KUBRICKY CONSTRUCTION CORP.
269 BALLARD ROAD

WILTON, NY 12831
518 792-5864

KUBRICKY CONSTRUCTION CORP.
A PROUD MEMBER OF THE J.A. COLLINS™ COMPANIES

Rutland City BRF 3000 (2014036)
SUBMITTAL 29

Issued 02/06/15
Respond by 02/13/15

To

Timothy Pockette, PE

Topic	505.45 Dynamic Pile Loading Test
Status	For Approval
Spec section	505.45
Sent to approver	2/6/15
Required from approver	2/13/15

From

Volker H.D. Burkowski

Signed by _____ Date 2/6/15

Proceed as Indicated _____ Date _____
Owner Authorized Representative

GEOSCIENCES TESTING AND RESEARCH, INC.

55 Middlesex Street, Suite 225, N. Chelmsford, MA 01863
Ph: (978)251-9395, Fx: (978)251-9396

February 5, 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 #5 - Abutment 2
Bridge Replacement Rutland City BRF 3000 (16)
Rutland, Vermont

Dear Volker:

At your request, we were on site on January 28 through the 30 and February 4, 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 HP12x84 test pile was installed and tested in Abutment 2 during the end of driving (EOD) on January 30, 2015 and during the beginning of restrike (BOR) on February 4, 2015.

Field Details

Subsurface Conditions

The generalized subsurface conditions at the abutments consist of granular soil varying from silty sand to sandy. The soil is primarily medium dense and becomes very dense over the lower depths. Boulders and cobbles were encountered sporadically within the granular soil. Bedrock was not encountered. For a more detailed description of the subsurface conditions, refer to the Geotechnical Report and/or the boring logs.

Pile Details

One steel HP12x84 H-pile was tested. The pile length was 70 feet. The factored axial load was reported to be 318 kips. Based on AASHTO LRFD Bridge Design Specifications, the

resistance factor is 0.65 (dynamic load testing) and the required nominal resistance is 489 kips. The cross-sectional area of the piles is 24.6 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 with a rated energy of 71.4 kip-ft (ram weight of 7 kips and a max stroke of 10.2 feet) was used to drive the pile.

Instrumentation

The instrumentation consists of two strain gages and two accelerometer transducers attached around 3 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 first 40 foot long section of the test pile was installed to around 36.5 feet below grade and spliced. The dynamic testing gages were then attached to the pile and the pile was driven to around 61 feet below grade at 6 blows per inch (bpi). The hammer was operated at a pump fuel pressure of 400 psi resulting in a stroke of around 6.5 to 7 feet (corresponding to an averaged transferred energy around 20 to 22 kip-ft). Restrike testing to assess time dependent changes in pile capacity was performed approximately 5 days after EOD. The hammer was operated at a pump fuel pressure of 400 psi corresponding to a typical stroke of around 6.5 to 7.5 feet with transferred energy of around 18 to 22 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) ranged from 490 to 520 kips during EOD. The Case Method field capacity ranged from 490 to 620 kips during BOR. The CAPWAP capacity on a selected EOD and BOR blows ranged between 505 to 515 kips. 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 (#5) in Abutment 2, an BOR CAPWAP capacity of 515 kips was obtained at 61 feet below ground surface. The pile was driven to 6 bpi at EOD. The ICE I60s hammer was operated at pump fuel pressure of 400 psi, resulting in a stroke of 6.5 to 7 feet (20 to 22 kip-ft average transferred energy).

2. Based on the CAPWAP analysis, around 80 to 85% of the pile capacity was developed in end bearing.

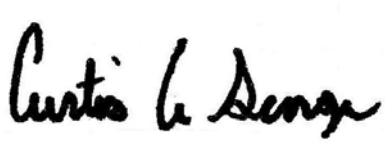
3. The maximum compressive and tensile driving stresses were below the allowable limit during testing. The dynamic records did not indicate pile damage.

4. We recommend a driving criterion of 6 blows per inch for 3 consecutive inches. 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 6.5 to 7 feet and transferred energy of 20 to 22 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. P.E.
Project Manager

Les R. Chernauskas, P.E.
Principal

Attachments: Tables 1 and 2, Appendices A through C
14.227 Rutland City Bridge BRF 3000 (16) PDA Report - Abutment 2

TABLES

TABLE 1
SUMMARY OF DYNAMIC TESTING
PROPOSED BRIDGE REPLACEMENT RUTLAND CITY BRF 3000 (16)
RUTLAND, VT
HP12x84 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)
Abut 2 Pile #5	1/30/2015	EOD	61'-4"	6,6,5	801-818	6.9	20.6	0.65	25.9	23.2	510	505
	2/4/2015	BOR	61'-8"	6,6,6,6	4	7.7	23.3	0.69	28.7	24.0	516	515

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
HP12x84 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)
Abut 2 Pile #5	EOD	811	90	415	505	82%	0.10	0.33	0.20	0.08
	BOR	4	95	420	515	82%	0.10	0.33	0.22	0.05

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.

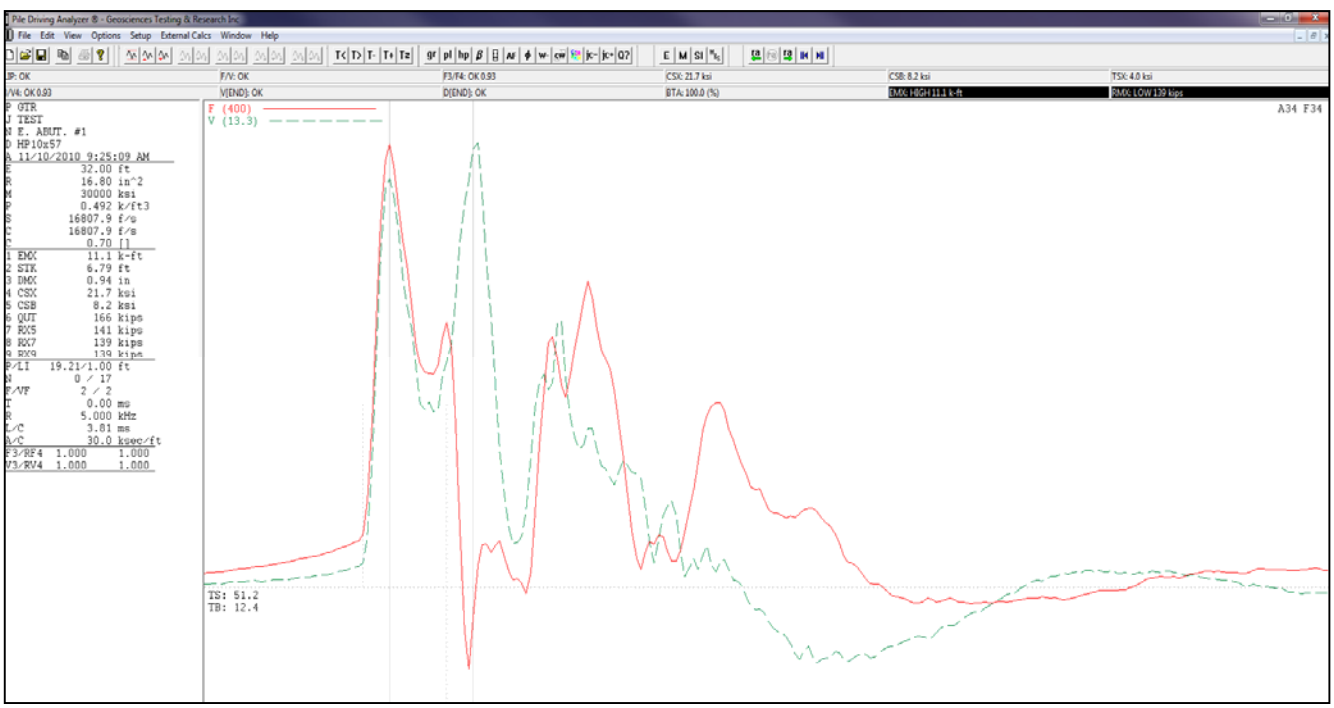


Figure 1. Data collection during pile driving in the (PDI - PDA®-Win Program).

