SUBMITTAL

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Submittal number	78	Log entry date	11/12/2015
Project	Rutland City BRF 3000	River Street Rutland, VT	
Project number	2014036		
Spec Section	505.45	**Subsection**	(19) Ripley Road

Submitter	Reviewer	Administrator
Submission due date	Review due date 11/19/2015	Scheduled release
Date submitted 11/12/2015	Date returned	Released for submission
		Released for review
		Date closed
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Notes

For Approval

Dynamic Pile Load Test (Abutment 1)

GEOSCIENCES TESTING AND RESEARCH, INC.

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November 6, 2015 GTR Project # 14.227

Mr. Volker Burkowski
Project Manager
Kubricky Construction Corp.
269 Ballard Road
Wilton, NY 12831

RE: Dynamic Pile Testing Report – Pile #23 – Abutment 1
Bridge Replacement Rutland City – BRF 3000 – Bridge 19
Rutland, Vermont

Dear Volker:

At your request, we were on site on November 3 and 5, 2015 to perform dynamic testing. The dynamic testing was requested in order to evaluate pile capacity, driving stresses, and hammer performance during test pile installation. Testing was conducted using the Pile Driving Analyzer™ (PDA), which records, digitizes, and processes the force and acceleration signals for use in the Case Method and CAPWAP analyses. The dynamic testing was carried out in general accordance with ASTM D4945, "Standard Test Method for High Strain Dynamic Testing of Piles".

Background and Site Description

A bridge replacement is proposed to be constructed in Rutland, Vermont. H-piles are planned for the support of the structure. One HP14x102 test pile was installed and tested in Abutment 1. Pile #23 was tested during the end of driving (EOD) on November 3, 2015 and tested during the beginning of restrike (BOR) on November 5, 2015.

Field Details

Subsurface Conditions

The generalized subsurface conditions at the abutments and pier consist of granular soil varying from silty sand to sandy gravel overlying bedrock. The soil is primarily medium dense and becomes very dense over the lower depths. Boulders and cobbles were frequently encountered within the granular soil. Bedrock was encountered at elevations ranging from +453 feet to +459 feet. For a more detailed description of the subsurface conditions, refer to the Geotechnical Report and/or the boring logs.

Pile Details

One steel HP14x102 H-pile was tested. The total pile length was 50 feet. The factored axial load was reported to be 174 kips. Based on AASHTO LRFD Bridge Design Specifications, the resistance factor is 0.65 (dynamic load testing) and the required nominal resistance is 268 kips. The cross-sectional area of the piles is 30.0 in^2. The maximum allowable compressive and tensile

driving stresses are 45 ksi, based on AASHTO guidelines of 90% of the reported minimum yield strength of 50 ksi. A reinforced point was attached to the tip of the pile.

Driving System

An ICE 60S single acting diesel hammer was used to drive the piles. The maximum continuous rated energy for the hammer is 60 kip-ft (based on a ram weight of 7 kips and a stroke 8.6 feet). The over-stroke and maximum rated energy is 10.2 feet and 71.4 kip-ft, respectively. The cushion material, as reported by the manufacturer, is a Nylon and Aluminum, with an elastic modulus of 175 ksi, thickness of 2 inches, and coefficient of restitution of 0.92. The hammer cushion area is 491 square inches. The helmet weight (including anvil and insert) is 2.44 kips.

Instrumentation

The instrumentation consists of two strain gages and two accelerometer transducers attached around 4 feet below the pile top. One strain gage and one accelerometer were placed on opposite sides of the pile to minimize the effects of uneven impact and pile bending. This instrumentation provides information about driving stresses (compressive and tensile) and pile integrity, hammer performance (transferred energy), and pile bearing capacity.

The PDA is a computer fitted with a data acquisition and signal conditioning system. During driving, the strain and acceleration signals are recorded and processed for each hammer blow. The strain signal is converted to a force record and the acceleration signal is converted to a velocity record. The PDA saves selected hammer blows containing this information to disk and determines the compressive stresses, displacement, and energy at the point of measurement (pile top). In addition, the pile bearing capacity can be estimated in the field using the Case Method. This information can be viewed on the computer screen during driving. Selected blows can be further processed to predict the static pile capacity using the CAPWAP analysis. Refer to Appendix A for literature on the dynamic testing, the Case Method, and CAPWAP.

Results

General

The results of the dynamic testing program are summarized in Table 1, which include the driven depth, blow count, stroke, maximum transferred energy, maximum pile top displacement, and maximum compressive stress at the gage location and pile tip. The blow count was recorded by others.

Also included in Table 1 is the pile bearing capacity as determined by the Case Method in the field and CAPWAP analysis in the office. Three separate PDA plots of various parameters (maximum transferred energy and stroke - left plot, RMX Case Method capacity with Jc=0.5 and Jc=0.7 - middle plot, and maximum measured compressive stress at the pile top and max estimated compressive stress at the pile tip - right plot) are presented for the test pile with depth in Appendix B. Appendix B also contains the above data, and additional data, in tabular form.

In Table 1, the Case Method capacity represents an average over the blows or blow indicated for end of driving (EOD) or the beginning of restrike (BOR). A CAPWAP analysis was

performed on a selected blow from EOD and BOR data. Appendix C contains the full results of the CAPWAP analysis and Table 2 summarizes the CAPWAP results.

Field Observations and Hammer Performance

The dynamic testing gages were attached to the pile and driven to around 17 feet below grade at around 21 blows per foot. The hammer was operated at a pump fuel pressure of around 400 psi resulting in a stroke of around 6 feet (corresponding to an averaged transferred energy around 20 kip-ft). The pile was then driven an additional 20 feet in an attempt to reach the required minimum embedment in the contract drawings. The blow count increased to 38 blows for 2 inches at that point. The hammer was operated at a pump fuel pressure of around 400 psi resulting in a stroke of around 8 to 8.5 feet (corresponding to an averaged transferred energy around 26 kip-ft) during the overdrive.

Restrike testing to assess time dependent changes in pile capacity was performed 2 days after EOD. The hammer was operated at a pump fuel pressure of around 400 psi corresponding to an average typical stroke of around 7.5 to 8 feet with transferred energy of around 26 kip-ft at BOR.

Pile Integrity and Stresses

The maximum compressive and tensile driving stresses were below the allowable limit (45 ksi) throughout testing. The pile cap should be positioned directly over the pile axial center of gravity to maintain good hammer alignment during driving. This minimizes bending stresses and keeps local stress concentrations to a minimum. There were no signs of damage or significant misalignment between the pile and hammer during testing.

Pile Bearing Capacity

The Case Method field capacity (using the RX7 relationship) was around 350 kips and 950 kips during EOD at blow counts ranging from around 2 bpi to 20 bpi, respectfully. The CAPWAP capacity on a selected EOD blow was 280 kips and 825 kips at BOR. Table 2 presents the results of the CAPWAP analyses in more detail. The total capacity, frictional capacity, end bearing capacity, and percentage of end bearing are included. The quake and damping soil parameters as determined from the CAPWAP analyses are also presented in Table 2.

Conclusions

The presented data from the dynamic measurements and their analyses leads to the following findings and conclusions.

1. For the test pile (#23) in Abutment 1, a CAPWAP capacity of 280 kips was obtained at 17 feet below grade. The pile was driven to around 21 bpf at this depth. The ICE I60s hammer was operated at pump fuel pressure of around 400 psi, resulting in a stroke of around 6 feet (20 kip-ft average transferred energy) during EOD.

2. Based on the CAPWAP analysis, around 75% to 85% of the pile capacity was developed in end bearing.

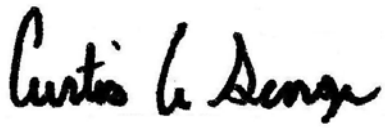
3. The maximum compressive and tensile driving stresses were below the allowable limit during testing. The dynamic records did not indicate pile damage.

4. We recommend a driving criterion of 3 blows per inch for 3 consecutive inches for the remaining piles. The piles should also achieve the minimum tip elevation as specified in the contract drawings. The hammer should be operated at a stroke of around 6 feet and transferred energy of 20 kip-ft).

Static pile capacity evaluations determined from dynamic testing provide an estimate of the axial pile bearing capacity at the time of testing. At very high blow counts (low pile set), the Case Method and CAPWAP analyses tend to predict lower capacities, since not all of the soil resistance may be fully mobilized, particularly at the pile toe. Other factors not considered in this analysis are time dependent changes in pile capacity (setup and/or relaxation), bending, downdrag, lateral and uplift requirements, cyclic loading, effective stress changes (e.g. due to changes in the water table, excavations, and/or fills), settlement, and pile group effects. The foundation designer should evaluate if any of these issues are applicable to the pile design.

This report has been prepared in accordance with generally accepted geotechnical engineering principles with specific application to this project. Our conclusions are based on applicable standards of practice, including any information reported to and/or prepared for us. No other warranty, expressed or implied, is made. If you have any questions regarding this report, please do not hesitate to contact us.

Sincerely,
Geosciences Testing and Research, Inc.



Curtis A. George
Project Manager

Les R. Chernauskas P.E.
Principal

Attachments: Tables 1 and 2, Appendices A through C
14.227 Rutland City Bridge 19 Abut 1 - PDA Report

TABLES

TABLE 1
SUMMARY OF DYNAMIC TESTING
PROPOSED BRIDGE REPLACEMENT RUTLAND CITY BRF 3000 (19)
RUTLAND, VT
HP14x102 H-PILES ICE I-60S OPEN-ENDED DIESEL HAMMER

Test Pile	Date	Time of[1] Driving	Driven[2] Depth (feet)	Observed Blow Count (blows/inch)	Blow Number(s)	Stroke [3] (feet)	Maximum [3] Transferred Energy (kip-ft)	Maximum [3] Displacement (inches)	Maximum [3] Comp. Stress Pile Top (ksi)	Maximum [4] Comp. Stress Pile Tip (ksi)	Case [5] Method Capacity (kips)	CAPWAP Capacity (kips)
Abutment 1 Pile #23	11/3/2015	EOD	17	21 bpf	133-154	6.1	19.9	0.78	22.6	11.8	350	280
			~37	38 for 2"	1353-1389	8.2	25.9	0.56	28.5	31.4	959	-
	11/5/2015	BOR		27 for 2"	5	9.8	35.6	0.64	33.1	32.2	879	825

Notes:

1. Indicates that the data was obtained during driving or during the end of driving (EOD) or the begining of restrike (BOR).
2. Depth is referenced from grade next to pile.
3. The stroke, maximum transferred energy, maximum pile top displacement, and maximum pile top compressive stress are determined by the PDA at the gage locations. These values represent an average over the blow(s) indicated.
4. The maximum compressive stress at the pile tip is estimated by the PDA. These values represent an average over the blow(s) indicated.
5. The Case Method capacity was determined using the RMX method and a JC value of 0.7. These values represent an average over the blow(s) indicated.

