FOUNDATION TESTING & CONSULTING, LLC
Knowledge To Build On®

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August 22, 2012

Mr. Travis Slayton
Robertson Contractors, Inc.
1909 South Westwood Blvd.
Poplar Bluff, Missouri 63901

Subject: WEAP Analysis Results
Route 67 Bridge over Cane Creek
Lincoln County, MO
FTC Project Number 049-2012

Dear Mr. Slayton,

Please find attached the results of our wave equation analysis for the referenced project. We recommend that you use your Delmag D19-42 hammer for driving pile at the end bents and a Delmag D30-32 hammer for driving pile at the intermediate bents to achieve the required axial pile capacity ranging from 168 to 387 kips, at the end and intermediate bents respectively, as listed in the project plans in order to maintain reasonable values of blow count and stroke while staying within allowable stress limits for the piles. Please refer to attached plots from the WEAP program output.

We analyzed the driving of HP14X73 H-pile at the end bents and 20 inch diameter, 1/2-inch wall pipe pile at the intermediate bents. We found that for each case, required axial capacity should be at met at or above plan length.

Please note that we performed our analysis using the available soil boring data, typical hammer performance and our judgment acquired from experience at previous projects. As such, actual driving conditions may vary from those modeled.

It should also be noted that this analysis is based on installation of the initial pile at each bent. It is possible that pile displacement effects following installation of subsequent pile at each bent (more so at the intermediate bents) could increase the capacity of the piling at a given depth.

It was our pleasure performing this analysis for you. Please contact me with any questions.

Sincerely,

STATE OF MISSOURI
WILLIAM C. JONES
NUMBER
E-2001003894
REGISTERED PROFESSIONAL ENGINEER

8/22/12

William C. Jones, P.E., P.G. – President, FTC

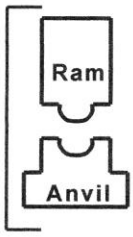
Enclosure: WEAP Program Output

Pile Driving and Equipment Data Form (English Units)

Contract No.: _____
Project: _____
County: Butler Co.

Structure Name and/or No.: Bridge A 7669 Bent 1/4
Pile Driving Contractor or Subcontractor: Robertson
(Piles driven by)

Hammer Components



Hammer

Manufacturer: Delmag Model No.: _____
Hammer Type: D19-42 Serial No.: _____
Manufacturers Maximum Rated Energy: 43.24 (ft-k)
Stroke at Maximum Rated Energy: 10.81 (ft)
Range in Operating Energy: 21.39 to 48.68 (ft-k)
Range in Operating Stroke: _____ to _____ (ft)
Ram Weight: ~~6.6~~ 4 (kips)
Modifications: _____

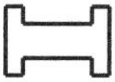
Striker Plate

Weight: _____ (kips) Diameter: _____ (in)
Thickness: _____ (in)

Hammer Cushion

	Material #1	Material #2 (for Composite Cushion)
Name:	50 Alum / 50 Composite	
Area:	227 (in²)	(in²)
Thickness/Plate:	2 (in)	(in)
No. of Plates:	1	

Total Thickness of Hammer Cushion: 2 (in)

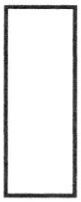


Helmet (Drive Head)

Weight: 1.899 including inserts (kips)

Pile Cushion

Material: N/A
Area: _____ (in²) Thickness/Sheet: _____ (in)
No. of Sheets: _____
Total Thickness of Pile Cushion: _____ (in)



Pile

Pile Type: 14X73
Wall Thickness: _____ (in) Taper: _____
Cross Sectional Area: 21.4 (in²) Weight/Meter: _____
Ordered Length: 55 (ft)
Design Load: _____ (kips)
Ultimate Pile Capacity: 168 (kips)

Description of Splice: _____
Driving Shoe/Closure Plate Description: _____

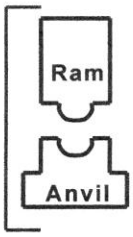
Submitted By: FT&C Date: 8-20-12
Telephone No.: 913 626 8499 Fax No.: 913 439-1703
e-mail: _____

Pile Driving and Equipment Data Form (English Units)

Contract No.: _____
Project: _____
County: Butler, CO.