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.

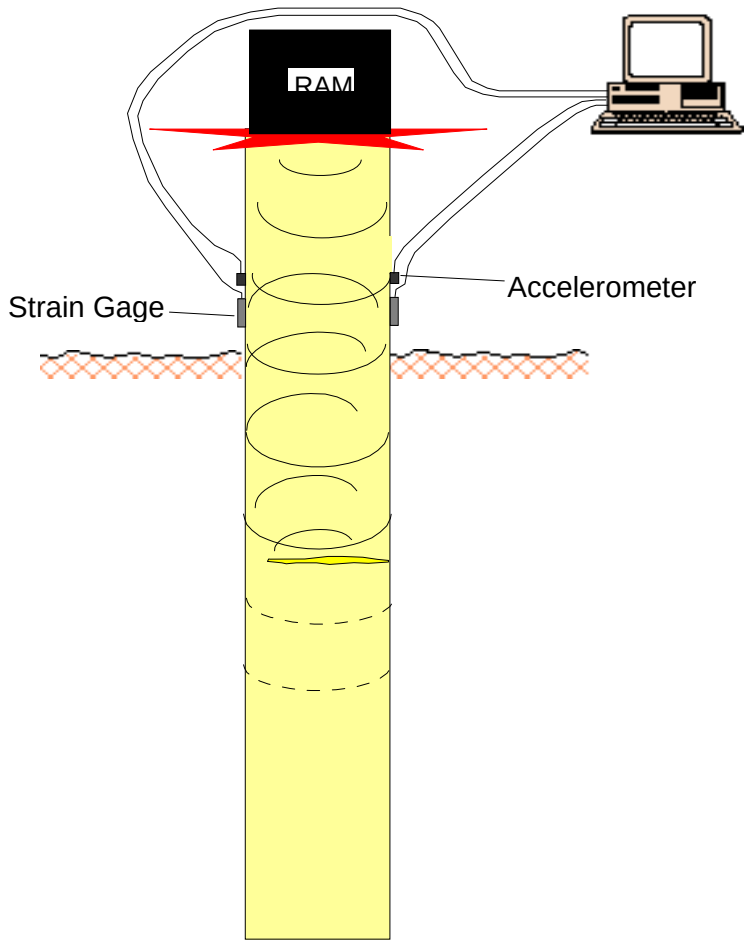


Figure 2. Pile instrumentation and hammer impact.

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).

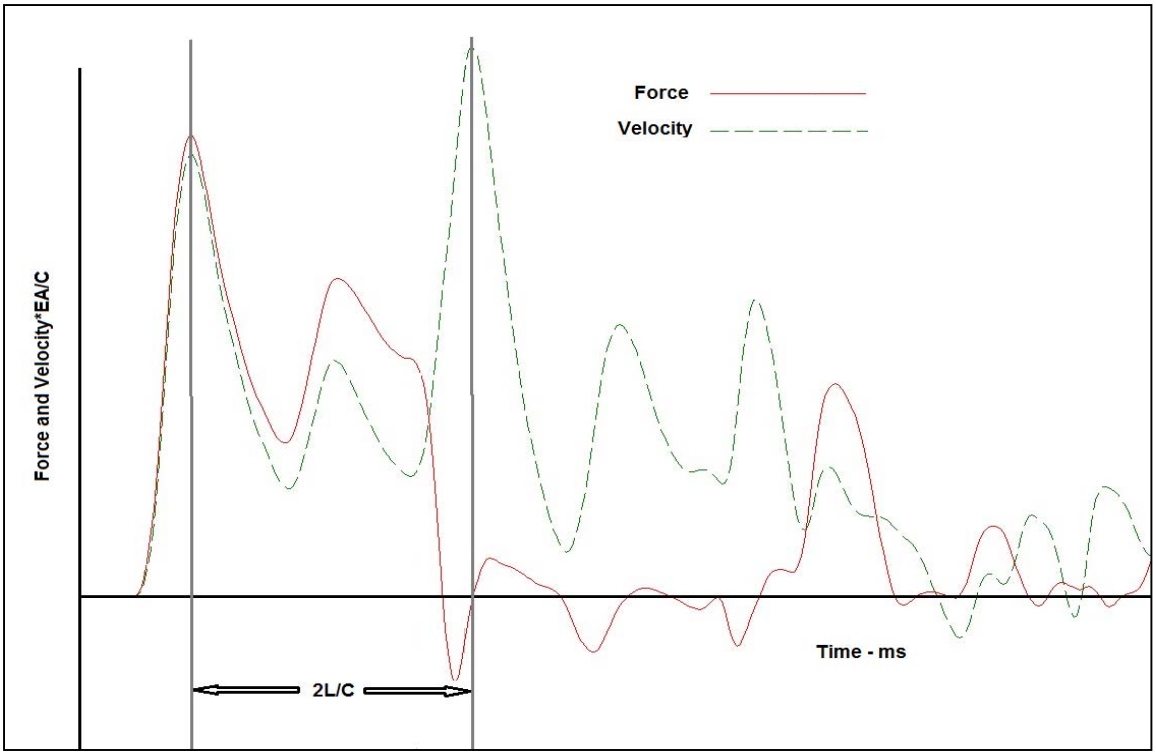


Figure 3. Typical Force and Velocity traces for a pipe pile driven into soft clay (high velocity and low force at tip - 2L/C).