TABLE 2
SUMMARY OF CAPWAP RESULTS
PROPOSED BRIDGE REPLACEMENT RUTLAND CITY BRF 3000 (16)
RUTLAND, VT
HP14x102 H-PILES ICE I-60S OPEN-ENDED DIESEL HAMMER

Test Pile	Time of Driving	Blow Number				Percent End Bearing	Quake		Damping	
			Side	Tip	Total		Side (inch)	Tip (inch)	Side (sec/ft)	Tip (sec/ft)
Abutment 1 Pile #23	EOD	155	45	235	280	84%	0.08	0.53	0.33	0.05
	BOR	5	190	635	825	77%	0.10	0.24	0.15	0.06

APPENDIX A
DYNAMIC ANALYSIS LITERATURE

HIGH STRAIN DYNAMIC PILE TESTING

Introduction

Dynamic pile testing (a.k.a. High Strain Dynamic Pile Testing - HSDPT) is commonly employed for evaluating the capacity of driven piles. It is also provides information about hammer performance and pile integrity/stresses. Dynamic testing is carried out in accordance with ASTM D4945, "Standard Test Method for High Strain Dynamic Testing of Piles". Dynamic pile testing involves using strain gages and accelerometers to record an impact wave and its reflections generated by a piling hammer. Both driven piles and drilled foundations can be tested (provided that an impact hammer is used to create the high strain wave for the drilled foundations).

Procedure

Dynamic pile testing was performed using a Pile Driving Analyzer (PDA®), such as the PAK®, PAL®, or PAX® systems, manufactured by Pile Dynamics, Inc. (PDI) of Cleveland, Ohio. These systems are computers fitted with data acquisition and signal conditioning components. The instrumentation consists of two strain gages and two accelerometer transducers attached a minimum of 1.5 pile diameters below the pile top. During impact, the strain and acceleration signals are recorded and processed for each hammer blow. The strain signal is converted to a force record and the acceleration signal is converted to a velocity record. The PDA® saves selected hammer blows containing this information to disk and determines the transferred energy, compressive/tensile stresses, displacement, pile integrity, and the estimated pile bearing capacity using the Case Method. This information can be viewed on the computer screen during driving. A screen shot of data collection in the PDA® Windows (PDA-W®) Program is provided in Figure 1. Selected blows can be further processed to predict the static pile capacity using signal matching programs.

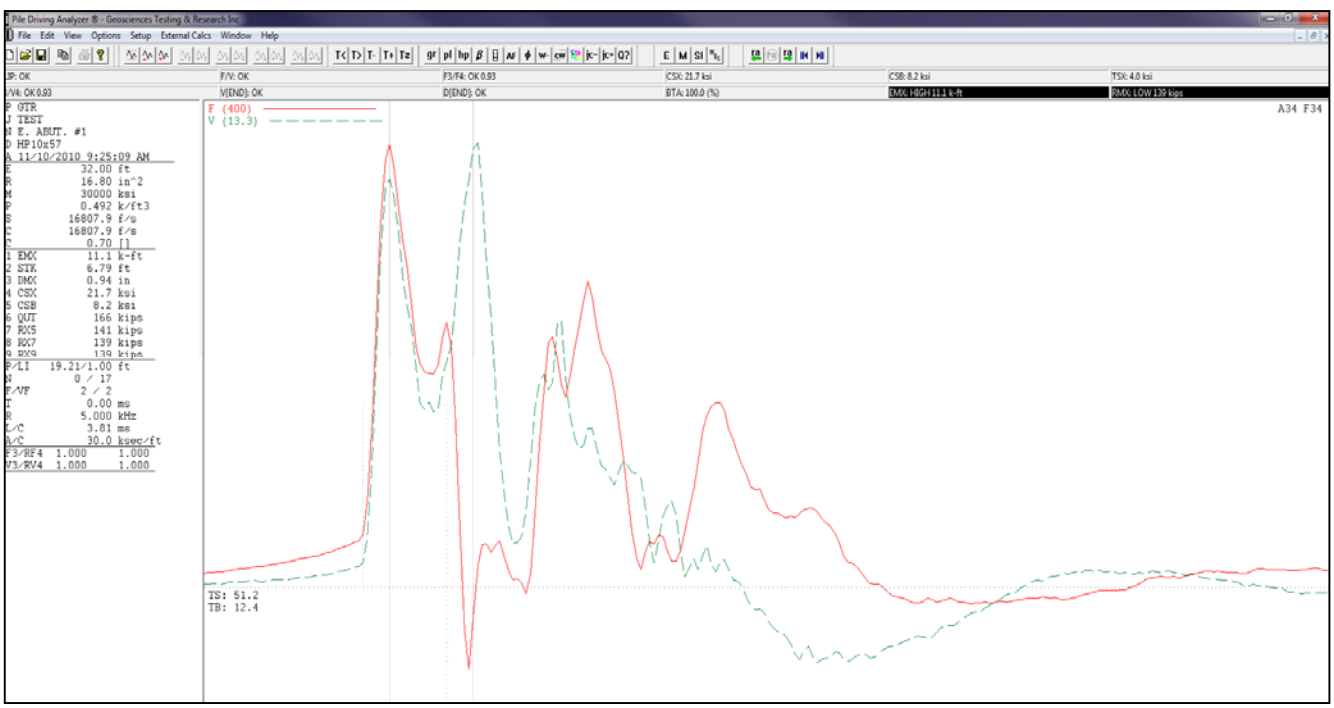


Figure 1. Data collection during pile driving in the (PDI - PDA®-Win Program).

Theory

When a ram strikes the pile head, it initiates a large strain wave that propagates down the pile as illustrated in Figure 2. External soil resistance or changes in the pile's impedance (due to variations in the pile's material or geometry) causes reflection waves that are recorded by the instrumentation. Knowing the material properties and pile geometry at the point of measurement, the strain can be converted to force, while the acceleration is integrated with time to produce velocity.

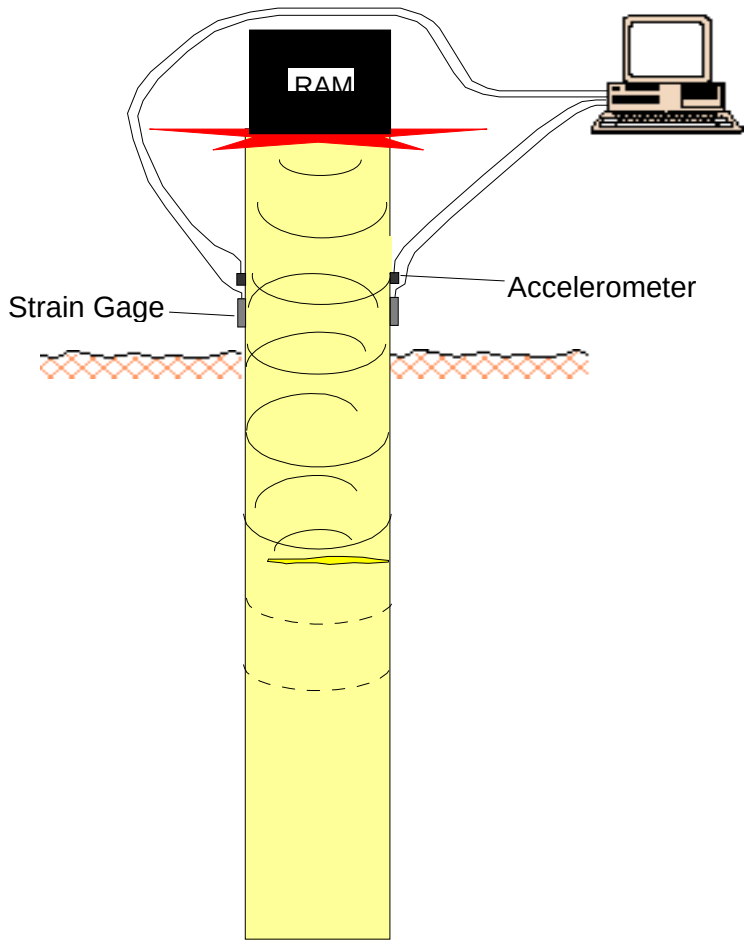


Figure 2. Pile instrumentation and hammer impact.

As long as there is no change in the pile impedance and there are no external forces (i.e. friction), the force and velocity are proportional (equal). Reflections at the tip can be explained by two classical boundary conditions. Free end conditions (analogous to easy driving through soft clay) require zero force and no velocity restrictions at the tip, resulting in a compression wave returning as a tension wave and an increase in velocity (theoretically doubling). Figure 3 graphically presents a typical reflection from a pipe pile during penetration into soft clay. Fixed end conditions (analogous to hard driving into bedrock) require zero velocity and no force restrictions at the tip, resulting in a compression wave being reflected with a greater magnitude than the incident wave (theoretically doubling) and the tip velocity at theoretically zero. Figure 4 graphically presents a typical reflection from an H-pile driven to bedrock. The time the wave takes to travel down to the tip and reflect back to the transducers is twice the pile length divided by the wave speed of the pile material (2L/C).

