FOUNDATION TESTING & CONSULTING, LLC
Knowledge To Build On®

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May 4, 2013

Mr. Grant Baquet, E.I.T., Project Engineer
APAC-Missouri, Inc.
PO Box 407
Clinton, MO 64735

Subject: WEAP Submittal – Bridge A7932
Driven Pile Testing Services
Route V Bridge Project
Livingston County, Missouri
FTC Project Numbers 027-2013

Dear Mr. Baquet,

Please find attached the results of our wave equation analysis for the referenced project. We find that the proposed Delmag D19-42 hammer will perform satisfactory for installation of the 14-inch diameter, 3/8-inch wall pipe pile (closed-end) with a yield strength of 45 ksi that is planned for the project. This is to insure that you achieve the required axial pile capacity ranging from 220 to 232 kips as listed in the project plans for the Bents 1, 2, 3 and 4 piling locations while maintaining reasonable values of blow count and stroke and also staying within allowable stress limits for the piles. Anticipated total pile lengths range from 48 to 55 feet. Please refer to attached plots from the WEAP program output for additional details about our analysis.

We analyzed a soil profile that was based on information included in the project plans for borings that were performed near the end bents (no soil boring information was provided for the locations of Bents 2 and 3). This profile consists in general of an upper layer of stiff to very stiff clay approximately 80 feet thick overlying approximately 20 feet of medium dense to dense sand to boring termination depth. Groundwater was encountered at an approximate elevation of 760 feet at the time of drilling.

Through our WEAP analysis we concluded that the piles should attain required capacities at end-of-initial drive (EOID) at planned pile lengths at Bents 1, 2 and 3. We would anticipate that the piles at Bent 4 would reach required capacity at

EOID with an additional 10 feet total length or at planned length during restrike testing performed a few days following initial installation.

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.

Please contact me with any questions.

Sincerely,

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

Enclosure: WEAP Program Output

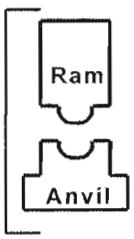
APAC – A7932 WEAP

Pile Driving and Equipment Data Form (English Units)

Contract No.: _____
Project: J2S0787
County: Livingston, Co MO

Structure Name and/or No.: A7932
Pile Driving Contractor or Subcontractor: APAC - MO
(Piles driven by)

Hammer Components



Hammer
Manufacturer: Delmag
Model No.: D19-42
Hammer Type: OED
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: 4 (kips)
Modifications: _____

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

Hammer Cushion

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

Total Thickness of Hammer Cushion: _____ (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: 14 inch diameter, closed-end pipe
Wall Thickness: 3/8 (in) Taper: none
Cross Sectional Area: 16.05 (in²) Weight/~~Meter~~ ft: 58
Ordered Length: 48-55 (ft)
Design Load: X (kips) — 220 to 232
Ultimate Pile Capacity: _____ (kips)
Description of Splice: none anticipated
Driving Shoe/Closure Plate Description: flat plate

Submitted By: FTC Date: 5/4/13
Telephone No.: 913-626-8499 Fax No.: 913-439-1703
e-mail: cj@FTandC.com

INPUT INFORMATION:

	Bent 1	Bent 2	Bent 3	Bent 4
Pile Type	PP 14x0.375	PP 14x0.375	PP 14x0.375	PP 14x0.375
Total Length (ft)	55	48	48	50
Pile Cutoff Elev.	804.51	773	773	803.27
Ground Elev.	803.01	772	772	801.77
Prebore Elev.	792			785
Min. Tip Elev.	782	762	762	775
Required Nominal Capacity (kips)	220	232	232	220

SOIL PROFILE: End Bent 1 and Intermediate Bent 2

792-784 Stiff Clay

784- 724 Very Stiff Clay

Intermediate Bent 3 and End Bent 4

785-767 Very Stiff Clay

767-718 Stiff to Very Stiff Clay

WEAP ANALYSIS:

End Bent 1: A PP 14x0.375 pile and a Delmag D19-42 hammer were modeled in the WEAP. A required capacity of 220 kips was used. The required capacity was modeled below in the Inspector's chart. Through the drivability analysis, the required capacity should reach capacity at plan length.

Intermediate Bent 2/3: A PP 14x0.375 pile and a Delmag D19-42 hammer were modeled in the WEAP. A required capacity of 232 kips was used. The required capacity was modeled below in the Inspector's chart. Through the drivability analysis, the required capacity should reach capacity at plan length.

