DYNAMIC PILE MONITORING REPORT

PROPOSED I-215 BRIDGES

SALT LAKE CITY, UTAH

FHWA-DP-66-10

Federal Highway Administration

Office of Highway Operations

Demonstration Projects Division

Washington, D.C.

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Introduction and Background

Field demonstrations for Demonstration Project 66, "Design and Construction of Driven Pile Foundations," include (1) dynamic pile monitoring by pile analyzer (field computer), and (2) static pile load testing using a mobile pile load test frame. The equipment and technical assistance are made available to a requesting State highway department.

A request for a field demonstration and use of the dynamic testing equipment was received from the Utah Department of Transportation (UDOT) in September 1984. UDOT had decided to perform a comprehensive design stage pile load test program for the proposed I-215 bridges in Salt Lake City. The Federal Highway Administration (FHWA) agreed to provide the dynamic monitoring equipment and personnel to operate the equipment. The FHWA also provided technical assistance for performing wave equation analysis. UDOT decided to use its own pile load test frame for performing static pile load tests.

The purpose for the load test program was; (1) to demonstrate the use of newer and more accurate techniques for determining pile load capacity during driving, (2) to verify the predictions made by the newer techniques by performing static load tests, and (3) to determine design pile load capacities for I-215 bridges. It was felt that cost savings could be achieved by using either higher design loads or shorter pile lengths.

The field work (pile driving and dynamic testing) was performed over a period of 4 weeks during March and April 1985. The dynamic tests were performed by Mr. H. Clark, Civil Engineering Technician, in the Demonstrations Projects Division, and Mr. S. Vanikar, Geotechnical Engineer in the Geotechnical and Materials Branch. The UDOT personnel performed static pile analysis and wave equation analysis. The piling contractor was W. P. Harlin Construction Co.

At the time of writing this report, the static load tests on eight test piles at four test sites were incomplete. Therefore, the static load test data is not included in this report. The wave equation analyses for test piles were performed by UDOT and those results are not included in the report.

On March 29, 1985, after the dynamic testing for piles at the first two test sites was completed, an informal presentation on the results of the analysis and preliminary recommendations were made to the UDOT and FHWA engineers. A detailed description of the work performed, test results, and recommendations follow in this report.

Location and Structure Information

The four pile load test sites are located in the interchange areas of I-80 and I-215 in Salt Lake-City. Test site numbers 1 and 2 are located in the West Valley interchange area of I-80. Test site number 1 is located in the vicinity of Sta. 380+55, I-80 WBL and the test site number 2 is located in the vicinity of Sta. 397+33, I-80, M Ramp. Test sites 3 and 4 are located in the I-80/I-215 interchange area. Test site number 3 is at the fifth South Street bridge site and the test site number 4 is at the Indiana Avenue bridge site.

The structures at these four sites will be supported on driven pile foundations because of the existence of loose silty sand deposits (test sites numbers 1 and 2) and soft to medium silt and clay deposits (test sites numbers 3 and 4)

Pile Data

At each test site one short and one long test piles were driven. The test piles were 12 3/4-inch O.D., 0.375-inch wall closed end pipe piles. Steel plates were welded at the pile tips to close the pile. The piles were driven in two or three sections. The section lengths varied from 20 feet to 60 feet. Full penetration butt welds were used for splicing pile sections. The total lengths of long test piles varied from 109 feet to 135 feet. The total lengths of short test piles varied from 81 feet to 120 feet. Both short and long test piles were dynamically monitored by pile analyzer at each test site.

The reaction pile system at each test site consisted of four 14-inch O.D., 0.375-inch wall closed end pipe piles. They were driven in two or three sections. The section lengths varied from 40 feet to 60 feet. Full penetration butt welds were used to splicing piles. Only one reaction pile was dynamically monitored at each site. The total length of each dynamically monitored reaction pile varied from 120 feet to 147 feet.

The short and long test piles were retapped 24 hours to 60 hours after the initial driving was completed. The purpose for retapping the piles was to determine whether there was any gain in the pile capacity due to setup.

Subsurface Conditions

Log of boring at test site number 1 shows alternate layers of very loose clayey sand and soft clay to a depth of 50 feet below the existing ground. Medium to dense deposits of silty sand with clay lenses exist below the 50 foot depth. Standard Penetration Test (SPT) "N" values vary from 18 to 100 in dense silty sand deposits. Subsurface conditions at test site number 2 are similar to those at test site number 1 except that the loose silty sand deposits extend to 40 feet below the existing ground. Log of boring at test site number 3 shows loose to medium silty sand deposits with intermixed layers of silty clay to a depth of 120 feet below ground (SPT "N" values vary from 4 to 27) was terminated at the 120-foot depth.

Subsurface conditions at the test site number 4 are quite different from those at test sites 1, 2, and 3. Soft to medium silty clay deposits which include sand lenses extend to a deptn of 55 feet below the existing ground. Medium to very dense silty sands and stiff to very stiff silty clays exist below 55 feet. SPT "N" values up to 90 in dense silty sands were recorded on the boring log.

Hammer Data

The following is the data for the hammer system selected by the contractor:

Delmag D-3002, open end diesel Hammer (4 step)

Rated Energy = 66,1000 Foot Pounds

Hammer Cushion - alternate layers of micarta and aluminum

Total thickness = 3 1/2 inches

Pile cushion - none

Dynamic Monitoring (Pile Analyzer) Results

The dynamic monitoring results shown in Tables 1 through 12 are self-explanatory. The compressive and tensile driving stresses did not exceed the limitations of 32.4 KSI except in few isolated cases. The diesel hammer did not perform well in easy driving situations, particularly in the early driving stages of each pile. The hammer performance was adequate once the pile developed some resistance.

Snort and long test piles at each site were monitored during initial driving. These piles were retapped after a period of 24 to 60 hours to determine the gain in capacity due to setup. One reaction pile at each test site was dynamically monitored. The reaction piles were not retapped.

