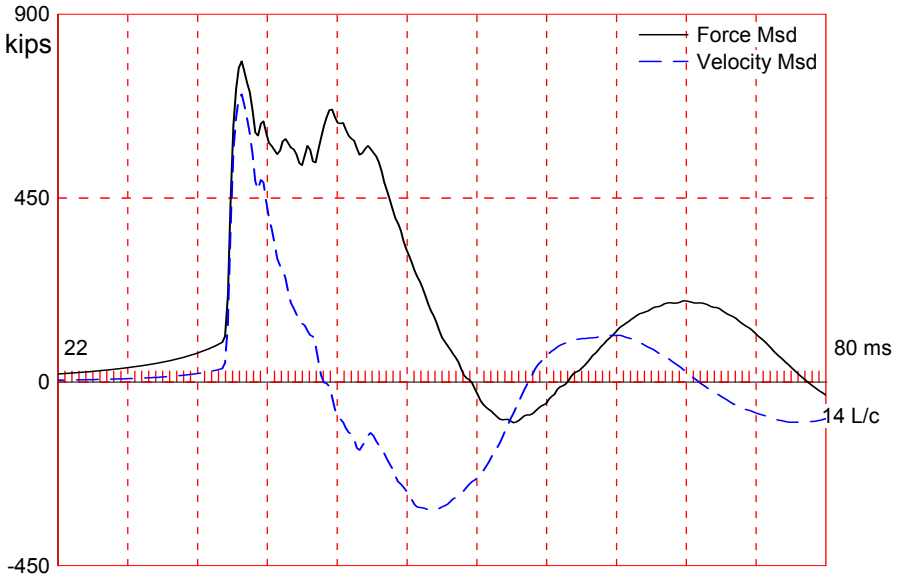
Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.0	21.4	29992.2	492.000	4.70
77.5	21.4	29992.2	492.000	4.70

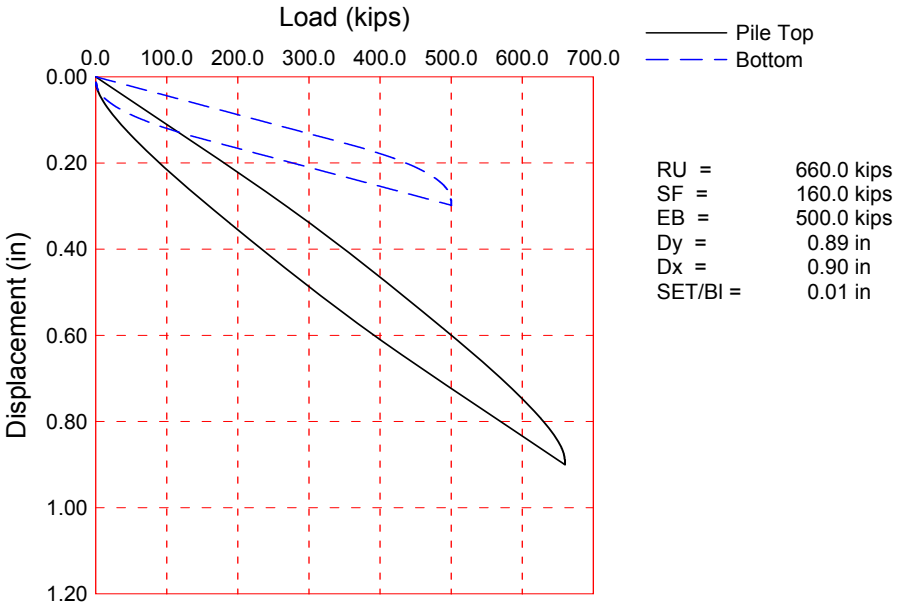
Toe Area 198.5 in^2

Segmnt Number	Dist. B.G. ft	Impedance kips/ft/s	Imped. Change %	Tension Slack in	Tension Eff.	Compression Slack in	Compression Eff.	Perim. ft	Wave Speed ft/s	Soil Plug kips
1	3.4	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16721.3	0.000
22	74.1	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16721.3	0.040
23	77.5	38.20	0.00	0.00	0.000	-0.00	0.000	4.70	16721.3	0.040

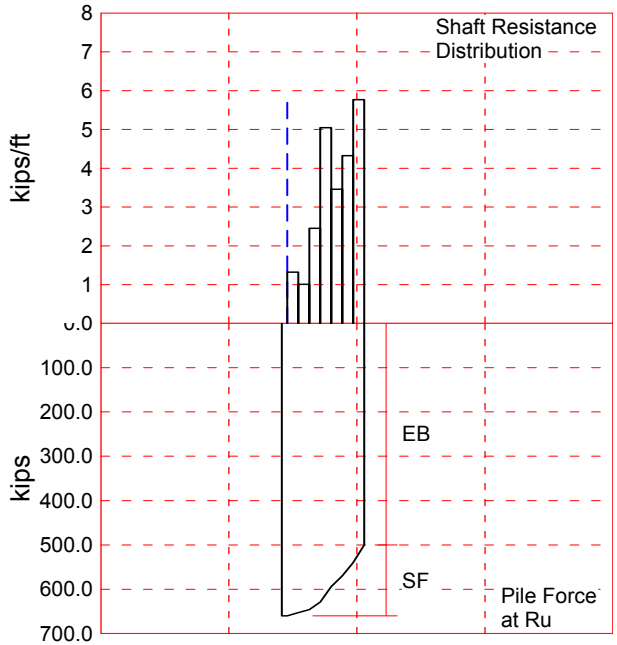
Wave Speed: Pile Top 16807.9, Elastic 16807.9, Overall 16721.3 ft/s
Pile Damping 1.00 %, Time Incr 0.202 ms, 2L/c 9.3 ms
Total volume: 11.517 ft^3; Volume ratio considering added impedance: 1.000