End Bent 4: A PP 14x0.375 pile and a Delmag D19-42 hammer were modeled in the WEAP. A required capacity of 220 kips was used. The required capacity was modeled below in the Inspector's chart. Through the drivability analysis, the required capacity was not reached at plan length. The pile length was extended by 10 feet in order to model attaining required capacity at end-of-initial drive.

APAC – A7932 – END BENT 1 – DRIVEABILITY

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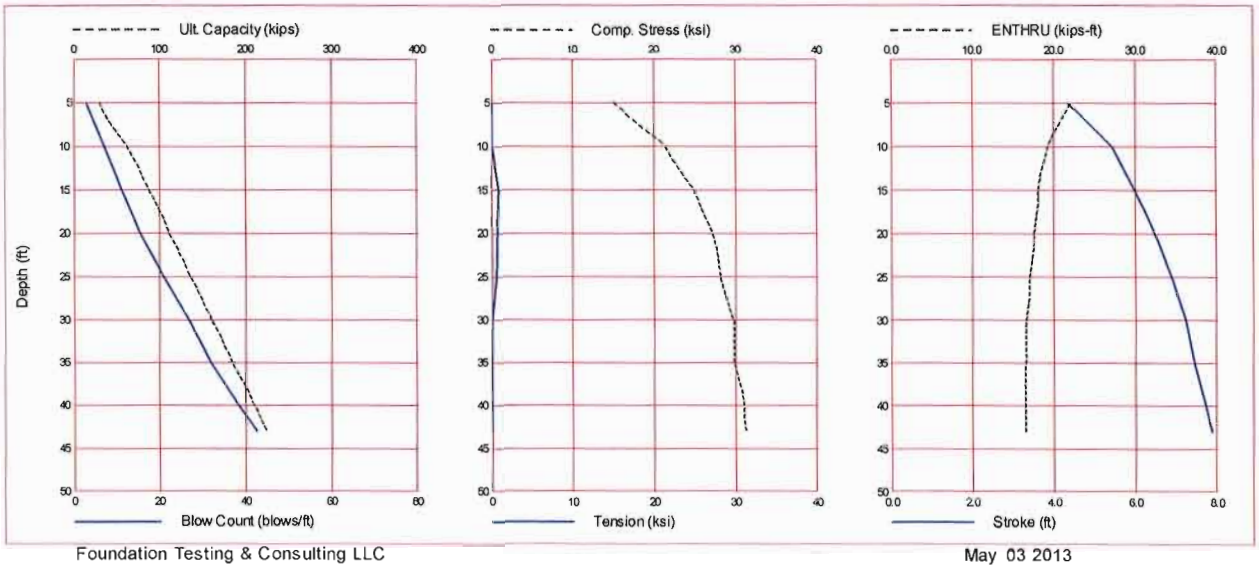
APAC - A7932 - End Bent 1

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

GRLWEAP Version 2010



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APAC - A7932 - End Bent 1

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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	29.4	14.9	14.5	2.9	14.956	0.000	4.36	22.0
10.0	62.7	33.7	29.0	7.2	21.433	0.000	5.42	19.3
15.0	87.2	58.2	29.0	11.3	24.855	-0.957	5.99	18.1
20.0	111.7	82.7	29.0	15.5	27.253	-0.681	6.49	17.5
25.0	136.2	107.2	29.0	20.9	28.201	-0.538	6.90	17.0
30.0	160.7	131.7	29.0	26.8	29.764	0.000	7.24	16.6
35.0	185.2	156.2	29.0	31.8	29.842	0.000	7.46	16.5
40.0	209.7	180.7	29.0	38.3	31.099	0.000	7.73	16.5
43.0	224.4	195.4	29.0	42.7	31.305	0.000	7.89	16.5