Structure Name and/or No.: Bridge A7669 Bent 2/3
Pile Driving Contractor or Subcontractor: Robertson
(Piles driven by)

Hammer Components



Hammer

Manufacturer: Delmag Model No.: _____
Hammer Type: 30-32 Serial No.: _____
Manufacturers Maximum Rated Energy: 75.40 (ft-k)
Stroke at Maximum Rated Energy: 11.43 (ft)
Range in Operating Energy: 39.40 to 75.97 (ft-k)
Range in Operating Stroke: _____ to _____ (ft)
Ram Weight: 6.6 (kips)
Modifications: _____

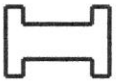
Striker Plate

Weight: _____ (kips) Diameter: _____ (in)
Thickness: _____ (in)

Hammer Cushion

	Material #1	Material #2 (for Composite Cushion)
Name:	50 Alum/50 cork	
Area:	415 (in²)	(in²)
Thickness/Plate:	2 (in)	(in)
No. of Plates:	1	

Total Thickness of Hammer Cushion: 2 (in)

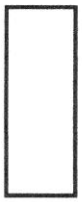


Helmet (Drive Head)

Weight: 3.4 including inserts (kips)

Pile Cushion

Material: _____
Area: _____ (in²) Thickness/Sheet: _____ (in)
No. of Sheets: _____
Total Thickness of Pile Cushion: _____ (in)



Pile

Pile Type: C.I.P 20" x 0.5"
Wall Thickness: 0.5 (in) Taper: _____
Cross Sectional Area: 30.63 (in²) Weight/Meter: _____

Ordered Length: 97 (ft)
Design Load: 387 (kips)
Ultimate Pile Capacity: 387 (kips)

Description of Splice: _____

Driving Shoe/Closure Plate Description: _____

Submitted By: ET&C Date: 8-20-12
Telephone No.: 913 626-8479 Fax No.: 913 439-1703
e-mail: _____

Input Information:

Bent	**1**	**2**	**3**	**4**
Pile Type	HP 14x73	PP 20x0.5	PP 20x0.5	HP 14x73
Plan Length	53	96	97	55
Required Capacity	168	387	387	168
Cut Off Elev.	331.08	330.51	330.51	331.08
Min Tip Elev.	290	265	265	290
Ground Elev.	329.58	312	312	329.58

Bent 1 Soil Profile 0-35 medium clay

35-47 soft clay

47-65 medium sand

Bent 2/3 Soil Profile 0-30 soft clay

30-65 medium sand

65-80 stiff clay

Bent 4 Soil Profile 0-15 soft clay

15-35 medium clay

35-60 medium sand

WEAP Summary:

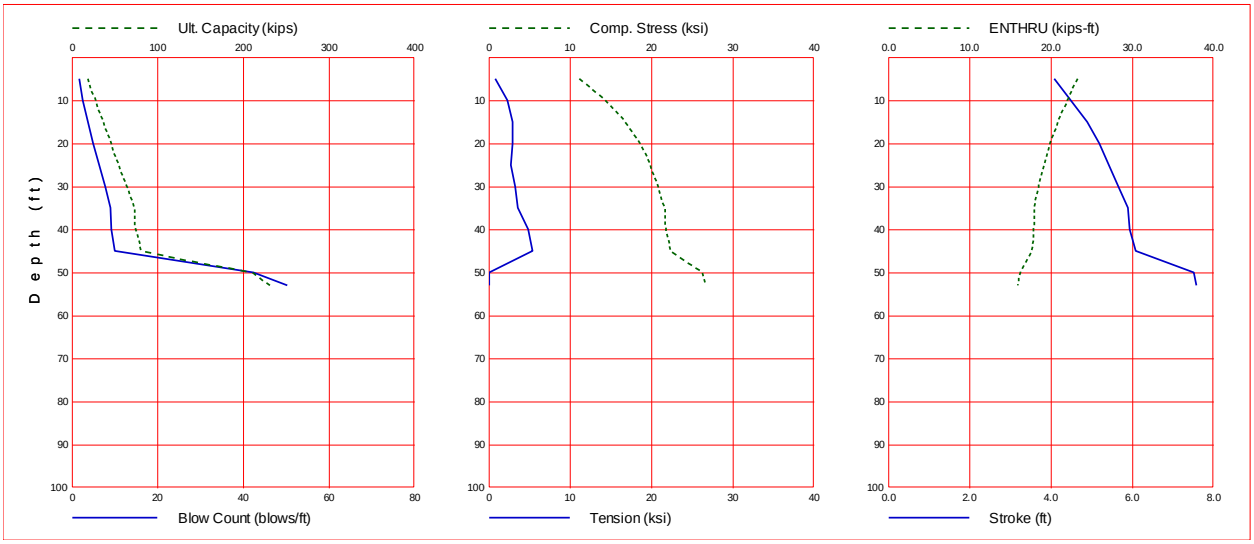
For Bridge # A7669 Bent 1/4, a D 19-42 hammer was model at a Plan Length of 55'. At plan length the pile should be able to hit or exceed the required capacity of 168kips.