The Table 13 shows ultimate pile load capacities for all the tested piles. It should be noted that damping factor (J) was assumed to be 0.2 in making the ultimate pile capacity predictions. After the static load tests are completed, a back analysis can be performed to determine the validity of this assumption.

TABLE 13 PREDICTED ULTIMATE PILE LOAD CAPACITIES

(Reaction Piles - 14 "O.D., Test Piles - 12 3/4" O.D.)

TEST SITE	PILE	PREDICTED ULTIMATE PILE CAPACITY (INITIAL)	PREDICTED ULTIMATE PILE CAPACITY (AFTER SETUP)
1	Reaction Pile No. 4	222 Tons	-
	Long Test Pile No. 1	192 Tons	349 Tons
	Short Test Pile No. 2	103 Tons	193 Tons
2	Reaction Pile No. 3	145 Tons	-
	Long Test Pile No. 1	112 Tons	303 Tons
	Short Pile No. 2	60 Tons	283 Tons
3	Reaction Pile No. 2	208 Tons	-

TABLE 13 (contd.)

TEST SITE	PILE	PREDICTED ULTIMATE PILE CAPACITY (INITIAL)	PREDICTED ULTIMATE PILE CAPACITY (AFTER SETUP)
3	Long Test Pile No. 1	115 Tons	275 Tons
	Short Test Pile No. 2	83 Tons	305 Tons
4	Reaction Pile No. 4	182 Tons	-
	Long Test Pile No. 1	215 Tons	304 Tons
	Short Test Pile No. 2	128 Tons	252 Tons

Conclusion and Recommendations

1. The pile analyzer performed well in monitoring driving stresses, pile capacities and hammer performance. The predicted ultimate pile load capacities by the analyzer should be compared with the static pile load

test results. The pile analyzer also provides a tool to detect and assess pile damage. This demonstrates the tremendous advantages provided by the equipment.

2. Significant gain in pile capacities due to setup was measured at each site. This fact should be considered in developing pile driving criteria for the production piles.

3. Since the longer test piles provided substantial higher pile load capacities, it seems that longer and fewer piles in each foundation unit may prove to be cost effective.

4. The diesel hammer used for test pile driving was adequate. A hammer with similar characteristics should be required for the production pile driving.

5. It is strongly recommended that the wave equation analysis be used for the I-215 bridges and future bridge projects for determining pile capacities and the use of pile formula be phased out.

6. It is recommended that the UDOT acquire a pile analyzer and accessory equipment for the construction control on I-215 bridges and future major pile foundation projects. Dynamic pile testing by the analyzer is not necessary for all piles. Usually about 10 percent of the piles should be tested dynamically. The remaining piles should be driven based on the wave equation criteria.

7. For production pile driving for the I-215 bridges, a revised wave equation analysis should be performed by UDOT to refine the analysis and to evaluate the contractor's proposed driving system.

Suneel N. Vanikar

Suneel N. Vanikar, P. E.

Geotechnical Engineer

I-215, SALT LAKE CITY, UTAH

TABLE 1 SUMMARY OF DYNAMIC MONITORING RESULTS
Site No. 1

Dates March 25, 1985 Pile Length (40'-3") + (40'-3") + (40'-3") = 120'-9"

Pile Type 14"O.D.,0.375 wall, closed end pipe Pile No. 4 (Reaction), Site No. 1

Hammer Type Single-Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.20 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
40'-3" long pile section, driving started on March 25, 1985.											
10'	---	13	17	61	3.8	0	0	2.6	Rated Hammer Energy = 66,100 Foot Kips	3.9 percent	Hammer stroke was not measured during driving. Therefore, transfer efficiency is computed based on rated hammer energy rather than actual hammer energy.
20'	---	5	20	50	3.1	10	0.6	0.5		0.8 percent	
35'	---	5	109	310	19.3	56	3.5	9.8		14.8 percent	
Driving completed at 36'-0". Another 40'-3" section was welded to the driven section and driving continued on March 25, 1985. (Total length = 80'-6".)											
45'	---	1	103	301	18.8	54	3.3	9.2		13.9 percent	
50'	35	16	203	382	23.8	34	2.1	9.8		14.8 percent	
54'	---	38	278	398	24.8	0	0	9.7		14.7 percent	
59'	---	46	408	434	27.0	0	0	11.6		17.5 percent	
65'	67	---	267	292	18.2	0	0	4.6		7.0 percent	
70'	35	54	325	395	24.4	0	0	8.8		13.3 percent	
75'	44	50	404	404	25.2	0	0	9.6		14.5 percent	
77'	38	45	372	404	25.2	0	0	9.5		14.4 percent	
Driving completed @ 77'-2". Another 40'-3" section was welded to the driven section and the driving continued on March 25, 1985.											

*Distance from the ground line to pile tip.
RS TC= Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

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TABLE 1 SUMMARY OF DYNAMIC MONITORING RESULTS (continued) Site No. 1

Dates March 25, 1985 Pile Length = (40'-3") + (40'-3") + (40-3") = 120'-9"

Pile Type 14"O.D. 0.375" wall, closed end pipe Pile No. 4 (Reaction), Site No. 1

Hammer Type Single-Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth, Feet*	Blow Count Per Foot From Analyzer	Blow Count Per Foot From Driving Record	RS With J=0.20 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
120'-9" long pile section											
80'	79	40	463	382	23.8	0	0	10.9	Rated Hammer Energy = 66,100 Foot Kips	16.5 percent	
85'	47	34	366	355	22.1	0	0	9.1		13.8 percent	
90'	46	32	390	379	23.6	0	0	10.9		16.5 percent	
92'	35	33	381	392	24.4	0	0	12.2		18.5 percent	
94'	46	33	397	400	24.9	0	0	11.8		17.9 percent	
95'	46	31	384	394	24.5	0	0	11.4		17.2 percent	
96'	46	38	417	398	24.8	0	0	11.7		17.7 percent	
97'	66	51	376	348	21.7	0	0	9.7		14.7 percent	
98'	61	52	392	377	23.5	0	0	10.8		16.3 percent	
99'	103	56	451	401	25.0	0	0	12.2		18.5 percent	
99'-4"	97	80	444	394	24.5	0	0	11.0		16.6 percent	

