

Client: Elliott Van Stelle
Structures, Inc.
4 Inverness Court East, Suite 250
Englewood, CO 80112

Forest Lakes Bridges

Report Date: Aug 4, 2021

Work Order No.: 21-8536.PileDynamicAnalysis.0002; ver:

Work Order Date: Jul 28, 2021

Reviewed by:

Pile Dynamic Load Testing

General Contractor: STRUCTURES, INC.

Performed by: Jaro Lepic

Pile Driving Contractor: STRUCTURES, INC.

Representative Notified: Mark Workman with STRUCTURES, INC.

Hammer Used: DELMAG D19-32

Number of Test Piles: 1

Hammer Max Energy: 14.8 k-ft

PDA Equipment: PAX

Placement Location: Item #502 - Driven piles for Abutment #3 of the Mesa Top Drive South over North Beaver Creek bridge

Comments: Upon arrival GROUND was notified by STRUCTURES, INC. that the minimum tip elevations specified in the plan set had been waived.

Design Requirements

PDA Test Pile ID #	Date of Drive	Pile Location	Pile Type and Size	Est. Tip Elevation (ft.)	Min. Tip Elevation (ft.)	Design Load (kips)	PDA Factor	PDA Test Load (kips)
TP-2	7-28-21	STA 16+76.5 at 5' LT	12x53	7026.0	N/A	200	0.65	308

Pile Measurements

PDA Test Pile ID #	Yield Stress (ksi)	Fuel Setting	Predrill Depth (ft.)	Predrill Dia. (in.)	Installed Length (ft.)	Batter	Ground Elev. (ft.)	Tip Elev. (ft.)	Pile Toe Attachments	Pile Head Cond. After Driving
TP-2	45 ksi	4	N/A	N/A	24.3	N/A	7053.0	7028.7	Commercial Pile Tip	Not deformed

PDA Results

PDA Test Pile ID #	Average CASE Capacity at Refusal (kips)	Restrike Age	Average CASE Capacity at Restrike (kips)	Additional Soil Setup at Restrike	Refusal Criteria	Minimum Depth Specified (ft.)
TP-2	340	N/A	N/A	N/A	15 Blows/3 inches	N/A

Prior to PDA monitoring Test Pile #2 (TP-2) was driven to a depth of approximately 22.75 feet below existing grade and a blow count of 10 blow per 3 inches.

Hammer Performance

An DELMAG D19-32 diesel fired hammer was used to drive the HP 12 X 53 piles as referenced previously. During the end of driving, the efficiency of the hammer ranged from approximately 61 to 66 percent (based on stroke). This efficiency is considered good for open-ended diesel hammers.

Conclusions

The capacity analysis was performed by PDA using the Case Method during initial drive. The initial test pile was driven at fuel setting #4 of the hammer. Based on the measurements obtained on the test pile (TP-2), the production piles for Abutment #3 should be driven to a minimum of 15 blows per 3 inches at fuel setting #4 to achieve the required capacity of 308 kips. At the specified nominal driving resistance a hammer stroke ranging from 5.49 to 5.86 feet was observed.

It should be noted that records of the PDA measurements were edited to remove data that was generally the result of pile hammer stops, calibration testing, or other inconsequential causes.

Closure

The design team should review this report and the data presented herein. Any recommendations provided by our office were based on the data obtained from the piles tested, at the depths achieved during which the testing was performed, and for the subsurface conditions present at the tested pile locations. This report may not be sufficient for adjacent piles if the subsurface geology, piling, hammer settings, or any other portion of the pile driving is modified or otherwise differs from the conditions encountered during the testing. Our office should be contacted immediately if subsequent pile driving operations on this project appear to differ with respect to the conditions or observations presented herein, including, but not limited to, bedrock elevation, design loads, piling type, hammer type or condition, etc. In no case should the information in this report be used to terminate pile driving operations prior to achieving any minimum tip elevations, bedrock penetration or any other requirement contained in project plans or other project documents without the written consent of the structural engineer of record.

Results apply only to the specific items and locations referenced and at the time of testing, observations or special inspections. This report should not be reproduced, except in full, without the written permission of GROUND Engineering Consultants, Inc.