For Bridge # A7669 Bent 2/3, a D 30-32 hammer was model at a Plan Length of 96'. At plan length the pile should be able to hit or exceed the required capacity of 387kips.

A7669 – Bent 1 – Drivability

Foundation Testing & Consulting LLC — Aug 20 2012

Robertson - A7669 Bent 1 — Gain/Loss 1 at Shaft and Toe 1.000 / 1.000 — GRLWEAP Version 2010



Foundation Testing & Consulting LLC — Aug 20 2012

Robertson - A7669 Bent 1 — GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

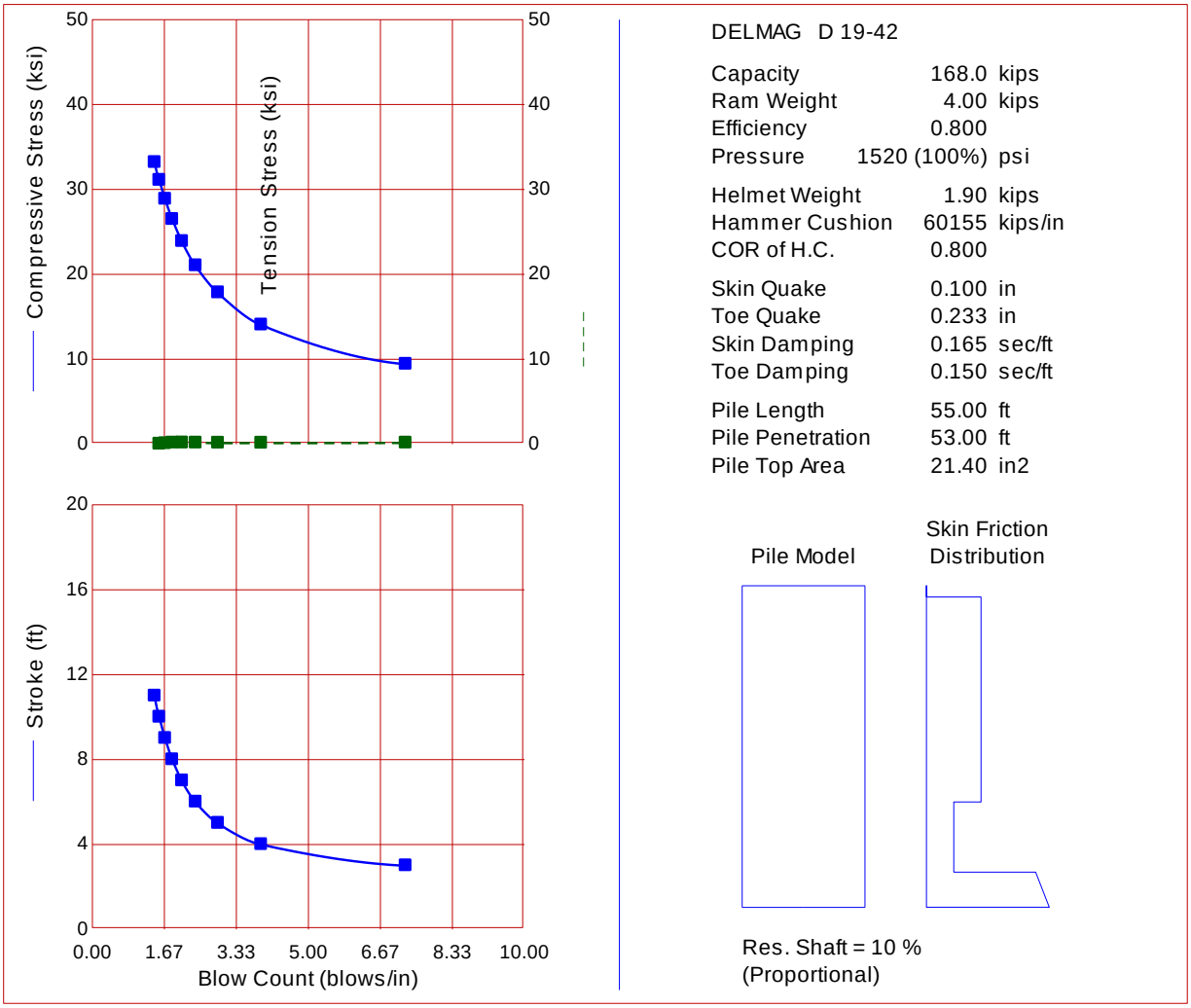
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	18.4	9.3	9.1	1.7	11.154	-0.853	4.09	23.3
10.0	27.6	18.5	9.1	2.6	14.321	-2.310	4.50	22.0
15.0	36.9	27.8	9.1	3.8	16.794	-2.928	4.90	20.9
20.0	46.1	37.0	9.1	5.0	18.592	-2.962	5.20	19.9
25.0	55.4	46.3	9.1	6.4	19.881	-2.771	5.42	19.1
30.0	64.7	55.6	9.1	7.7	20.838	-3.277	5.66	18.5
35.0	73.9	64.8	9.1	9.1	21.740	-3.600	5.89	18.0
40.0	74.7	70.2	4.6	9.3	21.799	-4.896	5.95	17.9
45.0	80.1	75.6	4.6	10.1	22.334	-5.420	6.09	17.7
50.0	211.2	89.2	122.1	42.5	26.292	-0.056	7.53	16.3
53.0	231.4	101.4	130.0	50.3	26.560	0.000	7.58	15.9