Total Continuous Driving Time 18.00 minutes; Total Number of Blows 798

APAC – A7932 – END BENT 1 – INSPECTOR'S CHART

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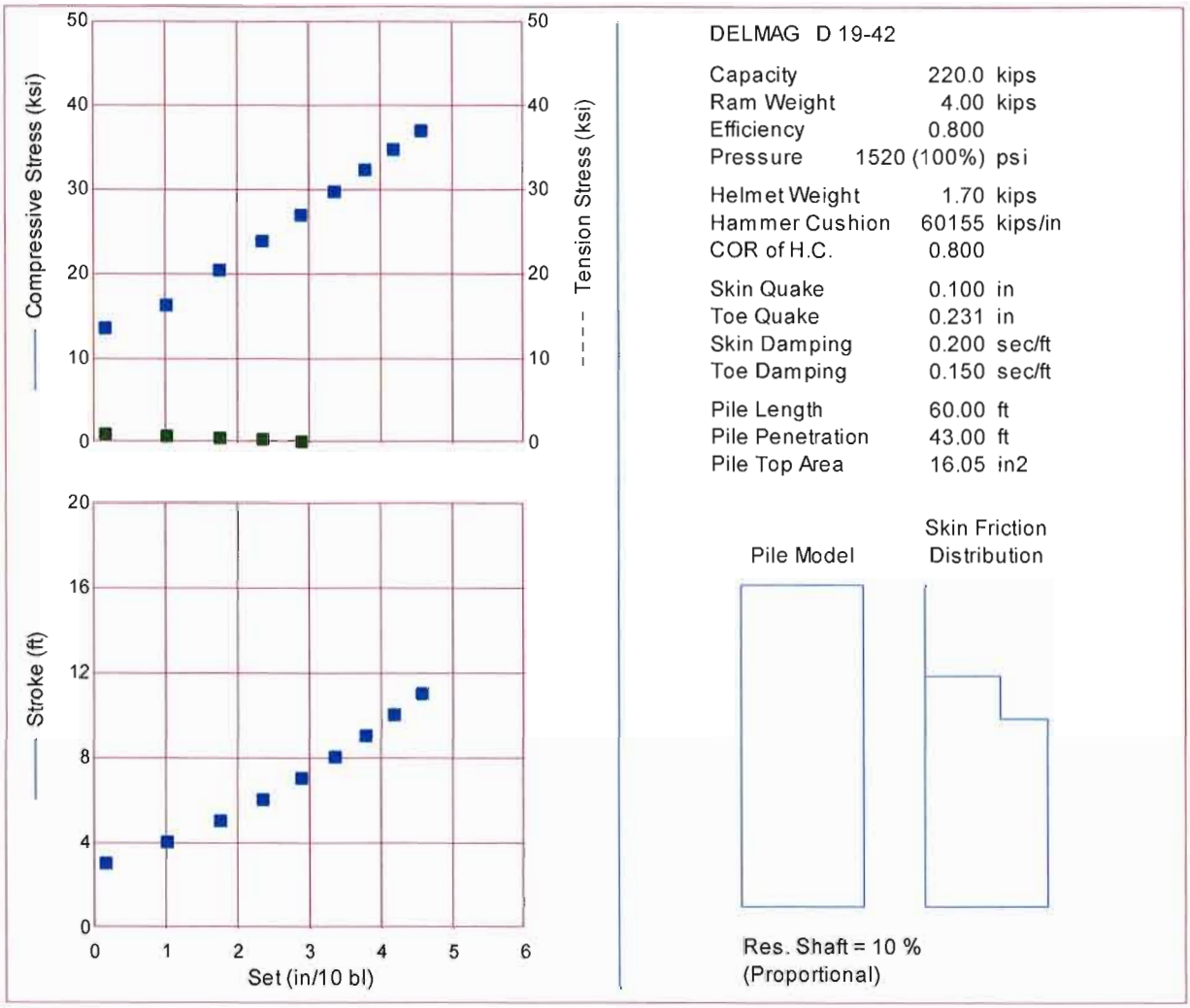
APAC - A7932 - End Bent 1

03-May-2013
GRLWEAP Version 2010



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03-May-2013
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Set in/10 bl	Stroke ft	Energy kips-ft
220.0	13.51	0.94	0.2	3.00	5.23
220.0	16.23	0.70	1.0	4.00	8.34
220.0	20.35	0.48	1.8	5.00	11.26
220.0	23.81	0.30	2.4	6.00	14.02
220.0	26.88	0.05	2.9	7.00	16.78
220.0	29.64	0.00	3.4	8.00	19.41
220.0	32.23	0.00	3.8	9.00	22.01
220.0	34.64	0.00	4.2	10.00	24.57
220.0	36.88	0.00	4.6	11.00	27.15