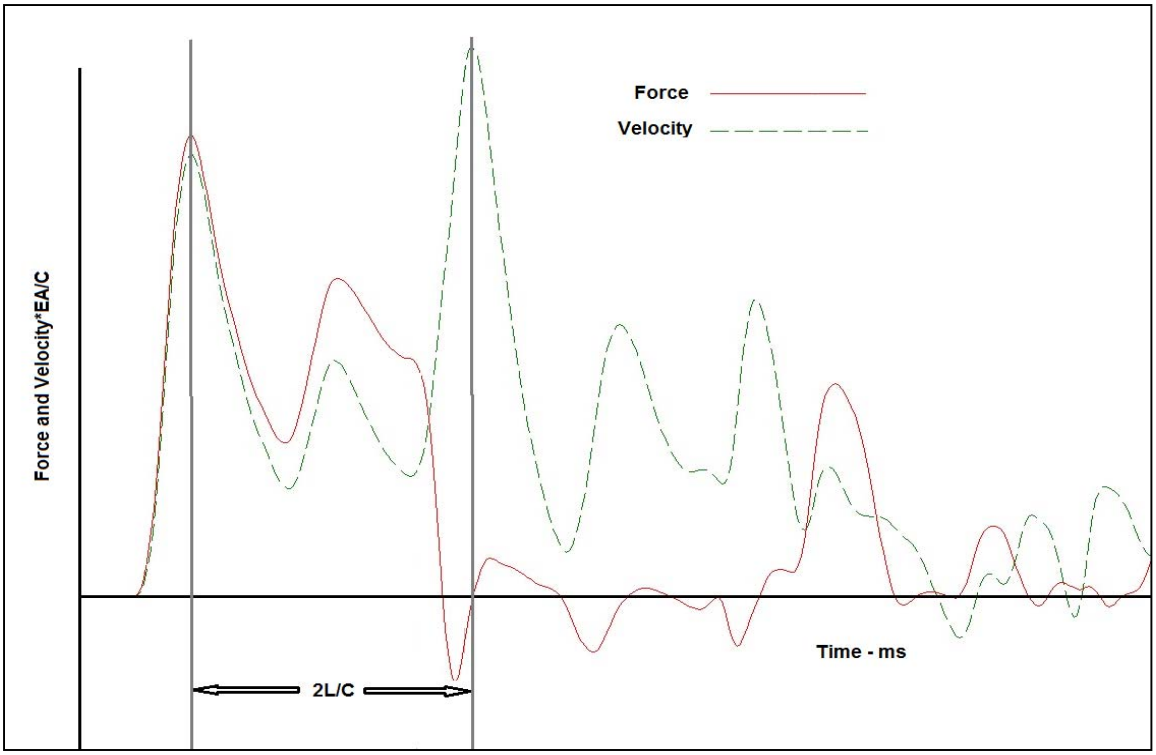


Figure 3. Typical Force and Velocity traces for a pipe pile driven into soft clay (high velocity and low force at tip - 2L/C).

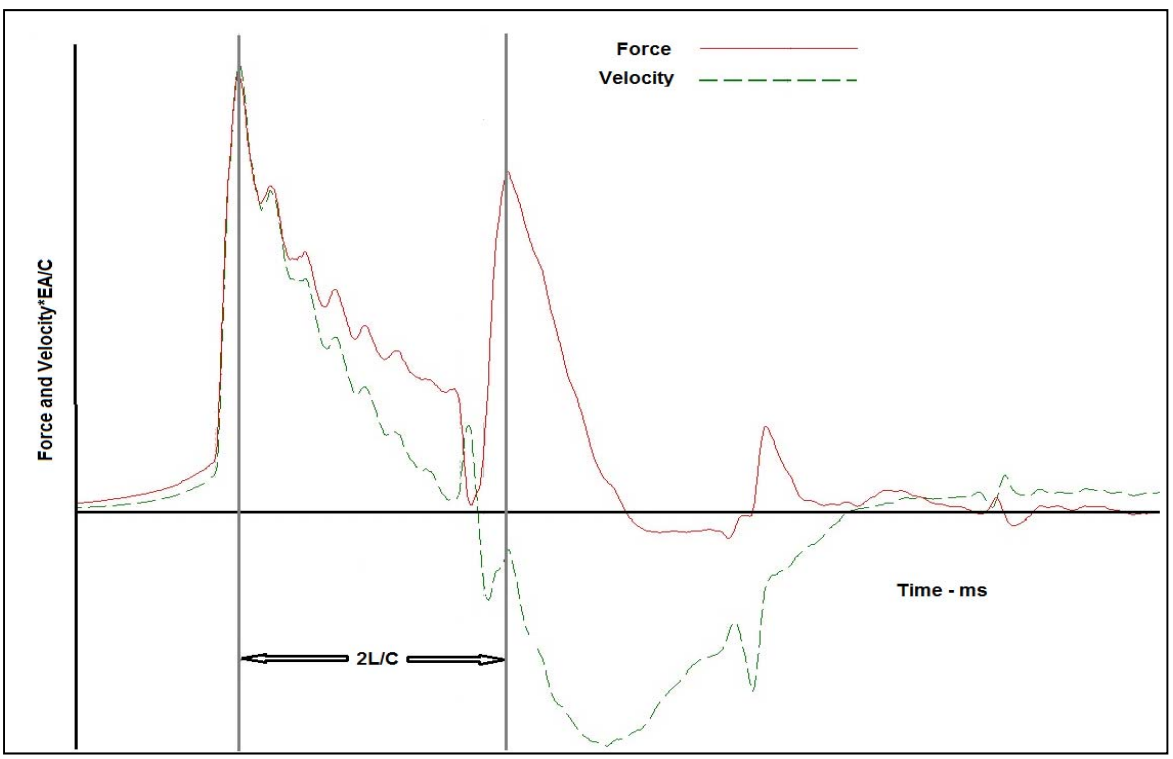


Figure 4. Typical Force and Velocity traces for an H-pile driven into bedrock (high force and low velocity at tip - 2L/C).

If a pile contains a defect or is damaged (e.g. reduction in impedance) during driving, the wave reflecting from the zone of decreased impedance will show a reduction in the force and increase in the velocity (somewhat comparable to "free end conditions"). These reflections would arrive to the measuring transducers before the expected reflections associated with the pile tip as the damaged zone is at a point along the pile between the transducer location and pile tip. The detection of damage during driving is usually easily identifiable and typically associated with cracking of concrete piles or splice breakage.

Dynamic Testing Summary Output

After data collection, the most pertinent output quantities from the dynamic pile testing can be summarized in a graphical manner. The data can be also presented in tabular format, averaging the results based on penetration depth or blow number as specified by the user. Figure 5 shows typical graphical output. Each of the three plots presents two quantities sharing the vertical (penetration) axis.

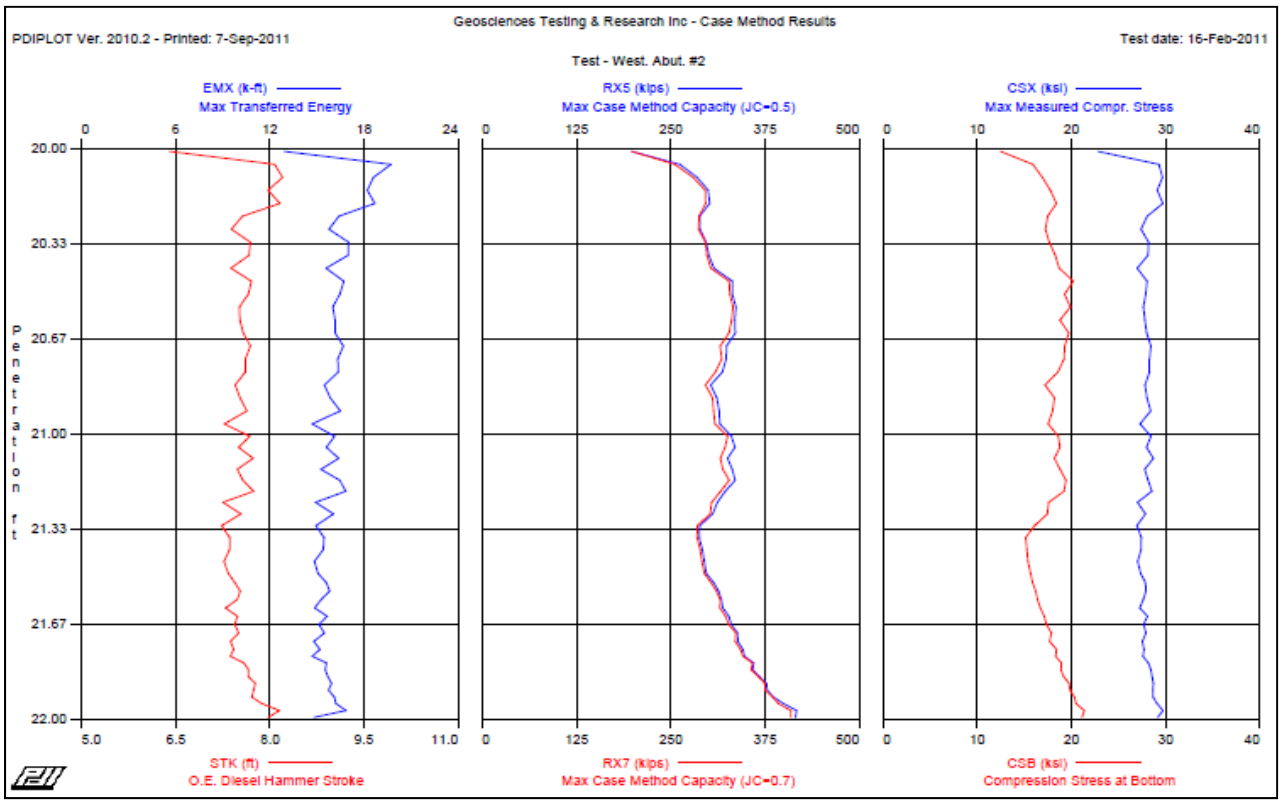


Figure 5. Typical Dynamic Testing summary Output (PDI Plot® Program)

Signal Matching Analyses

Signal matching using the dynamic testing data can be performed to predict the static pile capacity. Programs such as CAPWAP® (developed by Pile Dynamics, Inc.) or TEPWAP/PWAP (developed by GTR) are numerical analyses used to solve the one dimensional wave equation using the measured force and velocity. E.A Smith (1960) suggested modeling the hammer-pile-soil system for use in the wave equation by a series of masses, springs and dashpots as shown in Figure 6. The signal matching programs determine the best match between measured and calculated pile top forces and

replace the hammer input with the measured force and velocity. The pile is separated into many small segments, often 1 meter in length. The velocity record obtained from the dynamic pile testing transducers is used as input to the top pile segment. The resistance, damping, and quake are the primary soil parameters assigned by the user to each pile segment below grade. The signal matching programs will calculate the displacement, velocity, and stresses (forces) for each pile segment based on the input velocity record and the user assigned soil parameters. These parameters are adjusted and modified in an iterative fashion until the best match is obtained between the force calculated for the pile top segment and the force measured at the pile top during testing. The user assigned soil parameters based on the best match represent the "actual soil conditions", including the resistance (and therefore pile capacity). This capacity is based on the resistance at the time of the testing. Static load tests are typically conducted several days or weeks after driving. Therefore, restrike tests are recommended to be performed some time after driving to assess time dependent changes in pile capacity, such as setup or relaxation.