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Photos



Pile driving at Abutment #3



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21-8536 FOREST LAKES BRIDGES - TP-3 ABUT 3

12X53

OP: JL

Date: 28-July-2021

AR: 15.50 in²

SP: 0.492 k/ft³

LE: 27.00 ft

EM: 30,000 ksi

WS: 16,807.9 f/s

JC: 2.60

STK: O.E. Diesel Hammer Stroke

ETH: Energy Transfer Ratio - Stroke

EMX: Max Transferred Energy

RMX: Max Case Method Capacity

CSX: Max Measured Compr. Stress

BL#	Depth ft	BLC bl/in	STK ft	EMX k-ft	CSX ksi	ETH (%)	RMX kips
39	23.83	5.0	5.80	15.5	26.9	66.8	322.7
40	23.85	5.0	5.66	14.3	26.0	63.4	325.0
41	23.87	5.0	5.49	14.0	26.5	63.8	334.4
42	23.88	5.0	5.63	14.8	26.9	65.8	334.3
43	23.90	5.0	5.66	13.9	26.5	61.5	350.4
44	23.92	5.0	5.86	15.5	27.3	66.4	340.9
45	23.93	5.0	5.68	14.9	27.2	65.6	344.3
46	23.95	5.0	5.80	15.4	27.7	66.5	343.1
47	23.97	5.0	5.78	15.1	27.4	65.4	357.1
48	23.98	5.0	5.80	14.8	28.6	63.7	356.7
Average			5.72	14.8	27.1	64.9	340.9
Std. Dev.			0.11	0.6	0.7	1.6	11.4
Maximum			5.86	15.5	28.6	66.8	357.1
Minimum			5.49	13.9	26.0	61.5	322.7