Driving completed at 99'-4" on March 25, 1985. Predicted ultimate static load capacity = 444 Kips = 222 Tons

*Distance from the ground line to pile tip.
RSTC = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

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TABLE 2 SUMMARY OF DYNAMIC MONITORING RESULTS

Site No.1

Dates March 22 and 25, 1985 Pile Length (40'-3") + (40'-3") + (40'-3") = 120'-9"

Pile Type 12-3/4"O.D.,0.375 wall, closed end pipe Pile No. 1 (Long Test Pile), Site No.1

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3202

Hammer Rated Energy 66,100 Foot Pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.2 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
40'-3" long pile section. Driving started on March 22, 1985.											
6'	20	--	58	219	15.0	47	3.2	8.7	Rated Hammer Energy = 66.1 Foot Kips	13.2 percent	Hammer stroke was not measured during driving. Therfore, transfer efficiency is computed based on rated hammer energy rather than the actual hammer energy. Hammer did not work properly from 10' to 50'.
26'	--	1	14	203	13.9	57	3.9	8.2		12.4 percent	
35'	--	1	14	196	13.4	51	3.5	10.2		15.4 percent	
Driving completed at 37'-0". Another 40'-3" section was welded to the driven section and driving was continued on March 22, 1985. (Total Length = 80'6").											
45'	--	3	53	270	18.5	79	5.4	9.3		14.1 percent	
50'	--	8	80	279	19.1	67	4.6	8.1		12.3 percent	
52'	--	47	116	217	14.9	10	0.7	3.8		5.7 percent	
55'	82	83	183	291	20.0	2	0.1	7.1		10.7 percent	
60'	60'	62	209	304	20.9	0	0	7.6		11.5 percent	
64'	70	64	196	284	19.5	0	0	6.5		9.8 percent	
69'	37	34	157	254	17.4	0	0	5.3		8.0 percent	
73'	31	34	256	367	25.2	0	0	11.6		17.5 percent	
77'	32	25	195	330	22.6	0	0	8.3		12.6 percent	
Driving completed at 77'-0". Another 40'-3" section was welded to the driven section and driving continued on March 22, 1985.											

*Distance from the ground line to pile tip.

RS TC = Ultimate Static Resistance

FMAX = Maximum measured force in pile at the transducer location.

CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I

J = Damping parameter (depends on soil type)

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TABLE 2 SUMMARY OF DYNAMIC MONITORING RESULTS
(Continued) Site No. 1

Dates March 22 and 25, 1985 Pile Length = (40'-3") + (40'-3") + (40'-3") = 120'-9"

Pile Type 12-3/4"O.D.,0.375" wall closed end pipe Pile No. 1 (Long Test Pile), Site No.

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0. 2 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
120'-9" long pile section											
80'	40	37	280	333	22.8	0	0	8.9		13.5 percent	
81'	53	49	371	425	29.1	0	0	16.1		24.4 percent	
85'	24	25	227	309	21.2	0	0	7.5		11.3 percent	
90'	31	25	188	289	19.8	12	0.8	6.6		10.0 percent	
92'	--	25	190	321	22.0	27	1.9	8.9		13.5 percent	
94'	23	22	181	315	21.6	31	2.1	8.5		12.9 percent	
98'	60	38	199	301	20.6	12	0.8	7.4		11.2 percent	
100'	76	81	270	302	20.7	0	0	7.3		11.0 percent	
101'	131	123	358	396	27.2	0	0	13.5		20.4 percent	
101'-7"	86/7"	85/7"	385	407	27.9	0	0	15.0		22.7 percent	
Driving completed at 101'-7" on March 22, 1985. Predicted ultimate pile load capacity = 387 Kips = 192 Tons. Retap (redriving) was performed on March 25, 1985 (60 hours after initial driving was completed).											
101'-7 1/2"	57 blows for 1/2"	50	697	564	38.7	0	0	29.2		44.2 percent	
Predicted ultimate pile load capacity after setup = 697 Kips = 349 Tons									Rated Hammer Energy = 66.1 Foot Kips		

*Distance from the ground line to pile tip.
RSTC = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

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TABLE 3 SUMMARY OF DYNAMIC MONITORING RESULTS

Site No. 1

Dates March 22 and 25, 1985 Pile Length (40'-6") + (43'-0") = 83'-6"

Pile Type 12-3/4"O.D.O.375"wall closed end pipe Pile No. 2(Short Test Pile),Site No.1

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth,Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.2 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
40'-6" long pile section. Driving started on March 25, 1985.									Rated Hammer Energy = 66.1 Foot Kips		
5'	26	--	55	147	10.1	2	0.1	4.3		6.5 percent	Hammer stroke was not measured during driving. Therefore, transfer efficiency is computed based on rated hammer energy rather than the actual hammer energy. Hammer problems from 8' to 47'.
20'	--	4	13	174	11.9	46	3.2	7.4		11.1 percent	
25'	--	1	35	227	15.6	58	4.0	7.1		10.7 percent	
30'	--	1	48	229	15.7	50	3.4	10.9		16.5 percent	
35'	--	5	62	173	11.9	4	0.3	6.7		10.1 percent	
Driving completed at 36'-0". A 43'-0" section was welded to the driven section and driving was continued on March 22, 1985 (total length = 83'-6").											
40'	--	2	18	237	16.3	96	6.6	10.9		16.5 percent	
45'	--	4	20	242	16.6	99	6.8	10.5		15.9 percent	
50'	23	22	120	274	18.8	56	3.8	7.3		11.0 percent	
51'	43	42	160	337	23.1	60	4.1	11.1		16.8 percent	
52'	48	48	145	322	22.1	61	4.2	9.9		15.0 percent	
53'	48	47	165	311	21.3	39	2.7	9.0		13.6 percent	
54'	62	62	202	336	23.0	22	1.5	10.7		16.2 percent	
54'-6"	30/6"	33/6"	205	329	22.6	28	1.9	8.9		13.5 percent	

*Distance from the ground line to pile tip.