New PDA Appendix.docx

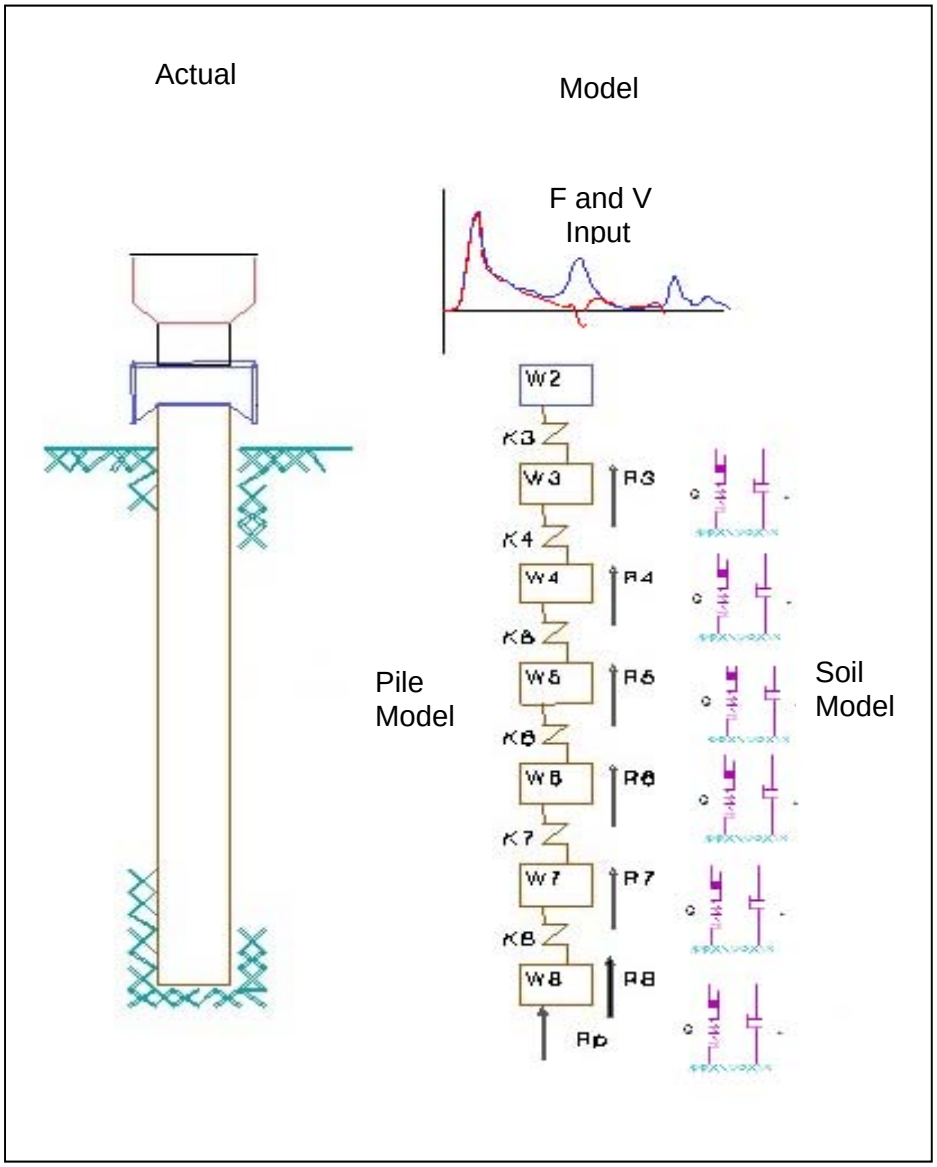


Figure 6. Signal Matching Model (i.e. CAPWAP® or TEPWAP/PWAP).

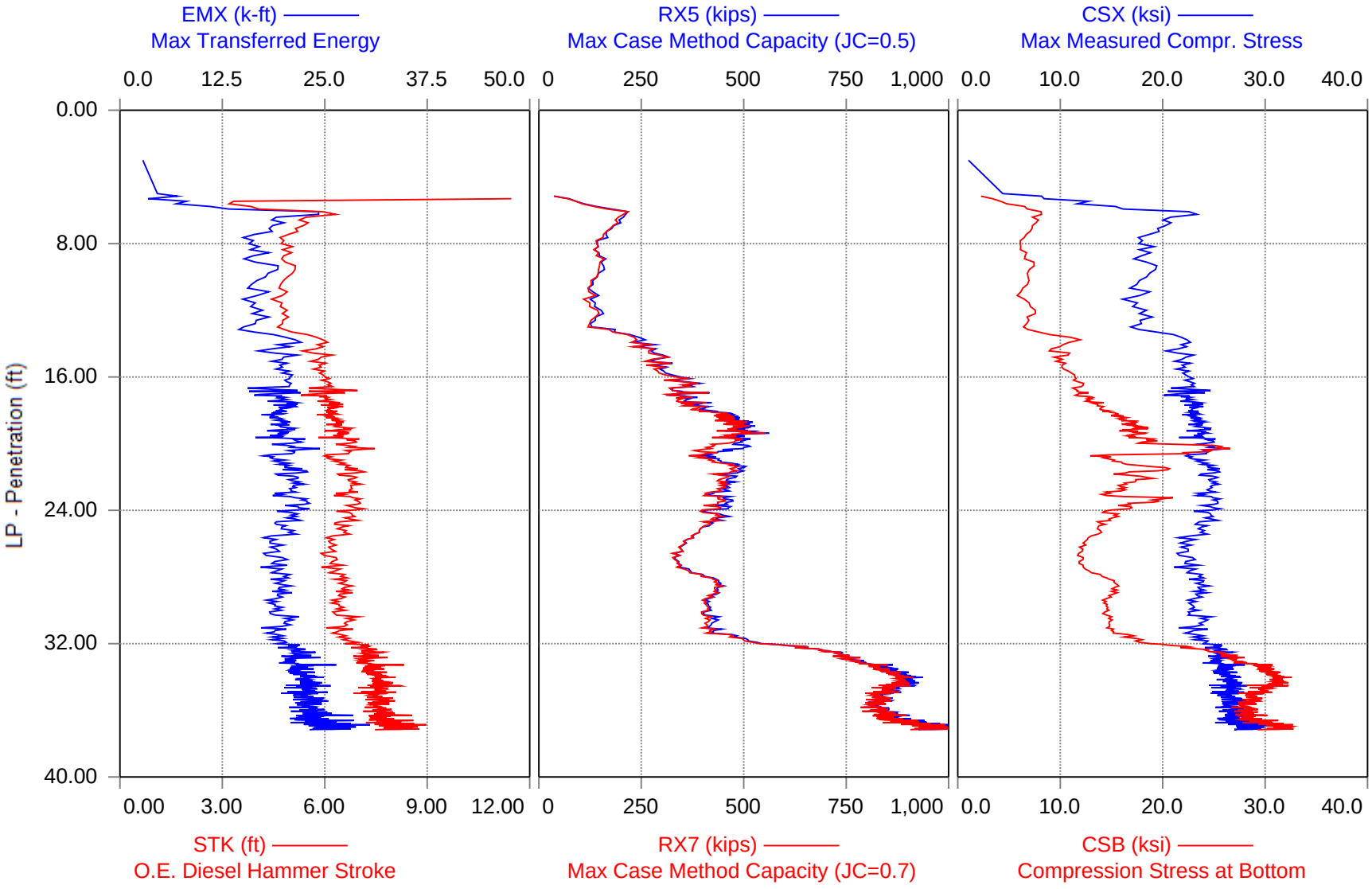
APPENDIX B
PDA VARIABLES

Geosciences Testing & Research Inc - PDIPLOT2 Ver 2014.2.48.1 - Case Method & iCAP® Results

Printed: 04-November-2015 **Test started: 03-November-2015**

Rutland City Br - ABUT1N23

hp14x102 i60s



Rutland City Br - ABUT1N23
OP: CAG

HP14x102 I60S
Date: 03-November-2015

AR: 30.00 in²
LE: 47.00 ft
WS: 16,810.0 f/s

SP: 0.492 k/ft³
EM: 30,000 ksi
JC: 0.50 []

EMX: Max Transferred Energy
STK: O.E. Diesel Hammer Stroke
RX5: Max Case Method Capacity (JC=0.5)
RX7: Max Case Method Capacity (JC=0.7)
CSX: Max Measured Compr. Stress

CSB: Compression Stress at Bottom
DMX: Maximum Displacement
TSX: Tension Stress Maximum
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	TYPE	EMX	STK	RX5	RX7	CSX	CSB	DMX	TSX	RX9
	ft		k-ft	ft	kips	kips	ksi	ksi	in	ksi	kips
1	3.00	AV1	2.8	**	0	0	1.0	0.0	12.02	0.0	0
		MAX	2.8	**	0	0	1.0	0.0	12.02	0.0	0
		@BL	1	**	1	1	1	1	1	1	1
3	5.00	AV1	4.6	**	0	0	4.4	0.0	12.01	3.0	0
		MAX	4.6	**	0	0	4.4	0.0	12.01	3.0	0
		@BL	3	**	3	3	3	3	3	3	3
5	5.15	AV1	7.0	**	37	37	8.2	2.3	2.13	4.8	37
		MAX	7.0	**	37	37	8.2	2.3	2.13	4.8	37
		@BL	5	**	5	5	5	5	5	5	5
17	6.08	AV6	11.2	5.30	135	131	14.5	5.6	0.99	4.6	130
		MAX	24.2	11.46	218	217	22.6	8.1	1.32	8.0	217
		@BL	17	7	17	17	17	17	17	17	17
29	7.09	AV6	19.8	5.51	196	189	20.8	7.6	1.20	7.6	186
		MAX	24.2	6.32	212	206	23.3	8.2	1.32	8.9	203
		@BL	19	19	19	19	19	19	19	19	19
39	8.00	AV5	16.4	4.87	156	152	18.3	6.5	1.20	6.6	149
		MAX	18.6	5.21	168	165	19.6	7.0	1.26	7.3	165
		@BL	31	31	35	31	31	31	31	31	31
51	9.11	AV6	16.5	4.87	148	146	18.2	6.6	1.26	6.6	145
		MAX	18.2	5.06	163	159	19.2	7.4	1.37	7.7	156
		@BL	45	41	49	49	41	51	45	41	49
59	10.00	AV4	18.6	5.06	152	145	19.0	7.0	1.44	7.5	141
		MAX	19.3	5.14	160	148	19.4	7.5	1.47	8.3	144
		@BL	53	53	55	53	53	53	57	57	57
69	11.11	AV5	16.7	4.76	132	127	17.7	6.4	1.51	8.1	123
		MAX	18.2	4.90	146	138	18.7	7.0	1.66	8.9	131
		@BL	67	67	69	69	67	61	67	67	69
77	12.00	AV4	16.2	4.70	138	125	17.3	7.0	1.33	6.9	117
		MAX	17.4	4.90	152	143	18.4	7.6	1.33	7.3	135
		@BL	77	77	77	77	77	77	73	77	77
87	13.00	AV5	16.5	4.77	138	131	17.9	6.9	1.33	7.5	128
		MAX	18.2	4.94	158	147	19.0	7.6	1.49	8.4	138
		@BL	81	81	79	79	81	79	81	81	79
101	14.06	AV7	18.9	5.56	230	219	21.0	9.7	0.97	6.8	214