APAC – A7932 – INTERMIDIATE BENT 2/3 – DRIVEABILITY

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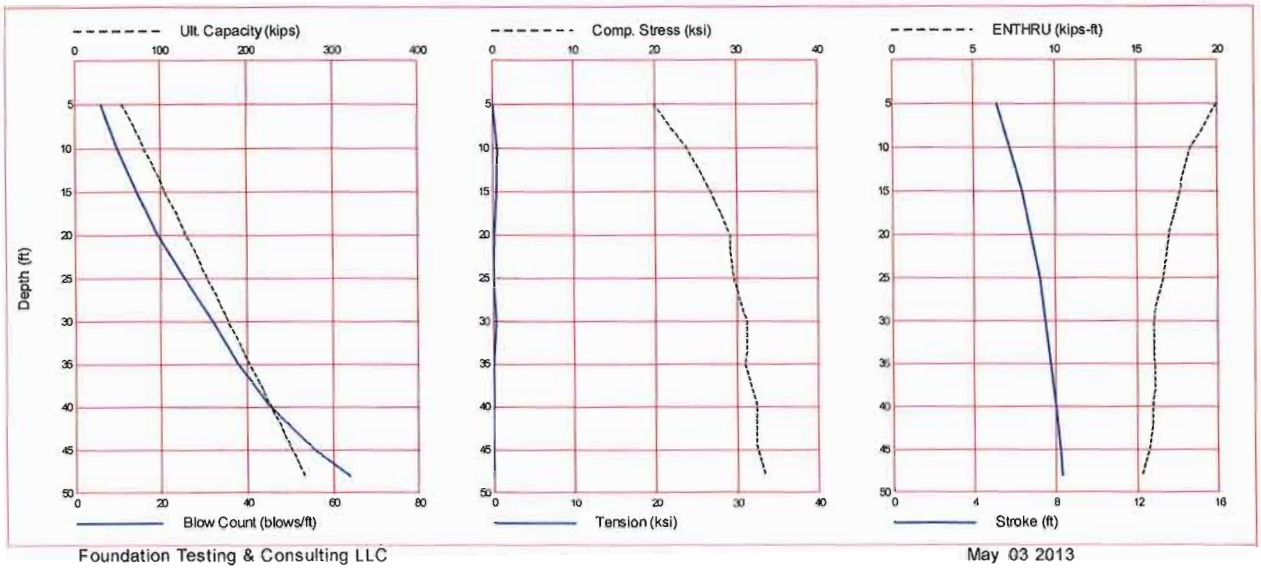
APAC - A7932 - Intermediate Bent 2/3

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

GRLWEAP Version 2010



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APAC - A7932 - Intermediate Bent 2/3

May 03 2013

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	55.5	24.5	31.0	6.1	19.814	0.000	5.16	19.9
10.0	80.0	49.0	31.0	10.0	23.818	-0.610	5.79	18.3
15.0	104.5	73.5	31.0	14.4	26.877	-0.513	6.39	17.7
20.0	129.0	98.0	31.0	19.3	29.128	-0.135	6.82	17.0
25.0	153.5	122.5	31.0	25.6	29.635	0.000	7.22	16.6
30.0	178.0	147.0	31.0	32.2	31.165	-0.327	7.48	16.0
35.0	202.5	171.5	31.0	37.9	30.994	0.000	7.76	16.1
40.0	227.0	196.0	31.0	45.5	32.403	0.000	7.99	15.9
45.0	251.5	220.5	31.0	55.7	32.433	0.000	8.20	15.7
48.0	266.2	235.2	31.0	63.8	33.356	0.000	8.29	15.3

Total Continuous Driving Time 30.00 minutes; Total Number of Blows 1273

APAC – A7932 – INTERMIDIATE BENT 2/3 – INSPECTOR'S CHART

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APAC - A7932 - Intermediate Bent 2/3

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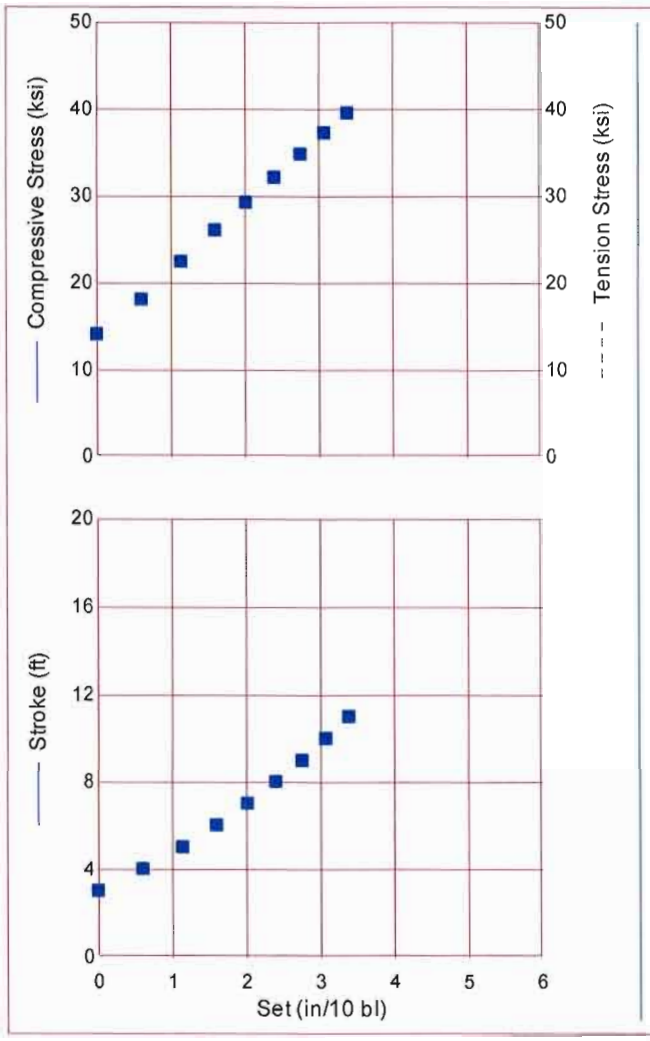
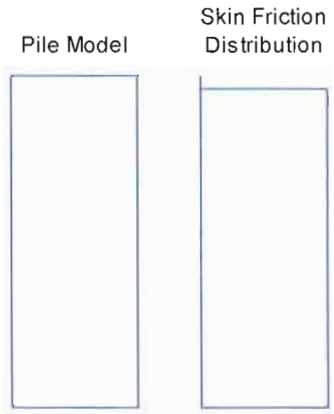