RS^{TC} = Ultimate Static Resistance

FMAX = Maximum measured force in pile at the transducer location.

CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I

J = Damping parameter (depends on soil type)

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TABLE 3 SUMMARY OF DYNAMIC MONITORING RESULTS
(Continued) Site No. 1

Dates March 22 and 25, 1985 Pile Length (40'-6") + (43'-0") = 83'-6"

Pile Type 12-3/4"O.D.,0.375 wall closed end pipe Pile No.2(Short Test Pile), Site No.

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth,Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.2 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
Driving completed at 54'-6" on March 22, 1985. Predicted ultimate pile load capacity = 205 Kips = 103 tons.											
Retap (redriving) of 83'-6" long pile was performed on March 25, 1985 (60 hours after the initial driving was completed).											
54'-10"	55/4"	43/4"	386	398	27.3	0	0	13.2		20.0 percent	
Predicted ultimate pile load capacity after setup = 386 Kips = 193 Tons.											

Rated Hammer Energy = 66.1 Foot Kips

*Distance from the ground line to pile tip.
RSTC = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

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TABLE 4 SUMMARY OF DYNAMIC MONITORING RESULTS

Site No. 2

Dates March 28, 1985 Pile Length = (40'-6") + (40'-6") + (40'-6") = 121'-6"

Pile Type 14"O.D.,0.375" wall closed end pipe Pile No.3 (Reaction), Site No. 2

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.2 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
40'-6" long pile section, driving started on March 28, 1985.											
20'	--	1	0	225	14.0	88	5.5	6.4	Rated Hammer Energy = 66.1 Foot Kips	9.7 percent	Hammer stroke was not measured during driving. Therefore, transfer efficiency is computed based on rated hammer energy rather than actual hammer energy. Hammer operated erratically from beginning to 60' depth.
20'	--	7	0	237	14.8	105	6.5	11.1		16.8 percent	
Driving completed at 35'-0". Another 40'-6" section was welded to the driven section and driving was continued on March 28, 1985 (total length = 81'0").											
40'	--	33	131	437	27.2	136	8.5	17.6		26.6 percent	
45'	11	6	56	282	17.6	97	6.0	9.5		14.4 percent	
50'	17	14	71	222	13.8	55	3.4	4.4		6.7 percent	
55'	10	5	30	272	16.9	101	6.3	11.7		17.7 percent	
60'	--	10	31	213	13.3	79	4.9	4.4		6.7 percent	
68'	--	40	133	290	18.1	40	2.5	6.3		9.5 percent	
72'	9	13	56	214	13.3	47	2.9	5.1		7.7 percent	
74'	--	9	43	177	11.0	35	2.2	3.1		4.7 percent	
Driving completed at 74'-6". Another 40'-6" section was welded to the driven section and driving continued on March 28, 1985 (total length = 121'-6").											

*Distance from the ground line to pile tip.

RSTC = Ultimate Static Resistance

FMAX = Maximum measured force in pile at the transducer location.

CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I

J = Damping parameter (depends on soil type)

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TABLE 4 SUMMARY OF DYNAMIC MONITORING RESULTS
(Continued) Site No. 2

(40'-6") + (40'-6") + (40'-6")

Dates March 28, 1985 Pile Length = 121'-6"

Pile Type 14"O.D.,0.375" wall closed end pipe Pile No. 3 (Reaction, Site NO. 2

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0. 20Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
121'6" long pile section											
75'	--	8	193	233	14.5	1	0	3.5		5.3 percent	
80'	--	95	262	332	20.7	0	0	8.1		12.3 percent	
81'	107	126	187	217	13.5	0	0	3.4		5.1 percent	
82'	240	215	207	270	16.8	0	0	5.6		8.5 percent	
83'	106	115	213	302	18.8	14	0.9	7.0		10.6 percent	
84'	107	78	292	340	21.2	0	0	8.9		13.5 percent	
85'	126	117	288	331	20.6	0	0	8.4		12.7 percent	
85'-6"	210/6"	---	289	335	20.9	0	0	8.5	Rated Hammer Energy = 66.1 Foot Kips	12.9 percent	

Driving completed at 85'-6" on March 28, 1985. Predicted ultimate pile load capacity = 289 Kips = 145 Tons.

*Distance from the ground line to pile tip.
RSTC = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH

TABLE 5 SUMMARY OF DYNAMIC MONITORING RESULTS

Site No. 2

Dates March 28-29, 1985 Pile Length = (40'-6") + (40'-6") +(28'-6") = 109'-6"

Pile Type 12-3/4"O.D.,0.375" wall closed end pipe Pile No. 1(Long Test Pile),Site NO. 2

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth,Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.20 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
40'-6" long pile section. Driving started on March 28, 1985. Monitoring was not performed for the first 40'-6" section since it was driven in very soft soils without developing any resistance. Another 40'-6" section was welded to the driven section and the driving was continued on March 28, 1985.											
36'	--	--	0	279	19.1	135	9.3	10.0	Rated Hammer Energy = 66.1 Foot Kips	15.1 percent	Hammer stroke was not measured during driving. Therefore, transfer efficiency is computed based on rated hammer energy rather than the actual hammer energy. Hammer operated erratically until the pile tip reached 79' below the existing ground.
40'	--	--	103	293	20.1	68	4.7	7.3		11.0 percent	
45'	--	5	36	281	19.3	95	6.5	13.8		20.9 percent	
50'	--	7	48	273	18.7	69	4.7	11.4		17.2 percent	
60'	--	8	81	282	19.3	89	6.1	7.4		11.2 percent	
66'	--	6	12	226	15.5	33	2.3	18.2		27.5 percent	
70'	--	14	41	258	17.7	82	5.6	9.1		13.8 percent	
76'-5"	--	--	1	251	17.2	107	7.3	8.1		12.3 percent	
Driving completed at 76'-5". A 28'-6" long section was welded to the driven section and driving was resumed on March 28, 1985.											