Rutland City Br - ABUT1N23
HP14x102 I60S
OP: CAG
Date: 03-November-2015

BL#	depth ft	TYPE	EMX k-ft	STK ft	RX5 kips	RX7 kips	CSX ksi	CSB ksi	DMX in	TSX ksi	RX9 kips
		MAX	22.1	6.08	284	271	22.7	11.9	1.02	7.9	258
		@BL	99	99	101	101	99	97	93	93	101
117	15.06	AV8	19.4	5.77	282	274	21.7	9.9	0.91	7.6	266
		MAX	21.6	6.22	317	314	23.0	10.9	0.96	8.3	311
		@BL	111	111	113	113	111	109	103	107	113
133	16.00	AV8	20.1	5.90	312	300	22.2	10.7	0.87	7.3	291
		MAX	21.0	6.02	346	335	22.7	11.4	0.89	8.1	325
		@BL	131	119	133	133	119	133	123	119	133
154	17.00	AV12	19.9	6.11	358	350	22.6	11.8	0.78	7.5	343
		MAX	22.0	6.95	416	414	24.7	12.8	0.83	10.3	412
		@BL	153	150	153	153	150	153	150	150	153
176	18.00	AV22	19.8	6.08	376	360	22.6	13.2	0.75	6.7	347
		MAX	21.7	6.54	422	409	24.0	14.4	0.79	7.5	396
		@BL	166	168	166	166	171	176	166	157	166
210	19.00	AV34	19.4	6.27	477	460	23.3	16.2	0.65	4.6	444
		MAX	20.8	6.56	528	515	24.1	18.0	0.71	6.4	502
		@BL	200	200	208	208	200	210	178	178	208
255	20.04	AV37	20.0	6.52	497	478	23.9	17.7	0.62	3.1	464
		MAX	22.6	7.01	562	553	25.2	21.4	0.66	4.8	544
		@BL	241	241	226	226	241	255	241	225	226
303	21.04	AV16	20.2	6.54	449	408	23.9	20.2	0.60	1.7	398
		MAX	24.4	7.46	515	435	26.4	26.6	0.62	4.6	434
		@BL	267	267	261	279	267	267	300	288	279
348	22.02	AV15	20.7	6.70	479	461	24.6	17.8	0.60	1.7	446
		MAX	22.9	7.16	505	486	25.6	20.7	0.67	3.5	471
		@BL	333	333	318	318	324	324	333	339	318
393	23.04	AV15	21.0	6.76	453	439	24.7	16.2	0.65	3.4	428
		MAX	22.5	7.05	480	459	25.5	19.1	0.68	6.1	454
		@BL	366	366	360	366	366	351	387	387	366
438	24.05	AV15	21.6	6.83	449	430	24.8	17.2	0.67	2.9	418
		MAX	23.1	7.14	474	456	25.6	21.0	0.72	5.0	438
		@BL	417	432	411	411	432	402	417	438	399
474	25.00	AV12	20.5	6.65	429	421	24.3	14.6	0.69	6.0	414
		MAX	22.0	6.98	465	449	25.4	15.7	0.71	6.9	436
		@BL	459	459	450	450	459	450	444	447	444
504	26.08	AV10	19.5	6.34	374	373	23.0	13.1	0.73	6.3	372
		MAX	21.5	6.73	394	394	24.4	14.0	0.77	7.2	394
		@BL	486	486	477	477	486	483	504	486	477
528	27.07	AV8	18.9	6.17	340	338	22.3	12.0	0.75	6.6	336
		MAX	20.4	6.36	351	351	23.2	12.2	0.79	7.5	351

Rutland City Br - ABUT1N23
HP14x102 I60S
OP: CAG
Date: 03-November-2015

BL#	depth ft	TYPE	EMX k-ft	STK ft	RX5 kips	RX7 kips	CSX ksi	CSB ksi	DMX in	TSX ksi	RX9 kips
		@BL	525	525	513	513	525	522	525	525	513
555	28.05	AV9	19.4	6.36	375	369	22.9	13.0	0.70	5.5	366
		MAX	20.7	6.65	426	421	24.0	14.5	0.75	7.1	416
		@BL	549	555	555	555	555	555	534	534	555
591	29.03	AV12	19.6	6.56	438	432	23.7	15.3	0.65	4.0	426
		MAX	21.0	6.81	452	448	24.6	15.7	0.67	4.6	443
		@BL	588	588	573	573	573	573	588	588	573
624	30.00	AV11	19.1	6.42	416	410	23.1	14.6	0.66	4.3	406
		MAX	19.8	6.60	427	424	23.8	15.0	0.68	4.8	421
		@BL	618	624	597	597	597	597	618	624	597
657	31.05	AV11	19.7	6.53	419	407	23.3	14.7	0.68	5.2	400
		MAX	21.9	7.00	440	420	24.8	15.1	0.71	6.2	411
		@BL	636	636	636	636	636	642	636	636	654
693	32.00	AV12	19.3	6.57	479	470	23.5	16.7	0.62	3.6	463
		MAX	20.3	6.98	543	537	24.4	18.8	0.67	6.1	532
		@BL	690	690	693	693	687	693	660	660	693
771	33.01	AV26	21.5	7.25	706	702	25.5	24.7	0.58	2.5	700
		MAX	24.5	7.83	793	785	27.1	28.0	0.62	3.2	785
		@BL	756	756	771	771	756	756	699	699	756
918	34.00	AV48	21.9	7.39	849	834	25.9	29.8	0.56	3.2	826
		MAX	26.4	8.32	920	903	28.0	31.9	0.63	3.9	888
		@BL	810	810	915	915	810	915	810	915	915
1077	35.01	AV53	23.0	7.63	882	866	26.8	30.6	0.56	3.8	862
		MAX	25.7	8.24	937	913	28.3	32.6	0.59	4.3	905
		@BL	1002	1002	921	921	999	921	999	999	921
1215	36.01	AV46	23.1	7.59	832	828	26.8	28.5	0.56	3.7	824
		MAX	25.4	8.04	863	859	28.0	29.7	0.59	4.1	857
		@BL	1137	1134	1113	1113	1137	1113	1137	1206	1137
1353	37.01	AV46	24.4	7.86	898	880	27.5	29.3	0.56	4.8	869
		MAX	30.5	8.97	1,021	997	30.5	32.7	0.61	6.7	984
		@BL	1332	1332	1350	1350	1332	1332	1254	1350	1350
1371	37.09	AV6	26.1	8.19	990	967	28.7	31.8	0.57	6.3	950
		MAX	28.1	8.57	1,021	1,000	29.6	32.6	0.58	6.6	979
		@BL	1365	1365	1365	1365	1365	1365	1365	1362	1365
1389	37.16	AV6	25.2	8.04	968	945	28.1	30.9	0.56	6.2	925
		MAX	28.2	8.76	1,029	1,001	29.5	32.8	0.59	6.9	979
		@BL	1377	1377	1377	1377	1377	1377	1377	1389	1377
		Average	20.9	6.80	583	570	24.3	20.4	0.72	4.4	562
		Maximum	30.5	11.46	1,029	1,001	30.5	32.8	12.02	10.3	984
		@ Blow#	1332	7	1377	1377	1332	1377	1	150	1350

Total number of blows analyzed: 549

BL#	Sensors
1-1389	F3: [] 91.5 (1.00); F4: [] 91.8 (1.00); A3: [] 380.0 (1.00); A4: [] 372.0 (1.00)

Time Summary

Drive 43 minutes 43 seconds 12:31 PM - 1:15 PM BN 1 - 1389

Rutland City Br - ABUT1N23
HP14x102 I60S
OP: CAG
Date: 03-November-2015

AR: 30.00 in²
LE: 47.00 ft
WS: 16,810.0 f/s
SP: 0.492 k/ft³
EM: 30,000 ksi
JC: 0.50 []

EMX: Max Transferred Energy
STK: O.E. Diesel Hammer Stroke
RX5: Max Case Method Capacity (JC=0.5)
RX7: Max Case Method Capacity (JC=0.7)
CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom
DMX: Maximum Displacement
TSX: Tension Stress Maximum
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	EMX	STK	RX5	RX7	CSX	CSB	DMX	TSX	RX9
	ft	k-ft	ft	kips	kips	ksi	ksi	in	ksi	kips
1353	37.01	28.4	8.60	1,005	984	29.8	32.5	0.59	6.6	969
1356	37.02	26.8	8.33	1,001	977	29.2	32.2	0.58	6.2	963
1359	37.04	23.7	7.73	948	927	27.2	30.8	0.54	5.7	909
1362	37.05	27.2	8.40	1,003	980	29.4	32.2	0.58	6.6	967
1365	37.06	28.1	8.57	1,021	1,000	29.6	32.6	0.58	6.6	979
1368	37.08	25.3	8.03	977	956	28.2	31.5	0.56	6.1	934
1371	37.09	25.7	8.11	988	964	28.6	31.7	0.56	6.2	948
1374	37.10	23.5	7.72	939	916	27.4	30.2	0.54	6.2	901
1377	37.11	28.2	8.76	1,029	1,001	29.5	32.8	0.59	6.2	979
1380	37.13	26.8	8.34	1,002	978	28.9	31.8	0.57	6.5	954
1383	37.14	25.9	8.20	981	958	28.8	31.3	0.57	6.2	938
1386	37.15	23.7	7.75	934	913	27.0	30.0	0.55	5.4	892
1389	37.16	23.2	7.47	926	907	27.2	29.3	0.54	6.9	888
	Average	25.9	8.16	981	959	28.5	31.4	0.56	6.3	940
	Maximum	28.4	8.76	1,029	1,001	29.8	32.8	0.59	6.9	979
	@ Blow#	1353	1377	1377	1377	1353	1377	1377	1389	1377