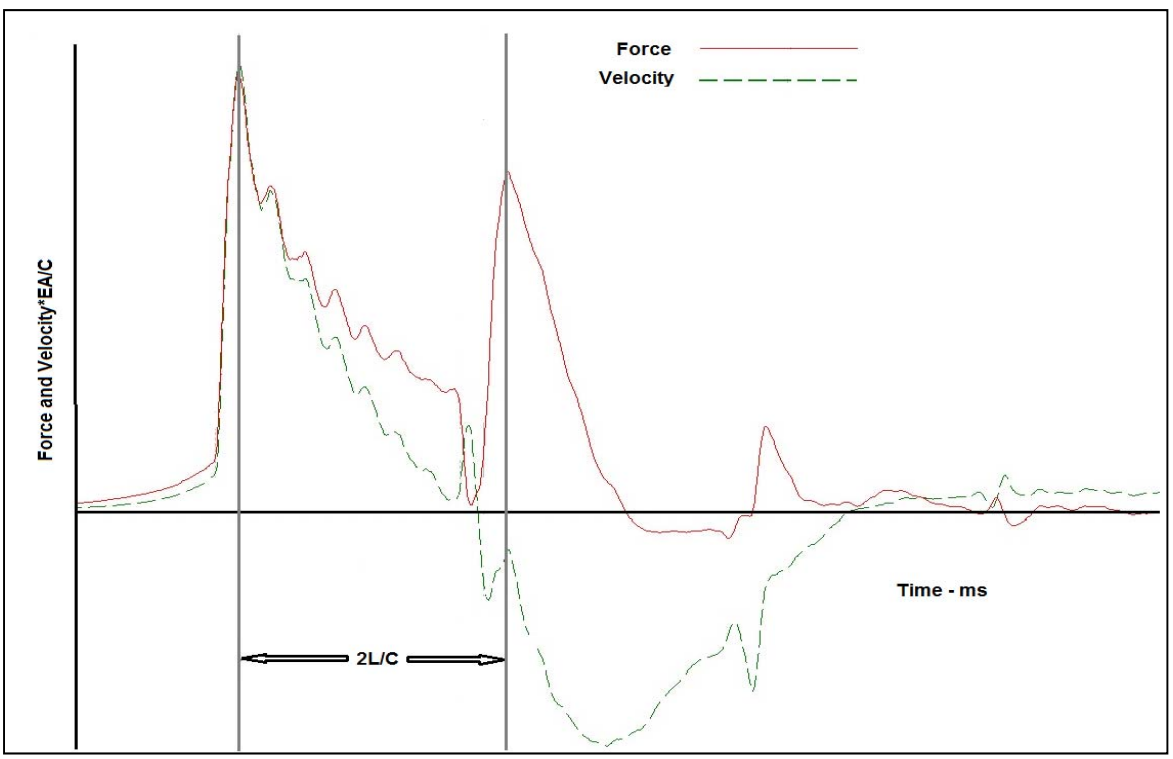


Figure 4. Typical Force and Velocity traces for an H-pile driven into bedrock (high force and low velocity at tip - 2L/C).

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.

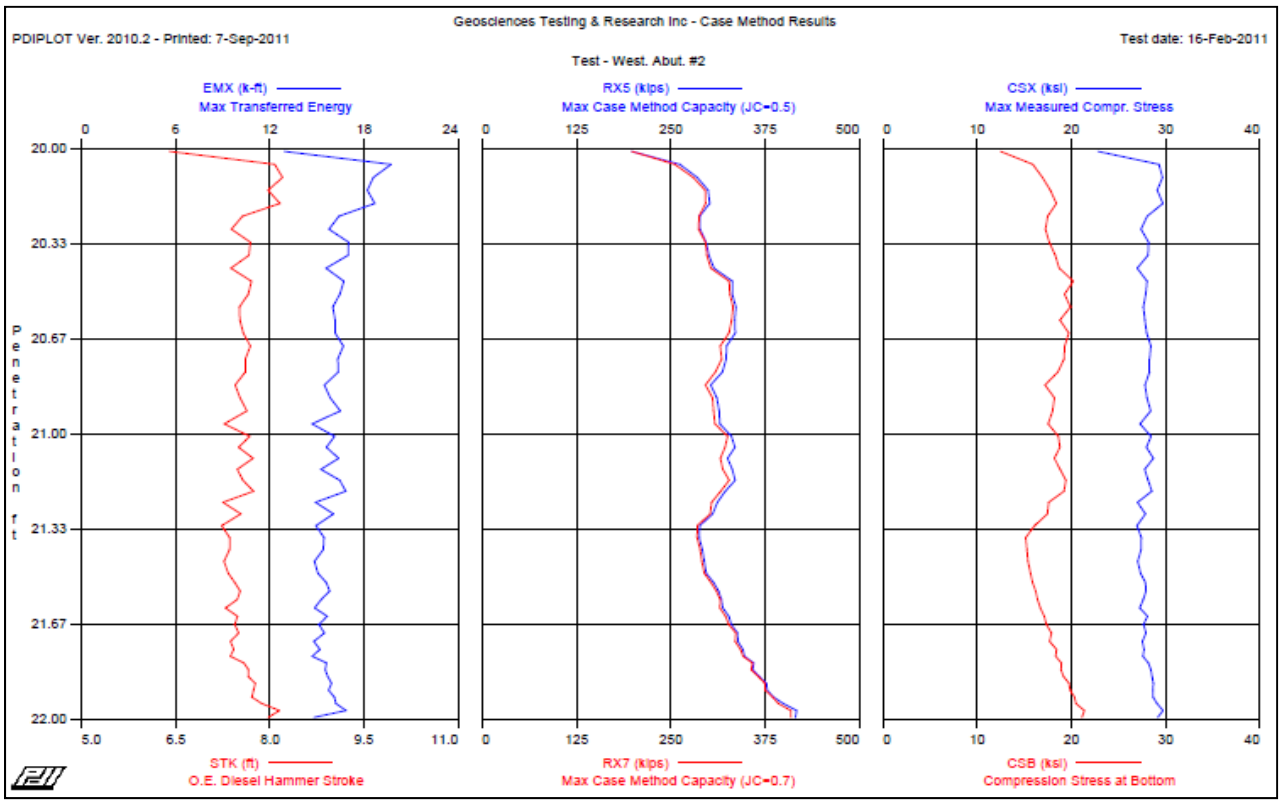


Figure 5. Typical Dynamic Testing summary Output (PDI Plot® Program)