*Distance from the ground line to pile tip.

RSTC = Ultimate Static Resistance

FMAX = Maximum measured force in pile at the transducer location.

CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I

J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH

TABLE 5 SUMMARY OF DYNAMIC MONITORING RESULTS
(Continued) Site No. 2

Dates March 28-29, 1985 Pile Length = 109'-6" (40'-6") + (40'-6") + (28'-6

Pile Type 12-3/4"O.D.,0.375"wall closed end pipe Pile No.1(Long Test Pile),Site No. 2

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth,Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.20 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
109'-6" long pile section											
78'	--	38	238	327	22.4	12	0.8	9.1		13.8 percent	
79'	80	73	201	294	20.2	11	0.7	7.7		11.6 percent	
80'	96	93	230	311	21.3	2	0.1	8.4		12.7 percent	
80'-4"	47/4"	--	224	302	20.7	1	0	8.1		12.3 percent	
Driving completed at 80'-4" on March 28, 1985. Predicted ultimate pile load capacity = 224 Kips = 112 tons. Retap (redriving) performed on March 29, 1985 (24 hours after the initial driving was completed).											
80'-6"	62	--	606	485	33.3	0	0	21.8		33.0 percent	
Predicted ultimate pile load capacity after setup = 606 Kips = 303 tons.											

Rated Hammer Energy = 66.1

*Distance from the ground line to pile tip.
RS TC= Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

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TABLE 6 SUMMARY OF DYNAMIC MONITORING RESULTS

Site No. 2

Dates March 28-29, 1985 Pile Length (40'-6") + (40'-6") = 81'-0"

Pile Type 12-3/4"O.D.,0.375"wall closed end pipe Pile No. 2(Short Test Pile),Site No. 2

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth,Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0. 20 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
Driving for the first 40'-6" long section was not monitored because the driving was performed in very soft soils. Another 40'6" section was welded to the driven section and the driving was continued on March 28, 1985.											
40'	--	--	102	293	20.1	75	5.1	9.0		13.6 percent	Hammer stroke was not measured during driving. Therefore, transfer efficiency is computed based on rated hammer energy rather than the actual hammer energy.
43'	18	21	48	116	8.0	15	1.0	1.2		1.8 percent	
48'	8	7	28	201	13.8	79	5.4	4.7		7.1 percent	
50'	14	6	24	191	13.1	76	5.2	5.0		7.6 percent	
55'	--	3	4	125	8.6	49	3.4	3.0		4.5 percent	
60'	--	17	59	158	10.8	22	1.5	3.3		5.0 percent	Hammer operated erratically during driving of this pile.
65'	--	9	20	112	7.7	22	1.5	3.0		4.5 percent	
68'	--	20	119	296	20.3	23	1.6	14.8		22.4 percent	
Driving completed at 70'-0" on March 28, 1985. Predicted ultimate pile load capacity = 119 Kips = 60 tons.											
Retap (redriving) performed on March 29, 1985 (24 hours after the initial driving was completed)											
70'8"	75	78	566	475	32.6	0	0	19.4		29.3 percent	
Predicted ultimate pile load capacity after setup = 566 Kips = 283 tons.											

Rated Hammer Energy = 66.1

*Distance from the ground line to pile tip.

RS TC= Ultimate Static Resistance

FMAX = Maximum measured force in pile at the transducer location.

CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I

J = Damping parameter (depends on soil type)

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TABLE 7 SUMMARY OF DYNAMIC MONITORING RESULTS

Test Site No. 3

Dates April 8-9, 1985 Pile Length (61'-0") + (59'-0") + (27'-0") = 147'-0"

Pile Type 14" O.D.,0.375" wall closed end pipe Pile No. 2 (Reaction Pile), Site No. 3

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 foot pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
61'-0" long pile section, driving started on April 8, 1985.									Rated Hammer Energy = 66.1 foot kips		
10'	--	--	62	376	23.4	95	5.9	10.7		16.2 percent	Hammer stroke was not measured during driving, therefore, transfer efficiency is computed based on rated hammer energy rather than the actual hammer energy.
15'	--	--	161	343	21.4	38	2.4	7.1		10.7 percent	
20'	--	--	149	299	18.6	5	0.3	6.0		9.1 percent	
30'	--	--	87	262	16.3	34	2.1	5.3		8.0 percent	
42'	--	19	64	264	16.4	48	3.0	5.6		8.5 percent	
50'	17	16	67	283	17.6	55	3.4	5.6		8.5 percent	
55'	20	20	79	255	15.9	0	0	6.4		9.7 percent	
56'	23	21	65	250	15.6	37	2.3	5.1		7.7 percent	
56'-2"	8/2"	--	69	256	15.9	12	0.7	4.9		7.4 percent	
Driving completed @ 56'-2". A 49'-0" section was welded to the driven section and driving was resumed on April 9, 1985. (Total length = 120'-0".)											
59'	--	21	131	202	12.6	21	1.3	2.2		3.3 percent	
65'	28	18	145	413	25.7	85	5.3	13.3		15.1 percent	
70'	30	15	130	446	27.8	105	6.5	16.0		24.2 percent	
80'	53	54	139	290	18.1	36	2.2	5.9		8.9 percent	

*Distance from the ground line to pile tip.

RS = Ultimate Static Resistance

FMAX = Maximum measured force in pile at the transducer location.

CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I

J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH
TABLE 7 SUMMARY OF DYNAMIC MONITORING RESULTS
(continued) Test Site No. 3

Dates April 8-9, 1985 Pile Length (61'-0") + (59'-0") + (27'-0") = 147'-0"
Pile Type 14"O.D.,0.375" wall, closed end pipe Pile No. 2(Reaction Pile),Site No. 3
Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002
Hammer Rated Energy 66,100 foot pounds

Depth,Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
Driving of 120'-0" long section (April 9, 1985).											
90'	22	21	85	249	15.5	43	2.7	5.2		7.9 percent	
93'	41	38	174	311	19.4	12	0.7	6.7		10.1 percent	
98'	26	26	114	270	16.8	28	1.7	5.4		8.2 percent	
102'	53	52	103	182	11.3	0	0	2.0		3.0 percent	
105'	20	17	123	304	18.9	40	2.5	6.3		9.5 percent	
110'	36	34	140	287	17.9	19	1.2	5.1		7.7 percent	
115'	19	20	137	357	22.2	40	2.5	7.9		12.0 percent	
115'-4"	13/4"	--	119	383	23.9	72	4.5	8.0		12.1 percent	
Driving completed at 115'-4". A 27'-0" long section welded to the driven section and driving was continued on April 9, 1985. (Total length = 147'-0").											
118'	52	51	275	387	24.1	0	0	8.6		13.0 percent	
120'	50	48	332	475	29.6	0	0	13.6		20.6 percent	
121'	183	179	377	471	29.3	0	0	14.4		21.8 percent	
122'	420	--	397	466	29.0	0	0	13.8		20.9 percent	
122'-1"	179	--	416	477	29.7	0	0	12.8		19.4 percent	
Driving completed @ 122'-1" on April 9, 1985 Predicted ultimate pile load capacity = 146 kips = 208 tons.											

Rated Hammer Energy = 66.1 foot kips

*Distance from the ground line to pile tip.
RS = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH

TABLE 8 SUMMARY OF DYNAMIC MONITORING RESULTS
Site No. 3

Dates April 8-9, 1985 Pile Length = 135'-0" (55'-0") + (40'-0") + (40'-0")

Pile Type 12-3/4"O.D.,0.375"wall closed end pipe Pile No. 1(Long Test Pile),Site No. 3

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth,Feet*	Blow Count Per Foot From Analyzer	Blow Count Per Foot From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
Driving of 55'0" long section was not monitored because predrilling was performed and casing was installed to avoid any negative skin friction forces on the pile. A 40'-0" long section was welded to the driven pile section and the driving was continued on April 9, 1985. (Total length = 95'0".)											
60'	--	30	0	243	16.7	101	6.9	10.9	Rated Hammer Energy = 66.1 Foot Kips	16.5 percent	Hammer stroke was not measured during driving. Therefore, transfer efficiency is computed based on the rated hammer energy rather than the actual hammer energy. Hammer performed erratically until the pile driving was completed at 126'-8".
70'	--	48	62	118	8.1	0	0	2.4		3.6 percent	
80'	--	23	0	243	16.7	80	5.5	12.2		18.5 percent	
85'	--	41	95	239	16.4	17	1.2	5.4		8.2 percent	
90'	--	38	15	265	18.2	80	5.5	10.1		15.3 percent	
End of driving at 94'-0". A 40'-0" long section was welded to the driven section and the driving was continued on April 9, 1985 (total pile length = 135'-0").											
95'	49	25	141	240	16.5	18	1.2	4.7		7.1 percent	
100'	89	135	144	239	16.4	1	0.1	5.0		7.6 percent	
105'	--	63	42	268	18.4	78	5.3	8.7		13.2 percent	
110'	--	42	55	249	17.1	53	3.6	8.5		12.8 percent	
115'	--	--	113	241	16.5	0	.0	7.5		10.7 percent	
120'	--	35	135	168	11.5	0	0	3.6		5.4 percent	
125'	--	--	89	267	18.3	52	3.6	7.0		10.6 percent	

*Distance from the ground line to pile tip.
RSTC = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH

TABLE 8 SUMMARY OF DYNAMIC MONITORING RESULTS
(continued) Site No. 3

Dates April 9-10, 1985 Pile Length (55'-0") + (40'-0") + (40'-0") = 135'-0"

Pile Type 12-3/4"O.D.,0.375"wall closed end pipe Pile No. 1(Long Test Pile),Site No. 3

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 Foot Pounds

Depth,Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
126'	147	--	189	235	16.1	0	0	4.2		6.4 percent	
126'-8"	215/8"	--	229	220	15.1	0	0	3.1		4.7 percent	
Driving completed at 126'-8". Predicted ultimate pile load capacity = 229 Kips = 115 tons.											
Retap (redriving) performed on April 10, 1985 (24 hours after the initial driving was completed).											
126'-9"	136/1"	--	549	583	40.0	0	0	17.3		26.2 percent	
Predicted ultimate pile load capacity after setup = 549 Kips = 279 tons.											

*Distance from the ground line to pile tip.
RSTC = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

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TABLE 9 SUMMARY OF DYNAMIC MONITORING RESULTS

Test Site No. 3

Dates April 9-10, 1985 Pile Length (40'-0") + (40'-0") + (40'-0") = 120'-0"

Pile Type 12 3/4"O.D.,0375" wall, ~~closed end pipe~~ Pile No. 2(Short Test Pile),Site No. 3