Total Continuous Driving Time 11.00 minutes; Total Number of Blows 523

A7669 – Bent 1 – Inspector's Chart

Foundation Testing & Consulting LLC 20-Aug-2012

Robertson - A7669 Bent 1 GRLWEAP Version 2010



Foundation Testing & Consulting LLC 20-Aug-2012

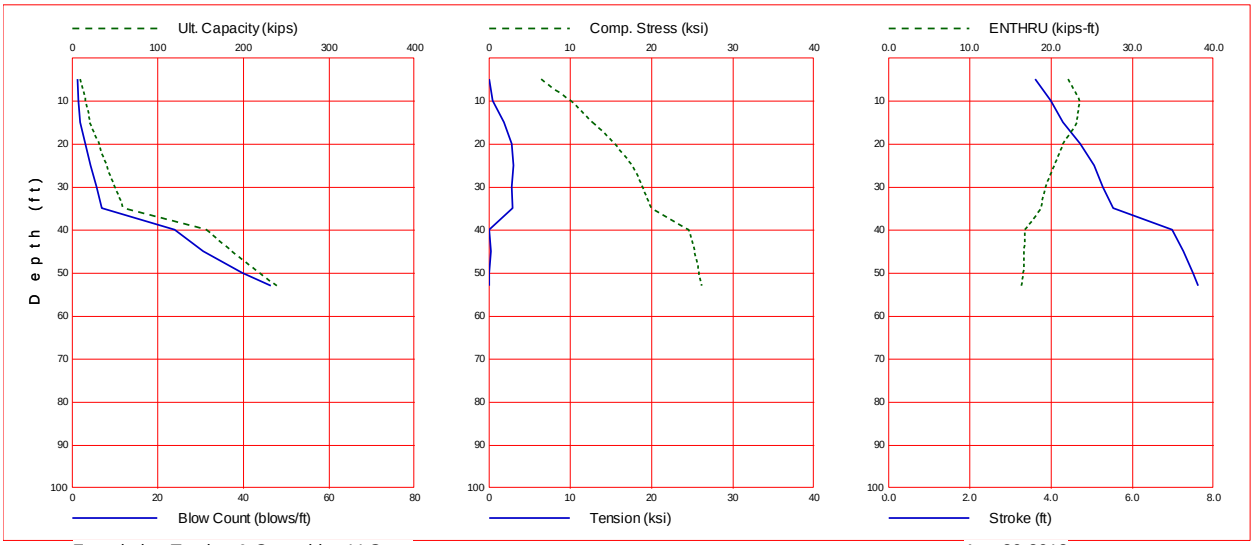
Robertson - A7669 Bent 1 GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
168.0	9.43	0.15	7.3	3.00	5.02
168.0	14.04	0.13	3.9	4.00	8.40
168.0	17.84	0.14	2.9	5.00	11.44
168.0	21.03	0.15	2.4	6.00	14.34
168.0	23.88	0.15	2.1	7.00	17.16
168.0	26.48	0.15	1.9	8.00	20.01
168.0	28.86	0.09	1.7	9.00	22.75
168.0	31.09	0.03	1.6	10.00	25.46
168.0	33.19	0.00	1.4	11.00	28.15