DELMAG D 19-42

Capacity	232.0	kips
Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1520 (100%)	psi
Helmet Weight	1.70	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.231	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	50.00	ft
Pile Penetration	48.00	ft
Pile Top Area	16.05	in2



Res. Shaft = 89 %
(Proportional)

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APAC - A7932 - Intermediate Bent 2/3

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Set in/10 bl	Stroke ft	Energy kips-ft
232.0	14.09	0.00	0.0	3.00	2.83
232.0	18.07	0.00	0.6	4.00	5.30
232.0	22.43	0.00	1.1	5.00	7.76
232.0	26.04	0.00	1.6	6.00	10.14
232.0	29.23	0.00	2.0	7.00	12.55
232.0	32.11	0.00	2.4	8.00	14.93
232.0	34.77	0.00	2.8	9.00	17.32
232.0	37.19	0.00	3.1	10.00	19.69
232.0	39.48	0.00	3.4	11.00	22.09

APAC – A7932 – END BENT 4 – DRIVEABILITY – PLAN LENGTH

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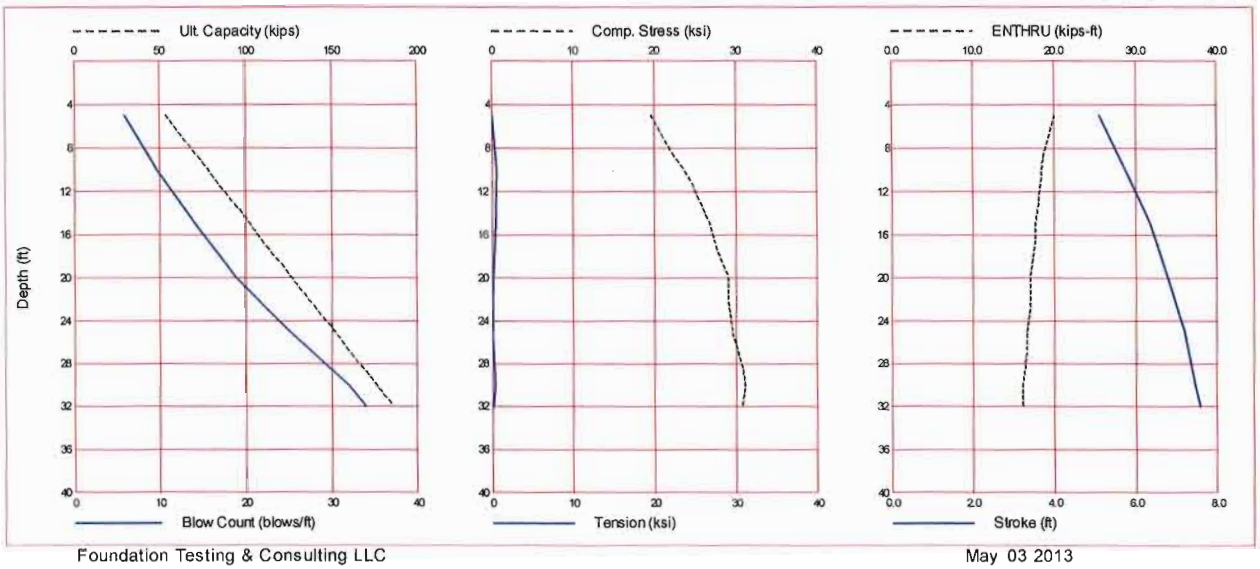
APAC - A7932 - End Bent 4