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 foot pounds

Depth,Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
Driving of first 40'-0" section was not monitored because predrilling was performed. Another 40'-0" section was welded to the driven section and driving was continued on April 4, 1985. (total length of pile = 80'-0").											
50'	---	14	0	257	17.6	123	8.4	9.2	66.1	13.9 percent	Hammer stroke was not measured during driving. Therefore, transfer efficiency is computed based on the rated hammer energy rather than the actual hammer energy.
55'	---	1	0	257	17.6	103	7.1	8.5		12.9 percent	
60'	---	1	0	239	16.4	100	6.9	9.4		14.2 percent	
70'	---	23	102	147	10.1	0	0	2.6		3.9 percent	
75'	---	22	101	185	12.7	0	0	4.0		6.1 percent	Erratic hammer performance from beginning to 100' penetration.
77'-8"	---	--	91	196	13.4	0	0	4.0		6.1 percent	
Driving completed at 77'-8". Another 40'-0" long section was welded to the driven pile section and the driving was continued on April 9, 1985. (Total length = 120'-0").											
80'	---	22	128	203	13.9	0	0	3.4		5.1 percent	
95'	---	10	76	189	13.0	7	0.5	5.0		7.6 percent	
100'	16	23	90	230	15.8	9	0.6	7.5		11.3 percent	
110'	---	4	53	262	18.0	59	4.0	9.2		13.9 percent	
115'	69	70	156	214	14.7	0	0	3.7		5.6 percent	
116'	79	74	168	252	17.3	0	0	5.2		7.9 percent	
117'	74	75	174	227	15.6	0	0	3.9		5.9 percent	

*Distance from the ground line to pile tip.

RS = Ultimate Static Resistance

FMAX = Maximum measured force in pile at the transducer location.

CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I

J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH

TABLE 9 SUMMARY OF DYNAMIC MONITORING RESULTS
(continued) Test Site No. 3

Dates April 9-10, 1985 Pile Length (40'-0") + (40'-0") + (40'-0") = 120'-0"

Pile Type 12 3/4"O.D.,0375" wall closed end pipe Pile No. 2(Short Test Pile),Site NO.3

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 foot pounds

Depth,Feet*	Blow Count Per Foot From Analyzer	Blow Count Per Foot From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
119'-1"	110/13"	108/13"	165	223	15.3	0	0	3.5		5.3 percent	
Driving completed at 119'-1" on April 9, 1985. Predicted ultimate pile load capacity = 165 kips = 83 tons.											
Retap (redriving) performed on April 10, 1985 (24 hours after the initial driving was completed)											
119'-4"	77/4"	71/4"	609	530	36.4	0	0	25.1	66.1		
Predicted ultimate pile load capacity after setup = 609 kips = 305 tons.											

*Distance from the ground line to pile tip.
RS = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

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TABLE 10 SUMMARY OF DYNAMIC MONITORING RESULTS
Test Site No. 4

Dates April 4, 1985 Pile Length (60'-0")+(60'-0") = 120'-0"
Pile Type 14"O.D.,0.375"wall closed end pipe Pile No.4 (reaction pile), Site No.4
Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002
Hammer Rated Energy 66,100 foot pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
60'-0" long pile section, driving started on April 4, 1985.											
10'	---	---	0	239	14.9	40	2.5	21.0	66.1	31.8 percent	Hammer stroke was not measured during the driving. Therefore, transfer efficiency is computed based on rated hammer energy rather than actual hammer energy.
20'	---	---	0	271	16.9	88	5.5	15.5		23.4 percent	
30'	---	2	0	251	15.6	84	5.2	13.8		20.9 percent	
45'	---	5	65	126	7.9	4	0.2	0.9		1.4 percent	
50'	---	8	30	111	6.9	19	1.2	1.2		1.8 percent	
57'	---	9	57	334	20.8	101	6.3	7.9		12.0 percent	Erratic hammer performance until the pile tip reached 64' below the existing ground.
Driving completed at 57'-0". Another 60'-0" section was welded to the driven section and driving was resumed on April 4, 1985. (Total length = 120'-0")											
60'	47	29	148	316	19.7	34	2.1	7.5		11.3 percent	
65'	200	263	322	467	29.1	0	0	11.7		17.7 percent	
70'	37	41	322	448	27.9	0	0	10.3		15.6 percent	
73'	---	152	422	435	27.1	0	0	13.6		20.6 percent	
Driving of 120'-0" section (April 4, 1985).											
75'	284	217	383	378	23.6	0	0	10.6		16.0 percent	
80'	38	37	299	367	22.9	0	0	11.0		16.6 percent	

*Distance from the ground line to pile tip.
RS = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH
TABLE 10 SUMMARY OF DYNAMIC MONITORING RESULTS
(Continued) Test Site No. 4

Dates April 4, 1985 Pile Length (60'-0")+(60'-0") = 120'-0"
Pile Type 14"O.D., 0.375" wall closed end pipe Pile No. 4(reaction pile),Site No. 4
Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002
Hammer Rated Energy 66,100 foot pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.30, Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
82'	43	42	310	325	20.2	0	0	7.9	66.1	12.0 percent	
84'	107	108	278	287	17.9	0	0	5.6		8.5 percent	
86'	42	42	253	305	19.0	0	0	6.7		10.1 percent	
87'	65	65	273	297	18.5	0	0	6.3		9.5 percent	
88'	224	240	395	397	24.7	0	0	12.5		18.9 percent	
88'-6"	196/6"	185/6"	363	370	23.1	0	0	9.7		14.7 percent	

Driving completed at 88'-6" on April 4, 1985
Predicted Ultimate Pile Load Capacity = 363 Kips = 182 tons.

*Distance from the ground line to pile tip.
RS = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH

TABLE 11 SUMMARY OF DYNAMIC MONITORING RESULTS

Test Site No. 4

Dates April 4-5, 1985 Pile Length (60'-0")+(60'-0") = 120'-0"

Pile Type 12 3/4"O.D., 0.375" wall ~~closed end pipe~~ Pile No. 1 (Long Test Pile), Site No. 4