A7669 – Bent 4 – Drivability

Foundation Testing & Consulting LLC | Aug 20 2012

Robertson - A7669 Bent 4 | Gain/Loss 1 at Shaft and Toe 1.000 / 1.000 | GRLWEAP Version 2010



Foundation Testing & Consulting LLC | Aug 20 2012
Robertson - A7669 Bent 4 | GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

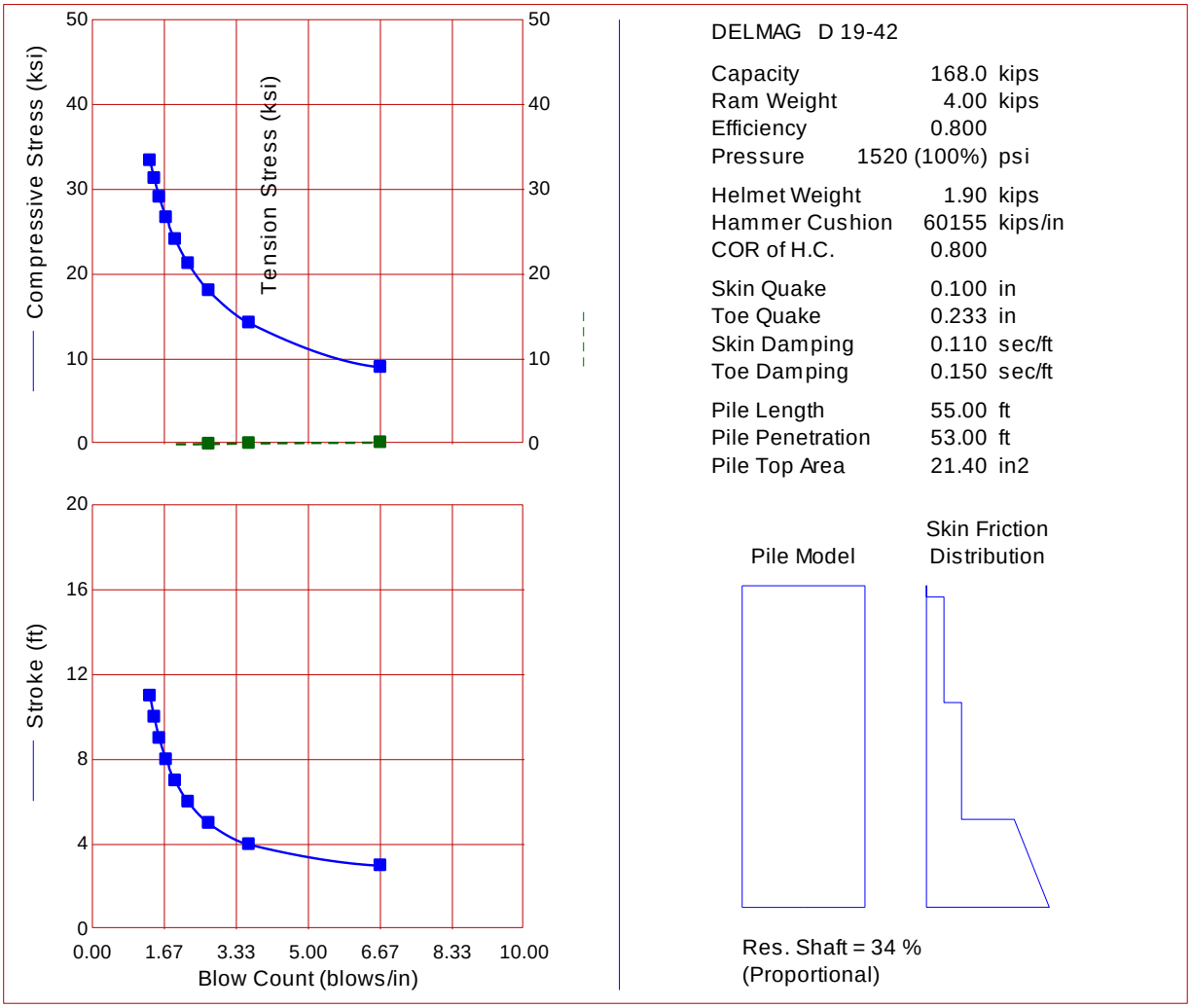
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	9.9	5.4	4.6	1.3	6.468	-0.032	3.61	22.1
10.0	15.3	10.7	4.6	1.6	10.061	-0.478	4.00	23.5
15.0	20.6	16.1	4.6	2.0	12.712	-1.910	4.29	23.2
20.0	32.1	23.0	9.1	3.2	15.559	-2.784	4.72	21.5
25.0	41.4	32.3	9.1	4.4	17.642	-3.038	5.06	20.4
30.0	50.6	41.5	9.1	5.7	18.897	-2.846	5.28	19.4
35.0	59.9	50.8	9.1	7.0	20.027	-2.887	5.54	18.8
40.0	157.5	62.3	95.2	24.1	24.625	-0.083	6.99	16.8
45.0	187.2	78.8	108.4	30.7	25.347	-0.218	7.26	16.7
50.0	219.0	97.4	121.6	39.7	25.814	-0.094	7.50	16.6
53.0	239.2	109.6	129.6	46.5	26.174	-0.015	7.63	16.4