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

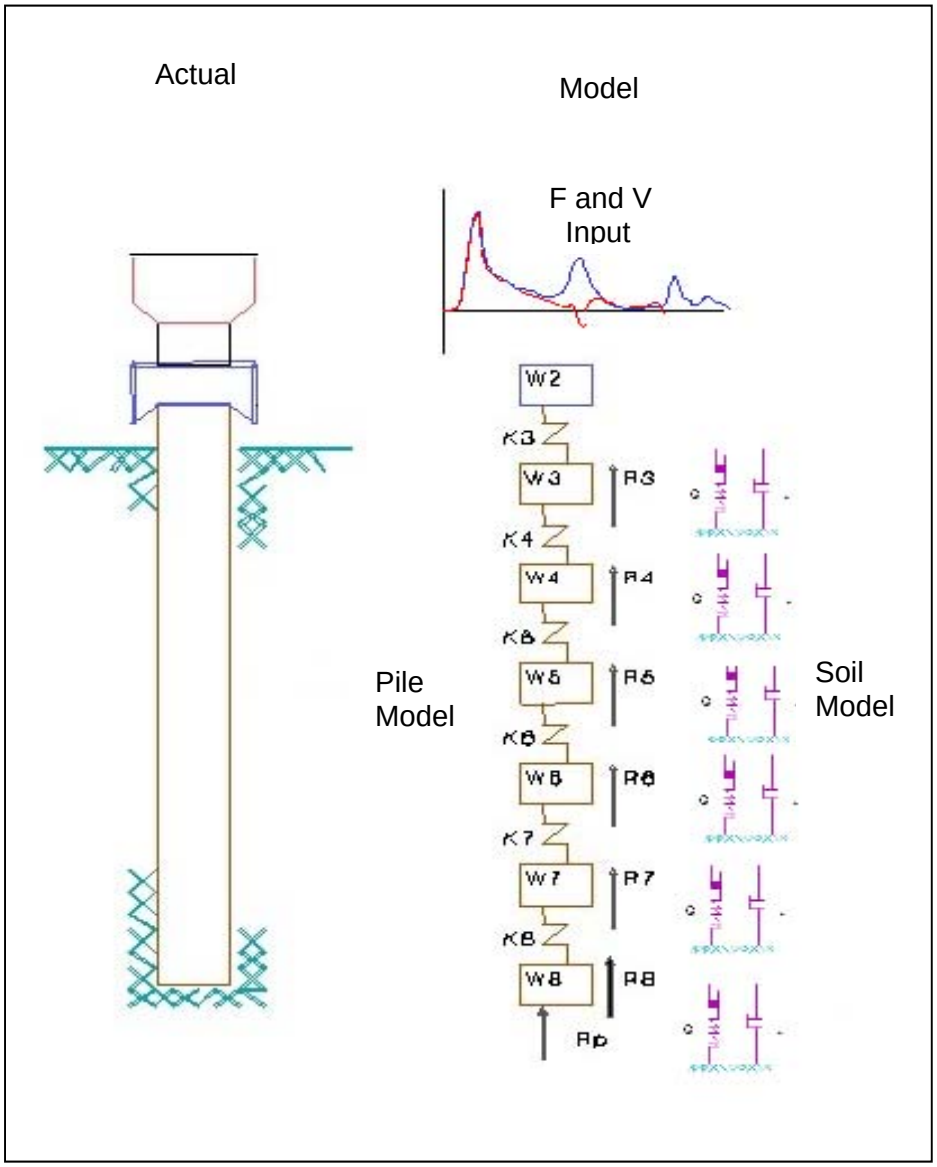


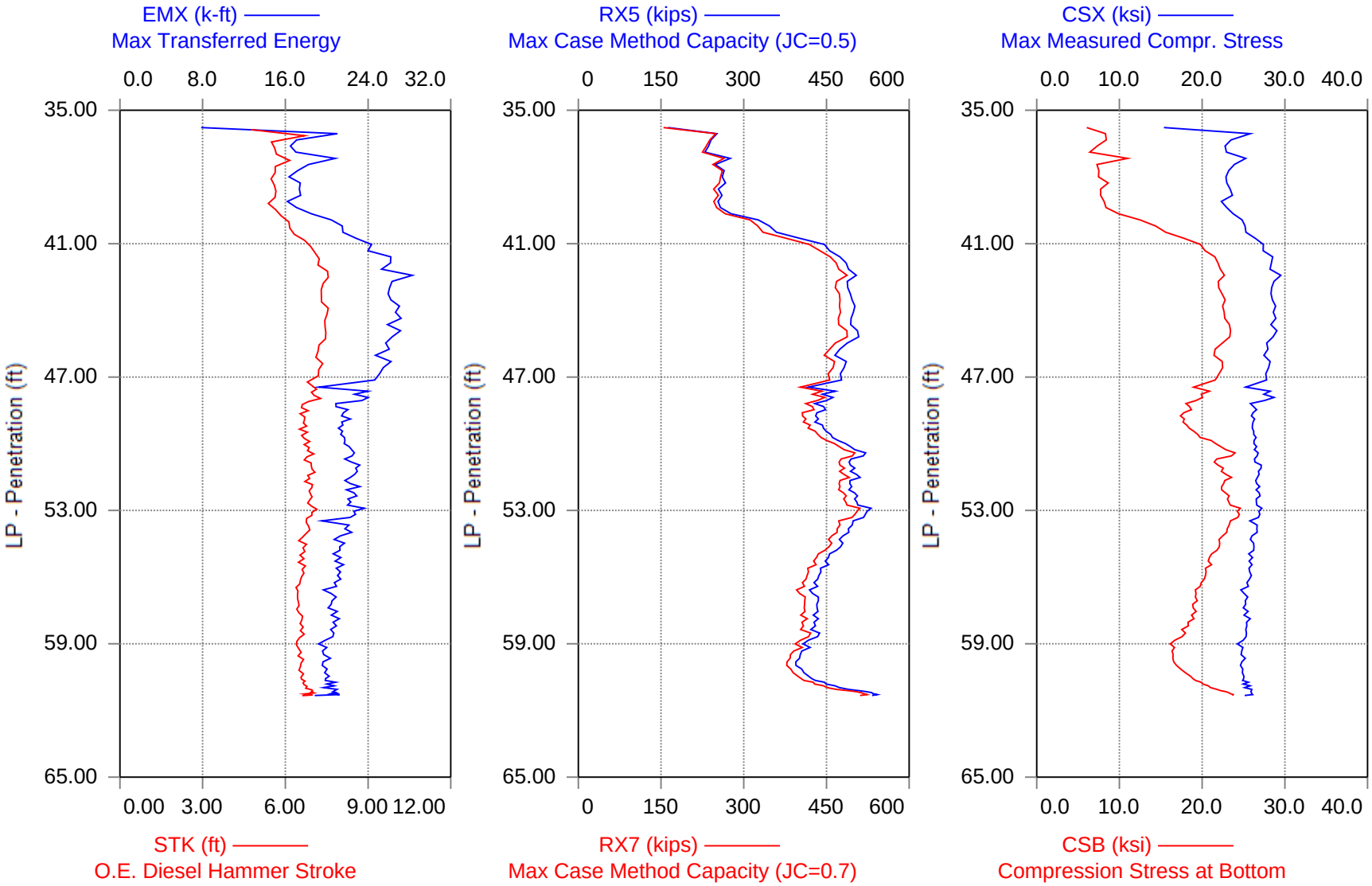
Figure 6. Signal Matching Model (i.e. CAPWAP® or TEPWAP/PWAP).

APPENDIX B
PDA VARIABLES

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

Printed: 05-February-2015 **Test started: 30-January-2015**

Rutland Vtrans - A2N5E
HP12x84 I60



Rutland Vtrans - A2N5E
HP12x84 I60
OP:
Date: 30-January-2015

AR: 24.60 in²
LE: 67.00 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
CSX: Max Measured Compr. Stress
CSB: Compression Stress at Bottom
QUT: Energy formula (DFN)
DMX: Maximum Displacement
RX5: Max Case Method Capacity (JC=0.5)
RX7: Max Case Method Capacity (JC=0.7)

BL#	TYPE	EMX	STK	CSX	CSB	QUT	DMX	RX5	RX7
		k-ft	ft	ksi	ksi	kips	in	kips	kips
260	AV128	22.3	6.6	26.1	16.5	385	0.85	390	374
	MAX	29.4	8.1	30.3	24.6	489	1.34	520	500
	@BL	204	204	204	202	260	12	210	204
520	AV129	22.2	6.8	26.6	21.4	527	0.73	481	460
	MAX	27.6	8.1	30.2	25.0	600	0.83	539	518
	@BL	264	264	264	494	262	264	494	494
801	AV151	20.6	6.6	25.5	19.5	507	0.70	439	419
	MAX	23.7	7.2	27.4	23.4	587	0.74	505	481
	@BL	536	522	522	536	801	696	524	524
818	AV17	20.6	6.9	25.9	23.2	584	0.65	529	510
	MAX	22.2	7.2	26.9	24.2	608	0.70	552	533
	@BL	815	811	811	816	810	815	816	816
Average		21.6	6.7	26.0	19.3	479	0.75	440	422
Maximum		29.4	8.1	30.3	25.0	608	1.34	552	533
@ Blow#		204	204	204	494	810	12	816	816

Total number of blows analyzed: 425

BL# Sensors

4-818 F3: [] 92.0 (1.00); F4: [] 93.3 (1.00); A3: [] 365.0 (1.00); A4: [] 365.0 (1.00)

Time Summary

Drive 5 minutes 32 seconds 1:58 PM - 2:03 PM (1/30/2015) BN 4 - 258
Stop 11 minutes 40 seconds 2:03 PM - 2:15 PM
Drive 21 minutes 54 seconds 2:15 PM - 2:37 PM BN 260 - 818