RU =	660.0 kips
SF =	160.0 kips
EB =	500.0 kips
Dy =	0.89 in
Dx =	0.90 in
SET/Bl =	0.01 in



Length b. Sensors	52.0 ft
Embedment	46.9 ft
Top Area	21.4 in^2
End Bearing Area	198.5 in^2
Top Perimeter	4.70 ft
Top E-Modulus	29992 ksi
Top Spec. Weight	492.0 lb/ft^3
Top Wave Spd.	16808 ft/s
Overall W.S.	16774 ft/s
Match Quality	1.59
Top Compr. Stress	36.6 ksi
Max Compr. Stress	38.1 ksi
Max Tension Stress	-6.43 ksi
Avg. Shaft Quake	0.19 in
Toe Quake	0.22 in
Avg. Shaft Smith Dpg.	0.29 s/ft
Toe Smith Damping	0.28 s/ft

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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: 660.0; along Shaft 160.0; at Toe 500.0 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
				660.0			
1	10.4	5.3	7.0	653.0	7.0	1.32	0.28
2	17.3	12.2	7.0	646.0	14.0	1.01	0.21
3	24.3	19.2	17.0	629.0	31.0	2.45	0.52
4	31.2	26.1	35.0	594.0	66.0	5.05	1.07
5	38.1	33.0	24.0	570.0	90.0	3.46	0.74
6	45.1	40.0	30.0	540.0	120.0	4.33	0.92
7	52.0	46.9	40.0	500.0	160.0	5.77	1.23
Avg. Shaft			22.9			3.41	0.73
Toe			500.0				362.72

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.29	0.28
Quake	(in)	0.19	0.22
Case Damping Factor		1.21	3.67
Damping Type		Viscous	Sm+Visc
Reloading Level	(% of Ru)	100	100
Soil Plug Weight	(kips)		0.028

CAPWAP match quality = 1.59 (Wave Up Match) ; RSA = 0
Observed: Final Set = 0.01 in; Blow Count = 960 b/ft
Computed: Final Set = 0.05 in; Blow Count = 248 b/ft
Transducer F3(F590) CAL: 95.0; RF: 1.00; F4(F607) CAL: 93.6; RF: 1.00
A3(K2253) CAL: 325; RF: 1.12; A4(K2524) CAL: 360; RF: 1.12

max. Top Comp. Stress = 36.6 ksi (T= 36.1 ms, max= 1.038 x Top)
max. Comp. Stress = 38.1 ksi (Z= 24.3 ft, T= 37.3 ms)
max. Tens. Stress = -6.43 ksi (Z= 24.3 ft, T= 56.8 ms)
max. Energy (EMX) = 40.4 kip-ft; max. Measured Top Displ. (DMX)= 0.84 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	3.5	784.5	-103.3	36.6	-4.83	40.4	18.4	0.82
2	6.9	794.7	-116.5	37.1	-5.44	39.3	18.2	0.78
3	10.4	807.0	-127.7	37.7	-5.97	38.1	17.8	0.74
4	13.9	774.5	-126.0	36.2	-5.88	35.1	17.6	0.69
5	17.3	796.6	-135.6	37.2	-6.34	33.8	17.0	0.65
6	20.8	776.5	-131.3	36.3	-6.13	31.1	16.4	0.60
7	24.3	814.5	-137.5	38.1	-6.43	29.7	15.7	0.56
8	27.7	759.1	-118.8	35.5	-5.55	25.6	14.5	0.51
9	31.2	789.4	-124.6	36.9	-5.82	24.3	13.8	0.46
10	34.7	700.7	-82.0	32.7	-3.83	18.6	13.1	0.42
11	38.1	732.1	-89.0	34.2	-4.16	17.4	12.5	0.38
12	41.6	720.7	-68.5	33.7	-3.20	14.1	11.7	0.33
13	45.1	736.9	-71.4	34.4	-3.34	13.0	11.5	0.29
14	48.5	685.2	-54.8	32.0	-2.56	10.3	10.8	0.26
15	52.0	715.7	-56.9	33.4	-2.66	8.6	8.5	0.22
Absolute	24.3			38.1			(T =	37.3 ms)
	24.3				-6.43		(T =	56.8 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	1055.5	963.8	872.1	780.5	688.8					
RX	1068.4	982.3	899.8	828.4	777.6	740.8	721.5	702.1	688.4	688.2
RU	1055.5	963.8	872.1	780.5	688.8					

RAU = 665.9 (kips); RA2 = 881.9 (kips)

Current CAPWAP Ru = 660.0 (kips); Corresponding J(RP)= 0.86; matches RX20 within 5%

VMX ft/s	TVP ms	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips	KEB kips/in
18.8	35.87	718.7	795.0	795.0	0.84	0.01	0.01	41.8	1177.1	2273

PILE PROFILE AND PILE MODEL

Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.0	21.4	29992.2	492.000	4.70
52.0	21.4	29992.2	492.000	4.70

Toe Area 198.5 in^2

Top Segment Length 3.47 ft, Top Impedance 38 kips/ft/s

Wave Speed: Pile Top 16807.9, Elastic 16807.9, Overall 16774.2 ft/s
Pile Damping 1.00 %, Time Incr 0.207 ms, 2L/c 6.2 ms
Total volume: 7.728 ft^3; Volume ratio considering added impedance: 1.000