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 foot pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
Driving of 60'-0" long section.											
10'	---	---	0	185	6.9	58	4.0	11.1	66.1	16.8 percent	Hammer stroke was not measured during driving. Therefore, transfer efficiency is computed based on the rated hammer energy rather than the actual hammer energy.
20'	---	---	0	216	14.8	72	4.9	12.3		18.6 percent	
30'	---	4	10	228	15.6	52	3.6	12.5		18.9 percent	
40'	21	---	92	206	14.1	0	0	3.6		5.4 percent	
50'	---	6	46	153	10.5	0	0	4.9		7.4 percent	
56'-3"	---	---	49	135	9.3	0	0	3.1		4.7 percent	
End of driving at 56'-3". Another 60'-0" long section was welded to the driven pile section and the driving was continued on April 4, 1985. (Total length = 120'-0")											
61'-0"	83	77	160	347	23.8	34	2.3	9.8		14.8 percent	
66'-0"	71	74	247	320	21.9	0	0	8.3		12.6 percent	
71'-0"	79	76	286	360	17.8	0	0	10.8		16.3 percent	
75'-0"	125	129	266	266	18.2	0	0	5.3		8.0 percent	
79'-0"	52	51	219	280	19.2	0	0	5.8		8.8 percent	
86'-0"	32	32	169	248	17.0	0	0	4.3		6.5 percent	
89'-0"	206	210	367	354	24.3	0	0	9.9		15.0 percent	
94'-0"	59	59	282	306	21.0	0	0	6.7		10.1 percent	

*Distance from the ground line to pile tip.

RS = Ultimate Static Resistance

FMAX = Maximum measured force in pile at the transducer location.

CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I

J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH

TABLE 11 SUMMARY OF DYNAMIC MONITORING RESULTS
(continued) Test Site No. 4

Dates April 4-5, 1985 Pile Length (60'-0")+(60'-0") = 120'-0"

Pile Type 12 3/4"O.D.,0.375" wall closed end pipe Pile No. 4 (Long Test Pile), Site NO. 4

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 foot pounds

Depth, Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
96'-0"	59	55	258	301	20.6	0	0	6.7	66.1	10.1 percent	
98'-0"	57	55	240	285	19.5	0	0	5.6		8.5 percent	
100'-0"	72	79	264	274	18.8	0	0	5.1		7.7 percent	
102'-0"	---	196	404	378	25.9	0	0	11.6		17.5 percent	
102'-8"	220/8"	---	349	306	21.0	0	0	7.0		10.6 percent	
103'-1"	55/1"	---	429	370	25.4	0	0	10.8		16.3 percent	
Driving completed at 103'-1" on April 4, 1985. Predicted Ultimate Pile Capacity = 429 Kips = 215 Tons											
Retap (redriving) of 120'-0" long pile was performed on April 5, 1985 (24 hours after the initial driving was completed).											
103'-1"	56	50	608 (J = 0.3)	486	33.3	0	0	20.0	66.1	30.3 percent	
103'-1"	56	50	639 (J = 0.2)	488	33.5	0	0	20.4	66.1	30.9 percent	
Predicted ultimate pile load capacity after set-up = 608 kips = 304 tons.											

*Distance from the ground line to pile tip.
RS = Ultimate Static Resistance
FMAX = Maximum measured force in pile at the transducer location.
CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I
J = Damping parameter (depends on soil type)

I-215, SALT LAKE CITY, UTAH

TABLE 12 SUMMARY OF DYNAMIC MONITORING RESULTS

Test Site No. 4

Dates April 4-5, 1985 Pile Length (40'-0")+(71'-0") = 111'-0"

Pile Type 12-3/4" O.D.,0.375"wall closed end pipe Pile No. 2(Short Test Pile),Site No. 4

Hammer Type Single Acting Diesel Hammer Model Delmag, D-3002

Hammer Rated Energy 66,100 foot pounds

Depth,Feet*	Blow Count Per Foot: From Analyzer	Blow Count Per Foot: From Driving Record	RS With J=0.30 Kips	FMax. Kips	Max. Comp. Stress KSI	CTEN Kips	Max. Tensile Stress K S I	Max. Transfer Energy FT. Kips	Hammer Energy (Ram Wt.) X Stroke FT. Kips	Transfer Efficiency (Transfer Energy / Rated Hammer Energy)	Remarks
Driving of 40'-0" long section.											
20'	---	---	0	212	14.5	76	5.2	10.4	66.1	15.7 percent	Hammer stroke was not measured during driving. Therefore, transfer efficiency is computed based on the rated hammer energy rather than the actual hammer energy.
30'	---	6	0	203	13.9	67	4.6	9.4		14.2 percent	
36'-2"	---	---	44	248	17.0	30	2.1	5.6		8.5 percent	
End of driving at 36'-2". A 71'-0" section was welded to the driven pile section and the driving was continued on April 4, 1985. (Total pile length = 111'-0")											
40'	---	2	0	239	16.4	81	5.6	13.3		20.1 percent	
50'	---	7	0	252	17.3	76	5.2	8.3		12.6 percent	
60'	22	24	105	272	18.7	10	0.7	6.0		9.1 percent	
62'	35	33	190	399	27.4	2	0.1	12.1		18.3 percent	
64'	67	63	270	445	30.5	0	0	14.5		21.9 percent	
65'	61	63	252	392	26.9	0	0	10.5		15.9 percent	
66'-6"	110/18"	---	256	378	25.9	0	0	9.4		14.2 percent	
Driving completed at 66'-6" on April 4, 1985. Predicted ultimate pile capacity = 256 kips = 128 tons. Retap (redriving) of 111'-0" long pile was performed on April 5, 1985. (24 hours after initial driving was completed).											
66'-11"	60/5"	54/5"	503 (J=0.3)	458	31.4	0	0	14.7	66.1	22.2 percent	
66'-11"	60/5"	54/5"	541 (J=0.2)	454	31.1	0	0	15.1	66.1	22.8 percent	
Predicted ultimate pile load capacity after setup = 503 kips = 252 tons.											

*Distance from the ground line to pile tip.

RS = Ultimate Static Resistance

FMAX = Maximum measured force in pile at the transducer location.

CTEN = Maximum computed tensile force anywhere in the pile.

Maximum allowable compressive or tensile driving stress = 0.9 Fy = 0.9 X 36 = 32.4 K S I

J = Damping parameter (depends on soil type)