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

GRLWEAP Version 2010



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APAC - A7932 - End Bent 4
May 03 2013
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	53.5	24.5	29.0	5.9	19.532	0.000	5.11	20.0
10.0	78.0	49.0	29.0	9.7	23.614	-0.601	5.75	18.4
15.0	102.5	73.5	29.0	14.1	26.806	-0.532	6.37	17.7
20.0	127.0	98.0	29.0	18.9	29.032	-0.124	6.80	17.0
25.0	151.5	122.5	29.0	25.2	29.553	0.000	7.19	16.6
30.0	176.0	147.0	29.0	31.9	31.104	-0.364	7.46	16.0
32.0	185.8	156.8	29.0	34.0	30.741	-0.119	7.58	16.0

Total Continuous Driving Time 11.00 minutes; Total Number of Blows 515

APAC – A7932 – END BENT 4 – INSPECTOR'S CHART – PLAN LENGTH

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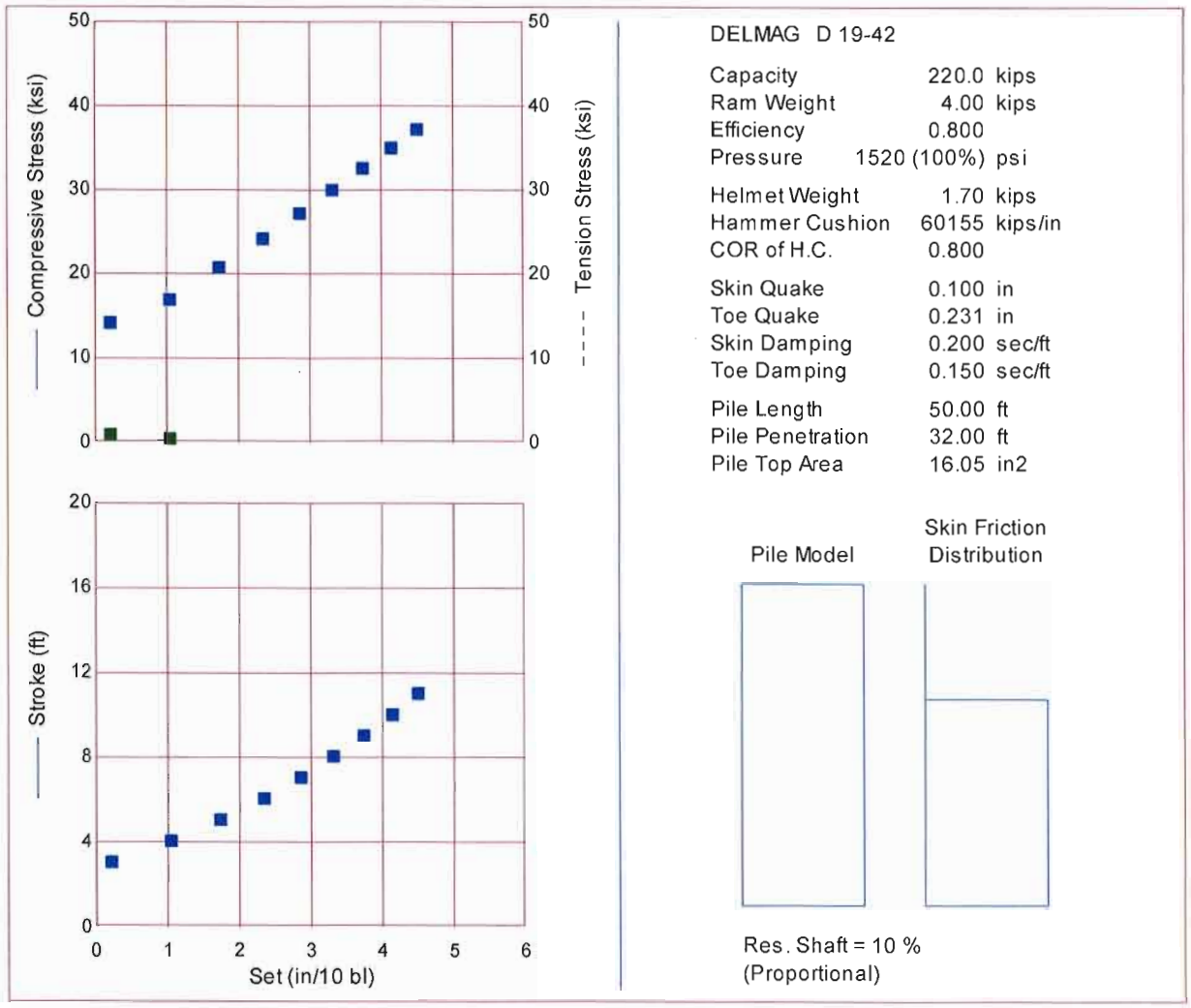
APAC - A7932 - End Bent 4