Total Continuous Driving Time 14.00 minutes; Total Number of Blows 628

A7669 – Bent 4 – Inspector's Chart

Foundation Testing & Consulting LLC 20-Aug-2012

Robertson - A7669 Bent 4 GRLWEAP Version 2010



Foundation Testing & Consulting LLC 20-Aug-2012

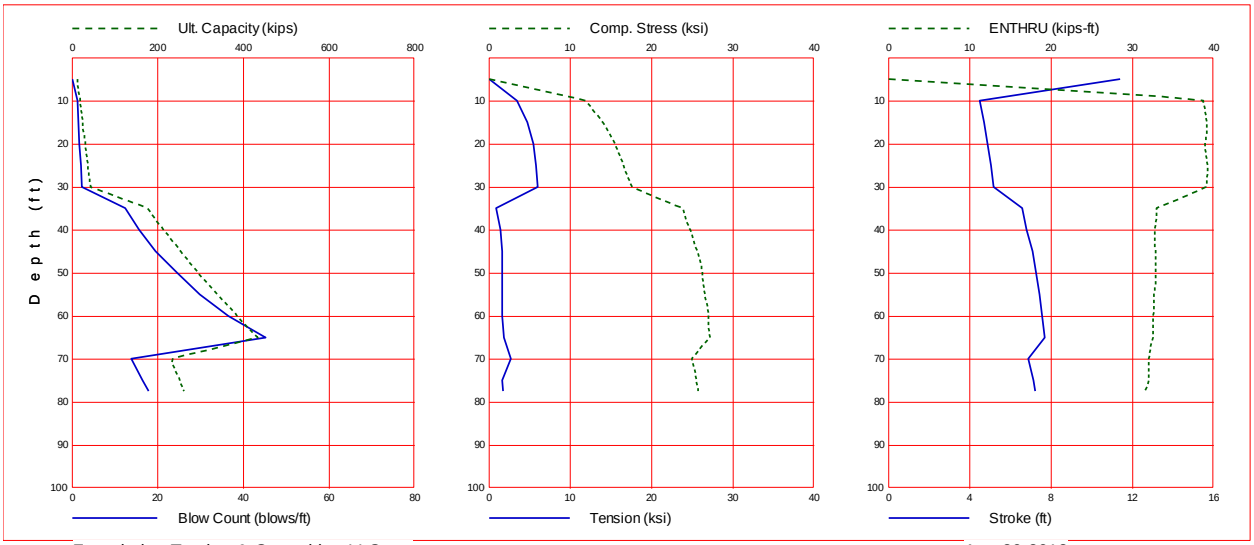
Robertson - A7669 Bent 4 GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
168.0	9.06	0.19	6.7	3.00	4.92
168.0	14.30	0.10	3.6	4.00	8.30
168.0	18.09	0.02	2.7	5.00	11.39
168.0	21.28	0.00	2.2	6.00	14.35
168.0	24.12	0.00	1.9	7.00	17.23
168.0	26.69	0.00	1.7	8.00	20.03
168.0	29.10	0.00	1.6	9.00	22.82
168.0	31.29	0.00	1.4	10.00	25.53
168.0	33.39	0.00	1.3	11.00	28.27

A7669 – Bent 2/3 – Drivability

Foundation Testing & Consulting LLC | Aug 20 2012

Robertson - A7669 Bent 4 | Gain/Loss 1 at Shaft and Toe 1.000 / 1.000 | GRLWEAP Version 2010



Foundation Testing & Consulting LLC | Aug 20 2012

Robertson - A7669 Bent 4 | GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