Total number of blows analyzed: 13

BL# Sensors

1-1389 F3: [] 91.5 (1.00); F4: [] 91.8 (1.00); A3: [] 380.0 (1.00); A4: [] 372.0 (1.00)

Time Summary

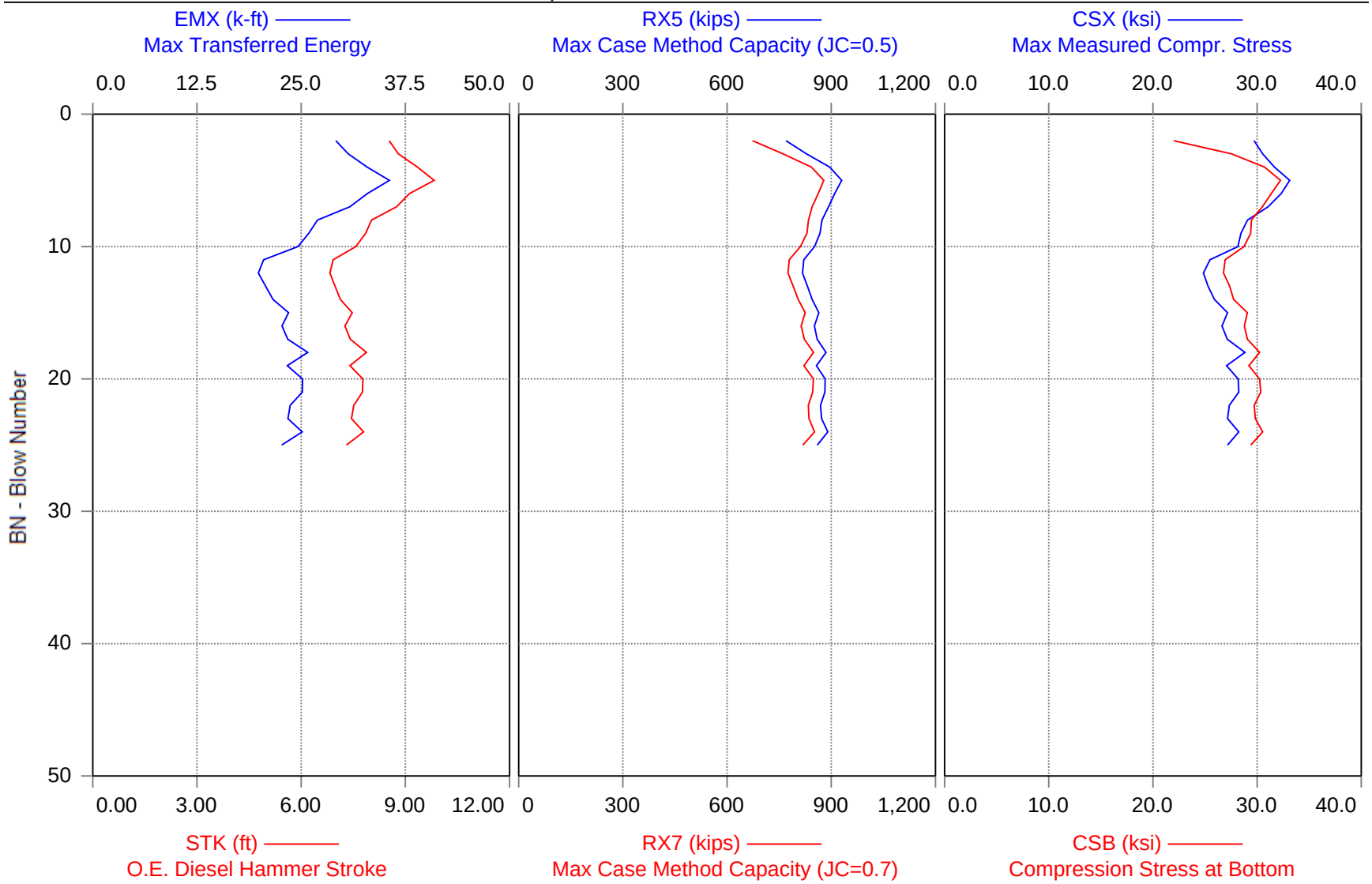
Drive 43 minutes 43 seconds 12:31 PM - 1:15 PM BN 1 - 1389

Geosciences Testing & Research Inc - PDIPLOT2 Ver 2014.2.48.1 - Case Method & iCAP® Results

Printed: 06-November-2015 **Test started: 05-November-2015**

Rutland City Br - AB1N23R

hp14x102 i60s



Rutland City Br - AB1N23R
OP:

hp14x102 i60s
Date: 05-November-2015

AR: 30.00 in²
LE: 47.00 ft
WS: 16,810.0 f/s

SP: 0.492 k/ft³
EM: 30,000 ksi
JC: 0.50 []

EMX: Max Transferred Energy
STK: O.E. Diesel Hammer Stroke
RX5: Max Case Method Capacity (JC=0.5)
RX7: Max Case Method Capacity (JC=0.7)
CSX: Max Measured Compr. Stress

CSB: Compression Stress at Bottom
DMX: Maximum Displacement
TSX: Tension Stress Maximum
RX9: Max Case Method Capacity (JC=0.9)

BL#	depth	EMX	STK	RX5	RX7	CSX	CSB	DMX	TSX	RX9
	ft	k-ft	ft	kips	kips	ksi	ksi	in	ksi	kips
2	37.20	29.2	8.53	770	673	29.7	22.0	0.57	3.9	645
3	37.20	30.6	8.80	829	761	30.5	27.5	0.58	4.0	705
4	37.20	32.9	9.35	895	843	31.7	30.7	0.61	4.1	790
5	37.20	35.6	9.83	930	879	33.1	32.2	0.64	5.3	827
6	37.20	32.9	9.11	910	862	32.3	31.4	0.63	5.6	815
7	37.20	30.8	8.75	892	845	31.1	30.5	0.62	5.6	802
8	37.20	27.0	8.03	873	835	29.1	29.5	0.57	5.1	796
9	37.20	25.9	7.86	867	830	28.4	29.4	0.56	5.2	793
10	37.20	24.6	7.57	852	811	28.2	28.7	0.56	5.3	775
11	37.20	20.5	6.92	821	779	25.5	26.9	0.51	4.3	741
12	37.20	19.9	6.82	817	776	24.8	26.8	0.50	4.2	739
13	37.20	20.7	6.98	832	790	25.3	27.4	0.51	4.3	757
14	37.20	21.6	7.13	845	805	25.9	27.7	0.52	4.5	772
15	37.20	23.5	7.47	864	825	27.2	29.1	0.55	4.9	787
16	37.20	22.7	7.26	852	813	26.6	28.8	0.54	4.7	779
17	37.20	23.4	7.41	859	822	27.1	29.1	0.55	4.6	788
18	37.20	25.8	7.88	885	849	28.8	30.2	0.57	5.3	816
19	37.20	23.3	7.40	857	821	27.1	29.2	0.56	4.8	788
20	37.20	25.2	7.78	883	849	28.2	30.2	0.57	5.1	816
21	37.20	25.1	7.76	882	847	28.2	30.4	0.57	5.2	815
22	37.20	23.7	7.52	869	834	27.3	29.7	0.56	5.0	800
23	37.20	23.4	7.45	872	836	27.2	29.8	0.55	4.8	803
24	37.20	25.1	7.80	890	852	28.2	30.5	0.57	5.2	820
25	37.20	22.7	7.30	860	819	27.2	29.4	0.55	5.5	785
	Average	25.7	7.86	863	819	28.3	29.0	0.56	4.8	781
	Maximum	35.6	9.83	930	879	33.1	32.2	0.64	5.6	827
	@ Blow#	5	5	5	5	5	5	5	7	5

Total number of blows analyzed: 24

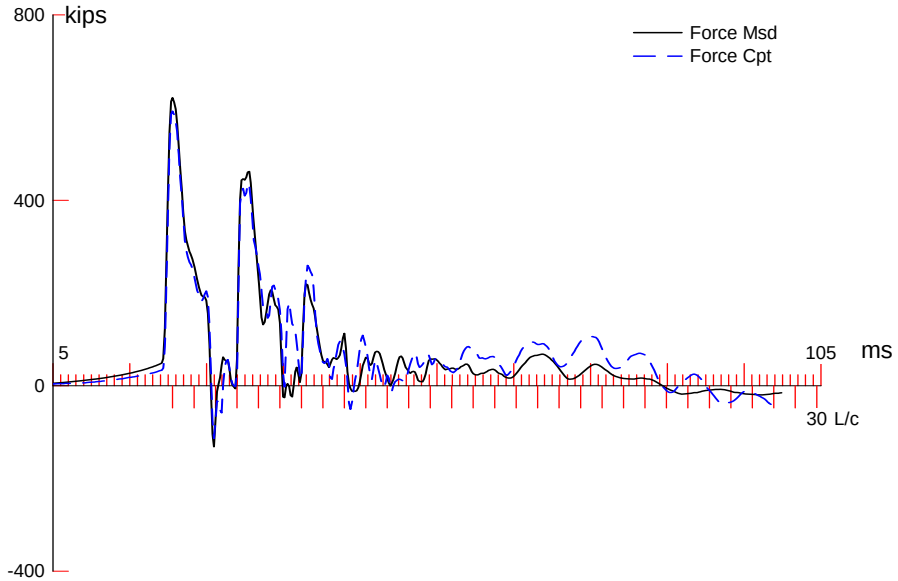
BL# Sensors

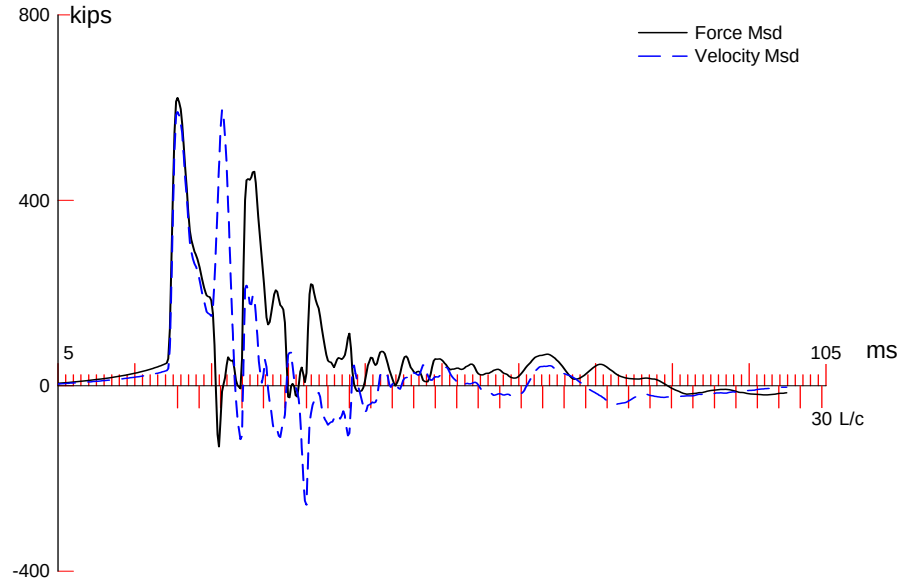
1-27 F3: [] 91.5 (1.00); F4: [] 91.8 (1.00); A3: [] 380.0 (1.00); A4: [] 372.0 (1.00)