03-May-2013
GRLWEAP Version 2010



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APAC - A7932 - End Bent 4

03-May-2013
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Set in/10 bl	Stroke ft	Energy kips-ft
220.0	14.06	0.83	0.2	3.00	4.93
220.0	16.79	0.37	1.1	4.00	7.96
220.0	20.61	0.00	1.7	5.00	10.76
220.0	24.04	0.00	2.4	6.00	13.58
220.0	27.07	0.00	2.9	7.00	16.25
220.0	29.84	0.00	3.3	8.00	18.85
220.0	32.43	0.00	3.8	9.00	21.43
220.0	34.86	0.00	4.2	10.00	24.10
220.0	37.09	0.00	4.5	11.00	26.56

APAC – A7932 – END BENT 4 – DRIVEABILITY – 60'

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APAC - A7932 - End Bent 4

Gain/Loss 1 at Shaft and Toe 1.000 / 1.000

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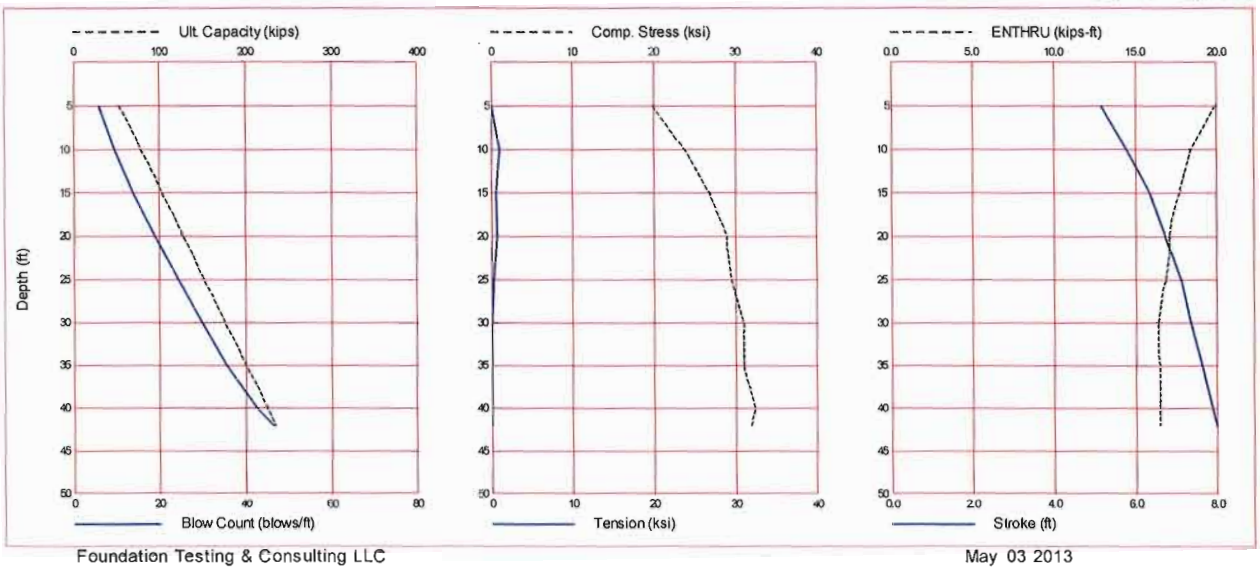

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APAC - A7932 - End Bent 4

May 03 2013

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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	53.5	24.5	29.0	5.9	19.766	0.000	5.15	19.9
10.0	78.0	49.0	29.0	9.7	23.690	-0.960	5.77	18.4
15.0	102.5	73.5	29.0	13.8	26.834	-0.616	6.34	17.7
20.0	127.0	98.0	29.0	18.9	28.978	-0.689	6.74	17.1
25.0	151.5	122.5	29.0	24.4	29.527	-0.282	7.12	16.8
30.0	176.0	147.0	29.0	29.9	30.987	0.000	7.35	16.4
35.0	200.5	171.5	29.0	35.6	30.938	0.000	7.63	16.5
40.0	225.0	196.0	29.0	42.7	32.418	0.000	7.89	16.5
42.0	234.8	205.8	29.0	46.4	31.950	0.000	7.99	16.5

Total Continuous Driving Time 20.00 minutes; Total Number of Blows 888

APAC – A7932 – END BENT 4 – INSPECTOR'S CHART – 60'