Total number of blows analyzed: 10

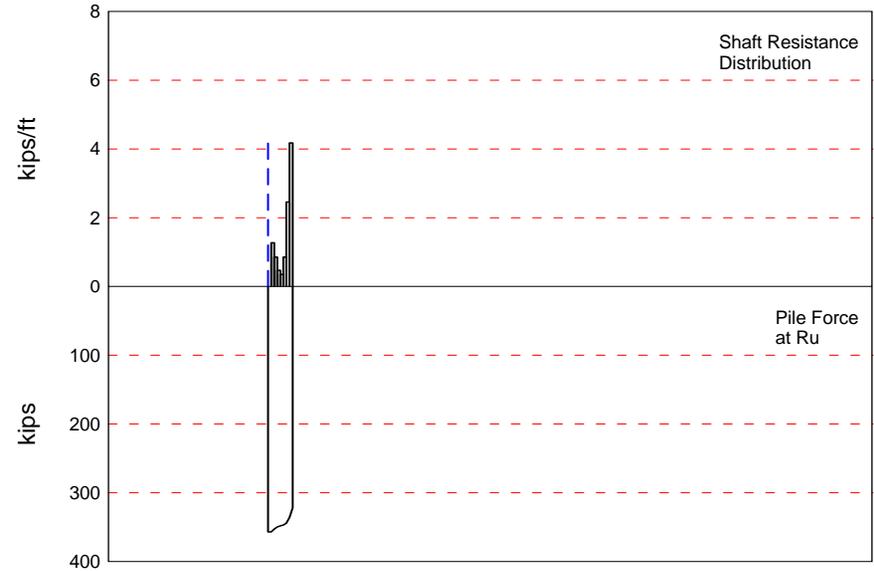
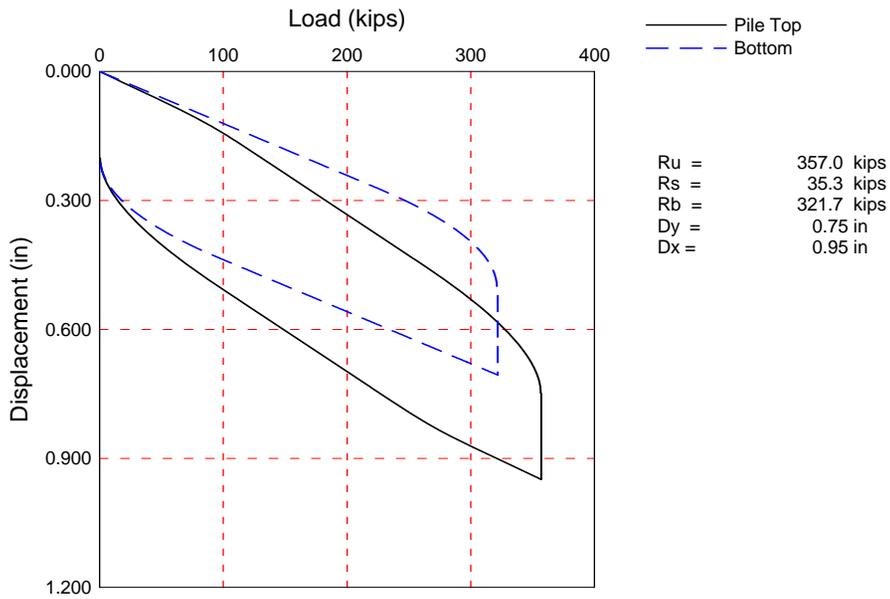
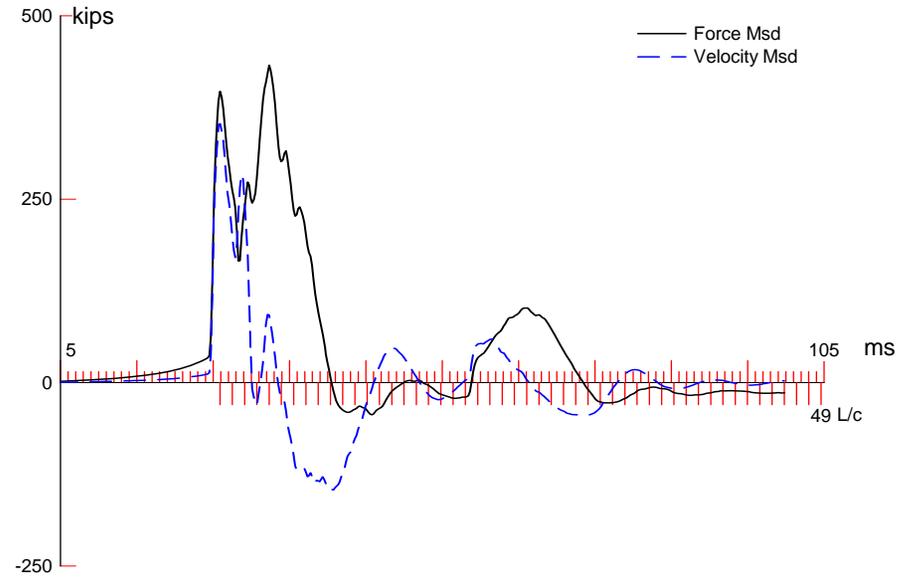
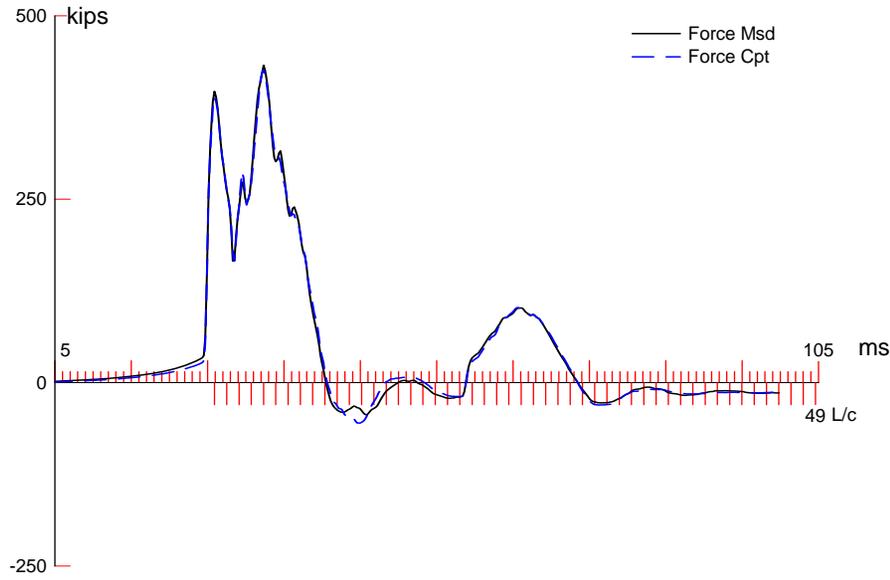
BL# Sensors