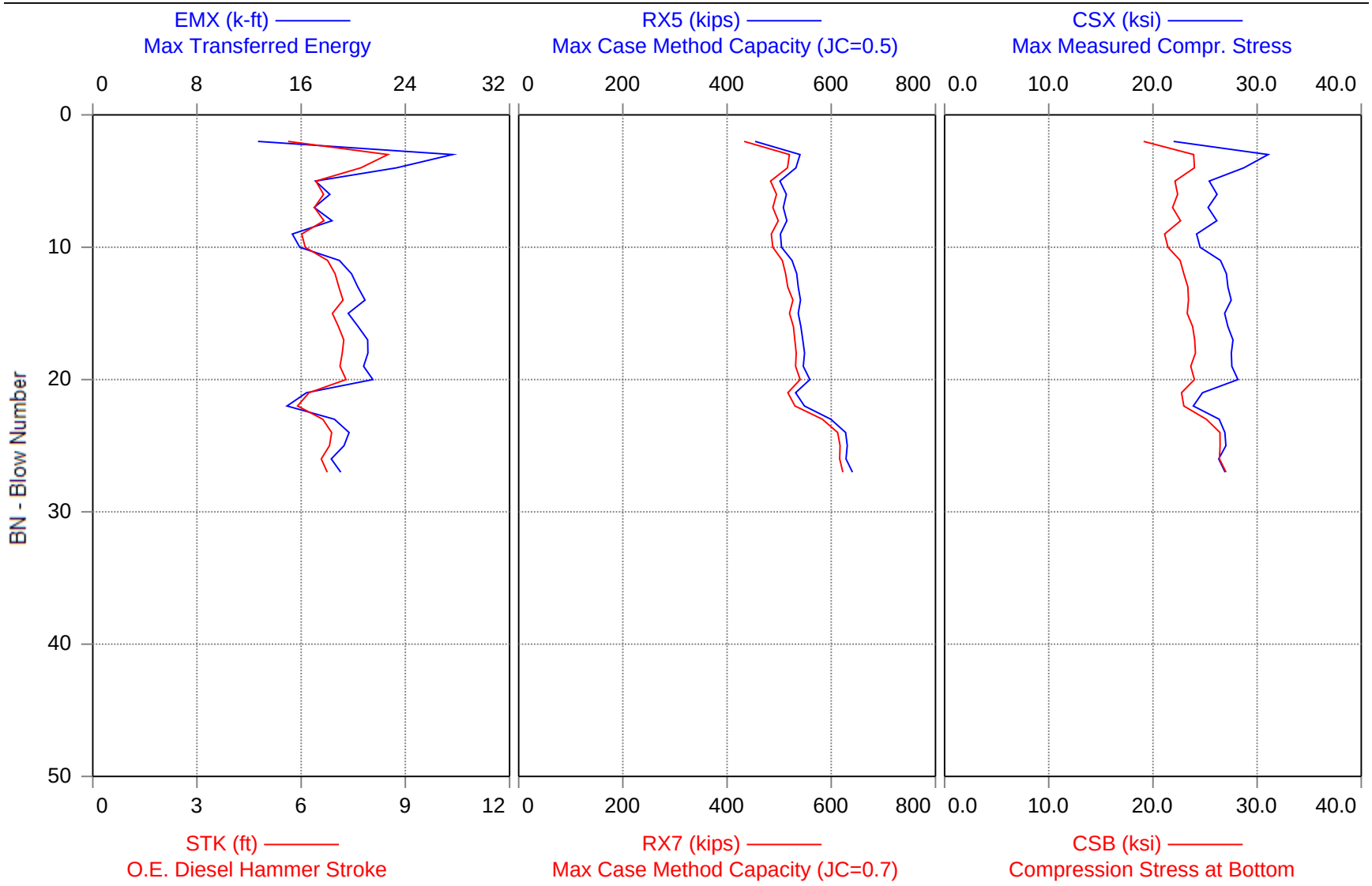
Total time [00:39:06] = (Driving [00:27:26] + Stop [00:11:40])

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

Printed: 05-February-2015 **Test started: 04-February-2015**

Rutland Vtrans - A2N5R

HP12x84 I60



Rutland Vtrans - A2N5R — HP12x84 I60
OP: — Date: 04-February-2015

AR: 24.60 in² — SP: 0.492 k/ft³
LE: 67.00 ft — EM: 30,000 ksi
WS: 16,810.0 f/s — JC: 0.50 []

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

BL#	EMX	STK	CSX	CSB	QUT	DMX	RX5	RX7
	k-ft	ft	ksi	ksi	kips	in	kips	kips
2	12.7	5.6	22.0	19.1	577	0.45	454	433
3	27.6	8.5	31.0	23.9	593	0.77	540	520
4	23.3	7.7	28.7	24.0	550	0.69	532	516
5	17.1	6.4	25.4	22.1	733	0.57	502	483
6	18.2	6.6	26.2	22.4	574	0.59	514	495
7	17.0	6.4	25.3	21.9	601	0.57	508	488
8	18.4	6.7	26.1	22.6	686	0.59	515	498
9	15.3	6.0	24.2	21.1	603	0.53	502	485
10	15.9	6.1	24.5	21.4	578	0.54	505	488
11	18.9	6.8	26.5	22.6	591	0.61	525	506
12	19.9	7.0	27.1	23.0	584	0.62	534	512
13	20.3	7.1	27.2	23.4	583	0.64	537	517
14	20.9	7.2	27.5	23.4	583	0.65	541	526
15	19.6	6.9	26.9	23.3	615	0.62	537	520
16	20.4	7.1	27.2	23.8	588	0.63	542	527
17	21.1	7.2	27.7	24.0	620	0.64	545	530
18	21.1	7.2	27.5	24.1	586	0.65	549	533
19	20.8	7.1	27.6	23.6	597	0.64	546	532
20	21.5	7.3	28.2	24.0	598	0.65	559	540
21	16.4	6.2	24.8	22.7	689	0.56	532	517
22	14.9	5.9	23.9	23.0	650	0.52	548	530
23	18.6	6.6	26.4	25.1	658	0.59	599	583
24	19.7	6.9	26.9	26.4	672	0.61	628	612
25	19.3	6.8	27.0	26.4	670	0.59	631	617
26	18.3	6.6	26.3	26.4	723	0.57	628	616
27	19.0	6.8	26.9	27.0	591	0.58	641	622
Average	19.1	6.8	26.5	23.5	619	0.60	546	529
Maximum	27.6	8.5	31.0	27.0	733	0.77	641	622
@ Blow#	3	3	3	27	5	3	27	27