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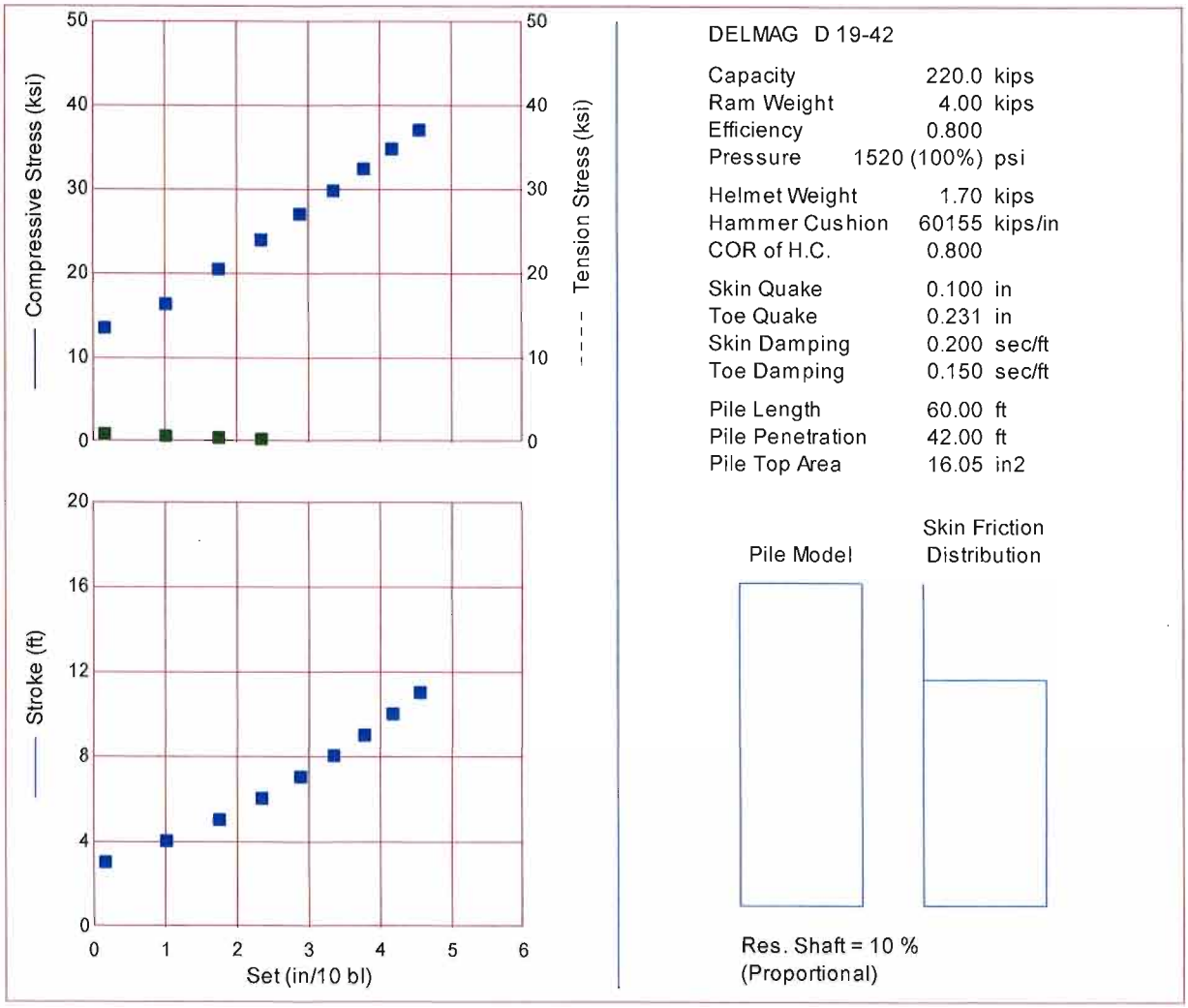
APAC - A7932 - End Bent 4

03-May-2013
GRLWEAP Version 2010



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APAC - A7932 - End Bent 4

03-May-2013
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Set in/10 bl	Stroke ft	Energy kips-ft
220.0	13.45	0.89	0.2	3.00	5.22
220.0	16.26	0.62	1.0	4.00	8.33
220.0	20.38	0.42	1.8	5.00	11.25
220.0	23.86	0.25	2.4	6.00	14.01
220.0	26.91	0.00	2.9	7.00	16.77
220.0	29.70	0.00	3.4	8.00	19.39
220.0	32.30	0.00	3.8	9.00	21.99
220.0	34.67	0.00	4.2	10.00	24.55
220.0	36.93	0.00	4.6	11.00	27.13