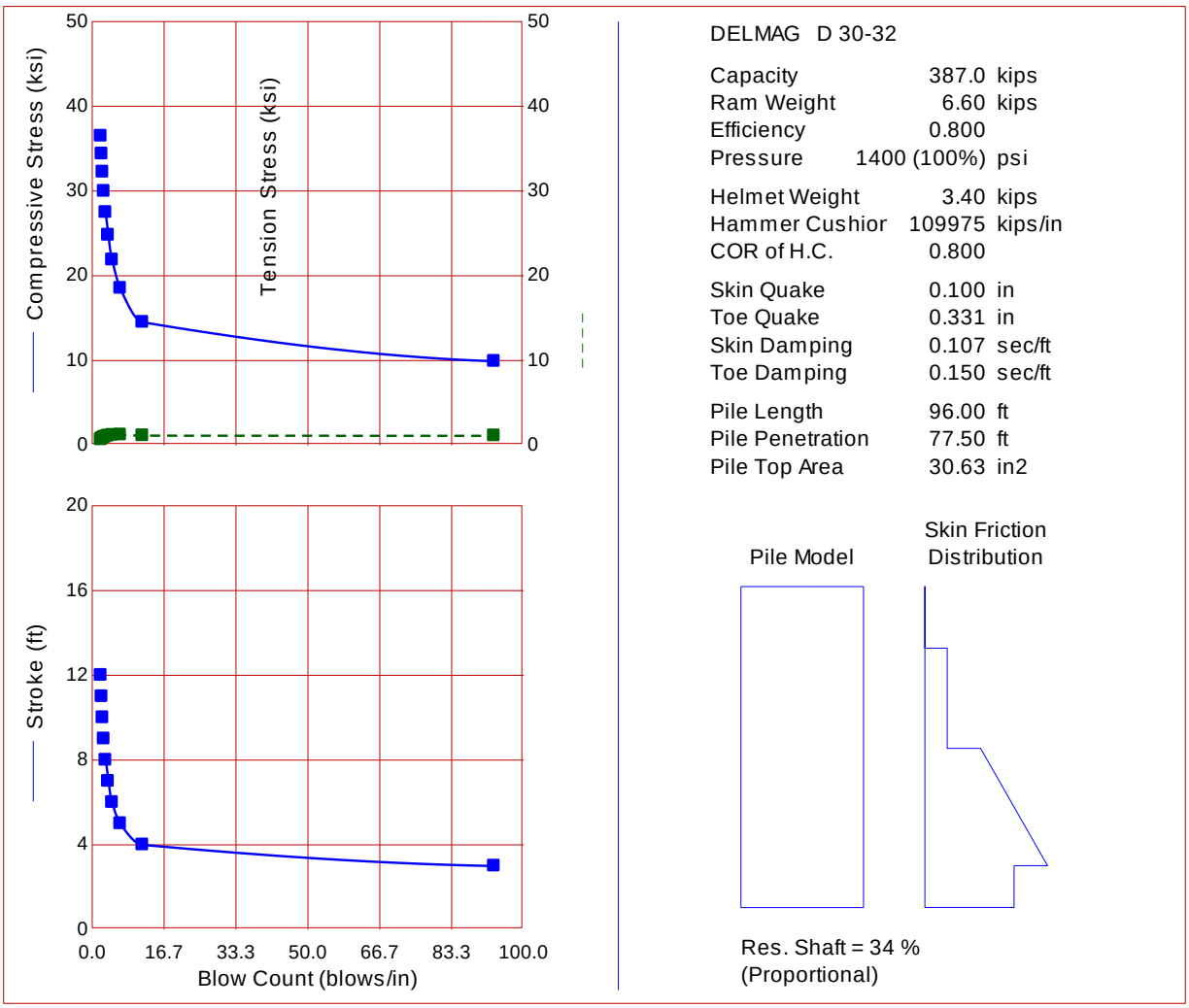
Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	13.3	6.0	7.3	0.0	0.000	0.000	11.43	0.0
10.0	19.3	12.0	7.3	1.4	11.970	-3.486	4.52	38.8
15.0	25.4	18.1	7.3	1.6	14.034	-4.794	4.73	39.2
20.0	31.4	24.1	7.3	1.8	15.526	-5.470	4.90	39.0
25.0	37.4	30.1	7.3	2.1	16.631	-5.784	5.05	39.3
30.0	43.4	36.1	7.3	2.4	17.653	-6.035	5.20	39.1
35.0	177.1	49.4	127.7	12.4	23.844	-0.949	6.58	33.0
40.0	213.9	65.0	148.9	15.7	24.792	-1.478	6.82	32.8
45.0	253.2	83.1	170.1	19.6	25.604	-1.639	7.10	32.9
50.0	294.8	103.5	191.3	24.7	26.246	-1.703	7.29	32.9
55.0	338.9	126.4	212.5	29.9	26.600	-1.650	7.43	32.7
60.0	385.3	151.6	233.7	36.5	27.024	-1.600	7.56	32.6
65.0	434.2	179.3	254.9	45.2	27.209	-1.916	7.68	32.6
70.0	230.2	200.6	29.6	13.8	25.015	-2.773	6.91	32.0
75.0	251.5	221.9	29.6	16.5	25.597	-1.691	7.16	32.0
77.5	262.2	232.6	29.6	17.9	25.767	-1.732	7.23	31.6

Total Continuous Driving Time 25.00 minutes; Total Number of Blows 1122

A7669 – Bent 2/3 – Inspector's Chart

Foundation Testing & Consulting LLC | 20-Aug-2012

Robertson - A7669 Bent 4 | GRLWEAP Version 2010



Foundation Testing & Consulting LLC | 20-Aug-2012

Robertson - A7669 Bent 4 | GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
387.0	9.91	1.13	93.2	3.00	8.64
387.0	14.53	1.14	11.7	4.00	14.81
387.0	18.53	1.23	6.5	5.00	20.06
387.0	21.88	1.20	4.7	6.00	25.02
387.0	24.79	1.11	3.7	7.00	29.70
387.0	27.48	1.01	3.1	8.00	34.28
387.0	29.97	0.92	2.7	9.00	38.95
387.0	32.24	0.83	2.5	10.00	43.46
387.0	34.39	0.75	2.2	11.00	47.99
387.0	36.48	0.66	2.1	12.00	52.44