Total number of blows analyzed: 26

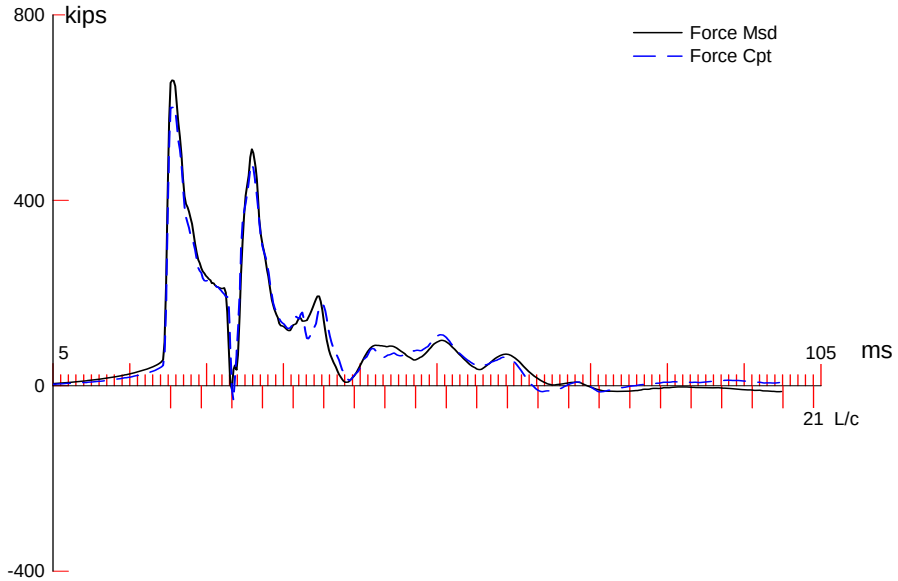
BL# Sensors

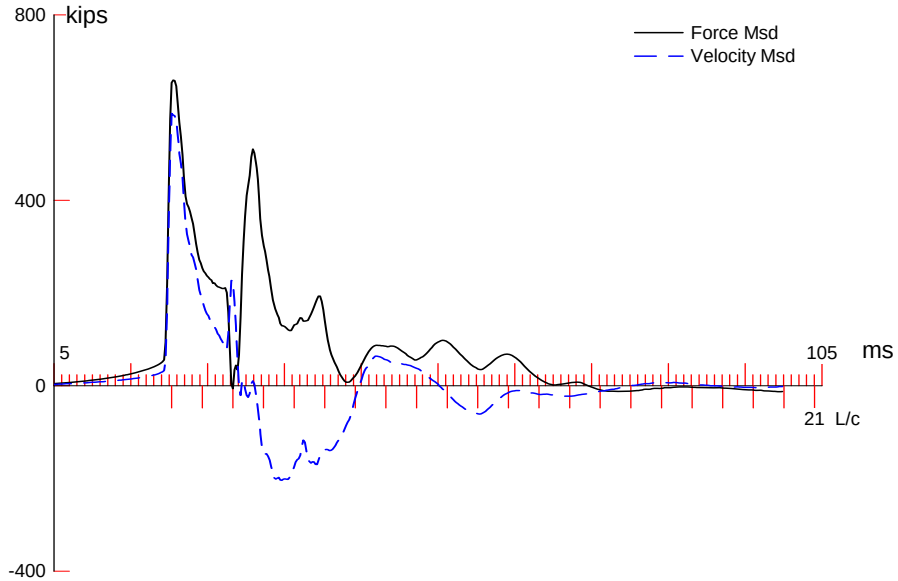
1-29 F3: [] 92.0 (1.00); F4: [] 93.3 (1.00); A3: [] 365.0 (1.00); A4: [] 365.0 (1.00)

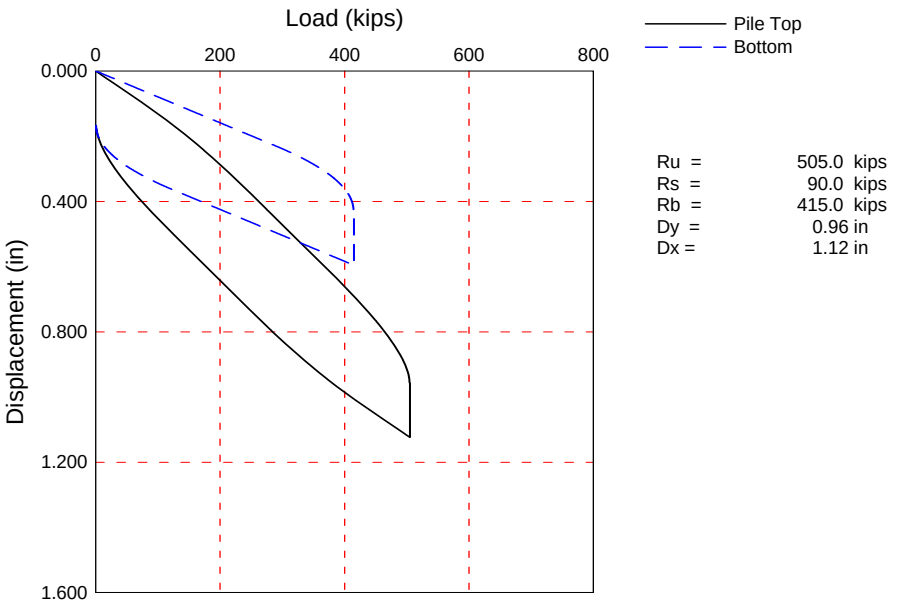
Time Summary

Drive 37 seconds 11:35 AM - 11:36 AM BN 1 - 29

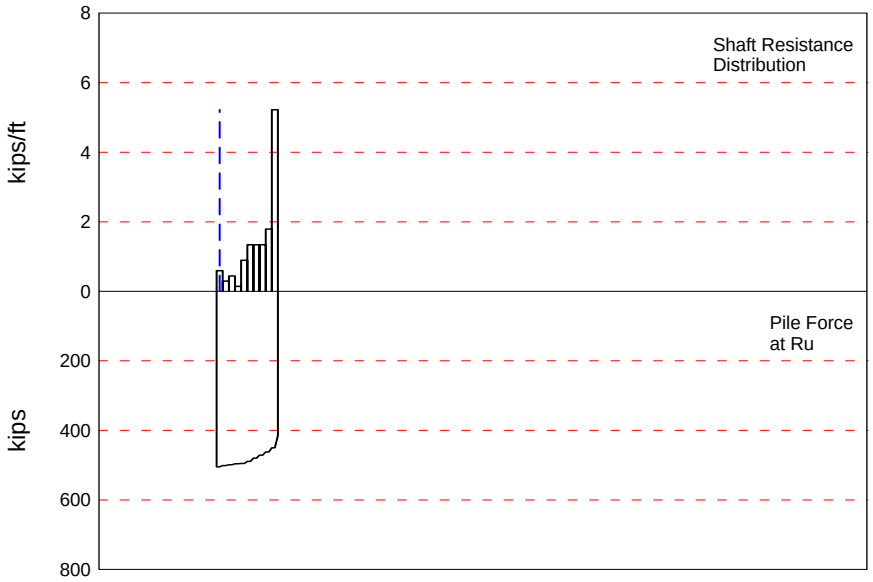
APPENDIX C
CAPWAP RESULTS







Ru =	505.0	kips
Rs =	90.0	kips
Rb =	415.0	kips
Dy =	0.96	in
Dx =	1.12	in



CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 505.0; along Shaft 90.0; at Toe 415.0 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
				505.0				
1	6.7	2.9	4.0	501.0	4.0	1.37	0.34	0.200
2	13.4	9.6	2.0	499.0	6.0	0.30	0.07	0.200
3	20.1	16.3	3.0	496.0	9.0	0.45	0.11	0.200
4	26.8	23.0	1.0	495.0	10.0	0.15	0.04	0.200
5	33.5	29.7	6.0	489.0	16.0	0.90	0.22	0.200
6	40.2	36.4	9.0	480.0	25.0	1.34	0.34	0.200
7	46.9	43.1	9.0	471.0	34.0	1.34	0.34	0.200
8	53.6	49.8	9.0	462.0	43.0	1.34	0.34	0.200
9	60.3	56.5	12.0	450.0	55.0	1.79	0.45	0.200
10	67.0	63.2	35.0	415.0	90.0	5.22	1.31	0.200
Avg. Shaft			9.0			1.42	0.36	0.200
Toe			415.0				304.90	0.080

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(in)	0.100	0.330
Case Damping Factor		0.410	0.756
Damping Type			Smith
Unloading Quake	(% of loading quake)	41	48
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	0	
Resistance Gap (included in Toe Quake)	(in)		0.060
Soil Plug Weight	(kips)		0.04