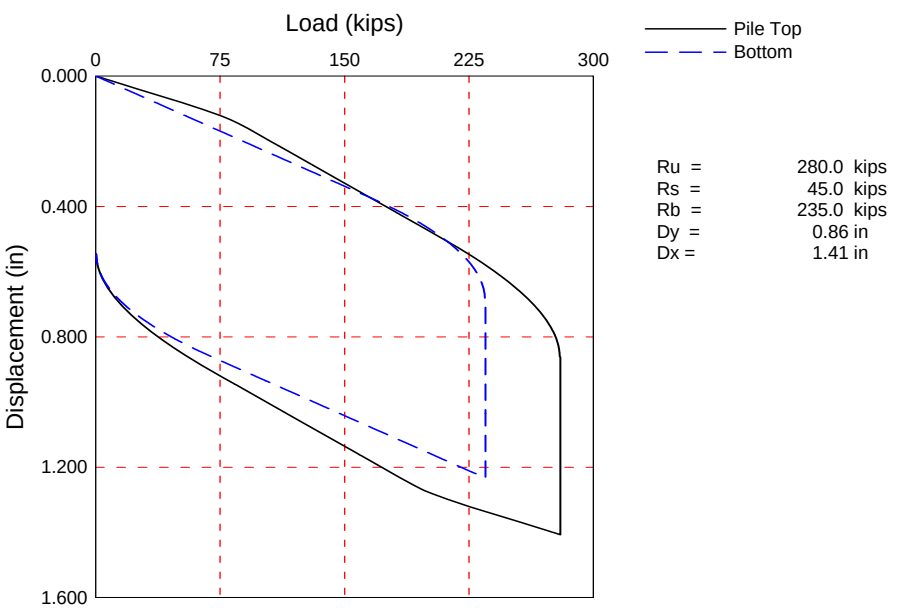
Time Summary

Drive 37 seconds 12:35 PM - 12:36 PM BN 1 - 27

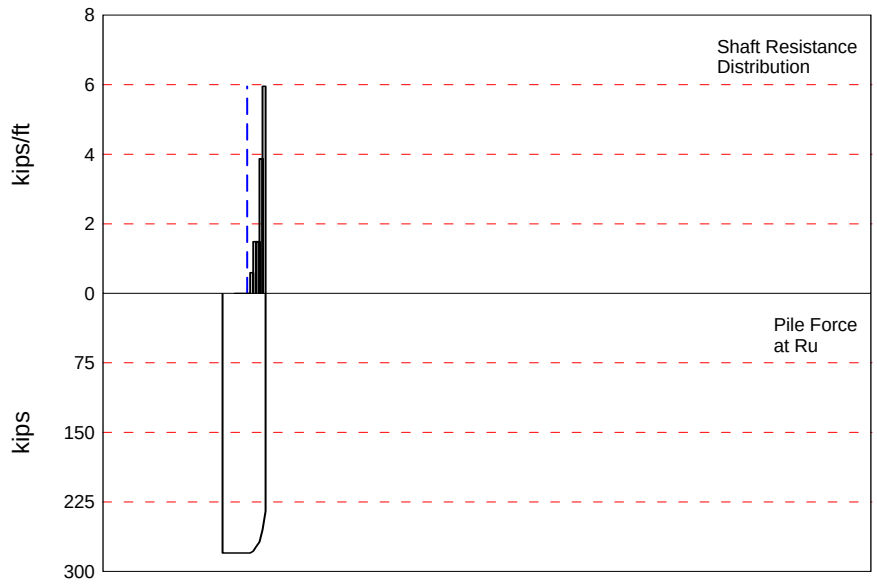
APPENDIX C
CAPWAP RESULTS







Ru =	280.0	kips
Rs =	45.0	kips
Rb =	235.0	kips
Dy =	0.86	in
Dx =	1.41	in



CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 280.0; along Shaft 45.0; at Toe 235.0 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
				280.0				
1	16.8	-13.2	0.0	280.0	0.0	0.00*	0.00*	0.000
2	20.1	-9.8	0.0	280.0	0.0	0.00*	0.00*	0.000
3	23.5	-6.5	0.0	280.0	0.0	0.00*	0.00*	0.000
4	26.9	-3.1	0.0	280.0	0.0	0.00*	0.00*	0.000
5	30.2	0.3	0.0	280.0	0.0	0.00	0.00	0.000
6	33.6	3.6	2.0	278.0	2.0	0.60	0.13	0.330
7	36.9	7.0	5.0	273.0	7.0	1.49	0.32	0.330
8	40.3	10.3	5.0	268.0	12.0	1.49	0.32	0.330
9	43.6	13.7	13.0	255.0	25.0	3.87	0.83	0.330
10	47.0	17.0	20.0	235.0	45.0	5.96	1.28	0.330
Avg. Shaft			4.5			2.64	0.32	0.330
Toe			235.0				172.65	0.050

*Guide friction or other non-soil resistance.

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(in)	0.080	0.530
Case Damping Factor		0.277	0.219
Damping Type			Smith
Unloading Quake	(% of loading quake)	40	30
Reloading Level	(% of Ru)	100	100
Resistance Gap (included in Toe Quake)	(in)		0.300
Soil Plug Weight	(kips)		0.07

CAPWAP match quality = 4.79 (Force Match) ; RSA = 0
Observed: final set = 0.545 in; blow count = 22 b/ft
Computed: final set = 0.560 in; blow count = 21 b/ft

max. Top Comp. Stress = 19.7 ksi (T= 20.8 ms, max= 1.030 x Top)
max. Comp. Stress = 20.3 ksi (Z= 36.9 ft, T= 23.0 ms)
max. Tens. Stress = -5.18 ksi (Z= 6.7 ft, T= 26.4 ms)
max. Energy (EMX) = 15.6 kip-ft; max. Measured Top Displ. (DMX)= 0.76 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	592.2	-113.1	19.7	-3.77	15.64	11.0	0.748
2	6.7	592.7	-155.5	19.8	-5.18	15.78	11.0	0.739
3	10.1	592.8	-137.3	19.8	-4.58	15.66	11.0	0.727
4	13.4	593.1	-142.3	19.8	-4.74	15.50	11.0	0.715
5	16.8	593.1	-142.5	19.8	-4.75	15.35	11.0	0.702
6	20.1	593.5	-127.1	19.8	-4.23	15.21	11.0	0.698
7	23.5	593.5	-105.3	19.8	-3.51	15.19	11.0	0.694
8	26.9	594.9	-75.6	19.8	-2.52	15.16	11.0	0.688
9	30.2	599.5	-63.5	20.0	-2.11	15.11	11.0	0.681
10	33.6	607.7	-83.1	20.3	-2.77	15.07	12.1	0.675
11	36.9	609.8	-60.1	20.3	-2.00	14.62	13.8	0.666
12	40.3	568.7	-39.5	19.0	-1.32	13.50	15.7	0.656
13	43.6	414.4	-30.6	13.8	-1.02	12.32	16.6	0.645
14	47.0	339.5	-19.1	11.3	-0.64	5.44	17.1	0.634
Absolute	36.9			20.3			(T =	23.0 ms)
	6.7				-5.18		(T =	26.4 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	294.6	202.3	110.0	17.7	0.0	0.0	0.0	0.0	0.0	0.0
RX	360.4	340.6	325.4	313.0	300.6	296.2	293.7	293.2	292.8	292.8
RU	294.6	202.3	110.0	17.7	0.0	0.0	0.0	0.0	0.0	0.0

RAU = 292.8 (kips); RA2 = 311.8 (kips)

Current CAPWAP Ru = 280.0 (kips); Corresponding J(RP)= 0.02; matches RX9 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
11.28	20.77	594.7	622.9	625.1	0.758	0.546	0.545	17.4	320.3