1 F3: [ST CAL] 147.5 (1.00); F4: [ST CAL] 147.5 (1.00); A3: [PR CAL] 1000.0 (1.00);
A4: [PR CAL] 1000.0 (1.00)

2-69 F3: [K025] 95.0 (1.00); F4: [K024] 94.0 (1.00); A3: [K4437] 382.0 (1.00); A4: [K4438] 362.0 (1.00)

Time Summary

Drive 4 minutes 47 seconds 7:32 AM - 7:37 AM BN 1 - 69



21-8536 FOREST LAKES BRIDGES; Pile: TP-3 ABUT 3
 12X53; Blow: 48
 Ground Engineering Consultants

Test: 28-Jul-2021 07:36:
 CAPWAP(R) 2006-3
 OP: JL

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 357.0; along Shaft 35.3; at Toe 321.7 kips

Soil Sgmt No.	Dist. Below Gages ft	Depth Below Grade ft	Ru kips	Force in Pile kips	Sum of Ru kips	Unit Resist. (Depth) kips/ft	Unit Resist. (Area) ksf	Smith Damping Factor s/ft
				357.0				
1	6.8	3.5	4.3	352.7	4.3	1.23	0.31	0.255
2	10.1	6.9	2.9	349.8	7.2	0.86	0.22	0.255
3	13.5	10.3	1.6	348.2	8.8	0.47	0.12	0.255
4	16.9	13.6	1.2	347.0	10.0	0.36	0.09	0.255
5	20.3	17.0	2.9	344.1	12.9	0.86	0.22	0.255
6	23.6	20.4	8.3	335.8	21.2	2.46	0.62	0.255
7	27.0	23.8	14.1	321.7	35.3	4.18	1.05	0.255
Avg. Shaft			5.0			1.49	0.37	0.255
Toe			321.7				326.48	0.078

Soil Model Parameters/Extensions		Shaft	Toe
Quake	(in)	0.078	0.389
Case Damping Factor		0.325	0.908
Damping Type			Smith
Unloading Quake	(% of loading quake)	46	52
Reloading Level	(% of Ru)	100	100
Resistance Gap (included in Toe Quake)	(in)		0.032
Soil Plug Weight	(kips)		0.06

CAPWAP match quality = 2.39 (Wave Up Match) ; RSA = 0
 Observed: final set = 0.200 in; blow count = 60 b/ft
 Computed: final set = 0.161 in; blow count = 75 b/ft

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CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	372.1	333.2	294.3	255.3	216.4	177.5	138.6	99.7	60.7	21.8
RX	435.0	425.1	415.1	405.2	395.3	386.6	378.8	373.0	369.1	367.9
RU	372.1	333.2	294.3	255.3	216.4	177.5	138.6	99.7	60.7	21.8

RAU = 333.4 (kips); RA2 = 381.7 (kips)

Current CAPWAP Ru = 357.0 (kips); Corresponding J(RP)= 0.04; matches RX9 within 5%

VMX	TVP	VT1*Z	FT1	FMX	DMX	DFN	SET	EMX	QUS
ft/s	ms	kips	kips	kips	in	in	in	kip-ft	kips
13.16	26.10	364.0	397.4	443.3	0.623	0.186	0.200	14.8	431.3

PILE PROFILE AND PILE MODEL

Depth	Area	E-Modulus	Spec. Weight	Perim.
ft	in ²	ksi	lb/ft ³	ft
0.00	15.50	29992.2	492.000	3.971
27.00	15.50	29992.2	492.000	3.971

Toe Area 0.985 ft²

Top Segment Length 3.38 ft, Top Impedance 27.67 kips/ft/s

File Damping 1.0 %, Time Incr 0.201 ms, Wave Speed 16807.9 ft/s, 2L/c 3.2 ms