CAPWAP match quality = 2.48 (Force Match) ; RSA = 0
Observed: final set = 0.167 in; blow count = 72 b/ft
Computed: final set = 0.156 in; blow count = 77 b/ft

max. Top Comp. Stress = 24.4 ksi (T= 20.9 ms, max= 1.009 x Top)
max. Comp. Stress = 24.7 ksi (Z= 6.7 ft, T= 21.3 ms)
max. Tens. Stress = -1.29 ksi (Z= 3.4 ft, T= 28.7 ms)
max. Energy (EMX) = 20.4 kip-ft; max. Measured Top Displ. (DMX)= 0.70 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	601.5	-31.7	24.4	-1.29	20.39	13.3	0.697
2	6.7	607.0	-13.1	24.7	-0.53	20.47	13.2	0.688
3	10.1	594.6	-12.9	24.2	-0.52	19.80	13.1	0.676
4	13.4	596.8	-15.9	24.3	-0.65	19.57	13.1	0.659
5	16.8	592.4	-17.5	24.1	-0.71	19.08	13.0	0.643
6	20.1	593.8	-18.8	24.1	-0.76	18.89	12.9	0.628
7	23.5	584.5	-20.2	23.8	-0.82	18.30	12.9	0.612
8	26.8	588.2	-21.0	23.9	-0.85	18.07	12.8	0.594
9	30.2	589.7	-24.9	24.0	-1.01	17.70	12.7	0.576
10	33.5	595.4	-28.0	24.2	-1.14	17.43	12.6	0.558
11	36.9	581.5	-29.0	23.6	-1.18	16.45	12.4	0.539
12	40.2	587.5	-30.1	23.9	-1.22	16.15	12.3	0.519
13	43.6	563.3	-30.2	22.9	-1.23	14.87	12.1	0.499
14	46.9	569.0	-29.4	23.1	-1.19	14.52	12.0	0.479
15	50.3	544.7	-25.5	22.1	-1.03	13.23	11.8	0.457
16	53.6	550.9	-27.2	22.4	-1.11	12.83	13.2	0.434
17	57.0	523.1	-26.8	21.3	-1.09	11.51	14.5	0.410
18	60.3	488.5	-28.3	19.9	-1.15	11.03	15.8	0.385
19	63.7	490.8	-26.8	19.9	-1.09	9.49	16.3	0.360
20	67.0	553.8	-26.3	22.5	-1.07	7.31	15.4	0.334
Absolute	6.7			24.7			(T =	21.3 ms)
	3.4				-1.29		(T =	28.7 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	534.0	461.6	389.1	316.7	244.2	171.8	99.4	26.9	0.0	0.0
RX	655.2	620.1	591.3	568.4	554.3	544.0	535.1	526.2	518.5	510.7
RU	534.0	461.6	389.1	316.7	244.2	171.8	99.4	26.9	0.0	0.0

RAU = 435.3 (kips); RA2 = 570.8 (kips)

Current CAPWAP Ru = 505.0 (kips); Corresponding J(RP)= 0.04; 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
13.68	20.53	600.9	657.5	662.4	0.704	0.158	0.167	22.2	611.2

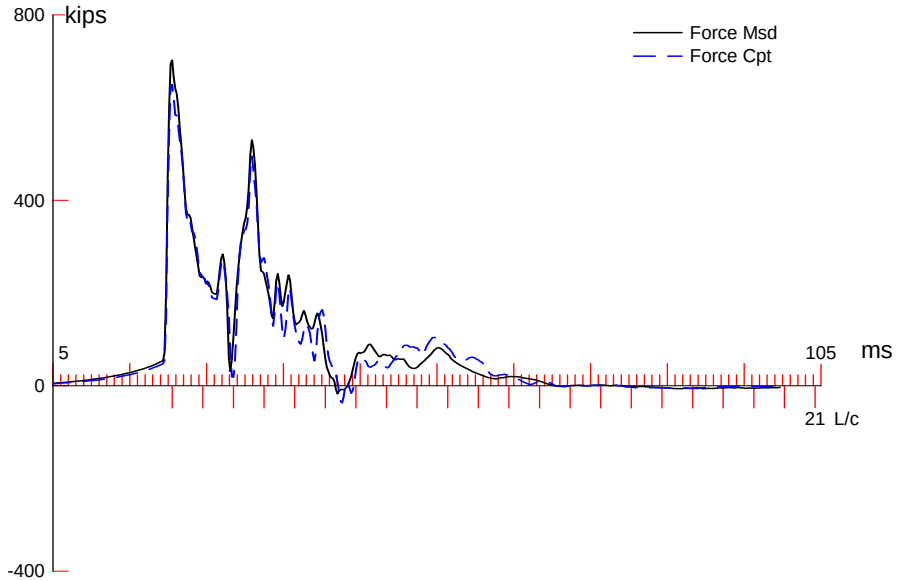
PILE PROFILE AND PILE MODEL

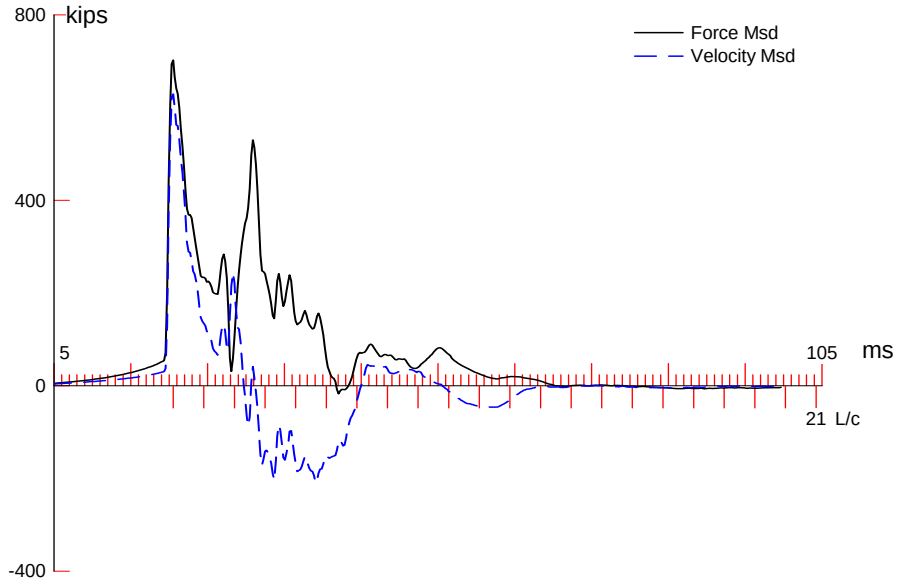
Depth ft	Area in²	E-Modulus ksi	Spec. Weight lb/ft³	Perim. ft
0.00	24.60	29999.9	492.000	4.000
67.00	24.60	29999.9	492.000	4.000