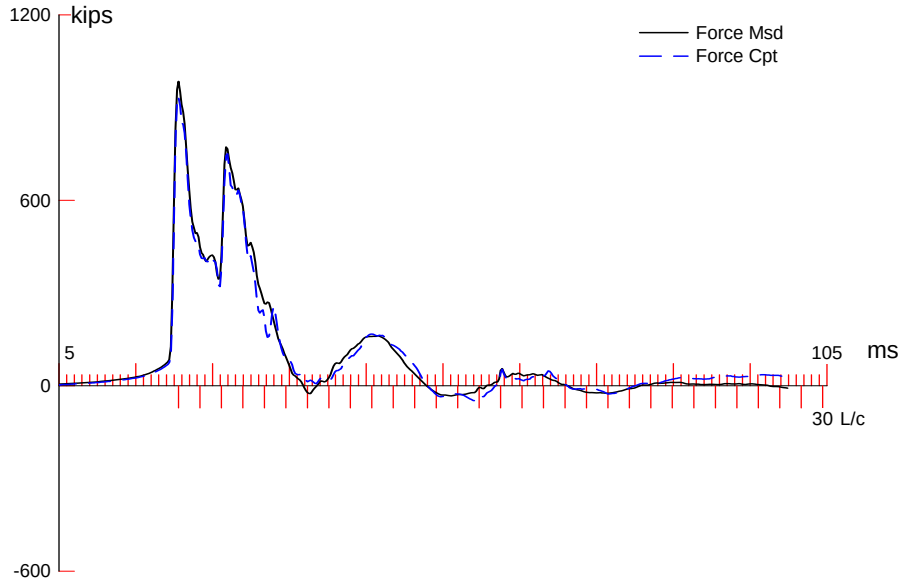
PILE PROFILE AND PILE MODEL

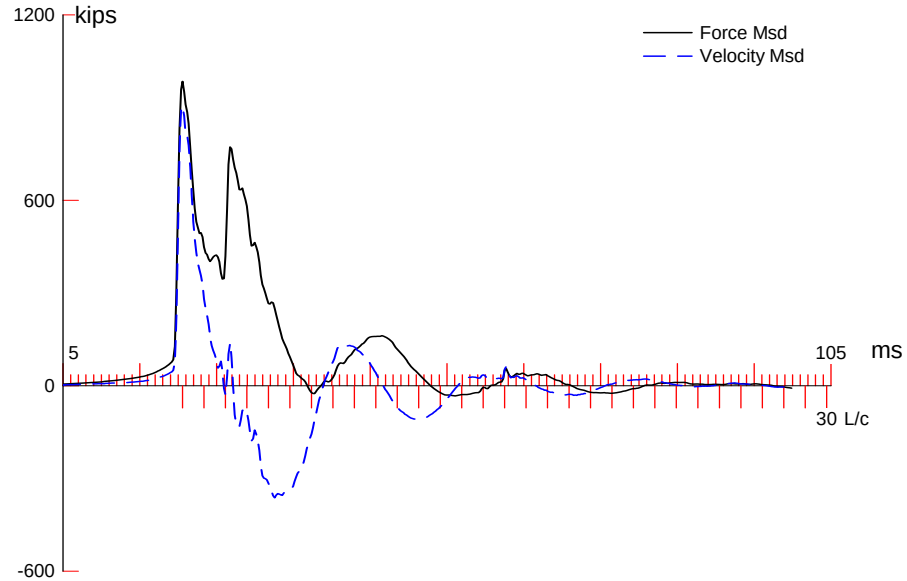
Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.00	30.00	29992.2	492.000	4.670
47.00	30.00	29992.2	492.000	4.670

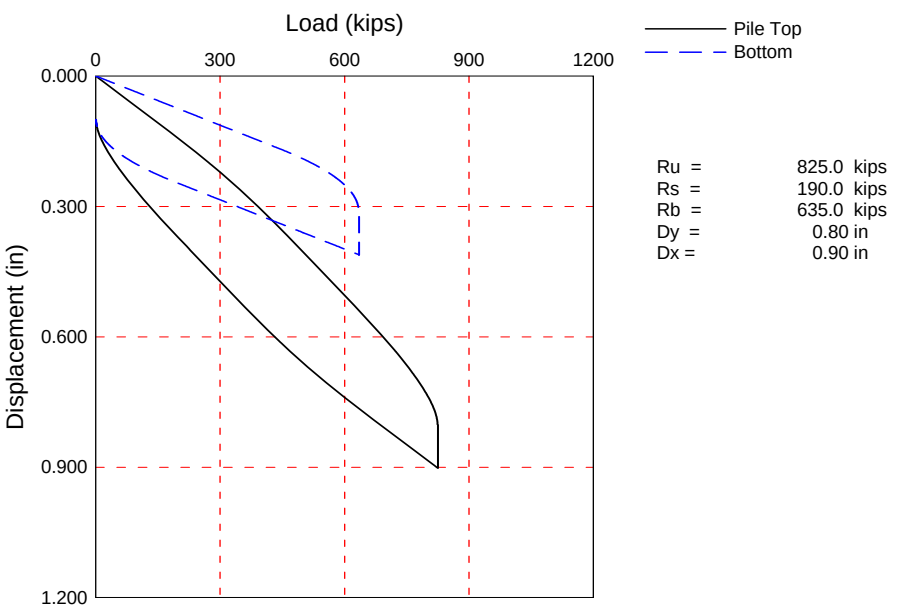
Toe Area 1.361 ft^2

Top Segment Length 3.36 ft, Top Impedance 53.55 kips/ft/s

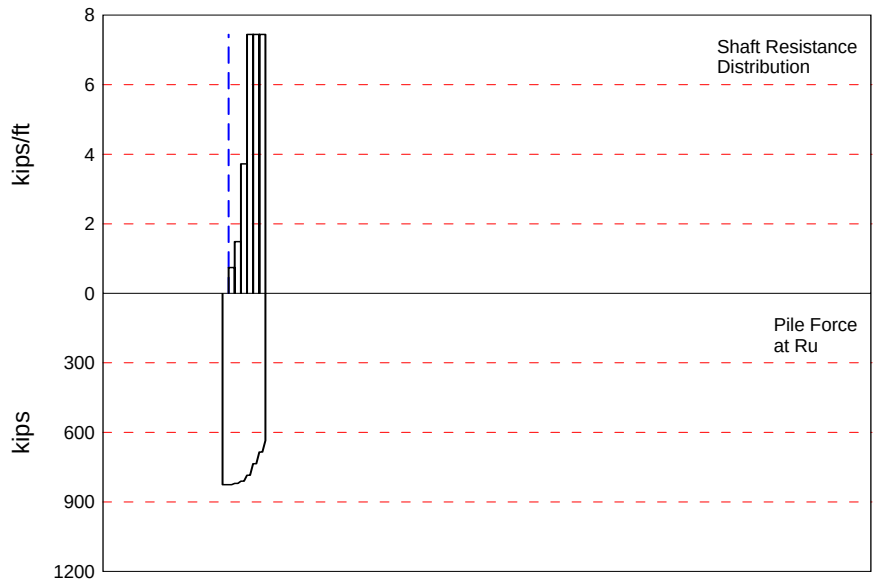
Pile Damping 0.0 %, Time Incr 0.200 ms, Wave Speed 16807.9 ft/s, 2L/c 5.6 ms







Ru =	825.0 kips
Rs =	190.0 kips
Rb =	635.0 kips
Dy =	0.80 in
Dx =	0.90 in



Rutland City Br; Pile: AB1N23R Test: 05-Nov-2015 12:36:
hp14x102 i60s; Blow: 5 CAPWAP(R) 2006-3
Geosciences Testing & Research Inc

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 825.0; along Shaft 190.0; at Toe 635.0 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
				825.0				
1	13.4	3.6	5.0	820.0	5.0	1.38	0.30	0.150
2	20.1	10.3	10.0	810.0	15.0	1.49	0.32	0.150
3	26.9	17.1	25.0	785.0	40.0	3.72	0.80	0.150
4	33.6	23.8	50.0	735.0	90.0	7.45	1.59	0.150
5	40.3	30.5	50.0	685.0	140.0	7.45	1.59	0.150
6	47.0	37.2	50.0	635.0	190.0	7.45	1.59	0.150
Avg. Shaft			31.7			5.11	1.09	0.150
Toe			635.0				466.53	0.060

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(in)	0.100	0.240
Case Damping Factor		0.532	0.716
Unloading Quake	(% of loading quake)	30	75
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	45	
Resistance Gap (included in Toe Quake) (in)			0.040

CAPWAP match quality = 1.96 (Force Match) ; RSA = 0
Observed: final set = 0.100 in; blow count = 120 b/ft
Computed: final set = 0.085 in; blow count = 141 b/ft

max. Top Comp. Stress = 31.1 ksi (T= 20.8 ms, max= 1.032 x Top)
max. Comp. Stress = 32.1 ksi (Z= 26.9 ft, T= 22.4 ms)
max. Tens. Stress = -3.85 ksi (Z= 33.6 ft, T= 38.5 ms)
max. Energy (EMX) = 31.4 kip-ft; max. Measured Top Displ. (DMX)= 0.63 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	934.5	-48.7	31.1	-1.62	31.43	16.8	0.594
2	6.7	938.7	-46.1	31.3	-1.54	31.38	16.8	0.575
3	10.1	944.6	-53.7	31.5	-1.79	30.98	16.7	0.554
4	13.4	950.6	-63.8	31.7	-2.12	30.53	16.6	0.532
5	16.8	943.6	-74.2	31.4	-2.47	29.49	16.4	0.509
6	20.1	954.8	-89.2	31.8	-2.97	28.95	16.2	0.485
7	23.5	942.9	-91.2	31.4	-3.04	27.37	15.8	0.460
8	26.9	964.4	-104.6	32.1	-3.49	26.68	15.4	0.432
9	30.2	921.4	-100.9	30.7	-3.36	23.88	14.9	0.404
10	33.6	950.6	-115.5	31.7	-3.85	23.05	14.2	0.374
11	36.9	833.6	-97.5	27.8	-3.25	18.73	13.7	0.345
12	40.3	843.3	-103.2	28.1	-3.44	17.80	13.2	0.313
13	43.6	791.0	-76.2	26.4	-2.54	14.16	13.6	0.283
14	47.0	865.1	-75.7	28.8	-2.52	12.46	12.9	0.252
Absolute	26.9			32.1			(T =	22.4 ms)
	33.6				-3.85		(T =	38.5 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	1131.9	1055.6	979.3	903.0	826.7	750.4	674.1	597.8	521.5	445.2
RX	1192.7	1123.3	1062.9	1012.5	967.3	941.0	916.4	891.8	867.2	842.5
RU	1131.9	1055.6	979.3	903.0	826.7	750.4	674.1	597.8	521.5	445.2

RAU = 619.0 (kips); RA2 = 853.6 (kips)

Current CAPWAP Ru = 825.0 (kips); Corresponding J(RP)= 0.40; matches RX9 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
17.21	20.77	921.5	973.4	994.0	0.626	0.092	0.100	34.8	1151.7

PILE PROFILE AND PILE MODEL

Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.00	30.00	29999.9	492.000	4.670
47.00	30.00	29999.9	492.000	4.670

Toe Area 1.361 ft^2

Top Segment Length 3.36 ft, Top Impedance 53.55 kips/ft/s

Pile Damping 0.0 %, Time Incr 0.200 ms, Wave Speed 16810.0 ft/s, 2L/c 5.6 ms