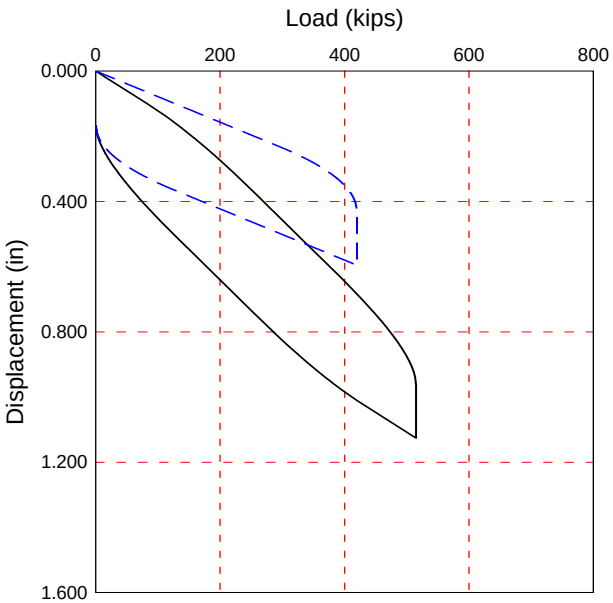
Toe Area 1.361 ft²

Top Segment Length 3.35 ft, Top Impedance 43.91 kips/ft/s

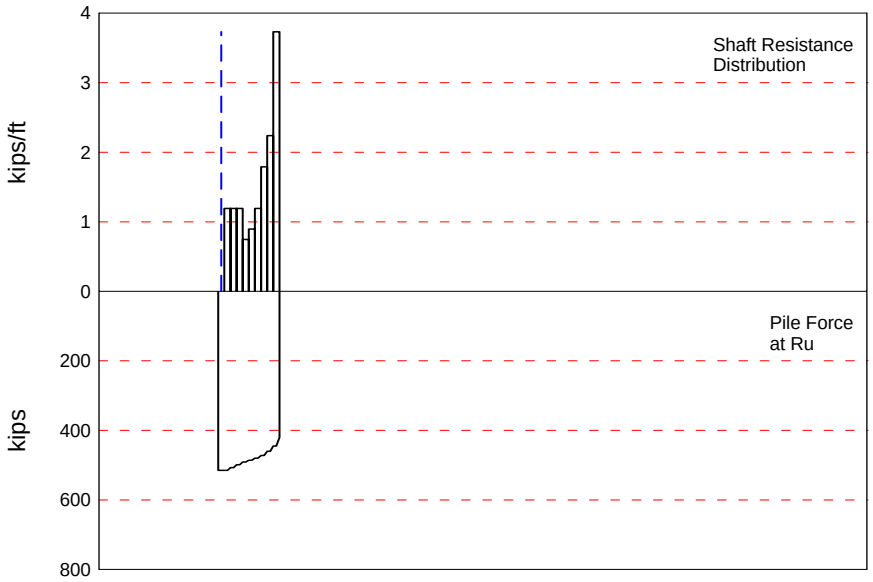
Pile Damping 3.0 %, Time Incr 0.199 ms, Wave Speed 16810.0 ft/s, 2L/c 8.0 ms







Ru =	515.0 kips
Rs =	95.0 kips
Rb =	420.0 kips
Dy =	0.96 in
Dx =	1.13 in



CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 515.0; along Shaft 95.0; at Toe 420.0 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
				515.0				
1	13.4	7.8	8.0	507.0	8.0	1.03	0.26	0.220
2	20.1	14.5	8.0	499.0	16.0	1.19	0.30	0.220
3	26.8	21.2	8.0	491.0	24.0	1.19	0.30	0.220
4	33.5	27.9	5.0	486.0	29.0	0.75	0.19	0.220
5	40.2	34.6	6.0	480.0	35.0	0.90	0.22	0.220
6	46.9	41.3	8.0	472.0	43.0	1.19	0.30	0.220
7	53.6	48.0	12.0	460.0	55.0	1.79	0.45	0.220
8	60.3	54.7	15.0	445.0	70.0	2.24	0.56	0.220
9	67.0	61.4	25.0	420.0	95.0	3.73	0.93	0.220
Avg. Shaft			10.6			1.55	0.39	0.220
Toe			420.0				420.00	0.050

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(in)	0.100	0.330
Case Damping Factor		0.476	0.478
Damping Type			Smith
Unloading Quake	(% of loading quake)	30	34
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	1	
Resistance Gap (included in Toe Quake)	(in)		0.050

CAPWAP match quality = 3.05 (Force Match) ; RSA = 0
Observed: final set = 0.167 in; blow count = 72 b/ft
Computed: final set = 0.156 in; blow count = 77 b/ft

max. Top Comp. Stress = 26.4 ksi (T= 20.7 ms, max= 1.025 x Top)
max. Comp. Stress = 27.1 ksi (Z= 13.4 ft, T= 21.5 ms)
max. Tens. Stress = -3.14 ksi (Z= 46.9 ft, T= 45.6 ms)
max. Energy (EMX) = 21.3 kip-ft; max. Measured Top Displ. (DMX)= 0.71 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	649.5	-36.9	26.4	-1.50	21.32	14.3	0.689
2	6.7	652.2	-45.0	26.5	-1.83	21.28	14.3	0.671
3	10.1	660.6	-59.6	26.8	-2.42	21.11	14.0	0.657
4	13.4	665.9	-54.8	27.1	-2.23	20.91	13.9	0.641
5	16.8	641.5	-43.0	26.1	-1.75	19.60	13.7	0.625
6	20.1	646.6	-51.8	26.3	-2.10	19.36	13.6	0.608
7	23.5	622.4	-64.5	25.3	-2.62	18.01	13.4	0.588
8	26.8	626.9	-75.2	25.5	-3.06	17.79	13.2	0.572
9	30.2	600.0	-75.4	24.4	-3.07	16.67	13.1	0.560
10	33.5	603.2	-74.5	24.5	-3.03	16.51	13.0	0.546
11	36.9	588.6	-66.9	23.9	-2.72	15.73	12.8	0.531
12	40.2	592.3	-69.8	24.1	-2.84	15.52	12.7	0.515
13	43.6	575.7	-73.6	23.4	-2.99	14.60	12.5	0.498
14	46.9	580.8	-77.2	23.6	-3.14	14.34	12.4	0.480
15	50.3	559.9	-71.2	22.8	-2.89	13.18	12.1	0.460
16	53.6	567.0	-66.7	23.0	-2.71	12.81	13.4	0.438
17	57.0	534.2	-60.1	21.7	-2.44	11.13	14.8	0.415
18	60.3	508.0	-59.6	20.6	-2.42	10.66	15.7	0.390
19	63.7	457.4	-52.7	18.6	-2.14	8.74	16.6	0.366
20	67.0	517.3	-48.8	21.0	-1.98	7.17	15.9	0.341
Absolute	13.4			27.1			(T =	21.5 ms)
	46.9				-3.14		(T =	45.6 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	593.8	517.8	441.8	365.7	289.7	213.7	137.6	61.6	0.0	0.0
RX	672.5	626.8	597.3	567.8	547.6	540.0	532.5	524.9	517.4	509.8
RU	593.8	517.8	441.8	365.7	289.7	213.7	137.6	61.6	0.0	0.0

RAU = 430.8 (kips); RA2 = 577.7 (kips)

Current CAPWAP Ru = 515.0 (kips); Corresponding J(RP)= 0.10; J(RX) = 0.83

VMX ft/s	TVP ms	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips
14.74	20.73	647.4	706.8	706.8	0.707	0.155	0.167	23.3	639.3

PILE PROFILE AND PILE MODEL

Depth ft	Area in²	E-Modulus ksi	Spec. Weight lb/ft³	Perim. ft
0.00	24.60	29999.9	492.000	4.000
67.00	24.60	29999.9	492.000	4.000

Toe Area 1.000 ft²

Top Segment Length 3.35 ft, Top Impedance 43.91 kips/ft/s

Pile Damping 3.0 %, Time Incr 0.199 ms, Wave Speed 16810.0 ft/s, 2L/c 8.0 ms